BEFORETHE NATIONAL ELECTRIC POWER REGULATORY AUTHORITY

APPLICATION FOR GRANT OF GENERATION LICENCE

ON BEHALF OF

CJ HYDRO (PRIVATE) LIMITED

FOR

25 MW HYDROPOWER PLANT
AT C-J LINK (TAIL), DISTRICT KHUSHAB, PUNJAB
(BASED ON UPDATED FEASIBILITY STUDY)

February 2, 2018

C J HYDRO (PRIVATE) LIMITED

15-Peshawar Block, Fortress Stadium, Lahore.

Telephone: (042) 36675595, 36660085 & 36673818

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CJ

CJ Hydro (Pvt) Limited
15 Peshawar Block, Fortress Stadium
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Tel : 92 (42) 36675595, 36660085
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Our Ref: CJHPL/Gen Licence App/II-2018/ **February 2, 2018**

Registrar,
National Electric Power Regulatory Authority,
NEPRA Tower, Attaturk Avenue (East),
G-5/1, Islamabad.

Subject: **APPLICATION OF CJ HYDRO (PRIVATE) LIMITED FOR GRANT OF GENERATION LICENCE FOR 25 MW HYDRO POWER PROJECT AT C-J LINK CANAL (TAIL), DISTRICT KHUSHAB**

Dear Sir,

Kindly refer to your letter No. NEPRA/DL/LAG-143/9042-49 dated November 21, 2017 conveying the order of the Authority that due to significant changes in the main parameters of the project, our earlier application for the grant of the Generation Licence for 44 MW Hydropower Project at C-J Link (Tail), District Khushab, is not valid and that CJHPL is required to submit a fresh application for the grant of generation licence according to the revised feasibility study/revised parameters of the Project.

Pursuant to the above-mentioned decision of the Authority, I, Danish Haseeb Khan, Chief Executive Officer/Director of CJ Hydro (Private) Limited ("CJHPL"), duly authorized representative of CJHPL having its registered office at 15, Peshawar Block, Fortress Stadium Lahore, by virtue of the Company Resolution dated 11th January, 2018 (copy attached), apply to the National Electric Power Regulatory Authority ("**NEPRA**") for the grant of the Generation Licence to CJHPL for its 25 MW (Installed Capacity) hydropower generation facility proposed to be constructed, operated and maintained as an IPP project on Build, Own, Operate, and Transfer (BOOT) basis on Chasma-Jhelum Link Canal (Tail) in District Khushab, Punjab province, pursuant to Section 15 of Generation, Transmission and Distribution of Electric Power Act (XL of 1997).

I certify that the documents-in-support, attached with this application, have been prepared and submitted in conformity with the provisions of the NEPRA Licensing (Application and Modification Procedure) Regulations, 1999, as amended, and undertake and confirm 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. I also affirm that all further documentation and information, furnished, if required in connection with this application for the generation licence, shall be true and correct to the best of my knowledge and belief.

A Bank Draft No. 2485437 of MCB Fortress stadium, Lahore for the sum of Rs.310,000/- (Pak. Rupees three hundred & ten thousand only), being the non-refundable licence application fee calculated in accordance with Schedule II to the National Electric Power Regulatory Authority Licensing (Application and Modification Procedure) Regulations, 1999, as amended, is also attached herewith.

Yours Sincerely,

For and on behalf of
C J Hydro (Private) Limited

Danish Haseeb Khan
Chief Executive Officer/Director

Enclosure: One original and two copies of the Application for Generation Licence along with supporting documents

CJ HYDRO

CJ Hydro (Pvt) Limited
15 Peshawar Block, Fortress Stadium
Lahore 54810, Pakistan
Tel : 92 (42) 36675595, 36660085
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BOARD OF DIRECTORS' RESOLUTION OF C J HYDRO (PRIVATE) LIMITED PASSED ON JANUARY 11, 2017

RESOLUTIONS PASSED BY THE DIRECTORS OF CJ HYDRO (PVT) LTD

1. **RESOLVED THAT** pursuant to the decision of NEPRA on the review petition of CJHPL in regard to Review Motion for the grant of Generation Licence for 44 MW Hydropower Project at C-J Link (Tail) as conveyed vide Registrar NEPRA letter No. NEPRA/DL)/LAG-143/9042-49 dated November 21, 2017, it is agreed to submit a fresh application for the grant of generation licence based on the revised parameters of the project as determined in the Updated Feasibility Study.

2. **RESOLVED THAT** CJHPL shall file an 'Application for Generation Licence for 25 MW (Installed Capacity) hydropower generation facility proposed to be constructed, operated and maintained as an IPP project on Build, Own, Operate, and Transfer (BOOT) basis on Chasma-Jhelum Link Canal (Tail) in District Khushab, Punjab province as per draft prepared by CJHPL, which is hereby approved for submission to NEPRA;

3. **RESOLVED THAT** Mr. Danish Haseeb Khan, Chief Executive-cum-Director, is hereby authorized to proceed with and make any correction/amendment/addition, as required, in finalizing the said 'Application for Generation Licence' prior to its submission to NEPRA;

4. **RESOLVED THAT** Mr. Danish Haseeb Khan is hereby authorized to sign and submit the 'Application for Generation Licence' along with all necessary documents-in-support, and appear before NEPRA, as required, and do all such acts as are necessary in connection with the said application for and on behalf of the CJHPL; and

5. **RESOLVED THAT** these Board Resolutions shall remain in full force and effect until an amending resolution shall be passed by the Board.

Danish Haseeb Khan
Director/Chief Executive

Haseeb Khan
Director

APPLICATION FOR GRANT OF GENERATION LICENCE

Details of the Applicant

Name and Address of the Applicant

1. **C J Hydro (Private) Limited**
   15, Peshawar Block, Fortress Stadium,
   Lahore, Pakistan.

   Phone: +92-42-36675595, +92-42-36660085 & +92-42-36673818
   Fax: +92-42-36664349 & +92-42-36673960
   Email: danish@khan.net

   Certificate of Incorporation dated 6th May, 2009(CorporateUniversal Identification No: 0069345(Copy at Attachment - I)
   Memorandum & Articles of Association (Copy at Attachment - II)

Project Sponsors

2. Major sponsors/shareholders are as under:

   a. Haseeb Khan,Director ..... Main Sponsor
   b. Danish Haseeb Khan, Director

Grounds for Application

3. Under the "Regulation of Generation, Transmission and Distribution of Electric Power Act (XL of 1997), hereinafter referred to as the NEPRA Act, and the rules and regulations framed thereunder, a Generation Licence is required to be obtained from the National Electric Power Regulatory Authority (NEPRA) for construction, owning or operation of an electric power generation facility.

4. Pursuant to above, C J Hydro (Private) Limited (the **"CJHPL" or** the "**Company**") requires a Generation Licence for its 25 MW (Installed Capacity) hydropower generation facility (based on Updated Feasibility Study) proposed to be constructed, operated and maintained as an IPP project on Build, Own, Operate, and Transfer (BOOT) basis on Chashma-Jhelum Link Canal (Tail) in District Khushab, Punjab province (the "**Project**") for a period of thirty (30) years after its Commercial Operations Date (COD).

Original Feasibility Study and Application for Generation Licence

5. A brief background of the Project is that in March, 2007, the Government of Punjab through its Punjab Power Development Board ("PPDB") conceptualized and advertised a 40 MW hydropower project at Chashma-Jhelum Link (Tail) for development in the private sector under the Punjab Power Generation Policy2006. The then sponsors formed "HK Consortium" and submitted the bid to undertake the feasibility study and develop the said Project. PPDB prequalified HK Consortium. Being ranked first among the bidders, PPDB issued Letter of Interest ("LOI") (Copy placed at Attachment – III) to the Consortium on 8th November 2007for conducting the feasibility study of thisProject.Through a competitive bidding process, the HK Consortium engaged National Engineering Services Pakistan Limited (NESPAK) and Integrated Consulting Services (ICS) ("Consultants"), for conducting the feasibility study for the Project. The feasibility study of the project was completed within the stipulated period. The final draft of the feasibility study was submitted to PPDB on 10th February 2009 and presentation thereon was given to the Panel of Experts(POEs)/PPDB on 5th March 2009. The salient project parameters determined by the Consultants based on the hydrological data for the post Water Accord period i.e. from 1991 to 2007 are as under:

Design Discharge	320 m^3/s
Head: Minimum / Maximum	11.605 m / 13.809 m
Installed Capacity of the Plant	44.331 MW
No. of Units	3
Installed Capacity of each Unit	14.777 MW
Annual Energy Generation	212.249 GWh
Annual Plant Factor	55.21%
Technology	Horizontal Bulb Turbines
Headrace Channel Length / Cross Section Area	1350 m / 262 m^2
Tailrace Channel Length / Cross Section Area	370 / 264 m^2

6. The feasibility study was approved by the POEs as conveyed vide PPDB letter No. PPDB/328/2009 dated 30th March 2009. PPDBalso advised the HK Consortium to file Tariff Petition and application for the grant of Generation Licence to NEPRA.

7. In the meantime, C J Hydro (Private) Limited ("CJHPL") was established as a private limited company and registered under the Companies Ordinance, 1984 in May, 2009 exclusively for implementation of the proposed Project. On 8th June

2009, CJHPL submitted application to NEPRA for grant of generation licencefor the then proposed hydropower plant capacity of 44.331 MW (Installed) comprising three units of 14.777 MW each, for a period of 30 years.

8. NEPRAsought comments from the stakeholders and held a public hearing on 3rd September 2009 on the matter of grant of Generation Licence requested by CJHPL. All the stakeholders in particular the Power Purchaser supported grant of Generation Licence to CJHPL except IRSA and the Government of Sindh (GoS) which made certain observations. IRSA clarified that the CJ Link is not a perennial canal. GoSraised certain concerns regarding insufficient water-flows of the CJ Link, whereby, in its opinion the CJ Link (being a non-perennial canal) is not a regular canal, and its operation period is not fixed, and as such no assured supplies of water were available,the operation of this canal was not mentioned in the 1991 Water Accord and that the water release to the CJ Link Canal for the proposed hydropower project would render it to be a permanent canal and resultantly the water supply to the Sindh province would be affected. All the concerns/observations raised by IRSA and GoS were duly addressed by CJHPL by way of providing the historical flows in CJ Canal, and it was elaborated that the water supply to the province of Sindh will not be affectedand that it will continue to be allocated as per the Water Apportionment Accord by IRSA based on the share of each province.

9. NEPRA also sought clarification from the Ministry of Water & Power. After holding a meeting with the stakeholders, the Ministry of Water & Power confirmed that the Project was of non-consumptive nature and would not have any effect on the water allocation share of the GoS as CJ Link canal was dependent on the authorization of IRSA based on the share of the provinces. CJHPL has been continuously requesting NEPRA for grant of the generation licence for its Project. In the Authority Regulatory meeting 09-467 held on 30th December 2009, the Authority, after detailed deliberations, approved grant of Generation Licence to CJHPL as conveyed vide Registrar, NEPRA letter No. NEPRA/R/LAG-143/957-63 dated 3rd February 2010 (Attachment - V).

10. GoS filed a Review Petition with NEPRA on 11th February 2010 reiterating its arguments and informing that it does not accept the river water availability estimates prepared by WAPDA. GoS also informed that on 28th January 2010, the provincial assembly of Sindh passed a unanimous resolution against the construction of the proposed Project and pleaded that theProject should be immediately shelved to maintain harmony among co-sharer provinces. PPDB contested the contents of the Review Motion and requested the Authority to grant

generation licence to CJHPL. The matter remained under correspondence for quite some time. The Authority held hearing on the Review Motion on 26th March 2014. During the hearing, the representative of GoS was invited to elaborate the grounds of their Review Motion. In the hearing, he raised the following major three issues:

a. There has been a change in the flow pattern of CJ Link Canal since the year 2003. The flows have been decreased.

b. IRSA has objected to the Project.

c. NEPRA did not properly follow its rules and procedures while approving grant of the Generation Licence.

Two of the above issues (b & c) were addressed in the hearing. The only outstanding observation (a) of GoS was to include flow data in CJ Link Canal from 2008 to 2013. Accordingly, NEPRA directed CJHPL to revisit the feasibility study considering the aforementioned flow data.

11. CJHPL engaged a consultant to collect and review the new flow data as directed by NEPRA. The consultant carried out the requisite study and issued a 'Hydrology, Power & Energy Estimation Report' of September, 2014 ('Updated Report'). The Updated Report was submitted by CJHPL to PPDB which was forwarded to NEPRA on October 28, 2014. The Updated Report reviewed the flow data of CJ Link Canal in detail and confirmed that there were insignificant differences in capacity and energy estimations while considering the new flow data.

12. In his letter dated December 17, 2015, addressed to Project Director, CJHPL, the Registrar, NEPRA,informed that CJHPL application was pending due to concerns raised by the GoSthat if the power plant is installed on Chashma Jhelum, it will become a permanent canal and water supply to Sindh will be affected by depriving it of its share of water. It was also informed that the Provincial Assembly of Sindh had passed a unanimous resolution on January 28, 2010 against the construction of the project and that the GoS had also approached the Federal Government and once again expressed its strong opposition to the proposed power plant.It was also informed through the same letter that the Authority, considering the matter in its Regulatory Meeting held on October 28, 2015, decided that the dispute over water supply did not fall within the mandate of NEPRA and the Authority decided that parties must resolve this issue at the appropriate forum as provided in the Constitution. It was also intimated that the Authorityhas also decidedto approach Government of Punjab for taking up the matter at appropriate forum and settle the dispute regarding water supply/flow within a period of three

(3) months failing which the application for Generation Licence of CJHPL will be rejected.

13. Responding to NEPRA's letter ofDecember 17, 2015, PPDB informed vide its letter dated January 13, 2016 that the issue regarding the water use of Chashma Jhelum Link canal had already been taken up on the forum of IRSA. The decision of IRSA as reproduced in the said letter is as under:

> *"Chashma Jhelum Canal is Non Perenial canal and operates intermittently as per availability of water in the system and regulation needed. Therefore you (NEPRA) are requested to keep in view the above aspect while awarding the Generation Licence."*

PPDB reiterated that the proposed CJ HPP has been designed on the basis of historical flows in the canal (Post water accord) as authorized by IRSA out of the Punjab share and that WAPDA operates CJ Link out of Punjab share allocated by IRSA and its operation would not affect the share of Sindh or any other province. PPDB requested NEPRA to grant Generation Licence to CJHPL.

14. The Registrar, NEPRA, informed through his letter dated 5th April 2016 addressed to Project Director, CJHPL, (Attachment - V) that the Authority did not receive any update on its directions to resolve the dispute over water flow/availability at the appropriate forum within three months and that the letter of IRSA forwarded by PPDB was already available in NEPRA record and that it was considered while taking the earlier decision. He further stated that the Authority observed that neither CJHPL nor PPDB has provided any new fact to resolve the matter even after lapse of three months and in view of said, the Authority has decided to reject CJHPL's application for the grant of Generation Licence.

15. Aggrieved by the above cited NEPRA decision, CJHPL filed a Review Motion emphasizing that the observations of the GoS hadalready been appropriatelyresponded and that the Authority after considering them in its meeting of 30th December 2009,had approved grant of generation licence to CJHPL. The only new issue was regarding variation of water flows in CJ Link Canal after Mangla Dam raising in 2013. In this connection, CJHPL also informed that according to the revised hydrology and power/energy estimation study, there were insignificant differences in the plant capacity and the energy estimates. Stressing thatit has fulfilled the requisites for grant of the generation licence, CJHPL requested the Authority to review its decision of 5th April 2016 and issue the requisite generation licence. The Authority considered the Review Motion and held hearing on it on 29thNovember 2016. During the hearing, the Authority

directed CJHPL to carry out a detailed revised feasibility study of the Project by incorporating the impact of increased capacity of Mangla Dam and all other associated and pertinent matters.

Updated Feasibility Study and Fresh Application for Generation Licence

16. Pursuant to the directions of NEPRA, CJHPL engaged QATZ (Private) Limited (Project Development and Management Consultants) for carrying out a comprehensive hydrology study of the project and updating the feasibility study based on their findings. The Consultants commenced the requisite study in December 2016 and submitted draft report in June 2017. The Updated Feasibility Studywas reviewed by the POEs on 27th July 2017. The salientfeatures of the Updated Feasibility Studyconducted by the Consultants are as under:

    (a) Hydrology of the project has been updated up to year 2016including the years that may account for changes in the water flow after Mangla Dam raising.

    (b) Hydrological data has been analyzed based on the historic water flows from 1991 to 2016 with and without Mangla Dam raising, and further extrapolated up to year 2041 in order to affirmthatthe projectremains viable. The analysis showed that the discharge in CJ Link would reduce by 0.42 MAF in the Rabi period due to improved flows at Trimmu Barrage by one (1) MAF on account of enhanced storage capacity at Mangla Dam. However,during Kharif, water flows in CJ Link canal were not likely to reduce due toMangla reservoir then being in the filling stage. Hence, CJ Link canal will remain operational and an important source to meet shortfalls at Trimmu Barrage.

    (c) Based on the updated hydrological data, the project parameters have been revised. The design discharge, plant output, plant factor (power potential), and the related electromechanical structure have changed. BOQ for the Civil Works, Electro-mechanical equipment have been revised and the costs have been updated accordingly.The design discharge has reduced from 320 cumecs proposed in the original feasibility study to 210 cumecsbased on the updated hydrological study. Accordingly, the plant capacity has reduced from the original 44.331 MW to 25 MW based on the updated hydrological study.Due to variable discharge in CJ Link, the annual energy generation will vary from 53.5GWh to 146.2GWh. The average annual energy works out as 110.6 GWh.

17. As concluded in the minutes of the meeting of the POEs held on 27th July, 2017 conveyed vide PPDB letter No. PPDB 1118/2017 dated 1st August 2017 (Attachment - IV), the POEshasapproved the revised capacity of the project as 25 MW along with other parameters as specifiedin the Updated Feasibility Study.

18. The salient project parameters determined by the Consultants based on the Updated Feasibility Study are compared hereunder with those determined in the original feasibility study:

Parameter	**Unit**	**Original Feasibility Study**	**Updated Feasibility Study**
Design Discharge	m^3/s	320	210
Head: Minimum / Maximum	M	11.605 / 13.809	11.58 / 13.52
Installed Capacity	MW	44.331	25
No. of Units	No.	3	3
Installed Capacity of each Unit	MW	14.777	8.333
Annual Energy Generation	GWh	212.249	110.6
Plant Factor	%	55.21%	50.3
Technology		Horizontal Bulb Turbines	Horizontal Bulb Turbines
Headrace Channel Length / Cross Section Area	m / m^2	1350 / 262	1350 / 176
Tailrace Channel Length / Cross Section Area	m / m^2	370 / 264	370 / 176
Total Estimated Project Cost&Price Index	m US$ Month & Year	84.9 September 2008	54.181 May 2017
Estimated Project Cost per MW	m US$	1.916	2.167
LevelizedFeasibility Stage Reference Tariff Over 30 Years at 10% Discount Rate	US Cents/kWh	6.89	8.85

Note: *Cost of FESCO transmission/interconnection facilities is not included in the Project Cost.*

19. Cross-sectional areas of the Headrace Channel and the Tailrace Channel based on the revised project parameters are as follows:

Headrace Channel	Tailrace Channel
Bed Width:36 m	Bed Width: 36 m
Water Depth at FSL: 4.0 m	Water Depth at FSL: 4.0 m
Side Slope1V:2H	Side Slope1V:2H
CrossSectional Area: 176 m^2	Cross Sectional Area: 176 m^2

20. CJHPL submitted the UpdatedFeasibility Study- July, 2017 duly approved by POEs/PPDB to NEPRA on 9th August 2017. After examining the Updated Feasibility Study and observing significant changes in the main parameters of the project viz reduction in design discharge and the resultant reduction in the plant capacity and energy production estimates and increase in per megawatt cost, etc.,the Authority rejected CJHPL's Review Motion based on the view that the earlier application of CJHPL was not valid and a fresh application for grant of the generation licence according to the revised/updated feasibility study and revised parameters of the project was required to be submitted. The decision of the Authority was conveyed vide Registrar, NEPRA, letter No. NEPRA/DL/LAG-143/9042 – 49 dated 21st November 2017, a copy of which is placed in Attachment – V.

21. CJHPL is hereby complying with theabove-mentioned decision of the Authority.

22. The salient project parameters per the Updated Feasibility Study are given above. As regards the project location, the powerhouse is located approximately in line of the last fall of the CJ tail structure. Its axis deviates from the axis of the fall by approximately 10 degrees. It is planned on the right side at tail end of the CJ Canal near RD 316+622 in Khusab District, Punjab Province.As regards infrastructure facilities, the project site is connected by a metalled road with the district headquarters Khushab which is situated at a distance of 40 km. The Site is also approachable from other local towns through metalled roads. The nearest railway station from the project site is Khushab which is connected with Karachi-Peshawar main Railway line through Kundian Junction. By rail, the distance of Khushab from Karachi via Kundian is 1310 km. The project area is accessible from Karachi Port through a good road network of National, Super Highway and Indus Highway. Road distance from Karachi to project site is approximately 1,164 km. The project area is accessible from Karachi via Muzaffargarh, Ahmadpur Said, AtharaHazari and from Chowk Azam to Bhakkar to Khushab. It is accessible from Lahore through a good metalled road via District headquarters Khushab or Joharabad. The distance between Project Site and Lahore by road is about 312 km. The Site is also approachable from Islamabad through Khushab. A concrete bridge on the headrace channel would be constructed for the main Khushab – AtharaHazari

road. On either bank of power channel, paved road would be prepared to monitor the canal bank etc. In addition to project office, a housing colony for the operation staff will be constructed near the Project area.

23. The Company requires a Generation Licence for engaging in the electric power generation business. Therefore, pursuant to the requirements of the NEPRA Act and Rules and Regulations made thereunder, CJHPL hereby submits this application, in accordance with the NEPRA (Application and Modification Procedure) Regulations, 1999, as amended, for the grant of the Generation Licence for its 25 MW (Installed Capacity) hydropower generation facility,based on the technical data given in the Updated Feasibility Study for the Project, and the salient features given in this Application, proposed to be constructed, operated and maintained by CJHPL as an IPP project on Build, Own, Operate, and Transfer (BOOT) basis on Chashma-Jhelum Link Canal (Tail) in District Khushab, Punjab province for a period of thirty (30) years after its COD. Upon expiry of the PPA term, the Project will be transferred to the Government of Punjab in accordance with the terms of the PPA. Documents-in-support, as required by the said Regulations, are listed hereinafter.

24. CJHPL will also submit a petition separately for the determination of the Feasibility Stage Reference Tariff for the Project based on the revised cost estimates and other parameters given in the Updated Feasibility Study in order to facilitate financing and implementation of the Project.

25. Subject to issuance of the Generation Licence and the Tariff Determination by NEPRA, CJHPL will implement the Project under the Government of Punjab's Power Generation Policy as revised in 2009 and the current Power Policy of the Government of Pakistan.

26. CJHPL willexecute a Power Purchase Agreement (PPA) with the Faisalabad Electric Supply Company (FESCO) on the usual format to sell the output of its Plant. Water Use Agreement (WUA) will be signed with the Government of Punjab. An Implementation Agreement (IA) will also be signed with the Government of the Punjab.The Government of Pakistan shall provide guarantee for the project to assure performance of the Power Purchaser under the PPA and of the provincial government under the WUA.

27. The information and the documents-in-support required under Regulation 3(5) and Regulation 3(6)of the National Electric Power Regulatory Authority Licensing (Application and Modification Procedure) Regulations, 1999 are as follows:

DOCUMENTS-IN-SUPPORT

Under Regulation 3(5) of the National Electric Power Regulatory Authority Licensing (Application and Modification Procedure) Regulations, 1999

Sub-Regulation	Requirement	Compliance
(5)(a)	Certified copies of: i) Certificate of incorporation ii) Memorandum & Articles of Association; iii) Last filed annual return;	Certified copies of the required documents are placed at: i) Attachment - I; ii) Attachment - II; iii) Copy of the CJHPL's annual return for the Tax Year 2017is placed at Attachment –VI.
(5)(b)	Profile of experience of applicant, management staff and members	Profiles of experience of Chief Executive, Executive Director, Project Director, Chief FinancialOfficerand other staff as presently employed by the Company are given in Attachment-VII.
(5)(c)	C.V's of senior management, technical and professional staff	CVs of the Company's Senior Management, Technical and Professional staff are presented in Attachment - VIII.
(5)(d)	Evidence of availability of financial & technical resources: i) Cash balances with bank certificates; ii) Expression of Interest	Evidence of financial and technical resources is as under: (i) Financial statements of CJHPL as on June 30, 2015, June 30, 2016 and June 30, 2017 are placed at Attachment -IX. (ii) Expression of Interest to provide credit or financing for the Project will be provided after issuance of LOS by the PPDB. After the LOS, the Company intends to conduct negotiations with several banks to finance the Project at the best available terms as a package deal. The requirement for submission of a performance guarantee @5000 US$/MW by the Company to PPDB against LOS and the commitment of the sponsors provide adequate security that the Company will manage financing of the

-	iii) Latest financial statements iv) Employment records of engineering and technical staff v) Profile of sub-contractors vi) Verifiable reference in respect of the experience of the applicant;	Project. Based on the past experience of the sponsors on financing projects, the lending required for the Project, which is viable and off-take is assured through the PPA & IA, will be easily arranged. (iii) Included in Attachment –IX. (iv) The list of engineering, technical and professional staff presently employed by the Company is at Attachment –X. (v) Not applicable. (vi) Verifiable reference in respect of the experience of the Applicant is placed at Attachment - XI.
(5)(e)	Details of any charges or encumbrances attached to the Company's assets of going concern	No Charge or encumbrances are attached to the Company assets. The Certificate by the Company Secretary is placed at Attachment - XII.
(5)(f)	Technical and financial proposals for the operation and maintenance of a going concern	Not applicable.
(5)(g)	Type, technology, model, technical details and design of the facilities	**Type:** Run-of-the-River/Canal Fall, Low Head **Technology:** Horizontal Bulb Turbine Hydropower **Technical Details/Design:** Model, technical details and design of the Plant will be provided after signing the EPC contract.
(5)(h)	Feasibility study (for a new facility)	As mentioned above, PPDB issued LOI (Attachment – III) for the Project. The Updated Feasibility Study of the Project(including interconnection study)is placed at Attachment - XIX.The information as required under Sub-Regulation (5)(h) (as amended) is included in the Updated Feasibility Study. POEs have approved the Updated Feasibility Study on July 27, 2017 (Attachment – IV).
(5)(i)	A prospectus	Prospectus is placed at Attachment – XIII.

28. The technical, financial and other information as required under Regulation 3(6) of the National Electric Power Regulatory Authority Licensing (Application and Modification Procedure) Regulations, 1999 are as follows:

Schedule III [Regulations 3(6)] – A (c) of the National Electric Power Regulatory Authority Licensing (Application and Modification Procedure) Regulations, 1999

Item No.	Requirement	Details
1	Location (location maps, site map), land	**Location**: The Project site is located between latitudes 31°-58'-04" North and longitudes 72°-12'-48" East. It is planned on the right side at tail end of the CJ Canal near RD 316+622 inKhusab District, Punjab Province;Location/Site Mapsare attached with Schedule - II
2	Plant: run-of-the-river, storage, veir)	Run-of-the-River/Canal Fall.
3	Head: minimum, maximum	Min: 11.58 m; Max: 13.52 m.
4	Technology: Francis, Pelton, etc., size, number of units	**Technology**: Low Head, Horizontal Bulb Turbine hydropower; **Size**: 25 MW;and **Number of Units**: Three (3).
5	Channel: length, cross sectional area	**Headrace Channel** • Length: 1350 m, • Cross Sectional Area: 176 m^2 **Tailrace Channel** • Length: 370 m, • Cross Sectional Area: 176 m^2
6	ESIA	EIA report is available in the Updated Feasibility Study. Based on the original feasibility Study, aapproval of the Initial Environmental Examination Report of the Project accorded by the EPA, Punjab, is placed at Attachment – XVIII. Fresh approval will be sought in due course.
7	Detailed Feasibility Study	Feasibility Study has been updated in July 2017. The Updated Feasibility Study(Attachment – XIX) has been approved

		by POEs of PPDB (Attachment – IV).
8	Resettlement issues	An amount of USD 0.097 million is provided in the project cost estimates for the environmental and social costs.
9	Consents	Consents as required are being applied and obtained. Application for Generation Licence is being filed. Tariff Petition based on Updated Feasibility Study will be filed shortly. Other consents will be applied and obtained on as required basis.
10	Infrastructure development	Detail of Infrastructure Facilities is given in Attachment - XVI.
11	Interconnection with national grid company, length of transmission line(s)	Load flow studies including interconnection arrangement have been re-conducted. Position remains the same as per previous Feasibility Study.Interconnection details are given in Schedule II attached with this Application.
12	Project cost, information regarding sources and amount of equity and debt	**Total Project Cost**: US$ 54.181 million. **Equity: 20%** (US$ 10.836 million); to be provided by the Project Sponsors/Shareholders **Debt: 80%** (US$ 43.345 million); to be arranged through a consortium of local and/or foreign banks after issuance of LOS by the PPDB.
13	Project Schedule, expected life	**<u>Project Schedule(Tentative)</u>** • Issuance of Generation Licence — Upon NEPRA's Approval. • Determination of FS Reference Tariff — ---------- do ---------- • Issuance of LOS by PPDB — 30 days after NEPRA approvals. • Execution of EPC Contract — Within 10 months after LOS issuance by PPDB. • Determination of EPC Ref Tariff — Within 15 months after LOS. • Execution of IA/PPA/WUA — Within 16 months after LOS. • Financial Closing (FC) — 24 months after LOS. • Construction Start — 30 days after FC

		• Commissioning 30/36 months after FC • COD 36 months after FC Tentative Implementation Schedule is placed at Attachment – XVII. **Expected Life** • Civil Works > 50 Years • Electromechanical Equipment > 30 Years PPA term 30 Years after COD
14	Peaking/base load operation	Base load operation.
15	Plant Characteristics: generation voltage, power factor, frequency, automatic generation control, ramping rate, control metering and instrumentation	**Plant Characteristics** • Generation Voltage 11 kV • Power Factor 0.8 Lagging 0.9 Leading • Frequency 50 HZ • AGC Yes • Ramping Rate As per manufacturer's recommendations. • Control, metering As per international Standards
16	System Studies; load flow, short circuit, stability	System studies have been re-conducted and submitted to FESCO.
17	Training & Development	Will be provided by the EPC Contractor.
18	Summary of Project Company, Management, Professional Staff and Financial Resources,etc.	Attachment – XIV.
19	Additional Information: Energy Production of the Project based on Historical Data	Attachment – XV.

Grant of Generation Licence

29. Authority is requested to grant Generation Licence to C J Hydro (Private) Limited, Lahore for its 25 MW (Installed Capacity) hydropower generation facility proposed to be constructed, operated and maintained as an IPP project on Build, Own, Operate, and Transfer (BOOT) basis on Chashma-Jhelum Link Canal (Tail) in District Khushab, Punjab province for a period of thirty (30) years after its COD.

ATTACHMENTS

I	Certification of Incorporation
II	Memorandum and Articles of Association
III	PPDB Letter of Interest dated November 8, 2007
IV	Approvals of the Panel of Experts/PPDB
V	NEPRA Decisions/Correspondence Concerning the Project
VI	Company's Annual Tax Return for the Year 2017
VII	Profile of Experience of Senior Management and Details of Applicant
VIII	CVs of the Company's Senior Management, Technical and Professional Staff
IX	Financial Statements of CJHPL as of June 30, 2017, June 30, 2016 and June 30, 2015
X	List of Engineering, Technical and Professional Staff
XI	Verifiable Reference in respect of the Experience of the Applicant
XII	No Charge or Encumbrances Certificate
XIII	Prospectus
XIV	Summary of Project Company, Management, Professional Staff and Financial Resources
XV	Energy Production of the Project based on Historical Hydrological Data
XVI	Infrastructure Facilities
XVII	Tentative Implementation Schedule
XVIII	Approval of the Initial Environmental Examination Report of the Project by the Environmental Protection Agency, Punjab
XIX	Updated Feasibility Study, July 2017 and Interconnection Study

SCHEDULES

Schedule I

Schedule II

SECURITIES AND EXCHANGE COMMISSION OF PAKISTAN

SECP

COMPANY REGISTRATION OFFICE
LAHORE

Company Registration Office Lahore * Securities and Exchange Commission of Pakistan * SECP

CERTIFICATE OF INCORPORATION

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

Corporate Universal Identification No.**0069345**

I hereby certify that **C J HYDRO (PRIVATE) 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 **Sixth** day of **May, Two Thousand** and **Nine**.

Fee Rs.**79,000/-**

(MAHBOOB AHMAD)
Joint Registrar of Companies

CERTIFIED TO BE TRUE COPY
31/12/14
ASSISTANT REGISTRAR OF COMPANIES
COMPANY REGISTRATION OFFICE
LAHORE.

THE COMPANIES ORDINANCE, 1984

(COMPANY LIMITED BY SHARES)

39

MEMORANDUM OF ASSOCIATION

OF

C J HYDRO (PRIVATE) LIMITED

Company Registration Office Lahore
Securities and Exchange Commission of Pakistan
SECP

I. NAME

The name of the Company is C J HYDRO (Private) Limited.

II. REGISTERED OFFICE

The registered office of the Company will be situated in the Province of Punjab.

III. OBJECT

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

1. To develop, design, ~~insure~~, construct, complete, own, possess, manage, operate and maintain electric power generation plant(s) in Pakistan at such location(s) as the applicable laws/policies permit, and in connection therewith to engage in the business of generation, transmission, sale, supply and distribution of electricity within Pakistan and to do all and everything necessary, suitable, proper, incidental or conducive to the accomplishment of this object and to do every other act or thing incidental or appurtenant to or arising out of or connected with this object.

2. To carry on and undertake the business of construction and development of power plants in all its forms and perspectives and for that purpose to own or acquire all types of land, building and requisite facilities and to do all such acts, deeds or things as would be required for the effective discharge of this object.

3. To acquire or purchase or take on lease or rent or in exchange or hire any kind of machinery, plant, equipment, spare parts, raw materials, natural fuel, supplies and related goods and services necessary and/or incidental to the development, ownership, construction, management, operation and maintenance of power plant(s).

4. To establish and maintain housing, transportation, communication and utility lines and other requisite logistic facilities for the construction, operation and maintenance of power plant(s).

5. To secure, subject to applicable laws, foreign equity and technical collaboration for the development, ownership, construction, operation and management of power plant(s).

6. To obtain loans, credit and financial facilities in local and/or foreign currency from banks and other financial institutions operating in Pakistan, and subject to necessary approvals under the applicable laws/policies, financing from international sources, proceeds of which are to be used for the development, ownership, construction, operation and maintenance of power plant(s).

7. To mortgage, hypothecate, create charges and other encumbrances on the properties and assets of the Company in such manner and on such terms and conditions as the Company may determine.

8. To enter into any arrangement or agreement with purchasers of power from the power plant(s).

9. To carry out rental agreements of power generating services including services agreement of operation or maintenance with any company including WAPDA.

10. To enter into contracts for the purchase of fuel for the power plant(s), for construction of the power plant(s), for operation and maintenance of the same and other agreements as may be necessary in the conduct and furtherance of business of the Company and to take all actions before competent forums for the enforcement of such agreements and contracts.

11. To take out any insurance that the Company deems necessary or appropriate in connection with the ownership, construction, operation and maintenance of power plant(s) and to pay the premium thereof.

12. To enter into any arrangement with, obtain consents and approvals of, secure interim and final orders from the Government of Pakistan, and any other governmental agency or body and to undertake efforts to promote or modify laws, regulations and policies, and where required, to seek like dispensation from any government or public authority or any corporation or private persons, or any foreign government, authority or person to further the development, ownership, construction, management, operation or maintenance of power plant(s) and to oppose by legal means within or outside Pakistan any actions or measures as are taken by any-governmental or other authority which the Company considers likely to adversely affect the development, ownership, construction, management, operation or maintenance of power plant(s) and to obtain or endeavor to obtain from any governmental or other public authority any charters,

13. To guarantee the performance of contracts and obligations (including payment of loans) of any person providing goods or services in connection with the construction, operation or maintenance of power plant(s) or purchasing electricity generated by power plant(s) but not in any event to carry on the business of banking.

14. To operate, maintain and manage power generation facilities, power stations, power houses and grid stations together with all machinery, equipment and works ancillary thereto and plan, survey, design, supply equipment and to do all such acts, deeds and things, without limitation whatsoever, as may be necessary or desirable in furtherance of the exclusive object which the Company has been incorporated.

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15. To carry on the business as engineers, designers, architects, operators, concessionaries, surveyors, builders, masonry and general construction contractors, erectors and to establish, operate, manage, maintain, equip, construct, repair, renovate, improve, work on, industrial,, commercial and residential buildings, parks, clubs, roads, motorways, highways, playlands, stadiums, gymnasiums, railways, roadways, airports, runways, docks, harbors, wharves, canals, water courses, reservoirs, embankments, irrigations, reclamations, sewerages, drainage and other sanitary works and systems, water, gas, electric and other supply works, godowns, mills, factories, installation and related or other works of all kinds and description and to equip the same or any part thereof with all or any conveniences and utilities which include, but are not limited to, electricity, gas, telephone, internet, drainage and sewage facilities and to do all such acts, deeds or things as would be required for effective discharge of these objects.

16. To carry on the business of estimation, drawing up of specifications and contracts, quantity surveying, supervision and execution of construction works and all installation and maintenance thereof.

17. To equip and furnish any property for the purpose of letting or hiring the same to visitors as guests whether in single or double rooms, suites, chalets, cottages or otherwise.

18. To carry on and undertake trading business of all sorts and to act as indentors, importers, exporters, traders, suppliers and commission agents of products, commodities and materials in any form or shape manufactured or supplied by any company, firm, association of person body, whether incorporated or not, individuals, government, semi-government or any local authority.

19. To apply for, tender, offer, accept, purchase or otherwise acquire any contracts and concessions for or in relation to the projection, execution, carryout out, improvements, management, administrations or control of works and conveniences and to undertake, execute, carry out, dispose of or otherwise turn to account the same.

20. To carry on all or any of the business as manufacturers, buyers, sellers, indentors, importers, exporters, distributors, agents, factors, stockists, commission agents and dealers of engineering goods, machine tools, hand tools, small tools, metals, alloys, iron pipe fittings, nuts and bolts, bicycles and accessories, automobile parts, steel and stainless steel and iron products, cutlerics, ores, and scraps.

21. To carry on agency business (except managing agency) and to acquire and hold selling agencies and to act as general agents, selling agents, mercantile agents, commission agents, carrier's agents, shipping agents, clearing and forwarding agents, indenting agents, managers, advertisers, stockists, manufacturers' representative and distributing agents of and for the distribution of all kinds of local and foreign merchandise, goods, commodities, products, materials, substances, articles and things whether finished, semi-finished, raw, under process, refined, treated or otherwise pertaining to trade and commerce and for that purpose to remunerate them and to open and maintain depots and branches.

22. To purchase, take on lease or in exchange, hire, apply for or otherwise acquire and hold for any interest, any rights, privileges, lands, building, easements, trade marks, patents, patent rights, copyrights, licenses, machinery, plants, stock-in-trade and any movable and immovable property of any kind necessary or convenient for the purposes of or in connection with the Company's business or any branch or department thereof and to use, exercise, develop, grant licenses in respect of or otherwise turn to account any property, information so acquired, subject to any permission required under the law.

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23. To act as representatives, for any local or foreign person, firm or company and to undertake and perform sub-contracts, and also act in the business of the Company through or by means of agents, sub-contractors and to do all or any of the things mentioned herein in any part of the world and either alone or in collaboration with others and by or through agents, sub-contractors or otherwise.

24. To enter into agreement(s) with any government or authority (foreign, supreme, municipal, local or otherwise) or any corporation, company or persons that may seem conducive to the Company's objects or any of them and to obtain from any such government, authority, corporation, company or person any charters, contracts, rights, privileges and commission which the Company may think desirable and to carry on exercise and comply with any such charters, contracts, decrees, rights, privileges and concessions.

25. To apply for and obtain necessary consents, permissions and licenses, rights, privileges and concessions from any local or foreign Government, State, Municipal, Local and other authorities or persons for enabling the Company to carry on its objects and to oppose any proceedings or application which may seem calculated directly or indirectly to prejudice the interests of the Company.

26. To, subject to the approval of the competent authority, make, amend and modify Articles of Association and rules and regulations not inconsistent with this Memorandum of Association to provide for all matters for which provision is necessary or expedient for the purpose of giving effect to the provisions of this Memorandum of Association and the efficient conduct of its objects.

27. To adopt such means of making known the Company as may seem expedient and in particular by advertising in the media, by circulars, by purchase and exhibition of works of art or interests, by publication of books and periodicals.

28. To appoint agents, sub-agents, attorneys, consultants, and contractors or to act as agent, sub-agent, attorney, consultant, and contractor in connection with the objects of the Company but not to act as managing agents.

29. To open, close and operate bank accounts of the Company with any bank or banks, financial institutions or co-operative societies and 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 a finance or banking company.

30. To borrow or raise money in such manner as the Company shall think fit in pursuance of its objects, and in particular by the issue of debentures, or debenture stock (perpetual or otherwise), ~~Modaraba Certificates, Participation Term Certificates, Term Finance Certificates~~ or otherwise and by issue of all securities including securities not based on interest for raising reasonable capital, resource funds from banks or financial institutions and by issue of shares in lieu of outstanding balance of any loan and by issue of securities as required by the rules and regulations of the banks, financial institutions and loan giving agencies and to secure the repayment of any money borrowed, raised or owing by mortgage, charge or lien upon all or any of the property or assets of the Company (both present and future).

31. To improve, manage, develop, exchange, lease, mortgage, enfranchise, dispose of or otherwise deal with, all or any part of the property, assets or undertaking of the Company for such consideration as the Company may think fit and to distribute among the members in specie any property of the Company, or any proceeds of sale or disposal of any property of the Company, but so that no distribution amounting to a reduction in capital may be made without the sanction of the Court, if required.

32. To make (subject to the applicable laws) loan, advance to any company and/or undertaking and/or person and/or give any guarantee or provide any security (including but not limited to charge, lien or mortgage of any of the company's assets) in order to secure the repayment of any loan, finance or advance obtained or to be obtained by such company and/or undertaking and/or person from any bank or financial institution.

33. To accept or give security, including but not limited to promissory notes, indemnity bonds, guarantees, assignments, receipts, bailments, pledges, hypothecations, liens, mortgages and charges, against the credit extended or moneys borrowed in connection with its objects.

34. To employ and remunerate managers and other officers, employees and servants of the Company or any person or firm or company rendering services to the Company upon such terms as the Company may determine.

35. To establish and maintain or procure the establishment and maintenance of any contributory or non-contributory pension, superannuation funds for the benefit of, and give or procure the giving of donations, gratuities, pensions, allowances or emoluments to any person who are or were at any time in the employment or service of the Company, or who are or were at any time directors or officers of the Company and the wives, widows, families and dependents of any such persons, and also to establish and subsidise and subscribe to any institutions, associations, clubs or funds calculated to be for the benefit of or to advance the interest and well-being of the Company.

36. To enter into a joint venture or a partnership or cooperation with any person or company or other legal entity, local or foreign, or otherwise assist any such person or company or legal entity in furtherance of its objects.

37. To pay out of the funds of the Company all expenses of and incidental to the formation, registration, advertisement of the Company and the issue and subscription of the share or loan capital or placing or guaranteeing the placing of shares or any debentures, debenture-stock and other securities of this Company and also all expenses relating to the issue of any circular or notice and the printing, stamping, circulating of proxies and forms to be filled up by the members of the Company.

38. To insure the property, assets, and employees of the Company in any manner deemed fit by the Company, and to create any reserve funds, 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 its objects but not to act as an insurance company.

39. To subscribe for, take or otherwise acquire and hold shares, debentures or securities of any other company having objects altogether or in part similar to those of this Company or carrying on any business capable of being conducted so as directly or indirectly to benefit this Company and to invest the moneys not immediately required for the business of the Company in, and to hold, sell and deal with the stocks, shares, bonds, debentures, debenture stocks, PTCs, TFCs, mutual fund certificates, NIT units, Modaraba certificates or certificates of investment obligations, notes and securities of any Government, Province, company, Corporation, Municipal or Local or other Body or Authority and to deal with the monies of the Company for such purposes conducive to the interest of the Company and to vary investments from time to time but not to act as an investment company.

40. To receive, declare and distribute profits and to capitalize such portion of the pr[illegible] Company as are not distributed among shareholders of the Compan[illegible] in [illegible] dividends, and as the Directors of the Company may think fit, and to issue [illegible] fully paid up, in favour of the shareholders of the Company.

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41. To subscribe or contribute or otherwise to assist or to guarantee money to charitable, benevolent, religious, literary, scientific, technical, national, public or any other institutions or for any exhibition or purpose.

42. To file or register any document required to be filed or registered under law, and to pay any fees, charges, expenses, rents, taxes, duties and other dues payable in connection with its objects.

43. To settle disputes by negotiation, reconciliation, arbitration, litigation or other means and to enter into compromise with creditors, members and any other persons in respect of any difference or dispute with them.

44. To establish laboratories, research and development centers to perform such research and development as the Company may deem advisable or feasible, and to expend 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 in furtherance of its objects.

45. To develop and/or transfer technology and to acquire or pass on technical know-how incidental or conducive to the attainment of its objects.

46. To train personnel and workers, both in Pakistan and abroad to obtain technical proficiency in various specialties connected with its objects.

47. To do all such other things as may be deemed incidental or conducive to the attainment of the main objects or any of them in any part of the world, and as principals, agents, contractors, trustees or otherwise, and by or through trustees, agents or otherwise and either alone or in conjunction with others.

48. It is hereby declared that:

(a) The word "company" in this clause except where used in reference to this Company, shall ~~be deemed to include any partnership or other body of~~ persons, ~~whether corporate~~ or un-incorporate, ~~and whether domiciled in~~ Pakistan or ~~elsewhere~~. mean private, public, listed or unlisted company.

(b) The Company shall have full authority, power and competence to do any and all other things and acts to further the activities specified in sub-Clauses 1 to 47 in support of and in relation to (directly or indirectly) of the objects of the Company.

(c) Notwithstanding anything contained in the foregoing Object Clause of this Memorandum of Association, nothing contained therein shall be construed as empowering the Company to undertake or indulge in the business of banking company, banking, leasing, investment, managing agency or insurance business directly or indirectly as restricted under law or in any lawful operation.

(d) The Company would not indulge in any sort of real estate business, housing colonies/purchase and sale of plots and developments of land, and leasing finance company business as required by the applicable laws.

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(e) The Company undertakes that the Company shall not, by advertisement, pamphlets, or by any other means or through negotiation offer for sale or take advance money for further sale of plots, houses, flats etc to the general public or individuals unless such plots, houses flats etc are owned and/or have been developed by the Company.

(f) Notwithstanding any thing stated in the foregoing Object Clauses of this Memorandum of Association, 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. LIABILITY

The liability of the members is limited.

V. SHARE CAPITAL

The Authorized Capital of the Company is Rs. 10,000,000/- (Rupees Ten Million only) divided into 1,000,000 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

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We, the several persons whose names 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 the Company as set opposite to our respective names.

Name and Surname (Present & Former) in Full (in Block Letter)	Father's / Husband's Name in Full	Nationality	Occupation	Residential Address (in Full)	Number Of shares taken by Each subscriber	Signature
1. Haseeb Khan 35201-1261577-3	Sardar Abdul Muqeet Khan	Pakistani	Chartered Accountant	H.No.254, St.9, Cavalry Ground Ext. Lahore (Cant)	510	
2. Shan-E-Abbas Ashary, Passport No. BA 508353	Ali Abbas Ashary	Canadian	Trading Businessman	H.No. 15/I, Khayaban-i-Muhafiz, Phase-VI, DHA, Karachi	150	
3. Liaqat Ali 16202-4940437-1	Haji Munir Khan	Pakistani	Trading Businessman	H.N.1015-C, Canal View, Lahore	150	
4. Danish Haseeb Khan 35201-1241270-3	Haseeb Khan	Pakistani	Trading business ~~Chartered Accountant~~	H.No.254, St.9, Cavalry Ground Ext. Lahore (Cant)	90	
5. Irfan Ali 35202-8633033-9	Muhammad Ali	Pakistani	Trading Businessman	H.No. 195-N, Model Town Extension, Lahore	100	
				TOTAL	1000	

Date this 25th day of April

Witness to the above Signature:

Full Name: .....Abdur Rehman Babar.....

Father's Name: ...Ghazanfar Hussain Khan.....

CNIC No. ..... 35201-1389376-3.....

Signature.....

Nationality: .....Pakistani.....

occupation: .....Private Service.....

Full Address: ...15-Peshawar block, Fortress...

.....Stadium, Lahore (Cant)....

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CERTIFIED TO BE TRUE COPY
27/12/10
DEPUTY REGISTRAR OF COMPANIES
COMPANY REGISTRATION OFFICE
LAHORE.

THE COMPANIES' ORDINANCE' 1984

-:o:-

(PRIVATE COMPANY LIMITED BY SHARES)

-:o:-

ARTICLES OF ASSOCIATION

OF

C J HYDRO (PRIVATE) LIMITED

PRELIMINARY

1. Subject as hereinafter provided, has Regulation contained in Table 'A' of the First Schedule to the Companies Ordinance, 1984, (hereinafter referred to as Table 'A') shall apply to the Company so far as those are applicable to Private Companies, with the exception of the Regulation which are modified, altered or added hereunder.

PRIVATE LIMITED COMPANY

2. The Company is a Private Company within the meaning of Clause (28) of Section 2(1) of the Companies Ordinance, 1984 and accordingly

   (a) No invitation shall be issued to the public to subscribe for any shares, debentures or debenture-stocks of the Company.

   (b) The number of members of the Company (exclusive of persons in the employment of the company) shall be limited to fifty provided that for the purpose of this provision whets two or more persons hold one or more shares in the Company jointly they shall for the purposes of this clause be treated as a single member and

   (c) The right to transfer shares in the Company is restricted in the manner and to the extent hereinafter appearing.

BUSINESS

3. The Company is entitled to commence business from the date of its incorporation.

4. The business of the company shall include all or any of its objects enumerated in the Memorandum of Association.

5. The business of the company shall be carried out at such place or places in the whole of Pakistan or elsewhere as the Directors may deem proper or advisable from time to time.

CAPITAL

6. The Authorised Capital of the Company is Rs. 10,000,000/- (Rupees Ten Million only) divided into 1,000,000 ordinary shares of Rs. 10/- (Rupees Ten only) each with powers to increase, reduce, consolidate, sub-divide or otherwise re-organize the share capital of the Company.

7. The shares shall be under the control of the Board of Directors who may allot or otherwise dispose of the same to such persons, firm, corporation or corporations on such terms and conditions and at any such time as may be thought fit.

8. The shares in the capital of the Company may be allotted or issued in payment of any property, land, machinery or goods supplied or any services rendered to the Company or promotion or formation of the Company or conduct of its business and any shares so allotted may be issued as fully paid shares.

SHARES, TRANSFER AND TRANSMISSION

9. Every person whose name is entered as a member in the Register of Members shall without payment, be entitled to a certificate under the Common Seal of the Company specifying the shares held by several persons. The Company shall not be bound to issue more than one certificate and delivery of a share certificate to any one of several joint holders shall be sufficient delivery to all.

10. The Directors may decline to register any transfer of share to transferee of whom they do not approve and shall not be bound to show any reasons for exercising their discretion subject to the provisions of Section 77 and 78 of the Companies Ordinance, 1984.

11. No share can be mortgaged, pledged, sold, hypothecated, transferred or disposed off by any member to non-member without the previous sanction of the Board of Directors.

12. The legal heirs, executors or administrators of a deceased holder shall be the only persons to be recognised by the Directors as having title to the share. In case of shares registered in the name of two or more holders the survivors and the executors of the deceased shall be the only persons to be recognised by the Company as having any title to the shares.

GENERAL MEETING

Baber 27/04/07

13. The First Annual General Meeting shall be held within 18 months from the date of incorporation of the Company in accordance wills the provisions of Section 158 and thereafter once at least in every year and within a period of ~~three~~ 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 Directors. The Directors may whenever they think fit, call an Extraordinary General Meeting of the shareholders in terms of Section 159 of the Companies Ordinance, 1984.

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PROCEEDINGS AT GENERAL MEETING

14. Twenty one days' notice at least specifying the place, day and hour of the General Meeting and in case of special business the general nature of such business, shall be given to the member in the manner provided in Table "A" but accidental omission to give such notice to or non-receipt of such notice by the member shall not invalidate the proceedings of use General Meeting.

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

QUORUM,

16. No business shall be transacted at any General Meeting unless a Quorum of member is present at the time when use meeting proceeds to business. Two members, present in person, representing not less than 51% of the total voting power either on their own account or as proxies, shall from a Quorum for a General Meeting.

VOTES OF MEMBERS

17. At any General Meeting a resolution put to the vote of the General Meeting shall be decided on a show of hands, unless a poll is demanded its accordance with the provisions of Section 167 of Site Companies Ordinance, 1984.

18. On a show of hands every member present shall have one vote and on a poll, every member present in person or by proxy shall have one vote in respect of each share held by him.

19. The instrument appointing a proxy and the power of attorney or other authority under which it is signed or notarially certified copy of that power of attorney or authority shall be deposited at the Registered Office of the Company 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 will not be treated as valid.

CHAIRMAN

20. 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 such Board of Directors and members of the Company. In his absence, the Directors may elect one of them to preside over Board's General Meetings. The questions arising at the meeting of such Directors shall be decided by a majority of votes. In the case of equality of votes, the Chairman Director presiding over the meeting, as the case may be, shall have a casting vote.

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CHIEF EXECUTIVE

21. 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.

22. Unless otherwise determined, the number of Directors shall not be less than two. The following are the First Directors of the Company.

    1. Haseeb Khan
    2. Shan-E-Abbas Ashary
    3. Liaqat Ali
    4. Danish Haseeb Khan

23. The election of the Directors shall be held in accordance with the provisions of Section 178 of the Companies Ordinance, 1984. The qualification of director is the holding of One ordinary share of the company.

24. The first Directors including the Chief Executive shall hold office upto the First Annual General Meeting in accordance with the provisions of the Companies Ordinance, 1984, unless any one of them resigns earlier or becomes disqualified for being Director or otherwise ceases to hold office.

25. A resolution for removing a Director shall not be deemed to have been passed if the number of votes against him is equal to, or less than the number of votes that would have been necessary for the election of Directors at the immediately preceding annual election of Directors in the manner aforesaid but as provided under Section 181 of the Companies Ordinance, 1984.

26. The remuneration of Directors except regularly paid Chief Executive and full time working Directors shall, from time to time, be determined by the Board of Directors but it shall not exceed Rs. 500/- per meeting at which the Directors are present.

27. The Directors may sanction the payment of such additional sum as they may think fit to any Director for any special service he stay render to the Company or be thought capable of rendering either by fixed sum or in any other form as may be determined by the Directors subject to the provisions of the Companies Ordinance, 1984.

28. The Director who resides out of station shall also be entitled to be paid such travelling and other expenses for attending the meeting for site Company as may be fixed by the Directors from time to time according to the provisions of the Companies Ordinance, 1984.

29. Any casual vacancy occurring on the Board of Directors shall be filled in by a resolution of the Board of Directors and the person so appointed shall hold office for the remainder of the term of the Directors in whose place he it appointed.

30. No Director shall be disqualified from his office by contracting with the Company either as vendor, purchaser or otherwise nor shall any Director be liable to account for any profit realisation from any such contract or arrangement or the fiduciary relation thereby established, but the nature of the interest must be disclosed by him at the first meeting of the Directors after acquisition of his interest.

Company Registration Office Lahore
Securities and Exchange Commission of Pakistan
SECP

NOMINEE DIRECTOR

31 In addition to the elected Directors, the financial institutions shall be entitled, during the period 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 holders of share(s) in the Capital of the Company and regulations and/or rules pertaining to the election, retirement, qualification and/or disqualification of Directors shall not apply to him.

NOTICES

32. Notices for every meeting of the Board of Directors will be given in writing and there must be given a reasonable time in advance the nature of the business to be transacted at an intended Board meeting will be specified in the notice.

MANAGEMENT

33. The whole business and affairs of the Company shall, subject to the control and supervision of the Board of Directors, be managed and controlled by the Chief Executive.

34. A resolution in writing circulated to all the Directors and signed by a majority of the total number of Directors or affirmed by them through secured email, facsimile, 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.

35. Subject to the limit fixed by the Directors, the Chief Executive may from time to time raise or borrow any sums of money for and on behalf of the Company from other companies, person, banks or financial institutions on such terms as may be approved by the Board of Directors from time to lime.

36. Without prejudice to the powers conferred by these Articles, the Board of Directors shall have the following powers:-

(a) To take on lease, purchase, erect or otherwise acquire for the Company any assets, stocks, land, buildings, property, rights or privileges which the Company is authorised to acquire at such price and generally on such terms and conditions as they think fit.

(b) To let, mortgage, sell, exchange or otherwise dispose of absolutely or conditionally all or any part of the assets, stocks, raw material, properties, privileges and undertaking of the Company upon such terms and conditions for such consideration as they think fit.

(c) To appoint any person or persons to be attorney or attorneys of the Company for such purposes and with such powers, authorities and discretion's and for such period and subject to such conditions as they may, from time to time, think fit.

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SECP

(d) To enter into, carry out, rescind or vary all financial arrangements with any bank, person, company, firm or corporation or in connection with such arrangements to deposit, pledge or hypothecate property of the Company or the documents representing or relating to the same.

(e) To make and give receipts, release and discharge all moneys payable to the Company and for the claims and demands of the Company.

(f) To compound or allow time to the payment or satisfaction of any debt due to or by the Company and any claim and demands by or against the Company and to refer claims or demands by or against Site Company to arbitration and observe and perform the awards.

(g) To institute, prosecute, compromise, withdraw or abandon any legal proceedings by or against the Company or its affairs or otherwise concerning the affairs of the Company.

(h) To raise and borrow money from time to time for the purposes of the Company, on the mortgage of its property or any part thereof and/or on any bond or debenture payable to bearer otherwise on interest and repayable in such a manner and generally upon such terms as they think fit.

(i) To open, operate and maintain bank/banks account(s) individually or jointly as the Board may authorise or to any other person on its behalf.

BORROWING POWERS

37. The Directors may from time to time raise, borrow or secure the payment of any sum for the purposes of the Company in such manner and upon such terms and conditions as they think fit and in particular by the issue of debentures, debenture-stock or other securities charged upon all or any part of the property of the Company present or future.

38 Debentures, debenture-stock, bonds or other securities may be issued with any special privileges as to redemption, surrender, allotment of shares, attending and appointment of Directors or other privileges subject to any permission required by law.

THE SEAL

39. The Company shall have a Common Seal and the Directors shall provide for the safe custody of the same The Seal shall not be applied on any instrument except by the authority of the Board of Directors and in the presence of at-least two Directors who shall sign every instrument to which site Seal shall be affixed in their presence. Such signature shall be conclusive evidence of the fact that the Seal has been properly affixed.

Company Registration Office Lahore
Securities and Exchange Commission of Pakistan
SECP

ACCOUNTS

40. The Directors shall cause to be kept proper books of account as required under Section 230 of the Companies Ordinance, 1984.

41. The books of account shall be kept at the registered office of the Company or at such other place at the Directors shall think fit subject to the provisions of Section 230 of the Companies Ordinance, 1984.

AUDIT

42. Once at least in every year the accounts of the Company shall be audited and correctness of the Balance Sheet shall be ascertained by one or more Auditors. The Auditors shall be appointed and their duties regulated in accordance with the provisions of Section 252 So 255 of the Companies Ordinance, 1984

INDEMNITY

43. In connection with carrying on the business of the Company, the Chief Executive, every Director, or other officers of the Company shall be indemnified by the Company for all losses and expenses occasioned by error of judgement or oversight on his part, unless the same happens through his own dishonesty or willful act and defaults.

SECRECY

44. No member shall be entitled to visit and inspect the Books of the Company without the permission of the Chief Executive or one of the Directors or to require discovery of any information regarding any detail of the Company's business or any matter which is or may be in the nature of trade secret, or secret process which may relate to the conduct of the Company's business and which in the opinion of the Directors, will not be in the interest of the members of the Company to communicate to the public.

ARBITRATION

45. Whenever any difference arises between Site Company on the one hand and the members, their executors, administrators or assignee on the other hand, touching the true intent or construction or the incident or consequence of these present or of the statutes or touching any thing thereafter done, executed, omitted or suffered its pursuance of these presents or otherwise relating to these presents or to any statutes affecting the Company, every such difference shall be referred for the decision of the arbitrator or umpire under the Arbitration Act, 1940 as amended from time to time.

46. The cost incidental to any such reference and award shall be at the discretion of the arbitrator or umpire respectively who may determine the amount thereof and direct-the same to be shared between the attorney and client or otherwise and may award by whom and in what manner the same shall be borne and paid.

Company Registration Office Lahore
Securities and Exchange Commission of Pakistan
SECP

WINDING UP

47. If the company is wound up whether voluntarily or otherwise the liquidator may, with the sanction of a special resolution, divide among the contributories in specie any part of the assets and liabilities of the Company, subject to Section 421 and other provisions of the Companies Ordinance, 1984 as may be applicable.

Company Registration Office
Lahore
Securities and Exchange Commission of Pakistan
SECP

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

Name and Surname (Present & Former) in Full (in Block Letter)	Father's / Husband's Name in Full	Nationality	Occupation	Residential Address (in Full)	Number Of shares taken by Each subscriber	Signature
1. Haseeb Khan 35201-1261577-3	Sardar Abdul Muqeet Khan	Pakistani	Chartered Accountant	H.No.254, St.9, Cavalry Ground Ext. Lahore (Cant)	510	
2. Shan-E-Abbas Ashary, Passport No. BA 508353	Ali Abbas Ashary	Canadian	Trading Businessman	H.No. 15/1, Khayaban-i-Muhafiz, Phase-VI, DHA, Karachi	150	
3. Riaqat Ali 35202-4940437-1	Haji Munir Khan	Pakistani	Trading Businessman	H.N.1015-C, Canal View, Lahore	150	
4 Danish Haseeb Khan 35201-1241270-3	Haseeb Khan	Pakistani	Trading business ~~Chartered Accountant~~	H.No.254, St.9, Cavalry Ground Ext. Lahore (Cant)	90	
5. Irfan Ali 35202-8633033-9	Muhammad Ali	Pakistani	Trading Businessman	H.No. 195-N, Model Town Extension, Lahore	100	
				TOTAL	1000	

Date this .....25th..... day of ...April...2008

Witness to the above Signature:

Full Name: .....Abdur Rehman Babar.....

Father's Name: ...Ghazanfar Hussain Khan.....

Fortress...

CNIC No. ..... 35201-1389376-3.....

Signature.....

Nationality: .....Pakistani.....

Occupation: .....Private Service.....

Full Address: ...15-Peshawar block,

.....Stadium, Lahore (Cant)....

Company Registration Office Lahore — Securities and Exchange Commission of Pakistan — SECP

CERTIFIED TO BE TRUE COPY

27/12/10

DEPUTY REGISTRAR OF COMPANIES
COMPANY REGISTRATION OFFICE
LAHORE.

Attachment - III

PPDB Letter of Interest Dated November 8, 2007

No. MD-PPDB/H-034/ 450 /2007
OFFICE OF THE MANAGING DIRECTOR
PUNJAB POWER DEVELOPMENT BOARD
IRRIGATION & POWER DEPARTMENT
1st Floor, Central Design Building,
Irrigation Secretariat, Old Anarkali, Lahore
(Ph: 9212794 Fax: 9212796)

Date 8-11- /2007

To:

M/S Haseeb Khan & Co.
(HK Consortium)
15-Peshawar Block,
Fortress Stadium, Lhr

Subject: **LETTER OF INTEREST (LOI) FOR APPROXIMATELY 40.00 MW HYDRO POWER PROJECT AT C.J.LINK TAIL CANAL FALL RD 316+622.**

Reference: Your proposal, dated 28.07.2007 in response to Expression of Interest invited by the Punjab power Development Board through advertisement in the daily "NAWA-I-WAQAT" (dated 29.03.2007), which has been duly considered by the Board in hits meeting held on 22.10.2007 whereby your firm / company has qualified the eligibility criteria as set out in the policy of the Provincial Government regarding power generation i.e. the Punjab Power Generation Policy, 2006 (hereinafter referred to as the "Policy") upon provision of performance guarantee No.59/14 dated 31-10-2007 amounting to US $ 40,000.00.

Now, this letter of interest (hereinafter referred to as "LOI") is being issued on behalf of the Government of the Punjab, in terms of the provisions of the Policy. The Government of Punjab hereby confirms its interest in your proposal for conducting a feasibility study (hereinafter referred to as the "Feasibility Study") for establishing an approximately 40.00MW private power project to be located at C.J.Link Tail Canal Fall RD 316+622 subject to the following: -

a) As per the Policy, you are required to complete your Feasibility Study for the Subject Project, at no risk and cost to, and without any obligation on the part of, the Govt. of the Punjab and its agencies, within twelve (12) months from the date of this LOI.

b) You are required o carry out the Feasibility Study; complete, at internationally acceptable standards and in accordance with the terms and conditions stipulated in the Policy. The Feasibility Study must include an Environmental Impact Assessment Study, detailed design of power house, load flow and stability studies, design of interconnection / transmission lines, details pertaining to infrastructure, project cost, financing and, financing terms, tariff calculations and assumptions of financial calculations including economic / financial analysis. You are advised to liaise with the power purchaser while determining your plant size and site, project layout, transmission line and interconnection arrangements, etc.

c) You will carryout the Feasibility Study according to the specific milestones appended herewith at Annex – A, and submit monthly progress reports showing progress against these milestones.

d) PPDB will appoint a Panel of Experts to monitor the conduct of the Feasibility Study and its progress, to verify attainment of the aforesaid milestones and to ensure implementation of the project consistent with

e) The Main Sponsor will be liable for all obligations and liabilities of and on behalf of other Sponsors. Further processing of the Feasibility Study is subject to Govt. of the Punjab acceptance in accordance with the Policy.

f) The validity of this LOI is twelve (12) months from the date of its issuance, where after it will automatically lapse immediately. Issuance of this LOI or the lapsing of its validity, or your conducting a Feasibility Study there under, cannot form the basis of any claim for compensation or damages by the Sponsors or the project company or any party claiming through them against the Government or Punjab / PPDB or any of its agencies, employees or consultants on any grounds whatsoever, during or after the expiration of its validity.

g) You are, therefore, required to complete the Feasibility Study for the Subject Project within the validity of this LOI. In case there is delay in completion of the Feasibility Study within the validity of this LOI, a one-time extension may be granted up to a maximum period of 180 days, provided the Panel of Experts is satisfied that the Feasibility Study is being conducted in a satisfactory manner and is likely to be completed shortly. Furthermore, extension in validity of the LOI will only be provided upon submission of a bank guarantee in double the original amount and valid beyond six months of the extended LOI period.

h) **In case, if you fail to meet the relevant milestones and standards, PPDB will terminate this LOI and encash the Bank Guarantee.**

i) This LOI has been issued in duplicate on the date hereof, and it shall come into effect when one copy hereof is received by PPDB after having been duly countersigned by you. Nevertheless, this LOI shall lapse if the countersigned copy is not received at PPDB within thirty (30) days of its issuance.

(Engr: Muhammad Yaqoob)
MANAGING DIRECTOR
PUNJAB POWER DEVELOPMENT BOARD

Accepted and agreed
for & on behalf of

Date: Nov 13 2007

Encl: As stated above

CC.

1. Secretary, Ministry of Water & Power, Islamabad
2. Chairman, NEPRA, Islamabad
3. Secretary Irrigation & Power Department, Govt. of the Punjab, Lahore.
4. Chairman, P & D, Govt. of the Punjab, Lahore
5. Chairman WAPDA, Lahore
6. Chief Executive Officer, DISCO

No. PPDB/ 1118 /2017

PUNJAB POWER DEVELOPMENT BOARD

ENERGY DEPARTMENT

1st Floor, Central Design Building,
Irrigation Secretariat, Old Anarkali, Lahore
(Ph: 042-99212794 Fax: 99212796)

Date 01 /08 /2017

1. The Managing Director, Private Power & Infrastructure Board, Government of Pakistan, Bureau of Emigration & Overseas Employment Emigration Tower, G-8/1, Islamabad
2. The Chief Executive Officer, Faisalabad Electric Supply Company (FESCO), Lahore
3. Chief Engineer-I, O/o General Manager (Hydro), Planning, WAPDA, Sunny View, Lahore
4. Chief Engineer-(M.P), NTDC, 4th Floor, PIA Tower, Egerton Road, Lahore
5. The Project Director, Punjab Power Management Unit, 77-Shahjamal Colony, Lahore
6. Dr. Engineer Javed Yunas Uppal, Chairman, Engineering Project Development Consultants, 1-A, Aibak, New Garden Town, Lahore

Subject: **MINUTES OF MEETING OF PANEL OF EXPERTS (POEs) REGARDING FEASIBILITY STUDY REPORT OF 25 MW CHASHMA JHELUM LINK CANAL HYDROPOWER PROJECT AT RD. 316+622, DISTRICT KHUSHAB**

A meeting of Panel of Experts (POE's) was held on July 27, 2017 in the Committee Room of Punjab Power Development Board (PPDB), under the Chairmanship of undersigned to discuss and review the feasibility study of subject cited Hydropower project.

2. The minutes of said meeting are enclosed for your kind information please.

Regards,

Managing Director
Punjab power Development Board

Encl: *As stated above*

CC:

1. PS to Additional Chief Secretary, Government of the Punjab, Energy Department, Lahore
2. PS to Secretary Energy, Government of the Punjab, Energy Department, Lahore
3. PS to Secretary Irrigation, Government of the Punjab, Irrigation Department, Lahore
4. M/s CJ Hydro (Pvt.) Limited, 15-Peshawar Block, Fortress Stadium, Lahore Cantt.

PUNJAB POWER DEVELOPMENT BOARD
ENERGY DEPARTMENT

MINUTES OF MEETING OF PANEL OF EXPERTS (POEs) REGARDING FEASIBILITY STUDY REPORT OF 25 MW CHASHMA JHELUM LINK CANAL HYDROPOWER PROJECT AT RD. 316+622, DISTRICT KHUSHAB

A meeting of Panel of Experts (POE) was held on July 27, 2017 in the Committee Room of Punjab Power Development Board (PPDB). Managing Director (MD) PPDB convened the meeting. List of the participants is attached at **Annex-A**.

2. M D PPDB welcomed the members of POEs and representatives of CJ Link Hydropower (the "Sponsor") and briefed the members about the Agenda of the meeting; to review the updated feasibility study in light of direction of NEPRA. Afterwards, the convener requested the Sponsor to give a presentation to the POE members.

3. The Consultants of the Sponsor made a presentation about the status of development of the Project, with specific reference to following matters.

- The Project History
- Hydrology Study
- CJ Link Canal Operation
- Power and Energy Study
- Cost Estimation
- Tariff

It was informed to POE that:

- In light of direction of NEPRA during hearing held on 29 Nov 2016, the Sponsor has carried out the following activities:

  i. Updated the hydrology of the project up to year 2016, including the years that may account changes in flow after Mangla Dam raising.
  ii. Based on historic flows the flow data has been extrapolated for future years in order to assure the viability of the project.

  Sponsor has updated hydrology data and the feasibility has been updated on the basis of revised hydrology. The output, design discharge and plant factor (power potential), and the related electromechanical equipment has been changed. BOQ for civil structure and electro-mechanical equipment has been revised and the costs have been updated accordingly.

- The design discharge has been reduced from 320 to 210 cumecs and plant capacity has been reduced to 25 MW form original 44.3 MW, on the basis of updated hydrological study. The salient feature as below were shared with POE members

Description	Units	Updated Study
Net Head	m	13.65
Annual Energy	GWh	110.6
Runner Diameter	m	3.65
Headrace Length	m	1350
Bed Width	m	36
Tailrace length	m	370
Project Development Cost	Mill US$/MW	2.17
Flow Record		1991-2016, Post Water Accord, Post raised Mangla

- Electro-mechanical component has been revised according to revised plant capacity. Three bulb turbines of 8.3 MW are proposed.

- Hydrological data was analyzed for flows from 1991 to 2016 for scenarios with and without Mangla Dam raising and further projected to 2041. The analysis shows that discharge in CJ Link Canal will be reduced by 0.42 MAF in Rabi period due to improved flows at Trimmu Barrage by 1 MAF due to enhanced storage capacity at Mangla Dam. But flows in CJ Link canal are not likely to be reduced in Kharif season, when Mangla reservoir is in filling stage. So CJ Link canal will be operational and important component to meet shortfalls at Trimmu Barrage.

- Due to variable discharges in CJ Link canal the energy generation will vary from 54 to 134 Gwh. The energy generation against average discharge has been calculated as 110.6 Gwh.

- The financial model was presented for tariff calculation. Project development cost has been calculated as 2.17 million US $/ MW. The Sponsor informed POE they will opt for cost plus tariff.

4. PPIB comments regarding concerns of NEPRA Advisory regarding shortfalls in Estimated Energy. Sponsor was directed to also consider outage period during calculation of energy generation.

5. POE member from WAPDA Chief Engineer Sheikh Abid, shared finding of earlier study of WAPDA regarding CJ Link Hydropower Project and supported the result that discharge during Kharif season will remain same depending upon availability of flows in Indus river. He further added that project should be allowed to proceed forward. The Sponsor should submit the report to NEPRA, of development of project.

6. POE members from PPMU asked Sponsor to update interconnection study in line with revised Project capacity.

7. POE members from NTDC supported the comments of fellow members to update interconnection study in line with revised Project capacity in order to avoid difficulties in future approvals for development of project.

8. MD PPDB also required the Sponsor to take steps to updated IEE and Interconnection study.

9. The comments of PPMU and PPDB are attached to be incorporated in final feasibility report.

Conclusion

a. POE after due deliberations approved the revised size of the project as 25 MW (along-with other parameters as discussed above) as per the updated feasibility study based on the latest hydrological assessment carried out as required by NEPRA, and has required the Sponsor to also update the IEE and Interconnection study accordingly.

b. In light of the aforesaid recommendations of the POE, the Sponsor is advised to submit the updated hydrological assessment report to NEPRA as per its requirements, and pursue the pending Generation License.

The meeting ended with vote of thanks from and to the Chair.

x----------x----------x----------x----------x----------x

No. PPDB/ 328 /2009

OFFICE OF THE MANAGING DIRECTOR
PUNJAB POWER DEVELOPMENT BOARD
IRRIGATION & POWER DEPARTMENT
1st Floor, Central Design Building,
Irrigation Secretariat, Old Anarkali, Lahore
(Ph: 9212794 Fax: 9212796)

Date 30-03-/2009

To:

M/S Haseeb Khan & Co. (HK Consortium)
15-Peshawar Block, Fortress Stadium,
Lahore.

Subject: **APPROVAL OF FEASIBILITY STUDY FOR 40 MW HYDRO POWER PROJECT AT C.J.LINK TAIL CANAL FALL RD 316+622 CONDUCTED BY H.K. CONSORTIUM.**

Reference Letter of Interest (LOI) No. MD-PPDB / H-34 / 450/2007 dated 08.11.2007 to conduct feasibility study for the development of subject noted Hydro Power Project.

Final feasibility study completed by you after incorporating the recommendations of Panel of Experts (POE) has been reviewed by the POE and following is the decisions of Panel of Experts (POE) during meeting dated 05.03.2009.

(i) The Feasibility Study for Chasma Jehlum Hydro Power Project conducted by M/s NESPAK Lahore for HK Consortium Lahore has been approved.

(ii) POE certifies only the completion of the Feasibility Study. However, due to nature of data and resultant conclusions, POE jointly and/or individually will not be responsible for reliability of data contents and conclusions given in the feasibility study.

In accordance with the provisions of the Punjab Power Generation Policy 2006 and its subsequent amendments, upon the approval of the feasibility study by the POE, you are required to approach Power Purchaser / NEPRA for approval of the proposed tariff within stipulated period i.e. within three (3) months starting form 25th March 2009 and lapsing on 23rd June 2009.

Your effort for timely completion of the feasibility study is appreciated. You are requested to keep up same pace and spirit for negotiation of the tariff for early development of the Hydro Power Project to meet the energy needs of the country.

MANAGING DIRECTOR
PUNJAB POWER DEVELOPMENT BOARD

Endorsement No. PPDB/_____/2009 Dated _____/2009

A copy is forwarded for kind information to:-

1. The Secretary, Irrigation & Power Department, Govt. of the Punjab, Lahore.
2. The Chairman NEPRA, OPF, Building G-5/1, Islamabad.
3. The Member (Power) WAPDA, WAPDA House, Lahore.
4. The General Manager (WPPO) WAPDA, WAPDA House Lahore.

MANAGING DIRECTOR
PUNJAB POWER DEVELOPMENT BOARD

PUNJAB POWER DEVELOPMENT BOARD
ENERGY DEPARTMENT

MINUTES OF MEETING OF PANEL OF EXPERTS (POEs) REGARDING FEASIBILITY STUDY REPORT OF 25 MW CHASHMA JHELUM LINK CANAL HYDROPOWER PROJECT AT RD. 316+622, DISTRICT KHUSHAB

A meeting of Panel of Experts (POE) was held on July 27, 2017 in the Committee Room of Punjab Power Development Board (PPDB). Managing Director (MD) PPDB convened the meeting. List of the participants is attached at Annex-A.

2. MD PPDB welcomed the members of POEs and representatives of CJ Link Hydropower (the "Sponsor") and briefed the members about the Agenda of the meeting: to review the updated feasibility study in light of direction of NEPRA. Afterwards, the convener requested the Sponsor to give a presentation to the POE members.

3. The Consultants of the Sponsor made a presentation about the status of development of the Project, with specific reference to following matters.

- The Project History
- Hydrology Study
- CJ Link Canal Operation
- Power and Energy Study
- Cost Estimation
- Tariff

It was informed to POE that:

- In light of direction of NEPRA during hearing held on 29 Nov 2016, the Sponsor has carried out the following activities:

  i. Updated the hydrology of the project up to year 2016, including the years that may account changes in flow after Mangla Dam raising.
  ii. Based on historic flows the flow data has been extrapolated for future years in order to assure the viability of the project.

  Sponsor has updated hydrology data and the feasibility has been updated on the basis of revised hydrology. The output, design discharge and plant factor (power potential), and the related electromechanical equipment has been changed. BOQ for civil structure and electro-mechanical equipment has been revised and the costs have been updated accordingly.

- The design discharge has been reduced from 320 to 210 cumecs and plant capacity has been reduced to 25 MW form original 44.3 MW, on the basis of updated hydrological study. The salient feature as below were shared with POE members

No.PPDB/ 283-99 /2009

OFFICE OF THE MANAGING DIRECTOR
PUNJAB POWER DEVELOPMENT BOARD
IRRIGATION & POWER DEPARTMENT
1st Floor, Central Design Building,
Irrigation Secretariat, Old Anarkali, Lahore
(Ph: 9212794 Fax: 9212796)

Date 17-3- /2009

To:

1. **Mr. Munnawar Iqbal**
   Senior Project Manager (Hydel) PPIB, Islamabad.
2. **Chief Engineer & Project Director**
   Chashma Barrage & CRBC (WAPDA) Mianwali
3. **Mr. Wajid Hameed**
   Chief Engineer, (Coordination) C/o G.M Hydel, WAPDA House, Lahore
4. **Mr. Muhammad Nadeem Khan**
   Director Planning I & P Deptt. Lahore
5. **Superintending Engineer**
   Link Canal Circle, I & P Deptt. Lahore
6. **M/s Haseeb Khan & Co.**
   15-Peshawar Block, Fortress Stadium, Lahore
7. **M/s Olympia Chemicals,**
   23-Davis Road, Lahore

Sub: **MINUTES OF MEETING OF THE PENAL OF EXPERTS (POE) DATED 05.03.2009**

Enclosed please find minutes of meeting of the Penal of Experts (POE) held on 05.03.2009 at 11: 00 AM in the Committee Room of Punjab Power Drainage Authority (PIDA) I & P Department for information.

MANAGING DIRECTOR
PUNJAB POWER DEVELOPMENT BOARD

Endorsement No.PPDB/ 300 /2009 Dated 17-3- /2009

A copy is forwarded for kind information to Secretary I & P Department, Government of the Punjab, Lahore.

MANAGING DIRECTOR
PUNJAB POWER DEVELOPMENT BOARD

GOVERNMENT OF THE PUNJAB
IRRIGATION AND POWER DEPARTMENT
PUNJAB POWER DEVELOPMENT BOARD

MINUTES OF MEETING OF THE PANEL OF EXPERTS (POE) HELD ON 05.03.2009

A meeting of the Panel of Experts (POE) under Para 4.2 (51) of the "Punjab Power Generation Policy 2006 Revised 2009" was held on 05.03.2009 in the Committee Room of Punjab Irrigation & Drainage Authority (PIDA) to discuss the following agenda items: -

1. Final Feasibility Study of 40MW Hydro Power Project at C.J. Link Canal (Tail) RD 316+622 conducted by M/s NESPAK Lahore for M/s HK Consortium Lahore.
2. Draft Feasibility Study of 10 MW Hydro Power Project at B.S. Link Canal-1 RD 106+250 conducted by M/s Team Consultant Lahore for M/s Olympia Chemicals Limited Lahore.

Managing Director Punjab Power Development Board (PPDB) welcomed the participants, highlighted objectives of the meeting and requested the participant sponsors to facilitate Panel of Experts (POE) about the achievements through presentation session.

AGENDA ITEM NO. 1: FINAL FEASIBILITY STUDY OF 40MW HYDRO POWER PROJECT TO BE DEVELOPED ON C.J. LINK CANAL TAIL RD 316+622.

Representative of the consultant M/s NESPAK Lahore briefed about the recommendations of the POE already communicated to the sponsors for compliance and confirmed that the recommendations of the POE received through PPDB had been considered and suitably incorporated in the draft feasibility study. A copy of the Final feasibility study had already been submitted to the POE for review, verification regarding compliance of the recommendations. All Members POE endorsed compliance made by the consultant in the Final Feasibility Study. The Consultant highlighted features of the final feasibility study through presentation and the alternative layouts of the project, plant factor & the proposed tariff. Load flow study of the Power House was also discussed and the sponsors pointed out that the matter had been taken up with the WAPDA / NTDC Authorities for approval. POE advised the sponsors to pursue the case of approval of load flow with the concerned authorities at the earliest. POE approved the feasibility study and the Managing Director PPDB asked the sponsors to submit 5 sets of final feasibility study and soft copy for office record. POE also recommended to issue necessary approval to the sponsors for negotiating tariff with NTDC / WAPDA Authorities, and its further approved from NEPRA.

AGENDA ITEM NO. 2: DRAFT FEASIBILITY STUDY OF 10MW HYDRO POWER PROJECT TO BE DEVELOPED ON B.S. LINK-I, CANAL RD 106+250.

Representative of the consultant M/s Team Consultant Lahore briefed about the main features of draft feasibility study. Panel of Experts (POE) considered that the water flow of 15,000 cusecs during last 2 years was taken into account for calculation of the energy out put

after remodeling of the canal. POE suggested that previous history of the water flow as well as the constraints due to which the Canal, originally designed for 15,200 cusecs, could not run at full, be kept in view and to avoid over sized plant or to a minimize the Hydrological risks the design flow, be taken 10% less i.e. 13500 cusec. Proposed design layout of the project, selection of vertical shaft Kaplan turbines also came under discussion and POE observed that in such Head & flow conditions, the Horizontal or slightly inclined shaft is a world wide common practice due to overall economies of the Power House Complex. The sponsors were asked to provide a detailed comparison of over all civil and E/M Costs of the Power House Complex, keeping in view the Horizontal and vertical arrangement of Turbines and associated works. POE considered that the cost of the project calculated by the consultants was very high and suggested that the consultant should review the cost after considering proposed revision of the design of the project to achieve reasonable tariff. Final comments of POE on the Feasibility Study will also be communicated to the sponsor for compliance.

Meeting ended with a note of thanks from and to the Chair.

Attachment - V

NEPRA Decisions/Correspondence Concerning the Project

National Electric Power Regulatory Authority
Islamic Republic of Pakistan

Registrar

NEPRA Tower, Attaturk Avenue (East), G-5/1, Islamabad.
Ph: +92-51-9206500, Fax: +92-51-2600026
Web: www.nepra.org.pk, E-mail: registrar@nepra.org.pk

No. NEPRA/DL/LAG-143/ 19042 – 49 November 21, 2017

Project Director
CJ Hydro (Pvt.) Limited
15-Peshawer Block, Fortress Stadium,
Lahore

Subject: **ORDER OF THE AUTHORITY IN THE MATTER OF REVIEW PETITION FILED BY CJ HYDRO (PRIVATE) LIMITED (CJHPL) AGAINST THE DECISION OF THE AUTHORITY DATED APRIL 05, 2016**

Reference: CJHPL's review petition vide letter dated May 04, 2016 (received on May 05, 2016)

Please find enclosed herewith Order of the Authority (07 pages) in the subject matter for information and record.

Encl: **Order of the Authority** (07 pages)

21.11.17

(Syed Safeer Hussain)

CC to:

1. Chairman,
   Indus River System Authority
   35-Mauve Area, G-10/4,
   Islamabad.

2. Secretary,
   Irrigation & Power Department
   Govt. of Sindh,
   Sindh Secretariat, Karachi.

3. Secretary
   Power Division
   Ministry of Energy
   Government of Pakistan
   'A' Block, Pak Secretariat
   Islamabad

4. Secretary
   Irrigation Department,
   Govt. of Punjab,
   Old Anarkali, Lahore.

5. Managing Director
   Punjab Power Development Board
   1st Floor, Central Design Building,
   Irrigation Secretariat,
   Library Road, Old Anarkali, Lahore.

6. Chief Executive Officer
   Central Power Purchasing Agency
   Guarantee Limited (CPPA-G)
   Ground Floor, Enercon Building,
   G-5/2, Islamabad

7. Chief Executive Officer
   Faisalabad Electric Supply Company Limited (FESCO)
   West Canal Road, Abdullah Pur
   Faisalabad

National Electric Power Regulatory Authority
(NEPRA)

Order of the Authority
in the Matter of Review Petition of CJ Hydro (Private) Limited Against the Decision of the Authority Dated April 05, 2016

This order shall dispose of the proceedings of the review petition filed by CJ Hydro (Private) Limited (CJHPL) filed against the decision of the Authority dated April 05, 2016 wherein application of CJHPL for grant of the generation licence was rejected.

(A). Background

(i). CJHPL submitted an application for grant of the generation licence on June 08, 2009, in respect of its 44.30 MW Hydel Power Project (HPP). The said HPP was proposed to be located on Chashma-Jhelum (CJ) link canal, district Khushab, in the province of Punjab.

(ii). The Authority admitted the application on June 18, 2009 for and accordingly, a notice of admission was published in the press on June 20, 2009. Further, separate letters were also sent to Government ministries, their attached departments and representative organizations etc. on June 22, 2009. Through the said letters, the stakeholders were invited for submitting their comments in the matter for assisting the Authority.

(iii). In response to the above, the Authority received comments from nine (09) stakeholders including Indus River System Authority (IRSA), Securities & Exchange Commission of Pakistan, Central Power Purchasing Agency (CPPA) of National Transmission and Despatch Company Limited, Irrigation Department of Govt. of Sindh (GoS), Planning and Development Department of GoS, Punjab Power Development Board (PPDB), The Federation of Pakistan Chamber of Commerce & Industry, Irrigation and Power Department of Govt. of the Punjab, and Punjab Water Council. Except IRSA and GoS, all stakeholder supported grant of the generation licence to CJHPL.

NATIONAL ELECTRIC POWER REGULATORY AUTHORITY
REGISTRAR
NEPRA

(iv). IRSA submitted that CJ link canal is not a perennial canal and operates only intermittently as per availability of water and regulation needs. As such the water availability in the canal for the whole year cannot be guaranteed. GoS opposed the project on the plea that the project is not feasible as the CJ link canal is not a regular canal. Once the plant is installed, the said canal will be operated with justification of power generation and the province of Sindh will be deprived of its water share.

(v). Regarding the observation of IRSA, CJHPL admitted that CJ link canal is non perennial canal and during feasibility studies of the project due consideration was given to the issue. In the feasibility study, the historic/actual data of the canal from 1978 to 2007 (i.e. both pre and post Water Accord 1991 period) were considered. Further, the power estimation were based on the post Water Accord data, therefore, there is no problem in achieving the targeted generation. CJHPL further clarified that the proposed project is run of river type and will not affect the water share of the province of Sindh.

(vi). In view of the observations/comments of relevant stakeholders and importance of the matter, the Authority conducted a public hearing in the matter on September 03, 2009. In the said public hearing, GoS re-iterated its earlier comments and opposed implementation of the project.

(vii). The Authority considered the matter in its Regulatory Meeting held on February 03, 2010 and observed that except IRSA and GoS, all the stakeholders have supported grant of the generation licence to CJHPL. The Authority also considered the reply of CJHPL to the observations of IRSA and GoS and found the same plausible. Accordingly, the Authority decided to grant the generation licence to CJHPL.

(B). Review Petition Filed by GoS

(i). The decision of the Authority was communicated to all relevant stakeholders including GoS. In reply, GoS filed a review petition on February 11,

NATIONAL ELECTRIC POWER REGULATORY AUTHORITY
REGISTRAR
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2010 against the decision of the Authority under Regulation-3(2) of the NEPRA (Review Procedure) Regulations, 2009 (the "Review Regulations"). Salient points of the petition were as follow:-

(a). The project of CJHPL should be shelved as, if a power plant is installed at CJ link canal, it will become a permanent canal and water supply to Sindh will be affected by depriving it of its share of water;

(b). GoS does not accept the river water availability estimates prepared by WAPDA and unless this disagreement is resolved, estimation of surplus water availability is meaningless;

(c). On January 28, 2010, the provincial assembly of Sindh has passed a unanimous resolution against the construction of the proposed HPP on the CJ link canal;

(d). GoS is of firm view that the subject scheme should be immediately shelved to maintain harmony among co-sharer provinces.

(ii). In response, Govt. of the Punjab (GoPb) through PPDB) contested the contents of the review petition filed by GoS stating that:

(a). C-J link canal is operated out of Punjab share as determined by IRSA, it does not affect the water supply to Sindh;

(b). The river water availability estimates by WAPDA have not been used for deriving the power benefits. As such objection of GoS on river water availability estimates is not relevant, GoS is intermingling two issues one "the matter of sharing of water between the provinces" and the other "the installation of HPP at the tail of CJ link canal";

NATIONAL ELECTRIC POWER REGULATORY AUTHORITY
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(c). The proposed plant will not divert any extra water from the Indus except that authorized by IRSA out of Punjab's share and will have no ecological and environmental effect across provincial boundaries.

(iii). The Authority considered the above submissions and decided to hold a hearing of the relevant parties. Accordingly, the hearing was held on March 26, 2014. In the said hearing the Authority directed PPDB for submitting revised feasibility study of the HPP, after incorporating changes in water flow in the canal due to Mangla Dam raising project.

(iv). PPDB submitted a report titled "Hydrology and Power & Energy Estimation" stating that there is insignificant change in capacity and energy estimation of the proposed HPP due to Mangla Dam raising project therefore, revision of feasibility study is not required. GoS contested the reported submitted by PPDB and raised serious doubts about authenticity of data used in the feasibility study.

(v). In view of the above, the Authority again considered the matter and after detailed deliberations observed that GoS has taken a strong position against installation of the HPP and it emerges as a dispute over water supply/flow between the provinces. The Authority also noted that the dispute over water supply/flow does not fall within the mandate of NEPRA. Therefore the Authority decided that parties should resolve this issue at the appropriate forum as provided in the Constitution. In view of foregoing, the parties were directed to settle their issues regarding water supply/flow within a period of three (03) months, failing which the application of CJHPL for the grant of generation license shall be rejected.

(vi). In reply to the said, PPDB again submitted that the HPP has been designed on the basis of historical flows in the canal as authorized by IRSA out of Punjab share. WAPDA operates CJ link canal out of Punjab share allocated by IRSA and its operation would not affect the share of Sindh or any other province.

NATIONAL ELECTRIC POWER REGULATORY AUTHORITY
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In view of the said, PPDB requested the Authority to grant the generation licence to CJHPL.

(vii). The Authority considered the submissions of PPDB and noted that no new fact was presented before it even after lapse of given time of three (03) months to the parties to resolve the issue. The Authority further observed that that the parties failed to resolve the dispute over the water flow within the stipulated time. Accordingly, the Authority rejected the application of CJHPL for grant of the generation licence. Decision of the Authority was communicated to CJHPL through letter dated April 05, 2016.

(C). Review Motion Filed by CJHPL

(i). CJHPL, being aggrieved of the above mention decision of the Authority, filed a review petition on May 05, 2016, as stipulated in the Review Regulations. In its review petition, CJHPL submitted that:-

(a). The observations of GoS regarding the canal and water share of the province of Sindh, have properly been responded by GoPb and CJHPL and the same stand resolved;

(b). The Authority had already considered the said apprehensions of GoS in its regulatory meeting held on December 30, 2009 and approved grant of the generation licence to CJHPL;

(c). The only new issue raised by GoS during the hearing held on March 26, 2014 was that after 2007 the flows of CJ link canal have dropped significantly and the capacity of the HPP should be based on the reduced flow data;

(d). On the directions of the Authority, CJHPL carried out revised study i.e. "Hydrology and Power & Energy Estimation" based on new flow data i.e. from 1991 to 2013. The updated report showed that there were no significant differences in capacity

NATIONAL ELECTRIC POWER REGULATORY AUTHORITY
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and energy estimations;

(e). The project is technically and economically justified on the historical flows, does not require any extra water and will not affect the water share of the province of Sindh;

(f). The project will provide clean energy to the power-starved people of Pakistan. The Authority should decide the matter considering the facts and the interest of all the stakeholders and not based on the apprehensions of a single entity;

(g). The rejection of CJHPL application for grant of the generation licence at this advanced stage is not considered justified.

(ii). In view of the said grounds, CJHPL submitted that it has fulfilled the requisites for grant of the generation licence therefore the Authority may review its decision dated April 05, 2016 and issue the generation licence to it.

(D). Hearing

(i). The Authority considered the review motion and decided to give an opportunity of hearing to the relevant parties. Accordingly, the hearing was held on November 29, 2016. In the said hearing, after comprehensive deliberation on the issue, the Authority once again directed CJHPL to carry out a detailed revised feasibility study of the HPP duly incorporating the changes in flow due to Mangla Dam raising project.

(ii). CJHPL submitted the revised feasibility study of the project duly approved by PPDB on August 09, 2017. The Authority examined the same and observed that the findings of the revised feasibility study are in total contradiction of the earlier submission of PPDB and CJHPL wherein it was asserted that there is no significant change in flow of CJ link canal and capacity/energy estimates of the HPP due to Mangla Dam raising project. The Authority, further observed that according to the revised feasibility study there are significant changes in the main

NATIONAL ELECTRIC POWER REGULATORY AUTHORITY
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parameters of the project including (a). increase in per megawatt cost from Rs. 1.86 millions to 2.17 millions; (b). reduction in proposed installed capacity from 44 MW to 25 MW; (c). reduction in estimated annual energy production from 212 GWh to 110 GWh (d). reduction in design discharge from 320 m^3/s to 210 m^3/s; and (e). change in design/capacity of electromechanical equipment and net head of the project etc.

(E). Decision of the Authority

In view of foregoing, the Authority is of the view that due to the significant changes in the main parameters of the project, the earlier application of CJHPL for grant of the generation licence is not valid and CJHPL is required to submit afresh application for grant of the generation licence according to the revised feasibility study/revised parameters of the project. Hence, the review petition filed by CJHPL is hereby rejected.

Authority

17/11/17

Maj. Rtd. Haroon Rashid
(Member)

Syed Masood-Ul-Hassan Naqvi
(Member)

17.11.17

Himayat Ullah Khan
(Member)

Saif Ullah Chattha 17.11.2017
(Member/Vice Chairman)

NATIONAL ELECTRIC POWER REGULATORY AUTHORITY
REGISTRAR
NEPRA

21 11 17

Tariq Saddozai
(Chairman)

No. PPDB/ 520 /2016
PUNJAB POWER DEVELOPMENT BOARD
ENERGY DEPARTMENT
Irrigation Secretariat, Old Anarkali, Lahore
(Ph: 042-99213879 Fax: 99213885)
Date: 29 / 04 /2016

The Registrar
National Electric Power Regulatory Authority (NEPRA)
NEPRA Tower Ataturk Avenue (East), Sector G-5/1
Islamabad.

Subject: **APPLICATION OF CJ HYDRO (PVT.) LIMITED (CJHPL) FOR GRANT OF GENERATION LICENSE FOR DEVELOPMENT OF 44 MW HYDROPOWER PROJECT AT CHASHMA JHELUM (CJ) LINK CANAL AT RD. 316+622**

Kindly refer to your office letter No. NEPRA/D(Lic)/LAG-143/4488-89 dated 05th April 2016, intimating the rejection of application of M/s CJ Hydro (Pvt.) Limited (the "Sponsor") for grant of generation license.

2. It is submitted that during hearing in NEPRA on 26.03.2014 on the review petition filed by Government of Sindh (the "GoS") in connection with the release of withheld Generation License to be issued to CJ Hydro (Pvt.) Limited, the reservations of Government of Sindh were properly clarified/addressed. During the proceedings, representative of GoS expressed his apprehension that the flows during 2013 were on the lower side and the same should also be considered for the Project.

3. Concluding the proceedings of the meeting, the Authority stated that the dispute regarding water flow in CJ Link canal stood resolved and directed the Sponsor to update the Project's feasibility study, duly incorporating the flows during the period 2003-2013 in the CJ Link Canal. After compliance of NEPRA's directions, the updated Hydrology and Power & Energy Estimation Report was forwarded to the Authority vide this office letter No. PPDB/1156/2014 dated 28.10.2014. The report concludes that there is insignificant difference in capacity and energy estimations while considering the new flow data.

4. It is further submitted that the Sponsor has fulfilled all the requisites for grant of generation license. The Authority is requested to review the matter, revive the earlier decision conveyed vide NEPRA's letter No. NEPRA/R/LAG-143/957-63 dated 03.02.2010 and release the withheld generation license so that the Project may proceed further.

Regards,

SANIYA AWAIS
Managing Director

CC:
1. PS to Chairman PPDB Board / Additional Chief Secretary, Government of the Punjab, Energy Department, Lahore
2. PS to Secretary, Government of the Punjab, Energy Department, Lahore
3. M/s CJ Hydro (Pvt.) Limited, 15-Peshawar Block, Fortress Stadium, Lahore Cantt.

National Electric Power Regulatory Authority
Islamic Republic of Pakistan

NEPRA Office Building, G-5/1, Attaturk Avenue (East), Islamabad
Phone: 051-9206500, Fax: 051-2600026
Website: www.nepra.org.pk, Email: registrar@nepra.org.pk

OFFICE OF THE REGISTRAR

No. NEPRA/D(Lic)/LAG-143/ 4488-89 April 5, 2016

Project Director,
C.J Hydro Power (Pvt.) Limited (CJHPL)
15-Peshawar Block, Fortress Stadium,
Lahore.

Subject; - **Application of C.J Hydro (Pvt.) Limited (CJHPL) of 44 MW Hydro Power Project at C.J Link Canal For the Grant of Generation License.**

This is in continuation to this office letter No. NEPRA/D(Lic.) LAG-143/18025-27 dated December 17, 2015 wherein the Authority directed you to resolve the dispute over water flow/availability at the appropriate forum within three (03) months.(Copy attached).

2. In consideration of the above, the Authority did not receive any update from you, except a letter from PPDB dated January 13, 2016 through which it forwarded a copy of earlier correspondences of IRSA dated June 30,2009. The said letter stated that, Chashma-Jhelum Link Canal is non-perennial Canal and the Authority may consider this aspect while deciding the said application for Generation Licence. The Authority considered the above letter of the PPDB and observed that forwarded letter of IRSA were already available in its record and the same was duly considered by it while taking the earlier decision as explained above.

3. The Authority observed that neither you nor PPDB has provided any new fact to resolve the matter even after lapse of the stipulated time of three (03) months. In view of the said, the Authority has decided to reject your application for the grant of Generation Licence.

5/4/16

(Iftikhar Ali Khan)
Deputy Registrar

Copy to :

Managing Director
PujabPower Development Board(PPDB)
First Floor Central Design Building,
Irrigation Secretariat, Old Anar Kali,
Lahore.

{ With refence to your letter N0.PPDB/60/2016/Jan. 13,2016 }

No. PPDB/ 60 /2016
PUNJAB POWER DEVELOPMENT BOARD
ENERGY DEPARTMENT
1st Floor, Central Design Building,
Irrigation Secretariat, Old Anarkali, Lahore
(Ph: 042-99213876-9 Fax: 042-99212796)

Date: 13/01 / 2016

The Registrar
National Electric Power Regulatory Authority (NEPRA)
NEPRA Tower Ataturk Avenue (East), Sector G-5/1
Islamabad.

Subject: **Application of M/s CJ HYDRO (Pvt.) Limited of 44 MW Chashma Jhelum Link Canal Hydropower Project for The Grant of Generation License.**

Kindly Refer to Your Office Letter No. NEPRA/D(Lic)/LAG-143/8025-27 dated 17th Dec 2015.

2. It is informed that, the narrated issue on the water use of Chashma Jhelum Link canal for energy generation has already been taken up on the forum of Indus River System Authority (IRSA) vide IRSA letters NO.CE(O)/IRSA/232/CJHPL/7321.32 dated Jan 30, 2009 as placed at Annex-I. The decision of the Authority is reproduced here as under;

"Chashma Jhelum Canal is Non Perennial canal and operates intermittently as per availability of water in the system and regulation needed. Therefore you (NEPRA) are requested to keep in view the above aspect while awarding the Generation License"

3. The detail replies to the Government of Sindh (GoS) reservations by the Government of the Punjab (GoPb) was provided to NEPRA vide PPDB letter no. PPDB/7861/2010 dated 3 Oct 2010. It was clearly stated that the proposed CJ HPP has been designed on the basis of historical flows in the canal (Post water accord) as authorized by IRSA out of Punjab share. WAPDA operates CJ Link out of Punjab share allocated by IRSA and its operation would not affect the share of Sindh or any other province.

4. It is thus submitted to Authority to grant Generation License to M/s CJ HYDRO (Pvt.) Limited "The Sponsor" of CJ-Link canal Hydropower Project to proceed with the development of the Project.

Regards,

13.1.16
Managing Director
Punjab power Development Board

CC:

1. PS to Secretary Energy, Government of the Punjab, Energy Department, Lahore.
2. CJ Hydro (Pvt.) Limited, 15 Peshawar Block, Fortress Stadium, Lahore.

National Electric Power Regulatory Authority
Islamic Republic of Pakistan

NEPRA Office Building, G-5/1, Attaturk Avenue (East), Islamabad
Phone: 051-9206500, Fax: 051-2600026
Website: www.nepra.org.pk, Email: registrar@nepra.org.pk

OFFICE OF THE REGISTRAR

No. NEPRA/D(Lic)/LAG-143/ /8025-27 December 17, 2015

Project Director
C J Hydro Power (Private) Limited (CJHPL)
15-Peshawar Block, Fortress Stadium
Lahore

Subject: - **Application of CJ Hydro (Pvt) Limited (CJHPL) of 44 MW Hydro Power Project at C-J Link Canal For the Grant of Generation License.**

Your subject application is pending with the NEPRA due to the reason that Govt. of Sindh had raised its concerns regarding the installation of the power project that if power plant is installed at Cheshma- Jhelum, it will become a permanent canal and water supply to Sindh will be affected by depriving it of its share of water. Simultaneously the Provincial Assembly of Sindh has passed a unanimous resolution on January 28, 2010 against the construction of the project. Govt. of Sindh has also approached the Federal Government and once again expressed its strong opposition to the proposed power plant.

2. The Authority also conducted hearing in the matter. However, Govt. of Sindh and Govt. of Punjab have not been able to resolve the issue of water availability, discharge etc. The Authority considered the matter in its Regulatory Meeting held on October 28, 2015 and decided that as the dispute over water supply does not fall within the mandate of NEPRA. The Authority decided that parties must resolve this issue at the appropriate forum as provided in the constitution.

3. In view of the above, the Authority decided to approach Govt. of Punjab for taking up the matter at appropriate forum and settle their dispute regarding water supply/flow within a period of three (3) months of receipt of this letter, failing which the Authority, will be constrained to reject the application of CJHPL.

17/12/15

(Iftikhar Ali Khan)
Deputy Registrar

Copy to:

Secretary
Irrigation Department, Government of Sindh,
Sindh Secretariat No.-2 Tughlaq House. Karachi.

Managing Director
Punjab Power Development Board (PPDB) 1st Floor Central Design Building,
Irrigation Secretariat, Old Anarkali, Lahore

No. PPDB/ 14 /2014

PUNJAB POWER DEVELOPMENT BOARD
ENERGY DEPARTMENT

1st Floor, Central Design Building,
Irrigation Secretariat, Old Anarkali, Lahore
(Ph: 042-99213876-9 Fax: 042-99212796)

Date: 02/01 / 2015

The Registrar
National Electric Power Regulatory Authority (NEPRA)
NEPRA Tower, Attaturk Avenue, G-5/1,
Islamabad

Subject: **RELEASE OF HELD IN ABEYANCE GENERATION LICENSE OF 44.3MW HPP ON CJ LINK CANAL**

This is in continuation to our letter No. PPDB/1156/2014 dated 28.10.2014 regarding subject matter. In this regard, it is once again submitted that an LOI was issued to M/s C.J. Hydro (Pvt.) Limited (the "Sponsors") for the development of 44.3 MW HPP (Raw Site) on C.J. Link Tail Canal at RD. 316+622, District Khushab. The Sponsors completed the feasibility study during March 2009 and applied for issuance of Generation License in NEPRA as per provisions of Punjab power Generation Policy-2006 (Revised-2009). NEPRA approved the Generation License on 30.02.2010 but it was held in abeyance upon the Sindh Government's reservations.

2. Accordingly, the reservations of GoS were properly attended and replied on 08.09.2010. A public hearing was held on 26.03.2014 for release of Generation License for the subject power plant withheld by the Authority. During the hearing, it was directed to the Sponsors by the authority to revisit the feasibility study by using the actual flow data of C.J. Link Canal for the period 2003 to 2013 and satisfy the Authority that the project is viable with this flow.

3. In light of the above decision, the Sponsors have incorporated the actual flow data of 2003-2013 and submitted the Revised Power & Energy Estimation Report (copy enclosed).

4. The Sponsors have informed that there is insignificant difference in capacity and energy estimations there fore revision of feasibility study may not be required. It is requested to release the held in abeyance license to proceed further in the development of the project.

Regards,

Managing Director
Punjab power Development Board

CC:

1. P.S.to Additional Chief Secretary, Government of the Punjab, Energy Department, Lahore
2. M/s C.J. Hydro (Pvt.) Limited, 15 Peshawar Block, Fortress stadium, Lahore to pursue the case for development of the Project

No. PPDB/ 1156 /2014

PUNJAB POWER DEVELOPMENT BOARD
ENERGY DEPARTMENT

1st Floor, Central Design Building,
Irrigation Secretariat, Old Anarkali, Lahore
(Ph: 042-99213876-9 Fax: 042-99212796)

Date: 28/10 **/ 2014**

The Registrar
National Electric Power Regulatory Authority (NEPRA)
NEPRA Tower, Attaturk Avenue, G-5/1,
Islamabad

Subject: **RELEASE OF HELD IN ABEYANCE GENERATION LICENSE OF 44.3MW HPP ON CJ LINK CANAL**

It is hereby submitted that an LOI was issued to M/s C.J. Hydro (Pvt.) Limited (the "Sponsors") for the development of 44.3 MW HPP (Raw Site) on C.J. Link Tail Canal at RD. 316+622, District Khushab. The Sponsors completed the feasibility study during March 2009 and applied for issuance of Generation License in NEPRA as per provisions of Punjab power Generation Policy-2006 (Revised-2009). NEPRA approved the Generation License on 30.02.2010 but it was held in abeyance upon the Sindh Government's reservations.

2. Accordingly, the reservations of GoS were properly attended and replied on 08.09.2010. A public hearing was held on 26.03.2014 for release of Generation License for the subject power plant withheld by the Authority. During the hearing, it was directed to the Sponsors by the authority to revisit the feasibility study by using the actual flow data of C.J. Link Canal for the period 2003 to 2013 and satisfy the Authority that the project is viable with this flow.

3. In light of the above decision, the Sponsors have incorporated the actual flow data of 2003-2013 and submitted the Revised Power & Energy Estimation Report (copy enclosed).

4. The Sponsors have informed that there is insignificant difference in capacity and energy estimations there fore revision of feasibility study may not be required. It is requested to release the held in abeyance license to proceed further in the development of the project.

Regards,

Managing Director
Punjab power Development Board

CC:

1. The Additional Chief Secretary, Government of the Punjab, Energy Department, Lahore
2. M/s C.J. Hydro (Pvt.) Limited, 15 Peshawar Block, Fortress stadium Lahore .The request for release of generation license is being sent as discussed.

CJ Hydro (Pvt) Limited
15 Peshawar Block, Fortress Stadium
Lahore 54810, Pakistan
Tel : 92 (42) 36675595, 36660085
Fax: 92 (42) 36673960, 36664349

8th May 2014 CJHPL/PPDB/2014-003

Managing Director
Punjab Power Development Board
1st Floor, Central Design Building
Irrigation Secretariat, Old Anarkali
Lahore

Subject: Collection of Actual Recorded Flow Data at CJ Link Canal

Dear Madam,

Please refer to your letter number PPDB/557/2014 dated 2nd May 2005.

As you are aware, the data provided to CJ Hydro (Pvt.) Limited (CJHPL) vide letter no. IWT&R/14/410/21-CJ dated 3rd April 2014 was not appropriate as mentioned in our letter dated 7th April 2014 wherein we had explained that the data provided was the 10-Daily flow data obtained from IRSA, whereas we required the actual historic flow data at CJ Link Canal Tail as recorded by WAPDA. Finally, in response to our letter no. CJHPL/PPDB/2014-002 dated 17th April 2014, PPDB issued letter no. PPDB/500/2014 on 23rd April 2014 to the Chief Engineer/Project Director Chasma Barrage, Mianwali (CE Chasma) requesting the release of the required data to CJHPL. It took an additional few days for CE Chasma to receive the official copy of the said authority letter, after which our team visited Khushab, Shergarh, Mianwali and Chasma to meet the relevant functionaries and collected the required data.

We have handed over the data to our consultant to digitize, analyze and update the Project's hydrology data after which the consultant will issue a revised/updated hydrology report. CJHPL will submit the report to PPDB as soon as it is completed.

Kind Regards,
Yours Sincerely,

CJ Hydro (Pvt.) Limited

Copy To:

1. The Additional Chief Secretary, Gov. of Punjab, Energy Department, Lahore
2. The Deputy Registrar NEPRA, NEPRA Tower, Attaturk Avenue, G-5/1, Islamabad

CJ HYDRO

CJ Hydro (Pvt) Limited
15 Peshawar Block, Fortress Stadium
Lahore 54810, Pakistan
Tel : 92 (42) 36675595, 36660085
Fax: 92 (42) 36673960, 36664349

30th April 2014 CJHPL/NEPRA/2014/C-001

Deputy Registrar
Office of the Registrar
National Electric Power Regulatory Authority (NEPRA)
NEPRA Tower, Attatuk Avenue, G-5/1, Islamabad

Subject: Application of CJ Hydro (Pvt.) Ltd. ('CJHPL') for the Grant of Generation License

Dear Sir,

Please refer to NEPRA hearing held on 26th March 2014 on the subject matter and your letter no. NEPRA/R/LAG-143/4098 dated 23rd April 2014. We appreciate NEPRA's intention to expedite the resolution of this long outstanding issue and submit the following for your kind consideration;

1. As directed by the Authority during the meeting, we will review the Feasibility Report in the light of actual flows of the CJ Link Canal for the period 2008-2013, as the PPDB Approved Feasibility Report of May 2009 already submitted to NEPRA, caters for the flows from 1991 to 2007.
2. We are in the process of collecting actual recorded flow data from Chasma Jhelum Link Canal Tail; on receipt of the data, it needs to be digitized and analyzed. Thereafter, we intend to review the hydrology and effect of the updated actual flows for the period 1991-2013 on CJHPP.
3. As far as the effect of Mangla Dam Raising Project on CJHPP is concerned, this aspect has already been thoroughly discussed in the Feasibility Report submitted to NEPRA.

Sir, collection of actual recorded flow data is a lengthy process as it involves authorization and support from PPDB, WAPDA Chief Engineer & PD Chasma Barrage, WAPDA XEN Water and relevant SDO & Sub Engineers at Chasma Jhelum Link Tail. Out team is currently in the field and have almost completed data collection and hope to start digitizing the same this week.

Kind Regards,
Yours Sincerely,

Danish Haseeb Khan
Chief Executive

National Electric Power Regulatory Authority
Islamic Republic of Pakistan

NEPRA Tower, Attaturk Avenue, G-5/1, Islamabad
Phone: 051-2013200, Ext.905, Fax: 2600026
Website: www.nepra.org.pk, Email: info@nepra.org.pk

OFFICE OF THE REGISTRAR

No. NEPRA/R/LAG-143/ 4098

23-4- 2014

Mr. Danish Haseeb Khan
Project Director,
CJ Hydro (Private) Limited,
15-Peshawar Block, Fortress Stadium,
Lahore.

Subject: **Application of CJ Hydro (Pvt.) Limited (CJHPL) for the grant of Generation License.**

This is in continuation to the hearing held on March 26, 2014 pertaining to the review petition filed by Govt. of Sindh (GoS) against the grant of Generation License to CJHPL.

2. The Authority in above mentioned hearing directed you for submitting a revised Feasibility Study of the project (duly incorporating the flows during the period 2003-2013 in the C-J Link canal) on account of Mangla Dam raising Project. The said information was required to be submitted within fifteen (15) days. It is regretted that despite the lapse of stipulated deadline, this office has not received the required information.

3. Please expedite the submission of the same within seven (07) days of receipt of this letter without any delay, enabling the Authority to decide the long outstanding issue.

23/4/14

(Iftikhar Ali Khan)
Deputy Registrar

No. MD (PPDB)/ 7405 /2010
PUNJAB POWER DEVELOPMENT BOARD
IRRIGATION & POWER DEPARTMENT

Dated 28-06 /2010

The Adviser
National Electric Power Regulatory Authority
2nd Floor, OPF Building, G-5/2
Islamabad

Subject: **Grant of Generation License for 44.331 MW Hydel Power Project at Chashma Jehlum Link Canal.**

Please refer to our letter No.PPDB/2010/9214-18 of 1st June 2010 (copy enclosed for ready reference) regarding captioned subject. Data/information requested therein is still awaited. It is, therefore, once again requested to expedite the matter and provide requisite outstanding data/information enabling us to clarify the objections raised by GoS with respect to subjected hydropower project.

(Managing Director)
Punjab Power Development Board

DA/as above

Cc to:

1. Secretary to Chief Minister of the Punjab, Lahore.
2. Secretary, Irrigation and Power Department, Government of the Punjab, Lahore.
3. Registrar, NEPRA, 2nd Floor, OPF Building, G-5/2, Islamabad.
4. Chief Executive, CJ Hydro (Private) Limited, 15-Peshawar Block, Fortress Stadium, Lahore.

No.PPDB/1922-3 /2010
PUNJAB POWER DEVELOPMENTN BOARD
IRRIGATION & POWER DEPARTMENT
1st Floor, Central Design Building,
Irrigation Secretariat, Old Anarkali, Lahore
(Ph: 99212794, Fax: 99212796)

Dated 12-04- /2010

To

The Advisor,
National Electric Power Regulatory Authority (NEPRA),
Second Floor, OPF Building, G-5,
Islamabad.

Subject: - **GRANT OF GENERATION LICENCE FOR 44.331 MW POWER PROJECT AT CHASHMA JHELUM LINK CANAL.**

This is with reference to your letter No.NEPRA-M&E(PPDB)/29 dated 06-04-2010 on the subject noted above.

It is requested to provide the following information to this office enabling it to provide parawise comments as desired:-

i. Source of water flow data referred in the observations of Government of Sindh.

ii. Flow data detail at Head & Tail of CJ Link available with Government of Sindh.

iii. Government of Sindh states that 25% of the time/year plant will operate on full capacity. What is the detail of partial operation i.e. 49% of time as indicated in table (Annex-1 of observations by Government of Sindh), in the view point of Sindh.

iv. Estimate of Energy Generated/year and plant factor, made by Government of Sindh.

v. Detail of tariff Calculation/Capacity payments by the Government of Sindh, on the basis of which the project is stated as unviable

vi. Detail of Canal/Projects implementation schedule & discharges/releases highlighted by Government of Sindh.

12/4/2010

MANAGING DIRECTOR
PUNJAB POWER DEVELOPMENT BOARD

C.C

A copy is forwarded to the Secretary, Irrigation & Power Department, Punjab, Lahore alongwith copy of letter from NEPRA as referred above, for information.

12/4/10

No. SO(P)/Misc/C3-12/2010
IRRIGATION AND POWER DEPARTMENT
GOVERNMENT OF THE PUNJAB

Dated 22.03. /2010

1. The Chairman,
National electric Power Regulatory Authority (NEPRA),
2nd Floor, PIA Building, Blue Area,
Islamabad.
2. Engr. Arshad Mahmood,
Senior Advisor,
National electric Power Regulatory Authority (NEPRA),
2nd Floor, PIA Building, Blue Area,
Islamabad.

SUBJECT: - VIEW POINT OF PUNJAB GOVERNMENT ON 44 MW CJ HYDRO POWER PLANT AT CHASHMA JHELUM CANAL.

Reference is invited to your letter No.NEPRA-M&E(I&PD)/013 dated 01-03-2010 on the subject" Government of Punjab has withdrawn from its claim on Chashma Jhelum Power Project on the protest of Government of Sindh", where in the comments of this Department have been called.

2. Accordingly it is stated that the Punjab Government to mitigate energy crises in the country has taken steps to develop power projects in public as well as private sector under the Punjab Power Generation Policy 2006 (Revised 2009). Punjab as a first step decided to develop 48 preferred raw Hydel sites available on its canal falls through private sector. An advertisement in this regard was released in press on 29-03-2007. The site at the tail of Chashma Jhelum Canal having pre-feasible potential of 40 MW was also included in the said advertisement. M/s Haseeb Khan & Co. was selected and Letter of Interest (LOI) was issued to the said company for carrying out the feasibility study of the site on 24-11-2007. The sponsor completed the study on 25-10-2008. The main features of the Project as brought out in the feasibility study are as under:

:1.	Location	CJ Link Canal Tail in District Khushab
2.	Name of Canal	CJ Link Canal
3.	Design discharge of CJ Link	21000 Cusecs
4.	Design head	13.86 m
5.	Head Race	Brick lined
6.	Design discharge (Head race	10500 Cusecs

	channel of power house)	
7.	Capacity of power house	44 MW
8.	Plant factor of Power House	55%
9.	Annual energy generation	212.249 GWh
10.	Tariff	6.89 US Cents/unit

3. After the approval of feasibility study by the Panel of Experts (POE) comprising members from PPIB, WPPO/WAPDA, Irrigation & Power Department Punjab, the sponsor was asked to carry out power purchase agreement with the concerned DISCO and to apply for power generation license and tariff determination to NEPRA. During public hearing for the grant of generation license to the said project by NEPRA on 03-09-2009, the Sindh Province opposed the project on the plea that project is non-feasible and should not be implemented.

4. Chashma Jhelum Canal off-takes from River Indus at Chashma District Mianwali, Punjab. It was constructed in 1970 in consequence of Indus Waters Treaty signed with India in 1960 in order to meet the requirements of Pakistan Canals off taking from the three Eastern Rivers i.e. Ravi, Beas and Sutlej. It was part of the replacement works that Pakistan was required to construct to transfer supplies from the Western Rivers to the Eastern Rivers. Accordingly, Indus Basin Replacement Project comprising two Mega Dams (at Mangla and Tarbela), six new Head Works and seven new Link Canals were completed during the period 1960-1976.

5. Chashma Jhelum Link is one of the aforesaid Link Canals constructed to off take from Chashma Barrage and transfer Tarbela/Indus River water to feed the Punjab Eastern Rivers Canals. It has a full supply capacity of 21700 Cusec at head whereas hydropower plant has been designed at 10500 Cusec keeping in view the post accord water flow in CJ link authorized by IRSA. C-J Link is operated by WAPDA out of Punjab share allocated by IRSA.

6. In this context a meeting was held in the Ministry of Water and Power on 13-11-2009 which was attended by the Irrigation Secretaries of both the provinces as well as sponsor of the project. The Ministry of Water & Power observed that the project being non-consumptive 'nature' did not in any way affect the water allocation / share of Government of Sindh as the canal operation was dependant on IRSA's authorizations based on shares of the provinces. The Secretary, Water & Power requested Government of Sindh to reconsider their reservations in the light of clarification on the operation of the project, specific provision of the Water Accord with priority for irrigation and assurances of the Government of the Punjab.

7. Government of Punjab at all levels has assured that project would be operated as per availability of water in the canal out of Punjab share allocated by

IRSA. NEPRA has also conducted the hearing for tariff determination on 28-01-2010 and announced that generation license for the project has been approved. This project will be able to supply cheap renewable energy in the National Grid.

8. This matter was discussed in a meeting of Prime Minister of Pakistan with Chief Ministers on 18-02-2010. A delegation of Government of the Punjab visited Karachi on 20.02.2010 and had a meeting with Government of Sindh to discuss Water Apportionment Accord 1991 and other issues. As a follow up of the said meeting, technical teams of Irrigation Departments of the two provinces met in Lahore on 22nd February, 2010. The issue of CJ HPP was also discussed in the said meeting. Briefly, the Punjab Government took the following stand:

i. CJ HPP is not a public sector financed project; it is a private sector initiative based on a feasibility prepared by experts.

ii. CJ HPP has been designed on the basis of historical flow in the canal (Post Water Accord) as authorized by IRSA out of Punjab share.

iii. WAPDA operates CJ Link out of Punjab share allocated by IRSA and its operation would not affect the share of other provinces.

iv. Para 14(d) of the Water Accord 1991 gives freedom to Provinces to operate any system during any period remaining within the Provincial shares.

v. The matter falls in the purview of NEPRA where Government of Sindh has already registered its opinion on the project.

vi. NEPRA should decide the project in the light of its technical and financial viability worked out by experts.

9. In view of the foregoing, Government of Punjab forcefully supports this project in view of its technical and financial viability and other features as listed in para 8 above.

DA/As above.

(RAB NAWAZ) 22/03
SECRETARY

c.c.

Secretary to Chief Minister, Punjab, for information.

National Electric Power Regulatory Authority

Islamic Republic of Pakistan

2nd Floor, OPF Building, G-5/2, Islamabad
Ph : 9206500, 9207200, Fax : 9210215
E-mail: registrar@nepra.org.pk

Registrar

No. NEPRA/R/LAG-143/957-63 February 3, 2010

Secretary
Ministry of Water & Power
Government of Pakistan
'A' Block, Pak Secretariat
Islamabad

Subject: **Grant of Generation Licence to C J Hydro (Private) Limited (CJHPL) for its 44.331 MW Hydel Power Plant at Chashma Jhelum (Link) in District Khushab**

Enclosed please find herewith minutes/decision of the Authority in the matter of grant of Generation Licence to C J Hydro (Private) Limited for its 44.331 MW Hydel Power Plant at Chashma Jhelum (Link) in District Khushab, Punjab, for information.

Enclosure: As above

(Syed Safeer Hussain)

CC along with enclosure:

1. Principal Secretary to the Prime Minister, Prime Minister's Secretariat, Islamabad.
2. Secretary to the Chief Minister Sindh, Government of Sindh, Karachi.
3. Secretary Irrigation & Power Department, Govt. of Sindh, Sindh Secretariat No.2, Tughlaq House, Karachi.
4. Secretary, Irrigation & Power Department, Govt. of Punjab, Near Old Anarkali, Lahore.
5. Chairman, Indus River System Authority (IRSA), Block R-3, Sitara Market, G-7 Markaz, Islamabad.
6. Mr. Danish Haseeb Khan, Chief Executive / Director, C J Hydro (Private) Ltd., 15-Peshawar Block, Fortress Stadium, Lahore.

General Public and other interested/affected parties, in favor or against the Grant of the Licence. Apart from the NOA in the press, separate notices were also sent to Individual Experts/Government Ministries/Representative Organizations etc., for submitting their views/comments in the matter. Dy. Director (Lic) explained that in reply to the NOA, comments from eight (08) different stakeholders were received. These included comments from Indus River System Authority (IRSA), Securities & Exchange Commission of Pakistan (SECP), Central Power Purchasing Agency (CPPA) of National Transmission and Dispatch Company Limited (NTDC), Irrigation and Power Department, Govt. of Sindh (I&PDGoS), Planning & Development (Energy Section), Govt. of Sindh (P&DESGoS), PPDB, The Federation of Pakistan Chambers of Commerce and Industry (FPCCI), Irrigation and Power Department Government of Punjab (I&PDGoP) and Punjab Water Council (PWC). It was clarified that all the above stakeholders supported the grant of Generation Licence except IRSA and Government of Sindh (GoS). IRSA informed that CJ Link Canal was not a perennial canal. GoS while opposing the project submitted that the C–J Link Canal was not a regular canal and its operation period was not fixed and therefore, no assured supplies of water were available. Also there was no mention of operation of C–J Link Canal in the 1991 Water Accord. The water release to the C-J Link Canal for HPP would render it to be a permanent canal and as a result of which the water supply to the Province of Sindh would be affected.

The sponsors explained that in view of the divergent opinion expressed by IRSA, GoS and GoP comments made on the operation of the C-J Link canal, a clarification was sought from the Ministry of Water & Power (MoW&P) of Government of Pakistan. MoW&P convened a meeting of all the relevant stakeholders in the matter on November 13, 2009 at Islamabad. MoW&P while communicating the Minutes of the Meeting confirmed that the project was of non-consumptive nature and would not have any affect on the water allocation share of GoS as the CJ link canal was dependent on the authorization of IRSA based on the share of the provinces. Sponsors further stated that in view of the clarification from the MoW&P, the objection of GoS had been suitably addressed. He further submitted that CJHPL had completed all the requisite requirements of the relevant Rules and Regulations. He recommended the grant of Generation Licence to CJHPL.

Member (S&P) did not agree to the grant of the Generation Licence to CJHPL. He opined that the matter of sharing of water between the provinces was very sensitive subject. He further stated that in the past GoS and GoP had severe differences with each other on the water issue and had taken up the matter in the Council of Common Interest (CCI). He explained that the severity of the matter could be gauged from the fact that even in the particular case of CJHPL, the Chief Minister of Sindh had already sent a D.O. Letter to the Prime Minister to intervene in the matter. Moreover, Ministry of Water and Power (GoP) have not given any clear clarification or view point of Government on the matter and have simply forwarded Minutes of the Meeting.

Other Authority Members were of the view that MoW&P had given its clarification in the matter, stating that the project was of non-consumptive nature and even IRSA, the Water Regulator had not objected to the grant of Generation Licence to CJHPL. Further Chairman also drew the attention of the Members of the Authority towards the Legal opinion of the Legal Advisor-II rendered in the matter. Legal Advisor-II had confirmed that for the purpose of CCI, it was only the concerned Provincial Government which could raise any dispute with CCI and NEPRA stands nowhere for referring any such dispute to CCI. Further, the Authority was required to decide the application of CJHPL after providing an opportunity of hearing to all the stakeholders. Dy. Director Licensing pointed out that all legal requirements for grant of licence as envisaged in Regulation of Generation, Transmission and Distribution of Electric Power Act (XLof 1997) and NEPRA Licensing (Generation) Rules, 2000 had been fulfilled and that request for grant of lecense should, therefore, not be denied.

Attachment – XIII

Prospectus

Attachment -XIII

PROSPECTUS

Brief details of the Applicant and Introduction of the Company

Details of the Applicant

Name of the Company and its Registered Office

C J Hydro (Private) Limited,
15 – Peshawar Block, Fortress Stadium, Lahore Cantt.
Tel: 042- 36675595, 36680695
Fax: 042- 36664349
Email: danish@khan.net

Project Sponsors

Major sponsors/shareholders are as under:

a. Haseeb Khan
   Proprietor, Haseeb Khan & Company ..... Main Sponsor
b. Danish Haseeb Khan, Director

Location of the Project

The Project site is located between latitudes 31°-58'-04" North and longitudes 72°-12'-48" East. It is planned on the right side at the tail end of the CJ Canal near RD 316+622 in Khusab District, Punjab Province

Representative of CJ Hydro (Private) Limited

Mr. Danish Haseeb Khan, Chief Executive & Director
Mr. Haseeb Khan,Director
Syed Qasim Askari, Project Director
Mr. Muhammad Akbar, Project Advisor
Mr. Abdul Rashid, Chief Financial Officer
Mr. Ali Akbar Javed, Senior Manager (Technical)
Mr. Abdur Rehman Babar, Company Secretary

A. Introductionof the Applicant

C J Hydro (Private) Limited ("CJHPL") was established as a private limited company and registered under the Companies Ordinance, 1984 in May, 2009 exclusively for development, construction, operation and maintenance of Hydropower Plant at C-J Link (Tail) District Khushab, Punjab, as an Independent Power Producer (IPP) Project on Build, Own, Operate and Transfer (BOOT) basis as offered by the Punjab Power Development Board (PPDB) for implementation in the private sector under and in accordance with the Punjab Power Generation Policy 2006. The Board of Directors of CJHPL currently consists of the following directors:

1. Mr. Haseeb Khan; and
2. Mr. Danish Haseeb Khan

Mr. Danish Haseeb Khan is the Chief Executive Officer of the Company. It is intended to associate further partners/shareholders, having the financial strength and the relevant experience, when the Project moves forward and the Letter of Support (LOS) for the Project is issued by the PPDB. A few parties have already shown interest in this regard.

The profile of the sponsors is given in Attachment VII.

B. Salient Features of the Project – Background and Description

The Sponsors, having the requisite technical and financial strength, constituted a consortium named "HK Consortium" to undertake the feasibility study of the40 MW Hydropower Project at C-J Link (Tail) under the Punjab Power Generation Policy 2006 and the GOP's Policy for Power Generation Projects 2002, as amended. The Consortium submitted its bid for feasibility study of the Project to the Punjab Power Development Board (PPDB). The consortium members were prequalified and a Letter of Interest (LOI) for conducting feasibility study of the project was issued by PPDB to the Consortium on 8th November 2007 (Attachment – III). The Consortium engaged National Engineering Services Pakistan Limited (NESPAK) and Integrated Consulting Services (ICS) ("Consultants"), for preparing the feasibility study for the development of the said 40MW Hydropower Project at C-J Link (Tail). The work on the feasibility study was commenced in March 2008. The assignment included site investigations, environmental study, the collection and review of the previous studies and existing data, optimization of project parameters, cost estimates and economic and financial

analyses. The Feasibility Study wasprogressively reviewed by the PPDB's Panel of Experts (POEs). The capacity of the plant as proposed in the feasibility study was 44.331 MW with annual energy generation estimated at 212.249 GWh. The POEs approved the final Feasibility Report as conveyed vide PPDB letter No. PPDB/328/2009 dated 30th March, 2009.

As pointed out above, the project sponsors formed the new company namely "C J Hydro (Private) Limited" ("**CJHPL**") for implementation of the Project. CJHPL is a private limited company registered under the Companies Ordinance 1984 for implementation of the Project and engaging in electric power generation business.

CJHPLfiled application for grant of Generation License on 8th June, 2009, as per the requirements of the NEPRA Act and the rules framed there-under. CJHPL simultaneously submitted a Petition for determination/approval of the Feasibility Stage Reference Tariff for the proposed hydropower generation facilityin accordance with the NEPRA (Tariff Standards and Procedure) Rules 1998.

CJHPL's application and petition have been lingering on for a long time due to the observations raised by IRSA and the Government of Sindh (GoS). IRSA clarified that the CJ Link is not a perennial canal. GoS raised certain concerns regarding insufficient water-flows of the CJ Link, whereby, in its opinion, the CJ Link (being a non-perennial canal) is not a regular canal, and its operation period is not fixed, and as such no assured supplies of water were available, and that the operation of this canal was not mentioned in the 1991 Water Accord and that the water release to the CJ Link Canal for the proposed hydropower project would render it to be a permanent canal and resultantly the water supply to the Sindh province would be affected. All the concerns/observations raised by IRSA and GoS were duly addressed by CJHPL by way of providing the historical flows in CJ Canal, and as such it was assured that the water supply to the province of Sindh will not be affected and that the water will continue to be allocated by IRSA as per the Water Apportionment Accord based on the share of each province.

CJHPL has been requesting NEPRA for grant of the generation licence for the Project. In the Authority Regulatory meeting 09-467 held on 30th December 2009, the Authority, after detailed deliberations, approved grant of Generation Licence to CJHPL.GoS filed a Review Petition with NEPRA on 11th February 2010 reiterating its arguments and informing that it does not accept the river water availability estimates prepared by

WAPDA. GoS also informed that on 28th January 2010, the provincial assembly of Sindh passed a unanimous resolution against the construction of the proposed Project and pleaded that the Project should be immediately shelved to maintain harmony among co-sharer provinces. The matter remained under consideration/correspondence for quite some time.

In the meantime, Mangla Dam Raising project was completed in 2013. A new issue regarding variation of water flows in CJ Link Canal after Mangla Dam raising cropped up. In this connection, CJHPL also informed that according to the revised hydrology and power/energy estimation study, there were no significant differences in the plant capacity and the energy estimates. In April, 2016, NEPRA rejected the application of CJHPL for grant of generation licence and directed CJHPL to carry out a detailed revised feasibility study of the project by incorporating the changes in water flow in C-J Link canal due to Mangla Dam raising project. Details in this regard are given in the main application.

Pursuant to the directions of NEPRA, CJHPL engaged QATZ (Private) Limited (Project Development and Management Consultants) for carrying out a comprehensive hydrology study of the Project and updating the feasibility study based on their findings. The Consultants commenced the requisite study in December 2016 and submitted draft report in June 2017. The final Updated Feasibility Study was submitted in July, 2017. The salient features of the Updated Feasibility Study conducted by the Consultants are as under:

(a) Hydrology of the project has been updated up to year 2016 including the years that may account for changes in the water flow after Mangla Dam raising.

(b) Hydrological data has been analyzed based on the historic water flows from 1991 to 2016 with and without Mangla Dam raising, and further extrapolated up to year 2041 in order to affirm that the project remains viable. The analysis showed that the discharge in CJ Link would reduce by 0.42 MAF in the Rabi period due to improved flows at Trimmu Barrage by one (1) MAF on account of enhanced storage capacity at Mangla Dam. However, during Kharif, water flows in CJ Link canal were not likely to reduce due to Mangla reservoir then being in the filling stage. Hence, CJ Link canal will remain operational and an important source to meet shortfalls at Trimmu Barrage.

(c) Based on the updated hydrological data, the project parameters have been revised. The design discharge, plant output, plant factor (power potential), and the related electromechanical structure have changed. BOQ for the Civil Works, Electro-mechanical equipment have been revised and the costs have been updated accordingly. The design discharge has reduced from 320 cumecs proposed in the original feasibility study to 210 cumecs based on the updated hydrological study. Accordingly, the plant capacity has reduced from the original 44.331 MW to 25 MW based on the updated hydrological study. Due to variable discharge in CJ Link, the annual energy generation will vary from 53.5 GWh to 146.2 GWh. The average annual energy works out as 110.6 GWh.

The Updated Feasibility Study was reviewed by the POEs on 27th July 2017. The POEs has approved the revised capacity of the Project as 25 MW along with other parameters specified in the Updated Feasibility Study.

The salient project parameters determined by the Consultants based on the Updated Feasibility Study are given hereunder:

Parameter	**Unit**	**Values as per Updated Feasibility Study**
Design Discharge	m^3/s	210
Head: Minimum / Maximum	M	11.58 / 13.52
Installed Capacity of the Plant	MW	25
No. of Units	No.	3
Installed Capacity of each unit	MW	8.33
Annual Energy Generation	GWh	110.6
Plant Factor	%	50.3
Technology		Horizontal Bulb Turbines
Headrace Channel Length / Cross Section Area	m / m^2	1350 / 176
Tailrace Channel Length / Cross Section Area	m / m^2	370 / 176
Total Project Cost& Price Index	m US$ Month & Year	54.181 May 2017
Project Cost per MW	m US$	2.167
Financing Structure (Tentative)		25% Equity & 75% Debt
Construction Period	Years	Three (3)

Concession Period	Years	30
Levelized Feasibility Stage Reference Tariff over 30 Years at 10% Discount Rate	US Cents/kWh	8.85

Complying with NEPRA's decision dated 21st November 2017, CJHPL is hereby submitting a fresh application for grant Generation Licence for the 25 MW (Installed Capacity) hydropower generation facility (based on Updated feasibility Study) proposed to be constructed, operated and maintained as an IPP project on Build, Own, Operate, and Transfer (BOOT) basis on Chasma-Jhelum Link Canal (Tail) in District Khushab, Punjab province for a period of thirty (30) years after its COD. All the pertinent information about the Project i.e. technical description, the environmental and social impact assessment (ESIA) report, financial data, sponsors' information and the Updated Feasibility Study Report are submitted/attached with this application for the grant of Generation Licence.

C. Proposed Investment

The summary of the cost estimates as per Updated Feasibility Study is as under:

Bill No.	Description	Amount (Rs.)	Amount in US$
1	Preliminary Works		1,067,156
2	General Items	290,722,220	2,773,273
	WORKS		
3	- Power Channel	1,088,031,260	10,379,007
4	- Bridges	69,868,286	666,491
5	- Power House	650,205,934	6,202,480
6	- Mechanical Works	1,252,934,339	11,952,059
7	- Electrical Works	317,289,346	3,026,704
	SUB-TOTAL	**3,378,329,164**	**32,226,740**
8	Environmental and Social Cost	10,120,000	96,537
	SUB-TOTAL	**3,791,041,384**	**36,163,707**
9	Design and Engineering	318,033,792	3,033,805

	TOTAL	4,109,075,176	39,197,512
	TOTAL CONSTRUCTION COST	4,109,075,176	39,197,512
10	Custom Duties	50,814,360	484,731
11	Project Company's Costs	573,241,889	5,468,300
12	Interest During Construction	946,626,285	9,030,109
	TOTALPROJECT COST / INVESTMENT	5,679,757,710	54,180,652
	Amount in Million:	Rs. 5,680	US$ 54.181

Note: Cost of FESCO transmission/interconnection facilities is not included.

Equity investment for the Project will be 20% to 30% depending on the requirements of the lenders and will be a mix of local and foreign currencies. The remaining amount will be financed through a consortium of banks. Financial closing will be achieved within about 24 months after issuance of Letter of Support by the PPDB.

D. Social and Environmental Impact of the Proposed Facility

As indicated in the Updated Feasibility Study, the environmental and social impact Assessment (ESIA) study has been carried out in accordance with Pakistan legislative standards. It focuses on the impacts resulting from the construction of the power channel and powerhouse. Both environmental and social impacts of the proposed scheme have been examined and discussed in the technical and economic feasibility study for the Project. On the basis of the site selection risk assessment, the construction of power house on the right side of the existing fall structure,having the designed capacity to produce maximum 25MW, has been proposed as no major settlements exist on the right side of the C-J Link outfall structure.The Project includes construction of all the necessary items associated with the construction of powerhouse i.e. power channel, turbines, grid station, escape channel, siltation pond etc. A new road bridge, for relocation of the Khushab Muzaffargarh road and a public park are also included in the scope of work.

Groundwater can be found as shallow as 3m from ground level at certain places on the site. Hand pumps and tube wells are the two most common sources of water within the area of influence (AOI) of the Project. Groundwater can be used as a source of water supply to the contractor's camp and batching plant. However, it is the contractor's responsibility to confirm the suitability and availability of the water to the site workers

at an appropriate level. Surface water can be used for spraying on earth to minimize the dust pollution.

The biological environment of the site is typical Thal environment. The common trees and shrubs are the Van (Salvadora Abeoides), Karir (Capparis Aphylla), Jand (Prosopisn Spicigera), Malla (Zizyphus Nummularia), Sarkanda (Saccharum Munja) together with growth in the uncultivated lands. Different types of grass species are found along the canal's banks and within the riverian track. Tahli (Dalbergia Sisso) and Kiker (acacia nilotica) are the common trees found along the canal and adjacent land of Jhelum river.

Part of the site falls within the wildlife game reserve area which can be classified as environmentally sensitive area, under Section 12 of Pakistan Environmental Protection Act 1997. As per Guidelines for Preparation of IEE/EIA 1997, the Initial Environmental Examination (IEE) Report was prepared based on the original Feasibility Study and filed with the Punjab EPA for obtaining NOC. EPA, Punjab, accorded approval for the construction phase of the Project vide its letter No. DD/(EIA)/EPA/F-72(IEE)/2805/2009/2579 dated June 8, 2009 (Attachment XVIII). This approval was valid for commencement of construction up to a period of three years. Fresh IEE Report willbe prepared based on the Updated Feasibility Study and will be filed with the Punjab EPA in due course for obtaining fresh NOC.

Canal and River water provide friendly habitate to hundreds of migrating birds including some rare species of duck and geese. Under the RAMSER Convention it is the responsibility of Pakistan Government to protect these rare species of birds. Other local game birds found in Thal environment include Gray Partridge (Tetar) and Hubra Bustard (Talor). Terrrestrial fauna including wolves, jackals, wild cats, foxes, badgers, wild bores, neel gai (blue bull), deer and the wild hill goats (Urial) are found in deep in thal forest. Occasional sighting of endangered species of Baz, Chankara (deer) have also been reported in the project area.

The main settlements near the project area is the village Sharegareh, consisting of approximately 50 houses. The nearest city is Khushab about 40km from the project site. The average house hold size in district Khushab is 6.2. The dominate brathery of Village Sharegarh is Joya caste. Majority of the local population involve in farming activities.Other common occupations include milk processing, running grocery shop, daily wage work, transportation and working at Khushab Atomic Plant. The common

type of crop cultivated in the project area is gram with a yield capacity of approximately 300 kg/acre. Hand pump is the common source of drinking water in the project area. Electricity supply is available at this site.

There is sufficient WAPDA land available at the site for setting up labour camp and batching plant and no private land is required for these activities. However, a part of the proposed power channel and relocated Khushab-Muzaffargarh road fall within private land. About 9000m^2 of cultivated WAPDA's land is identified within the power channel. Three houses (two residential and one medical dispensary) and a tube-well are also interfering in the proposed power channel location, built in WAPDA's land. The private land owners/residents of the affected properties will be compensated and the Social Framework Agreement (SFA) will be executed by the concerned parties. Majority of the local community is involved in seasonal agricultural activities.

It is envisaged that about 59 number of trees will be required to cut for the construction of the power channel. It is proposed to grow two plants at site for every one tree cut by the contractor and protect these plants until these are matured.

The potential environmental impacts of the Project have been analyzed and the mitigation measures and residual impacts are discussed in the EIA Report. The nature and scope of the construction works and the environmental setting of the Project are such that there is no significant adverse environmental impact. The project will bring about significant positive social impacts in the area. Employment opportunity and training will be provided to a large number of unemployed youth. They will receive life-time benefit through skill training, capacity building and poverty alleviation. A large number of semi-skilled and unskilled workers in the project area will be hired during construction. Greater awareness about healthcare amongst the labour folk and the local community shall be created. At micro level, economic activities may reduce the cost of living by making essential commodities available in greater bulks and at cheaper rates.

A public park will be developed at the right side of the canal under this Project. This will provide a picnic spot to the local community and improve the aesthetic level of the area.

In conclusion, many positive economic and social impacts will appear in the quality of the lives of the people of the area due to implementation of the 25 MW Hydropower

project at C-J Link (Tail). These include generation of direct and indirect employment, business opportunities, infrastructure development, and improvement of living standards. Through adequate environmental management and mitigation measures, the Project will have least adverse impact on the environment and the surrounding community. The implementation of the Project will not thus result in any unacceptable impact on the environment either during construction or during subsequent operation of the Project.

Attachment – XIV

Summary of Project Company, Management & Professional Staff and Financial Resource

Attachment - XIV

Summary of Project Company, Management, Professional Staffand Financial Resources etc,

a) Profile, Financial Strength and Experience of the Sponsors of C J Hydro (Private) Ltd.

C J Hydro (Private) Limited ("CJHPL") has been established as a private limited company and incorporated under the Companies Ordinance, 1984, for the special purpose of generation of electricity. Major Sponsors/Shareholders are as under:

i. Mr. Haseeb Khan Main Sponsor/Shareholder
ii. Mr. Danish Haseeb Khan, Director & Chief Executive Officer

Profile of their experience, technical capability and financial resources are briefly explained below:

1. Mr. Haseeb Khan

Mr. Haseeb Khan is the Chief Executive Officer (**CEO**) of Haseeb Khan & Company – Chartered Accountants. He is a Chartered Accountant by profession. In 1990, Mr. Haseeb Khan established 'Haseeb Khan & Co.' ("**HKC**"), a Chartered Accountancy firm, which has progressively grown into a **project development & investment company**.

Mr. Haseeb Khan isone of the well-known and respected personalities in Pakistan particularly in the power sector. He has worked with leading international groups i.e. equipment manufacturers/suppliers, EPC contractors, and operators of power plants. Mr. Khan has also been closely associated with various investors & financiers of power projects in the country. Due to his extraordinary vision and persistent hard work, HKC has developed to the present level whereby it is capable of undertaking projects of any magnitude particularly in the power sectors in Pakistan and the Middle East.

Mr. Khan is presently working on various new IPP projects. He has been the Chief Executive Officer of **870 MW Suki Kinari Hydropower Project** till December, 2016. He along with Mr. Danish worked hard with the various Government agencies and the project Lenders to complete all the pre-requisites and successfully achieved financial closing of this Project by 31st December 2016. Mr. Haseeb Khan is on the

Board of Directors of **CJ Hydro (Private) Limited**and several other companies. His services are utilized for CJ Hydropower project on as-needed basis. Based on his expertise and past experience, he can conveniently arrange financing, both equity and debt, for this small project.

2. **Mr. Danish Haseeb Khan**

Mr. Danish Haseeb Khan is the Chief Executive (**CEO**) of C J Hydro (Private) Limited. He is the overall incharge of the Project. He is responsible for the development, financing, construction and the successful commissioning of the project and thereafter for its smooth and efficient operation and maintenance during the PPA term. He also handles general administration and financial discipline of the company.

Mr. Danish Haseeb Khan is a Certified Public Accountant (CPA). He has been looking after the affairs of Haseeb Khan & Company – Chartered Accountants, for the last thirteen years. Haseeb Khan & Company was established by his father, Mr. Haseeb Khan, in 1990. The Company has been working as project developer and managing financing of various projects including IPP projects in the Power Sector of Pakistan. Haseeb Khan and Company developed several IPP projects which include DHA Cogen Limited, 190 MW Green Electric Thermal Power project, Dadu, 870 MW Suki Kinari Hydropower Project in KPK and 84 MW Gulf Powergen Project in Eminabad, Gujranwala. He is the Deputy CEO for the 870 MW Suki Kinari Hydropower Project presently under construction. Due to his dedication and hard work, the financial closing of 870 MW Suki Kinari Hydropower Project was achieved on 31st December, 2016 and the project is now in the construction phase. He assisted the sponsors of 1100 MW Kohala Project (AJK)in preparation of tariff proposals and related matters. He also assisted the Company in preparation of IA, PPA, WUA and AJ&K IA and in negotiations with various stakeholders for 720 MW Karot Hydropower Project.

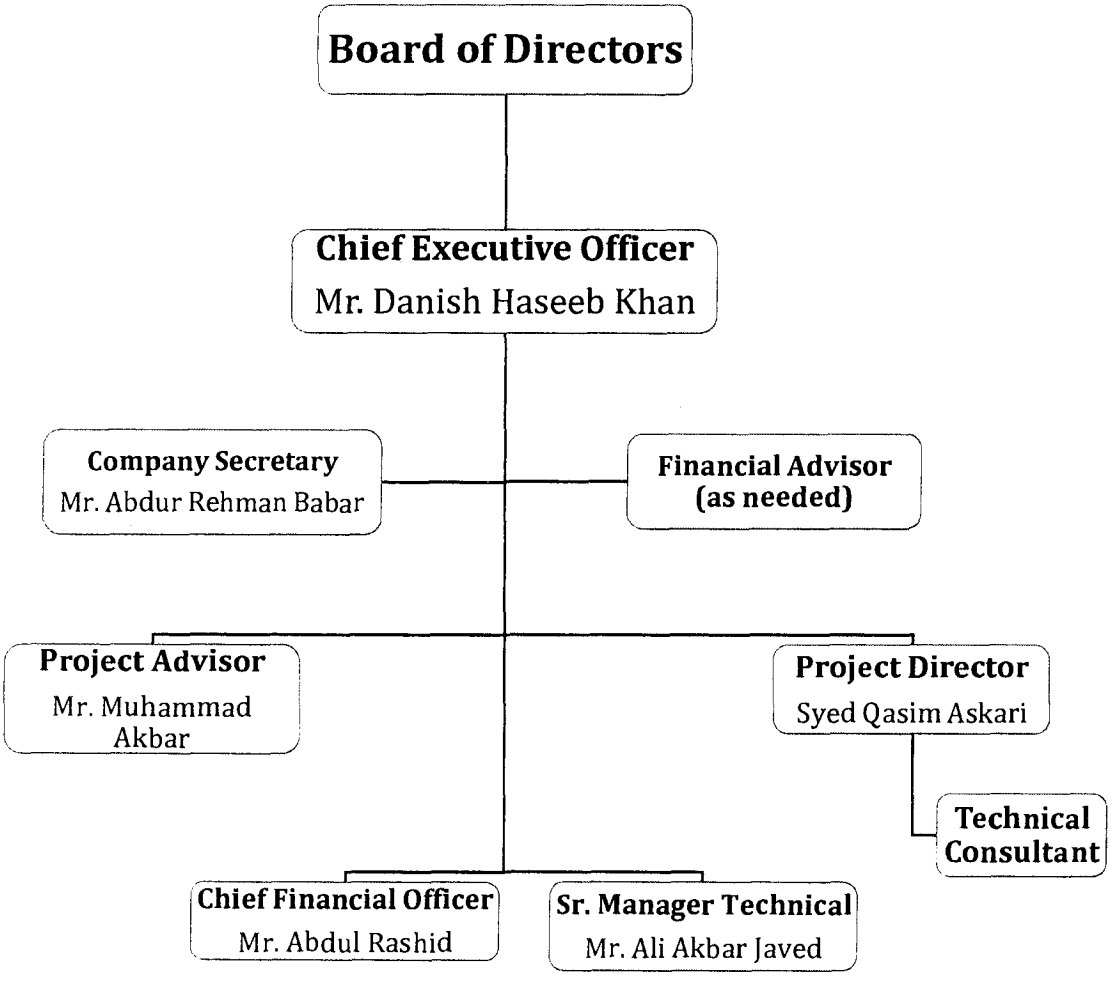
b) **Senior Management/ Technical and Professional Staff**

The information regarding Senior Management/ Technical and Professional Staff is given in Attachments VII and VIII. Additional management,technical and professional staff shall be engaged on as needed-basis as soon as the Project moves forward from development to construction phase. All major activities shall be outsourced.

Organization Chart

The Organization Chart showing the current staff strength is as under:

Organizational Chart



c. Evidence of Adequate Financial and Technical Resources/Experience

As regards the technical experience and technical resources, the Sponsors have managed/are managing the following IPP power projects in Pakistan:

1. 94 MW DHA Cogen Phase I Project (completed/commissioned)
2. 870 MW Suki Kinari Hydropower Project. Project achieved Financial Closing on 31st December, 2016 and is now in the detailed design/construction phase.
3. 84 MW Gulf Powergen Project, Eminabad, Gujranwala. (Completed/commissioned)

The Sponsors thus fully comply with the qualifications/experience requirements of the Punjab Power Generation Policy 2006 and GOP's Policy for Power Generation Projects 2002 and have adequate technical and financial strength to undertake and complete the proposed project effectively and efficiently.

d. Financing Structure / Equity

Equity investment for the project will be 20% to 30% depending on the requirements of the lenders and will be a mix of local and foreign currencies. The remaining amount will be financed through a consortium of banks. Financial closing will be achieved within about 24 months after issuance of Letter of Support by the PPDB.

Attachment – XV

Energy Production of the Project based on Historical Hydrological Data

Year	Annual Energy (GWh)	Year	Annual Energy (GWh)
1991	92.3	2004	110.1
1992	76.4	2005	128.2
1993	127.3	2006	145.3
1994	125.7	2007	146.2
1995	134.0	2008	90.1
1996	113.2	2009	63.2
1997	141.1	2010	80.5
1998	124.3	2011	110.4
1999	189.8	2012	89.6
2000	124.9	2013	92.5
2001	114.8	2014	53.9
2002	107.7	2015	53.5
2003	129.7	**Mean**	**110.6**
		Plant Factor	**50.5%**

Attachment – XVI

Infrastructure Facilities

Attachment - XVI

Infrastructure Facilities

The Power House is planned on the right side at the tail end of the CJ Canal near RD 316+622 in Khusab District, Punjab Province.The project site is connected by a metalled road with the district headquarters Khushab which is situated at a distance of 40 km. The site is also approachable from other local towns through metalled roads.

The project area is accessible from Karachi Port through a good road network of National, Super Highway and Indus Highway. Road distance from Karachi to project site is approximately 1,164 km. The project area is accessible from Karachi via Muzaffargarh, Ahmadpur Said, Athara Hazari and from Chowk Azam to Bhakkar to Khushab.

The project area is accessible from Lahore through a good metalled road via District headquarters Khushab or Joharabad. The distance between project site and Lahore by road is about 312 km. The site is also approachable from Islamabad through Khushab.

The nearest railway station from the project site is Khushab which is connected with Karachi-Peshawar main Railway line through Kundian Junction. By rail, the distance of Khushab from Karachi via Kundian is 1310 km.

In addition to project layout, switchyard, and project office, a residential colony for the operation staff for the Plantwould be constructed near the Project area. A concrete bridge on the Headrace Channel would also be constructed for the main Khushab – Athara Hazari road. On either bank of the Power Channel, paved road would be prepared to monitor the canal bank etc.

Attachment - XVII

Tentative Implementation Schedule

Sr. No.	Activity	Start	Finish
1	Issue of Letter of Interest (LOI) by PPDB	08.11.2007	08.11.2007
2	Feasibility Study of the Project	03.03.2008	30.03.2009
3	Approval of Feasibility Study by POEs	05.03.2009	30.03.2009
4	Submission of Application for Generation Licence	08.06.2009	08.06.2009
5	Application for Generation Licence was approved but remained pending due to the objections raised by Govt of Sind and water flow variations in CJ Canal due to Mangla raising project andresulted in NEPRA directions to update Feasibility Study	03.02.2010	29.11.2016
6	Updated Feasibility Study (UFS)	01.12.2016	10.07.2017
7	Review and Approval of UFS by POEs/PPDB	27.07.2017	09.08.2017
8	Review of UFS by NEPRA &Directions to File Fresh Application for Generation Licence	09.08.2017	21.11.2017
9	Filing Fresh Application for Generation Licence	02.02.2018	02.02.2018
10	Filing Feasibility Stage Tariff Petition	10.03.2018	10.03.2018
11	Processing and Issuance of Generation Licence	15.02.2018	31.05.2018
12	Determination of Feasibility Stage Reference Tariff	17.03.2018	13.07.2018
13	Issuance of Letter of Support (LOS)	15.08.2018	15.08.2018
14	Execution of EPC Contract	17.09.2018	17.06.2019
15	Determination of EPC Stage Reference Tariff	01.07.2019	01.11.2019
16	Execution of IA / PPA / WUA	21.08.2018	20.12.2019
17	Financial Closing	17.06.2019	17.08.2020
18	Construction Start	15.09.2020	15.09.2020
19	Detailed Design	15.09.2020	15.12.2021
20	Civil Works Execution	19.10.2020	16.12.2022
21	Plant Equipment Supply & Transportation to Site	01.03.2021	01.03.2022
22	Mechanical & Electrical Works Installation	01.12.2021	16.01.2023
23	Commissioning of Units & Complex	01.02.2023	15.08.2023
24	Commercial Operations Date	16.08.2023	16.08.2023

Attachment - XVIII

Approval of the Initial Environmental Examination Report of the Project by the Environmental Protection Agency, Punjab

SCHEDULE - I

Plant Details

1. General Information

i.	Name of Applicant	C J Hydro (Private) Limited
ii.	Registered/Business Office	15, Peshawar Block, Fortress Stadium, Lahore, Punjab, Pakistan
iii.	Plant Location	Chashma-Jhelum Link Canal Tail Regulator, District Khushab, Punjab.
iv.	Type of Generation Facility	Hydropower Plant – Canal Fall/Run-of-the-River

2. Plant Configuration

i.	Plant Size Installed Capacity (Gross)	25 MW	
ii.	Plant type	Canal Fall/Run-of-River	
iii.	Water Source	Chashma-Jhelum Link Canal	
iv.	Maximum Design Discharge	240 m^3/s	
v.	Design Discharge	210 m^3/s	
vi.	Gross Head	Maximum: 15.0 m Minimum:12.9 m	
vii.	Design Head	13.65 m	
viii.	Head Race Channel	Length 1350 m	Cross Sectional Area 176 m^2
ix.	Tail Race Channel	370 m	176 m^2
x.	Head Race Water Level	El. 182.962 m	
xi.	Tail Race Water Level	El. 167.878 m	
xii.	No. of Units	3	
xiii.	Type of Turbines	Horizontal Bulb	

xiv.	Turbine Maximum Power	3 x 9.8 MW
xv.	Unit Make & Model	Hydro turbines are especially designed and manufactured to meet the specific requirements of each site and are not available as per models. Turbines meeting the following specifications shall be procured for the Project: • Rated Discharge = 70 m^3 / s • Net Head at Rated Discharge = 12.232 m • Maximum Net Head = 13.809 m • Minimum Net Head = 11.605 m • Setting to Tail Water Level = - 3.0 m • Efficiency = 94.8%
xvi.	De-rated Capacity at Mean Site Conditions	25 MW
xvii.	Auxiliary Consumption	0.25 MW
xviii.	Commissioning and Commercial Operation Date (COD)	August 16, 2023 (Tentative)
xix.	Expected Life of the Facility from COD	More than 30 years

3. Plant Characteristics

i.	Generation Voltage	11 kV
ii.	Frequency	50 Hz
iii.	Power Factor	0.8 lagging to 0.90 leading
iv.	Automatic Generation Control	Yes
v.	Ramping Rate	Will be provided later
vi.	Time required to Synchronize to Grid and loading the Complex to full load.	Will be provided later

SCHEDULE – II

The capacity (ies) of C J Hydro (Private) Limited power plant to be incorporated in the Licensee's Generation Facilities

SCHEDULE – II

1.	**Installed Capacity**	**25 MW**
2.	**De-rated Capacity at Site Conditions**	**25 MW**
3.	**Auxiliary Consumption**	**0.25 MW**
4.	**Net Capacity at Site Conditions**	**24.75 MW**

INTERCONNECTION SCHEME FOR THE POWER DISPERSAL OF THE 25 MW HYDROPOWER PLANT at C-J LINK (TAIL), Distt. Khushab

Interconnection studies were carried out by the Consultants for the original Feasibility as well as for the Updated Feasibility Study. In both the cases,it has been proposed that the power generated from the power plant can be dispersed to the load centre of Faisalabad Electric Supply Company (FESCO) by construction of 132 kV Double Circuit Transmission Line (Two Outgoing Circuits) through one of the following alternatives:

I. Loop one circuit of Jauhrabad - Army Base Camp (ABC) Girot 132 kV D/C OHL at C-J Link (Tail) HPP Substation. It involves construction of about 7 km long 132 kV double circuit transmission line.

II. Install a direct double circuit of 132 kV from C-J Link (Tail) HPP to existing Jauhrabad 132 kV substation. It involves construction of about 36 km long double circuit transmission line plus addition of two 132 kV Line Bays in the existing Jauhrabad Substation.

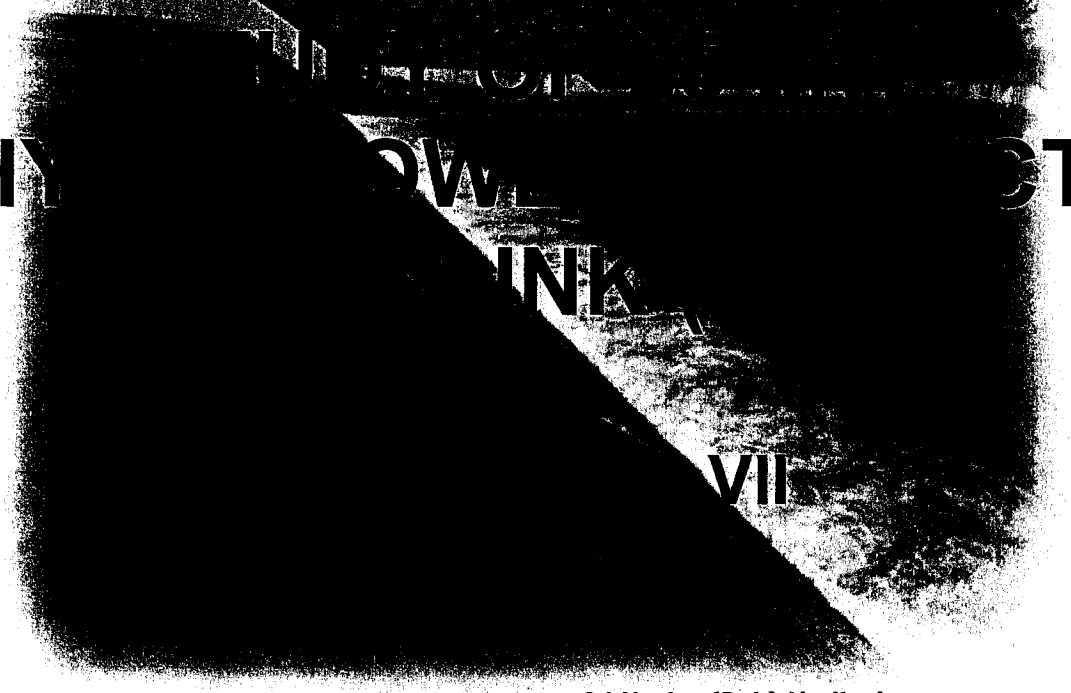
Both the Alternatives I and II have been proved technically feasible through load flow, short circuit and dynamic stability analyses.

The Chief Executive, FESCO, in his request for procurement of power from the proposed Project as conveyed to NEPRA through letter No. 4448 dated 2nd September, 2009, has opined to use Option No. 1 being more feasible as it will give power at 132 kV Bus Bar of ABC Girot Grid Station and 132 kV Bus Bar of Jauharabad Grid Station with lesser cost. The General Manager Planning (Power), NTDC, throughhis letter dated 30th September 2009has also commented that the power from CJ Hydropower Project can be dispersed by using Option # I which has been found technically and financially feasible.

Alternative I shall, therefore, be used for interconnection of CJ Link (Tail) Hydropower Plant for dispersal of power from the Plant to the FESCO Grid System.

PUNJAB POWER DEVELOPMENT BOARD

UPDATED FEASIBILITY



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Project Consultants

QATZ
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www.qatz.org

UPDATED FEASIBILITY STUDY OF 25 MW HYDROPOWER PROJECT AT C-J LINK (TAIL)

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Volume – I
Main Report

SECTION – 1

INTRODUCTION

SECTION – 1

INTRODUCTION

1.1 GENERAL

Exploitation of short gestation low-head hydropower potential on the existing barrages and canal falls can contribute significantly in reducing power shortage in the country. To facilitate smooth and proper exploitation of this potential and implementation of the program for development of hydropower at barrages and canal falls, GTZ, the German Agency for Technical Cooperation assisted the Water and Power Development Authority (WAPDA), and in 1984 WAPDA and GTZ jointly carried out a Ranking Study of ten potential sites at barrages and canal falls in the Indus plains, where power generation can be undertaken.

In the ranking study of 1984 the Chashma-Jhelum Link Tail Hydro Power Project was ranked first amongst the identified schemes on canals/canal falls. The work on the feasibility study was started in July 1985. However in October 1985, the work was suspended on the instructions of Ministry of Water and Power, Government of Pakistan. The remaining work on the feasibility study was re-started in October 1990 under the Authority's decision and was completed in 1995 and a 33 MW capacity plant at the site was found feasible.

The Water Accord was signed in 1991, which allocated provincial shares in surface water supplies and consequently affects the operation of CJ Link. At the time of completion of the WAPDA/GTZ feasibility only limited post Accord data was available. Subsequent to the completion of the feasibility study of 33 MW Power Plant in 1985-1995; several new events took place, which affect power capacity, these include:

- Greater Thal Canal has been constructed and will draw supplies from CJ Link and thus affect available flows for power generation.
- Raising of Mangla Dam which resulted into increased availability of flows in River Jhelum.
- New storages are planned on the Indus, which will affect water availability and operation of CJ Link. Effect of possible new storages needs to be studied.

Effect of these factors on water availability for power generation capacity has been evaluated in the Study.

1.2 PROJECT BACKGROUND

The low head hydroelectric potential in Pakistan has been recognized since long and is partly being utilized for the last three decades. Some low head power stations are already functional in the country using approximately the head range similar to available in this project.

The Power Generation Policy of the Government of Pakistan allows the provinces and AJK to develop power generation projects of sufficient capacity in public and/or private sectors at the least cost to utilize the available natural resources for power generation and to avoid capacity shortfall. This Policy is aimed at attracting investors to develop and implement power generation projects up to maximum capacity of 50 MW. The Irrigation and Power Department Punjab has decided to utilize the existing barrages and canal fall structures for hydropower generation.

The Government of Punjab through the Punjab Power Development Board (PPDB) has issued a Letter of Interest (LOI) to HK Consortium in November 2007 for development of hydropower at CJ Link tail. Accordingly HK Consortium had undertaken the feasibility study which was approved by the panel of experts appointed by the PPDB in early 2009, and on the basis of which generation license of the project was applied in June 2009.

The project capacity was initially proposed as 44 MW based on historic flows. The hearing conducted by NEPRA regarding the Generation License of the Project necessitated to up-date the Feasibility Study of the Project keeping in view the latest water flows especially after raised Mangla Dam. Accordingly the water flows available at the tail end of the CJ Link Canal have been critically examined keeping in view all the relevant factors, and the original Feasibility Study approved in 2009 have been revised to incorporate the results of hydrological assessment carried out as advised by NEPRA.

As advised by NEPRA a comprehensive hydrology study has been carried out and the feasibility has been updated on the basis of revised hydrology. The output, design discharge and plant factor (power potential), and the related electromechanical structure has been changed. BOQ for civil structure and electrical mechanical equipment has been revised and the costs have been updated accordingly. The field information such as the EIA, Geological investigations and topographic survey, and the project layout including power house, headrace and tailrace channel remained unchanged as per the feasibility study already approved by the PPDB (POE) in 2009

After examining all the relevant factors (particularly described in detailed hydrological assessment report attached as Volume II), the project capacity has been reduced as per anticipated flows in CJ Link and sized as 25 MW. With this capacity, the project would be more productive and beneficial. This project is conceived to satisfy local or regional power requirements.

Although the power station of this project would contribute only a relatively small share of the total power requirements in the country, the contribution in terms of the energy generated by this station is quite significant.

1.3 OBJECTIVE OF THE PROJECT

The total national demand in 2016, excluding Karachi, peaked at 19,500MW against the generation of 15,886MW. As per its details, thermal sector generated some 9,900MW, hydle 4,850MW and wind 175MW. The situation has further worsened in 2017 and WAPDA has to resort to load shedding to meet the gap in demand and generation. There is an urgent need to add more power generation capacity to the Power System. The proposed Power Plant will add about 25 MW to the System and contribute to reducing the gap in demand and power generation.

1.4 SCOPE OF FEASIBILITY STUDY

WAPDA/GTZ Feasibility Study of the project was based on hydrological data up to 1989. The Water Apportionment Accord between the four provinces was signed in 1991. The WAPDA/GTZ Feasibility Study included only a brief discussion on the post-Accord situation. NESPAK prepared Feasibility Report in 2009 based on historic flows especially post water Accord. The power capacity of 44 MW based on post water Accord flows raised number of observations as how with intermittent flow pattern, such high capacity

justified. The present feasibility report has focused on the availability of flows with raised Mangla. The reduced capacity is based on the forecasted flows in CJ Link based on irrigation demand at Trimmu and water flows in Indus to be diverted in CJ during Kharif.

With changed flows pattern of CJ Link 2009 to date, there was need to update the Feasibility taking into account the present day and future requirements / projections for making the investment fruitful, particularly in the light of prevailing situation of power shortage in the country.

Work on the present Feasibility Study commenced in December 2016 by QATZ (Private) Limited (Project Development and Management Consultants) for which purposes a detailed hydrological assessment was carried out. The draft feasibility report has been prepared in June 2017. The objective of the present study was mainly to update the status of the previous study with incorporation of additional data and relevant information and provide a complete project evaluation to form the basis of the information and planning necessary for the expeditious development of the project taking into account the interest of all the relevant stakeholders including the power purchase and the potential financiers of the project. The main activities which have been undertaken during the feasibility study include:

- Review of previous studies
- Collection and updating of data
- Hydrological and sedimentation study
- Topographic Surveys
- Geotechnical and geophysical investigations
- Power and energy potential evaluation
- Layout design and optimization
- Electromechanical equipment selection
- Load flow and interconnection study
- Environmental impact assessment
- Project costing
- Construction planning
- Economic and financial analyses

1.5 PROJECT SPONSORS

The sponsor of this Project known as the HK Consortium are well experienced in power sector of Pakistan who are committed for the development of the 25MW hydropower at CJ Link tail as described herein.

1.6 PROJECT LOCATION AND SITE CONDITIONS

The proposed site for 25 MW Hydropower Project is located at the tail of CJ Link canal In District Khushab of Punjab Province of Pakistan. CJ Canal transfers flows of Indus River to Jhelum River to augment the water- flow of Jhelum River for downstream command of canal system. The construction of the powerhouse was recommended by GTZ on right side of the Link canal which was examined during the present study and was found to be the proper location mainly due to availability of land. The left bank is already occupied by Kundian Chemical Plant.

Land acquisition is not required as the land in the project area is owned by the Government. However, there is a huge soil dump (about 10m high) at the location of the proposed works. This soil bank was formed by excavations of the CJ Link outfall structure and is not well compacted. This soil will have to be shifted / dressed to clear the site.

The CJ Link Canal was designed in 1967 and constructed in the years 1967 to 1971 under Indus Basin Replacement Works Project to transfer water from the Indus River at Chashma Barrage to river Jhelum at a point approximately 97 km (60 miles) upstream of Trimmu Barrage and 42 km (26 miles) downstream of Khushab Bridge. The canal has a design capacity of 615 m^3/s (21,700 ft^3/s). From Chashma Barrage, it extends in South East direction. The upper half portion of the canal traverses the area irrigated by Thal Canal which off-takes from Jinnah Barrage while the lower half passes through the Thal desert.

En route to river Jhelum, CJ Link Canal also feeds cooling water to Chashma Nuclear Power Plant having 300 MW Capacity, which is being enhanced to 1000 MW in various phases. The cooling water from the 300 MW Plant is discharged to the River. Currently construction of CHASNUPP-2 of 325 MW capacity is in progress. The siting studies for the Chashma Nuclear Power Plant carried out in 1970s proposed arrangements that would allow the cooling water taken from the canal to be discharged back either into the Canal or in the river Indus downstream of Chashma Barrage. The Kundian Chemical Plant of the PAEC exists on the left bank of CJ Link near the tail.

The Project site is situated in the upper part of Indus basin in Thal Doab. The land included in the project area is classified as 'Barani land' and is only cultivated with rain water. The CJ Link –Tail structure is located at elevation of 188.0 masl between 31^0 .0" latitude and 32.20^0 North and longitudes 72^0 and 72.2^0 East about 40 km (25 miles) from Khushab and about 30 km (18.6 mile) south east of Johrabad. The Location Plan of the project is shown in Fig. 1.1.

1.6.1 Climate

The Climate of the Project area is arid characterized by hot summers and low rainfall. The temperature at site varies from maximum 48°C in summer to minimum 0°C in winter. The maximum mean daily temperature is 41.7 °C during the month of June and 19.4 °C during January. Minimum daily temperature varies between 5.0 °C and 27.2 °C for January. The monthly average rainfall ranges from 122 mm to 5 mm.

1.7 ACCESS TO PROJECT SITE

1.7.1 Access through Road

The project site is connected by a metaled road with the district headquarters Khushab which is situated at a distance of 40 km (25 miles). The site is also approachable from other local towns through metaled roads as shown in Fig. 1.2.

The project area is accessible from Karachi Port through a good road network of National, Super Highway and Indus Highway. Road distance from Karachi to project site is approximately 1,164 Km (723 miles). Two metaled roads lead to the site from Muzaffargarh; one via Ahmadpur Said, Athara Hazari to Khushab and the other via Chowk Azam, Bhakkar, Jhang to Khushab.

The project area is accessible from Lahore through a good metaled road via District headquarters Khushab or Joharabad. The distance between Project Site and Lahore by road is about 312 Km (194 miles). The site is also approachable from Islamabad through Khushab.

1.7.2 Access through Railway

The nearest railway station from the project site is Khushab, which is about 40 Km (25 miles) from the site. Khushab is connected with Karachi-Peshawar main Railway line through Kundian Junction. By rail the distance of Khushab from Karachi via Kundian is 1310 km (814 miles).
The requirement for transportation of over-sized consignments by railway from Karachi to Kundian, would be as follows:

- Overall length of the consignment = 823 cm (27 ft)
- Approximate weight = 20 tons

1.8 AVAILABLE INFORMATION / DATA

The consultants reviewed available reports and documents including:

- Chashma Jhelum Link Tail Hydropower Project Feasibility Study June 1995 by WAPDA/GTZ
- Independent Energy Partners Pakistan Ltd. Feasibility Study 1996
- Operation of CJ Link Canal since Water Accord 1991
- Layouts of Spurs and Flood protection works carried out by PID near Khushab
- Satellite imageries (SPOT)
- Greater Thal Canal Project Report for off-take arrangement from CJ Link
- Plan and Profiles of CJ Link from WAPDA/PID

1.9 DATA AVAILABILITY

1.9.1 Topographic Maps of Project Area

GT Sheets of 1:50,000 scale for the project area were obtained from Survey of Pakistan.

1.9.2 Satellite Imageries

Imageries of 1992 were available. Acquisition of fresh imageries at this stage was considered not necessary as no major change in features has taken place.

1.9.3 Climatological, Hydrological / Sediment Data

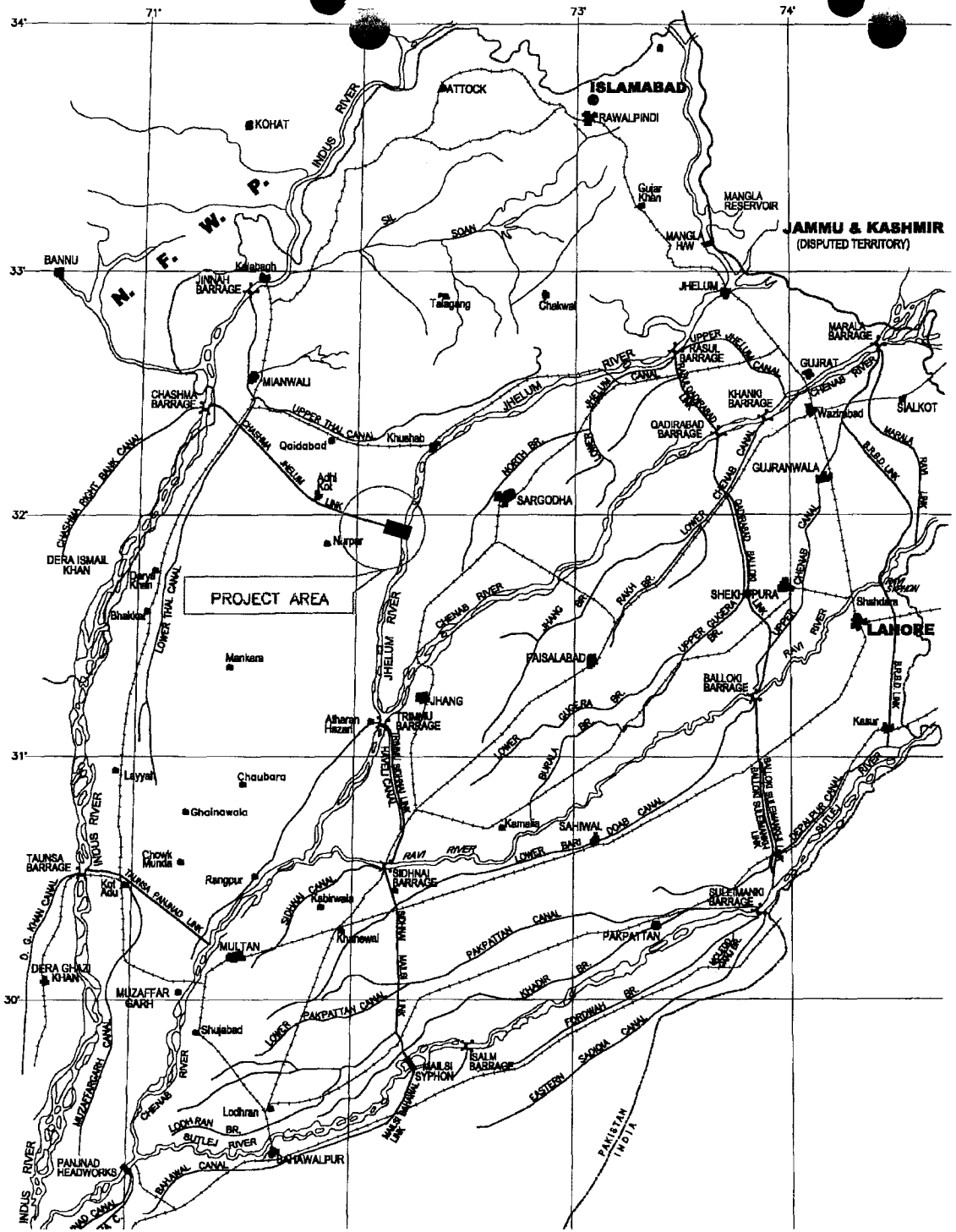
The previous study by WAPDA/GTZ was based on hydrological and sediment data for period 1978-1989 which covered the period prior to the Water Accord of 1991. Hydrological and power potential estimations were based on the canal flow and head data received from PID and WAPDA which have now been updated to year 2007.

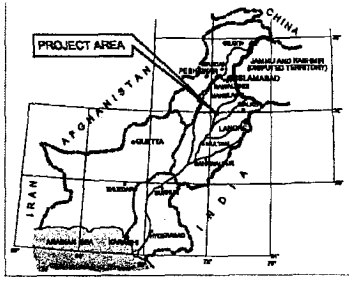
As all canal water flow is regulated and it does not depend on precipitation or river flow. Therefore the hydrological calculations have been based on the discharge measurements in the canal itself only.

1.11 KEY PARAMETERS OF THE PROJECT – INITIAL AND REVISED

Here-below is a summary of the all key parameters of the project:

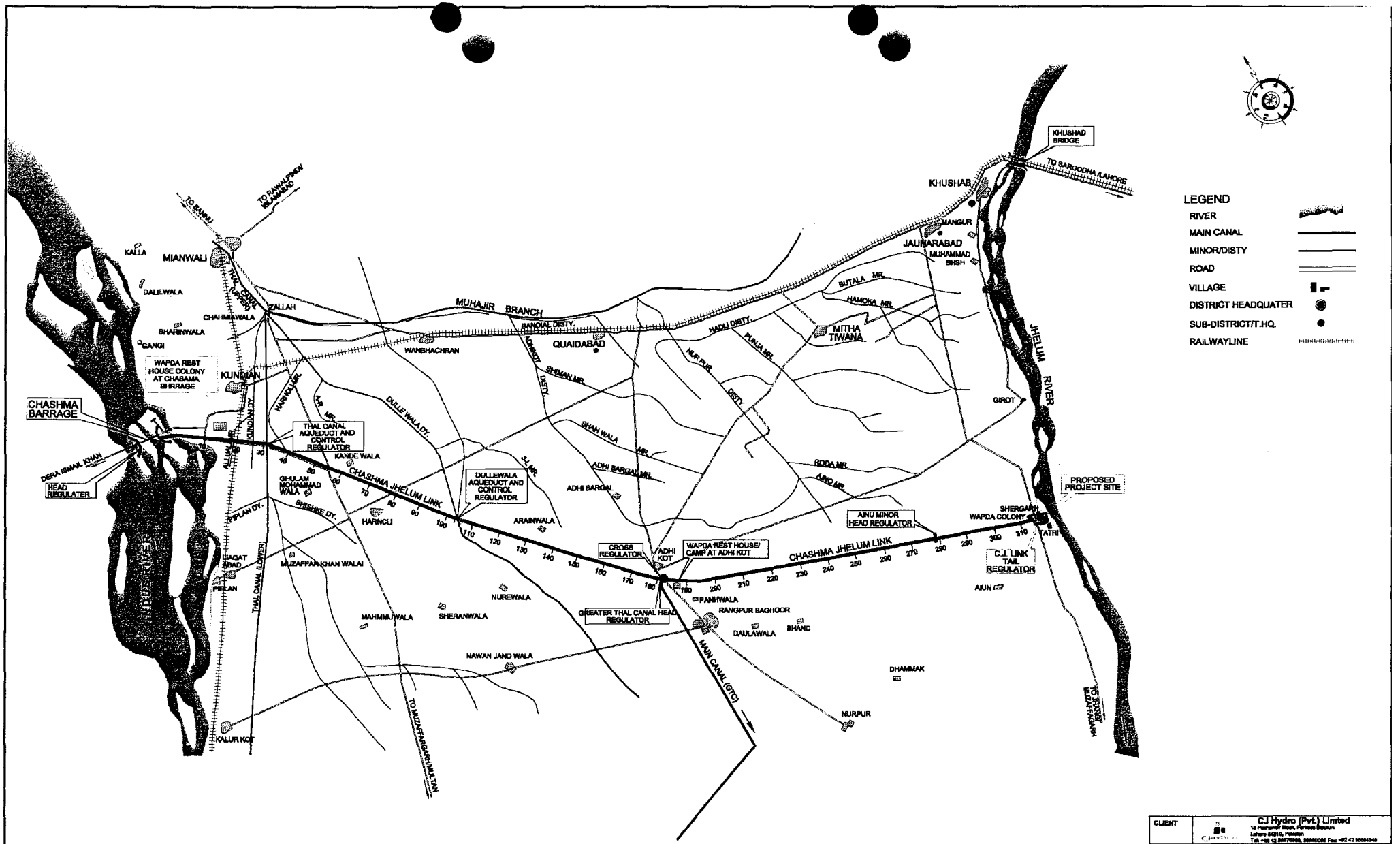
Description	Units	Previous Study	Updated Study
Design Discharge	m^3/s	320	210
Net Head	m	13.65	13.65
Installed Capacity	MW	44.0	25.0
Annual Energy	GWh	212.49	110.6
Plant Factor	%	55.1	50.3
Availability of Ouput		Optimistic	Conservative
No. of Units		Three (03)(14.6MW)	Three (03)(8.4MW)
Type of Units		Horizontal Bulb	Horizontal Bulb
Runner Diameter	m	4.25	3.65
Generator	MVA	18.3	10.4
Headrace Length	m	1350	1350
Bed Width	m	46	36
Tailrace length	m	370	370
Bed Width	m	53	36
Flow Record		1991-2007, Post Water Accord, Pre Raised Mangla	1991-2016, Post Water Accord, Post raised Mangla
Construction Cost	Million US$ Price Index	60.7 September 2008	39.2 May 2017
Cost per kW	US$	1379	1568
Construction Period	Month	42	36
Project costs	US$ Million	84.9	59.9
Levelized Tariff	US cents/kWh	6.9	8.85





INDEX MAP

CLIENT	C.J Hydro (Pvt.) Limited 16 Pakistan Block, Fortress Stadium Lahore 54810, Pakistan Tel: +92 42 36370886, 36602866 Fax: +92 42 36604346
PROJECT	FEASIBILITY STUDY 25 MW HYDROPOWER PROJECT AT C. J. LINK (TAIL)
TITLE	PROJECT VICINITY MAP
CONSULTANT	QATZ (Pvt.) Limited 115/7-A, Barwar Road Ext. Lahore Cantt., Pakistan Tel: +92 42 36073345-47 Email: office@qatz.org www.qatz.org



CLIENT	CJ Hydro (Pvt.) Limted 18 Pashawar Block, Fortress Stadium Lahore 54810, Pakistan Tel: +92 42 36675505, 36660066 Fax: +92 42 36664349
PROJECT	FEASIBILITY STUDY 25 MW HYDROPOWER PROJECT AT C. J. LINK (TAIL)
TITLE	**PROJECT LOCATION MAP**
CONSULTANT	QATZ (Pvt.) Limted 115/7-A, Sarwar Road Ext. Lahore Cantt., Pakistan Tel: +92 42 36673345-47 Email: office @qatz.org www.qatz.org

JOB NO.	SCALE N.T.S	DATE MAT. 2017	DWG. NO. 02

SECTION – 2

PROJECT DEVELOPMENT

SECTION – 2

PROJECT DEVELOPMENT

2.1 ACTIVITIES PRIOR TO COMMENCEMENT OF STUDY

The Government of Punjab through the Provincial Irrigation and Power Department issued a Letter of Interest (LOI) on November 8, 2007 to HK Consortium to carry out Feasibility Study to develop and construct a power plant in private sector on Chashma-Jhelum Link Canal (Tail) by utilizing its natural fall / elevation difference.

On receipt of Letter of Interest and submission of the Guarantee, H.K Consortium issued "Request for Proposals" to invite various consultants to provide services to carryout Feasibility Study for development of the project.

The Feasibility Report was initially prepared by NESPAK and Integrated Consulting Services in 2009. While examining the application of Generation License of the Project, NEPRA had advised to update the Feasibility Study after a detailed hydrological assessment especially with reference to the increased capacity of Mangla Dam. Accordingly, a detailed hydrological assessment was carried out and on the basis of which the original Feasibility Study has been updated and the size of the Project has been revised from 44MW to 25MW.

2.2 SALIENT FEATURES OF PROJECT

The proposed 25 MW hydropower plant at C-J Link (tail) will comprise the following.

i. Intake from CJ Link
ii. Headrace Channel
iii. Power House
iv Tailrace Channel
v Escape Structure
vi. E & M Plant
vii. Workshops & Maintenance Facilities
viii. Roads and bridges
ix. Staff Colony

- **Headrace Channel** The headrace will off take from upstream of the existing regulator structure at an angle for smooth diversion of flow. The maximum design discharge of power channel has been based on analysis of hydrological data. The channel will be concrete lined.

- **Powerhouse** The Powerhouse will be constructed on right bank of the C-J Link. The centerline of the powerhouse and C-J Link would be about 200 – 250 m (656 – 820 ft) apart. The major components of power house will be machine hall, service bay, drainage gallery, cable and pipe gallery, trash rack etc.

- **Tailrace Channel** The design discharge and bed width will be same as that for headrace. The tail race channel will be stone pitched. The maximum and minimum water levels will be taken to exploit the full potential.

- **E&M Plant** Trash Racks: The powerhouse intake will be equipped with a trash rack. The trash rack will be installed at an angle with the horizontal which will reduce head loss and facilitate mechanical cleaning with mechanical rack cleaner.

  Stop Logs and Intake Gates: Closure of intake and draft tube is needed for maintenance and erection of turbines. Stop log closure on upstream and downstream side will be provided due to relatively high water levels. Upstream stop log slots will be provided between the trash rack and upstream gate, keeping a safe distance from both. Vertical electrical operated gates will be provided. Downstream stop log slots will be provided at the end of draft tube.

  Turbines: Bulb Type double regulated turbines having runner diameter of 3.65 meters (11.97 feet) and equipped with 4 blades of stainless steel are proposed. The turbines shall be capable to operate within a wide range of head and discharge.

Generators: The generators will be selected matching the turbine out put
Cranes: Following types of cranes are proposed to be installed at various locations of the powerhouse for loading, unloading, erection and maintenance of the equipment during installation, operation and maintenance.

1 Gantry Crane. One gantry crane having main hook of sufficient capacity to lift the heaviest trash rack / gate equipment / stop logs.

2 Powerhouse Crane. One overhead bridge crane having main and auxiliary hooks of adequate capacity to lift the various equipment including turbine, generator, valves etc.

3 Workshop Crane. One single girder crane of 5,080 -10,160 Kg (5-10 tons) capacity is to be installed in workshop to facilitate handling of various equipment.

Trash Rack Cleaning Machine: A trash rack cleaning machine would be required to remove the debris from the trash racks.
Dewatering and Drainage Equipment: Dewatering and drainage equipment would be provided to remove the leakage water from various levels of the powerhouse.

Maintenance Workshop: As the plant is located at remote site, a well-equipped workshop would be required to handle various jobs of repair and maintenance.

Roads and Bridges: Where existing roads are disrupted, rods will be re-aligned and bridges will be provided where necessary

Staff Colony: The details of the housing requirements will be established by the contractor. For the supervisory staff the requirements can be indicated in the 'Tender Documents' or 'RFP'. Tentatively following housing facilities are planned to be constructed;

- D type houses 6 for Engineers
- E type houses 6 for sub engineers and foremen
- F type houses 12 for support staff
- One block of bachelors' quarter for 24 persons

- Mosque
- Market
- Guest House and Recreation Club
- Park

2.2.1 Interconnection Studies for Power Dispersal

As the power produced by the Plant will be purchased by NTDC so it was necessary to investigate that how interconnection will be made with its networks. In E&M design most important components will be the transformer, the generators and an outdoor switchyard of 132 kV for connection to the transmission line. The high voltage winding may be in Y form which will be connected with the neutral point taken out for direct connection to earth. The main transformer may be feeding through the single busbar the 132 kV transmission line. The station supply will be defined as the AC and DC power supply system to the power plant control systems and auxiliary systems.

The C-J Link (tail) Canal Hydropower Project is proposed to be interconnected to the nearest NTDC grid at Jauhrabad grid station (132 kV). The transmission line might be a double circuit 132 kV overhead length of transmission line is approximately 36 km (22.36 mile). Steel reinforced (ACSR) panther conductors with steel lactic towers will be foreseen which are according to the national standard. Synchronizing with NTDC grid system will be done in the powerhouse control room. The powerhouse switchyard is the point of energy delivery to the NTDC. Revenue meter should be located at the switchyard for measurement of energy delivered to NTDC. The proposed 132 kV transmission line will be equipped with directional distance protection system with relays in the 132 kV Jauhrabad grid station and in the powerhouse. A back-up protection at both stations with directional over current relays might be included.

2.3 SITE EVALUATION STUDIES

A number of studies have been carried out for site evaluation. A brief description follows:

2.4 SURVEYS AND GEOTECHNICAL/GEOPHYSICAL INVESTIGATIONS

Requirement for topographic survey and geotechnical/geophysical investigations were established and topographic surveys were carried out.

2.5 TOPOGRAPHIC SURVEYS

Survey requirements of the project area were prepared. The HK Consortium arranged the surveys through Geo Engineers of Islamabad which was supervised by the Consultants.

Digital Terrain Model (DTM) of the Project area has been developed from the survey work carried out under this project. This has been used to extract profiles and cross-sections wherever required for alignment of proposed channel and road network.

Under Second Flood Protection Sector Project (FPSP-II), flood risk maps for 5 year and 50 year return period for Jhelum River at a scale of 1:50,000 were developed by NESPAK. These maps were used for obtaining the 10 daily average water levels at the confluence of CJ Link with Jhelum River which influence the downstream levels at the powerhouse.

2.6 GEOTECH AND GEOPHYSICAL INVESTIGATIONS

Geotechnical investigations were earlier carried out by WAPDA / GTZ. At that time two boreholes were executed, one at the power channel and one at the powerhouse location. These investigations are not sufficient for the project of this size. Standard Penetration tests were carried out in the boreholes at 3 m (9.84 ft) intervals by WAPDA / GTZ. This interval is too large and some information is inevitably missing. Generally, SPTs should be done at 1m (3.28 ft) vertical intervals. In addition some investigations were also done previously for CJ Link and other structures. The information provided by these investigations was useful but not sufficient for the current project. It was therefore considered necessary to carry out further investigations to supplement the previous investigations. In addition to boreholes geophysical investigations have been carried out. These were used to determine the dynamic parameters such as the shear modulus at low strains.

2.7 SEISMICITY

During the previous feasibility stage, the seismic design was based on old "Seismic Zoning Map" of Pakistan prepared by Meteorological Department. Since then the Seismic Zoning Map has been revised and higher seismic design factors are required.

The seismic design parameters were determined during the current study based on updates/available information about seismicity and tectonics of the region and the latest Seismic Zoning Maps as well as a down-hole seismic test conducted at site. This is described in Section-5 of this report.

2.8 HYDROLOGICAL AND SEDIMENTATION STUDIES

2.8.1 Climatological, Hydrological / Sediment Data

The previous study by WAPDA/GTZ was based on hydrological and sediment data for period 1978-1989 which covered the period prior to the Water Accord of 1991. Prior to the Accord the CJ Link was operated on an adhoc basis. At the time when studies were concluded in 1995 post Water Accord data beyond 1991 was available only for a short period. Hydrological and Power Potential estimations have now been based on canal flow and head data received from IPD and WAPDA for period up to 2007.

The following on going and proposed developments subsequent to the earlier feasibility study would affect the water availability at the CJ Link Tail for hydropower generation.

- Implementation of Greater Thal Canal Project
- Implementation of Mangla Dam Raising Project
- Extension of CHASHNUPP
- Future storages on Indus river

Flow duration curves have been developed from the daily flow records at C-J Link tail for the post-Accord period (1991-2016) to determine the flow durations corresponding to different probabilities. The impact of various on going and proposed developments on water availability has been studied.

The scope of work included the following:

i. Review of the previous studies including feasibility study carried out by WAPDA in collaboration with German Agency for Technical Cooperation (GTZ) and to assess the requirement of further data to be collected.

ii. Collection of additional historic daily flow and sediment data.

iii. Evaluation of long term daily flows to assess the flow availability and monthly/seasonal variation after incorporating effect of diversions to Greater Thal Canal.

- Assessment of anticipated impact on flows due to raising of Mangla Dam and proposed future projects, and
- Assessment of sediment transportation.

A detailed description of the hydrological and sedimentation aspects is given in section-6 of this report.

2.9 HYDRAULIC STUDIES

2.9.1 Review of Available Data & Reports

The available data /reports were reviewed and the feasibility level designs of all hydraulic structures related to the hydropower project were checked for following parameters:

- Adequacy to pass the required discharge
- Safety/stability against possible scour and uplift pressures
- Approach and tailrace conditions
- Adequacy of protection works on both ends of the structure
- Hydraulic performance capability of guide/training works
- Safety against cavitation and related problems
- Adequacy of energy dissipation device
- Intake and outlet conditions and their safety/performance under different operation conditions

2.10 PROJECT PLANNING AND LAYOUT STUDIES

2.10.1 General Approach

The main scope of the present study included a review of the previous feasibility study and its validation as per present and projected future demands and developments. It is essentially an up date to the post-accord situation keeping in view the needs of the country for a couple of decades ahead when more reservoirs may be in place which could substantially change the flow patterns of large canals including the CJ Link.

2.10.2 Project Planning

The starting point was the previously recommended layout of the powerhouse works. Updating was done based on new parameters and data.

2.10.3 Review of Canal Diversion and Off-takes

Diversion of the canal or temporary closure of canal works was considered while planning construction activities. Review of the proposed power station components was carried out in the light of updated surveys and investigations as well as updated flow magnitudes and durations in the CJ Link Canal to include the following;

- Reassessment of Power Intake Structure
- Power Facilities
- Proposed Installed Capacity

- Arrangement of the Power Facilities
- Switchyard Arrangement

In the recommended layout of WAPDA/GTZ studies, arrangements for dewatering of the lower parts of the headrace area were not provided. This is required for maintenance works and suitable arrangements have been incorporated in the design.

2.11 PRELIMINARY LAYOUT STUDIES

Different possible alternatives for layout of the powerhouse were reviewed including those originally considered and after comparison of each alternative; the alternative best suited to site conditions has been developed for further study.

2.12 HYDRAULIC DESIGNS FOR SELECTED LAYOUT COMPONENTS

Hydraulic design of structures included adequate provision for the safe passage of anticipated surface flows to allow excess energy dissipation with minimum water turbulence and subsurface flow analysis in order to make the structures safe and stable against possible piping action and uplift pressures.

2.12.1 Off-Take Structure

The off-take structure was selected from the various options available keeping in view the hydraulic and economic considerations. Selection was based on the available space, the foundation conditions, and the approach and tailrace conditions. A proper streamlined shape of the structure was adopted so that the water surface profile over the structure stays within reasonable limits.

2.12.2 Sediment Trap

Outlet works for the flushing of the trapped sediments have been designed to substantially clear the power channel at regular intervals. Parameters considered for the design of sediment trap were the flow velocity through it and the settling velocity of the sediment particles.

2.12.3 Head Race / Power Channel

Head race channel has been designed for the smooth entrance of flow in the structure. Keeping in view the topography and space limitations, alignment of the Power channel was checked from the new survey plans as well as field visits and finalized. The power channel will be lined to cater for high velocities and to minimize losses. About 460 m (1,500 ft) length of the CJ Link Canal upstream of the Tail regulator will be lined on the sides with bricks to avoid water logging in adjoining areas, which may result from ponding. Means of dewatering for maintenance works have been provided.

2.12.4 Tailrace channel

The tail water channel is designed to make a smooth confluence with the river. Adequate safety measures and protection works have been provided against possible scour and stability of high embankments and curves. The tailrace channel is designed to smoothly dispose the water from the power house into the river downstream. The protection works have been designed at the end of the channel to account for the probable scour.

2.12.5 Tail water rating curve

Tail-water rating curves were developed for different flow conditions used in the hydraulic designs of the outlet control.

2.13 STRUCTURAL DESIGN AND DRAWINGS

2.13.1 General

Feasibility level structural design has been carried out for the recommended proposed layout. Quantity and cost estimates were prepared. Preliminary engineering drawings, covering plans, elevations and sections were developed to effectively define the nature, materials and dimensions of each of the structure. Computer - based AutoCAD drafting was adopted for this purpose.

Development of Conceptual Design

Conceptual development of structural systems and preparation of sketches has been based on additional and updated inputs about geotechnical, hydrological, seismic, hydraulic and electromechanical parameters.

2.13.2 Project Planning

a) Delineation of Performance Requirements

Based on a comprehensive and effective integration and interpretation of project objectives, geological, hydrological and seismological conditions, and functional requirements of various structures, basic project parameters have been developed to define the performance requirements of different structures. Level of acceptable risk has been defined for various hazards.

b) Development of Design Options

Conceptual structural designs for intake structures, penstocks, powerhouse, tail race and other related facilities have been developed for proposed alternative layout of the power house in consideration of the following factors:

- Best fit of the structural configurations for the specific topography and geology
- Optimum project configuration in conjunction with the evaluations by other disciplines, including geotechnical, hydraulics, environmental, electrical and mechanical.

2.14 FEASIBILITY LEVEL DESIGN OF STRUCTURES

The type and configuration of powerhouse, intake structure, penstocks, tail race and other facilities have been selected. This has been aimed at arriving at appropriate details of all structural systems, defining their principal dimensional and material characteristic, and preparing cost estimates and construction plans for the project.

The engineering design process for this objective covered the following steps,

i. Refinement of Performance and Design Criteria.

ii. Stability Analysis At this preliminary stage, sizing of structures has been done based on simple computations and engineering judgment. Basic objective is to enumerate, for further screening and analysis, a comprehensive range of design options, so as not to exclude any potentially attractive design solution.

2.15 POWER AND MECHANICAL STUDIES

2.15.1 Power Output and Energy Potential of the Project

The computations for power output and the average annual energy potential have been based on the 10

daily mean discharge data for the period from 1978 through 2007 The historic flow pattern were examined.

The Feasibility Report indicates annual energy potentials ranging from 53 to 146 GWH for historic flow pattern. The corresponding power outputs range from 25 MW.

2.16 POWERHOUSES AND RELATED FACILITIES

2.16.1 General

Based on the review and optimization of available data/reports, feasibility study for the selection of E&M equipment of the project was carried out.

Typical designs of gate equipment, turbines, generators & auxiliaries, switching equipment and transformers have been prepared as well as selection of the characteristics of the generating equipment and the dimensioning has been done.

2.16.2 Fixation of Equipment

All main equipment including the turbine generator, switching equipment and the transformers will be accommodated within the proposed power house layout. Dimensional criteria were established for the purpose of evaluating alternative arrangements. Typical plans at individual floor levels, as well as transverse and longitudinal sections were prepared.

2.17 UNIT SIZE AND THE GENERATING EQUIPMENT

2.17.1 Turbines

The WAPDA-GTZ Feasibility Report recommends three (3) vertical Kaplan double regulated hydro turbines each with a rated output of 8.33 MW and speed of 150 RPM.

The type, speed and arrangement of hydraulic turbines were finalized and the design parameters of turbines were evolved, keeping in view the latest technological developments.

2.17.2 Generators

The generators will be three phase synchronous machines meeting the requirements of the latest edition of IEC 60034 and will be designed taking into consideration the operating experience gained at other similar units installed elsewhere.

2.17.3 Electrical Main Connections & Station Auxiliary Supply System

The electrical main connections constitute the major part of the electrical equipment in a hydropower plant having close relation with a power system, protective relaying and the selection of electrical equipment. The main connections directly affect the operation, maintenance and investment in the hydropower plant; comprising connections between the generators, transformers, circuit breakers, CTs, PTs, transmission and station auxiliary supply power distribution. The main electrical connections are un-doubtfully the key to the electrical design of the hydropower plant. The pre-requisites for the selection of the main connections are the reliability of the power supply to the consumer, simplicity in the design, operational flexibility, and ease in maintenance and of course low capital and operation costs.

For dimensioning, design and layout of the various plant components and installations, the following features and aspects were considered:

- Ratings to safely cope with normal and fault conditions, the prevailing site conditions, avoiding any over-stressing of material and equipment.
- Equipment to be of standard design, providing highest degree of safety, reliability, availability, redundancy concepts and ease in operation.
- Equipment arrangements to consider adequate space and access for transport, installation, commissioning, operation and maintenance.

The main ratings of all major electrical equipment such as transformers and switchgears etc have been determined.

2.17.4 Protection Scheme

A protection scheme utilizing numerical protection relays is proposed for the protection of generator, transformer and other power plant equipment. The primary function of the protection system will be to isolate the disturbed part of the system in the event of fault and abnormal operation conditions as far as reliability, speed and selectivity are concerned. Tripping of a faulty part of the system shall take place before mechanical and electrical adjacent parts of the system are damaged and early enough to maintain the power system stability.

2.17.5 Power Plant Control System

The control system is proposed to ensure safe, efficient and reliable operation of the plant under all regimes and operating modes, namely start-up, shutdown, normal operation, part-load operation, and under emergency conditions resulting in cost effective power generation.

The design of the control system is such as to minimize operator interventions and shall facilitate the operator to take pre-planned actions required in case of process drift or if unsafe trends or conditions develop in any regime of operation. It shall alert the operators as to any abnormal conditions or situations requiring manual intervention in a timely manner.

Ease of maintenance shall be given due importance at system design and erection stage. The design of the control system shall be such as to permit on-line localization, isolation and rectification of faults in the minimum possible time with the necessary self-diagnostic features.

The operating, monitoring and control system envisaged for the unit shall be a state of the art microprocessor system having positive references for the employment in power stations with similar main design parameters.

2.17.6 132 kV Switchyard

The associated 132 kV Switchyard will utilize a one and half breaker scheme.

2.17.7 Station Mechanical Auxiliaries

Feasibility level studies have been made regarding the requirements, typical layout and design of the following:

- Station/unit cooling water system.
- Oil handling and purification system.

- Station water supply and drainage system.
- Compressed air system.
- Potable water system.
- Fire protection system.
- Heating, ventilation and air-conditioning system.
- Overhead cranes and other lifting devices.
- Workshop equipment.

2.18 LOAD FLOW AND INTERCONNECTION STUDY

A Load flow analysis and interconnection study related to this particular hydropower project and overall situation of the country has been done as a part of this feasibility and is presented in Volume IV.

2.19 ENVIRONMENTAL AND SOCIAL IMPACT STUDY

The study of environment examination has been undertaken as part of the overall feasibility study for the C-J Link (tail) Canal Hydropower Project and has been designed to meet the requirements for Environmental Assessment (EA) under the guidelines of Environment Protection Department (EPD). The EIA Report will be submitted for review and approval by the Punjab Environmental Protection Agency under the Environmental Assessment (EA) laws of Pakistan.

The environmental impact of the Project has been assessed on the basis of the publication of World Bank Policy and Pak-EPA Environmental Act 1997. Base Line conditions of Physical environment, Biological environment and Socio-Economic aspects have been developed under the ESIA study. Primary and secondary data was collected in order to have bench mark for the environment monitoring.

Surface Water and Groundwater have been tested for the determinants specified in NEQS, Irrigation Water Quality Standards and WHO drinking water standard. The results were analyzed to determine the suitability of the use of the water for recreation, irrigation or human consumption purposes.

Historical flows of C.J. Link indicate that in some months of the year the flows are negligible, which may further reduce after operation of Greater Thal Canal. Therefore chances of fish breeding are less.

The Project environmental and social impacts have been evaluated and detailed environmental management plan (EMP) developed. The EMP includes a detailed Mitigation Plan, Environmental Monitoring Program, delineation of responsibilities and Environment Management cost.

Socio – economic study has been undertaken to update prevailing socio-economic condition of the related community. Most of the land which shall be utilized for the construction of project (inclusive of staff colony), belong to WAPDA. The Project does warrant acquisition of small area of private land and resettlement of two families and a medical dispensary. It is purposed to grow two plants at site for every one tree cut by the contractor and protect these plants until they are matured.

2.20 COST ESTIMATES

2.20.1 Basis

The cost estimates have been established on the basis of the Bill of Quantities worked out from the drawings prepared for Feasibility Design of the project. Rate analysis has been carried out for major work items; earthwork, concrete, reinforcement etc . For other items Government of Punjab Composite

Schedule of Rates (CSR) for 4th quarter 2008 has been used to work out the estimated cost of the project. The CSR is revised and updated every quarter to account for escalation and is posted on Government of Punjab's web site. The costs have been converted to equivalent dollars using the exchange rate of May 15, 2017 i.e. I US $= Rs 104.83

The basic cost of the Hydro power scheme for feasibility study is divided into several parts:

- Preliminary works
- Civil works
- Hydro-mechanical equipment
- Electrical equipment
- Other costs

The basic cost estimated include all work and supply items worked out from the the feasibility level drawings prepared during the Study.

2.20.2 Foreign and Local Components of Cost

The cost estimate has been split into foreign and local components of costs, which vary with the individual items.

2.21 CONSTRUCTION PLANNING

The consultants have proposed the construction schedule, Construction planning for the Project works primarily focuses on following aspects:

i. Access to the Site.
ii. Weather conditions and River flow pattern.
iii. Excavation for project works.
iv. Preparation of Site, Installation of Temporary Facilities and Internal Roads.
v. Availability of Construction Material and Location of Borrow Areas.
vi. Manufacturing and Placing of Concrete.
vii. Power Supply.
viii. Contractor(s)' Camps.
ix. Work Areas for Workshops and other Logistics.
x. Area to be identified for disposal of excavated material.
xi. Phasing of works.

The proposed Construction Planning and Scheduling are described in Section 13.

2.22 ECONOMIC & FINANCIAL ANALYSES

The feasibility of the proposed project has been tested by determining the levelized tariff required to allow recovery of the estimated weighted average cost of capital for a typical project sponsor. In addition, the project's FIRR at a notional tariff has been estimated. The standard methodology used by international funding agencies for appraising similar projects has been used for basic analysis. In this analysis, the economic selection criteria on the ERRs is based on the ERRS commonly used by the Asian Development Bank (ADB). The hurdle rate used by ADB is around 17 to 18%. If ERRs are below this hurdle rate, the project tends not to be considered worthwhile from an economic perspective.

- Sensitivity Analysis has been carried out for following cases:
- Project cost increase by 10%
- Benefits decreased by 10%
- Cost increase by 10% and benefits decreased by 10% both occurring simultaneously.

SECTION – 3

TOPOGRAPHIC SURVEY AND MAPPING

SECTION - 3

TOPOGRAPHIC SURVEY AND MAPPING

3.1 GENERAL

A credible topographic survey and mapping in digital format is the key requirement of the project for its detailed engineering design and related infrastructures. The topographic survey was carried out by Geo Engineers and was supervised by the Consultants.

3.2 SCOPE OF WORKS

The Scope of Works was as under:

- Erection / fixation of permanent control points of concrete monuments in the entire project area for establishment of horizontal and vertical control stations / points to acquire field survey data in digital format.
- Detailed topographic survey of the project site to acquire the field data for production of topographic maps on required scale and contour interval.
- Processing of field data and production of maps of project site showing all above-mentioned features on 1: 5,000 scale with 0.5 m contour interval.

3.3 SURVEY EQUIPMENT

Automatic level and electronic total stations were used for topographic survey of project site.

3.4 FIXING OF PERMANENT SURVEY MONUMENTS / POINTS

Nine (9) traverse stations for horizontal controls and four (4) vertical controls i.e., Bench Marks (B.M) were established in the entire area of interest to acquire field survey data comprising natural / man-made features in digital format.

List of survey control points is provided in **Appendix – I of Volume II** of this Report.

3.5 LOCATION OF CONTROL POINTS

The locations of survey control points have been selected such as to cover the entire site and are inter-visible / readily accessible for any present and future survey needs i.e., setting out works or any other tasks etc.

3.6 HORIZONTAL CONTROL POINTS

3.6.1 Reference Datum

Survey of Pakistan (SOP) National Grid was not available in the vicinity of project area for use as reference datum for topographic survey and mapping work. Therefore, hand held GPS was used to establish horizontal control points.

The coordinates and elevations of two (2) survey stations used for this task are as follows:-

The linear measurement units used in survey and mapping work are meters and the angular measurement are in degrees, minutes and seconds of arc.

3.6.2 Orientation

Due to non-availability of National Grid Reference, the orientation was worked out from the co-ordinates of station SBM-1 and GO -1 established for this project and same bearing was used throughout the project area.

3.6.3 Traversing

Closed loop traversing was used to establish horizontal control points in the area using total station with an accuracy rating of ± 5 mm + 5 ppm or better. For this task, two (2) loops were run in the project area. All traverse distances were measured in two directions (forward and backward) and mean distance adopted, provided the two agreed to an accuracy limit of 1:10,000 or better.

Horizontal angles were measured on two zeros (four pointing each way) on face left and right positions of the instrument. Mean of the four (4) angles was used in traverse computations, provided the maximum spread of angles was not more than 20 seconds of arc.

Point No.	Easting (m)	Northing (m)	Elevation (m)
SBM-1	3,140,771.000	863,868.0000	186.164
GO-1	3,140,971.168	863,784.084	193.394

The traverse computations of all loops are provided in Appendix –II of Volume II of this Report.

3.6.4 Topographic Survey Data Acquisition

Bulk of the topographic field survey data were acquired using electronic total stations and data recorder on digital format having x, y, z coordinates. The data were down-loaded to the computer at site for further processing.

3.7 VERTICAL CONTROL POINTS

3.7.1 Reference Datum

Survey of Pakistan (SOP) mean sea level (msl) datum was available in the project area i.e., in WAPDA colony Chashma- Jhelum link canal having an elevation of 186.164 m. Total four (4) stations were fixed at safe and stable locations for vertical control points. Metric units were used for vertical control points.

3.7.2 Bench Mark Leveling

Leveling and check leveling were carried out using automatic leveling instruments of quality and compatible metric leveling staves. The minimum acceptable leveling accuracy for out and in runs was aimed to be ± 12 mm $\sqrt{k}$ where k is distance in kilometers and same accuracy level was maintained through out Bench Mark leveling process.

BM leveling computations are provided in **Appendix- III** of Volume II of this Report.

3.8 SURVEY DATA PROCESSING

3.8.1 Traverse Computations

The traverse field survey data are computer processed using in-house developed computer software and the accuracy achieved is in a range of 1:34,800 to 1:51,200. Small misclosures were adjusted among the respective traverse legs.

3.8.2 Topographical Survey Data Processing

Electronic total stations used for topographic survey had electronic data recording facility and the same were used for acquiring bulk of the field data. The data were computer-processed to create DTM and computer-aided mapping was produced at the desired scale. Contours were generated at required interval from the DTM. The mapping was field verified and maps were finalized.

3.8.3 X-Sections of Jhelum River and CJ Link

Four (4) x-sections of river and canal were taken at different locations. All above x-sections were marked on the sheet produced and data of each x-section was provided in the form of x, y, z coordinates for plotting of x-sections.

]SECTION – 4

ENGINEERING GEOLOGY AND

GEOTECHNICAL INVESTIGATIONS

SECTION – 4

ENGINEERING GEOLOGY AND GEOTECHNICAL INVESTIGATIONS

4.1 GENERAL

This section describes the Site Geology and results of Geotechnical Investigations carried out at the project site for the feasibility studies.

4.2 GEOLOGY AND SEISMICITY

The project area lies in "THAL DOAB" which extends from the foothills of salt range in the north to the confluence of Indus and Chenab rivers in the south. Physiographically the Thal Doab is divided into two major groups, the Piedmont and the alluvial planes. The site exhibits typical characteristics of deep sand deposits of the Indus Plane.

According to the Building Code of Pakistan (Seismic Provisions)-2007 the project area lies in Seismic Zone 2B where the peak ground acceleration generated by earthquakes can be of the order of 0.16 to 0.24g.

4.3 GEOTECHNICAL AND GEOPHYSICAL INVESTIGATIONS

The Geotechnical and Geophysical Investigations for the project have been undertaken to establish geotechnical parameters for planning and construction of the power scheme, especially addressing the design of the foundations of the bridge, the power channel and the powerhouse. The investigations were carried out during June-August 2008 by Geo Engineers according to the Investigation Plan specified by NESPAK-ICS. The Layout Plan which was considered for taking up the Geotechnical Investigation for the Project is shown on Fig.4.1.

The principal objective of geotechnical investigation focuses on determination of the engineering characteristics and parameters of the subsurface strata for foundation design and execution of earthwork. The scope of work specifically refers to identification and characterization of the subsurface materials, which would be of special concern for the design of the foundations of structures and earthwork. Detailed report related to Geotechnical and Geophysical Investigations is separately presented as Volume III of the feasibility report.

4.4 THE INVESTIGATION PROGRAM

The investigations carried out at the site consisted of following:

1. Drilling of 5 boreholes at the locations shown on Fig.4.1.
   (a) Two 30 m deep boreholes (BH-1 and BH-2) were drilled at the bridge site.
   (b) One Borehole (30 m deep) at the power channel bed between the bridge and the powerhouse
   (c) One borehole of 50 m depth was drilled at the alternative site of the powerhouse.
   (d) One borehole of 30 m depth was drilled at the alternative site of the powerhouse
2. Four (4) test pits along the route of the power channel to determine soil conditions related to excavation and other earthworks.

3. Down-the-hole seismic test was carried out at Borehole No. 5 to determine seismic wave velocities for designating dynamic shear modulus for the design of the turbines and generators.

4. Standard Penetration Tests (SPTs) were carried out in all the bore holes at one meter depth interval in the soil layers down to the drilled depth and soil samples were obtained through the split spoon samplers used in performing SPTs.

5. Depths to water table were recorded in each borehole and groundwater samples were obtained.

6. Laboratory tests were performed on selected soil and groundwater samples as specified on samples taken from boreholes and test pits including performance of the following tests:

- Sieve Analysis
- Hydrometer Analysis
- Liquid Limit, Plastic Limit
- Bulk and dry density
- Direct Shear Test
- Unconfined Compression Test
- Modified AASHTO Compaction Test
- CBR Test
- Sulphate content of soil
- Chloride content of soil
- Organic matter content of soil

4.5 DESCRIPTION OF SUBSURFACE STRATA

The investigation has shown occurrence of typical deposits of the Indus sandy alluvium comprising light grey to dark grey, fine to coarse grained, medium dense to dense sand extending right down to the investigated depth of 50 m. Only at some locations small lenses of silty/sandy clay were encountered which is known to be a typical characteristic of Indus alluvial deposits. The stratigraphy specific to the locations at which the investigations was performed is described as follows.

Location	**Strata**	**SPT Values (No. of blows / ft)**	**Water Table Depth**
Bridge Location (BH-1 and BH-2)	light grey to dark grey , medium dense to dense , medium to coarse sand	20 to 40	8 to 8.5 meters
Power Channel between bridge and power house	Similar to that at bridge location, however in-situ compactness appears to be somewhat on higher side. At some deep horizons silty/clay material appeared to be dominant.	20 to 50+	14 meters

Powerhouse Location (BH-4)	sandy illusion is lose to medium dense state in upper 5 to 6 meter and below that strata exhibits medium dense to dense state. A distinct layer of sandy/silty clay was observed at depth of 6.5 to 8 meters. The sandy clay is yellowish brown in color, firm to stiff and has low plasticity.	40+	13.8 m
Alternate Location of Powerhouse (BH-5)	Conditions similar to those at Power House Location (BH-4). The upper 5-6 meter of the strata is in lose to medium dense condition after which it improves to very dense state	Starting from 30 in upper 5-6 meter strata, increasing to 100+ with depth.	14.5 m

Parameter	Recommendations
Unit Weight	1682/m3 has been considered representative for all the subsurface soil layers above groundwater level.
Shear Strength Parameters	Angle of internal friction (φ value) of 30 degrees
Modulus of Subgrade Reaction	Es = 11250 kN / sq.meter K = 8653 kN/ sq.m for 1 meter wide footing
Bridge Foundations	The foundation of the bridge at this location will have to be laid well below El. 179.6m, i.e., at a level below 5.2 meters with respect to the present ground level. The logs of Bore Holes 1 & 2 drilled at the location of the bridge show that the soil strata appears to be competent to support the bridge on spread foundations without danger of shear failure. It is recommended that the bridge be supported on pile foundations. A pile of 24 inches (0.6m) diameter with embedded length of 45 feet (13.72 meters) below the bed level of the channel will have the allowable load carrying capacity of 100 Tons.
Power House Foundation	See Volume III for detailed recommendations
Recommendations for the foundations of small structures	The foundations of the small structures including foot bridges etc can be constructed as spread footings designed for a net allowable bearing capacity not exceeding 1.5 Tons per sft (15 Tons per sq.m). It is also recommended that in no case any spread foundation be placed at a depth less than 1.5 meters from the finally prepared grade level.

Parameter	Recommendations
Excavations	The excavations for construction can be made manually or by using conventional earth moving machinery such as dozers and trenchers. It is recommended that immediately after excavation for construction of foundation or other substructures, the excavation bottoms and slopes are cleared of all debris, proof rolled and immediately covered by a blinding concrete layer
Earthfill	The on-site materials, available from "cuts" in the upper horizons of the site (topsoil) are considered unsuitable to meet the structural fill requirements for supporting the structural loads. The fill intended to raise the existing ground and support the structural foundations or floors must comprise only the "select fill materials", which must be free of organic and other deleterious substances. The material should conform to requirements laid out in Volume III.
Erosion Protection	All the earth fill surfaces and slopes must be protected against wind and erosion.
Design Against Hydrostatic Uplift and Waterproofing	All the substructures should be designed to counter the hydrostatic uplift and be made waterproof.

Protection of Subsurface Concrete against Corrosion	The chemical tests performed on the on-site soils indicate varying degree of sulphates, chlorides and carbonate contents which can cause corrosion. It is recommended that foundations, basements and other concrete structures coming in contact with the soil be constructed using appropriate type of cement with suitable additives where applicable. In this regards trial mixes must be prepared and tested appropriately. A layer of bitumen coating should be applied to the exterior of all the foundation and other concrete coming in contact with soil.
Protection of Utilities	It is necessary that all the utility lines (water, sewage, oil pipes and cable conduits, etc.) be protected against corrosion due to presence of deleterious salts in the soil materials used for backfilling of utility trenches.

4.6 GEOTECHNICAL PARAMETERS AND RECOMMENDATIONS

The Geotechnical parameters relate to characteristics of the subsurface materials for design and construction of foundation and execution of earthwork. These parameters have been developed on the basis of evaluation of the engineering characteristics of the subsurface soils as determined through field exploration, in-situ testing (SPTs) and laboratory testing of the representative samples of materials obtained from the bore holes. The relevant Geotechnical parameters as well as necessary design recommendations are given in Volume III.

SECTION – 5

SEISMIC HAZARD STUDY

SECTION – 5

SEISMIC HAZARD STUDY

5.1 GENERAL

The project site is located on the bank of Jhelum River in the western part of Punjab plain which is characterized by low to moderate level of seismicity. The collisional zone of the Indian tectonic plate lies north of project site. Several devastating earthquakes have originated from this collisional zone. However, away from the collisional zone, low to moderate level of seismicity have been recorded in the stable basement mass.

The seismic hazard evaluation for the project was conducted through the study of regional geological and tectonic information collected from the available literature and maps and collection of historical and instrumental earthquake records. On the basis of this data, the critical tectonic features affecting the project site were identified and seismic hazard evaluation was conducted accordingly.

5.2 GEOLOGY

The project site is covered with thick alluvial deposits of Quaternary age laid down by Jhelum River. The geological map of the project area published by the Geological Survey of Pakistan is shown in Fig.5.1. The Quaternary sediments of the Punjab plain near the project area comprise the following:

Stream Deposits

Qm -Streambed and meander-belt deposits Qf -Floodplain deposits

Deposits of Extinct Streams

Qmx -Streambed and meander-belt deposits Qfx -Floodplain deposits (lower terrace)

Older Eolian Deposits

Qsc -Eolian deposits of extinct stream Qs -Eolian sand.

The alluvial deposits are underlain by the basement rocks (p€k) of the Indian shield, exposed at places in area between Shahkot and Sargodha. Based on borehole data and gravity survey, a Basement High having northwest to southeast trend is marked by Kazmi & Rana (1982), which is shown in Fig.5.2. The project site lies on the western side of this Basement High. Based on the contours of depth to basement rocks, the thickness of alluvial deposits at the project site is more than 365 meters (1200 ft.).

5.3 TECTONIC SETTING

The geodynamic framework of northern Pakistan is characterized by the collision and coalescence of Eurasian and Indian continental plates, which were once separated by the oceanic domains, and creation of the Kohistan island arc in the late Cretaceous. The collisional process started in the late Eocene to early Oligocene with the formation of the Himalayan Ranges and this process still continues. Relative to Eurasia, the Indian plate is still moving northwards at a rate of about 4 cm/year. The subduction of the Indian plate beneath the Eurasian plate has resulted in folding and thrusting of the upper crustal layers near the collisional boundary which lead to the formation of high Himalayan Mountains. The thrusting has been depicted from north to south in the shape of MKT (Main Karakoram Thrust), MMT (Main Mantle Thrust), MBT (Main Boundary Thrust) and SRT (Salt Range Thrust). The Salt Range Thrust which is southern most fault is located about 42 km north of the site.

Quittmeyer et al. (1979) have classified the entire area of Pakistan into fifteen seismotectonic provinces. Out of these, the three distinct provinces which are influencing the project site are:

- Salt Range province;
- Himalayas province; and
- Indus basin province

A brief description of the salient features of these seismotectonic provinces is given below.

5.3.1 Salt Range Province

The Salt Range is bounded on the north by Hazara seismotectonic province, on the south by Punjab plain and extends from the Suleiman range on the west to the Himalayas in the east. General orientation of this range is east-northeast, but prominent southeast trending transverse features offset parts of it. It is composed of folded and faulted thrust sheets and represents thin-skinned internal deformation within the Indian plate resulting from its collision with Eurasia.

Although it is the frontal zone of deformation in this region, the Salt Range is characterized by low level seismic activity, in contrast to other parts of the frontal zone in Pakistan. It has limited known history of moderate or large magnitude earthquakes. Micro-earthquake studies, however, indicate that at low magnitude levels (ML < 4), the entire Salt Range is active, especially along transverse faults at points where it is offset. Cambrian salt deposits may provide an explanation for this seismic character of the Salt Range. Deformation may result from a seismic slip along a decollement surface mechanically detached by the salt. The micro-seismic activity may represent small readjustments within the decollement sheets.

5.3.2 Himalayas Province

The Himalayas represent one of the primary compressional features that have resulted from the collision of the Indian plate with Eurasia. This zone of deformation is the result of folding and thrusting associated with the development of large nappe structures and deep crustal shortening. The Himalayas trends in a southeasterly direction just east of the Hazara-Kashmir syntaxis and further east, it has an east-west trend.

Seismicity within this seismotectonic province is characterized as moderate to high level. Most events are associated with the frontal zone of deformation. They are located parallel to and northeast of the surface trace of the main frontal thrust. One great earthquake, the 1905 Kangra earthquake with Ms=7.8 occurred within this zone, probably rupturing a 300 km portion along the main frontal thrust.

In the vicinity of the Hazara-Kashmir syntaxis, the mapped surface trace of the main frontal thrust bends around from a southeast trend to a southwest orientation. The seismically defined fault zone, however, does not follow the mapped surface faults; it appears to continue for an additional about 100 km to the northwest of the Hazara-Kashmir syntaxis.

5.3.3 Indus Basin Province

The Indus basin is located within the Indian plate south and southwest of the Himalayas and Salt Range and east of the predominantly northward trending mountain ranges of western part of Pakistan. This feature is a foredeep basin. The seismicity occurring within this zone is generally of low level. Although

infrequent, some events have caused considerable damage. Southwest of the Himalayas, the events occur along a discontinuous, but nevertheless, linear trend about 200 km from the main frontal thrusts (e.g. Main Boundary thrust). This same trend parallels the Salt Range, but not at as great a distance. This activity within the Indus basin may be related to the bending of the lithosphere, active basement faults transverse to the fold and thrust belts, and/or development of a new frontal thrust.

Surface faults have not been mapped in the Indus basin; the extensive alluvial cover has buried any structural evidence of faulting. Inferences based on gravity data, however, indicate basement faults may exist in some portions of the Indus Basin.

The Punjab Plain, which is the upper part of the Indus basin, shows low to moderate level of seismicity which is associated with the faulting in the Basement rocks covered by the alluvial deposits. The Basement High, depicted by outcrops of Basement rocks near Sargodha, Chiniot and Shahkot and extending from Sargodha to Faisalabad and further southeast towards the Indian border (Fig.5.2), shows a concentration of earthquakes with magnitude up to 5.5 on the Richter scale. A moderate earthquake originated from the Basement High in Punjab Plain could produce appreciable ground shaking at the project site due to thick alluvial deposits.

5.4 EARTHQUAKE RECORD

The ground motions produced by earthquakes pose a multitude of hazard to structures, either by direct loading of the structures or by initiating a sequence of events that may lead to damage to the structure, or even failures unless this has been catered for in the design.

The available earthquake record for the region in which the project is located can be classified into the following two types;

- Historical Seismicity
- Instrumental Seismicity

5.4.1 Historical Seismicity

The historical seismicity data is available in the form of descriptive account of damage due to past earthquakes mostly at the populated places. Since no historical city is located near the project site, therefore authenticated historical seismicity data is not available for the project region.

5.4.2 Instrumental Seismicity

In Pakistan and most other parts of the world, the seismic record is too short and incomplete to develop a complete sample that is truly representative of the spatial and temporal distribution of shocks over a large period. Nevertheless, all the available information has been gathered for the period covering the last century, which was used to develop a satisfactory and safe assessment of seismic hazard for the project.

A composite list of earthquakes that occurred in the project region and adjoining areas has been prepared. It is based upon earthquakes reported by International Seismological Center (ISC), United States Geological Survey (USGS), Tarbela Seismic Observatory (Pakistan) and Pakistan Meteorological Department. This composite list includes events within an area of more than 300 km radius of the site lying between latitudes 28^{0} to 34^{0} and longitudes 71° to 77°.

This earthquake list contains 1302 events having different magnitudes recorded between 1904 and 2008. In preparing this composite catalogue, more weight was given to the data listed in the ISC catalogue because data within this catalogue tends to be more accurate, having been calculated with more data than is used in the other listings, and less likely to contain duplicates. The source catalogues overlap considerably and both automatic and manual procedures that incorporate judgment about source catalogue reliability and priority were used to help eliminate duplicate entries from the combined listing.

The reporting agencies have given a variety of definitions for magnitudes viz., Body-wave magnitude (mb), Surface-wave magnitude (MS), Richter/Local magnitude (ML) or Duration-magnitude (MD) etc. All these types of magnitudes were converted into a uniform magnitude-scale i.e., MW (Moment magnitude) as given in the earthquake catalogue. MW represents area source rather than a point source and the same type of magnitude is mostly being used in the seismic hazard analysis.

Conversion from MS and mb to MW was achieved through latest equation suggested by Scordilis (2006):

$MW = 0.67\ MS + 2.07$ for $3.0 \leq MS \leq 6.1$ $MW = 0.99\ MS + 0.08$ for $6.2 \leq MS \leq 8.2$ $MW = 0.85\ mb + 1.03$ for $3.5 \leq mb \leq 6.2$

For ML, the value of ML was taken equal to MW as suggested by Idriss (1985) and supported by operators of local networks in Pakistan.

The recorded seismicity is plotted in Fig. 5.3. The concentration of seismicity in the north and northeast is associated with Himalayan frontal faults. The Punjab plain shows low to moderate level of seismicity. As seen from Fig. 5.3, there is a concentration of magnitude 45 earthquakes associated with Basement High which indicates the presence of buried faults along the Basement High. In the plain area west of the site, low level of seismic activity is observed.

5.5 SEISMIC HAZARD EVALUATION

For seismic hazard evaluation both deterministic and probabilistic methods of seismic hazard evaluation were used.

5.5.1 Deterministic Procedure

In the deterministic procedure, critical seismogenic sources, like faults, representing a threat to the project are identified and a maximum magnitude assigned to each of these faults.

The capability of the faults is ascertained through observation of historical and instrumental seismic data and geological criteria such as rupture length – magnitude relationship or fault movement – magnitude relationship.

The maximum ground motion is then obtained by considering the most severe combination of maximum magnitude and minimum distance to the project site, independently of the return period.

The main tectonic features within about 200 km of the project site which could be controlling the earthquake hazard at site are as follows:

- Main Boundary Thrust,
- Salt Range Thrust, and
- Buried Fault associated with Basement Faulting.

Empirical correlations have been developed between maximum potential of a fault and key fault parameters like rupture length, fault area, fault displacement and slip rate. Out of these fault parameters, only fault lengths are known with sufficient accuracy. For the faults around the site, the half length rupture of the fault has been taken and the maximum earthquake magnitude (in moment magnitude Mw scale) of each of the fault was calculated using Wells & Coppersmith (1994) relationship between fault rupture length and magnitude potential. The maximum magnitude for the buried fault in basement rocks is taken equal to the maximum recorded magnitude. The maximum potential magnitudes associated with the above mentioned tectonic features are given in Table 5.1.

Table 5.1 Maximum Potential Magnitudes

Tectonic Feature	Fault Rupture Length (km)	Magnitude (Mw)
Main Boundary Thrust	50	7.0
Salt Range Thrust	50	7.0
Buried Fault	-	5.5

The peak horizontal ground acceleration at the site caused by the earthquake with maximum magnitude occurring at closest distance to the fault was then calculated by using the latest attenuation relationships developed by various researchers from strong motion data from USA and worldwide. These relations were used as due to absence of enough strong motion data for the south Asian region, no attenuation relation for this region is available. The 50percentile (median) values of the peak horizontal ground acceleration (PGA) obtained by four attenuation relationships are given in Table 5.2. For all the faults, thrust rupture mechanism and stiff soil site conditions have been assumed.

Table 5.2 Peak Horizontal Ground Accelerations (PGA)

Tectonic Feature	Maximum Magnitude (Mw)	Closest Distance to Fault (km)	Peak Horizontal Acceleration (g) Median			
			Campbell & Bozorgnia (2008) NGA	Idriss (2008) NGA	Boore and Atkinson (2008)	Abrahamson & Silva (2008)
Main Boundary Thrust	7.0	200	0.03	0.01	0.01	0.03
Salt Range Thrust	7.0	42	0.12	0.09	0.15	0.10
Buried Fault	5.5	10	0.24	0.14	0.16	0.16

The results show that the maximum ground motions at the site will be due to earthquake associated with buried fault under Punjab plain.

5.5.2 Probablistic Procedure

In probabilistic seismic hazard evaluation, the seismic activity of seismic source (line or area) is specified

by a recurrence relationship, defining the cumulative number of events per year versus the magnitude. Distribution of earthquake is assumed to be uniform within the source zone and independent of time.

The procedure consists of subdividing the study area into a number of elementary zones (seismic sources) and computing the probability of one or several earthquakes of specified size occurring within each zone during a specified period. For each source, the probability of the earthquake being of a specified magnitude and the attenuation of the resulting ground motion are combined to derive the probabilities associated with the exceedance of different levels of ground motion at the site. The contributions of all sources are then summed up to give the total hazard in terms of probability or annual frequency of occurrence of the ground motion at the project site.

The recorded earthquake data presented in earthquake catalogue was used as database for the probabilistic seismic hazard analysis and frequency-magnitude relationship. Due to incompleteness, the data prior to 1960 was not used in the probabilistic analysis.

The distribution of seismicity and faults (Fig. 5.3) is such that it is difficult to associate the observed seismicity with a particular fault. Moreover most of the area is covered by thick alluvial deposits. Therefore a source model based on area source was employed in the probabilistic analysis.
Magnitude-frequency curve was developed for area source of about 300 km radius around the site. The plot of magnitude 'Mw' against cumulative number of earthquake per year 'Nc' was made for the area source (Fig. 5.4) from which recurrence relation was developed in the form of Richter' equation which is:

$$\text{Log } Nc = a - bm$$

Coefficients 'a' and 'b' are derived from least square linear regression of the data up to a minimum or threshold magnitude above which the seismic record is assumed to be complete.
The evaluation of return period of different levels of ground motions was carried using probabilistic method originally developed by Cornell (1968) and later developed by various researchers. The NGA attenuation relationships used for deterministic analysis for soil site with VS30=300m/sec was used in the analysis. These equations were developed for shallow crustal earthquakes in tectonic environment similar to that of the project area. The hazard analysis was carried out through EZ-FRISK software developed by Risk Engineering, USA. Idriss (2008) equation was not available in EZ-FRISK software used for hazard analysis. The results of the probabilistic seismic hazard analysis are presented in Fig. 5.5, showing annual frequency of exceedance of horizontal ground acceleration at the project site and also tabulated below:

• PGA for stiff soil condition (VS30=300m/sec)

5.6 SEISMIC DESIGN PARAMETERS

As the failure of the project under severe earthquake loading would not pose any significant life hazard and would result only in economic loss, it could be designed for lower return period.

Keeping in view the results of deterministic and probabilistic hazard, it is recommended that important project components should be designed for peak horizontal ground acceleration of 0.20g having a return period of 1,000 years. Other less important structures could be designed for peak horizontal ground

acceleration of 0.17g having a return period of '500 years.

5.7 CONCLUSIONS AND RECOMMENDATIONS

The seismic hazard evaluation for 44 MW Hydropower Project at Chashma-Jhelum Link Canal was carried out through a study of all the available geological, tectonic and seismicity data of the region in which the project is located.

The project is located in a stable region which is south of the collisional boundary of the Indian and the Eurasian plates.

Annual Frequency of Exceedance	Return Period (years)	Peak Ground Acceleration (g)*
0.01	100	0.10
0.005	200	0.13
0.002	500	0.17
0.001	1000	0.20
0.0004	2500	0.26

The Project area is covered with thick alluvial sediments deposits by ancient streams of Indus basin. The Basement rocks underlying alluvial deposits show high elevations and site area lies near the southeastern side of this Basement High. The thickness of the alluvial deposits is estimated to be about 365 meters (1200 ft.)

The recorded seismicity of the area is depicted mainly by small to moderate earthquake activity in the Punjab Plain. The area northeast of the project is active.

The main active tectonic features affecting the site area are the Main Boundary Thrust, Salt Range thrust and buried faults beneath the Punjab plain. Except Buried faults below the Punjab plain, other faults have low magnitude potential or pass at a distance from site area, and therefore, are not expected to cause appreciable shaking at the project site.

Several small to moderate earthquakes have originated from the Punjab plain which is thought to be caused by small blind thrusts in the Basement rocks, particularly associated with Basement High, as this area shows relatively more seismicity.

The results of probabilistic analysis show that peak horizontal ground acceleration with a return period of about 500 years is 0.17g and with a return period of 1000 years is 0.20g for stiff soil (SD type soil profile) foundation condition. It is recommended that important components of the project should be designed for PGA of 0.20g to avoid economic loss due to earthquake hazard. Other less important structures could be designed to withstand PGA of 0.17g.

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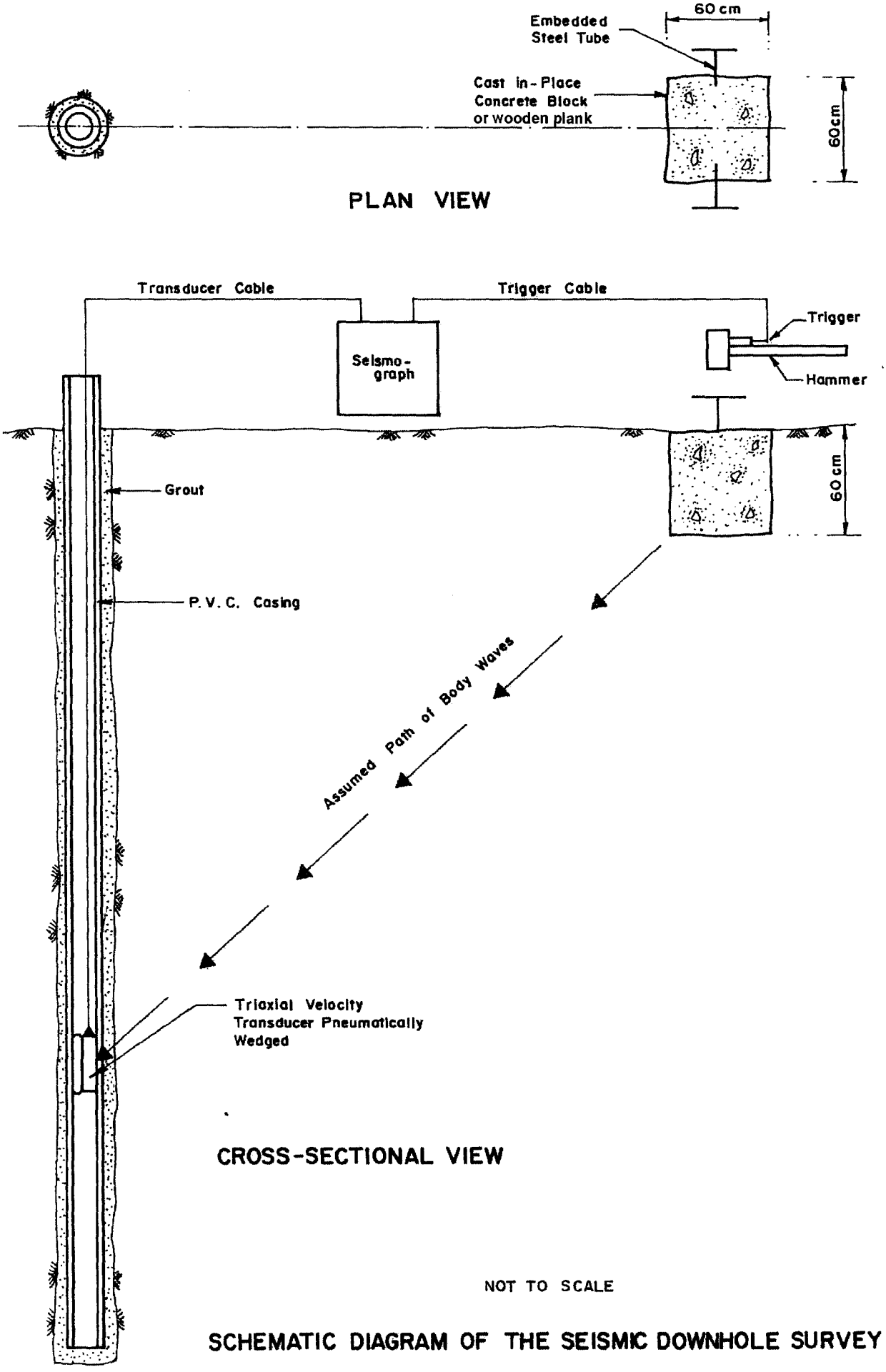
TABLE - 1

DOWNHOLE SEISMIC SURVEY ARRIAL TIME OF P AND S WAVES

Depth (m)	Arrival Time (msec)		Arrival Time (msec)	
	P1	P Corr	S1	S Corr
1	14	2.941	23.5	4.937
2	15	5.929	21	8.300
3	15	8.137	26	14.105
4	15	9.788	29	18.923
5	16	11.713	33	24.158
6	19	15.020	36	28.458
7	20	16.667	39	32.500
8	21.5	18.595	43	37.189
9	23.5	20.879	46.5	41.313
10	25	22.665	48.5	43.971
11	27.5	25.335	51	46.985
12	26.5	24.709	52.5	48.951
13	28	26.358	58	54.598
14	30	28.475	59	56.000
15	32	30.573	60.5	57.803
16	35	33.613	62.5	60.024
17	37	35.698	66.5	64.160
18	38	36.794	69	66.810
19	39	37.883	71	68.967
20	40	38.967	72.5	70.628
21	41	40.028	74	72.245
22	41	40.107	76	74.344
23	41.5	40.669	79.5	77.908
24	43	42.209	82	80.491
25	43.5	42.764	85	83.563
26	44	43.317	89.5	88.111
27	45	44.343	91	89.672
28	45.5	44.891	93	91.755
29	46	45.420	95.5	94.297

Source to borehole distance = 4.65m

Figure-1



SCHEMATIC DIAGRAM OF THE SEISMIC DOWNHOLE SURVEY

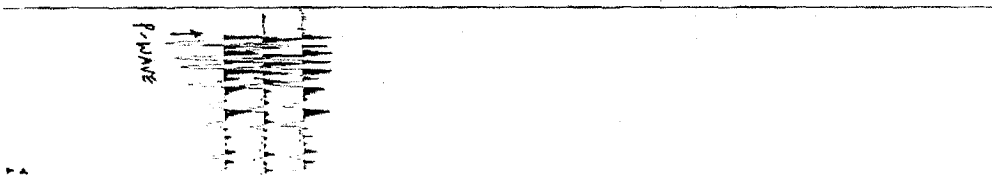
Figure-2
TYPICAL SEISMIC RECORD

▸▲Creator: TERRALOC MK6 Ver 2.22 Serial number: 4061921

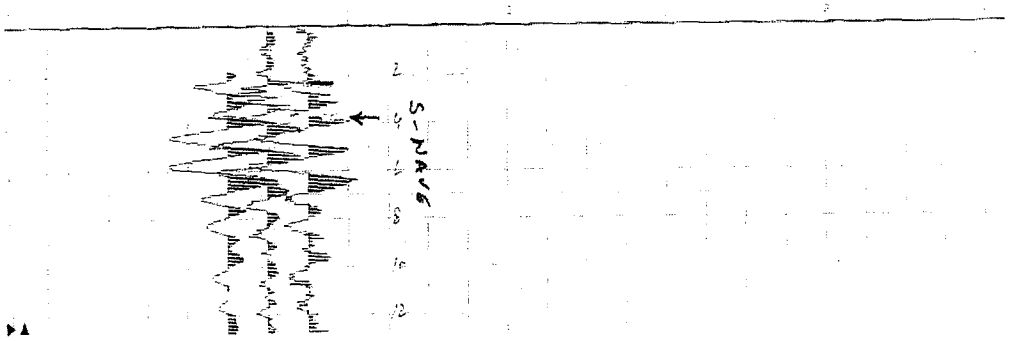
Record:	001491	Date:	23/OCT/2008
Sampling interval:	0.250 ms	Time:	10:14:04
Number of samples:	512 (128.0 ms)		
Delay:	0 ms		
Highpass filter:	Off	Plotmode:	Normalize (3x, clip=2
Notch filter:	On		
Digital filter:	None		

SHOT LOCATION: X = 0.000 m Y = 0.000 m Z = 0.000 m

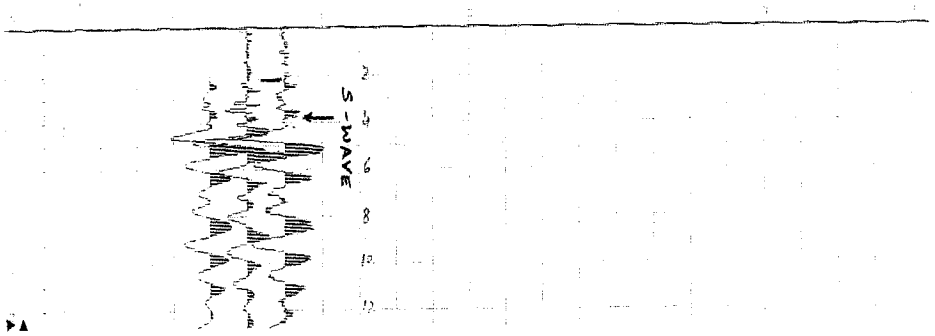
DEPTH – 7 meter
P – WAVE



DEPTH – 7 meters
S-Wave - SIDE-1



DEPTH – 7 meter
S-WAVE - SIDE-2



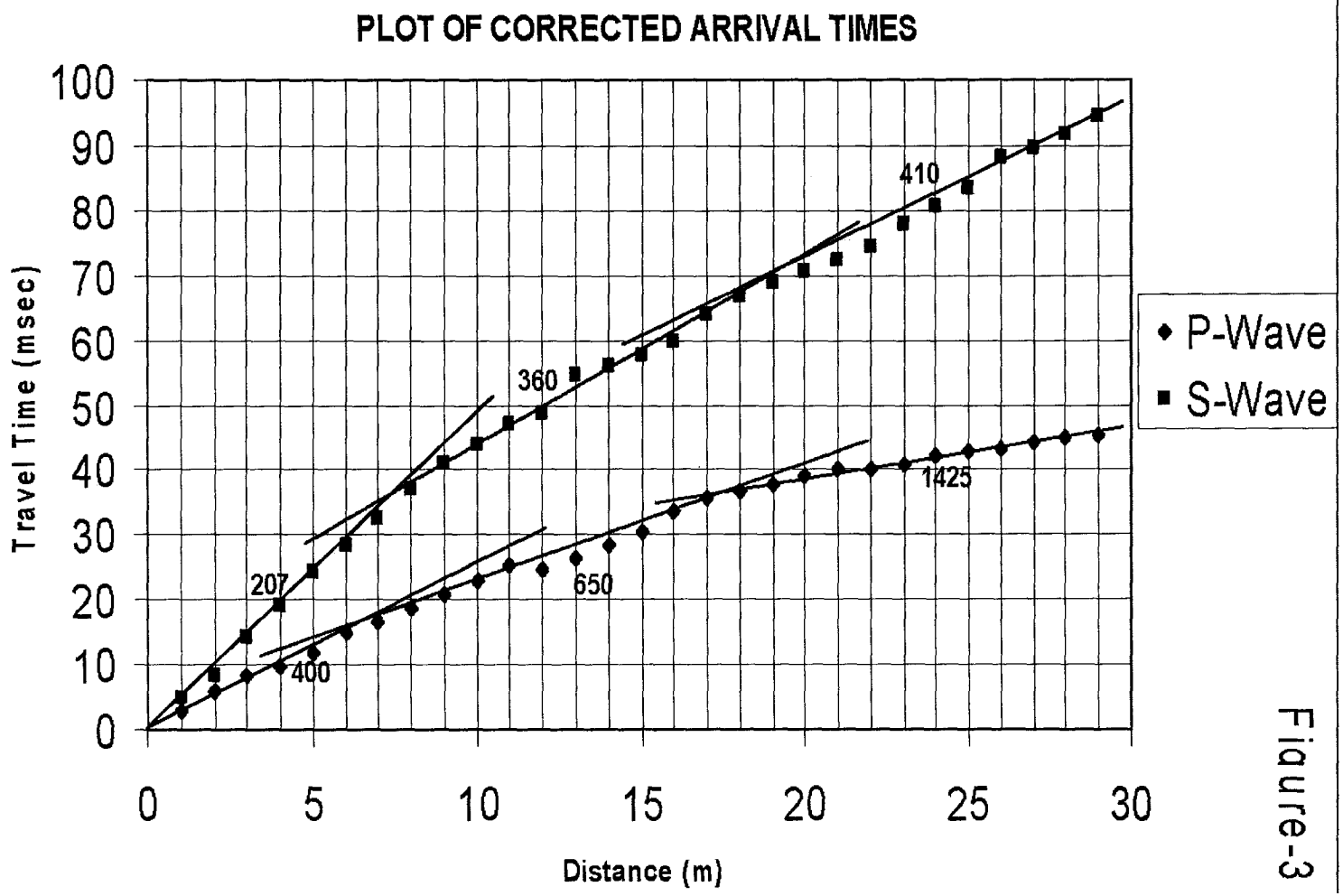

PLOT OF CORRECTED ARRIVAL TIMES
Travel Time (msec)
Distance (m)
0
10
20
30
40
50
60
70
80
90
100
0
5
10
15
20
25
30
207
360
410
400
650
1425
P-Wave
S-Wave

Figure-3

SECTION – 6

HYDROLOGICAL ASSESSMENT

1 BACKGROUND AND OBJECTIVE

1.1 On 29 November 2016, NEPRA had conducted hearing on the review petition filed by CJ Hydro (Private) Limited for issuance of the 'Generation License' in respect of its 44MW CJ Canal Hydropower Project ("Project").

1.2 The Authority expressed its concern regarding hydrological risk of the Project and required an updated feasibility study (duly approved by the POE) showing the latest hydrological projections of the Chashma Jhelum Link Canal("CJ Canal") for life of the Project, based on which output/size of the plant is determined, and can form basis for issuance of the Generation License.

1.3 The hydrology of the Project was required to be examined in light of the availability of water at tail end of the said CJ Canal (where the Project is located) after taking into account all relevant factors such as historical water-flows in River Indus and its diversion towards River Jhelum, and the impact of increased capacity at Mangla Dam upon the operations of CJ Canal.

1.4 To start-with, historical water-flows of the two rivers (i.e., Indus and Jhelum) have been studied to ascertain the natural volumes and the shortfall as per the irrigation requirements which is to be fulfilled either from (a) Indus River through CJ Canal, or (b) additional storage in Mangla Dam. Based thereon, the flows of CJ Canal with raised 'Mangla' for next 30 to 40 years are forecasted.

1.5 The estimated 'size/output', 'plant factor' and 'design discharge' of the Project have been reassessed in light of the conclusions drawn herein this report, which (subject to approval of other stakeholders) shall form basis to update other aspects of the feasibility study, and accordingly approval from the POE shall be obtained as required by NEPRA for issuance of the Generation License.

2 PROJECT LOCATION - CJ CANAL

2.1 The proposed site of the Project site is located between latitudes 31°-58'-04" North and longitudes 72°-12'-48" East. The Project has been planned on the right side at tail end of the CJ Canal near RD 316+622. CJ Canal transfers Indus River water to Jhelum River at a point which is about 97 km upstream of 'Trimmu Barrage' (one of the major barrages to distribute the water-flows for irrigation network in the province of Punjab). CJ Canal is approximately 103 km long starting from Chashma Barrage towards south-easterly direction with the upper half traversing the area irrigated by Thal Canal.

2.2 CJ Canal is non-perennial and its operations have been depending on water requirements of eastern river command area as well as surplus flows in Indus River. CJ Canal normally operates during summer in Kharif months when there are surplus flows in Indus River and the shortfall in flows of Jhelum River due to filling of Mangla Reservoir. The historical flows (as described below) depicts that CJ Canal has been operated during Rabi period, whenever there are shortfall of flows in Chenab River provided Indus River has surplus flows in addition to downstream requirements.

Tail/Outfall Regulator

2.3 The outfall at lower end of the CJ Canal consists of a combined gated link canal regulator, fall, and arterial road bridge, followed by three closely-spaced un-gated fall structures. The regulator, located at RD 315+622, has twelve conventional fixed-wheel gates (7.3 m wide by 3.96 m high). The three un-gated fall structures are located immediately below the regulator structure and are designed to drop link water surface from its full supply level above the regulator (a total of 14.2 m) to the low water level of the Jhelum River.

2.4 The three concentration falls at tailrace and adequate flows in summer months attracts to harness the potential resources for power generation. The head available for power generation varies from 9.8m to 14.2m depending on the flows in the canal and water level in Jhelum River. An average gross head of 13.8m can be considered to estimate power and energy.

CJ Canal Operation

2.5 CJ Canal transfers flows of Indus River to Jhelum River to augment the water- flow of Jhelum River for downstream command of canal system. The CJ Canal off-takes from the left bank of Chashma Barrage to a point on the Jhelum River about 40-km downstream from Khushab bridge. The designed capacity of CJ Canal is 615-m^3/s and is in operation since its inception in 1971.

2.6 CJ Canal operation is with a number of control regulators to cope with varying operational conditions to stability of canal bank slopes. This envisaged a very gradual opening of the link with an initial discharge of 85m^3/s in six hours followed by 109 hours till it attained the full supply of 615m^3/s. Similarly for closure due to operational or emergency reasons a gradual schedule was prescribed to bring down the link from full supply to zero in a period of 83 hours.

2.7 CJ Canal has experienced very erratic flows due to closure of discharge from Chashma Barrage. Such state of flows and varying water depths lead to erosion of unprotected slopes or berms due to rainwater at times of very low canal water level or especially during closure periods. Erosion due to the drainage effect of the link in some reaches when the flows are reduced or when the canal is fully closed. The severity of such erosion depends upon the period of draw down.

2.8 Seepage losses in the CJ Canal were estimated at $26m^3/s$ ($918\text{-}ft^3/s$) at full discharge after the link has been in operation for several years. Initial losses are expected to be higher, but they diminish rapidly with time during initial operation of the link. While the link will function as a drainage channel through areas of high groundwater, primarily the Harnoli depression area, and while a small amount of surface drainage may enter the link, the link will generally lose water.

2.9 CJ Canal is normally operated to fulfill water requirements rather than on the basis of sediment transport criteria. Generally silt free water enters in canal which has adversely affected its hydraulic geometry.

2.10 CJ Canal has been mainly operated to fulfill the shortfall of water requirement at Trimmu Barrage. The downstream water demand in dry period is met through another link canal known as 'TP link'. Due to heavy losses in Chenab River along the reach from Trimmu Barrage to Punjnad and keeping in view its requirements, water is diverted from River Indus to River Chenab to meet the requirements of Punjnad through TP Link Canal (the second canal after CJ Canal for diversion of water from River Indus towards River Chenab).

2.11 Water logging along the link include remedial measures for which control infrastructure exists near Adhikot (approximately 42kms ahead from the tail end of the CJ Canal). This causes the seepage downstream of Adhikot of which point the historical data of water-flows pertaining to the years 1991 to 2013 has been observed depicting the flows pattern of Indus and Jhelum Rivers which are vital for ascertaining the position of CJ Canal in terms of its historical and future water-flows which contribute towards to the irrigation canal system dependent on discharge available at Trimmu Barrage.

3 IMPORTANT ASPECTS FOR OPERATION OF CJ CANAL

3.1 The flows in CJ Canal are dependent on a variety of factors which mainly include the following:

(a) The CJ Canal is operated keeping in view the water inflows in rivers (Indus and Jhelum) and available storage volumes at the above mentioned reservoirs. Any change in the storage volume either on Indus or Jhelum River would likely to have some impact on the operations of CJ Canal.

(b) The underlying objectives of setting up CJ Canal were to (a) transfer surplus flows of Indus River to Jhelum River (downstream irrigation system of Indus River),and (b) to overcome flood impact in Indus River.

(c) Distribution of water in four provinces of Pakistan which is controlled by Indus River System Authority (IRSA) created in 1992 to implement the Water Apportionment Accord agreed amongst provinces in 1991.

(d) The reservoirs at Tarbela, Mangla and Chashma are operated to fulfill the irrigation requirements in accordance with the agreed proportionate water-share of the provinces (as per Water Accord 1991).

(e) CJ Canal has been operated both during Kharif as well as Rabi period. Water Accord in 1991 has refined the flows and share of distribution among provinces as per irrigation demand and flow available in the river system.

Historic Flows

3.2 CJ Canal has been in operation since 1971. After Water Accord of 1991 amongst four provinces, the operation of canal is managed by IRSA as per the allocation of water share for irrigation network to respective provinces.

3.3 The flows in CJ Canal have been consistent from 1991 to 2008. The reduction in annual flows of CJ Canal has been observed since 2009. The annual flow volume varies from 1.7 MAF to 9.1 MAF with average value of 5.26 MAF.

3.4 The transfer of excessive flows of Indus River to Jhelum River is well expected during Kharif period as and when there is shortage of water in Chenab and Jhelum Rivers. With less annual flow volume and storage in Jhelum River and Chenab River System, Rabi period is more critical for canals in southern Punjab. The shortage of water has been observed in Chenab River at Trimmu during Rabi period, for which CJ Canal had to be operated during Rabi period.

3.5 CJ Canal has been operated as non-perennial canal to meet water requirements of irrigation system of Jhelum and Chenab Rivers and to transfer surplus water of Indus River mainly in Kharif period. The annual flow volume is graphically presented below.

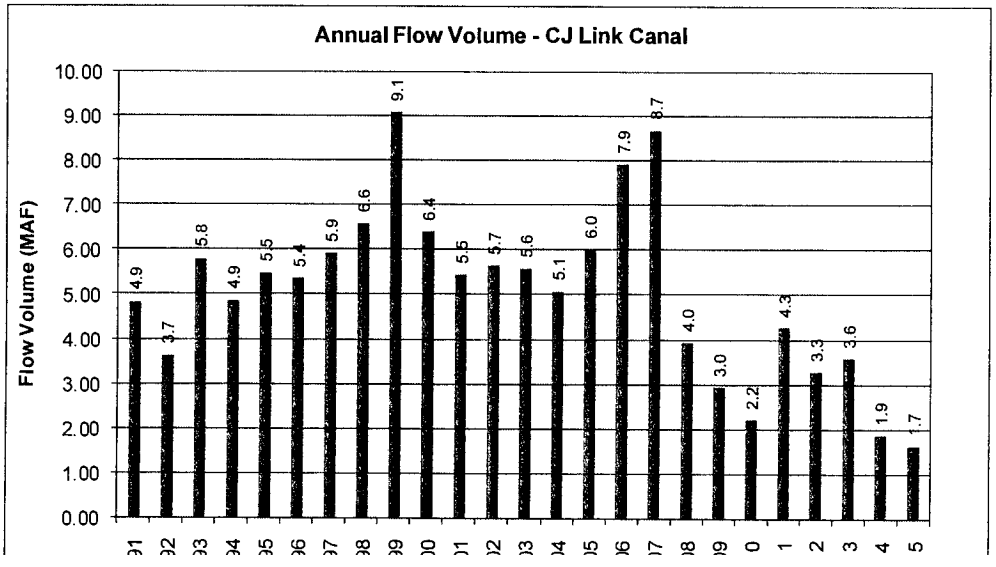


Figure – 02 Annual Flow Volumes – CJ Canal

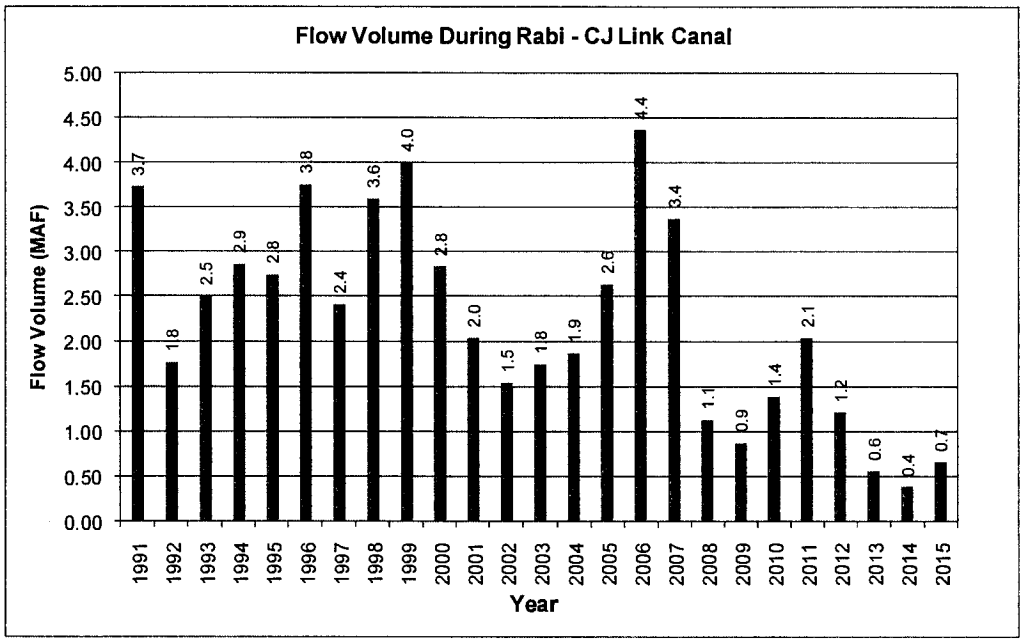


Figure – 03 - Flow Volume during Rabi – CJ Canal

3.6 CJ Canal operates in Rabi period as per the requirements of canal system at Trimmu Barrage. Flow volume in Rabi and Kharif period from 1991-2016 are presented in Figures -3 and 4 respectively. The flows in Rabi significantly vary from 0.4 MAF to 4.4 MAF with average value of 2.2 MAF.

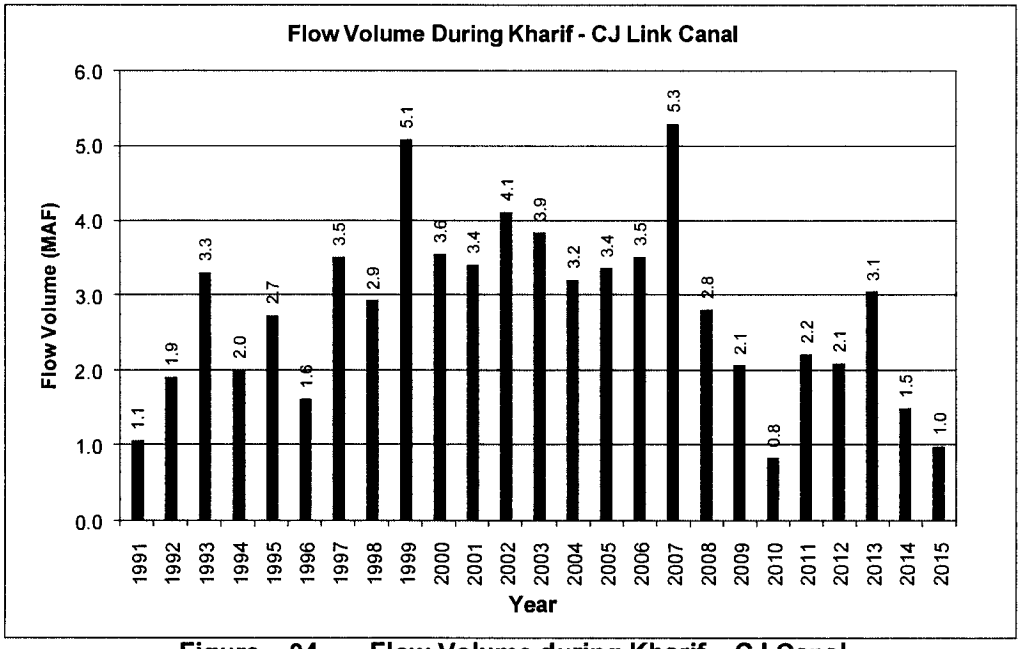


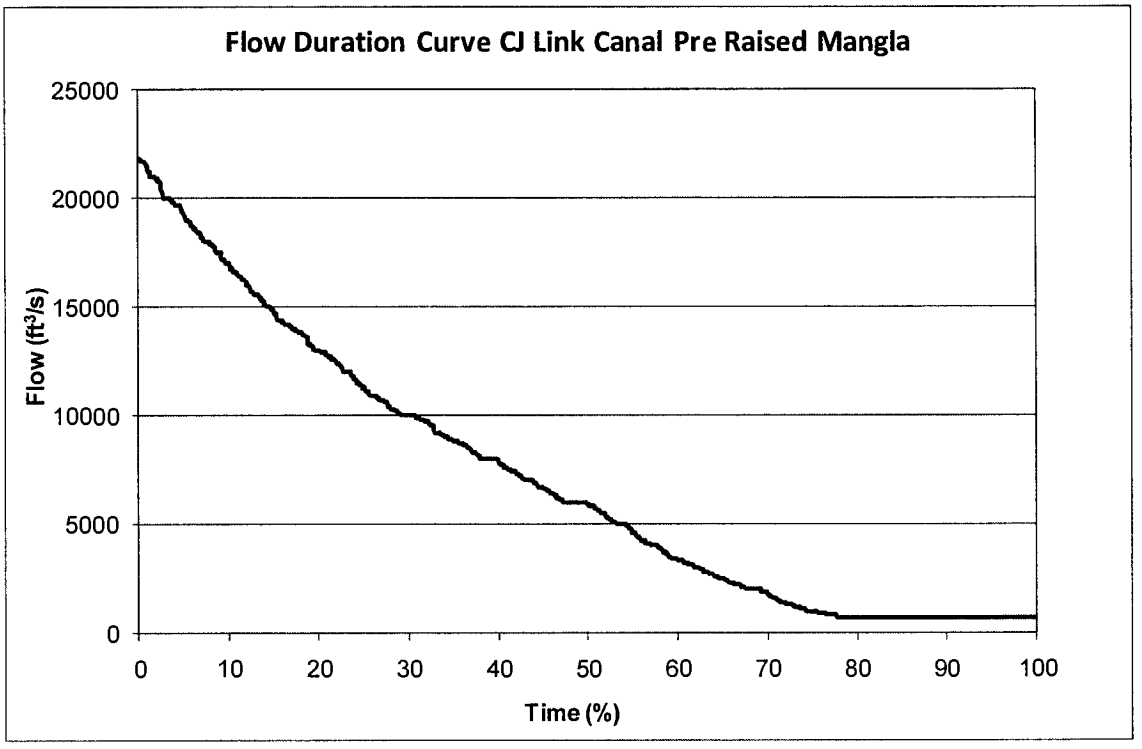
Figure – 04 - Flow Volume during Kharif – CJ Canal

3.7 The flows of CJ Canal during Kharif period depends on the availability of surplus flows in Indus River. The flows in Kharif period varies from 0.8 MAF to 5.3 MAF with average value of 3.02 MAF. The observed data of CJ Canal is at various points including Adhikot (about 42 Kms upstream of tail end falls). During canal closure period, seepage water from surrounding downstream of Adhikot has been observed at tail falls of the CJ Canal.

3.8 The flow duration curve for CJ Canal has been prepared to assess the flow availability over 25 years (1991-2016). This indicates that for about 22% time, the canal was found closed however seepage water flows has been witnessed during closure period. A discharge of 5000, 10000 and 15000 cfs has been observed for 58%, 30% and 13% time of the year.

3.9 The change in flow pattern of CJ Link has been observed with raised Mangla in operation since 2013.

3.10 Since 2008, the water-flows of CJ Canal are somewhat reduced which is commonly understood due to increased capacity of Mangla Reservoir, Based on historic 10 daily flow data, flow duration curve of the water availability in CJ Link has been prepared and is presented in Figure-05.



4.1 CJ Canal is primarily operated to meet water requirements of Trimmu Barrage or to transfer surplus flows of Indus River to Jhelum and Chenab rivers. The use of flows in Indus River is regulated by IRSA as per the Water Accord 1991.

4.2 The formula for water distribution is as follows.

Table -1 Provinces Water Share as per Water Accord 1991

Province	Kharif (MAF)	Rabi (MAF)	Total (MAF)
Punjab	37.07	18.87	55.94
Sindh*	33.94	14.82	48.76
N.W.F.P. (a)	3.48	2.30	5.78
Baluchistan	2.85	1.02	3.87
Total	77.34	37.01	114.35
N.W.F.P civil canals**	1.80	1.20	3.00

* Including already sanctioned urban and industrial uses for Metropolitan Karachi.

** Un-gauged Civil Canals above the rim stations.

4.3 Balance river supplies including flood supplies and future storage shall be distributed as below:

Punjab	*Sindh*	*Baluchistan*	*NWFP*	*Total*
37%	37%	12%	14%	100%

4.4 After Water Accord of 1991, CJ Canal has been operated to divert water-flows from River Indus towards River Jhelum/Chenab as per the allocation of water to the respective provinces (in particular to meet the shortfalls otherwise experienced at the irrigation network in Punjab linked with Trimmu Barrage).

4.5 The variation in flows in Rivers Indus and Jhelum and storage available at Tarbela and Mangla are of the contributing factors to operate the CJ Canal as per requirement at Trimmu Barrage after due consideration of downstream irrigation requirement mainly of Sindh Province.

4.6 The historical data pertaining to availability of water in River Jhelum and Chenab suggest that there is not enough water in the said rivers to fulfill the irrigation requirements as per the water allocation envisaged as per the Water Accord 1991.

4.7 It is however acknowledged that the aforesaid shortage of water at Trimmu Barrage is partially met (approximately 1 MAF) through the increased capacity of Mangla Reservoir (as further discussed below).

4.8 Surplus flows in Indus as per the Water Accord 1991 is to be utilized to meet the shortfall of River Jhelum and Chenab through the operations of CJ Canal.

5 METHODOLOGY FOR FLOW ANALYSIS OF CJ CANAL

5.1 It is commonly understood that CJ Canal is used to divert surplus water in River Indus towards River Jhelum primarily to meet the shortfall of water at Trimmu Barrage which is one of the major diversion structure to deal with the water-flows requirements for irrigation network in Punjab.

5.2 The irrigation network has been working on a pattern established after Tarbela Reservoir being operated since 1976. CJ Canal (starting from Chashma Barrage) has been in operation since its inception in 1971 when Chashma Barrage was completed under Indus Basin project.

5.3 To ascertain the requirement of CJ Canal (or the justification for its future operations), the following methodology has been adopted.

(a) Collection of daily or 10 daily flows of Indus, Jhelum, Chenab River and CJ Canal withdrawal in Punjab.

(b) Analysis of inflows at Mangla, Marala and Kalabagh Rim Stations and flows withdrawal in irrigation canals in the province of Punjab.

(c) Determinations of water-flow requirements in CJ Canal with due consideration of irrigation requirement at Trimmu and Punjnad barrages.

(d) The impact of increased capacity of Mangla Reservoir on CJ Canal operation pattern and the forecast for CJ Canal flows with the following due considerations:

- The additional storage of 2.8 MAF at Mangla Reservoir and its implications on CJ Canal flows as observed during 2013-16 due to raised Mangla are to be forecasted.
- To assess the Mangla outflows using historic inflow data between 1991 and 2013, as post raised Mangla. The comparison of pre-raised and post-raised Mangla outflows would provide difference of flows at Mangla.
- The net increase or decrease of Mangla outflows would be transposed at Trimmu Barrage to assess the reduction or increase of flows from CJ Canal. The historic data of Mangla inflow, outflows, Trimmu upstream, downstream and CJ Canal is also made part of this analysis.

(e) Critical analysis of the flow data at Adhikot which is available from the date of canal in operation till-date. Post Water Accord data from 1991 to 2015 is also critically analyzed for power and energy estimation. The flows in CJ Canal are reduced during Rabi period while the flows in Kharif remains in similar range as observed historically.

5.4 Energy estimation is worked out based on the analysis of forecasted flows as much as possible.

5.5 The final proposed capacity and energy has been evaluated on 10 daily basis availability of water-flows foreseeable at CJ Canal.

6 DATA COLLECTION

6.1 Historical data pertaining to the following locations have been gathered to analyze the water flows of Indus, Jhelum and Chenab River, (inclusive of impact of increased capacity of Mangla Reservoir) and the water-flows of CJ Canal.

- Indus River at Kalabagh seasonal flow volume 1976-2013.
- Indus River at Kotri barrage seasonal flow volume 1976-2013.
- Jhelum River at Mangla seasonal flow volume 1976-2013.
- Jhelum River at Rasul barrage 10-daily flow data 1992-2016.
- Chenab River at Qadirabad barrage 10-daily flow data 1985-2016.
- Chenab River at Trimmu barrage 10-daily flow data 1985-2016.
- Chenab River at Punjnad barrage 10-daily flow data 2002-2016.
- CJ Canal at Adhikot 10-daily flow data 1991-2016.
- TP Link canal at Tail 10-daily flow data 1991-2016.

6.2 The 10-daily data of Indus River available upstream of Chashma barrage and downstream of Kotri barrage provide the historic water requirement downstream of Chashma barrage. Flow data of Indus River at Chashma and at Kotri is useful to assess the water availability for diversion into CJ Link. Flows downstream of Kotri helps to make decision for CJ Link operation in Kharif as well in Rabi.

6.3 The flows availability of Chenab River at Qadirabad Barrage upstream, Jhelum River at Rasul Barrage upstream and Trimmu Barrage upstream indicate the historic water requirement in command area between Mangla, Marala and Trimmu stations.

6.4 The data has been analyzed without raised Mangla to understand historic flow pattern of CJ Canal as pre-raised Mangla, and to assess the flows in CJ Canal with post-raised Mangla scenarios.

6.5 With revised flow scenarios, an appropriate design discharge is chosen (discussed below) which could be a safe discharge to have the proposed installed capacity. The annual energy and plant factor based on mean monthly flows has also been determined (as further discussed below).

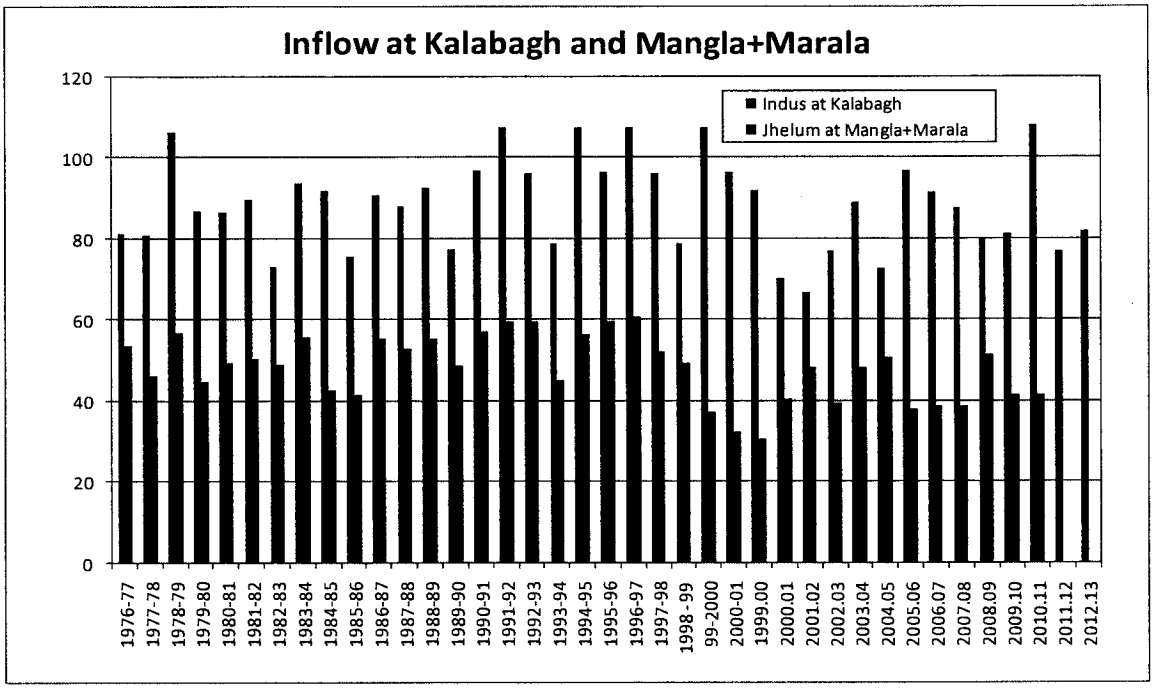
7 FLOWS AT RIM STATIONS (WATER AVAILABILITY - IRRIGATION SYSTEM)

7.1 As explained above, the water flows in CJ Canal are mainly dependent on availability of water in Indus River and the shortage in Jhelum and Chenab River systems which have been critically examined.

7.2 As such the flows in Indus River at Chashma Barrage and surplus water downstream of Kotri are one of the major driving factors and provide basis for operations of CJ Canal. The average annual flows of Indus, Jhelum and Chenab River is about 137.44 to 167 MAF approximately. The annual flows of Indus River at Kalabagh vary from 63 MAF to 110 MAF and total volume of flows of Jhelum at Mangla and Chenab River at Marala varies from 31 MAF to 60 MAF. The overall flows in three rivers indicate the flows for irrigation system in Punjab and the probability of diverting flows from Indus through CJ and TP Links canals.

Table – 2 Inflow of Indus River and its Western Tributaries

PERIOD	Kharif (MAF)	Rabi (MAF)	Total (MAF)
MAX	136.862	40.803	167.209
MIN	79.852	16.562	97.563
AVG	110.325	27.115	137.440



7.3 The increase in inflows of Indus River increases the probability of flows in CJ Canal. The surplus flows in Indus River during Kharif provide basis for CJ operation. During Rabi, the flows in CJ Canal depends on the shortage of water at Trimmu Barrage. At Trimmu Barrage, two rivers: Jhelum and Chenab Rivers join, therefore inflows series in both rivers has been analyzed (as further discussed below in the report).

7.4 The average annual flows of Jhelum River (at Mangla) and Chenab River (at Marala) is 45.931 MAF. The irrigation requirement of Punjab Province has been on average 49.761 MAF with varying range

from 37.044 MAF to 58.19 MAF. The shortfall in flows has to be met from Indus River at Jinnah, Chashma and Taunsa Barrages through link or irrigation canals. Chenab river at Marala and Khanki and Jhelum river at Rasul divert the flows to upper central part of Punjab and irrigation demand is managed from Chenab and Jhelum river flows. For southern Punjab, Trimmu and Punjnad barrages on Chenab River and Taunsa barrage on Indus River are main diversion points. Indus river diversion through CJ and TP Link depends on shortfall in Chenab River and available flows in Indus river on 10 daily basis.

Table – 3 Rim Station Inflows of Chenab and Jhelum Rivers

PERIOD	Kharif (MAF)	Rabi (MAF)	Total (MAF)
MAX	52.367	14.228	60.877
MIN	24.201	5.012	30.749
AVG	36.378	9.553	45.931

Table – 4 Irrigation Demand Punjab Province

PERIOD	Kharif (MAF)	Rabi (MAF)	Total (MAF)
MAX	37.664	23.120	58.190
MIN	27.238	9.806	37.044
AVG	33.262	16.499	49.761

7.5 Table-3 presents the combined available flows of Chenab river at Marala and Jhelum river at Mangla. During Rabi period flows vary from 5 MAF to 14 MAF, whereas irrigation demand varies from 9.0 MAF to 23 MAF.

7.6 During Kharif, flows are generally surplus to irrigation demand and excessive flows downstream of Punjnad barrage join Indus river at Kot Mithan. The most of shortfall in flows at downstream barrages; Trimmu and Punjnad.

7.7 The seasonal shortfall for the period 1976 to 2013 is presented in Table-5.

7.8 The water deficit both in Kharif and Rabi in the irrigation network of Punjab in terms of water availability and irrigation demand in tabulated in Table-5.

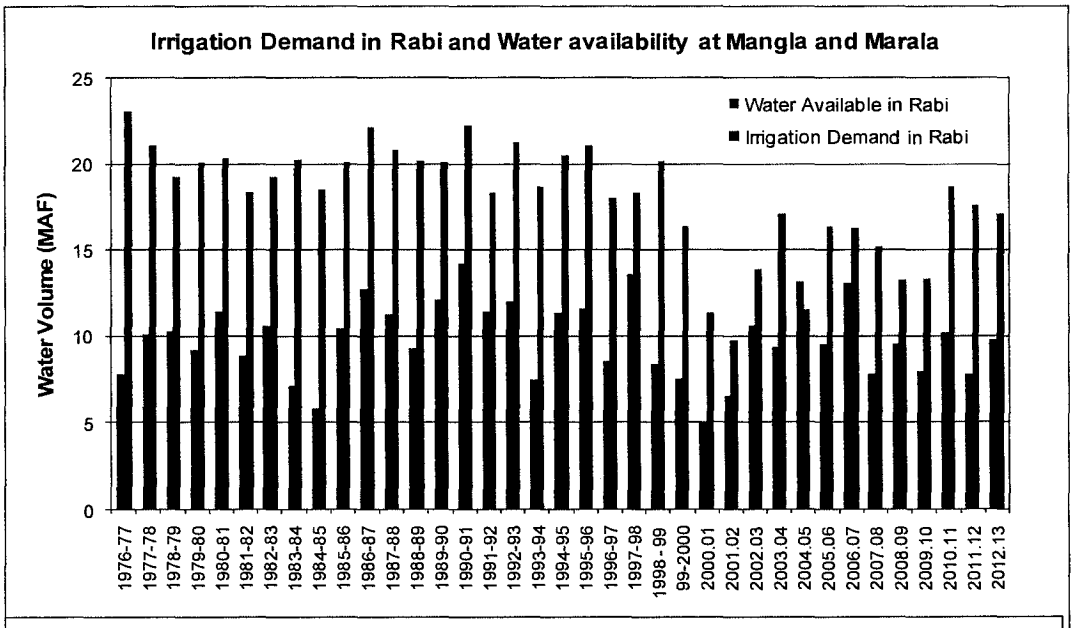
Table -5

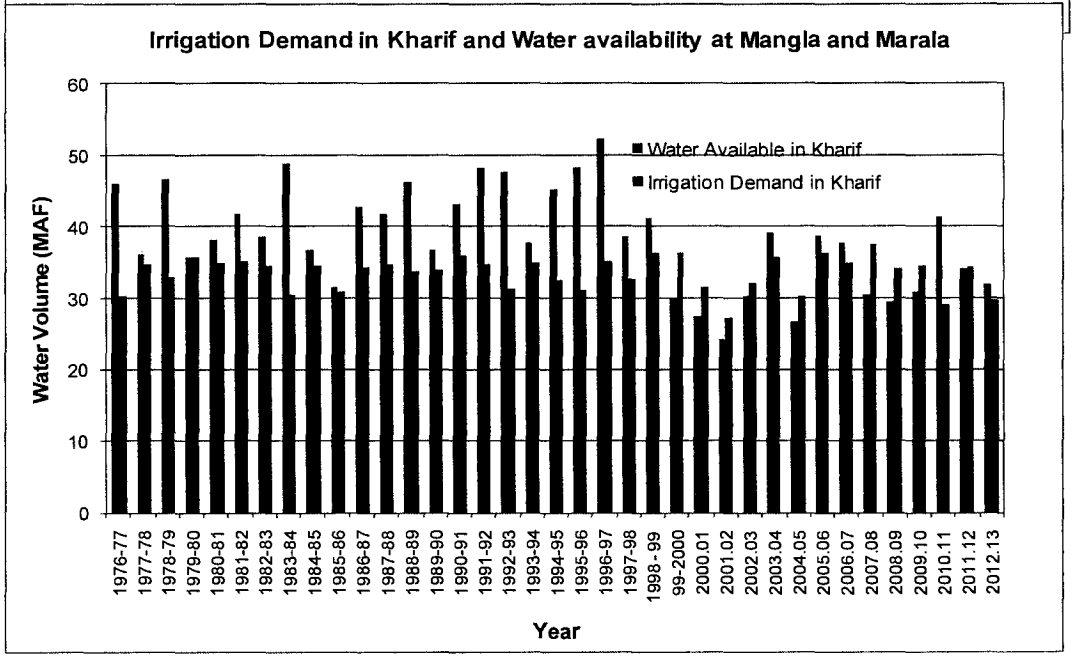
Chenab and Jhelum Rivers at Rim Stations

PERIOD	Water Availability (MAF)			Irrigation Demand (Punjab)			Deficit	
	Kharif	**Rabi**	**Total**	**Kharif**	**Rabi**	**Total**	**Kharif**	**Rabi**
	(MAF)	(MAF)	(MAF)	(MAF)	(MAF)	(MAF)	(MAF)	(MAF)
1976-77	46.055	7.771	53.826	30.22	23.12	53.34	15.835	-15.349
1977-78	36.161	10.063	46.223	34.82	21.08	55.90	1.341	-11.017
1978-79	46.637	10.258	56.896	32.93	19.28	52.21	13.707	-9.022
1979-80	35.839	9.167	45.005	35.67	20.14	55.81	0.169	-10.974
1980-81	38.207	11.418	49.625	34.85	20.38	55.23	3.357	-8.962
1981-82	41.813	8.859	50.671	35.06	18.36	53.42	6.753	-9.501
1982-83	38.524	10.592	49.117	34.53	19.32	53.85	3.994	-8.728
1983-84	48.919	7.126	56.045	30.43	20.3	50.73	18.489	-13.174
1984-85	36.841	5.817	42.658	34.56	18.57	53.13	2.281	-12.753
1985-86	31.440	10.426	41.866	30.83	20.11	50.94	0.610	-9.684
1986-87	42.805	12.733	55.537	34.25	22.21	56.46	8.555	-9.477
1987-88	41.783	11.252	53.035	34.67	20.88	55.55	7.113	-9.628
1988-89	46.217	9.276	55.494	33.79	20.2	53.99	12.427	-10.924
1989-90	36.816	12.072	48.889	33.95	20.1	54.05	2.866	-8.028
1990-91	43.136	14.228	57.364	35.89	22.3	58.19	7.246	-8.072
1991-92	48.302	11.456	59.758	34.84	18.34	53.18	13.462	-6.884
1992-93	47.694	11.994	59.688	31.28	21.27	52.55	16.414	-9.276
1993-94	37.761	7.464	45.225	34.91	18.75	53.66	2.851	-11.286
1994-95	45.335	11.303	56.638	32.62	20.5	53.12	12.715	-9.197
1995-96	48.264	11.588	59.852	31.07	21.09	52.16	17.194	-9.502
1996-97	52.367	8.510	60.877	35.12	18.06	53.18	17.247	-9.550
1997-98	38.663	13.606	52.269	32.81	18.41	51.22	5.853	-4.804
1998 - 99	41.221	8.385	49.606	36.4	20.2	56.6	4.821	-11.815
99-2000	29.933	7.539	37.472	36.46	16.38	52.834	-6.522	-8.840
2000.01	27.479	5.012	32.491	31.49	11.36	42.854	-4.015	-6.348
2001.02	24.201	6.548	30.749	27.24	9.81	37.044	-3.038	-3.258
2002.03	30.291	10.562	40.854	32.12	13.87	45.992	-1.827	-3.311
2003.04	39.163	9.368	48.532	35.80	17.17	52.973	3.362	-7.803
2004.05	26.643	13.132	39.775	30.33	11.54	41.874	-3.691	1.592
2005.06	38.837	9.488	48.325	36.43	16.40	52.832	2.403	-6.910
2006.07	37.819	13.105	50.924	34.92	16.28	51.202	2.900	-3.178
2007.08	30.468	7.800	38.268	37.66	15.25	52.914	-7.196	-7.451
2008.09	29.585	9.488	39.073	34.23	13.28	47.518	-4.649	-3.796
2009.10	30.941	7.949	38.890	34.57	13.36	47.933	-3.629	-5.414
2010.11	41.338	10.207	51.544	29.00	18.73	47.731	12.339	-8.526
2011.12	34.114	7.770	41.884	34.29	17.61	51.901	-0.176	-9.841
2012.13	31.826	9.799	41.625	29.75	17.14	46.891	2.076	-7.342
MAX	**52.367**	**14.228**	**60.877**	**37.664**	**23.120**	**58.190**	**18.489**	**1.592**
MIN	**24.201**	**5.012**	**30.749**	**27.238**	**9.806**	**37.044**	**-7.196**	**-15.349**
AVG	**36.378**	**9.553**	**45.931**	**33.262**	**16.499**	**49.761**	**3.116**	**-6.946**

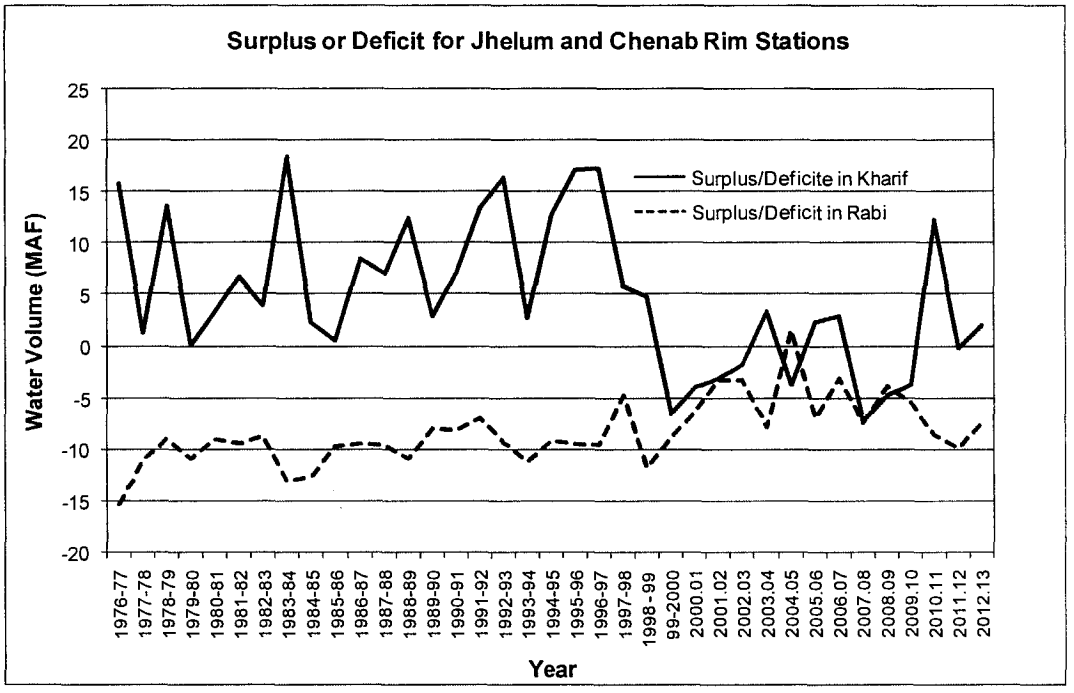
7.9 The above table shows that there is significant shortfall of water for Chenab Jhelum system which has to be met mainly from Indus River.

7.10 The following graphs show the irrigation demands at Mangla and Marala during Rabi and Kharif periods.





7.11 The shortage of water has been critically observed at Trimmu Barrage during Rabi period in addition to Punjnad Barrage. These shortages are met from Indus River through CJ Canal for Trimmu Barrage and Taunsa Punjnad Link Canal for Punjnad Barrage.



8 CHENAB RIVER FLOWS AT RASUL, QADIRABAD AND TRIMMU

8.1 The availability of water in River Chenab at Trimmu Barrage is mainly dependent on the flows coming from Barrages at Qadirabad and Rasul after fulfilling the requirement of upper irrigation system.

8.2 Chenab River at Trimmu receives flows from Qadirabad Barrage, Rasul Barrage and CJ Canal. The average flow volumes during Kharif and Rabi at Rasul barrage are 6.288 MAF and 3.487 MAF as tabulated below:

Table – 6 Jhelum River at Rasul

PERIOD	Kharif (MAF)	Rabi (MAF)	Total (MAF)
MAX	17.497	6.915	15.335
MIN	0.678	0.803	4.625
AVG	6.288	3.487	8.972

8.3 The average flow volumes during Kharif and Rabi at Qadirabad barrage are 9.013 MAF and 0.928 MAF respectively.

Table – 7 Chenab River at Qadirabad

PERIOD	Kharif (MAF)	Rabi (MAF)	Total (MAF)
MAX	20.051	2.305	13.365
MIN	2.246	0.277	2.929
AVG	9.013	0.928	7.893

8.4 The canal system from Rasul, Marala, Khanki and Qadirabad barrages depends on flows of Jhelum and Chenab rivers.

8.5 Barrages at Trimmu and Punjnad on Chenab River also take share of Indus River through links canals: CJ Canal and TP Link.

Table 8 Flows at Rasul and Qadirabad Downstream

Year	Rasul Downstream			Qadirabad Downstream		
	Khalif (MAF)	Rabi (MAF)	Annual (MAF)	Khalif (MAF)	Rabi (MAF)	Annual (MAF)
1991-92	16.08	1.81	17.89	13.32	1.61	14.93
1992-93	17.50	3.18	20.68	12.81	1.33	14.14
1993-94	7.06	0.86	7.92	9.90	0.10	10.01
1994-95	9.13	1.59	10.72	17.46	2.37	19.83
1995-96	11.54	1.74	13.28	20.05	1.43	21.48
1996-97	15.47	1.73	17.20	18.64	0.66	19.31
1997-98	8.17	5.82	13.98	13.31	3.02	16.33
1998-99	10.03	1.38	11.40	11.56	0.86	12.41
1999-00	1.42	0.41	1.83	4.80	0.35	5.15
2000-01	0.68	0.17	0.85	4.52	0.27	4.79
2001-02	0.97	0.35	1.31	4.42	0.75	5.18
2002-03	1.08	2.85	3.94	5.68	2.24	7.92
2003-04	5.08	2.22	7.29	8.46	0.48	8.94
2004-05	2.29	2.86	5.15	2.25	3.16	5.40
2005-06	5.68	1.90	7.58	9.38	0.53	9.91
2006-07	5.44	2.33	7.77	10.39	2.92	13.31
2007-08	3.82	0.80	4.62	4.82	0.28	5.09
2008-09	3.09	2.78	5.87	4.88	0.37	5.24
2009-10	4.25	1.93	6.19	2.52	0.41	2.93
2010-11	9.67	2.72	12.39	10.04	0.75	10.79
2011-12	4.84	3.05	7.89	6.13	0.48	6.61
2012-13	4.25	3.06	7.31	4.64	0.96	5.61
2013-14	3.12	4.17	7.29	8.38	1.00	9.38
2014-15	7.91	5.95	13.86	9.72	2.31	12.02
2015-16	8.42	6.91	15.34	11.56	1.80	13.36
	6.68	**2.50**	**9.18**	**9.19**	**1.22**	**10.40**

8.6 With flows in CJ Canal, the water requirements at Trimmu Barrage are generally met. The canal withdrawals have been on average 2.86 MAF in Rabi and 5.01 MAF in Kharif.

8.7 The flow volume at Trimmu during Rabi varies 1.81 MAF to 10.65 MAF with average value of 4.98 MAF.

8.8 The upstream and downstream flows at Trimmu are summarized as below.

Table -9 Flows at Trimmu and Canal Withdrawals

Year	Trimmu Upstream			Canal Withdrawal at Trimmu			Trimmu Downstream		
	Khalif (MAF)	Rabi (MAF)	Annual (MAF)	Khalif (MAF)	Rabi (MAF)	Annual (MAF)	Khalif (MAF)	Rabi (MAF)	Annual (MAF)
1991	31.15	5.76	36.92	5.01	2.95	7.96	26.14	2.82	28.96
1992	33.67	6.88	40.56	5.92	3.28	9.20	27.75	3.60	31.35
1993	18.28	2.97	21.25	4.47	2.62	7.09	13.81	0.34	14.15
1994	25.64	5.99	31.63	4.94	3.20	8.15	20.70	2.79	23.49
1995	32.68	5.89	38.57	5.07	3.43	8.51	27.61	2.46	30.07
1996	33.28	4.88	38.17	5.36	2.99	8.35	27.92	1.89	29.81
1997	22.31	10.65	32.96	5.70	3.16	8.86	16.61	7.49	24.10
1998	22.42	5.73	28.15	4.96	2.90	7.85	17.47	2.83	20.30
1999	9.53	2.89	12.43	5.75	1.94	7.69	3.79	0.95	4.74
2000	5.94	1.81	7.76	4.08	1.41	5.49	1.87	0.40	2.27
2001	6.71	2.16	8.87	4.52	2.03	6.55	2.19	0.13	2.33
2002	8.45	5.67	14.12	4.40	2.73	7.13	4.05	2.94	6.99
2003	16.53	3.87	20.40	5.39	2.43	7.81	11.15	1.44	12.58
2004	5.75	5.49	11.24	4.64	3.34	7.98	1.11	2.15	3.27
2005	15.26	6.51	21.77	4.63	3.01	7.64	10.62	3.51	14.13
2006	15.61	7.64	23.25	5.43	3.86	9.30	10.17	3.78	13.95
2007	10.53	2.61	13.14	4.87	1.97	6.84	5.65	0.64	6.29
2008	7.62	3.26	10.88	4.85	2.15	7.00	2.77	1.11	3.88
2009	7.65	2.16	9.82	5.41	1.95	7.36	2.24	0.21	2.46
2010	20.50	5.15	25.65	5.59	3.36	8.94	14.91	1.79	16.70
2011	8.37	3.82	12.20	2.28	2.02	4.30	6.09	1.81	7.90
2012	9.35	4.53	13.87	5.38	2.78	8.16	3.97	1.74	5.71
2013	13.59	4.57	18.16	5.46	3.02	8.47	8.13	1.55	9.68
2014	16.74	9.34	26.08	5.76	3.13	8.89	10.98	6.21	17.19
2015	21.08	8.18	29.26	5.40	5.90	11.29	15.68	2.28	17.97
	16.75	**5.14**	**21.88**	**5.01**	**2.86**	**7.87**	**11.74**	**2.27**	**14.01**

9 CHANGE IN JHELUM RIVER FLOWS WITH RAISED MANGLA

9.1 The capacity of Mangla reservoir was raised up-to 7.3 MAF which project was completed in 2013 after which the reservoir started filling. The filling of reservoir during Kharif period results into reduction of flows in Jhelum River, whereas flows in Rabi period are somewhat increased in River Jhelum. This has improved the flow availability of Chenab River at Trimmu.

9.2 To assess the changed flow scenario in Jhelum at Rasul, and Chenab River at Trimmu, Reservoir routing of Mangla flows is carried out for the period 1991-2013. The reservoir routing has been carried out to have maximum reservoir level to be attained each year with essential irrigation releases during Kharif. The results of reservoir routing are presented as Annex-2 of this report.

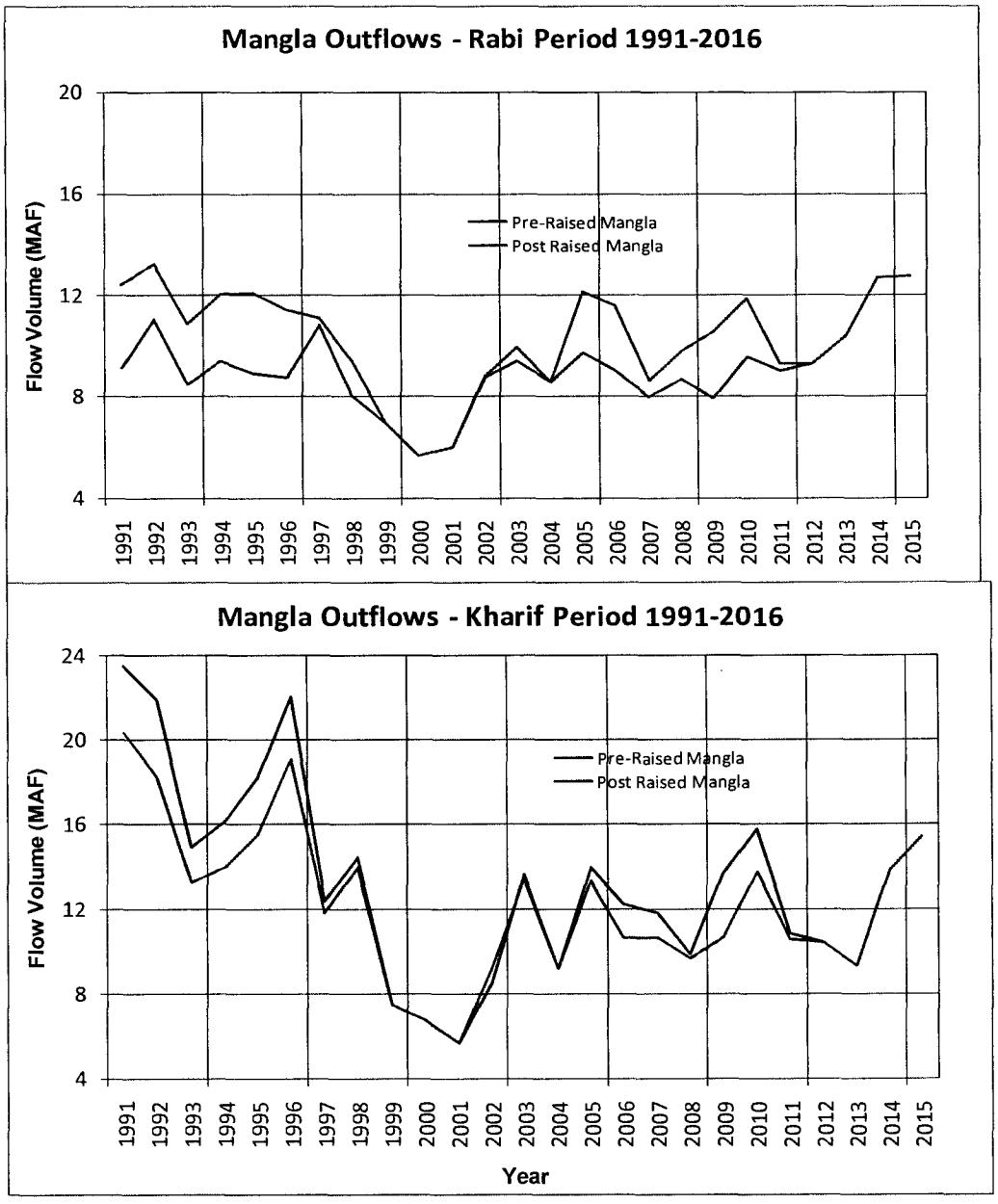
9.3 The flow volume for Pre and Post Raised Mangla outflows scenario during 1991-2013 is presented in table below.

Table -10 Mangla Outflows

Year	Pre-Raised Mangla Outflows			Post-Raised Mangla Outflows		
	Khalif (MAF)	Rabi (MAF)	Annual (MAF)	Khalif (MAF)	Rabi (MAF)	Annual (MAF)
1991-92	23.50	9.14	32.64	20.34	12.41	32.75
1992-93	21.92	11.06	32.97	18.24	13.26	31.51
1993-94	14.93	8.48	23.41	13.31	10.88	24.19
1994-95	16.11	9.39	25.50	14.00	12.01	26.01
1995-96	18.22	8.90	27.11	15.48	12.07	27.55
1996-97	22.08	8.73	30.81	19.10	11.41	30.52
1997-98	12.40	10.82	23.22	11.83	11.11	22.94
1998-99	14.47	8.04	22.51	13.96	9.36	23.32
1999-00	7.46	6.92	14.38	7.70	7.18	14.88
2000-01	6.79	5.67	12.46	6.45	6.19	12.65
2001-02	5.67	5.99	11.66	5.13	6.56	11.69
2002-03	8.49	8.76	17.26	8.01	10.48	18.49
2003-04	13.64	9.40	23.04	13.40	9.93	23.33
2004-05	9.19	8.55	17.74	10.13	6.80	16.93
2005-06	13.96	9.73	23.69	13.33	12.13	25.46
2006-07	12.24	8.99	21.23	10.65	11.62	22.27
2007-08	11.82	8.00	19.81	10.66	8.64	19.30
2008-09	9.88	8.71	18.59	9.68	9.76	19.44
2009-10	13.69	7.94	21.63	10.65	10.58	21.23
2010-11	15.75	9.54	25.29	13.73	11.87	25.60
2011-12	10.83	8.99	19.82	10.59	9.30	19.90
2012-13	10.48	9.30	19.78	10.48	9.30	19.78
2013-14	9.36	10.37	19.73	9.22	11.00	20.22
2014-15	13.80	12.67	26.47	13.55	13.07	26.61
2015-16	15.42	12.75	28.17	15.51	13.31	28.82
	13.28	**9.07**	**22.36**	**12.21**	**10.41**	**22.61**

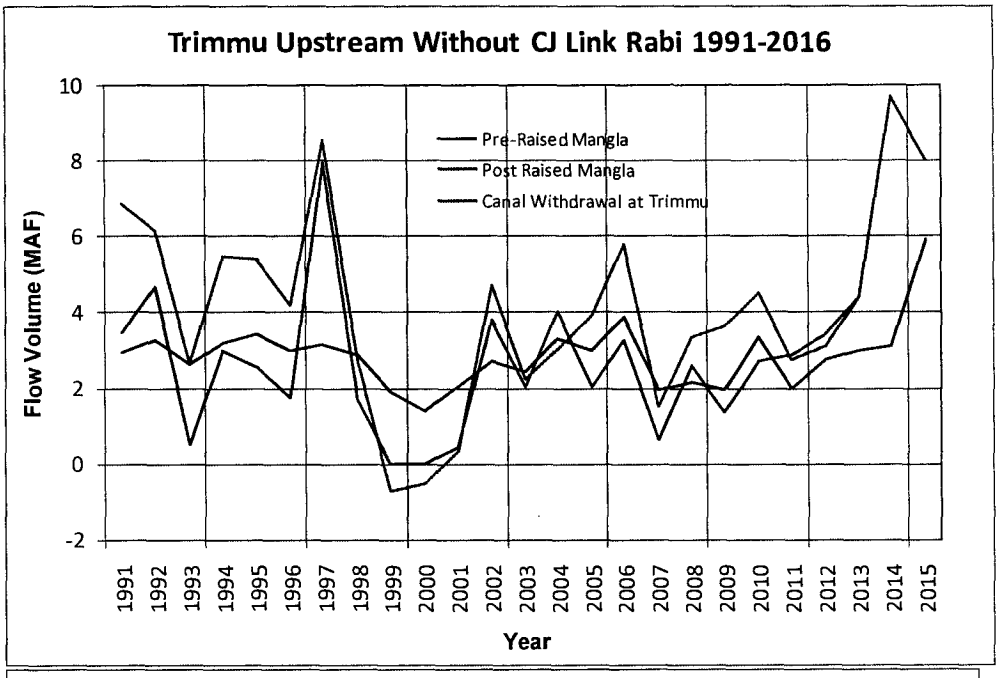
9.4 The impact on Kharif and Rabi volume can be observed at Mangla depending on inflow. Previously, average releases in Rabi have been 9.07 MAF and with Raised Mangla it has been increased to 10.41 MAF. This means with Raised Mangla the average net increase is 1.33 MAF.

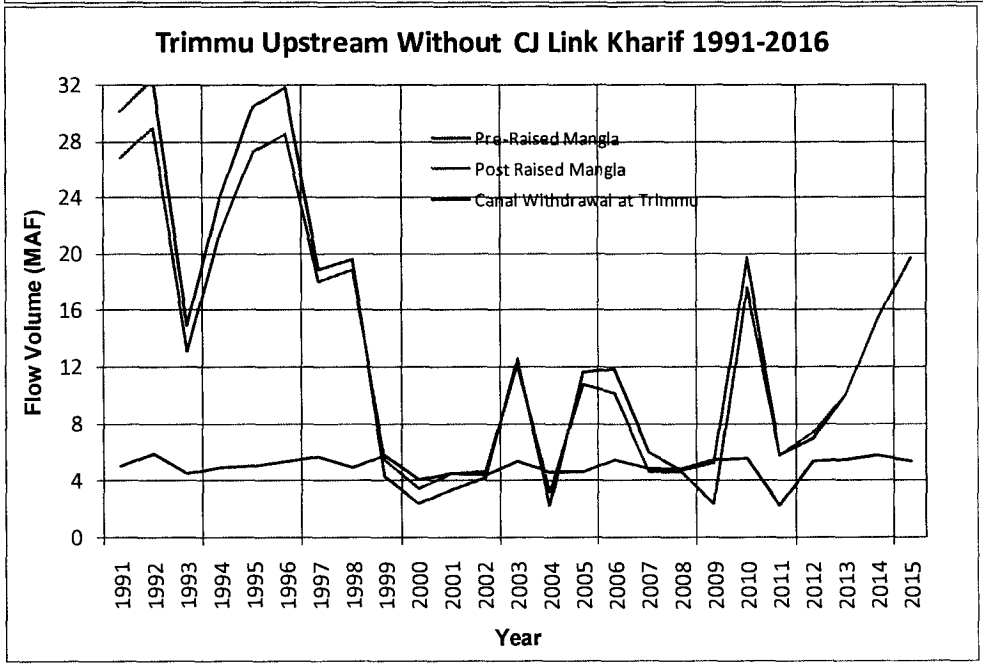
9.5 Mangla outflows during 1991-2016 for pre and post-raised scenarios during Rabi and Kharif are presented in Figure - 08 and 09 respectively.



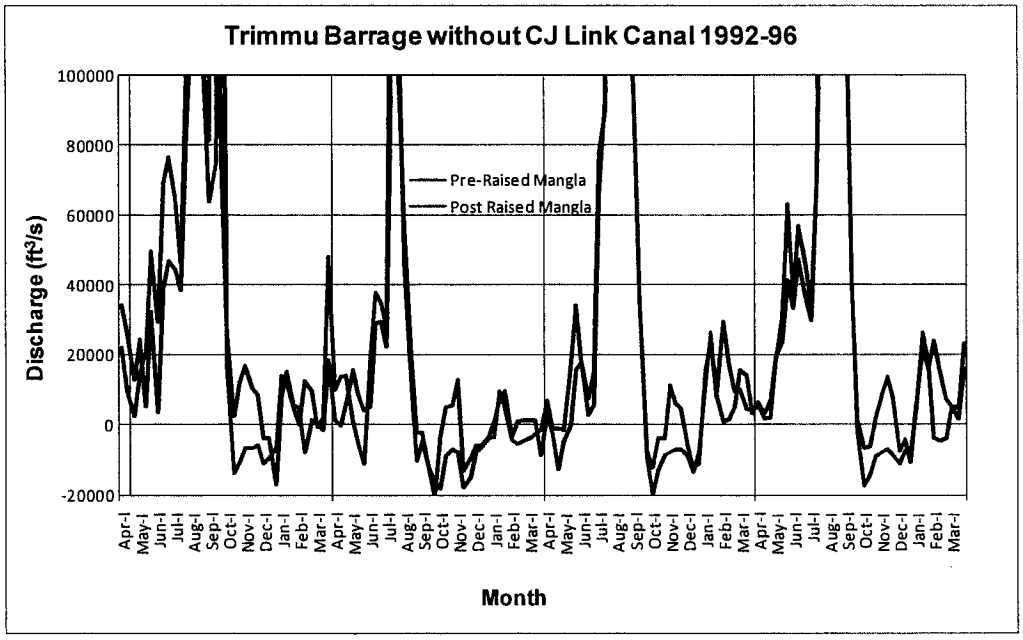
10 IMPACT OF RAISED MANGLA AT TRIMMU BARRAGE

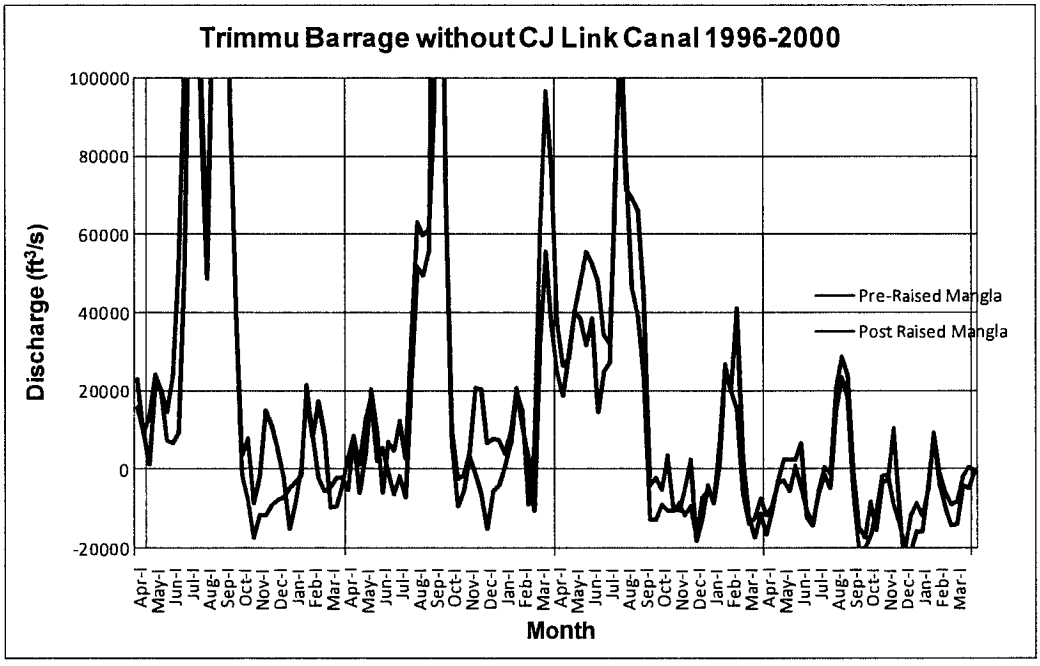
10.1 The 10-daily observed flow series at Trimmu Barrage have been modified to include the impact of raised Mangla. The change in flow series of Mangla has been transposed to Trimmu historic flows with 5% losses in the river regime between Mangla and Trimmu.



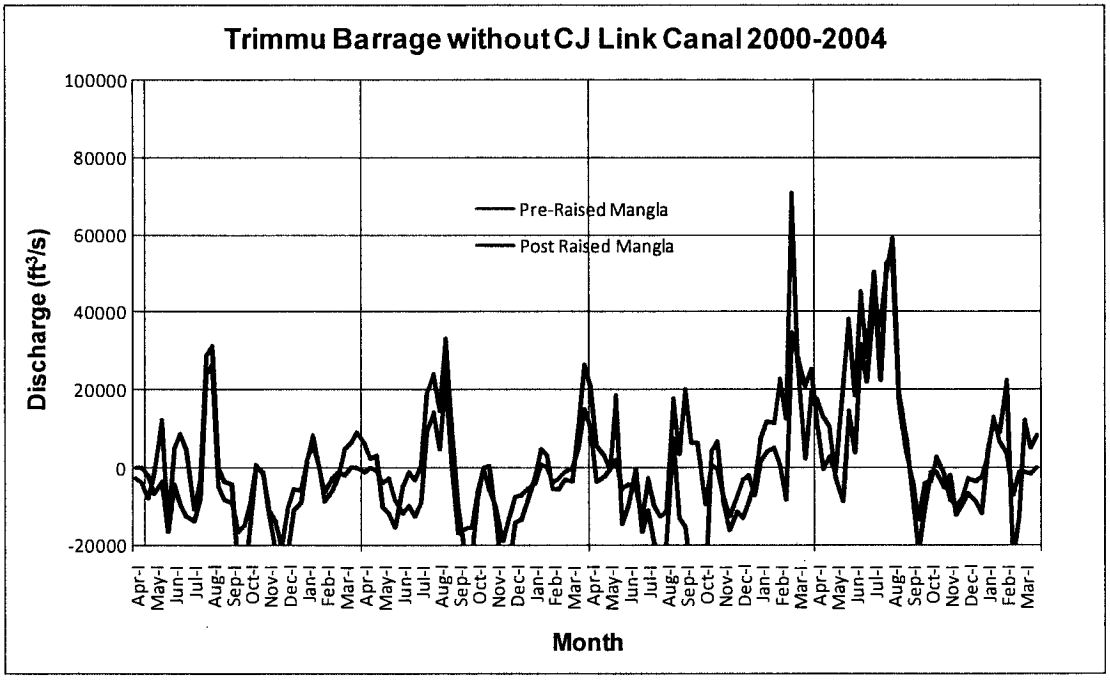


10.2 The impact of raised Mangla on Rabi flows is pronounced. During dry years, the deficit of flows in Kharif as well as Rabi requires CJ Canal to be operated. The impact of CJ Canal on Trimmu Barrage has been evaluated. Without CJ Canal, Trimmu flows are presented in Figures – 13 to 18.

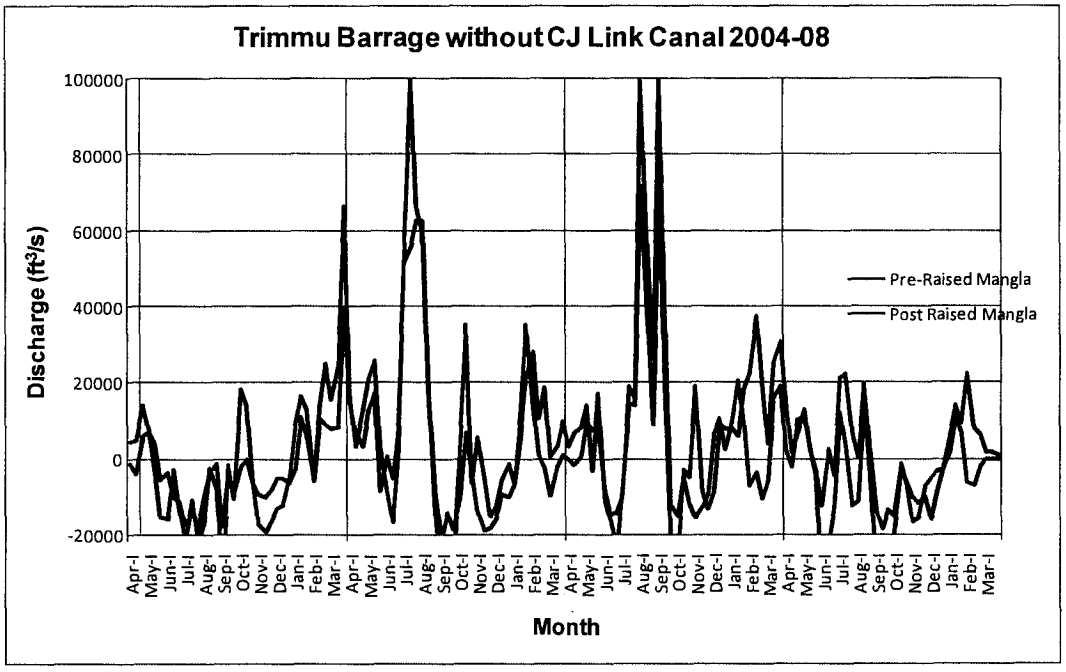


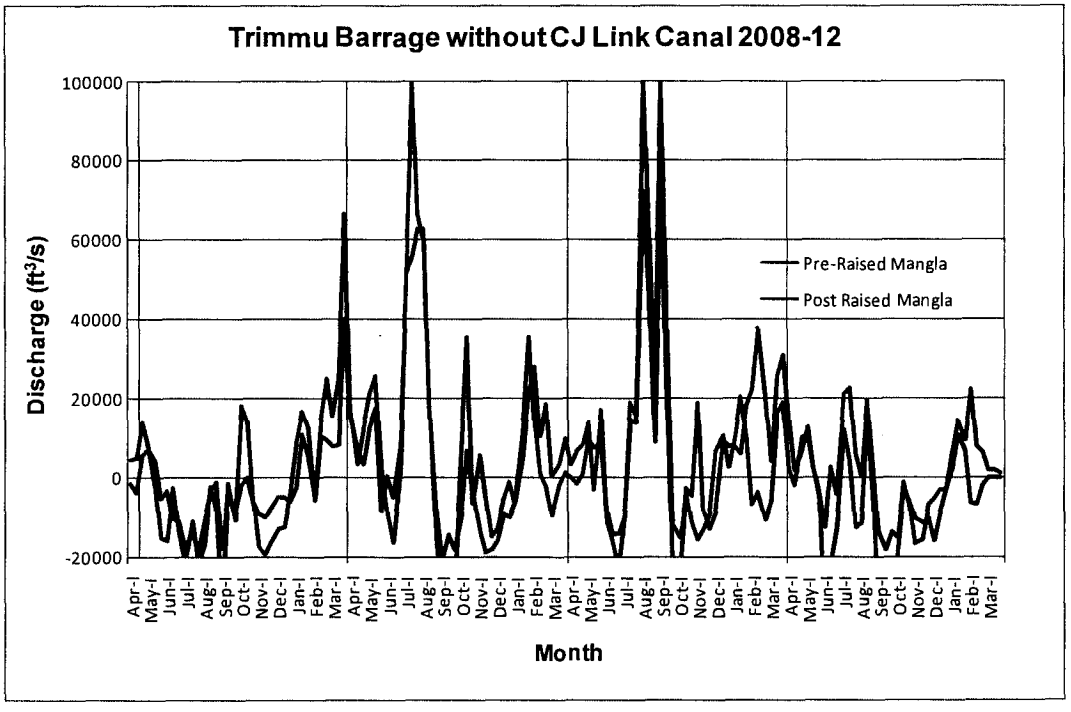


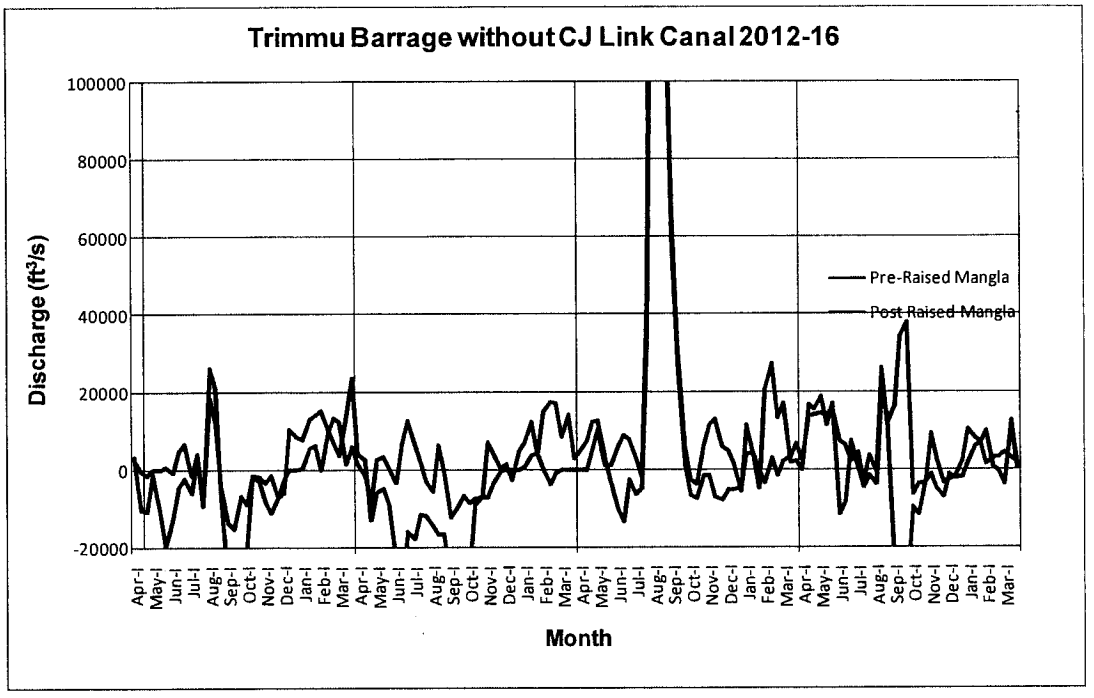
10.3 During August to February, flows are insufficient to support canal withdrawals; however from 1991-2012, the operation of CJ Canal has been found mandatory, and after raised Mangla, CJ Canal flows improved in November and February.



10.4 In dry years 2000 to 2003, water shortage in June, August to February has been observed even with raised Mangla scenario. The following graphs shows the shortage of water-flows at Trimmu Barrage without CJ Link Canal from the years 2004 onwards.






Trimmu Barrage without CJ Link Canal 2012-16
Discharge (ft³/s)
100000
80000
60000
40000
20000
0
-20000
Pre-Raised Mangla
Post Raised Mangla
Month

10.5 The flows of Chenab River would improve with Raised Mangla scenario. The average increase in Rabi has been estimated as 0.99 MAF at Trimmu and a decrease of 0.93 MAF during Kharif period.

Table -11 Chenab River Flows at Trimmu

Year	Pre-Raised Mangla Trimmu Upstream			Post-Raised Mangla Trimmu Upstream		
	Khalif (MAF)	Rabi (MAF)	Annual (MAF)	Khalif (MAF)	Rabi (MAF)	Annual (MAF)
1991-92	31.15	5.76	36.92	27.85	9.14	36.99
1992-93	33.67	6.88	40.56	30.28	8.36	38.64
1993-94	18.28	2.97	21.25	16.50	5.10	21.61
1994-95	25.64	5.99	31.63	23.17	8.47	31.64
1995-96	32.68	5.89	38.57	29.53	8.73	38.26
1996-97	33.28	4.88	38.17	29.97	7.32	37.29
1997-98	22.31	10.65	32.96	21.38	11.25	32.63
1998-99	22.42	5.73	28.15	21.64	6.75	28.39
1999-00	9.53	2.89	12.43	10.69	2.18	12.87
2000-01	5.94	1.81	7.76	7.02	1.31	8.32
2001-02	6.71	2.16	8.87	7.86	2.07	9.94
2002-03	8.45	5.67	14.12	8.90	6.58	15.47
2003-04	16.53	3.87	20.40	16.08	4.07	20.15
2004-05	5.75	5.49	11.24	6.63	4.49	11.13
2005-06	15.26	6.51	21.77	14.45	8.37	22.82
2006-07	15.61	7.64	23.25	13.91	10.14	24.05
2007-08	10.53	2.61	13.14	9.08	3.51	12.59
2008-09	7.62	3.26	10.88	7.53	4.01	11.54
2009-10	7.65	2.16	9.82	4.82	4.45	9.28
2010-11	20.50	5.15	25.65	18.34	6.96	25.30
2011-12	8.37	3.82	12.20	8.32	3.70	12.02
2012-13	9.35	4.53	13.87	9.85	4.22	14.07
2013-14	13.59	4.57	18.16	13.75	4.44	18.19
2014-15	16.74	9.34	26.08	16.91	10.13	27.04
2015-16	21.08	8.18	29.26	21.04	8.07	29.11
	16.75	**5.14**	**21.88**	**15.82**	**6.15**	**21.97**

11 CJ CANAL OPERATION DURING 2009 TO 2016

11.1 The flows in CJ Canal have been on decreasing trend after year 2008. The annual flows remained below 3.5 MAF. The reason for reduced flows is the below average annual flows in Indus river 2008-10, 2011-2013 and high annual flows in Jhelum-Chenab river system during 2014-2016. The impact of raised Mangla can be observed from 2013-16, where deficit without CJ Canal has been less as compared with period 1991-2008.

11.2 With post raised Mangla scenario, the flows during Rabi are improved and the need of operating CJ Canal remained less. The main reason for improved Rabi flows during 2014-15 and 2015-16 is relatively high inflows in Jhelum River as can be observed from the following Table.

Table -12 - Jhelum River Mangla Outflows

Year	Mangla Outflows		
	Khalif (MAF)	Rabi (MAF)	Annual (MAF)
2000-01	6.45	6.19	12.65
2001-02	5.13	6.56	11.69
2002-03	8.01	10.48	18.49
2003-04	13.40	9.93	23.33
2004-05	10.13	6.80	16.93
2005-06	13.33	12.13	25.46
2006-07	10.65	11.62	22.27
2007-08	10.66	8.64	19.30
2008-09	9.68	9.76	19.44
2009-10	10.65	10.58	21.23
2010-11	13.73	11.87	25.60
2011-12	10.59	9.30	19.90
2012-13	10.48	9.30	19.78
2013-14	9.22	11.00	20.22
2014-15	13.55	13.07	26.61
2015-16	15.51	13.31	28.82

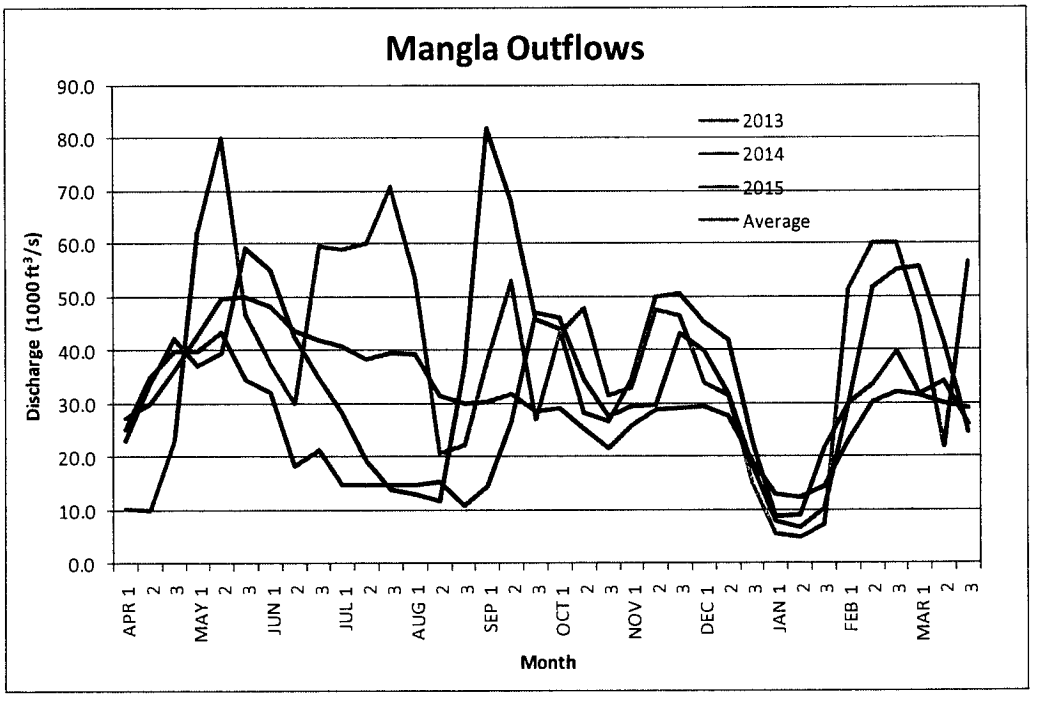


Figure – 20 Mangla Outflows

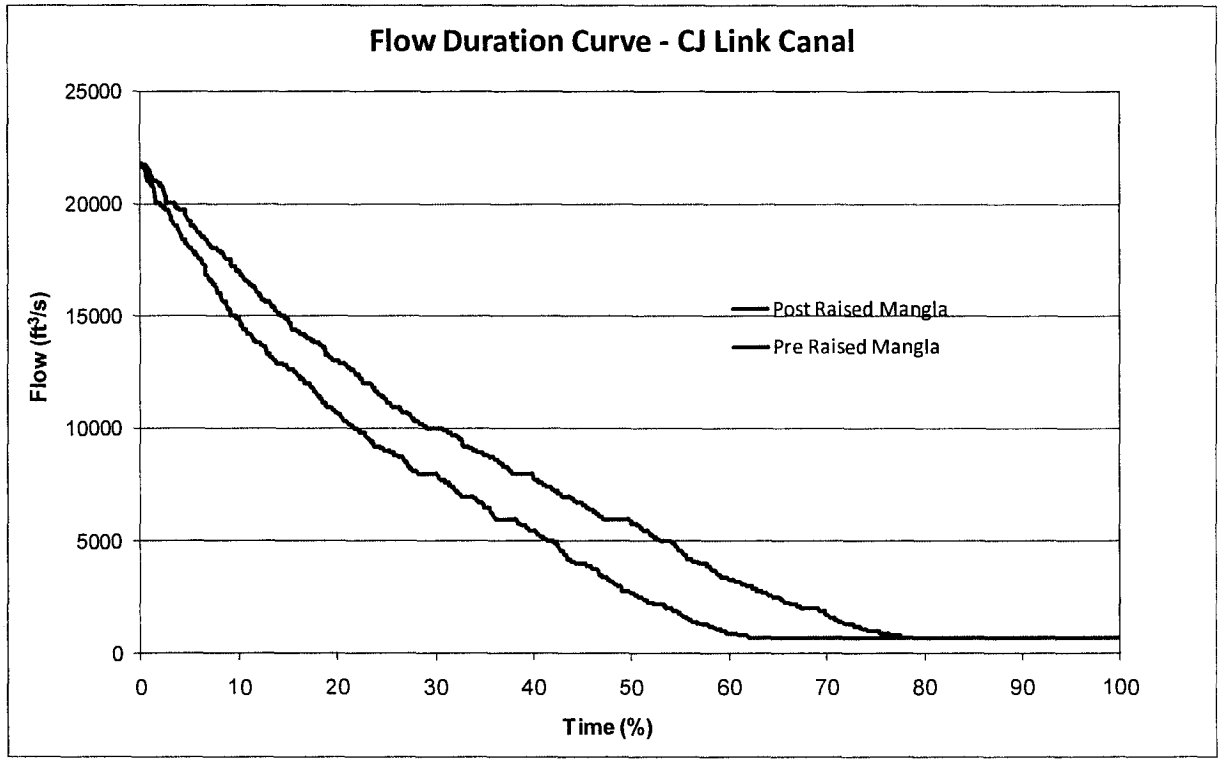


Figure – 21 Flow Duration Curve – Pre and Post Raised Mangla

12 CJ CANAL – POST MANGLA SCENARIO

12.1 Due to increased storage at Mangla Dam, the flows in CJ Canal during Rabi period would be rationalized. The improved flows at Mangla outflows by 1.33 MAF has been estimated as 0.99 MAF at Trimmu and the reduction in CJ flows during Rabi period is 0.42 MAF. Although flows in Kharif depends on surplus flows in Indus river. Keeping in view the CJ operation 2013-16, some reduction as compared with historic is anticipated on average 0.72 MAF with raised Mangla Dam. The Kharif and Rabi flows for pre and post Mangla scenarios are indicated in Table – 13 below.

12.2 The flows in CJ Canal have been estimated for Post Mangla scenario, using the historic flow series of CJ Canal and deducting the increased flow at Trimmu.

Table -13 Flows in Chashma Jhelum Link Canal

Year	Post Raised Mangla CJ Link Flows			Pre Raised Mangla CJ Link Flows		
	Kharif MAF	Rabi MAF	Total MAF	Kharif MAF	Rabi MAF	Total MAF
1991-92	0.89	1.99	2.88	0.93	2.24	3.17
1992-93	0.20	1.85	2.05	1.25	2.13	3.39
1993-94	2.07	2.37	4.44	3.32	2.46	5.77
1994-95	1.32	2.85	4.17	1.70	3.02	4.72
1995-96	1.27	3.11	4.38	2.18	3.29	5.47
1996-97	0.80	2.67	3.47	1.33	3.14	4.47
1997-98	2.79	1.67	4.46	3.34	2.85	6.19
1998-99	1.73	3.63	5.37	2.77	4.24	7.01
1999-00	4.96	1.86	6.81	5.17	2.98	8.15
2000-01	2.92	0.94	3.86	3.47	1.98	5.45
2001-02	2.70	0.67	3.37	3.32	1.70	5.02
2002-03	3.34	1.23	4.57	4.18	1.94	6.12
2003-04	3.00	1.21	4.20	3.88	1.83	5.71
2004-05	3.09	0.87	3.96	3.38	1.43	4.81
2005-06	3.06	3.81	6.87	3.56	4.46	8.02
2006-07	2.36	3.43	5.78	3.72	4.52	8.24
2007-08	2.74	1.61	4.35	4.47	1.95	6.42
2008-09	2.20	0.29	2.50	2.90	0.67	3.57
2009-10	1.18	0.51	1.70	2.35	0.79	3.14
2010-11	0.55	2.27	2.82	0.76	2.39	3.15
2011-12	1.84	0.68	2.52	2.54	0.92	3.47
2012-13	2.32	0.92	3.24	2.40	1.33	3.73
2013-14	3.20	0.25	3.46	3.46	0.29	3.75
2014-15	1.27	0.54	1.81	1.27	0.63	1.90
2015-16	1.16	0.30	1.46	1.16	0.31	1.47
	2.12	**1.66**	**3.78**	**2.75**	**2.14**	**4.89**

12.3 The 10-daily flows in CJ Canal for the period 2017 – 2029 (based on the historical data of 1991-2016) are presented in Tables 14 and 15.

Table 14 FLOWS (ft^3/s) OF CHASHMA JHELUM LINK CANAL

POST MANGLA SCENARIO (2017-2029)

Year	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
JAN 1	0	13800	11700	1800	19900	20000	20000	0	13900	20000	3900	1000	12600
2	0	0	0	0	0	17300	0	0	19000	4300	0	0	7500
3	0	0	0	200	5600	4100	0	0	2200	900	2200	500	0
FEB 1	0	0	0	0	6300	6000	6000	16400	0	2200	4000	4000	2200
2	0	0	0	0	6500	6000	6000	5100	10800	4000	0	0	8200
3	0	0	0	9600	2300	6000	0	0	18500	2600	0	0	1400
MAR 1	0	0	2200	12800	0	2000	0	0	8000	0	1900	0	0
2	0	0	0	13600	0	0	100	0	4500	0	100	0	0
3	0	0	0	7700	100	0	5100	0	6500	0	0	0	0
APR 1	0	0	0	0	4100	0	3000	0	8100	0	1300	0	4200
2	0	0	0	0	6700	0	0	6000	6000	0	100	3400	5000
3	0	100	0	0	7800	0	0	6000	8000	0	700	2200	5700
MAY 1	0	9800	0	0	8000	0	6000	0	7700	6700	0	500	9200
2	0	0	8500	0	0	0	9800	0	8600	10500	0	600	0
3	0	0	12800	0	0	0	0	0	20000	19500	5300	7600	0
JUN 1	0	0	0	8700	3000	0	11800	0	17700	9300	12200	13100	2200
2	0	0	4600	12200	0	0	16000	0	20000	9500	11800	20000	2800
3	0	0	8000	19700	0	0	16800	3300	20000	12600	13800	20000	7200
JUL 1	0	0	7600	14100	5000	0	15600	6000	18000	16500	11500	20000	5500
2	0	0	0	8500	5500	8000	13800	0	17200	13800	8000	18600	13800
3	0	0	0	8000	0	16800	12000	0	5500	9200	8000	15300	15000
AUG 1	0	0	3500	7100	0	900	12000	6000	8700	1000	8000	9200	15000
2	3400	0	4400	7000	0	900	10200	6000	5200	12400	8000	12900	16300
3	9400	0	12300	9100	8900	900	0	6000	19400	9000	10900	9000	18000
SEP 1	10000	0	14900	13300	1300	900	0	14200	20000	10000	17800	10300	17700
2	10000	0	15000	12100	8000	900	6000	18000	19800	6000	10600	5700	9400
3	12300	0	12800	19900	5500	11100	7700	15900	20000	1100	8100	0	4000
OCT 1	16700	3100	18100	0	17500	17800	9500	11900	5500	3800	3800	0	3700
2	13300	16000	10100	5600	14400	19800	5800	10300	900	0	0	0	0
3	10300	10600	7100	6300	9000	12900	4200	6900	1400	1700	5900	1600	2400
NOV 1	9700	6800	8000	6500	8000	11400	4800	11300	9000	9800	7900	6700	8300
2	10800	6600	17900	2300	7000	8700	9100	10700	13300	6000	7000	7000	10900
3	7000	6000	14900	0	8700	7600	15000	16500	14700	9000	0	4900	8800
DEC 1	6100	11100	8000	0	11000	7000	6900	6500	5700	0	500	0	2100
2	6800	11400	6400	100	7300	0	5000	8300	900	400	800	0	1300
3	5600	8000	4000	4100	12600	9100	2500	9200	8200	3200	2500	5700	0

12.4 The foreseeable water-flows of CJ Canal are based on the historical flow data of CJ Canal observed at Adhikot from 1991-2016, and the impact of increased capacity of Mangla Reservoir on the operations of CJ Canal operation. The long term data and year wise critical analysis would eliminate the observation regarding the flow availability of CJ Canal in future. The power energy so estimated would be logical and would provide reliability for operation the proposed power plant at CJ Link Tail.

Table -15 FLOWS (ft^3/s) OF CHASHMA JHELUM LINK CANAL

POST MANGLA SCENARIO (2030-2041)

Year	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041
JAN 1	7100	9900	7000	0	2900	2000	0	2000	0	1609	686	686
2	13600	2500	5000	0	0	200	0	14600	0	0	686	686
3	0	0	1100	10700	900	0	0	16000	0	736	686	686
FEB 1	0	5000	20000	9800	7000	0	0	8000	0	855	186	686
2	0	2800	20000	13700	7000	0	3700	4600	0	855	0	0
3	0	0	16600	13000	2100	0	1100	3300	0	855	0	0
MAR 1	1300	0	10300	11300	0	0	0	1200	0	0	686	0
2	0	0	2200	8000	0	0	0	0	0	0	686	686
3	0	0	0	12500	0	0	0	0	0	0	686	1662
APR 1	1500	0	0	10600	0	1900	0	0	0	5175	686	3885
2	3800	4100	1600	10200	0	5500	0	0	0	4910	1338	3771
3	300	0	0	10400	0	8100	0	0	1100	0	1643	6641
MAY 1	0	0	0	20000	0	0	0	2400	1700	0	1334	2634
2	0	0	1200	19700	0	0	0	0	1000	3239	1883	2455
3	3900	2200	12800	19700	0	900	0	2000	1000	6021	1361	2226
JUN 1	0	16600	15500	1800	0	2300	0	0	0	11644	1347	2268
2	12900	19300	14900	0	8100	0	0	1900	0	20000	1233	2689
3	18200	18400	13700	14400	10900	0	0	15200	0	17237	1380	2745
JUL 1	19000	600	15000	16400	15600	0	2700	10900	5600	16259	1491	2289
2	19000	0	12700	0	13200	400	10900	8000	17500	13009	1349	2364
3	18200	0	12600	0	14400	10100	3000	5300	18800	13108	8753	1435
AUG 1	12500	0	0	0	12000	17500	0	5800	10000	13862	8914	3481
2	14200	14000	0	0	12000	0	0	2000	14400	9517	18375	3199
3	7300	19900	3500	0	12000	4000	0	4000	2600	5037	8793	4877
SEP 1	12200	20000	0	12500	9800	9000	4600	20000	14600	14166	2729	4942
2	4100	20000	0	2400	3000	0	2800	7000	15700	5743	686	3373
3	8800	19100	15300	0	0	0	3800	8100	12900	2472	874	3148
OCT 1	1900	10200	13600	12900	2600	0	8900	10700	7700	1082	1201	2761
2	0	0	2300	0	0	7400	9900	2800	0	1148	11145	1267
3	6200	3100	11600	7400	0	2700	5300	0	0	1145	1475	840
NOV 1	9200	14200	18700	18400	0	7200	6500	3400	4000	804	804	686
2	0	19200	12900	15600	0	3300	7800	5800	4000	804	686	675
3	0	20000	9200	6900	7500	500	8600	7000	5200	804	686	686
DEC 1	0	17600	0	0	600	0	7600	1400	6000	698	686	686
2	0	12600	6000	0	0	0	6100	2000	5100	686	686	642
3	6500	13000	8900	0	0	0	3900	1300	4200	686	686	686

12.5 The historical data related to filling of Mangla Reservoir suggest that it is very unlikely that the increased capacity of Mangla Reservoir shall be fully utilized; as such the incremental flows available after increased capacity of Mangla Reservoir are to be estimated on the basis of overall filling of Mangla Reservoir in view of the historical water-flows..

12.6 The operation of CJ Canal is managed by IRSA as per Water Accord 1991to divert surplus water available in River Indus and also to cover-up the shortfalls at irrigation network of Trimmu Barrage (mainly dependent on River Jhelum and Chenab).

12.7 The flows in CJ Canal are not likely to be reduced due to increased capacity at Mangla Reservoir as it has been mainly operated during summer when Mangla Reservoir shall be filled.

12.8 The updated flow data has been incorporated along with historic flows of 1991 to 2013. CJ Canal depends on flows pattern of Indus and Jhelum rivers for reservoir to be filled and downstream irrigation canal system requirement. Flow duration curve based on daily flows has been updated in the report.

12.9 The canal closure may vary from year to year depending on the shortfall in Jhelum River and availability of flows in Indus River. The power and energy estimation based on forecasted 10 daily flows.

Impact of Future Storages on Indus River

12.10 [The future planned storages reservoirs including Bhasha Dam and Kalabagh Dam are likely to increase the flows in River Indus, however, such increase may be somewhat offset against the reduction in the overall water availability because of Tarbela storage depletion due to sedimentation.]

12.11 The existing live storage of Tarbela and Chashma has been estimated as 7.55 MAF during 1991-2016. With the addition of Bhasha Dam, the increase in storage would be 6.1 MAF and the total storage on Indus River would become 10.2 MAF in 2025. The average storage on Indus in 2016-2025 periods would be 11.4 MAF. This shows an increase of 3.85 MAF over the average storage of 1991-2016 periods. Assuming that the storage will be filled in 75 % of the years the addition in Rabi flows would be 2.88 MAF. Punjab share in this storage would be 1.06 MAF (37 %). This share would be transferred to Punjab through C-J Link and TP Link with total present Rabi withdrawals of 4.3 MAF. This implies that Punjab supplies in the Rabi would increase by 25% over the present supplies of post-Accord period. This implies that the estimated adverse impact of Mangla (25% reduction in Rabi season supplies through C-J link) would almost be offset after construction of Bhasha dam.

12.12 The addition of Kalabagh or any other storage would have similar effect but it depends on when that storage is added. In case of pronounced delay sedimentation may offset all the benefits that may accrue due to addition in storage. It is expected that the adverse impact of Mangla on CJ Canal flows during Rabi season would be offset by operation of Bhasha Dam. Keeping in view the above mentioned facts, no additional impact of future storages on the Indus on CJ Cana supplies is envisaged.

SECTION – 7

PROJECT LAYOUT

SECTION – 7

PROJECT LAYOUT

7.1 GENERAL

For developing the hydropower potential available at 04 tail end Falls of CJ Link, alternative location of powerhouse has been considered. The basic requirements and precautions for the selection of appropriate layout, under existing site conditions includes to retain the design discharging capacity of fall structures, Safety of structure and minimum hazards such as resettlement of inhabitants, acquisition of land etc.

The project utilizes the drop of 13.65 m of C-J Link Canal near its confluence with Jhelum River. The existing outfall structure consists of four cascaded fall structures. The first fall is a gated structure with twelve bays and the other three falls are ungated structures. In this section different layout alternatives about project location are discussed.

7.2 CJ LINK SYSTEM

The head regulator of the C-J Link Canal is located on the left bank of the Indus River at Chashma Barrage. The Link extends from its head regulator in a southeasterly direction for a distance of 96 Km (59.6 mile) to the outfall into the Jhelum River at a point 97 km (60.2 mile) upstream of Trimmu Barrage. The upper 34 km (21.12 mile) reach of the Link crosses the Thal irrigated area and the lower part of the Link crosses the Thal Desert. The upper reach of the Link crosses four irrigation channels, including the Thal Canal Main Line Lower and the Dullewala Branch. The Link is an unlined earthen canal with a capacity of 615 m^3/s (21,718 ft^3/sec), bottom width of 116 m (380.57 ft) and a normal depth of 4.27 m (14 ft).

The C.J. Link runs in a deep cut with its full supply level below the surrounding terrain up to 51 km (31.6 mile) where the level of the terrain falls below the Link's full supply level. From 63 km (39.1 mile) to the outfall structure at 96 km (59.6 mile), the terrain level fluctuates from slightly below to slightly above the full supply level. Canal roads are provided along both sides of the Link and excess excavated material is placed in spoil banks adjacent to the canal roads.

The Chashma Jhelum Link has four gated regulators to control water levels in the Link. The first cross regulator located at 11 km (6.8 mile) (RD 34+387) is a combined gated regulator and the Thal Canal Main Line Lower aqueduct section. The second regulator is located at 34 km (21.1mile) (RD 105+722). It is also a combined gated regulator and aqueduct structure, and it carries the Dullewala Branch across the Link. The cross regulator at 58 km (36 mile) (RD 180+222) near Adhikot is just below a large off take regulator on the right bank of the Link that will serve as the head regulator for the Greater Thal Canal having 241 m^3/s (8,500 ft^3/sec) capacity. The lowermost gated regulator is a cascaded fall structure that lowers the Link by 18 m (59 ft) to the Jhelum River level.

7.2.1 Design of the Link Canal

7.2.1.1 General

The following is a brief description of the principal features of the C-J Link, including the modifications that were made to the design of the works.

7.2.1.2 Capacity

The Chashma Jhelum Link has a design capacity of 615 m^3/s (21,700 ft^3/sec) for its full length. The Greater Thal off takes at RD 180+222 and will have a capacity of 241 m^3/s (8,500ft^3/sec) at full development. The Ainu Minor off takes in the lower reach with a capacity of 2.8 m^3/s (98 ft^3/sec).

7.2.1.3 Hydraulic Design

The Chashma Jhelum Link is expected to carry its maximum discharge during the summer months. The Link was designed as an unlined regime channel based on Lacey's approach. Taking into account various factors relating to the hydraulic design of alluvial channel in regime, the Canal was designed for following hydraulic parameters.

- Discharge = 615 m^3/s (21,700 ft^3/sec)
- Bed width = 116 m (380.5 ft)
- Designed FSD = 4,26m (14 ft)
- Slope = 1:10,000

7.2.1.4 Tail/Outfall Regulator

The outfall at the lower end of the C.J. Link consists of a combined gated canal regulator, fall, and arterial road bridge, followed by three closely-spaced ungated fall structures. The regulator, located at RD 315+622, has twelve conventional fixed-wheel gates 7.3 m (23.9 ft) wide by 3.96 m (12.9 ft) high. The three ungated fall structures are located immediately below the gated regulator structure and are designed to drop the Link's water surface from its full supply level above the regulator by a total of 14. m (45.3 ft), to the low water level of the Jhelum River. This head is proposed to be utilized for power generation under the Project.

7.2.1.5 Crest Lowering of Outfall Structure

All reaches of C-J Link in general and the middle reach in particular were subjected to severe water logging in the adjoining areas. To reduce the menace it was planned that the tail regulator crest of the Link be lowered by 1.8 meters (5.9 ft) in two stages. The first stage 0.91 m (3 ft) of lowering was completed in August 1981. It was considered that due to the crest lowering and the consequential drop in the water level at the tail, the water surface slope would become steeper, thereby causing retrogression

in the upstream stretch of the canal. ACOP WAPDA made a study on behavioral response of 0.91 m (3 ft) crest lowering. The observation of CJ Link bed levels taken in 1984 by ACOP WAPDA is presented in drawing No. 03 of Volume VI (Drawings). They concluded that operation of canal at a discharge of 425 m^3/s (15,000 ft^3/sec) and free flow condition at tail regulator will be safer and will help to reduce the water logging in the adjoining area in the stretch. The second removal of 0.91 m (3 ft) has not been undertaken so far.

7.3 LOCATION OF THE POWER PLANT

While locating the power house at the tail of C-J Link, three different locations were considered:

- The power house may be constructed within the existing fall structure.
- Second the power house may be constructed on left side of the fall structure.
- Third is the construction of power house on right side of the fall structure. .

The implication of the three alternatives is discussed below:

7.3.1 Location within the Structure

The power house would be located within the fall structure by using some bays for installation of powerhouse. But this has some technical drawbacks and site limitations such as:

- Utilizing space of some existing gate bays with powerhouse would result in reduction of discharge capacity
- Safety of the structure may be endangered during construction and differential settlement may occur during operation.
- Power plant capacity may be restricted.
- Construction of new bays and supply channel would be difficult
- Difficulties in planning and construction because of series of falls (outfalls) instead of one concentrated fall.

After considering these negative factors this alternative was dropped for further consideration.

7.3.2 Location on Left Side

There exists a WAPDA rest house and Sher garh village within the possible power channel alignment. This will involve the relocation of WAPDA rest house and resettlement of inhabitants of village Sher garh. So the idea of locating the power house on the left of the existing fall structure was abandoned.

7.3.3 Location on Right Side

No major settlements exist on the right side of the C-J Link outfall structure. Therefore, keeping in view the site conditions with lower social implications, the location of the project on right side of the fall structure has been adopted for further studies.

7.4 LOCATION ALTERNATIVES

7.4.1 General

For finalization of the power house layout, headrace and tailrace channels, desilting basin, side escape/spillway and bridge for the Joharabad-Attharan Hazari (Jhang) road crossing have been considered. The head across the power house has also been considered while selecting of the layout.

Keeping in view the above considerations, the following three alternatives were studied. In all these alternatives, the off-take point of the headrace, AR Bridge, silt collection pool, side spillway and the relocation of Joharabad-Atharan Hazari (Jhang) road remains the same and common. Only location of the power house and the tailrace layout will be different.

7.4.2 Alternative 1

The powerhouse is proposed to be located at 200 m (656 ft) from the right bank of the fall structure situated at a place downstream of fall No. 3 and upstream of fall No. 4 on the right side of the canal fall structure. The headrace channel is 710 m and tailrace length is 300 m. The tailrace channel falls into the C-J Link tail channel downstream of fall No. 4 as shown in Drawing No.06 of Volume VI (Drawings).

7.4.3 Alternative 2

In alternative 2, the powerhouse is proposed to be located downstream of fall No. 4 and the tailrace channel falls into the Jhelum river about 300 m (984 ft) downstream of the centerline of the C-J Link confluence point with Jhelum river as shown in Drawing No.07 of Volume VI (Drawings). The headrace channel is 1050 m and tailrace length is 370 m.

7.4.4 Alternative 3

In the third alternative, power house is proposed to be located further downstream than in alternative – 2 and will also be shifted further downstream along the Jhelum River as shown in Drawing No.08 of Volume VI (Drawings). In this option the alignment of the power channel passes through an area relatively clear of the huge spoil that exists on the right side of the CJ Link. As such, a smaller quantum of excavation is involved. The headrace channel is 1260 m and tailrace length is 350 m.

7.4.5 Recommended Alternative

In *Alternative* 1, head across the power house will be less than that in *Alternatives* 2 & 3. Furthermore the joining flow of tailrace channel will be almost in opposite direction of the Jhelum River flow. The head across the power house in *Alternative* 2 will be slightly lesser than in *Alternative*3 and the tailrace will join the Jhelum River at right angle.

Alternative 3 will provide more head-across than the other two options and the tailrace channel will join the Jhelum River at an angle towards downstream along the flow. Although some land acquisition will be required in this *Alternative*, It has other advantages. More land will be available for staff colony in between the C-J Link and the headrace of power channel. Due to the availability of a larger head-across in the power channel, more power will be produced.

Keeping in view the above considerations, *Alternative* 3 is adopted for further studies.

7.5 SELECTED LAYOUT

The alignment of power channel was made according to the model study results. The bell mouth shaped intake is inclined at an angle of 40 degree with the C-J Link and has a sill at an elevation of 180.75 m to avoid sediments entry in the power channel. The left intake embankment consists of vertical concrete retaining walls, with transition reaches to the adopted slope of 1:1.5 for the head race. The right intake embankment with a side slope of 1:1.5 curves smoothly to the 40 degree detour of the power channel. Beyond the intake sill portion, the head race is curved smoothly to have minimum head loss and uniform flow conditions in the whole x-section and it joins finally the 100 m long straight portion upstream of powerhouse which provides favourable hydraulic conditions for the powerhouse intake.

The length of head race is approximately 1350 m. The head race embankment level is taken as 186.50 masl, which is the same as the embankment level of C.J Link upstream of the gated fall structure. The powerhouse is located almost in line with the last fall of tail regulator and its axis deviates from the axis of fall by approximately 10 degrees. The distance between centre line of the powerhouse and centre line of C-J link canal is approximately 160 m.
The tail race with a length of approximately 370 m with base width of 36 m same as that of headrace but it expands gradually in curvature to rejoin Jhelum River on the right bank of CJ Link confluence.

7.6 Design Discharge and Installed Capacity

Project sizing and power potential have been computed on the basis of 10 daily mean data. A wide range of design discharges starting from 150 m^3/s to 360 m^3/s with an interval of 30 m^3/s have been considered for the selected layout on the right side of the Canal to estimate the power and energy potential of the project. The results including the incremental power and energy output are summarized in Table 9.2:

Table 7.1 Power and Energy for various Design Discharges

Design Discharge	Rated Head	Power	Energy	Plant factor	Incremental Energy
(m^3/s)	(m)	MW	GWh	%	GWh
150	13.65	17.9	88.5	56.5	
180	13.65	21.5	100.3	53.4	11.8
210	13.65	25.0	110.6	50.3	10.3
240	13.65	28.6	119.3	47.6	8.7
270	13.65	32.2	126.7	44.9	7.4
300	13.65	35.8	133.0	42.4	6.3
330	13.65	39.3	138.5	40.2	5.5
360	13.65	42.9	142.9	38.0	4.4

The incremental energy for different discharge combinations in intervals of 40 m^3/s are shown in above table. The incremental energy output shows a decreasing trend. The incremental energy decreases substantially at a plant discharge less than 50%, therefore the upper limit of rated design discharge has been fixed at 210 m^3/s where plant factor is about 50%.

The optimization studies identified that a three unit arrangement would be most suitable for this scheme because:

- Three machines give adequate operational flexibility. They can run between 25% and 100% of total flow capacity to provide adequate flexibility in the dry season.
- Unit redundancy during the low flow season allows essential maintenance to be carried out without affecting energy generation.
- A three turbine arrangement gives reasonable powerhouse dimensions for construction and operation.

7.6.1 Flow Rate

Hydropower potential is a function of flow and head (the difference in the water levels upstream and downstream of the turbine). To reduce the time taken for calculations the daily data was converted into average flows during 10-daily periods and these were used for the majority of the calculations.

7.6.2 Head Calculation

(i) Gross Head

The gross head calculated from difference of head water level to tail water level for each 10 daily discharges. The head water levels is the water level in CJ Link canal for various discharges and is taken as indicated in the Table 7.2.

Table 7.2 Head Water Level – CJ Link Canal

Discharge (ft^3/s)	HWL (m)	Discharge (ft^3/s)	HWL (m)
614.5	183.17	311.5	182.27
566.3	183.04	283.2	182.18
538.0	182.96	254.8	182.08
509.7	182.88	226.5	181.97
481.4	182.8	198.2	181.86
453.1	182.72	141.6	181.63
424.7	182.63	84.9	181.35
396.4	182.55	56.6	181.18
368.1	182.46	28.3	180.99
339.8	182.37	0.0	180.65

Table 7.3 Tail Water Level (m)

Month	10-Daily	Discharge in Jhelum (m^3/s)	Level in Jhelum River (m)
Apr	1	313	168.620
	2	441	169.014
	3	557	169.229
May	1	616	169.311
	2	792	169.586
	3	921	169.786
Jun	1	861	169.772
	2	841	169.771
	3	915	169.853
Jul	1	905	169.816
	2	1044	169.894
	3	1275	170.008
Aug	1	1010	169.813
	2	710	169.563
	3	855	169.754

Sep	1	714	169.649
	2	727	169.709
	3	172	168.983
Oct	1	72	168.650
	2	21	168.180
	3	2	168.000
Nov	1	7	168.268
	2	14	168.476
	3	5	168.510
Dec	1	67	168.470
	2	56	168.313
	3	215	168.878
Jan	1	279	169.201
	2	225	168.666
	3	74	167.904
Feb	1	86	168.204
	2	223	168.715
	3	335	168.951
Mar	1	309	168.720
	2	345	168.727
	3	319	168.611

(ii) Net Head

The components of the scheme that cause head losses are:

Trash rack.

Intake.

Draft tube.

Table 7.4 Calculation of Gross Head

Parameters	Values
Headrace Water Level	El. 182.9 m
Tailrace Water Level	El 167.9 m to 170.0 m
Gross Head	15.0 m to 12.9 m

Head losses caused by these components have been deducted from the gross head to arrive at the net head of 13.65 m at rated discharge.

7.6.3 Efficiency

The turbine maximum efficiency used in the calculation was 93.0%. The generator efficiency was fixed as 97.5% while that of transformer has been fixed at 99%.

7.7 Power Generation

With the flow series for Raised Mangla scenario, power and energy output has been estimated.

By using 210 m^3/s design discharge, 25 MW can be produced. 10 daily power output has been calculated assuming net head of 13.65 m is available over the year.

The 10 daily net head corresponding to each 10 daily discharges are presented in Table 7.5 and 7.6. The power output for 1991-2016 is presented in Table 7.7 and 7.8.

The annual energy for the period 1991-2015 has also been estimated. The energy varies from 53.5 to 146.2 GWh annually with average value of 110.6 GWh and plant factor of 50.3%.

Table – 7.5 Gross Head (m) CJ Canal HPP

Post Mangla Scenario (2018-2030)

Year	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
JAN 1	11.7	13.3	13.1	11.9	13.8	13.9	13.8	11.7	13.3	14.0	12.2	11.7	13.2
2	12.2	12.2	12.2	12.2	12.2	14.1	12.2	12.2	14.3	12.8	12.2	12.2	13.3
3	13.0	13.0	13.0	12.9	13.8	13.6	13.0	13.0	13.3	13.0	13.3	12.9	13.0
FEB 1	12.7	12.7	12.7	12.7	13.6	13.5	13.5	14.5	12.7	13.0	13.3	13.3	13.0
2	12.2	12.2	12.2	12.2	13.1	13.0	13.0	12.9	13.5	12.8	12.2	12.2	13.3
3	11.9	11.9	11.9	13.2	12.2	12.8	11.9	11.9	13.9	12.3	11.9	11.9	12.1
MAR 1	12.2	12.2	12.4	13.7	12.2	12.4	12.2	12.2	13.3	12.2	12.4	12.2	12.2
2	12.2	12.2	12.2	13.8	12.2	12.2	12.2	12.2	12.8	12.2	12.2	12.2	12.2
3	12.3	12.3	12.3	13.3	12.3	12.3	13.0	12.3	13.2	12.3	12.3	12.3	12.3
APR 1	12.3	12.3	12.3	12.3	12.9	12.3	12.7	12.3	13.4	12.3	12.4	12.3	12.9
2	11.9	11.9	11.9	11.9	12.8	11.9	11.9	12.7	12.7	11.9	11.9	12.4	12.6
3	11.7	11.7	11.7	11.7	12.7	11.7	11.7	12.5	12.8	11.7	11.7	11.9	12.5
MAY 1	11.6	12.9	11.6	11.6	12.7	11.6	12.4	11.6	12.6	12.5	11.6	11.5	12.8
2	11.3	11.3	12.4	11.3	11.3	11.3	12.6	11.3	12.5	12.6	11.3	11.3	11.3
3	11.1	11.1	12.6	11.1	11.1	11.1	11.1	11.1	13.4	13.2	11.9	12.2	11.1
JUN 1	11.1	11.1	11.1	12.3	11.5	11.1	12.6	11.1	13.1	12.3	12.6	12.7	11.4
2	11.1	11.1	11.8	12.6	11.1	11.1	12.9	11.1	13.4	12.4	12.6	13.3	11.5
3	11.0	11.0	12.1	13.2	11.0	11.0	12.9	11.5	13.3	12.6	12.7	13.2	12.0
JUL 1	11.1	11.1	12.1	12.7	11.8	11.1	12.8	11.9	13.0	12.9	12.5	13.2	11.9
2	11.0	11.0	11.0	12.1	11.8	12.1	12.6	11.0	12.9	12.6	12.1	13.0	12.6
3	10.9	10.9	10.9	12.0	10.9	12.7	12.4	10.9	11.7	12.1	12.0	12.6	12.6
AUG 1	11.1	11.1	11.6	12.1	11.1	11.1	12.6	11.9	12.2	11.1	12.2	12.3	12.8
2	11.8	11.3	12.0	12.3	11.3	11.4	12.6	12.2	12.1	12.8	12.4	12.9	13.1
3	12.4	11.1	12.6	12.3	12.3	11.2	11.1	12.0	13.2	12.3	12.5	12.3	13.1
SEP 1	12.5	11.2	13.0	12.8	11.4	11.3	11.2	12.9	13.5	12.5	13.2	12.6	13.2
2	12.5	11.2	12.9	12.7	12.3	11.2	12.0	13.1	13.3	12.0	12.5	12.0	12.4
3	13.4	11.9	13.4	14.0	12.7	13.3	13.0	13.7	14.2	12.0	13.0	11.9	12.5
OCT 1	14.1	12.7	14.2	12.2	14.2	14.2	13.5	13.7	13.0	12.8	12.8	12.2	12.8
2	14.3	14.5	14.0	13.5	14.4	14.8	13.5	14.0	12.7	12.7	12.7	12.7	12.7
3	14.2	14.2	13.9	13.8	14.1	14.4	13.5	13.9	13.0	13.1	13.7	13.1	13.2
NOV 1	13.9	13.6	13.7	13.5	13.7	14.0	13.3	14.0	13.8	13.9	13.7	13.6	13.7
2	13.8	13.3	14.4	12.7	13.4	13.6	13.6	13.8	14.0	13.3	13.4	13.4	13.8
3	13.4	13.2	14.1	12.4	13.5	13.4	14.1	14.2	14.1	13.6	12.4	13.1	13.6
DEC 1	13.3	13.8	13.5	12.4	13.8	13.4	13.4	13.3	13.2	12.4	12.4	12.4	12.7
2	13.5	14.0	13.5	12.6	13.6	12.6	13.3	13.7	12.6	12.5	12.6	12.6	12.7
3	12.8	13.1	12.6	12.6	13.5	13.2	12.3	13.2	13.1	12.5	12.3	12.8	12.0

Table – 7.6 Gross Head (m) CJ Canal HPP

Post Mangla Scenario (2031-2042)

Year	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
JAN 1	12.7	13.0	12.7	11.7	12.1	11.9	11.7	11.9	11.7	11.9	11.7	11.7
2	13.8	12.6	12.9	12.2	12.2	12.1	12.2	13.9	12.2	12.2	12.2	12.2
3	13.0	13.0	13.1	14.3	13.0	13.0	13.0	14.8	13.0	13.0	13.0	13.0
FEB 1	12.7	13.4	14.8	14.0	13.7	12.7	12.7	13.8	12.7	12.7	12.6	12.7
2	12.2	12.6	14.4	13.8	13.2	12.2	12.7	12.8	12.2	12.2	12.2	12.2
3	11.9	11.9	13.8	13.5	12.2	11.9	12.0	12.4	11.9	12.0	11.9	11.9
MAR 1	12.3	12.2	13.5	13.6	12.2	12.2	12.2	12.3	12.2	12.2	12.2	12.2
2	12.2	12.2	12.4	13.3	12.2	12.2	12.2	12.2	12.2	12.2	12.2	12.2
3	12.3	12.3	12.3	13.8	12.3	12.3	12.3	12.3	12.3	12.3	12.3	12.5
APR 1	12.4	12.3	12.3	13.6	12.3	12.5	12.3	12.3	12.3	13.0	12.3	12.8
2	12.4	12.5	12.0	13.2	11.9	12.7	11.9	11.9	11.9	12.6	12.0	12.4
3	11.6	11.7	11.7	13.0	11.7	12.8	11.7	11.7	11.7	11.7	11.8	12.6
MAY 1	11.6	11.6	11.6	13.8	11.6	11.6	11.6	11.9	11.8	11.6	11.7	11.9
2	11.3	11.3	11.4	13.4	11.3	11.3	11.3	11.3	11.4	11.8	11.5	11.6
3	11.7	11.4	12.6	13.2	11.1	11.1	11.1	11.3	11.2	12.0	11.2	11.4
JUN 1	11.1	13.0	12.9	11.3	11.1	11.4	11.1	11.1	11.1	12.6	11.2	11.4
2	12.7	13.2	12.8	11.1	12.2	11.1	11.1	11.3	11.1	13.8	11.2	11.5
3	13.0	13.0	12.7	12.7	12.4	11.0	11.0	12.8	11.0	12.9	11.2	11.4
JUL 1	13.1	11.0	12.8	12.9	12.8	11.1	11.4	12.5	11.9	12.9	11.2	11.4
2	13.0	11.0	12.5	11.0	12.6	10.9	12.4	12.1	12.9	12.6	11.1	11.3
3	12.9	10.9	12.4	10.9	12.6	12.2	11.3	11.6	12.9	12.4	12.1	11.0
AUG 1	12.6	11.1	11.1	11.1	12.6	13.0	11.1	11.9	12.4	12.7	12.3	11.6
2	13.0	13.0	11.3	11.3	12.8	11.3	11.3	11.6	13.0	12.6	13.3	11.8
3	12.1	13.3	11.6	11.1	12.6	11.7	11.1	11.7	11.5	11.9	12.3	11.8
SEP 1	12.7	13.5	11.2	12.8	12.5	12.4	11.9	13.4	12.9	12.9	11.6	12.0
2	11.8	13.4	11.2	11.5	11.6	11.2	11.6	12.2	13.0	12.0	11.2	11.7
3	13.1	14.0	13.6	11.9	11.9	11.9	12.5	13.0	13.5	12.2	11.9	12.3
OCT 1	12.5	13.6	13.8	13.8	12.6	12.2	13.4	13.6	13.3	12.3	12.3	12.6
2	12.7	12.7	13.0	12.7	12.7	13.7	14.0	13.1	12.7	12.8	14.1	12.8
3	13.8	13.3	14.3	13.9	12.9	13.3	13.7	12.9	12.9	13.0	13.0	12.9
NOV 1	13.8	14.3	14.6	14.6	12.6	13.6	13.5	13.1	13.2	12.6	12.6	12.6
2	12.4	14.5	14.0	14.2	12.4	12.9	13.5	13.2	13.0	12.4	12.4	12.4
3	12.4	14.6	13.6	13.3	13.4	12.3	13.5	13.4	13.1	12.4	12.4	12.4
DEC 1	12.4	14.3	12.4	12.4	12.4	12.4	13.5	12.6	13.3	12.4	12.4	12.4
2	12.6	14.1	13.4	12.6	12.6	12.6	13.4	12.8	13.3	12.6	12.6	12.6
3	12.9	13.6	13.2	12.0	12.0	12.0	12.6	12.1	12.6	12.0	12.0	12.0

Table – 7.7 POWER OUT (MW) CJ CANAL HPP

POST MANGLA SCENARIO (2017-2029)

Year	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
JAN 1	2.0	27.1	26.7	5.3	28.1	28.3	28.1	2.0	27.1	28.4	11.9	2.9	26.9
2	2.1	2.1	2.1	2.1	2.1	28.7	2.1	2.1	29.0	13.8	2.1	2.1	24.8
3	2.2	2.2	2.2	0.6	19.2	13.9	2.2	2.2	7.3	2.9	7.3	1.6	2.2
FEB 1	2.2	2.2	2.2	2.2	21.3	20.2	20.2	29.5	2.2	7.1	13.2	13.2	7.1
2	2.1	2.1	2.1	2.1	21.2	19.5	19.5	16.4	27.5	12.7	2.1	2.1	27.0
3	2.0	2.0	2.0	26.8	7.0	19.1	2.0	2.0	28.3	8.0	2.0	2.0	4.2
MAR 1	2.1	2.1	6.8	27.9	2.1	6.2	2.1	2.1	26.4	2.1	5.9	2.1	2.1
2	2.1	2.1	2.1	28.0	2.1	2.1	2.1	2.1	14.4	2.1	2.1	2.1	2.1
3	2.1	2.1	2.1	25.6	2.1	2.1	16.5	2.1	21.4	2.1	2.1	2.1	2.1
APR 1	2.1	2.1	2.1	2.1	13.1	2.1	9.5	2.1	27.0	2.1	4.0	2.1	13.5
2	2.0	2.0	2.0	2.0	21.4	2.0	2.0	19.0	19.0	2.0	2.0	10.5	15.7
3	2.0	2.0	2.0	2.0	24.7	2.0	2.0	18.7	25.4	2.0	2.0	6.5	17.7
MAY 1	2.0	26.1	2.0	2.0	25.3	2.0	18.6	2.0	24.2	20.9	2.0	1.4	26.0
2	1.9	1.9	25.3	1.9	1.9	1.9	25.6	1.9	25.3	25.7	1.9	1.7	1.9
3	1.9	1.9	25.7	1.9	1.9	1.9	1.9	1.9	27.2	26.8	15.7	23.0	1.9
JUN 1	1.9	1.9	1.9	25.0	8.6	1.9	25.6	1.9	26.5	25.1	25.6	25.8	6.2
2	1.9	1.9	13.5	25.6	1.9	1.9	26.3	1.9	27.2	25.1	25.6	27.0	8.0
3	1.9	1.9	24.2	26.7	1.9	1.9	26.2	9.5	27.1	25.5	25.7	26.8	21.6
JUL 1	1.9	1.9	23.0	25.9	14.7	1.9	26.1	17.8	26.5	26.2	25.4	26.9	16.3
2	1.9	1.9	1.9	24.7	16.2	24.1	25.7	1.9	26.2	25.7	24.1	26.4	25.7
3	1.9	1.9	1.9	23.9	1.9	25.9	25.1	1.9	16.0	24.6	23.9	25.7	25.6
AUG 1	1.9	1.9	10.1	21.3	1.9	2.5	25.5	17.8	24.9	2.8	24.3	25.0	26.0
2	10.0	1.9	13.1	21.5	1.9	2.5	25.7	18.2	15.6	26.1	24.8	26.2	26.7
3	25.2	1.9	25.7	25.1	25.1	2.5	1.9	17.9	26.9	25.1	25.4	25.1	26.6
SEP 1	25.5	1.9	26.3	26.1	3.7	2.5	1.9	26.2	27.5	25.5	26.8	25.5	26.8
2	25.4	1.9	26.2	25.7	24.5	2.5	18.0	26.7	27.0	18.0	25.5	17.0	25.2
3	27.3	2.0	27.3	28.5	17.4	27.0	24.9	27.8	28.9	3.3	26.3	2.0	12.4
OCT 1	28.7	9.8	28.9	2.1	28.8	28.8	27.4	27.9	17.9	12.1	12.1	2.1	11.8
2	29.1	29.5	28.5	18.9	29.2	30.2	19.6	28.5	2.9	2.2	2.2	2.2	2.2
3	28.9	28.9	24.6	21.6	28.6	29.4	14.1	23.8	4.5	5.5	20.2	5.2	7.9
NOV 1	28.2	23.0	27.3	21.9	27.3	28.5	15.9	28.5	28.1	28.3	27.0	22.6	27.9
2	28.0	21.9	29.2	7.3	23.4	27.6	27.7	28.0	28.5	19.8	23.4	23.4	28.0
3	23.3	19.8	28.6	2.1	27.5	25.4	28.7	28.9	28.6	27.6	2.1	16.0	27.6
DEC 1	20.2	28.1	26.9	2.1	28.1	23.4	23.0	21.6	18.8	2.1	1.5	2.1	6.6
2	22.9	28.5	21.5	2.1	24.7	2.1	16.6	27.9	2.8	1.2	2.5	2.1	4.1
3	17.9	26.1	12.5	12.9	27.5	26.9	7.7	26.9	26.7	9.9	7.7	18.2	2.1

Table -7.8 POWER OUT (MW) CJ CANAL HPP

POST MANGLA SCENARIO (2030-2041)

Year	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
JAN 1	22.4	26.4	22.1	2.0	8.7	5.9	2.0	5.9	2.0	4.8	2.0	2.0
2	28.1	7.8	16.1	2.1	2.1	0.6	2.1	28.3	2.1	2.1	2.1	2.1
3	2.2	2.2	3.6	29.2	2.9	2.2	2.2	30.1	2.2	2.4	2.2	2.2
FEB 1	2.2	16.7	30.1	28.4	23.8	2.2	2.2	27.5	2.2	2.7	0.6	2.2
2	2.1	8.8	29.3	28.0	22.9	2.1	11.7	14.7	2.1	2.6	2.1	2.1
3	2.0	2.0	28.0	27.4	6.4	2.0	3.3	10.2	2.0	2.5	2.0	2.0
MAR 1	4.0	2.1	27.4	27.6	2.1	2.1	2.1	3.7	2.1	2.1	2.1	2.1
2	2.1	2.1	6.8	26.4	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1
3	2.1	2.1	2.1	28.0	2.1	2.1	2.1	2.1	2.1	2.1	2.1	5.2
APR 1	4.6	2.1	2.1	27.7	2.1	5.9	2.1	2.1	2.1	16.8	2.1	12.4
2	11.8	12.7	4.8	26.8	2.0	17.4	2.0	2.0	2.0	15.4	4.0	11.7
3	0.9	2.0	2.0	26.4	2.0	25.8	2.0	2.0	3.2	2.0	4.8	20.8
MAY 1	2.0	2.0	2.0	28.0	2.0	2.0	2.0	7.1	5.0	2.0	3.9	7.8
2	1.9	1.9	3.4	27.3	1.9	1.9	1.9	1.9	2.8	9.5	5.4	7.1
3	11.3	6.2	25.7	26.9	1.9	2.5	1.9	5.7	2.8	17.9	3.8	6.3
JUN 1	1.9	26.4	26.2	5.1	1.9	6.5	1.9	1.9	1.9	25.5	3.8	6.4
2	25.8	26.8	26.1	1.9	24.7	1.9	1.9	5.4	1.9	28.0	3.4	7.7
3	26.5	26.5	25.7	25.8	25.2	1.9	1.9	26.0	1.9	26.3	3.8	7.8
JUL 1	26.7	1.7	26.0	26.2	26.1	1.9	7.7	25.3	16.6	26.2	4.2	6.5
2	26.5	1.9	25.5	1.9	25.6	1.1	25.2	24.1	26.3	25.5	3.7	6.7
3	26.1	1.9	25.2	1.9	25.5	24.8	8.4	15.4	26.3	25.3	24.5	3.9
AUG 1	25.6	1.9	1.9	1.9	25.5	26.4	1.9	17.2	25.1	25.8	24.9	10.0
2	26.4	26.4	1.9	1.9	26.0	1.9	1.9	5.8	26.4	25.6	27.1	9.4
3	22.1	27.0	10.1	1.9	25.6	11.7	1.9	11.7	7.4	14.9	25.0	14.4
SEP 1	25.9	27.4	1.9	25.9	25.4	25.3	13.6	27.2	26.3	26.2	7.9	14.7
2	12.0	27.3	1.9	6.9	8.7	1.9	8.1	21.2	26.3	17.2	1.9	9.8
3	26.6	28.4	27.7	2.0	2.0	2.0	11.8	26.3	27.4	7.5	2.6	9.7
OCT 1	5.9	27.6	28.1	28.0	8.2	2.1	27.3	27.6	25.5	3.3	3.7	8.7
2	2.2	2.2	7.5	2.2	2.2	25.3	28.5	9.1	2.2	3.7	28.7	4.0
3	21.3	10.3	29.1	25.7	2.2	8.9	18.0	2.2	2.2	3.7	4.8	2.7
NOV 1	28.1	29.0	29.8	29.7	2.2	24.4	21.9	11.1	13.2	2.5	2.5	2.2
2	2.1	29.4	28.4	28.8	2.1	10.6	26.2	19.1	12.9	2.5	2.1	2.1
3	2.1	29.7	27.6	22.9	25.1	1.5	27.5	23.3	17.0	2.5	2.1	2.1
DEC 1	2.1	29.2	2.1	2.1	1.9	2.1	25.5	4.4	19.8	2.2	2.1	2.1
2	2.1	28.7	20.1	2.1	2.1	2.1	20.4	6.4	16.9	2.1	2.1	2.0
3	20.9	27.6	26.8	2.1	2.1	2.1	12.2	3.9	13.2	2.1	2.1	2.1

Table 7.9 ANNUAL ENERGY CJ CANAL HPP

POST MANGLA SCENARIO (2017-2041)

Year	Annual Energy (GWh)	Year	Annual Energy (GWh)
2018	92.3	2031	110.1
2019	76.4	2032	128.2
2020	127.3	2033	145.3
2021	125.7	2034	146.2
2022	134.0	2035	90.1
2023	113.2	2036	63.2
2024	141.1	2037	80.5
2025	124.3	2038	110.4
2026	189.8	2039	89.6
2027	124.9	2040	92.5
2028	114.8	2041	53.9
2029	107.7	2042	53.5
2030	129.7	Mean	**110.6**
		Plant Factor (%)	50.3

Table 7.10 10 DAILY POWER – AVERAGE YEAR

POST MANGLA SCENARIO (2017-2041)

Month	Flows Canal (m^3/s)	Flows Power (m^3/s)	Head Water Level (m)	Tail Water Level (m)	Net Head (m)	Power (MW)	Energy (GWh)
JAN 1	201	201	181.9	169.2	12.5	22.1	5.30
2	385	210	182.5	168.7	13.6	25.2	6.05
3	19	19	180.9	167.9	12.8	2.2	0.58
FEB 1	19	19	180.9	168.2	12.5	2.1	0.51
2	19	19	180.9	168.7	12.0	2.0	0.49
3	19	19	180.9	169.0	11.7	2.0	0.38
MAR 1	37	37	181.0	168.7	12.1	3.9	0.94
2	19	19	180.9	168.7	12.0	2.0	0.49
3	19	19	180.9	168.6	12.1	2.1	0.54
APR 1	42	42	181.0	168.6	12.2	4.6	1.10
2	108	108	181.4	169.0	12.2	11.6	2.78
3	8	8	180.8	169.2	11.4	0.9	0.20
MAY 1	19	19	180.9	169.3	11.4	1.9	0.47
2	19	19	180.9	169.6	11.1	1.9	0.45
3	110	110	181.5	169.8	11.5	11.1	2.94
JUN 1	19	19	180.9	169.8	10.9	1.9	0.45
2	365	231	182.4	169.8	12.5	25.3	6.08
3	515	231	182.9	169.9	12.8	26.1	6.25
JUL 1	538	231	182.9	169.8	12.9	26.3	6.31
2	538	231	182.9	169.9	12.8	26.1	6.27
3	515	231	182.9	170.0	12.7	25.7	6.80
AUG 1	354	231	182.4	169.8	12.4	25.2	6.05
2	402	231	182.5	169.6	12.8	26.0	6.24
3	207	231	181.9	169.8	11.9	24.3	6.41
SEP 1	345	231	182.4	169.6	12.5	25.5	6.11
2	116	116	181.5	169.7	11.6	11.8	2.84
3	249	231	182.1	169.0	12.9	26.2	6.29
OCT 1	54	54	181.1	168.7	12.3	5.8	1.39
2	19	19	180.9	168.2	12.5	2.1	0.51
3	176	176	181.8	168.0	13.6	21.0	5.54
NOV 1	261	231	182.1	168.3	13.6	27.7	6.65
2	19	19	180.9	168.5	12.2	2.1	0.50
3	19	19	180.9	168.5	12.2	2.1	0.50
DEC 1	19	19	180.9	168.5	12.2	2.1	0.50
2	19	19	180.9	168.3	12.4	2.1	0.51
3	184	184	181.8	168.9	12.7	20.6	5.44
						Total	**110.85**

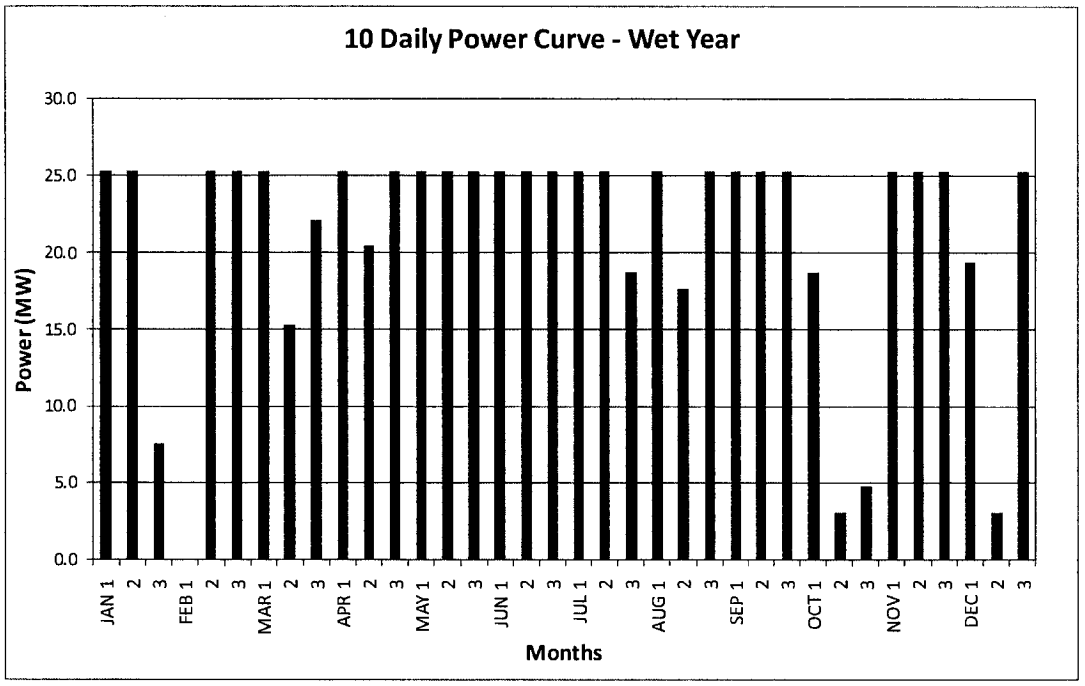


Figure -7.1 10 Daily Power – Wet Year

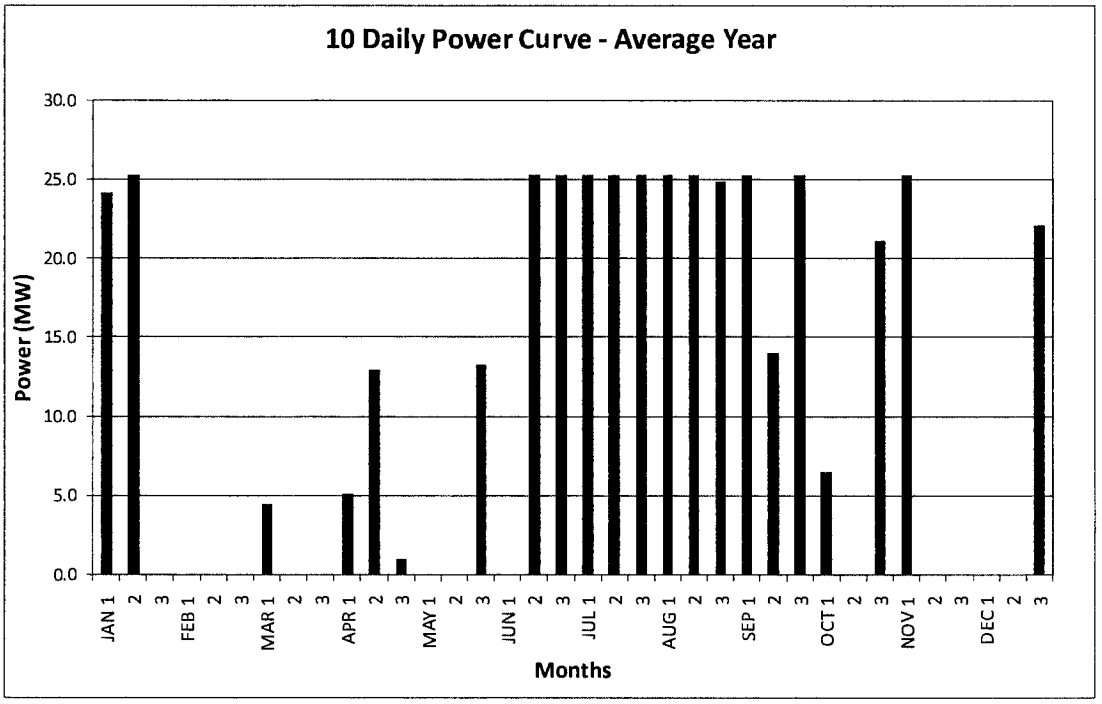
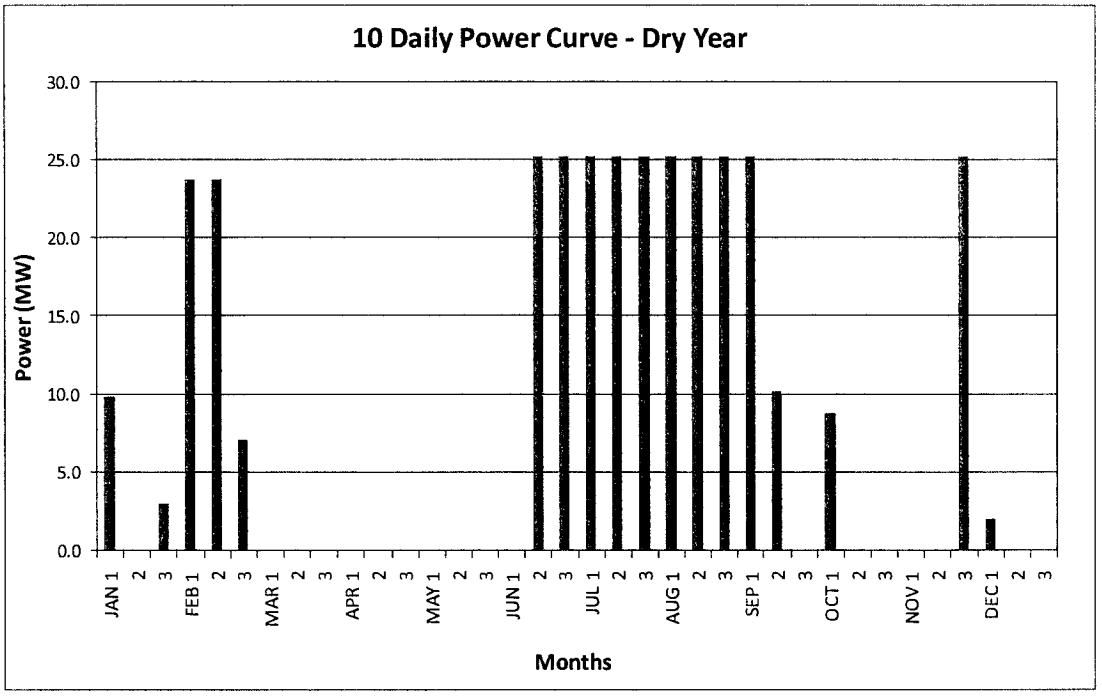


Figure -7.2 10 Daily Power – Average Year


10 Daily Power Curve - Dry Year
Power (MW)
30.0
25.0
20.0
15.0
10.0
5.0
0.0
JAN 1
2
3
FEB 1
2
3
MAR 1
2
3
APR 1
2
3
MAY 1
2
3
JUN 1
2
3
JUL 1
2
3
AUG 1
2
3
SEP 1
2
3
OCT 1
2
3
NOV 1
2
3
DEC 1
2
3
Months

SECTION – 8

DESIGN OF CIVIL STRUCTURE

SECTION – 8

DESIGN OF CIVIL STRUCTURES

8.1 GENERAL

The project layout comprised of headrace channel, sediment excluder, inlet bays, powerhouse, outlet bays and tailrace channel. The power channel off takes just upstream of gated fall structure with curved alignment and it joins the straight portion upstream of powerhouse. Downstream of powerhouse it rejoins the C-J Link canal with curved alignment.

The powerhouse is located approximately in line of last fall of the tail structure. Its axis deviates from the axis of the fall by approximately 10 degrees. The layout comprises the construction of head race, tail race and powerhouse to utilize the head available and part of the flows presently discharging through the gates of the tail regulator.

The power channel layout mainly depends upon discharge capacity which will give the bed width, bed level, water depth and type of intake which is affected by off-taking angle whereas the layout of powerhouse mainly depends upon the type of turbines and number of units. Therefore layout regarding power channel and powerhouse will be discussed separately in the following paras:

As discussed in Section-7, Alternate-3 has been selected. The following aspects are discussed in this chapter on the bases of the selected alternative:

1	Intake of power channel.
2	Power channel (Head race and Tail race)
3	Silt collection pool
4	Side spillway / Escape channel
5	Power House
6	Road crossing/Relocation of Road
7	Permanent and Temporary camps
8	Project Infrastructure Development

8.2 INTAKE OF POWER CHANNEL

Power channel will off take from the right bank of the C-J Link canal about 400 m upstream of the first fall structure. The off take angle of power channel centerline with C-J Link centre line is about 30°. Bed level of the off taking power channel is placed slightly higher than the bed level of C-J Link canal to reduce silt entry. The bed level of the C-J Link is taken as per survey carried out by ACOP WAPDA in 1984. as shown in **Table 8.1**.

TABLE 8.1
SURVEY OF CJ LINK OF ACOP WAPDA (May & July 1984)

Sr. No.	RD of Cross Section	Bed Level
1.	181+000	N.A.
2.	185+000	603.213
3.	190+000	603.559
4.	195+000	602.490
5.	200+000	602.691
6.	205+000	601.867
7.	210+000	601.453
8.	215+000	600.912
9.	220+000	600.579
10.	225+000	599.790
11.	230+000	599.717
12.	235+000	599.023
13.	240+000	599.110
14.	245+000	597.602
15.	250+000	597.455
16.	255+000	597.180
17.	260+000	596.487
18.	265+000	595.215
19.	270+000	594.450
20.	275+000	594.033
21.	280+000	593.891
22.	285+000	593.258
23.	290+000	591.068
24.	295+000	590.334
25.	300+000	590.371
26.	305+000	590.273
27	310+000	589.150
28	315+000	N.A.

8.3 POWER CANAL (HEAD AND TAIL RACE)

8.3.1 GENERAL

Power canal is an essential part of project comprises headrace and tailrace, to utilize a part of discharge available at tail regulator through the powerhouse. The hydraulic design of power canal mainly depends upon available discharge, bed width and water level. The embankments are also very important components of the power canal, therefore their stability should be verified.

Power channel is a major component of the project. It consists of two parts, headrace and tailrace channels. The power channel has been designed for a maximum discharge of 240 m^3/s which includes 10% additional discharge to the rated discharge for turbines and some provision for sediment flushing

through sediment excluder.

8.3.2 Headrace Channel

The longitudinal profile of headrace channel has been based on observed profile of CJ Link canal by ACOP WAPDA 1984. The water profile has been adopted as 1/8888 as per following observations.

The headrace channel is proposed as a concrete lined channel with the following parameters:

Maximum design discharge	= 240 m^3/s (8475 cusecs)
Bed width	= 36 m (118.1 ft)
Full Supply Depth	= 3.7 m (12.14 ft)
Manning Roughness n	= 0.016
Velocity	= 1.39 m/s (4.56 ft/sec)

8.3.2 HEADRACE

The maximum design discharge for the power canal is 240 m^3/s. The bed width is taken equal to the total width of the power house required for Three Horizontal Kaplan turbines which comes to be 36.0 m. The normal water level is 182.00 m.a.s.l. and the maximum water level 183.17 m.a.s.l. These levels are taken from the daily recorded upstream water levels at tail regulator.

The embankment level of headrace is fixed at 186.50 m.a.s.l. which is same as that of C.J embankment. The side slopes of the headrace canal is 1:2.0. The bed slope is taken as zero to minimize the head loss. The bed level of headrace is fixed at 179.17 m.a.s.l. The velocity and water levels were calculated using Manning's formula and Strickler coefficient equal to 62 for lined canal. The velocities in power channel are higher than in the C.J link, which is helpful in minimizing the sedimentation into the headrace. The change in water levels is very small and can be neglected.

The N.S.L in the headrace area varies from 184.00 m.a.s.l. to 191.00 m.a.s.l. and the ground water level is at 173.00 m.a.s.l. in the upper reach. Therefore the headrace is almost in cutting and no dewatering is required for construction. The layout of the intake of headrace was optimized by means of hydraulic model studies and the Cross Section are shown in Dwg. Nos. 18. The intake sill level at 179.47 m.a.s.l. was adopted as a result of hydraulic model studies to minimize the sediment entry. Headrace channel off takes from C-J Link and gives supplies to the power house for power generation. It joins with the power house through a proper transition designed to minimize the losses.

TABLE 8.2

Rating curve of Headrace channel

Wat. Dep.	Area	Wett.Par.	Hydr.Rad.	Discharge	Velocity	Froude No.
m	m^2	m	m	m^3/s	m/s	-
0.00	0.00	36.00	0.00	0.00	0.00	0.00
0.30	10.98	37.34	0.29	3.05	0.28	0.16
0.60	22.32	38.68	0.58	9.73	0.44	0.18
0.90	34.02	40.02	0.85	19.20	0.56	0.19
1.20	46.08	41.37	1.11	31.14	0.68	0.20
1.50	58.50	42.71	1.37	45.38	0.78	0.20
1.80	71.28	44.05	1.62	61.79	0.87	0.21
2.10	84.42	45.39	1.86	80.30	0.95	0.21
2.40	97.92	46.73	2.10	100.84	1.03	0.21
2.70	111.78	48.07	2.33	123.39	1.10	0.21
3.00	126.00	49.42	2.55	147.90	1.17	0.22
3.30	140.58	50.76	2.77	174.37	1.24	0.22
3.60	155.52	52.10	2.99	202.78	1.30	0.22
3.70	160.58	52.55	3.06	212.68	1.32	0.22
3.80	165.68	52.99	3.13	222.80	1.34	0.22
4.00	176.00	53.89	3.27	243.67	1.38	0.22

8.3.3 BED AND SLOPE PROTECTION

Concrete lining is provided in the bed and side slopes to avoid the loss of water from the headrace which is very important in the case of C.J Link tail hydro power project. The loss of water can occur toward the ground water as well as toward the C.J Link, because of the high difference in water level of headrace and downstream of C.J tail regulator as shown in Dwg. No. 04. The lining or any other kind of sealing along the out fall structure is also required to minimize the danger of increase in uplift pressure under fall structure No.2, 3 and 4. Taking into account cost of sealing and maintenance cost of headrace during operation, concrete lining is preferred.

The thickness of concrete lining is 15 cm and minimum reinforcement will be provided to reduce the chance of cracking. A good quality of concrete has to be applied to avoid any kind of seepage. Side drains and flip holes will be provided in the lining to reduce the danger of hydrostatic pressure beneath the side slopes.

Concrete lining will be constructed over a well prepared sub grade under dry condition. The intake of the headrace will be constructed during closure period.

8.3.4 EMBANKMENT STABILITY

A stability analysis of protected slope 1:2.0 of the headrace has been made. The stability analyses were carried out according to the design criteria. The analysis was made for normal condition and earthquake condition by taking an overburden of 20 kN/m^3 on the top of the embankment. These results show that slope is stable under both conditions.

8.3.5 TAILRACE

The tailrace channel is a stone pitched channel. The maximum discharge of the tailrace channel is 240 m^3/s. A typical section of tailrace channel is given in Drawing No.18. Top level of the stone pitching is fixed as the maximum water level in the CJ Link corresponding to maximum flood level in Jhelum river plus Freeboard. The other parameters of the tailrace are as follows:

Maximum discharge	= 240 m^3/s (8475 cusecs)
Bed width	= 36 m (118 ft)
FSD	= 4.0 m (13.1 ft)
Velocity	= 1.39 m/s (4.56 ft/s)
Side Slope	= 1:2 (V:H)
Longitudinal slope	= 1/10000 'n = 0.018

8.3.6 HYDRAULIC DESIGN

The bed width of the tailrace is equal to bed width of headrace, which is 36.0 m. The side slope is taken as 1:2. The maximum and minimum water levels are taken as 172.67 m.a.s.l. and 167.88 m.a.s.l. respectively. The top of the embankment is fixed at 174.50 m.a.s.l., which is higher than ever recorded maximum flood level of 174.7 m.a.s.l., in river Jhelum. The same embankment level was used for the C.J Link on downstream fall structure-4. The bed level of tailrace is taken 166.52 m.a.s.l. which is slightly lower than the existing bed level of the C.J Link. The adopted bed levels are higher than the level of the downstream stilling basin of the last fall structure. For detail about selection of downstream bed levels please see Section-6 "Hydrology and Sedimentation". The bed slope is taken as zero, because it does not affect the water levels due to its short length and the influence of C.J Link and Jhelum river.

The natural ground surface and ground water level lies at 191.0 m.a.s.l. and 174.0 m.a.s.l. respectively. Therefore construction of tailrace needs dewatering and also heavy excavation. The excavated material will be dumped on right side at a distance of 300 m from the centre line of the tailrace in the form of spoils.

The water levels and velocities were computed by using Strickler formula and taking co-efficient equal to 60 for lined channel. From computation of velocities it is clear that the minimum velocities in C.J Link are less than that of tailrace and therefore no sedimentation will occur. The maximum velocities are within the allowable limits.

8.3.7 EMBANKMENT STABILITY

The stability analysis for the protected embankment was made for normal operation condition and earthquake condition. The stability analyses were done by using design criteria. The overburden taken during analysis is about 20 kN/m^3. These results show that the slopes are stable for both conditions.

8.4 POWER HOUSE

8.4.1 GENERAL

The powerhouse is located almost in the line of last fall structure of tail regulator and its axis deviates from the axis of the fall by approximately 10 degree. The centre of powerhouse is located approximately at RD 1450 m from intake of power channel. The centre lines of powerhouse and Chashma-Jhelum link canal lies about 330 m apart for 3 unit and 169 m for 3 unit.

The powerhouse consist of 3 turbine blocks and one service block which is located on the left side of the powerhouse. The turbine blocks housing one unit each are separated by expansion joints. The service block is also separated from unit block with expansion joint. The powerhouse dimension will be determined primarily by the turbine water passage, the unit spacing and the space required for road, trashrack cleaning machines and stop logs.

The dimensions of the unit blocks and service block, shown in Dwg. Nos. 12 to 17 are as follows:

STRUCTURE	WIDTH	LENGTH	HEIGHT
TURBINE BLOCK	36.00	43.00	27.00
SERVICE BLOCK	16.00	36.60	11.00

8.4.2 DESCRIPTION OF POWERHOUSE STRUCTURE

8.4.2.1 MACHINE HALL

An enclosed type of machine hall instead of open type with a gantry crane is selected keeping in view the incidence of dust storm and extreme heat in this area specially in the summer. The machine hall is an enclosed concrete structure which supports overhead electric travelling cranes. It is extended over the generator floor, to facilitate the erection and repair of electro-mechanical equipment. The floor level of the machine hall is at 174.0 m.a.s.l. The width and length are 11.0 m and 43.0 m respectively. The height of the structure is about 9.0 m as shown in Dwg. Nos. 13 to 15. A proper ventilation and protection against direct sun light is also foreseen.

8.4.2.2 SERVICE BAY

The service bay as shown in Dwg. Nos.16 on the left side of the powerhouse. The floor level of service bay is kept same as that of the machine hall. It is used for loading and unloading of equipment. Loaded trailers can enter it through a multi panel vertical lift door on downstream side.

A basement (173.00 m.a.s.l.) below the service bay provides space for a work shop. An opening of 3.2 x 1.70 is provided in the floor for shifting of equipment to workshops for repair. A stair hall with dewatering sump is provided on downstream side. It is a separate structure from the statical point of view, but functionally it is well integrated in the powerhouse building. The foundation level of the service bay and unit block is kept almost the same, to reduce the danger of differential settlement in sandy (granular) soil.

The service bay is an enclosed concrete structure of the same width and height as that of the machine hall and will support over head electric cranes.

8.4.2.3 DRAINAGE GALLERY AND DRAINAGE SUMP

One drainage gallery (2.50 x 1.50 m) as shown in Dwg. No. 12 and 15 is provided in the powerhouse foundation. It extends over the entire length of the powerhouse and joins the drainage sump provided on downstream side of powerhouse. It also serves the following purpose:

- Act as inspection galleries. The relief wells used during the foundation works will be partially/totally connected to this gallery and used as piezometers during operation period.
- Foundation settlement and ground thrust measuring instrument will be installed.
- Drainage of infiltration and waste water upto pump sump.

- If necessary during operation foundation grouting work will be under taken through this gallery.

8.4.2.4 DEWATERING PIPE AND PUMP SUMP

Dewatering of intake, spiral casing and draft tube for maintenance purpose will be done by integrated pipe system. One pipe from each intake and draft tube is connected to main pipe through controlling valves. The main pipe running parallel to the powerhouse upto dewatering sump is laid under the draft tube. The dewatering sump is located in the service bay on downstream side and will be equipped with automatic controlled electric driven pumps. A valve shaft for turbine is provided in the pier to control the flow of water in the main pipe.

8.4.2.5 CABLE AND PIPE GALLERY

The main cable gallery is provided on the downstream side of the machine hall at elevation of 174.0 m.a.s.l. It runs parallel to the machine and goes upto the switchyard which is located on the left embankment of tailrace as shown in Dwg. Nos. 12 and 15. This cable gallery will accommodate the power cable and control cable. Power cables from generator to main gallery will come through a small gallery under the turbine floor.

Pipes from governor will come through a trench in the turbine floor. The pipes such as for fire fighting, cooling etc. will be placed at elevation of 170.00 m.a.s.l. and run upto turbine and generator through a trench under the turbine floor in the pier.

8.4.2.6 TRASH RACK

The powerhouse intake will be equipped with a trashrack, to prevent the turbine from any trash coming in the stream. The dimensions of the intake at this place are 9.00 x 15.00 m. Instead of providing intermediate pier, 3 horizontal steel beams are provided behind the trash rack bars. This arrangement will reduce the head loss through the trash rack.

The trash rack is installed at 78° angle with the horizontal which will reduce the head losses through the trash rack and also facilitate the mechanical cleaning. A mechanical rack cleaner is provided for cleaning purpose. While designing trash rack care should be given to vibration and cavitation.

8.4.2.7 STOP LOGS AND INTAKE GATE

Closure of intake and draft tube is needed for maintenance and erection of turbines. Stop log closure on upstream and downstream side is provided. But on upstream side gate closure is also provided due to relatively high head. Upstream stop log slots are provided between the trash rack and upstream gate, keeping a safe distance from both. Vertical electrical operated gates are provided. An alternative location for the stop logs just upstream of the trash rack was also considered. This alternative is dropped due to bigger size of stop log, increase in powerhouse dimensions and increase in head losses.

Downstream stoplog slots are provided at the end of draft tube. An alternative location of the slot was considered further upstream which would permit smaller size of stoplog. However the draft tube cross section has a large radius fillets in the corner and the slots for rectangular section create deep pocket in corner, which acts as a silt trap and can not be flushed even with flushing pipes. This would prevent proper closure of the stoplogs and in addition hydraulic losses would be high. This alternative was therefore rejected. Handling of upstream stoplogs will be done by trash rack cleaner. For the downstream stoplogs a separate gantry crane is suggested.

Storage area for the upstream stoplogs is provided on right side on a platform beside the retaining wall. Storage area for the downstream stoplogs is suggested on the right side of tailrace on platform beside the retaining wall.

8.4.2.8 SHEET PILES

Two rows of sheet piles are provided under the powerhouse structure, for safety against piping phenomena and uplift pressure. The suggested length for upstream and downstream piles will be 10 m and 20 m respectively.

8.4.2.9 ROAD CROSSING

Joharabad - Jhang road is crossing C.J Link at tail regulator. This road and bridge is designed for A class loading. A road over the intake structure of powerhouse of the same size and strength as that of the tail regulator is provided. Due to location of powerhouse some sharp bend was introduced in the road.

8.5 POWERHOUSE STRUCTURAL DESIGN

The powerhouse structure is divided into two (three) sections, each comprising one unit. An expansion joint is provided between the two (three) units.

The substructure is designed as a box on elastic foundation. It is designed for all internal and external loads such as loads imposed by turbines, superstructure, road, stoplogs vertical gate for closure, dead loads and wind loads etc.

This will be designed for two conditions.

- Normal operating case when water passage is filled with water and the units are in operation, with and without earthquake.
- Maintenance and construction condition , when the upstream and downstream stoplogs are installed, no unit load, no gate and the unit is also dewatered, with and without earthquake.

The superstructure is designed as a framed structure which also supports the crane girder. The other element such as walls, slabs and columns will be designed by normal structural methods.

8.5.1 POWERHOUSE STATICAL DESIGN

Powerhouse statical design has been done for single turbine block. For this, all the corresponding loads are calculated. Powerhouse stability analysis is done for the following requirement.

- Sliding
- Over turning
- floatation or uplift
- Bearing failure or over stressing

The following different loading conditions are taken for the above stability requirement.

- During construction
- Normal operation
- Above normal operation
- During repair
- Earthquake

The factor of safety computed for all the stability requirements for these loading conditions is higher than the minimum required.

8.6 INTAKE AND OUTLET BAY

8.6.1 GENERAL

Powerhouse is being constructed on the entirely alluvium requiring rigid bed and retaining walls of varying height at the intake and outlet bay. The headrace canal is concrete lined, therefore intake bay will be of concrete. But on downstream side concrete apron is suggested instead of stone apron to minimize the danger of scour due to high velocity in case of load rejection.

8.6.2 CONCRETE SLAB/APRON

Concrete slabs having different slopes are provided on upstream and downstream side of the powerhouse. The upstream slab starts at 179.17 m.a.s.l. bed level of head race and slopes down to a level 161.60 m.a.s.l. (intake of powerhouse). Slab is linked with powerhouse foundation slab through an expansion joint which will be sealed with sealing materials to avoid any seepage. Slab is 54.0 m long (in

the direction of flow) and 36.0 m wide, has normal thickness of 1.5 m, but at joint its thickness is about 2.5 m as shown in Dwg. No. 12.0.

The downstream slab starts at 161.30 m.a.s.l. invert level of draft tube and slopes upward to bed level of tailrace (166.82 m.a.s.l.). Slab having thickness of 1.50 m, length of 33.00 m and width of 36.00 m is shown in Dwg. Nos. 12. It is hinged with powerhouse foundation through an expansion joint which will be properly sealed to eliminate leakage. Thickness of slab at joint is 5.0 m. A sheet pile 5.00 m deep is provided at the end to protect against scour.

8.6.3 RETAINING WALL

Retaining walls of varying height are provided due to grade separation of powerhouse and power canal and bonding of intake/outlet concrete slab. Walls of either the gravity, semi-gravity and counterforts are more suitable Gravity type retaining walls are provided on upstream and downstream. These start from upstream and downstream of powerhouse and end up to the embankment of the power canal.

Expansion and construction joints are provided at specific interval and will be sealed with proper sealing materials. Expansion joints between retaining wall and powerhouse are provided, so that these will act as independent structures. Sheet piles under the retaining walls are provided to avoid piping and to reduce the uplift pressure.

There is no need of shear reinforcement however small quantity of reinforcement is required to meet the tension requirement.

8.7 SILT COLLECTION POOL

A silt collection pool is proposed in the power channel just downstream of the road bridge location. The silt collection pool is about 3 m deeper than the bed of the head race channel.

8.7.1 SIDE SPILLWAY / ESCAPE CHANNEL

A side spillway structure is proposed on the left side of the power channel to avoid any heading up effect in the channel Drawing No.20 and 21. The side spillway will start functioning when the water level in headrace is more than 0.15 m higher than the designed water level. The spillway is connected with an escape channel which falls into C-J Link downstream of fall No. 2.

A District Road bridge (DRB) is proposed at the head of escape channel to provide regular access to the power house. The escape channel has two fall structures. A foot bridge is also proposed on the 2nd fall of escape channel.

8.7.2 ROAD CROSSING / RECOLATION OF ROAD

The existing road crossing on the outfall structure will be extended straight to cross over the power channel and an Arterial Road Bridge will be constructed on the power channel. The road will be relocated in such a way that no hindrance occurs in traffic flow, as shown on the layout option drawing 8. Acquisition of land for relocation of the road will be required.

8.8 PERMANENT AND TEMPORARY CAMPS

The locations and requirements of the temporary labour camp during project construction period and a permanent camp to be used for maintenance purpose are marked on the layout of recommended scheme in drawing No. 09 in drawing volume VI.

8.9 PROJECT INFRASTRUCTURE DEVELOPMENT

The space between C-J Link and power channel is designated for staff colony is marked on the layout of recommended scheme on drawing No. 09 in drawing volume VI.

8.10 STRUCTURAL DESIGN ASPECTS

8.10.1 General

The structural design of different components of the project is influenced by a number of factors including functional requirements, ground water conditions, interpretation of geotechnical investigation data, construction restraints and time frame within which the project is to be executed. Main structural components of the project are as follows:

A brief description of the design of the above said components is given below:

8.11 A.R. BRIDGE

8.11.1 General

The A.R Bridge is a two span straight bridge. The superstructure is composed of pre-stressed concrete girders with deck slab and diaphragms. The substructure is composed of piers and abutments.

8.11.2 Foundation

The foundation of the bridge comprises a central pier and two abutments. The pier and abutment are supported on 1.00 meter diameter cast in-situ reinforced concrete piles as per recommendation of the geotechnical report. A 1.50 meter thick reinforced concrete pile cap will support four 1.2 meter (3.93 ft) diameter piers, 3.30 meters (10.83) apart. The analysis and design of the piles, piles cap, piers, transom and the abutment has been carried out for the loads from the superstructure, using the soil springs for the design of the piles. R C shear keys have been provided on the transom at the free ends of girders to restrain the lateral movement of the superstructure during earthquake. The structure has also been checked for seismic forces.

8.11.3 Superstructure

The superstructure is composed of pre-cast pre-stressed concrete girders with cast-in-situ concrete deck slab. The two-span system has been analyzed using grillage analysis for the vehicular loads. The girder is pre-stressed with 12.5 mm diameter pre-stressing strands with stressing from both ends. The girders are to be fixed to transom/beam seat with steel pins at fixed ends whereas laterally restrained by shear keys at free ends.

8.12 D.R. BRIDGE

8.12.1 General

The D R Bridge is a single span straight bridge over the escape structure. The basic design and other features of this bridge are similar to those of A R Bridge. However to design the reinforced concrete abutment, complete analysis of the superstructure has been carried out.

8.12.2 Foundation

The foundation of the D R bridge comprises two reinforced concrete abutments supported by piles. The analysis and design of the sub-structure is similar to that of A R Bridge.

8.12.3 Superstructure

The analysis and design of the superstructure is similar to that of A R Bridge.

8.13 ESCAPE STRUCTURE

8.13.1 General

The structure is a reinforced concrete structure. It consists of two side retaining walls and the base slab.

8.13.2 Retaining Walls

The retaining walls along the flow are reinforced concrete cantilever walls. Design of walls has been carried out in accordance AASHTO Code and structural design criteria using Soil pressure and other geotechnical parameters derived from the geotechnical report.

8.13.3 Base Slab

The base slab is 200 mm (7.87 inches) thick with thickened edges. The base slab was designed as a slab on grade in accordance AASHTO Code. Co-efficient of friction between slab and subgrade and other geotechnical parameters were derived from the geotechnical report.

8.14 FOOT BRIDGE

8.14.1 General

A reinforced concrete foot bridge 2.20 meters (7.21 ft) in width, has been provided over escape structure for pedestrian crossing. The bridge is a single-span bridge supported on end piers.

8.14.2 Foundations

The 500 x 500 mm (19.7 x 19.7 inches) square piers will support the superstructure. The end piers will be supported by 3 x 3 meter (9.84 x 9.84 ft) square footing. The piers designed for both pedestrian traffic load and the earthquake loads. The girders were designed for pedestrian loads, self loads and other imposed dead loads.

8.14.3 Superstructure

The superstructure is a pre-cast reinforced girder of 17.0 meters (48.85 ft) span with 2.20 meters (7.21 ft) wide flange as walkway. The Galvanized Iron (GI) pipes of 100 mm (4 inches) diameters have been provided on the flange slab for drainage purpose. The piers were designed for pedestrian loading and the earthquake loading.

8.15 POWER HOUSE

8.15.1 General

The power house accommodates three turbines of 8.33 MW capacity each, control room, battery room, switch gear room, lay down/maintenance area, spare parts rooms, GIS rooms, offices, draft tube, gates, overhead crane and hoist system etc. The main power house building (turbine area) is supported on raft foundation. The upper part of the power house is a column-beam frame structure.

8.15.2 Raft Foundation

Analysis and design of the raft foundation has been carried out for the loads of main power house and using the soil springs stiffness which was derived from the preliminary geotechnical report. The structure has also been checked for seismic forces.

8.15.3 Column-Beam Frame Structure

The column-beam frame structure consists of three floors of 26.5m x 20.0 m (96.94 x 65.62 ft). This system is supported on raft foundation. Structure analysis has been carried out using SAP 2000 computer program.

8.16 STRUCTURAL DESIGN CRITERIA

8.16.1 General

The main purpose and the objective of the structural design criteria is to formulate and finalize technical data, design assumptions, codes of practice, methods and procedures to be adopted in the structural design of various structures of the Project. The designs were accomplished using International System (SI units).

8.16.2 Codes and Standards

Following Codes and standards have been used in the design: BCP (1986) -Building Code of Pakistan WPCPHB (1967) -West Pakistan Code of Practice for Highway Bridges AASHTO (1996) -Standard Specifications for Highway Bridges.

The American Association of State Highway and Transportation Officials. ACI 318-02 -Building Code Requirements for Reinforced Concrete. American Concrete Institute. ACI 301-95 -Specifications for Structural Concrete. American Concrete Institute.

ASTM A-615 -Specifications for Deformed and Plain Billet Steel Bars for Concrete Reinforcement. ASTM C-150 -Specifications for Portland Cement ACI-350 R -Environmental Engineering Concrete Structures ASTM C-33 -Specifications for Concrete Aggregate UBC 1997 -Uniform Building Code of USA.

8.16.3 Loads

Structures were designed to be capable of resisting the following main loads and forces:

- Dead Load
- Live Load
- Impact
- Wind Load
- Longitudinal forces due to tractive/braking effort of vehicles
- Earth Pressure
- Earthquake Forces

8.16.4 Dead Loads

Dead Loads were computed from the unit weights of the materials as given in the Building Code of Pakistan.

8.16.5 Live Loads

Vertical live loads used were either Class "A" or Class "AA" live load, and the severer of the two was considered for design.

Class – "A" Truck-train loading as specified in Clause 2.4 of West Pakistan Code of Practice for Highways (WPCPHB-1967). Class - "AA" Military loading as specified in Section-4 of West Pakistan Code of Practice for Highways Bridges (WPCPHB-1967).

A uniform live load of 4 kN/m2 (85 lb/m2) on deck slab of Pedestrian bridge.

8.16.6 Impact

Impact on live loads was considered as specified in Clause 4.4 for 'Military Loading' and in Clause 2.9 for 'Truck Train Loading' of West Pakistan Code of Practice for Highway Bridges (WPCPHB-1967), as appropriated.

8.16.6.1 Wind Loads

Wind load was computed according to UBC considering wind velocity of 160 km per hour (100 miles/hour).

8.16.6.2 Longitudinal Forces

Longitudinal forces due to tractive/braking effort was taken equal to 30% of the weight of the vehicle considering that only one lane was occupied for Class 'A' Loading and 15% of weight of military vehicle for Class 'AA' Loading.

8.16.6.3 Earth Pressures

Lateral earth pressures due to backfill were computed by the classical theories taking into account the effect of submergence and seismicity of the area.

8.16.6.4 Earthquake Forces

Earthquake forces were computed using an earthquake acceleration considering the recommendations of seismic studies described in Section 5. The project components have been designed for peak horizontal ground acceleration of 0.20g. The less important structures have been designed for peak horizontal ground acceleration of 0.17g. zone as per latest Pakistan Seismic zone map.

8.16.6.5 Loading Combination Loading combinations used were as per AASHTO Code.

8.16.7 Materials

The following materials will be used in the construction of the project.

8.16.7.1 Concrete

All reinforcing steel used in reinforced concrete works was considered to conform to ASTM A615 Grade 60 with minimum yield strength of 4250 kg/cm2 (60,000 psi) or AASHTO M-31 Grade 60.

All pre-stressing steel used was normal relaxation strand conforming to AASHTO M203 (ASTM A-416), Grade 270 having minimum ultimate tensile strength of 19000 N/mm2 (270 ksi).

8.16.8 Foundation Parameters

The Geotechnical parameters relating to the bearing capacity, lateral earth pressures, depth of foundations, and the use of Sulphate Resisting Cement etc. was based on the actual geotechnical investigations at site.

8.16.9 Stability Criteria

The following stability criteria were used.

Factor of safety (Sliding) = 1.50 Factor of safety (Overturning) = 1.50 Bearing Pressure = The resultant of forces shall fall within middle third of the base.

8.16.10 Computer Software

Computer programs SAP 2000/STAAD-Pro were used for the analysis and designs of the project structures.

SECTION – 9

MECHANICAL EQUIPMENTS

SECTION – 9

MECHANICAL EQUIPMENTS

9.1 General

Hydro-mechanical equipment related to the generating plants and the equipment for miscellaneous auxiliary services are described here. It also provides a brief description of criteria applied for selection of equipment.

9.2 Operating Conditions

a) The generating units shall have to work mainly under power requirement varying head and discharge.

b) The turbine operation criteria are based on the following values of headrace water level (HWL) and tailrace water levels (TWL).

Table 9.1 Calculation of Gross Head

Parameters	Values
Maximum Headrace Water Level	El. 183.17 m
Minimum Head Water Level	El 181.92 m

Table 9.2: Tailrace water Levels (TWL)

Parameters	Values
Maximum Tail Water Level	El. 169.982 m
Minimum Tail Water Level	El. 167.878 m

9.2 Mechanical Equipment Standards

Broad base design standardization of equipment, material, metallurgy, and values is provided. All the equipment shall be designed and manufactured in accordance with reputed international standards. The mechanical equipment needed for the Hydropower Plants is divided as main plant, appurtenances and equipment for auxiliary systems.

All equipment and parts related to mechanical engineering design concerning choice of materials, main dimensions and function would conform to latest international standards applicable for design, calculations, materials and fabrication of the equipment.

The following standards are applicable:

- DIN German standards, issued by Deutsches Institute fur Normung
- JIS Japanese Standards Association.
- ISO International Organization for Standardization.
- IEC International Electro Technical Commission.
- ASTM American Society for Testing of Materials.
- AWS American Welding Society.
- ASME American Society of Mechanical Engineers.
- NFPA National Fire Protection Association, USA.
- FEM Federation European de Manufacturer and other standards as applicable.

9.3 Components of Mechanical Equipment

Main Plant

- Turbines and auxiliaries.
- Power house cranes

Auxiliary Systems

- Cooling Water System
- Lubrication / Oil Handling System
- Heating, Ventilation and Air Conditioning System
- Fire Fighting System
- Compressed Air System
- Dewatering System
- Drainage System
- Powerhouse Elevator
- Workshop Equipment (Electrical & Mechanical)

Hydraulic Steel Structures and Hoisting Equipment

- Intake Bulkhead / Stoplog
- Trashrack at intake -Trashrack Cleaning Machine
- Intake stoplog
- Draft tube gate
- Draft tube stoplog

9.4 TURBINES

The powerhouse shall consist of three horizontal shaft double regulated bulb turbines directly coupled to synchronous generators.

9.4.1 Selection of Turbine

The criteria for selection of unit rated output, is based on the economic and financial analysis as discussed earlier. Total estimated output is based on analysis of available head and discharge.

9.4.2 Type of Turbine

The available head and discharge variations are main factors leading to selection of type of turbines. Both pit-type horizontal Kaplan units and horizontal bulb turbines are suitable for low head run-of-canal hydropower projects and are more economical than vertical Kaplan configuration. Bulb units have high efficiency, low maintenance and are suitable for such sites with low head, large and variable water flow.

Low head bulb turbines represent mature and robust technology and have a higher efficiency, quicker erection time, lower civil work costs and easier accessibility for maintenance. Accordingly, the power potential shall be utilized through installation of three low speed bulb-turbine units and synchronous direct drive generators within the bulb housing. Important turbine parameters are mentioned in Table 9.3.

Table 9.3: Turbine Sizing Criteria

Description	Parameters
Maximum Turbine output, MW	9.80
Rated Turbine output, MW	8.33
Maximum Efficiency, %	94.8
Rated Discharge, m3/s	70.0
Net Head at Rated Discharge, m	12.232
Maximum Net Head, m	13.809
Minimum Net Head, m	11.605
Setting to tail water level, m	-3.0
Arrangement	Horizontal Bulb
Runner Diameter, mm	3625
Number of runner blades	4
Runner hub diameter, mm	1,508
Maximum runaway speed, rpm	418
Unit Speed, rpm	150
Approximate Runner weight, kg	14400
Intake Type	Straight
Inlet Height, mm	8230
Inlet Width, mm	8230
Bulb diameter, mm	4,170
Bulb length, mm	9790
Bulb support width, mm	2,377
Draft Tube Type	Straight
Overall length, mm	17400
Discharge cone length, mm	8,000
Exit Width, mm	7610
Exit Height, mm	5440
Wicket Gate Height, mm	1,464
Wicket Gate Circle Diameter, mm	5,360

9.4.3 Structural Description of Turbine Parts

a) Runner

The adjustable four blades runner shall consist of the following main components:

1. Runner blades
2. Blade operating mechanism
3. Runner hub

The four adjustable blades shall be made of solid non-corrosive cast steel CrNi 13/4 or of better quality as per latest practice. The blades shall be designed to permit interchanges of blades without dismantling parts inside the runner. The runner blade servomotor shall be located inside the runner hub.

The partially spherical runner hub shall be made of solid non-corrosive cast steel CrNi 13/4. The runner cone shall be fabricated of carbon steel plate and split into two pieces. Radiography/ ultrasound/ dye penetration tests shall be carried out on the runner before leaving the factory. The runner shall be subject to static balance test.

b) Main Shaft

The turbine generator shaft shall be made of open hearth carbon or alloy steel with integrally forged flanges on both ends for bolted connection of generator rotor and turbine runner.

c) Shaft Seal

A self adjusting shaft seal of radially flexible lip ring type in combination with pre-labyrinth rings without requirement of filtered lubrication water supply under normal operating conditions shall be provided. Easy replacement of wearing parts shall be possible without dismantling the guide bearing.

d) Bearings

The guide bearing on the turbine side and the combined thrust bearing on the generator side shall be of "oil filled" type.

e) Gate Operating Mechanism

The gate operating mechanism shall comprise of the wicket gates, speed regulating control ring, lever and links, closing weight, servomotor etc. Governor regulates the wicket gates opening to guarantee the synchronous speed under varying loads and shall shut off turbine in emergency.

f) Bulb body and stay columns

Bulb body and stay columns shall be made of welded steel plate. Access in the bulb body shall be provided through the stay columns.

g) Draft Tube

The draft tube shall be made of rolled steel sheet parts welded together.

9.4.4 Setting – Cavitations Effect

Overall plant efficiency is dependent on the design of the water passages from headrace, powerhouse and tailrace. However, the turbine manufacturer is only responsible for the design between the turbine inlet and the discharge of the draft tube. Therefore the following dimensions are adopted for inclusion in the turbine specifications as limiting dimensions:

. Elevation of centre-line of distributor.
. Elevation of low point of draft tube.

- Horizontal distance from centre-line of unit to the end of the draft tube.
- Exit velocity
- Suction Head (Hs) etc.

9.4.5 Unit Spacing

The criteria for unit spacing is to provide sufficient space between the units for ease of maintenance.

9.4.6 Speed Governor

Hydraulic turbine governor are designed to regulate the speed and output of turbine-generator units by controlling the wicket gates and runner blade position to adjust water flow through the turbine. The governor senses changes in load (or speed) and respond with a movement of the wicket gates and runner blade position in order to maintain synchronous speed. The criterion is the stability as well as sensitivity of the governor.

Keeping in view these essential requirements and latest trends in hydropower controls, a Proportional Integral Derivative (PID) Digital Electro Hydraulic Governor is proposed.

9.5 POWER HOUSE CRANES

9.5.1 Gantry Crane

One gantry crane with double girders shall be used for the equipment erection and maintenance purposes. The crane shall be used for the handling of intake bulkhead, trashrack, intake stoplog and removable roof. In addition it shall be used for the maintenance of step-up transformers, turbine and generator parts etc. The crane shall have an electrically operated motor, rated to transport the gantry with the load suspended from the main hook.

The main features are as follows:

Capacity of main hook : 50 tons
Capacity of auxiliary hook : 10 tons
Span between crane rails : 23.5 m

9.5 Bridge Crane

One bridge crane with double girders shall serve the entire turbine hall and the mechanical workshop and shall be used for the operation and maintenance of turbine and generators. The main features are as follows:

- Capacity of main hook 25 tons
- Capacity of auxiliary hook 5 tons
- Span between crane rails 12.5 m

9.6 AUXILIARY SYSTEMS

- Cooling Water System
- Lubrication / Oil Handling System
- Heating, Ventilation and Air Conditioning system
- Fire Fighting System
- Compressed Air System
- Dewatering System
- Drainage System
- Powerhouse Elevator
- Workshop Equipment (Electrical & Mechanical)

9.6.1 Cooling Water System

Cooling is required for the turbine bearings, governor, generator, generator bearing and transformer. Lubricating oil system shall be provided for the cooling of turbine bearings and governor including oil-water heat exchanger. For the cooling of generator and transformer separate water circuits shall be provided. Cooling water flow shall be controlled automatically depending on the oil temperature. Cooling water shall be taken from the upstream side and passed through full flow strainer before being fed to a header. Water shall be tapped off the header to feed the required locations. The system shall include cooling water pumps, heat exchangers, valves, piping etc. The cooling water shall be drained to tail race.

9.6.2 Lubrication and Oil Handling System

The system shall consist of two storage tanks for turbine lubrication and hydraulic governor. Oil treatment unit shall also be provided for cleaning of dirty oil. The equipment shall include equipment for taking oil samples, manual and electrical transfer pump with pipes/hoses and filters, as well as a mobile high grade filtering unit with oil separator. The mobile filtering unit shall also be able to be coupled in parallel to all oil systems, including transformers.

9.6.3 Heating, Ventilation and Air Conditioning System

9.6.3.1 Air-conditioning system

The air conditioning system shall maintain the indoor temperature at a pre-determined level in the offices and control rooms. The system shall include condensing units, air conditioners, air distribution and air diffusion system, humidifiers etc.

9.6.3.2 Ventilation system

The ventilation system shall be designed to provide clean air to air conditioned space by the filtration of re-circulated and outside fresh air and to pressurize the building so as to prevent the infiltration of uncontrolled out side air.

9.6.3.3 Air exhaust system

The air exhaust system shall be provided in order to complete the fresh air circuit. The system shall include exhaust fans, exhaust ducts, louvers etc.

9.6.4 Fire Fighting System

Fire fighting system shall be sufficient to overcome fire hazards in the powerhouse building and substation area. Fire fighting system shall consist of fire water pumps, storage tanks, hydrants, piping, hoses etc. For lubrication, oil handling system, generators and transformers automatic carbon dioxide (CO2) extinguishing system shall be provided. Mobile fire extinguishers shall be provided at most wanted locations in the power house. Also water tapping for fire fighting shall be provided in the power house to be used for fire hoses.

9.6.5 Compressed Air System

Compressed air shall be provided for governor oil pressurization and maintenance purposes. Twin system, one for governor oil pressurization and the other low pressure system for workshop and other maintenance purposes shall be provided. The system shall include air filters, compressors, after-coolers, storage tanks, valves, piping, hoses etc.

9.6.6 Dewatering System

Dewatering system shall be provided for dewatering of the turbine and associated water passages for repair and maintenance purposes. The system shall include dewatering pumps, sumps, valves, piping etc.

9.6.7 Drainage System

Drainage system shall be provided for the surface drainage of the powerhouse. The system shall include drainage pumps, sumps, valves, piping etc.

9.6.8 Powerhouse Elevator

One power house elevator shall be provided for the transportation of 6-8 persons and equipment.

9.6.9 Workshop Equipment (Electrical & Mechanical)

The workshop equipment should be sufficient for erection, assembly and dismantling of turbine parts as well as other components of the power house and to repair components.

9.7 HYDRAULIC STEEL STRUCTURE (GATE EQUIPMENT)

9.7.1 General

This sub-section describes the general and preliminary technical requirements for the hydraulic steel structure (gate equipment) to be installed in the proposed power house. The term gate equipment used herein includes gates, hoists, bulkheads, stoplogs and trashracks & their embedded metalwork. The gate equipment to be provided for the power house shall only be required to stop the flow for any emergency repair or inspection of the structure and other equipment located therein. Following type of gate equipment shall be provided:

- Intake Bulkhead / Stoplog
- Trashrack at intake
- Trashrack Cleaning Machine
- Intake stoplog
- Draft tube gate
- Draft tube stoplog

9.7.2 INTAKE BULKHEADS/STOPLOG

9.7.2.1 Functional Requirement

For installation, maintenance, inspection and repair of turbines, it is necessary to dewater the upstream area of the turbines and their adjacent waterway. Intake bulkhead is required for preventing entry of headrace water into the waterway when the turbine and their waterway are dewatered.

9.7.2.2 Type

The Intake bulkhead/stoplog shall be vertical lift roller type (at 75°), designed under maximum possible differential balanced head and operation at balanced conditions.

9.7.2.3 Size

One set of Intake bulkheads/Stoplog shall be provided; each set consisting of 10 sections, the bulkhead shall have 12.4 m nominal width and 23.6 nominal height.

9.7.2.5 Gate Leaf

The Intake bulkhead/Stoplog shall have downstream skin plates and seals. Each gate shall be fabricated in 10 sections. Each section shall be of welded steel construction 12.4 m wide by 2.36 m high. The gate shall have compression type bottom seals and 'J' type side and top seals. Guide wheels shall be provided at the top and bottom of each side of the intake bulkhead sections to engage the guides or slots embedded in the concrete. Lifting hooks shall be provided to handle the gate by a lifting beam.

9.7.2.6 Embedded Metalwork

A set of embedded metalwork shall consist of a sill beam, a lintel beam, two side seal plates, two guide channels for installation of bulkhead/stoplog. Three sets of embedded metalwork shall be required. The sill beam shall provide sealing surfaces for bottom of the gate. All sealing surfaces shall be of corrosion resisting clad plates.

9.7.2.7 Preliminary Parameters The preliminary parameters of the Intake bulkhead/stoplog equipment are given hereunder.

Type Vertical-lift bulkhead No. of set 1 No. of sections/set 10 Size of each section 12.4 m (W) x 2.36 m (H) Total size of bulkhead 12.4 m x 23.6 m No. of embedded parts 3 sets Sill elevation 161.8 m Maximum headrace water level 183.82 m Intake Bulkhead/Stoplog handling by lifting beam and gantry crane at balanced head condition

9.7.3 TRASHRACKS

Removable plane type trashrack set consist on five (5) section having 9.74 m wide and 14.2 m high shall be provided for each intake. The trashracks shall have a rack bar spacing of 50 mm c/c to protect the turbine against trash.

The trashracks shall be of welded construction with rectangular rack bars supported on horizontal box girders. The trashracks shall be designed for a 5 m differential head acting across the gross area of the trashrack.

One lifting beam for handling the trashracks and one mechanised trashrack for raking the trashrack. The lifting beam and trashrack shall be of welded construction which shall operate in the guides embedded in the concrete for removal of trashracks.

9.7.4 TRASHRACK CLEANING MACHINE

9.7.4.1 Functional Requirement

It is necessary to clean the trashrack to maintain the required level of water upstream and downstream of the trashrack machine. Trashrack cleaning machine is required to be installed upstream of the trashrack in form of trash rake and jib grab to arrest small and big particles, respectively.

9.7.4.2 Trashrack Cleaning Machine

The trashrack cleaner shall be equipped apart from the raking and driving mechanism with a rotating jib grab to pick up large trash pieces or wooden logs. Power supply to the traskrack cleaner shall be provided by enclosed conductor.

The trashrack cleaner structure shall consist of a portal-type frame of welded steel shapes, end trucks

supporting the long travel gears and, at the upper part service platform accommodating the control cab, electrical cubicle, hydraulic power pack, carriage operating hoist, carriage bucket operating gear and tilting apron operation. The jib grab shall be installed at convenient location.

Adequate size crane rails, its accessories and anchors with end stops shall also be installed.

9.7.4.3 Preliminary parameters

The preliminary parameters of the trashrack cleaning machine are given hereunder:

A.	**Trashrake**	
No. of set		1
Width of rake		3 m
Lifting capacity		10 ton
	Traveling height	28 m
	Lifting speed	20 m/min.
	Lowering speed	40m/min.
B.	**Jib**	
	Lifting capacity	5 ton
	Lifting height	15 m
	Lifting speed	20m/min.
	Radius of action from edge of parapet	2m
	Angle of rotation	190 degrees
C.	**Runaway rail and power conductor**	
	Span of runway rail	3m approx.
	Length of 3 units	42 m

9.7.5 INTAKE STOPLOG EQUIPMENT

9.7.5.1 Functional Requirement

For installation, maintenance, inspection and repair of turbines, it is necessary to dewater the turbines and their adjacent waterway. Intake stoplogs are required to act as bulkheads for preventing entry of tailrace water into the waterways when the turbines and their waterways are dewatered.

9.7.5.2 Type

The Intake stoplogs shall be vertical lift bulkheads or sliding gate type designed for maximum possible differential head conditions.

9.7.5.3 Size Three sets of Intake stoplogs shall be provided, each set consisting of 5 sections. The stoplog shall have 9.74 m nominal width and 12.40 nominal height.

9.7.5.4 Intake stoplog

The Intake stoplogs shall have downstream skin plates and seals, each gate being designed to close a waterway as shown on the drawing. The stoplog shall be fabricated in five (5) sections. Each section being of welded steel construction 9.74 m wide by 2.48 m high. Each section shall have compression type bottom seals and 'J' type side and upper most section shall have top seal. Guide shoes shall be provided at the top and bottom of each side of the stoplog section to engage the guides or slots embedded in the concrete.

Lifting hooks shall be provided to handle the gate by a lifting beam.

9.7.5.5 Embedded Metalwork

A set of embedded metalwork shall consist of a sill beam, a lintel beam, two side seal plates, two guide plates for installation of Intake stoplog. Three sets of embedded metalwork shall be required. Welding pads shall be embedded in first stage concrete to facilitate the alignment of the parts embedded in the second stage concrete. The sill and lintel beams shall provide sealing surfaces for bottom and top seals of the gate respectively. All sealing surfaces shall be of corrosion resisting clad plates.

9.7.5.6 Preliminary Parameters

The preliminary parameters of the Intake stoplog equipment are given hereunder.

- Type Vertical-lift bulkhead
- No. of stoplog sets 3
- No. of sections/set 5
- Size of one section 9.74 m (W) x 2.48 m (H)
- Total size of stoplog 9.74 m (W) x 12.4 m (H)
- No. of embedded parts 3 sets
- Sill elevation 160.4 m
- Maximum headrace water level 183.82 m
- Stoplog handling By lifting beam and gantry crane at balanced head condition

9.7.6 DRAFT TUBE GATE EQUIPMENT

9.7.6.1 Functional Requirement

For installation, maintenance, inspection and repair of turbines, it is necessary to dewater the turbines and their adjacent waterway draft tube gates are required to act as bulkheads for preventing entry of tailrace water into the waterways when the turbines and their waterways are dewatered.

9.7.6.2 Type

The draft tube gates shall be vertical lift roller type bulkhead or sliding gate type hydraulically operated designed under maximum possible differential head conditions.

9.7.6.3 Size

Three sets of draft tube gates shall be provided, each of 7.5 m nominal width and 6.6 nominal height.

9.7.6.4 General Arrangement

The general arrangement of the draft tube gate equipment is shown on Drawing No. 13.

9.7.6.5 Draft Tube Gate

The draft tube gates shall have upstream skin plates and seals, each gate being designed to close a waterway 7.35 m wide and 6.4 m high. The gate shall have compression type bottom seals and 'J' type side and top seals. Guide rollers shall be provided at each side of the gate leaf to engage the guides or slots embedded in the concrete. Lifting hooks shall be provided to handle the gate by a grappling beam.

9.7.6.6 Embedded Metalwork

A set of embedded metalwork shall consist of a sill beam, a lintel beam, two side seal plates, two guide rails for installation of draft tube gate. Three sets of embedded metalwork shall be required. Welding pads shall be embedded in first stage concrete to facilitate the alignment of the parts embedded in the second stage concrete. The sill and lintel beams shall provide sealing surfaces for bottom and top seals of the gate respectively. All sealing surfaces shall be of corrosion resisting clad plates.

9.7.6.7 Preliminary Parameters

The preliminary parameters of the draft tube gate equipment are given hereunder.

Type	Vertical-lift bulkhead
No. of gates	3
Size of gate leaf	8.5 m x 6.6 m
Sill elevation	162.0 m
No. of embedded parts	3 sets
Maximum tailwater level	172.67 m
Type of Hoist	Hydraulic

9.7.7 DRAFT TUBE STOPLOG EQUIPMENT

9.7.7.1 Functional Requirement

Total size of stoplog set	9.14 m x 11.5 m
No. of embedded parts	3 sets
Sill elevation	162.0 m
Maximum tailwater level	172.67 m
Stoplog Handling balanced head	By lifting beam and mobile crane at condition

For installation, maintenance, inspection and repair of waterway, draft tube and misc. embedded metal work. Draft tube stoplogs are required to act as bulkheads for preventing entry of tailrace water into the waterways when the turbines and their waterways are dewatered.

9.7.7.2 Type

The draft tube stoplogs shall be vertical lift roller type bulkheads or sliding gate type hydraulically operated designed under maximum possible differential head conditions.

9.7.7.3 Size

One (1) set of draft tube stoplogs shall be provided, each set consisting of five (5) sections of 9.14 m nominal width and 11.5 nominal height.

9.7.7.4 Draft Tube Stoplog

The draft tube stoplogs shall have upstream skin plates and seals, the stoplog being designed to close a waterway 9.0 m wide and 6.4 high. Stoplog shall be fabricated in five (5) sections. Each section being of welded steel construction 9.14 m wide by 2.3 m high. The stoplog sections shall have compression type bottom seals and 'J' type side seals. Guide shoes shall be provided at the top and bottom of each side of the stoplog sections to engage the guides or slots embedded in the concrete. Top of every section of stoplog shall act as sill beam. Lifting books shall be provided to handle the stoplog by a lifting beam.

9.7.7.5 Embedded Metalwork

A set of embedded metalwork shall consist of a sill beam, two side seal plates, and two guide plates for installation of draft tube stoplog. Three sets of embedded metalwork shall be required. Welding pads shall be embedded in first stage concrete to facilitate the alignment of the parts embedded in the second stage concrete. The sill beam shall provide sealing surfaces for bottom seal of the stoplog respectively. All sealing surfaces shall be of corrosion resisting clad plates.

9.7.7.6 Preliminary Parameters

The preliminary parameters of the draft tube stoplog equipment are given hereunder. Type Vertical-lift bulkhead No. of stoplogs 1 No. of sections / set 5 Size of each section 9.14 m (W) x 2.3 m (H)

SECTION – 9

MECHANICAL EQUIPMENTS

SECTION – 9

MECHANICAL EQUIPMENTS

9.1 General

Hydro-mechanical equipment related to the generating plants and the equipment for miscellaneous auxiliary services are described here. It also provides a brief description of criteria applied for selection of equipment.

9.2 Operating Conditions

a) The generating units shall have to work mainly under power requirement varying head and discharge.

b) The turbine operation criteria are based on the following values of headrace water level (HWL) and tailrace water levels (TWL).

Table 9.1 Calculation of Gross Head

Parameters	Values
Maximum Headrace Water Level	El. 183.17 m
Minimum Head Water Level	El 181.92 m

Table 9.2: Tailrace water Levels (TWL)

Parameters	Values
Maximum Tail Water Level	El. 169.982 m
Minimum Tail Water Level	El. 167.878 m

9.2 Mechanical Equipment Standards

Broad base design standardization of equipment, material, metallurgy, and values is provided. All the equipment shall be designed and manufactured in accordance with reputed international standards. The mechanical equipment needed for the Hydropower Plants is divided as main plant, appurtenances and equipment for auxiliary systems.

All equipment and parts related to mechanical engineering design concerning choice of materials, main dimensions and function would conform to latest international standards applicable for design, calculations, materials and fabrication of the equipment.

The following standards are applicable:

- DIN German standards, issued by Deutsches Institute fur Normung
- JIS Japanese Standards Association.
- ISO International Organization for Standardization.
- IEC International Electro Technical Commission.
- ASTM American Society for Testing of Materials.
- AWS American Welding Society.
- ASME American Society of Mechanical Engineers.
- NFPA National Fire Protection Association, USA.
- FEM Federation European de Manufacturer and other standards as applicable.

9.3 Components of Mechanical Equipment

Main Plant

- Turbines and auxiliaries.
- Power house cranes

Auxiliary Systems

- Cooling Water System
- Lubrication / Oil Handling System
- Heating, Ventilation and Air Conditioning System
- Fire Fighting System
- Compressed Air System
- Dewatering System
- Drainage System
- Powerhouse Elevator
- Workshop Equipment (Electrical & Mechanical)

Hydraulic Steel Structures and Hoisting Equipment

- Intake Bulkhead / Stoplog
- Trashrack at intake -Trashrack Cleaning Machine
- Intake stoplog
- Draft tube gate
- Draft tube stoplog

9.4 TURBINES

The powerhouse shall consist of three horizontal shaft double regulated bulb turbines directly coupled to synchronous generators.

9.4.1 Selection of Turbine

The criteria for selection of unit rated output, is based on the economic and financial analysis as discussed earlier. Total estimated output is based on analysis of available head and discharge.

9.4.2 Type of Turbine

The available head and discharge variations are main factors leading to selection of type of turbines. Both pit-type horizontal Kaplan units and horizontal bulb turbines are suitable for low head run-of-canal hydropower projects and are more economical than vertical Kaplan configuration. Bulb units have high efficiency, low maintenance and are suitable for such sites with low head, large and variable water flow.

Low head bulb turbines represent mature and robust technology and have a higher efficiency, quicker erection time, lower civil work costs and easier accessibility for maintenance. Accordingly, the power potential shall be utilized through installation of three low speed bulb-turbine units and synchronous direct drive generators within the bulb housing. Important turbine parameters are mentioned in Table 9.3.

Table 9.3: Turbine Sizing Criteria

Description	Parameters
Maximum Turbine output, MW	9.80
Rated Turbine output, MW	8.33
Maximum Efficiency, %	94.8
Rated Discharge, m3/s	70.0
Net Head at Rated Discharge, m	12.232
Maximum Net Head, m	13.809
Minimum Net Head, m	11.605
Setting to tail water level, m	-3.0
Arrangement	Horizontal Bulb
Runner Diameter, mm	3625
Number of runner blades	4
Runner hub diameter, mm	1,508
Maximum runaway speed, rpm	418
Unit Speed, rpm	150
Approximate Runner weight, kg	14400
Intake Type	Straight
Inlet Height, mm	8230
Inlet Width, mm	8230
Bulb diameter, mm	4,170
Bulb length, mm	9790
Bulb support width, mm	2,377
Draft Tube Type	Straight
Overall length, mm	17400
Discharge cone length, mm	8,000
Exit Width, mm	7610
Exit Height, mm	5440
Wicket Gate Height, mm	1,464
Wicket Gate Circle Diameter, mm	5,360

9.4.3 Structural Description of Turbine Parts

a) Runner

The adjustable four blades runner shall consist of the following main components:

1. Runner blades
2. Blade operating mechanism
3. Runner hub

The four adjustable blades shall be made of solid non-corrosive cast steel CrNi 13/4 or of better quality as per latest practice. The blades shall be designed to permit interchanges of blades without dismantling parts inside the runner. The runner blade servomotor shall be located inside the runner hub.

The partially spherical runner hub shall be made of solid non-corrosive cast steel CrNi 13/4. The runner cone shall be fabricated of carbon steel plate and split into two pieces. Radiography/ ultrasound/ dye penetration tests shall be carried out on the runner before leaving the factory. The runner shall be subject to static balance test.

b) Main Shaft

The turbine generator shaft shall be made of open hearth carbon or alloy steel with integrally forged flanges on both ends for bolted connection of generator rotor and turbine runner.

c) Shaft Seal

A self adjusting shaft seal of radially flexible lip ring type in combination with pre-labyrinth rings without requirement of filtered lubrication water supply under normal operating conditions shall be provided. Easy replacement of wearing parts shall be possible without dismantling the guide bearing.

d) Bearings

The guide bearing on the turbine side and the combined thrust bearing on the generator side shall be of "oil filled" type.

e) Gate Operating Mechanism

The gate operating mechanism shall comprise of the wicket gates, speed regulating control ring, lever and links, closing weight, servomotor etc. Governor regulates the wicket gates opening to guarantee the synchronous speed under varying loads and shall shut off turbine in emergency.

f) Bulb body and stay columns

Bulb body and stay columns shall be made of welded steel plate. Access in the bulb body shall be provided through the stay columns.

g) Draft Tube

The draft tube shall be made of rolled steel sheet parts welded together.

9.4.4 Setting – Cavitations Effect

Overall plant efficiency is dependent on the design of the water passages from headrace, powerhouse and tailrace. However, the turbine manufacturer is only responsible for the design between the turbine inlet and the discharge of the draft tube. Therefore the following dimensions are adopted for inclusion in the turbine specifications as limiting dimensions:

- Elevation of centre-line of distributor.
- Elevation of low point of draft tube.

- Horizontal distance from centre-line of unit to the end of the draft tube.
- Exit velocity
- Suction Head (Hs) etc.

9.4.5 Unit Spacing

The criteria for unit spacing is to provide sufficient space between the units for ease of maintenance.

9.4.6 Speed Governor

Hydraulic turbine governor are designed to regulate the speed and output of turbine-generator units by controlling the wicket gates and runner blade position to adjust water flow through the turbine. The governor senses changes in load (or speed) and respond with a movement of the wicket gates and runner blade position in order to maintain synchronous speed. The criterion is the stability as well as sensitivity of the governor.

Keeping in view these essential requirements and latest trends in hydropower controls, a Proportional Integral Derivative (PID) Digital Electro Hydraulic Governor is proposed.

9.5 POWER HOUSE CRANES

9.5.1 Gantry Crane

One gantry crane with double girders shall be used for the equipment erection and maintenance purposes. The crane shall be used for the handling of intake bulkhead, trashrack, intake stoplog and removable roof. In addition it shall be used for the maintenance of step-up transformers, turbine and generator parts etc. The crane shall have an electrically operated motor, rated to transport the gantry with the load suspended from the main hook.

The main features are as follows:

Capacity of main hook : 50 tons
Capacity of auxiliary hook : 10 tons
Span between crane rails : 23.5 m

9.5 Bridge Crane

One bridge crane with double girders shall serve the entire turbine hall and the mechanical workshop and shall be used for the operation and maintenance of turbine and generators. The main features are as follows:

- Capacity of main hook 25 tons
- Capacity of auxiliary hook 5 tons
- Span between crane rails 12.5 m

9.6 AUXILIARY SYSTEMS

- Cooling Water System
- Lubrication / Oil Handling System
- Heating, Ventilation and Air Conditioning system
- Fire Fighting System
- Compressed Air System
- Dewatering System
- Drainage System
- Powerhouse Elevator
- Workshop Equipment (Electrical & Mechanical)

9.6.1 Cooling Water System

Cooling is required for the turbine bearings, governor, generator, generator bearing and transformer. Lubricating oil system shall be provided for the cooling of turbine bearings and governor including oil-water heat exchanger. For the cooling of generator and transformer separate water circuits shall be provided. Cooling water flow shall be controlled automatically depending on the oil temperature. Cooling water shall be taken from the upstream side and passed through full flow strainer before being fed to a header. Water shall be tapped off the header to feed the required locations. The system shall include cooling water pumps, heat exchangers, valves, piping etc. The cooling water shall be drained to tail race.

9.6.2 Lubrication and Oil Handling System

The system shall consist of two storage tanks for turbine lubrication and hydraulic governor. Oil treatment unit shall also be provided for cleaning of dirty oil. The equipment shall include equipment for taking oil samples, manual and electrical transfer pump with pipes/hoses and filters, as well as a mobile high grade filtering unit with oil separator. The mobile filtering unit shall also be able to be coupled in parallel to all oil systems, including transformers.

9.6.3 Heating, Ventilation and Air Conditioning System

9.6.3.1 Air-conditioning system

The air conditioning system shall maintain the indoor temperature at a pre-determined level in the offices and control rooms. The system shall include condensing units, air conditioners, air distribution and air diffusion system, humidifiers etc.

9.6.3.2 Ventilation system

The ventilation system shall be designed to provide clean air to air conditioned space by the filtration of re-circulated and outside fresh air and to pressurize the building so as to prevent the infiltration of uncontrolled out side air.

9.6.3.3 Air exhaust system

The air exhaust system shall be provided in order to complete the fresh air circuit. The system shall include exhaust fans, exhaust ducts, louvers etc.

9.6.4 Fire Fighting System

Fire fighting system shall be sufficient to overcome fire hazards in the powerhouse building and substation area. Fire fighting system shall consist of fire water pumps, storage tanks, hydrants, piping, hoses etc. For lubrication, oil handling system, generators and transformers automatic carbon dioxide (CO_2) extinguishing system shall be provided. Mobile fire extinguishers shall be provided at most wanted locations in the power house. Also water tapping for fire fighting shall be provided in the power house to be used for fire hoses.

9.6.5 Compressed Air System

Compressed air shall be provided for governor oil pressurization and maintenance purposes. Twin system, one for governor oil pressurization and the other low pressure system for workshop and other maintenance purposes shall be provided. The system shall include air filters, compressors, after-coolers, storage tanks, valves, piping, hoses etc.

9.6.6 Dewatering System

Dewatering system shall be provided for dewatering of the turbine and associated water passages for repair and maintenance purposes. The system shall include dewatering pumps, sumps, valves, piping etc.

9.6.7 Drainage System

Drainage system shall be provided for the surface drainage of the powerhouse. The system shall include drainage pumps, sumps, valves, piping etc.

9.6.8 Powerhouse Elevator

One power house elevator shall be provided for the transportation of 6-8 persons and equipment.

9.6.9 Workshop Equipment (Electrical & Mechanical)

The workshop equipment should be sufficient for erection, assembly and dismantling of turbine parts as well as other components of the power house and to repair components.

9.7 HYDRAULIC STEEL STRUCTURE (GATE EQUIPMENT)

9.7.1 General

This sub-section describes the general and preliminary technical requirements for the hydraulic steel structure (gate equipment) to be installed in the proposed power house. The term gate equipment used herein includes gates, hoists, bulkheads, stoplogs and trashracks & their embedded metalwork. The gate equipment to be provided for the power house shall only be required to stop the flow for any emergency repair or inspection of the structure and other equipment located therein. Following type of gate equipment shall be provided:

- Intake Bulkhead / Stoplog
- Trashrack at intake
- Trashrack Cleaning Machine
- Intake stoplog
- Draft tube gate
- Draft tube stoplog

9.7.2 INTAKE BULKHEADS/STOPLOG

9.7.2.1 Functional Requirement

For installation, maintenance, inspection and repair of turbines, it is necessary to dewater the upstream area of the turbines and their adjacent waterway. Intake bulkhead is required for preventing entry of headrace water into the waterway when the turbine and their waterway are dewatered.

9.7.2.2 Type

The Intake bulkhead/stoplog shall be vertical lift roller type (at 75°), designed under maximum possible differential balanced head and operation at balanced conditions.

9.7.2.3 Size

One set of Intake bulkheads/Stoplog shall be provided; each set consisting of 10 sections, the bulkhead shall have 12.4 m nominal width and 23.6 nominal height.

9.7.2.5 Gate Leaf

The Intake bulkhead/Stoplog shall have downstream skin plates and seals. Each gate shall be fabricated in 10 sections. Each section shall be of welded steel construction 12.4 m wide by 2.36 m high. The gate shall have compression type bottom seals and 'J' type side and top seals. Guide wheels shall be provided at the top and bottom of each side of the intake bulkhead sections to engage the guides or slots embedded in the concrete. Lifting hooks shall be provided to handle the gate by a lifting beam.

9.7.2.6 Embedded Metalwork

A set of embedded metalwork shall consist of a sill beam, a lintel beam, two side seal plates, two guide channels for installation of bulkhead/stoplog. Three sets of embedded metalwork shall be required. The sill beam shall provide sealing surfaces for bottom of the gate. All sealing surfaces shall be of corrosion resisting clad plates.

9.7.2.7 Preliminary Parameters The preliminary parameters of the Intake bulkhead/stoplog equipment are given hereunder.

Type Vertical-lift bulkhead No. of set 1 No. of sections/set 10 Size of each section 12.4 m (W) x 2.36 m (H) Total size of bulkhead 12.4 m x 23.6 m No. of embedded parts 3 sets Sill elevation 161.8 m Maximum headrace water level 183.82 m Intake Bulkhead/Stoplog handling by lifting beam and gantry crane at balanced head condition

9.7.3 TRASHRACKS

Removable plane type trashrack set consist on five (5) section having 9.74 m wide and 14.2 m high shall be provided for each intake. The trashracks shall have a rack bar spacing of 50 mm c/c to protect the turbine against trash.

The trashracks shall be of welded construction with rectangular rack bars supported on horizontal box girders. The trashracks shall be designed for a 5 m differential head acting across the gross area of the trashrack.

One lifting beam for handling the trashracks and one mechanised trashrack for raking the trashrack. The lifting beam and trashrack shall be of welded construction which shall operate in the guides embedded in the concrete for removal of trashracks.

9.7.4 TRASHRACK CLEANING MACHINE

9.7.4.1 Functional Requirement

It is necessary to clean the trashrack to maintain the required level of water upstream and downstream of the trashrack machine. Trashrack cleaning machine is required to be installed upstream of the trashrack in form of trash rake and jib grab to arrest small and big particles, respectively.

9.7.4.2 Trashrack Cleaning Machine

The trashrack cleaner shall be equipped apart from the raking and driving mechanism with a rotating jib grab to pick up large trash pieces or wooden logs. Power supply to the traskrack cleaner shall be provided by enclosed conductor.

The trashrack cleaner structure shall consist of a portal-type frame of welded steel shapes, end trucks

supporting the long travel gears and, at the upper part service platform accommodating the control cab, electrical cubicle, hydraulic power pack, carriage operating hoist, carriage bucket operating gear and tilting apron operation. The jib grab shall be installed at convenient location.

Adequate size crane rails, its accessories and anchors with end stops shall also be installed.

9.7.4.3 Preliminary parameters

The preliminary parameters of the trashrack cleaning machine are given hereunder:

A.	**Trashrake**	
No. of set		1
Width of rake		3 m
Lifting capacity		10 ton
	Traveling height	28 m
	Lifting speed	20 m/min.
	Lowering speed	40m/min.
B.	**Jib**	
	Lifting capacity	5 ton
	Lifting height	15 m
	Lifting speed	20m/min.
	Radius of action from edge of parapet	2m
	Angle of rotation	190 degrees
C.	**Runaway rail and power conductor**	
	Span of runway rail	3m approx.
	Length of 3 units	42 m

9.7.5 INTAKE STOPLOG EQUIPMENT

9.7.5.1 Functional Requirement

For installation, maintenance, inspection and repair of turbines, it is necessary to dewater the turbines and their adjacent waterway. Intake stoplogs are required to act as bulkheads for preventing entry of tailrace water into the waterways when the turbines and their waterways are dewatered.

9.7.5.2 Type

The Intake stoplogs shall be vertical lift bulkheads or sliding gate type designed for maximum possible differential head conditions.

9.7.5.3 Size Three sets of Intake stoplogs shall be provided, each set consisting of 5 sections. The stoplog shall have 9.74 m nominal width and 12.40 nominal height.

9.7.5.4 Intake stoplog

The Intake stoplogs shall have downstream skin plates and seals, each gate being designed to close a waterway as shown on the drawing. The stoplog shall be fabricated in five (5) sections. Each section being of welded steel construction 9.74 m wide by 2.48 m high. Each section shall have compression type bottom seals and 'J' type side and upper most section shall have top seal. Guide shoes shall be provided at the top and bottom of each side of the stoplog section to engage the guides or slots embedded in the concrete.

Lifting hooks shall be provided to handle the gate by a lifting beam.

9.7.5.5 Embedded Metalwork

A set of embedded metalwork shall consist of a sill beam, a lintel beam, two side seal plates, two guide plates for installation of Intake stoplog. Three sets of embedded metalwork shall be required. Welding pads shall be embedded in first stage concrete to facilitate the alignment of the parts embedded in the second stage concrete. The sill and lintel beams shall provide sealing surfaces for bottom and top seals of the gate respectively. All sealing surfaces shall be of corrosion resisting clad plates.

9.7.5.6 Preliminary Parameters

The preliminary parameters of the Intake stoplog equipment are given hereunder.

- Type Vertical-lift bulkhead
- No. of stoplog sets 3
- No. of sections/set 5
- Size of one section 9.74 m (W) x 2.48 m (H)
- Total size of stoplog 9.74 m (W) x 12.4 m (H)
- No. of embedded parts 3 sets
- Sill elevation 160.4 m
- Maximum headrace water level 183.82 m
- Stoplog handling By lifting beam and gantry crane at balanced head condition

9.7.6 DRAFT TUBE GATE EQUIPMENT

9.7.6.1 Functional Requirement

For installation, maintenance, inspection and repair of turbines, it is necessary to dewater the turbines and their adjacent waterway draft tube gates are required to act as bulkheads for preventing entry of tailrace water into the waterways when the turbines and their waterways are dewatered.

9.7.6.2 Type

The draft tube gates shall be vertical lift roller type bulkhead or sliding gate type hydraulically operated designed under maximum possible differential head conditions.

9.7.6.3 Size

Three sets of draft tube gates shall be provided, each of 7.5 m nominal width and 6.6 nominal height.

9.7.6.4 General Arrangement

The general arrangement of the draft tube gate equipment is shown on Drawing No. 13.

9.7.6.5 Draft Tube Gate

The draft tube gates shall have upstream skin plates and seals, each gate being designed to close a waterway 7.35 m wide and 6.4 m high. The gate shall have compression type bottom seals and 'J' type side and top seals. Guide rollers shall be provided at each side of the gate leaf to engage the guides or slots embedded in the concrete. Lifting hooks shall be provided to handle the gate by a grappling beam.

9.7.6.6 Embedded Metalwork

A set of embedded metalwork shall consist of a sill beam, a lintel beam, two side seal plates, two guide rails for installation of draft tube gate. Three sets of embedded metalwork shall be required. Welding pads shall be embedded in first stage concrete to facilitate the alignment of the parts embedded in the second stage concrete. The sill and lintel beams shall provide sealing surfaces for bottom and top seals of the gate respectively. All sealing surfaces shall be of corrosion resisting clad plates.

9.7.6.7 Preliminary Parameters

The preliminary parameters of the draft tube gate equipment are given hereunder.

Type	Vertical-lift bulkhead
No. of gates	3
Size of gate leaf	8.5 m x 6.6 m
Sill elevation	162.0 m
No. of embedded parts	3 sets
Maximum tailwater level	172.67 m
Type of Hoist	Hydraulic

9.7.7 DRAFT TUBE STOPLOG EQUIPMENT

9.7.7.1 Functional Requirement

Total size of stoplog set	9.14 m x 11.5 m
No. of embedded parts	3 sets
Sill elevation	162.0 m
Maximum tailwater level	172.67 m
Stoplog Handling balanced head	By lifting beam and mobile crane at condition

For installation, maintenance, inspection and repair of waterway, draft tube and misc. embedded metal work. Draft tube stoplogs are required to act as bulkheads for preventing entry of tailrace water into the waterways when the turbines and their waterways are dewatered.

9.7.7.2 Type

The draft tube stoplogs shall be vertical lift roller type bulkheads or sliding gate type hydraulically operated designed under maximum possible differential head conditions.

9.7.7.3 Size

One (1) set of draft tube stoplogs shall be provided, each set consisting of five (5) sections of 9.14 m nominal width and 11.5 nominal height.

9.7.7.4 Draft Tube Stoplog

The draft tube stoplogs shall have upstream skin plates and seals, the stoplog being designed to close a waterway 9.0 m wide and 6.4 high. Stoplog shall be fabricated in five (5) sections. Each section being of welded steel construction 9.14 m wide by 2.3 m high. The stoplog sections shall have compression type bottom seals and 'J' type side seals. Guide shoes shall be provided at the top and bottom of each side of the stoplog sections to engage the guides or slots embedded in the concrete. Top of every section of stoplog shall act as sill beam. Lifting books shall be provided to handle the stoplog by a lifting beam.

9.7.7.5 Embedded Metalwork

A set of embedded metalwork shall consist of a sill beam, two side seal plates, and two guide plates for installation of draft tube stoplog. Three sets of embedded metalwork shall be required. Welding pads shall be embedded in first stage concrete to facilitate the alignment of the parts embedded in the second stage concrete. The sill beam shall provide sealing surfaces for bottom seal of the stoplog respectively. All sealing surfaces shall be of corrosion resisting clad plates.

9.7.7.6 Preliminary Parameters

The preliminary parameters of the draft tube stoplog equipment are given hereunder. Type Vertical-lift bulkhead No. of stoplogs 1 No. of sections / set 5 Size of each section 9.14 m (W) x 2.3 m (H)

SECTION – 10

ELECTRICAL EQUIPMENTS

SECTION - 10

ELECTRICAL EQUIPMENTS

10.1 GENERAL

The electrical equipment required for the hydropower plant will include:

- Generators
- Electrical Main Connections
- Miscellaneous Electrical Equipment
- Substation
- Control System

The design considerations for selection of electrical equipment follow;

10.2 GENERATORS

10.2.1 Design Considerations

The generators will be three phase synchronous machines meeting the requirements of the latest edition of IEC 60034 and will be designed taking into consideration the operating experience gained at other similar units installed elsewhere. The design should be for 30 years minimum operating lifetime.

The stator insulation specifications will be developed based on the Vacuum- Pressure Impregnated (VPI) technology, which is an almost universal standard. Stator and rotor insulation will be rated for Class F although temperature rises will be limited in operation to Class B values.

The generator is envisaged to have a state-of-the-art static excitation system with a digital Automatic Voltage Regulator (AVR). The AVR shall be equipped with fully redundant controllers with automatic and manual channels with auto-followers to track position of the digital controller that is in control to provide bump less, two-way transfers between controllers and manual-auto control. The digital AVR will be specified in line with the latest trends and recognizing that the analogue-electronic circuits are outdated and are being phased out rapidly.

The generators shall be designed for both interconnected and isolated load operation. The power generated will be dispersed through 132kV transmission line to the national grid. The generator shall be so designed that all repair works, maintenance and inspection of the generator and turbine parts may be done with a minimum of disassembly work.

A closed circuit air-cooling system with air/water heat exchangers will be specified.

10.2.2 Generator Parameters

The main parameters of the generators are shown in Table 10.1

TABLE 10.1: CJ Link HPP Generator Parameters

Main Parameters	Values
Rating [MW]	8.33
Rated Voltage [kV]	11
Speed [RPM]	150
No. of pair of poles	22
Efficiency [%]	96

Power Factor	0.8
Short Circuit Ratio	1.07
Runaway Speed [RPM]	418
Line Charging Capacity [MVars]	15.62
GD2 [t-m2]	1932.6
WR2 [lb-ft2]	11465312.9
Inertia Constant, H [kWs/kVA]	2.5
Turbine Starting Time, Tm [s]	5.0
Stored Energy, E [MWs]	46.2
Rotor Dia. [m]	3.38
Rotor Height [m]	1.18
Stator Outer Dia. [m]	4.40
Rotor Weight [tons]	34.0
Stator Weight [tons]	18.9
Gen. Total Weight [tons]	65
Synchronous Reactance, Xd, [pu]	1.25
Transient Reactance, Unsat. Xd', [pu]	0.4
Sub-transient Reactance Xd'', [pu]	0.2
OC Transient Time Constant T'do, [Sec]	3.9
OC Sub-transient Time Const. T''do, [Sec]	0.035

Note: The generator parameters have been determined assuming generator terminal voltages as indicated in the respective Tables. The data presented above is preliminary and would need to be firmed-up during detailed design stage.

10.2.3 Generator Voltage Selection

The generators are usually connected to the line through step-up transformers and the generator voltage rating is decided by minimum combined cost of generators, busbars, switchgear, cables and transformers.

Generally, the lower voltage systems cost more because there is more current per KVA to be carried, thereby, increasing the size of circuit breakers and conductors. On the other hand, the insulation and clearance / space requirements increase with the enhancement in the voltage level thereby increasing the cost. The generators and motors of one particular KVA rating may have different costs for different voltage ratings. i.e there is always a cut-off point for a certain range of KVA ratings of the machines beyond which the cost impact is more pronounced for different selected voltage ratings.

The generator terminal voltage is selected taking into consideration the ratings of commercially available connected equipment such as isolated phase bus / cable and the generator circuit breaker. There are only a few discrete choices of equipment that are commercially available. The equipment ratings are governed by international standards. The selection of rated generator voltage depends upon the benefits derived from overall reduction in losses and the generator design has the main effect in deciding the voltage. Experience has shown that for the generator design of a particular kVA rating to be economical, its terminal voltage shall

be selected from the voltage ranges indicated in Figure 10.1 for different generator ratings.

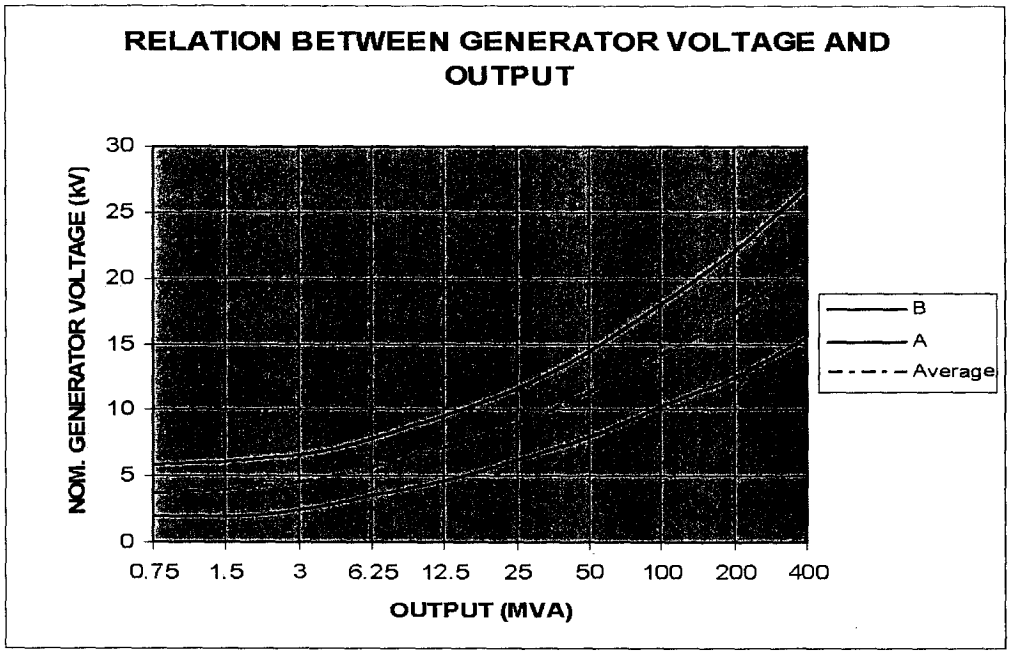


Figure 10.1: Optimum Generator Rated Voltage Range

It is not practical to build machines of all ratings for all rated voltages. In general, for AC machines, based on design and manufacturing considerations, preferred voltage ratings above 1 kV can be found from the above Figure 10.1. The rating of the generator for the selected alternative of the project under consideration and its corresponding rated voltage range is:

Based on above considerations, the generator rated voltage selectable within the above range is recommended for unit size. Suggested values are indicated in Table 10.1. Further investigations will be carried out at the detail design stage to firm up these values.

Generator Rating [MW]	Voltage Range
8.4	6kV to 11kV

10.3 ELECTRICAL SYSTEM DESIGN

10.3.1 Unit and Station Auxiliary Supply System Configuration

The electrical main connections constitute the major part of the electrical equipment in a hydropower plant having close relation with the power system, protective relaying and the selection of electrical equipment. The main connections directly affect the operation, maintenance and investment in the hydropower plant. Comprising connections between the generators, transformers, circuit breakers, CTs, PTs, transmission and station auxiliary supply power distribution, the main electrical connections are the key to the electrical design of the hydropower plant. The pre-requisites for the selection of the main connections are the reliability of the power supply to the consumer, simplicity in the design, operational flexibility, ease in maintenance and of course low capital and operation costs.

The final electrical configuration is chosen based on the size of generating units keeping in view the above mentioned selection requirements. There are several types of electrical main connections available, each

having advantages and disadvantages as compared to each other in terms of reliability, simplicity, operational flexibility etc. While some configurations offer maximum advantages, the same may not be economically justifiable, especially in case of small hydropower plants. For the CJ Link hydropower Project, one (1) type of main electrical connections have been considered based on typical schemes implemented in hydropower plants.

The main features of this configuration are briefly discussed below:

Unit Block Scheme

A typical single line diagram of this scheme is shown in Dwg No. 31. This scheme is judged to be the best from technical point of view. It offers maximum reliability, very high operation flexibility and ease of maintenance. Cost of this configuration is the highest amongst the unit and station auxiliary supply schemes typically used in power plant projects. Unit block scheme is used in large power plants and very rarely applied to micro, mini or small hydro power plants.

Although different configurations are workable from an engineering point of view and have been used in several power plants all over the world, the unit block scheme (E001) is judged to be the best. The advantages gained due to high reliability, operational flexibility and ease of maintenance throughout the power plant life cycle can easily offset the relatively small investment increase in the auxiliary supply equipment as compared to the other configurations. The Unit block scheme is, therefore, recommended. The scheme shown in E001 is conceptual only and is likely to be improved and firmed-up during the detailed design development stage.

The proposed size of emergency diesel generator for the selected alternative is 400 kVA, which will give supply to meet emergency loads including emergency lighting during blackout conditions. The ratings of the diesel generator will be firmed up during detailed design development stage.

10.4 MISCELLANEOUS ELECTRICAL EQUIPMENT

The miscellaneous electrical equipment will mainly comprise the following:

11 kV Generator Circuit Breaker Isolated Phase Busduct 400 V Switchgear. LV Power Distribution. DC System including batteries, battery chargers and DC distribution. Generator & Excitation System. Generator step-up and Main Auxiliary Transformers. Motors. LV Cables. Electrical Control System. Electrical Protection System. Lighting and Small Power Services. Earthing and Lightning Protection System. 132 kV Substation. For dimensioning, design and layout of the various plant components and installations, the following features and aspects will be considered:

Ratings to safely cope with normal and fault conditions, the prevailing site conditions, avoiding any over-stressing of material and equipment Equipment to be of standard design, providing highest degree of safety, reliability, availability, redundancy concepts and ease in operation Equipment arrangements to consider adequate space and access for transportation, installation, commissioning, operation and maintenance

The electrical plant shall be designed for continuous operation in interconnected as well as isolated modes to feed 132 kV network during normal operation. It shall include facilities for safe shutdown and black start capability in case of a total electrical system blackout. The layout, design and manufacturing of all electrical equipment shall comply with the latest edition of the relevant IEC standards.

The main design parameters of major equipment are shown in the following tables. These parameters are

preliminary and will be refined during the detail design development stage.

Table 10.3: Main Design Parameters of LV Switchgear

Parameters	Unit	Value
DC SYSTEM		
Nominal System Voltage (DC)	V	220
Rated Voltage (DC)	V	220
ESSENTIAL AC SYSTEM		
Nominal input Voltage (DC)	V	220
Nominal output voltage (AC)	V	230

* Note: These values will be decided during detailed design development stage.

Table 10.4: Generator Step-up Transformer Parameters for Unit Block Scheme

Parameters	Unit	Value
MV SWG		
Nominal System Voltage	kV	11
Rated Voltage	kV	12
Rated short time with stand current	kA	*
Rated Continuous current	A	*
Insulation medium		SF 6
Frequency	Hz	50
Aux, and Control Voltage (DC)	V	220

Parameters	Unit	Value
LV SWG		
Nominal System Voltage	V	400
Rated Voltage	V	1000
Rated short time with stand current	kA	*
Nominal current (bus bars)	A	*
Insulation medium		Air
Frequency	Hz	50
Aux. and Contol Voltage (DC)	V	220

Parameters	Unit	Type/Value
Type	-	Oil filled
Rating at IEC conditions (Step-up Transf.)	MVA	3X18.5
Vector group	-	Dyn11

Cooling		ONAN
Tap changer	-	OLTC
Number of steps	-	5
Tap-changing –range	%	2.5
Voltage adjustment	±%	5
Impedance	%	12
Manufac. Tolerance on Impedance	±%	10
Rated frequency	Hz	50
Dimensions		
Length	mm	5790
Width	mm	2685
Height	mm	5365
Total weight	kg	47050
Shipping Dimensions		
Length	mm	4460
Width	mm	2014
Height	mm	3025
Shipping weight incl. Oil	kg	43045

Table 10.6: Main Design Parameters of Unit Aux. Transformers

Parameters	**Unit**	**Type/value**
Type	-	Dry AN
Rating at IEC conditions (Main Aux. Trans f.)	kVA	3X250
Rated voltage ratio	kV / kV	11/0.4
Vector group	-	Dyn11
Tap changer	-	NLTC
Number of steps	-	5
Tap-changing –range	%	2.5
Voltage adjustment	±%	5
Impedance voltage (uk)	%	8
Rated frequency	Hz	50
Dimensions		
Length	mm	1350
Width	mm	740
Height	mm	1065
Total Weight	kg	990

Other plant systems such as lighting, small power services, lightening protection, earthing and cabling etc will be specified based on the current practice and in accordance with relevant international standards.

10.4.1 132 kV Substation

All the associated high voltage switchgears are envisaged to be of outdoor type conventional 132 kV substation. The HV switchgears utilize a breaker and a half scheme. The two busbars will be connected to the respective generator step-up transformers via 132 kV CBs and disconnect switches. The transmission

line feeders will also like wise be connected. The generator step-up transformers will be connected to the Substation via over head conductors.

Each substation will consist of the following main components and associated systems:

- Two 132 kV Busbars, each complete with one set of VTs and one earthing switch.
- Required sets of 132 kV CBs, flanking disconnect switches, earthing switches, generator and line disconnect switches
- Required sets of 132 kV CTs & PTs / CCVTs for metering and protection.
- Required sets of 132 kV Surge Arrestors.
- Substation Automation System for control, protection and metering of entire substation.
- DC batteries and battery chargers
- AC & DC distribution boards

The local control of the 132 kV switchgear shall be by means of microprocessor control logic. A Substation Automation System is envisaged for each substation. Hardwired interlocking functions and conventional backup control features are envisaged. All the control and protection equipment shall be compliant with the latest version of IEC 61850. A Man-Machine Interface (MMI) comprising a PC / Workstation loaded with appropriate software for the control and monitoring of the entire substation equipment is envisaged. The Substation Automation System will be interfaced with the power plant Distributed Control System (DCS) and the National Power Control Centre (NPCC), Islamabad through Remote Terminal Unit (RTU) or gateway, as appropriate.

The 132 kV substation will be controlled, in addition to the local control cubicles for individual feeders, from a centralized local control room through MMI. This control room is to be located in the substation building.

In addition to the above, it will be possible to control all the circuit breakers from the remote central control room of the power plant through DCS Operator Workstation. The requirements of SCADA control and monitoring will be incorporated in the 132 kV substation control & metering, as necessary.

AC & DC distribution panels of free- standing type shall be installed in the 132 kV substation power supply room.

The main parameters of 132 kV substation are shown in Table 10.8. The configurations of the power station scheme and its associated high voltage substation are shown in Drawings No. E001 for Site III.

Disconnect switches		
Applicable standard	**IEC**	62271-102
Rated short time withstand current	**kA**	25
Continuous Current rating:		

Generator feeders	**A**	1600
Bus Coupler	**A**	1600
Earthing Switches		
Applicable standard	**IEC**	6557-102
Rated making current	**kA**	100
Rated short time withstand (3 sec)	**kA**	25

10.5 CONTROL SYSTEM DESIGN

In line with the latest practice and trends in the hydropower plant controls, almost all the new schemes are based on Distributed Control Systems now a day. In view of above, a distributed control system is being proposed for the project.

The overall philosophy of the control system shall be as under:

10.5.1 Control Hierarchy

a) Station Control Level A computer based station control system (SCS) is envisaged for the supervisory control of the power plant including the generating units, 132 kV Substation and the LV switchgear.

b) Local Control Level One computer based local control unit (LCU) is envisaged for each generating unit, one for LV switchgear / auxiliaries and one for headworks / spillways. The power plant DCS will be interfaced with the Substation Automation System of the respective 132kV Substation

c) Manual Control Level
Manual control will be possible from each individual equipment's local control panels / boards. d) Prevention of Flooding of powerhouse will be prevented through controls.

Parameters	**Unit**	**132 kV S/S**
Applicable standard	**IEC**	62271-203,60517
Nominal System Voltage	**kV**	132
Rated Voltage	**kV**	145
Rated Short time withstand current (3 Sec).	**kA**	40
Lighting Impulse withstand voltage (across	**kV Peak**	650
Rated Power frequency withstand voltage	**kV Peak**	650
Rated Power frequency withstand voltage	**kV rms**	275
Rated Frequency	**Hz**	50
Bus Bars		
Current carrying capacity at 50 oC	**A**	1600
Circuit Breakers		
Rated short time breaking current (3 sec)	**kKA**	25
Continuous current ratings:		
Generator feeder CBs	**A**	1600
Transmission Line CBs	**A**	1600

Other requirements	**IEC**	62271-100

Parameters	**Unit**	**Type/value**
Type	-	Oil filled
Rating at IEC conditions (Main Aux. Trans f.)	kVA	1X630
Rated voltage ratio	kV / kV	11/0.4
Vector group	-	Dyn11
Tap changer	-	NLTC
Number of steps	-	5
Tap-changing –range	-	2.5
Voltage adjustment	±%	5
Impedance voltage (uk)	%	8
Rated frequency	Hz	50
Dimensions		
Length	mm	1740
Width	mm	1080
Height	mm	1940
Total Weight	Kg	1950

10.5.2 Redundancy

The redundancy of the control system will be ensured such that the failure of the SCS will not affect the plant operation. In case of failure of SCS, the control of the units will still be possible through LCUs of the respective units / other facilities. In case of failure of one or more LCUs, the manual operation of the Units shall still be possible through their respective local control cubicles / panels.

10.5.3 Interfacing to Data Communication

All the process inputs will be brought to the respective LCUs for interfacing of the same with the SCS. All the outputs from the SCS to the process (and vice versa) will be channelled through the respective LCUs. All the LCUs and SCS will communicate with each other through data communication buses of fibre optic type.

10.5.4 Location of the Equipment

The SCS will be located in the main control room for the generating units. The LCUs for the respective units will be located in the machine hall. The cubicles of the generator protection will be installed next to the respective LCUs. The LCU for the LV switchgear will be installed at suitable location to be determined at a later stage of specifications development.

10.5.5 Power Supply

The SCS will be powered from an uninterruptible power supply (UPS) with battery backup for the SCS to operate at least for one hour. The LCUs will be supplied from the plant 110 VDC Batteries / System.

10.5.6 Hardware

The LCUs are envisaged to be based on microprocessor controllers. The LCUs shall be complete with communication controllers, necessary software, signal interface equipment, redundant power supplies etc. Detailed specifications for the LCUs will be determined later during the project specifications development stage.

The SCS is envisaged to have two work stations each consisting of two full graphic colour display monitors with keyboard and mouse.

- One main server with disk storage system
- One front – end communication unit
- Tape storage backup system or optical disk
- One terminal server
- Printers and hard copy unit

Necessary equipment for interfacing with data communication system.
Control desk designed for installation of the workstation with chairs shall also be provided. Detailed specifications for the SCS will be determined later during the Project specifications development stage.

10.5.7 Software

The SCS software is envisaged to include all Man-Machine Interface (MMI) functions such as;

- Data acquisition from all LCUs
- Control commands transfer to LCUs

- Data acquisition from and control commands transfer to the Substation Automation System.
- Dynamic coloring and graphic displays for unit start / stop, circuit breakers open / close etc.
- Database functions such as storage of momentary status, measurement & fault information, long-term data archival, trend analysis etc.
- Status, measurement and production reports including energy reports. The above and other software functions will be elaborated / determined during the detailed specifications development stage. The overall control system configuration is shown in Dwg No. 32.

SECTION – 11

ENVIRONMENTAL IMPACT ASSESSMENT

SECTION - 11

ENVIRONMENTAL IMPACT ASSESSMENT

11.1 INTRODUCTION

Environmental Impact Assessment of the Project has been carried out as per requirements of the Pakistan Environmental Protection Act 1997. A separate Environmental Impact Assessment (EIA) Report has been prepared and is attached as Volume V of this Report. The Report will be submitted to Punjab EPA for obtaining clearance for the Project. A brief summary of the EIA is presented in this Section.

Today one of the major problems of Pakistan is to meet the energy requirement of the country. The country's economy as well as the living standard of the people is suffering adversely from the shortage of the energy. Keeping in view the past trend and the future developments, WAPDA, in collaboration with energy wing, Planning & Development Division, Government of Pakistan have made long term demand projections. The load forecast for year 2011-12 is 22,970 MW. The total demand and generating capability of WAPDA (including Thermal, Hydel and IPPs) for the year 2007 were 15,838 MW and 13,292 MW respectively (WAPDA Annual Report 2006-07). The proposed hydropower project at Chashma-Jhelum (CJ) Link Tail site is one of the important hydropower projects which will help in ameliorating the energy problems of the country.

11.2 PROJECT CONFIGURATION & SITE CONDITIONS

The Powerhouse is proposed to be constructed at the right bank of the tail end of CJ Link Canal to produce a maximum of 25 MW. The project includes constructing all the necessary items associated with the construction of powerhouse i.e., power channel, installation of turbines, grid station, escape channel, sedimentation basin etc. A new road bridge, relocation of a length of Khushab-Muzaffargarh road and a public park are also included in the scope of work.

Groundwater can be found as shallow as 3 m (9.8 ft) from ground level at certain places on site. Hand pumps and tube wells are the two most common sources of water within the area of influence (AOI) of the project. Groundwater can be used as a source of water supply to the contractor's camp and batching plant. However it will be the contractor's responsibility to confirm the suitability and availability of the water at the site at an appropriate level. Surface water can be used for spraying on earth to minimize dust pollution.

The climate of the area is arid characterized by long hot summer and short mild winter. It was found that ambient air is reasonably clean at present. The maximum temperature recorded during summer is about 50Co and minimum is 0o in winter. The data indicates that the maximum average rain fall recorded in the area is 121.4 mm in July and minimum average rain fall of 5.08 mm in October. Normal wind velocity varies from 1 to 10 km per hour (0.62 – 6.2 miles per hour). However in the case of a windstorm, the velocity can be as high as 50 km per hour (31 mile per hour). Wind direction varies over the seasons of the year as follow:

- Wind from south and southwest during summer months in the central and western parts of the

area.

- Winds from the east and southeast during summer months in the eastern and northeastern parts of the area and;
- Winds from the north, northeast and northwest during winter months over a major part of the area.

11.3 ENVIRONMENTAL ISSUES

Part of the site falls within the wildlife game reserve area which can be classified as environmentally sensitive area, under section 12 of Pakistan Environmental Protection Act 1997, it is therefore mandatory to prepare EIA and get NOC from EPA before the contractor mobilize at the site for the proposed works.

The site is situated in the upper part of Indus basin in Thal Doab. The word Thal is derived from Sanskrit and it means "sea of sand". The soils of Thal desert are predominantly of alluvial nature with sandy texture and are generally free of salinity and alkalinity but some are deficient in nitrogen and humus contents. The land included in the project area is classified as 'Barani land' and cultivates only with rain water.

CJ Link Canal passes through the Thal Doab. Khushab Atomic Plant raised the issue of severe waterlogging in the depressional area along the canal due to the seepage of water from the canal during early days of its operation. The crest level at the tail end regulator was therefore trimmed down by 0.914 m (3ft) to achieve 1.83 m (6ft) drop in maximum water level of the canal in 1981. This reduced the seepage of water and overcame the waterlogging problem to some extent. However it is crucial to maintain the maximum water level in the canal during construction and operation phase of the proposed power plant at a level that would avoid the return of the waterlogging problem.

Biological environment of the site is typical Thal environment. Common trees and shrubs are the Van (Salvadora Abeoides), Karir (Capparis Aphylla), Jand (Prosopis Spicigera), Malla (Zizyphus Nummularia), Sarkanda (Saccharum Munja) together with wild growth in the uncultivated lands. Different types of grass species are found along the canal's banks and within the riverian track. Tahli (Dalbergia Sisso) and Kiker (acacia nilotica) are the common trees found along the canal and adjacent land of Jhelum river.

Canal and river water provide friendly habitat to hundreds of migrating birds including some rare species of duck and geese. Under the RAMSER Convention it is the responsibility of Pakistan Government to protect these rare species of birds. Other local game birds found in Thal environment include Gray Partridge (Teetar) and Hubara Bustard (Talor). Terrrestrial fauna including wolves, jackals, wild cats, foxes, badgers, wild bores, neel gai (blue bull), deer and the wild hill goats (Urial) are found in Thal forest. Occasional sighting of endangered species of Baz, Chinkara (deer) have also been reported in the project area.

11.4 RESETTLEMENT REQUIREMENTS

The main settlement near the project site is village Shergarh with approximately 50 houses. The neareast city is Khushab, about 40km from the project site. The average house hold size in district Khushab is 6.2. The dominant beradery of village Sharegarh is Joya caste. Majority of the local population is involved in

farming activities; other common occupations include milk processing, running grocery shops, daily wage work, transportation and working at Khushab Atomic Plant. The common crop cultivated in Thal area is gram with a yield capacity of approximately 741 kg/ha. Hand pump is the common source of drinking water in the project area. Electricity supply is available on the project site. The average land price in the area around the project site is Rs. 100,000 per acre (247,000 per ha).

There is sufficient WAPDA land available at the site for setting up labour camp and batching plant and no private land is required for these activities. However part of the proposed power channel and relocated Khushab-Muzaffargarh road fall within private land. Approximate area of private land required to be acquired in this project is 12 ha (approximately 30 acres). About 9000m^2 of WAPDA's cultivated land is identified to fall within the power channel. Three houses (two used for living and one as medical dispensary) and a tube well built in WAPDA's land are also interfering in the proposed power channel location. The private land owners and residents of the affected properties will be compensated and Social Framework Agreement (SFA) will be signed by concerned parties. Majority of the local community is involved in seasonal agricultural activities.

11.5 ENVIRONMENTAL ASSESSMENT

The project will bring about significant positive social impacts in the area. Employment opportunity and training will be provided to a large number of unemployed youth. They will receive life time benefits through skill training, capacity building and poverty alleviation. A large number of semi-skilled and unskilled workers in the project area will be hired during construction. Greater awareness about healthcare including HIV/AIDS and Hepatitis amongst the labour folk and the local community shall be created. At micro level, economic activities may reduce the cost of living by making essential commodities available in greater bulks and at cheaper rates.

The potential environmental impacts of the project have been analyzed and mitigation measures and residual impacts are discussed in chapter 6 of the EIA Report presented in Volume V of this report. The nature and scope of the construction works and the environmental setting of the project are such that there is no significant adverse environmental impact. No permanent adverse impact is anticipated in respect of sensitive habitat, wildlife or cultural heritage. The project does warrant acquisition of small area of private land and resettlement of two families and a medical dispensary. But on the other side it is expected to produce 25.0 MW power which can play vital role in the development of local and national economy. A public park will be developed at the right side of the canal under this project, which will provide a picnic spot to the local community and improve the aesthetic level of the area.

It is envisaged that 59 trees will have to be cut down for construction of the power channel. It is proposed to grow two plants at site for every one tree cut by the contractor and to protect these plants until they are matured.

As no significant adverse environmental or social issue is likely to be encountered during construction and operation phases of the project, it could be safely concluded that the CJ Link Tail Hydropower Project is feasible for construction from environmental and social point of view.

11.6 ENVIRONMENTAL MANAGEMENT PLAN

The Environmental Management Plan (EMP) has been developed in chapter 8 of the EIA Report. The EMP will be implemented and monitored at all the stages of the project by competent staff.

SECTION – 12

PROJECT COST ESTIMATE

SECTION – 12

PROJECT COST ESTIMATE

12.1 GENERAL

This section describes the assumptions, methodology and conclusions relating to estimation of quantities and cost of Chashma Jhelum Link Hydropower Project. The cost estimates have been established on the basis of the quantities estimated from feasibility level design of the Project. The construction cost of the Project is divided into the following parts:

- Preliminary works
- Civil works
- Hydro-mechanical equipment
- Electrical equipment
- Engineering and Supervision
- Other costs

The construction cost estimates include all the works and supplied items utilized in the construction of permanent project works, investigation & planning costs, engineering & administration services and the cost of all the preliminary works.

The cost estimate does not include interest during construction as well as financing charges. The base cost is worked out at the rates prevailing in May 2017 and does not include allowance for escalation. The cost for implementing the Environmental Management Plan (EMP) and Resettlement are included in the base cost. No contingencies have been included in the base cost.

12.2 BASIS OF COST ESTIMATES

The cost estimates have been established on the basis of the Feasibility Design of the Project. The basic construction cost estimates include all the work and supplied items utilized in the construction of permanent project works, investigation & planning costs, engineering & administration services and the cost of all the preliminary works.

The rates used in the civil works cost estimates are derived by updating the rate analysis used by the Finance Department, Govt. of Punjab. The CSR unit rates have been updated and adjusted based on the market rates. However, in some items, unit costs were derived from the recent tenders of similar projects.

Lump sum provisions for some major work items have been made on the basis of experience of similar work items on other projects.

12.3 COST ESTIMATE

The items of cost included in various project components are discussed as under:

12.3.1 Preliminary Works

Preliminary works include the cost of land aquisition and the cost for compensation of trees removed during construction and the cost of construction of fence. Other costs under this head include: .

- Additional Surveys, Investigations and hydraulic model studies
- Cost of Feasibility Studies
- Consultancy Services Cost for EPC tender documents

12.3.2 Civil Works

Based on the feasibility level design drawings, the quantities have been calculated for the individual work items. The computed prices include the cost of labor, materials and equipment keeping in view the local conditions. The main structures have been subdivided into

- Dewatering of the project construction site
- Head Race and Tail Race Channel
- Power House
- Spillway/Escape Channel
- Road Bridges
- Silt Collection Pool
- Switch Yard / Offices
- Cut-off walls
- Earthworks
- Concrete works
- Miscellaneous (steel works)
- Others.

12.3.3 Hydromechanical Equipment

Based on the hydro-mechanical layout of the project, the hydro-mechanical equipment comprises turbines, gear boxes, generators, and electrical equipment. The prices provided in the cost estimation are based on quotations from manufacturers. Because of the nonexistent local production resources in Pakistan, a 100% foreign delivery of the complete hydro-mechanical equipment has been assumed. Partly local supply is foreseen for the mechanical and electrical equipment of the power house.

12.3.4 Electrical Equipment

Most of the electrical items can be purchased locally. Prices for electrical equipment depend on the market situation and may vary widely. The cost estimation is based on current prices in Pakistan market and from foreign suppliers.

12.3.5 Transportation and Shipment

For hydro-mechanical and electrical equipment, an amount of 5% of the net cost has been taken into consideration for sea transportation, inland transportation and insurance.

12.3.6 Erection Charges

Erection, commissioning and testing of equipment was charged at a rate of about 4% of the cost of electrical and mechanical equipment.

12.3.7 Insurance

Cost of insurance of works and plant has been calculated at 1.0 percent of EPC cost.

12.4 DESIGN AND ENGINEERING COST

This includes costs for foreign and local consultants for detailed design and engineering of the Project.

12.5 TOTAL BASE EPC COST

The estimated base EPC cost of the project for the selected alternative is estimated as Rs 4,109.075 million or US $ 39.197 milion equivalent at the exchange rate as on May 2017 when the cost estimates were prepared.

The summary and detailed cost estimates of the selected alternative are attached.

A portion of the cost will be incurred in foreign currency whereas the major portion of the cost will be incurred in local currency. The foreign currency component of cost is estimated as Rs 1,643 million which is equivalent to US $ 15.678 million.

12.7 GENERAL/ PROJECT COMPANY'S COST

An estimate of General/Project Company' costs are shown in Table 12.1, which are estimated as US $5.468 million.

12.8 TOTAL PROJECT COST

The Total Project Cost includes the EPC Cost, General/Project Company' costs and financing costs etc. The total Project cost is estimated at US $ 54.180 million as shown in Table 12.2. The cost per kW installed is US $2.167.

Table 12-1 Summary of Cost Estimates

Bill No.	Name of Channel / Structure	Amount (Rs.)	Amount (US$)
1	**SECTION 1 - PRELIMINARY WORKS**	111,870,000	1,067,156
2	**SECTION 2 - GENERAL ITEMS**	290,722,220	2,773,273
	SECTION 3 - WORKS		
3	POWER CHANNEL	1,088,031,260	10,379,007
4	BRIDGES	69,868,286	666,491
5	POWER HOUSE	650,205,934	6,202,480
6	MECHANICAL WORKS	1,252,934,339	11,952,059
7	ELECTRICAL WORKS	317,289,346	3,026,704
	SUB-TOTAL (SECTION-3)	3,378,329,164	32,226,740
8	SECTION 4 - ENVIORMENTAL AND SOCIAL COST	10,120,000	96,537
	SUB-TOTAL (SECTION-1,2,3 and 4)	3,791,041,384	36,163,707
	SECTION 5 - DESIGN AND ENGINEERING	318,033,792	3,033,805
	TOTAL (SECTION 1 + 2 + 3 + 4 + 5)	4,109,075,176	39,197,512
TOTAL CONSTRUCTION COST		4,109,075,176	39,197,512
	Custom Duties	50,814,360	484,731
9	Project Company's Costs	573,241,889	5,468,300
	Interest During Construction	946,626,285	9,030,109
	GRAND TOTAL	5,679,757,710	54,180,652
	Million:	5,680	54.181

SECTION – 13

CONSTRUCTION PLANNING AND SCHEDULING

SECTION - 13

CONSTRUCTION PLANNING AND SCHEDULING

13.1 INTRODUCTION

The construction planning aspects of the proposed hydro power station are given in this Section. It briefly describes the project area, pre-construction activities, procurement mode, contract packaging, sources of labour and materials, transportation of materials, construction methods, progress rates, planning, construction scheduling and arrangement for construction supervision.

The proposed construction schedule envisages commissioning of the Plant in 36 months considering that commissioning and testing operation of the power units will start after 31 months of issuance of Notice to Proceed (NTP) to the Contractor. The size of the project is large but its design features are not unusual to cause any unusual complication during the construction.

Implementing the Project on fast track basis starting construction activities during the year 2010 is perhaps the call of day due to shortage of electric power in Pakistan. In order to fast track implementation there shall be need for focused and timely actions in respect of preparation of detailed design and contract documents, award of contract(s) and arranging adequate requisite funding.

13.2 PROJECT AREA

13.2.1 Site Features and Climate

The site area of the proposed 25 MW Power Station at CJ Link Tail Regulator is flat land located in alluvial plain of Punjab. This plain has been built up by alluvium deposits brought by the rivers in Indus river system and it features generally fine sandy and silty deposits with clayey intrusions up to 12.2 m (40 ft) or more.

Arid climate prevails at the site. During monsoons the rain occurs with the systems originating from Bay of Bengal and Arabian Sea. During the winter season the area occasionally receives precipitation caused by weather systems originating primarily from the Mediterranean or from the Caspian Sea from air mass convective storms. Even in the summer there are indications that at least some of the higher-level precipitation is originating from westerly systems. However, in winter under the prevailing influence of the Tibetan anticyclone, more of the local conditions prevail.

The climate of the area is arid characterized by long hot summer and short mild winter. Maximum temperature of about 50o C occurs during the month of July, while the minimum temperature of about 0o C occurs during the month of January. The maximum mean daily temperature during the month of June is 41.7 °C and 19.4 °C during January respectively. Minimum daily temperature varies between 5.0 °C and 27.2 °C for January. Mean temperature range between minimum and maximum temperature is about 15o C. Despite the extreme temperatures during the winter and summer seasons, it will be possible to continue construction activities however the high temperatures will require steps to ensure adequate protection of concrete work during the hot weather. The temperature is also important for the design of the airconditioning system.

Maximum wind speed that may occur in the project area is of the order of 50 knots, which occurs only rarely due to the windstorms in summer season. Generally, wind speed is less than 5 knots and for 95 % of the time the site is calm. Wind speeds tend to be higher between April and September and lowest from November to January. However, often the wind is accumulated over short bursts of gusty convectional wind especially during the late spring and summer. These winds initiate dust storms from fine-grained particles.

The average annual rainfall varies from about 450mm for Sargodha in the east to about 300mm in the northeast for Mianwali. The average for the two stations, which is assumed to represent the average in the

Project area, is about 375mm. The monthly average rainfall ranges from 122 mm to 5 mm (4.8 – 0.19 inches), maximum occurring during the month of August.

There are no significant human settlements in the proximity of the proposed power station. The closest significant inhabitations are at Khushab and Adhikot, both about 40 km (24.8 mile) away.

13.2.2 Site Access

The proposed project site is connected by a hard top road from the city of Khushab, which is situated at a distance of 40 km (24.8 mile). The site is also approachable from other local towns through black top roads.

The project area is accessible from Karachi Port through a good road network of National, Super and Indus Highways. Road distance from Karachi to project site is approximately 1,164 km (723 mile). Two metalled roads lead to site from Muzaffargarh. One is via Ahmadpur Said, Athara Hazari to Khushab and the other via Chowk Azam, Bhakkar – Jhang Road to Khushab.

The project area is accessible from Lahore through a good metalled road via District headquarters Khushab or Joharabad. The distance between Project Site and Lahore by road is about 312 km (193.8 mile). The site is also approachable from Islamabad through Khushab.

All the paved approach roads have mild gradients (maximum 7 percent), most of them considered to be Class 70 roads (allowing for maximum single-axle loads of 26.4 tonnes and a maximum point load of 62.5 tonnes). The design speeds and the design capacity of the approach roads vary. It can however be assumed that there would be minimal problem for carrying the construction equipment, E&M equipment and increased passenger traffic as a consequence of construction activities.

There is no direct air link of the project site, located at Tail Regulator of Chashma-Jhelum link canal, to any city. The nearest commercial airport is located at Faisalabad where service is available to and from Karachi and Islamabad. It takes about 11/2 hours by air to reach Faisalabad from Karachi. From there on the project site, which is about 225 Km, can be approached in about 31/2 hours by road.

The nearest railway station is Khushab, which is about 40 Km (24.8 mile) from the site. Khushab is connected with Karachi-Peshawar main railway line through Kundian Junction. By rail distance of Khushab from Karachi via Kundian is about 1,310 Km. (814 mile). The limitations for transportation of over-sized consignments by railway from Karachi to Kundian, would be as follows.

Overall length of the consignment = 823 cm
Approximate weight = 20 tons

The heavy construction equipment, E&M equipment, cement, other supplies such as petroleum products and food items are expected to be brought from different parts of Pakistan or from abroad via Karachi port. For this purpose national highways in combination with other inter-city and canal patrol roads can be used.

In order to carry out construction of the components of the Project there will be a need to construct temporary access roads connecting stockpile areas, work areas such as location of cofferdams, batch plants and site workshops for hauling labour and materials within the work areas.

13.3 MAJOR WORK COMPONENTS

The major items and components of works are described in various chapters of the feasibility report and estimated quantities of materials are given in Section 12 hereof and Volume VII of the Report

13.4 PRE-CONSTRUCTION ACTIVITIES

Before construction of the Project begins the following tasks must be performed:

Completion of additional field investigations required for detailed design;
Design of various components of the Project and preparation of tender
drawings;
Preparation of tender documents for all contract packages required;
Prequalification of contractors and manufacturers;
Invitation of tenders and evaluation of bids; and
Award of contracts.

The investigations and engineering design of a power station in plain and flat area would normally require 6-9 months to complete. The decision making regarding award of consulting services contract and other contracts for investigations will have to be prompt and on fast track basis.

13.4.1 Additional Investigations, Engineering and Tendering

The extent of additional investigations should be determined and related activities started immediately if the implementation of the project on fast track has to be pursued. Also the detailed design and preparation of tender documents should start immediately after approval of the Feasibility Report.

After availability of the Feasibility Report, the approval from the concerned authority; Punjab Power Development Board (PPDB) should be sought as per LOI and the tariff negotiated, and the Letter of Support (LOS) obtained from PPDB. The works can be procured through an EPC contract for which a Request for Proposal (RFP Document) will have to be prepared.

13.4.2 CJ Link Tail Regulator

Some changes in CJ Link Tail Regulator will have to be made. This will involve comparatively small-scale work and no major problems are likely to arise.

13.4.3 Colony and Camps

A reasonable workforce, together with supervisory and support staff, will be required for the Project. Practically all this manpower will originate from other areas in Punjab, other regions of Pakistan and from overseas (a few short term experts of E&M appliances used in hydropower stations). Since local accommodation does not exist, it will be necessary to build adequate temporary camps, offices and ancillary facilities at convenient locations near the site.

The total peak manpower expected to be employed on the Project will be of the order of 500. In order to allow for quick mobilization, it is expected that all the temporary camps be built by the contractor immediately after the award of the contract. The details of the housing requirements will be established by the contractor. For the supervisory staff the requirements can be indicated in the 'Tender Documents' or 'RFP'. Tentatively following housing facilities are planned to be constructed;

D type houses 6 for Engineers

E type houses 6 for sub engineers and foremen

F type houses 12 for support staff

One block of bachelors' quarter for 24 persons

Mosque

Market

Guest House and Recreation Club

Park

13.4.4 Resettlement of Affected Population

Since all the land on which the project works will be located is owned by the Government of Pakistan no major resettlement issue should arise. Approximate area of private land required to be acquired in this project is 8 ha (approximately 20 acres). Three houses (two used for living and one as medical dispensary) and a tube well built in WAPDA's land will need relocation,

13.4.5 Labour

The region around the Project site will be able to provide all unskilled labour and some skilled labour such as drivers etc.

Skilled labour will be required for operating various construction equipment, production and laying of concrete, welding, heavy equipment repair mechanics, vehicle drivers and mechanics, carpenters, electricians and technicians required for installation of E&M equipment, batching plant operators, surveyors and technicians required for quality control and testing of construction materials and other construction related laboratory and field testing; etc.

Except for a very few short term skilled staff that may be needed for installation of some of E&M equipment in the power house, it is envisaged that the skilled labour will be all indigenous, but mostly will come from places away from the site. As Pakistan is a major exporter of skilled labour to the Middle East and this, coupled with the general lack of amenities in the Project area, will need to be reflected in the wage rates and employment conditions offered.

The total construction manpower employed on the Project is expected to peak at about 500 out of which approximately 40 percent will be unskilled labour.

13.5 EQUIPMENT

13.5.1 Construction Equipment

Practically all of the construction equipment required for the job will be available with the contractors in Pakistan or would be available on rental.

13.5.2 E&M Equipment

Large E&M equipment, which can pose transportation problems, includes turbine and transformers. The recommended power plant option i.e. three 14.8 MW units will have turbine propeller diameter of 4 m (13.1 ft). This size should not pose problem in transporting it to site.

Similarly, minimum transportation weight of single-phase transformer unit for the recommended option varies from 15 to 20 tonnes. This size should not pose problem in transporting it to site. Taking the allowable axle load of 12.5 tonnes per axle, 2-axle vehicle will be able to carry the load of the required transformer of around 20 tonnes as the transport weight.

13.5.3 Materials

13.5.3.1 Concrete Aggregate

The estimated total amount of coarse aggregate required for the project will be approximately 95,000 cubic meters. The estimated total amount of sand required for the project will be approximately 7,500 cubic meters (2, 64,860 cubic feet).

All the Project requirements of concrete aggregates can be met from the sources near the site such as quarries in Kirana Hills near Sargodha or Bulland Hill.

13.5.3.2 Fuel

The fuel required for the Project will be mainly diesel oil, with relatively minor quantities of gasoline. The quantity of fuel required for the Project will not be exclusively large. The average consumption for two weeks operation will easily be possible to store at the site. Transporting fuel on bi-monthly basis should pose no difficulty.

13.5.3.3 Cement

The quantity of cement required for the Project is estimated at about 35,000 tonnes, with a monthly average consumption of about 800 tonnes or 30 tonnes per day. About 40 percent of the cement quantity required will be sulphate resistant.

There is sufficient production capacity available with the existing cement factories in the proximity of Project (nearest being in Daudkhel), and cement can be transported to the Project site using normal trucks or long trailers. Daudkhel factory can supply needs of the Project, as it is conveniently close and has ample production capacity. The supply and haulage of cement should not pose any problem.

13.5.3.4 Reinforcing Steel

The quantity of reinforcing steel required for the Project will be about 6,500 tonnes, with a monthly average consumption of about 20 tonnes.

Several factories in the country produce small quantities of reinforcing steel, in the form of both plain and deformed bars. There is no factory producing or re-rolling reinforcing steel bars in the near vicinity of the proposed site of the hydropower station. The nearest location from where the reinforcing steel bars of the desired specification are available is Islamabad.

13.5.3.5 Lumber Products

The concrete needs to be fair-faced for which plywood sheet formwork would be required. From preliminary investigations, it appears that plywood sheets of the thickness and quality required for concrete formwork are not available in the country. The quantities involved are rather modest and no particular problem is expected to arise in getting the imported plywood.

13.5.3.6 Natural Materials

For the purposes of construction planning it is sufficient to note that most of the earthwork needed in fill will be produced as a result of required excavation of the power channel or will be obtained from existing spoil material of CJ Link Canal.

13.5.4 Storage of Materials

13.5.4.1 Concrete Aggregate

The space for work activities and storage is available in abundance near the Project site. Some facilities will have to be located close to the power house such as; the concrete batch plant with its bins, stockpiles and silos.

13.5.4.2 Cement

Two week storage may be sufficient to ensure that there are no interruptions in the construction of powerhouse and other structures. Cement storage for 7 days production of concrete near the batch plant will also be needed.

13.5.4.3 Reinforcing Steel

The total requirement of the reinforcing steel for the Project is approximately 6,500 tonnes. Due to sharp variation in the steel prices, it would be perhaps prudent to buy steel in suitable batches at appropriate intervals. The storage of about 500 tons of reinforcing steel should not pose a problem in the contractor's workshop area.

13.5.4.4 Petroleum Products

The storage tanks or drums are proposed to be used at the jobsite, sufficient for two weeks of peak operation.

13.5.4.5 Water

The quality of underground water at the project site indicates that the water is suitable for mixing and curing of concrete. Water for concrete production and other needs can be obtained by pumping water from ground. This water will be pure, with a very low level of dissolved solids.

13.6 PLANNING APPROACH

13.6.1 Non-productive periods

13.6.1.1 Non-productive periods

In order to determine the networking periods available for construction, it is necessary to evaluate the time that will not be productive due to a variety of reasons. The following will cause reduction in the working periods:

Sundays

Sunday is a weekly holiday in Pakistan. It is therefore assumed that, under normal circumstances, only six days would be worked each week, Monday through Saturday.

Fridays

Although Friday is a working day in Pakistan but it is the Muslim weekly day of special congregation. There will therefore be about two hours of working period not available on Fridays.

Public Holidays

There are 14 official public holidays in Pakistan. The dates of some holidays are subject to variation, depending on the lunar calendar. Additionally, there are some days of optional holidays, corresponding to particular religious or civil occasions.

Official Public Holidays

Pakistan Day 23 March 1 Labor Day 1 May 1 Independence Day 14 August 1 Iqbal Day 9 November 1 Eid-ul-Fitr - Variable (1) 3 Birthday of Quaid-e-Azam 25 December 1

and Christmas Eid-ul-Azha - Variable (1) 3 9 &10th of Muharram - Variable (1) 2 Eid-ul-Milad-un-Nabi - Variable (1) 1 Total Official Holidays 14 Note: (1) Timings of religious holidays are defined by Lunar calendar

Ramazan

During the month of Ramazan, all followers of the Islamic faith are required to fast from dawn until dusk. There is a consequential drop in labour productivity during this period, which is evaluated as corresponding to approximately 10 non-worked days.

13.6.2 Strikes and Miscellaneous Delays

Labour unrest, supply problems, delays at the port or on the railways will be inevitable during the project construction period. It is difficult to forecast the probable effect of such disruptions, particularly since their impact, during critical periods, may be disproportionate to their actual duration. The yearly loss due to these causes could be about 5 days.

13.6.3 Net Working Periods

As a result of the time which is expected to be lost, the following net working periods were determined:

25 days per month; or

10.5 months per year.

The ratio of net working months to elapsed calendar months is therefore 10.5/12, or 0.875.

All the required output rates need be computed taking into account only the net working time available.

13.6.4 Daily shifts

Although it is theoretically possible that all the works will proceed on triple-shift basis, this is not likely to be the case on the site due to; (i) non-availability of spare capacity of manpower and equipment available for peak production or emergency periods; (ii) difficulty in requisite maintenance of equipment, haul roads and jobsite installations; (iii) high day time temperatures during most of the year and (iv) non-availability of margin to perform all the time-consuming tasks unforeseen or omitted from the schedule.

It can therefore be assumed that work on the construction of facilities involving earthwork, brick masonry, conventional concrete, etc. may proceed in more than one shift (production and placing of concrete will be in one go for a pour with the batching plants operating 6 to 8 hours per day, most likely at the night time and/or during early hours of the day).

13.6.4.1 Assumed Working Periods

As a result of the above considerations, the net working period for the construction activities could be 5,250 hours per year. This net working period is based on 25 working days per month or 101/2 months per year. Special measures will have to be introduced to ensure completion of facilities due to tight timelines.

13.7 PROCUREMENT MODES AND CONTRACT PACKAGING

For a project of the size and nature of works of 44 MW Hydro Power Plant, it is desirable to have all works procured through single contract package. Except for a few major contractors there are not many local contractors available to handle the project involving civil works as well as procure from abroad and install hydropower station related E&M equipment. Foreign contractors may not be interested in undertaking the project on their own as it is not large enough for them. It is proposed that the project should be constructed through an EPC contract, involving a consortium of a main contractor, a consulting firm for detailed design and a supplier of hydropower related E&M equipment. Prequalification of contractors will be necessary.

13.7.1 Overall Implementation Schedule

Overall implementation schedule envisages completion of construction of the Project works and commencement of commercial operation in 48 months from the date of start of detailed design,.

Fig. 13.1 shows the overall implementation schedule.

13.8 CONSTRUCTION METHODS

13.8.1 General

The construction methods described hereunder are those considered appropriate in construction planning of the proposed scheme of the Project for the purpose of establishing its feasibility. These construction

methods should not preclude the contractors using other acceptable methods to advantages of time and cost.

13.8.2 Care and Handling of Water

Major handling of water in connection with this construction activity is the dewatering required to dry work areas such as the foundation of the Power House and other structures etc. included in the Project. Afterwards, arrangement will have to be in place for maintaining this area as dry area. Although there are no rains of high intensities at the project site arrangements need to be in place for taking care of low lying work areas after occurrence of rain.

13.8.3 Excavation above Ground

Major quantity of excavation will be in the construction of power channel including the excavation of foundation for the power house.

All excavation is in alluvial soil a substantial apportion of which will be wet excavation or excavation under subsoil water level. This will be carried out by mechanical means involving use of dragline as well. The plugs both upstream and downstream end of the power channel and upstream and downstream of foundation pit for the powerhouse shall be left to serve as cofferdams during the construction of power house and other structures in the power channel. Prior to the excavation for foundation pit the arrangements to dewater the pit should be in place to work continuously with standby arrangement.

The excavated material will be placed directly in location of the power channel banks and compacted as far as possible. The wet excavated material will be stock piled and dried to bring the moisture near to optimum moisture content before placing it in the location of fill.

The plugs shall be excavated after the power house building is completed and power plant is ready for commissioning and test run. The excavation work can be completed within the envisaged schedule possibly with a dragline, two excavators and 4-6 tractor trolleys.

13.8.4 Foundation Preparation for the Power House

Prior to foundation shaping dewatering will be carried out by two deep tubewells of 75 to 113 litres/sec (3-4 cusec) capacity each along with suitably installed well point system.

13.8.4.1 Powerhouse Construction

The Project includes construction of the power house building at the end of power channel. The work on the power house and transformer/switchyard can start any time after the contractor is fully mobilized, concurrent with the activities for the construction of other structures. In actual fact the major component of the Project is the power house. It is envisaged that its construction will commence once the excavation of the foundation of is complete and the batch plant for manufacturing concrete is installed.

Once the excavation of the foundation of the powerhouse is complete, various construction activities and installations can start. The concrete structure forming the lower levels of the powerhouse outside the turbine pits will then be constructed. At the same time the structure above the main floor will be built. The draft-tubes will then be placed and the sections welded together. These sections can be brought into place with chain hoists. The space will then be concreted in stages, filling the void between the steel and the face of excavation. The main powerhouse crane has to be installed by this stage. The spiral case will then be installed, welded and concreted. The walls surrounding the spiral case and the generator will be made at the same time. The construction of the generator stators will be followed by installation of the rotors with installation of various services and controls at the same time.

The total time for the placement of concrete in the powerhouse and installing the turbines, generators and other appurtenant equipment is estimated at 60 weeks or about 14 months.

The total time scheduled for completion of the power house, excluding commissioning of the units, is estimated at 76 weeks (171/2 months) from the start of civil works. Commissioning can start after completion of the power channel and the power house. There shall be no time difference, representing a float in the construction schedule, available as the commissioning does not depend on any impounding of water. There is strong interdependency between many critical activities and lost time is likely to have an adverse effect on the completion.

13.8.4.2 Transformer and Switchyard in the Power House

The transformer and switchyard gallery will house the two transformers on the lower floor and the switchgear on a concrete floor constructed above them. The concrete structure will have to be essentially complete before installation of equipment can start. The switchgear components will be brought in and lifted into place with the service crane provided at the site. The transformers will be rolled into place on permanent rails provided for the purpose. The HT riser to the surface will require concrete platforms at intervals and permanent ladder access.

13.8.5 Transmission Lines and Grid Station

The construction of transmission line is critical for commissioning and commercial operation of the powerhouse units. This activity, however, can proceed independently without having conflict or linkage with the activities of construction of various components of the Project.

The significant aspect for completing the transmission line on time is the marking of route corridors and acquisition of land for construction activities relating to transmission lines to commence concurrent and coordinated with the civil works, which should be carried out well in advance.

13.9 TRANSPOTATION, ASSEMBLY, ERECTION AND INSTALLATION OF E&M EQUIPMENT

All the E&M equipment, which includes turbine and generator parts, transformers, gate equipment, HV & MV switchgear, cranes and other auxiliaries, will be transported from Karachi port to site on trailers and containers via the National Highway/Motorway. The largest and the heaviest pieces of equipment foreseen are:

The larger pieces of equipment will be transported to site on low-bed trailers having adequate number of axles and control on turning of individual wheels.

The first item of equipment to be installed in powerhouse is the bridge crane, for which the civil contractor will complete the civil works in erection bay and complete the erection of crane rails. The bridge girders of the cranes will be brought in the powerhouse and installed on the crane rails using chain pulley block, and installation of the trolleys will follow. The cranes will be tested for travelling, traversing and carrying of the designed load with all protections in place, after completing installation of all parts of the cranes. Tandem operation of the two trolleys of main crane will also be tested.

As soon as the draft tube pit of unit No. 1 is ready, the draft tube sections will be brought in the powerhouse on trailers in the sequence of erection. All the other parts of the turbine like stayring, spiral case, bottom ring, runner wicket gates, head cover, turbine shaft seal, turbine guide bearing etc. will be brought in the powerhouse in the order of erection. Parts will be unpacked and cleaned, and pre-assembled as required and shifted to the turbine pit for installation using the overhead bridge cranes.

Soon after the shaft is fixed in position, centred and aligned, creating the "shaft free" turbine pit situation, the installation of stator, rotor and the bearing brackets will take place. First the stator segments will be brought to site for assembly, and later the rotor parts (spider, brake ring, laminations, poles, etc) will be brought to site and assembly work will start simultaneously with the assembly work of the stator. When the assembly of the stator will be complete, it will be lifted by the main crane using a lifting beam and placed on its foundation in the unit bay. Then the assembled rotor will be lifted by the main crane, with the two trolleys

in tandem operation, using a lifting beam and shifted to the unit bay and inserted in the stator and placed on the shaft supported by thrust bearing. Other assembled parts will then be shifted to unit bay area and erection of auxiliaries, cables, panels and instruments will be carried out.

While the erection work in powerhouse is in progress, the generator transformers will be brought to the transformer gallery. The transformers will be jacked up to release the trailer, and then lowered on wheels over the rails embedded in the floor. The transformers will be pulled by winches over the rails and positioned in the transformer bays, one by one. The IPBs will be erected between the powerhouse and the transformer gallery and connected to generator terminals at the lower end and with the single phase transformers.

The HV switchyard equipment will be transported to the transformer gallery and installed. The erection of switchyard equipment will be carried out by chain pulley blocks. Cabling for instrumentation, monitoring and controls along with cable terminations will be completed before the start of unit testing activity.

13.10 PROJECT CONSTRUCTION

The construction of the project may be divided into two parts:

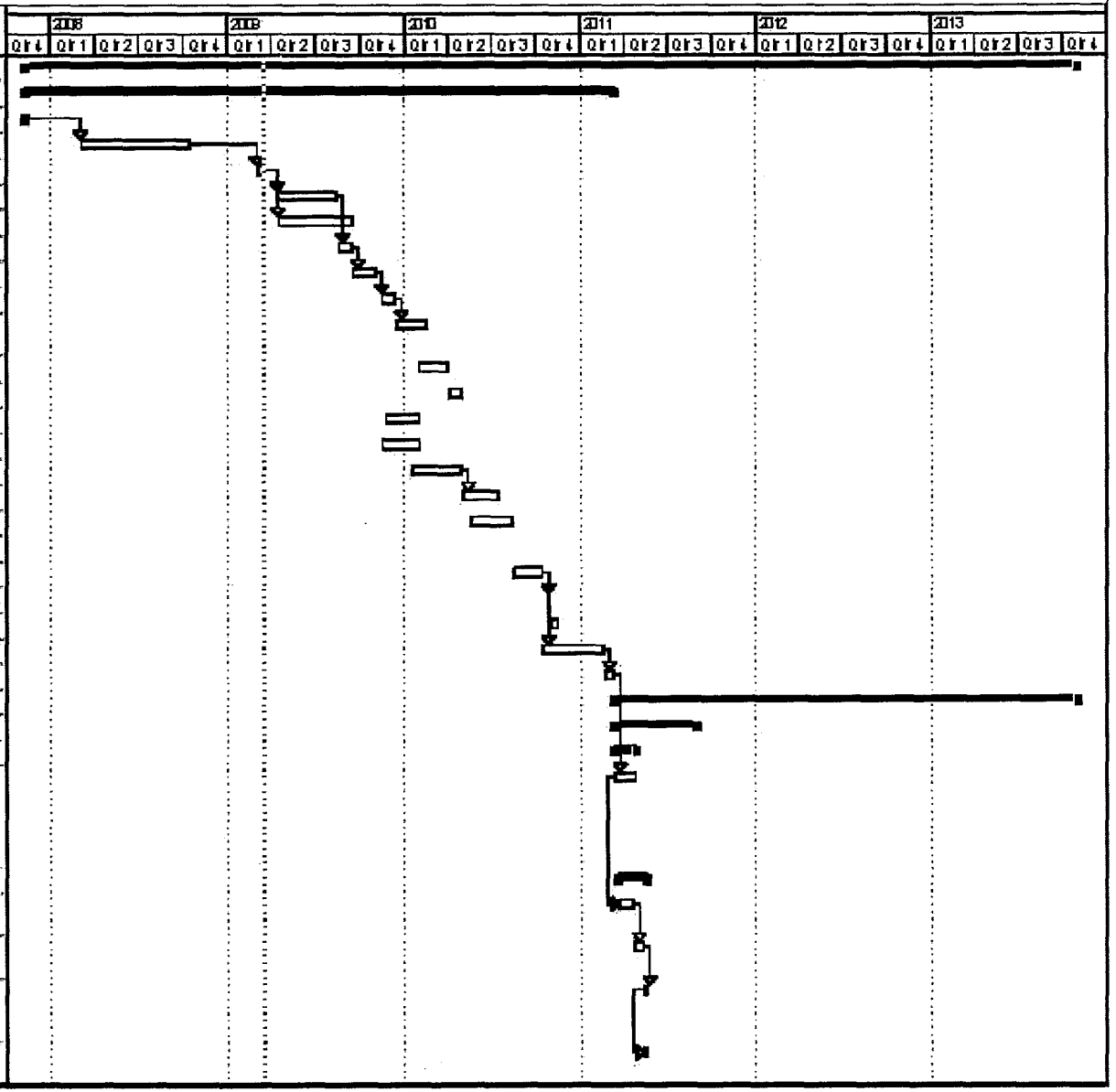
The hydropower station (powerhouse and its installations); and The Grid Station and connecting Transmission line to nearest location to link with the national grid.

The above mentioned two parts of the works are not linked and can be implemented independent of each other. The construction of transmission lines, however, is critical for commercial operation of the powerhouse units.

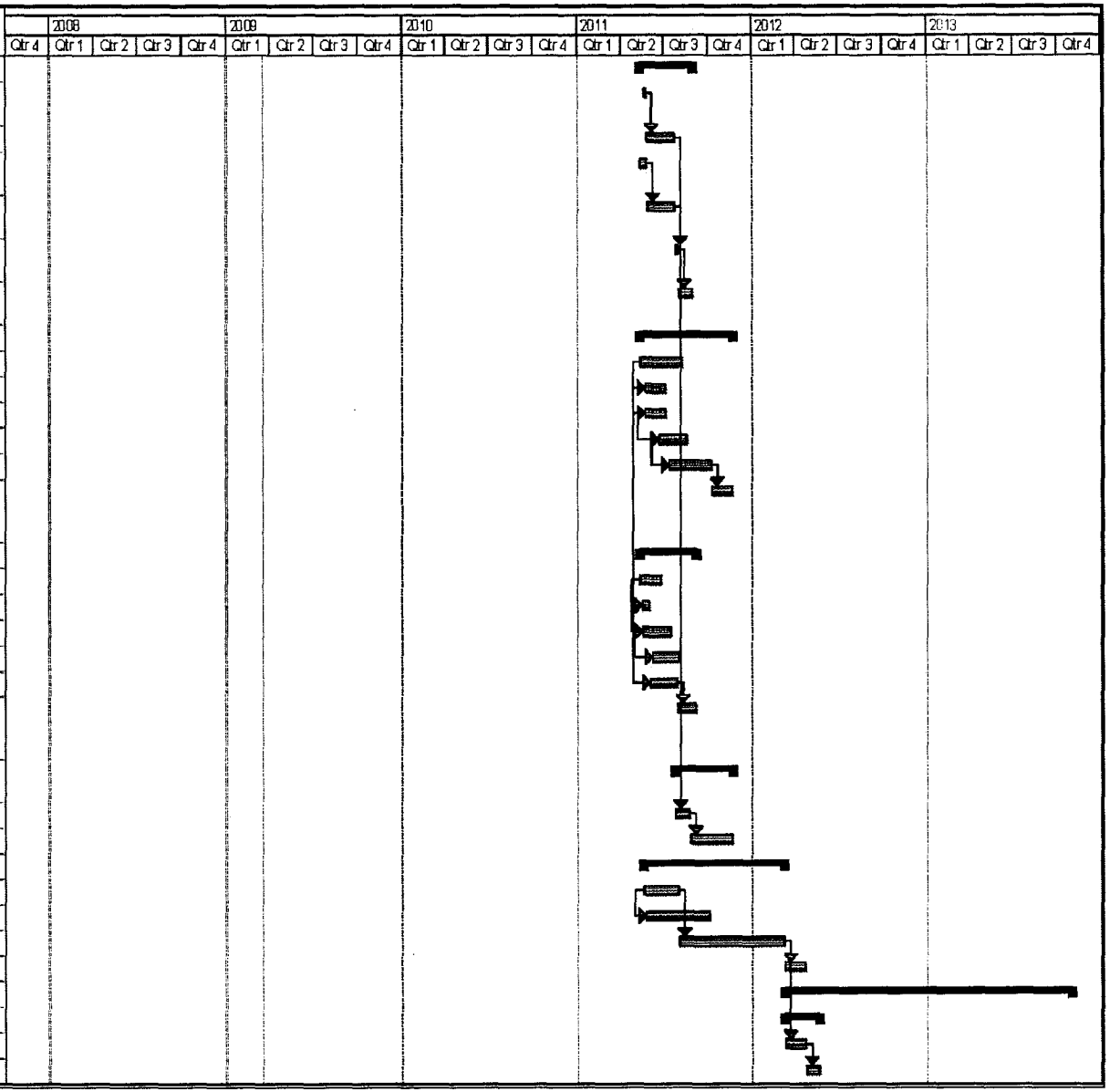
Keeping in view the methodology and estimated rate of accomplishment of various activities, as described above, the total duration from beginning of mobilization to the commissioning of the project will be 36 months. The proposed construction schedule is included, component wise, in Fig 13.1.

FIG.13.1

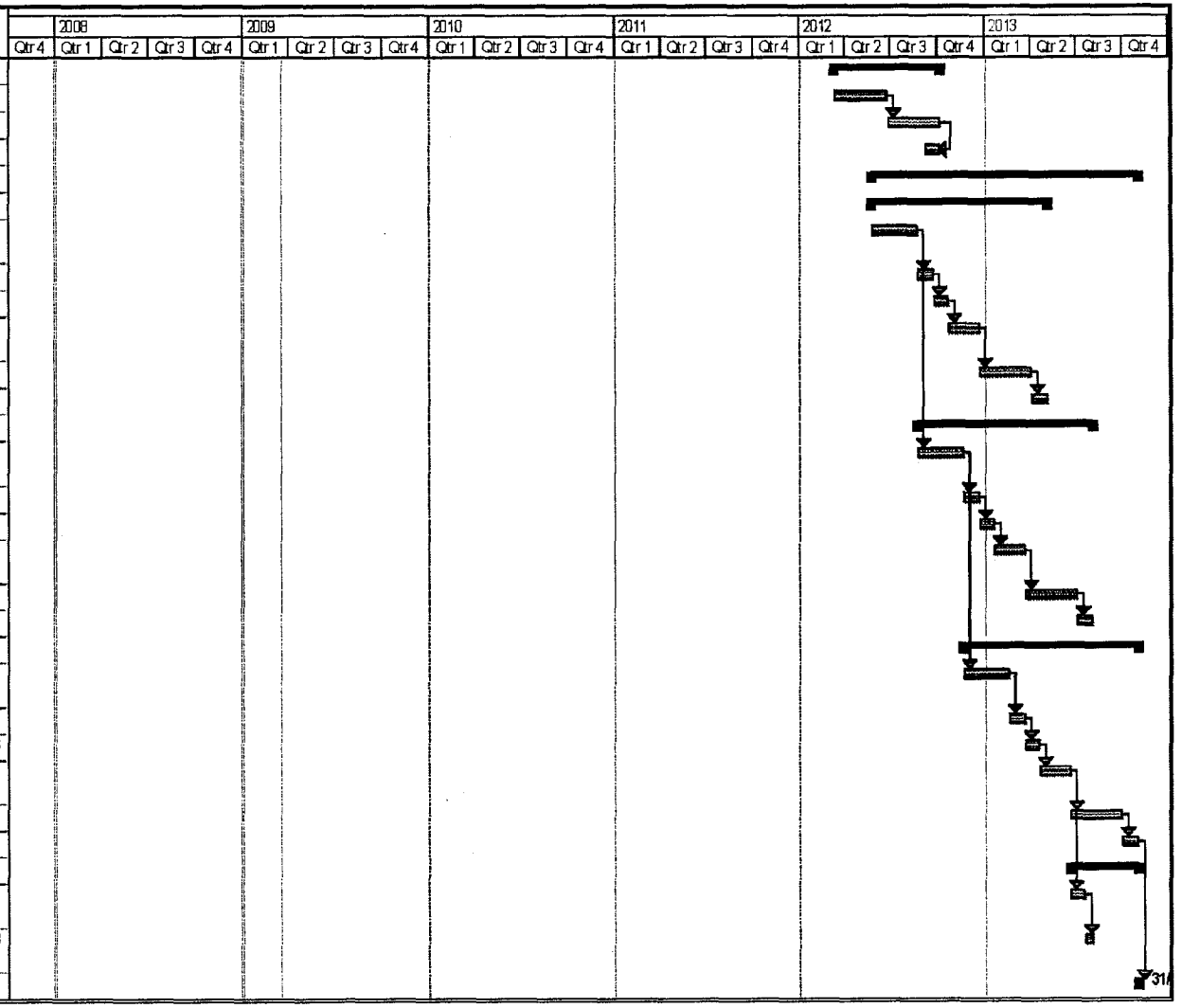
ID	Task Name	Start	Finish
1	40 MW Hydro power Station at CJ Link Tail Regulator	Thu 08/11/07	Thu 31/10/13
2	General	Thu 08/11/07	Thu 10/03/11
3	Letter of Interest (LOI)	Thu 08/11/07	Thu 08/11/07
4	Feasibility Study Completion	Mon 03/08/08	Fri 17/10/08
5	Approval of Feasibility Study	Thu 05/03/09	Fri 20/03/09
6	Tariff Determination	Wed 15/04/09	Fri 14/08/09
7	General on licence	Wed 15/04/09	Tue 15/09/09
8	Submission of Performance Guarantee to PPDB	Mon 17/08/09	Tue 15/09/09
9	Issuance of Letter of Support	Wed 16/09/09	Mon 02/11/09
10	Issuance of Security Package by PPIB	Mon 16/11/09	Tue 15/12/09
11	Submission of Black-Lined Version of Security Package	Wed 16/12/09	Mon 15/02/10
12	Negotiations on Security Package	Mon 01/02/10	Wed 31/03/10
13	Project Agreements Execution	Thu 01/04/10	Fri 30/04/10
14	Additional Site Investigations	Tue 24/11/09	Mon 01/02/10
15	EPC Documents Preparation & Detailed Design	Mon 16/11/09	Mon 01/02/10
16	Initiation to Bid	Fri 15/01/10	Fri 30/04/10
17	Signing of EPC Contracts	Sat 01/05/10	Thu 15/07/10
18	Finalization of Term Sheet with Lenders	Mon 17/05/10	Thu 12/08/10
19	Ground-Breaking of the Project	Sat 14/08/10	Sat 14/08/10
20	Financial Closing	Mon 16/08/10	Fri 15/10/10
21	Notice to Proceed	Mon 18/10/10	Mon 18/10/10
22	Advance Payment by the Owner/Construction Start	Mon 01/11/10	Mon 15/11/10
23	Engineering & Design	Sat 16/10/10	Thu 17/02/11
24	Mobilisation	Fri 18/02/11	Thu 10/03/11
25	Procurement of Works	Fri 11/03/11	Thu 31/10/13
26	Construction of Power Channel	Fri 11/03/11	Tue 30/08/11
27	Prism Earthwork	Fri 11/03/11	Sun 24/04/11
28	Excavate prism leaving cofferdams (two upstream & downstream near the CJ link and two upstream & downstream of powerhouse foundation pit), and platform to construct AR Bridge	Fri 11/03/11	Sun 24/04/11
29	Construction of Banks	Mon 21/03/11	Wed 18/05/11
30	Excavate from Borrow Areas and fill embankments blocks	Mon 21/03/11	Tue 19/04/11
31	Shape the power channel prism and trim banks	Wed 20/04/11	Wed 11/05/11
32	Relocate bank of CJ link at upstream end of power channel to create cofferdam for creating work space for concrete lining the	Thu 12/05/11	Wed 18/05/11
33	Construct downstream cofferdam to create workspace for stripping of	Thu 12/05/11	Wed 18/05/11

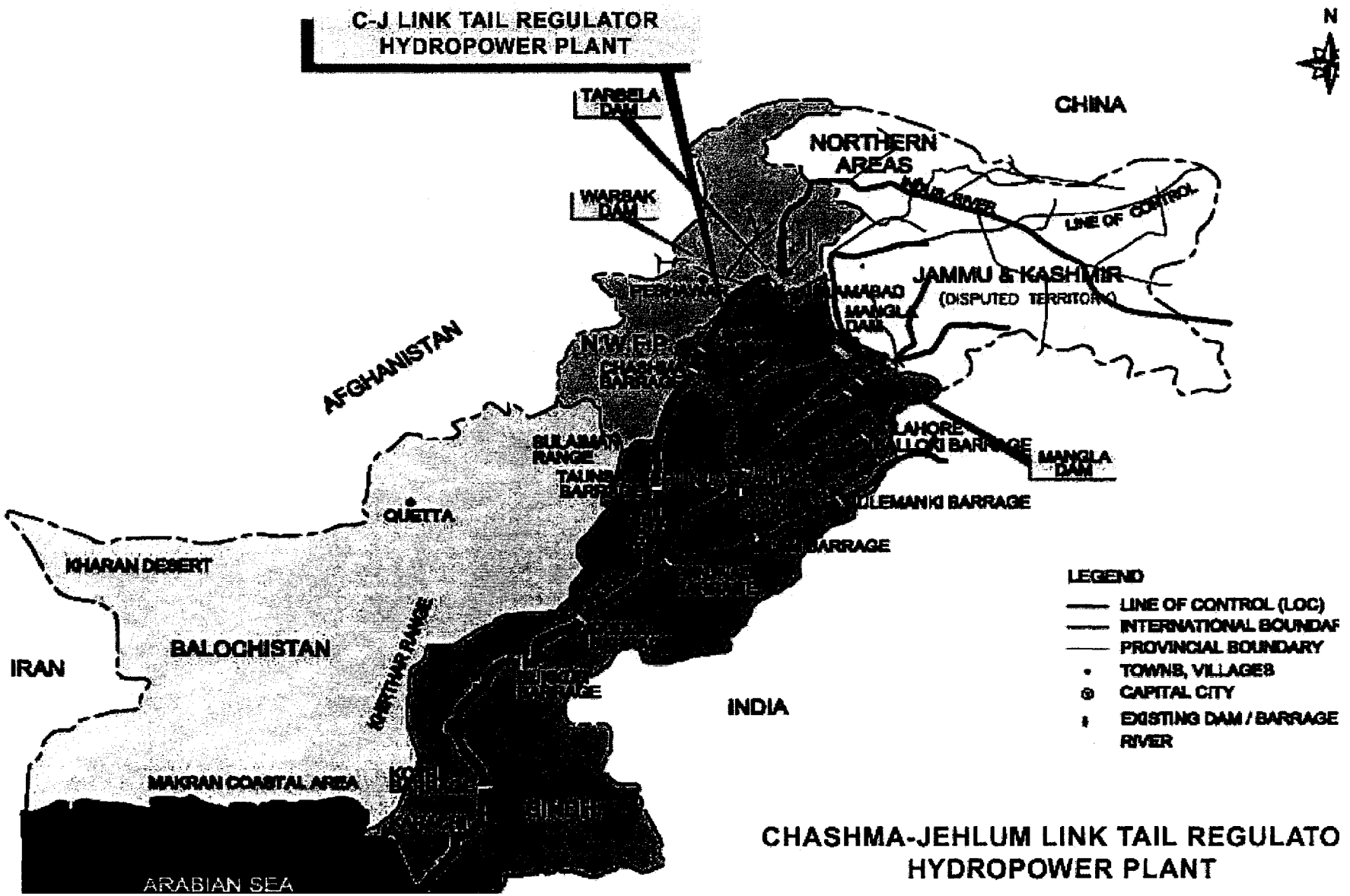


ID	Task Name	Start	Finish
34	**Concrete Linning of the Power Channel**	**Thu 12/05/11**	**Tue 30/08/11**
35	Dewater between the cofferdam and AR Bridge contraction platform	Thu 19/05/11	Wed 25/05/11
36	Line canal prism upstream of the AR Brigde	Thu 26/05/11	Sun 24/07/11
37	Dewater between the AR Bridge contraction platform and u/s cofferdamof	Thu 12/05/11	Thu 26/05/11
38	Line canal prism between the AR Brigde and cofferdamupstreamof the	Fri 27/05/11	Mon 25/07/11
39	Dewater the reach d/s cofferdam of powerhouse and the downstrean	Mon 25/07/11	Sun 31/07/11
40	Line the reach downsstream of the powerhouse pit to downstream	Mon 01/08/11	Tue 30/08/11
41	**Construction of AR Bridge**	**Thu 12/05/11**	**Tue 22/11/11**
42	Drill and construct in-situ piles	Thu 12/05/11	Tue 09/08/11
43	Construct abutments and pier bents	Sun 22/05/11	Tue 05/07/11
44	Precast girders and diaphrams	Sun 22/05/11	Tue 05/07/11
45	Place and install girders and diaphrams	Tue 21/06/11	Fri 19/08/11
46	Construct deckslabs	Mon 11/07/11	Sat 08/10/11
47	Miscellaneous items of work, excavation of canal prism under the deck and line the powerchannel under the bridge	Sun 09/10/11	Tue 22/11/11
48	**Construction of Foot Bridge**	**Thu 12/05/11**	**Wed 07/09/11**
49	Drill and construct in-situ piles	Thu 12/05/11	Sat 25/06/11
50	Construct abutments and pier bents	Tue 17/05/11	Tue 31/05/11
51	Precast girders and diaphrams	Tue 17/05/11	Fri 15/07/11
52	Place and install girders and diaphrams	Mon 06/06/11	Thu 04/08/11
53	Construct deckslabs	Wed 01/06/11	Sat 30/07/11
54	Miscellaneous items of work, excavation of canal prism under the deck and line the powerchannel under the bridge	Sun 31/07/11	Wed 07/09/11
55	**Construction of Escape Channel and its apputenanr Structures**	**Tue 26/07/11**	**Tue 22/11/11**
56	Earthwork	Tue 26/07/11	Wed 24/08/11
57	Appurtenant Structures	Thu 25/08/11	Tue 22/11/11
58	**Power House**	**Thu 19/05/11**	**Sat 10/03/12**
59	Excavate Foundation Pit	Thu 19/05/11	Mon 01/08/11
60	Dewater the Foundation Pit	Tue 24/05/11	Wed 05/10/11
61	Concrete Work	Tue 02/08/11	Sat 10/03/12
62	Control roommsc E & M	Sun 11/03/12	Tue 24/04/12
63	**Power House Installation**	**Sun 11/03/12**	**Thu 31/10/13**
64	**Crane**	**Sun 11/03/12**	**Thu 24/05/12**
65	Concrete to and incl. crane beams	Sun 11/03/12	Tue 24/04/12
66	Installation and Testing of Main Bridge Cranx	Wed 25/04/12	Thu 24/05/12



ID	Task Name	Start	Finish
67	**Transformer and SW Installation**	**Sun 11/03/12**	**Sat 06/10/12**
68	Transformers	Sun 11/03/12	Sat 23/06/12
69	Switchgear	Sun 24/06/12	Sat 06/10/12
70	Conductor to Surface	Fri 07/09/12	Sat 06/10/12
71	**Turbines and Generators**	**Fri 25/05/12**	**Thu 31/10/13**
72	**Unit 1**	**Fri 25/05/12**	**Sat 04/05/13**
73	Set, weld and assemble Turbine and Generator pack and cone in draft	Fri 25/05/12	Wed 22/08/12
74	Concreting	Thu 23/08/12	Fri 21/09/12
75	Testing	Sat 22/09/12	Sun 21/10/12
76	Assembly of governor and other auxiliaries	Mon 22/10/12	Thu 20/12/12
77	Commissioning Tests	Fri 21/12/12	Thu 04/04/13
78	Reliability Tests	Fri 05/04/13	Sat 04/05/13
79	**Unit 2**	**Thu 23/08/12**	**Fri 02/08/13**
80	Set, weld and assemble Turbine and Generator, and cone in draft tube	Thu 23/08/12	Tue 20/11/12
81	Concreting	Wed 21/11/12	Thu 20/12/12
82	Testing	Fri 21/12/12	Sat 19/01/13
83	Assembly of governor and other auxiliaries	Sun 20/01/13	Wed 20/03/13
84	Commissioning Tests	Thu 21/03/13	Wed 03/07/13
85	Reliability Tests	Thu 04/07/13	Fri 02/08/13
86	**Unit 3**	**Wed 21/11/12**	**Thu 31/10/13**
87	Set, weld and assemble Turbine and Generator, and cone in draft tube	Wed 21/11/12	Mon 18/02/13
88	Concreting	Tue 19/02/13	Wed 20/03/13
89	Testing	Thu 21/03/13	Fri 19/04/13
90	Assembly of governor and other auxiliaries	Sat 20/04/13	Tue 18/06/13
91	Commissioning Tests	Wed 19/06/13	Tue 01/10/13
92	Reliability Tests	Wed 02/10/13	Thu 31/10/13
93	**Miscellaneous Works**	**Wed 19/06/13**	**Thu 31/10/13**
94	Remove upstream and downstream coffer dams	Wed 19/06/13	Thu 18/07/13
95	Clearance of denies, Land levelling and Horticulture	Fri 19/07/13	Fri 02/08/13
96	Substantial Completion	Thu 31/10/13	Thu 31/10/13





CHASHMA-JEHLUM LINK TAIL REGULATO
HYDROPOWER PLANT

25MW HYDRO POWER PLANT AT CAHASHMA JEHLUM – INTERCONNECTION STUDY

Load Flow, Sort Circuit and Transient Stability Analysis

Abstract

The 25 MW Chashma Jehlum Hydro Power project is planned to be constructed near Army base camp Girot. The report deals with the technical aspects of the interconnection with respect to Load Flow, Short Circuit and Generator Transient Stability.

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25MW Hydro Project at Chashma Jehlum Inter-connection Report

SUMMARY

The objective of this study is to confirm the technical achievability of addition of 25MW hydro power plant at the tail of Chashma-Jehlum link canal. The power output of this plant has been planned to be inducted into the existing FESCO 132kV network, near 132kV Jauharabad grid station and 132kV Army Base Camp Girot grid stations. To assess the technical rationalization and viability, three type of studies have been carried out:

1. Load Flow Analysis
2. Short Circuit Analysis and
3. Generator Transient Stability Analysis.

All three studies have endorsed the project to be beneficial and technically feasible for the power system. The load flow study has shown that the adjacent load centers are catered now by newly introduced power plant, with a considerable improvement in the voltage level. The short circuit study has shown that the short circuit levels remain well within the switchgear short circuit ratings, so that the 25MW Chashma Jehlum Hydro power plant does not endanger the system with respect to short circuit levels. Thirdly the stability analysis has shown that even the worst fault conditions, the generators of Chashma Jehlum Hydro Power Plant restore the stability after the fault clearance. The power plants of the connecting areas have also been checked, and it is found that any fault on the Chashma Hydro power plant does not cause these neighboring units to cross the limits of stability. Hence with respect to the technical aspects, the project is found feasible.

CONNECTION WITH THE EXISTING FESCO NETWORK

In 2012 a report on the connectivity of 44MW CJHPP was conducted by others, based on the then hydrology studies, which envisaged that the water potential at Chashma Jehlum Link Canal tail was more than 45 MW. Accordingly the mentioned report was based on 44MW generation capacity and with various connection alternatives it concluded that the hydel power plant proposal with 44MW is justified.

However, the later hydrology studies revealed that the hydro potential was 25 MW. The purpose of this study is to assess the technical feasibility of the plant at the reduced power capacity. The new hydro power plant rated 25MW is planned to be installed into the network, near ABC camp Girot at the tail of Chashma Jehlum Link Canal.

There following two alternatives are considered:

Alternative-1

The site of the new Power Plant is 8 Km from Girot G/s and 32 Km from Jauharabad G/s. There are two circuits from 132kV Girot G/s to 132kV Jauharabad G/s. One of the two circuits will be diverted to 132kV Chashma Jehlum Power Plant with an IN-Out arrangement at CJHPP grid station. The new circuits will be:

(i) 132kV CJHPP to Jauharabad circuit

(ii) 132kV CJHPP to Girot circuit

Alternative-2

Two new circuits between 132kV CJHPP switchyard to 132kV Jauharabad grid station. Since Alternative -2 will require addition and modification work at Jauharabad G/s in addition to 132kV line work, several bottle necks like right of way, material procurement etc. are expected.

NETWORK DATA

The mentioned report pf 44MW power plant carry various data and assumptions. This study has performed a check to the data and assumptions of previous report besides the reflection of updated system data. The updated transmission line data used in this study is from FESCO, which gives the line lengths, type of the conductor, and types of poles for substations in the FESCO 132kV network. The line data used in this study has been shown in the following table with usual units.

Description		Length (KM)	Cond	R/km	X/km	Y/km
Chashma Hydel	Wan Bhachran	38	Lynx	0.1576	0.411544005	1.10055E-07
Chashma Hydel	Wan Bhachran	38	Lynx	0.1576	0.411544005	1.10055E-07
Chashma Hydel	Chashma Left Bank	1.34	Lynx	0.1576	0.411544005	1.10055E-07
Chashma Hydel	Chashma Left Bank	1.34	Lynx	0.1576	0.411544005	1.10055E-07
Wan Bhachran	Qaidabad	32	Lynx	0.1576	0.411544005	1.10055E-07
Wan Bhachran	Qaidabad	32	Lynx	0.1576	0.411544005	1.10055E-07
Qaidabad	Jauharabad	39.69	Lynx	0.1576	0.411544005	1.10055E-07
Jauharabad	Shahpur	37	Lynx	0.1576	0.411544005	1.10055E-07
Shahpur	Ludewala (New)	6	Lynx	0.1576	0.411544005	1.10055E-07
Jauharabad	ABC Grout	44.24	Lynx	0.1576	0.411544005	1.10055E-07
Jauharabad	CJ HPP	52.24	Lynx	0.1576	0.411544005	1.10055E-07
CJ HPP	ABC Grout	8	Lynx	0.1576	0.411544005	1.10055E-07
Wan Bhachran	Piplan	34	Lynx	0.1576	0.411544005	1.10055E-07
Wan Bhachran	T-Off Chashma N	38	Lynx	0.1576	0.411544005	1.10055E-07

25MW Hydro Project at Chashma Jehlum Inter-connection Report

T Off Chashma N	Chashma N	1	Lynx	0.1576	0.411544005	1.10055E-07
T-Off Chashma N	T-Paic	2	Lynx	0.1576	0.411544005	1.10055E-07
Chashma Left Bank	T-Paic	2	Lynx	0.1576	0.411544005	1.10055E-07
Chashma Left Bank	Piplan	25	Lynx	0.1576	0.411544005	1.10055E-07
Wan Bhachran	T-Off Pioneer CF	28	Lynx	0.1576	0.411544005	1.10055E-07
T Off Pioneer CF	Pioneer CF	8	Lynx	0.1576	0.411544005	1.10055E-07
T Off Pioneer CF	Zaman CF	45	Lynx	0.1576	0.411544005	1.10055E-07
Zaman CF	Ludewala (New)	57	Lynx	0.1576	0.411544005	1.10055E-07
Ludewala (New)	Sardarpur Noon	45	Rail	0.05969	0.385389537	1.02783E-07
Sardarpur Noon	Bhalwal	11.1	Cuckoo	0.07178	0.389490126	1.03923E-07
Bhalwal	Kuthiala Sheikhan	30.8	Cuckoo	0.07178	0.389490126	1.03923E-07
Ludewala	Kirana Hill	17	Zegalo	0.07178	0.389490126	1.03923E-07

25MW Hydro Project at Chashma Jehlum Inter-connection Report

Description		Length (KM)	Cond	R/km	X/km	Y/km
Ludewala	Ludewala(New)	3	Zegalo	0.07178	0.389490126	1.03923E-07
Ludewala	Ludewala(New)	3	Zegalo	0.07178	0.389490126	1.03923E-07
Ludewala	Ludewala(New)	3	Zegalo	0.07178	0.389490126	1.03923E-07
Ludewala	Ludewala(New)	3	Zegalo	0.07178	0.389490126	1.03923E-07
Ludewala (New)	Head Faqirian	60	Rail	0.05969	0.385389537	1.02783E-07
Ludewala	66 Ludewala	1	T1	0	10.89	0
Head Faqirian	66 Head Faqirian	1	T2	0	10.89	0
66 Head Faqirian	66 Pathan Kot	90	Dog	0.2733	0.352796699	9.37211E-08
66 Pathan Kot	66 Ludewala	36	Dog	0.2733	0.352796699	9.37211E-08
66 Head Faqirian	66 Malawal	27	Dog	0.2733	0.352796699	9.37211E-08
66 Head Faqirian	66 Bhabra	33	Dog	0.2733	0.352796699	9.37211E-08
Ludewala	T-Off Kudlathi	32	Brant	0.1432	0.411169258	1.0995E-07
T-Off Kudlathi	Kudlathi	1	Brant	0.1432	0.411169258	1.0995E-07
T-Off Kudlathi	Bhamb	53	Brant	0.1432	0.411169258	1.0995E-07
Kudlathi	Sargodha City	9.3	Lynx	0.1576	0.411544005	1.10055E-07
Ludewala	Sargodha-2	20	Zegalo	0.07178	0.389490126	1.03923E-07
Sargodha-2	Chak 126 SB	20	Zegalo	0.07178	0.389490126	1.03923E-07
Chak 126 SB	Liberty Power	32	Rail + Zigalo, 72:63	0.065332	0.387303145	1.03315E-07
Liberty	M3 Industrial	5	Rail	0.05969	0.385389537	1.02783E-07

25MW Hydro Project at Chashma Jehlum Inter-connection Report

Power						
M3 Industrial	Khadim Steel	4	Rail	0.05969	0.385389537	1.02783E-07
Khadim Steel	Millat Rd	15	Rail + Zigalo, 9:53	0.070025	0.388894879	1.03758E-07
Millat Rd	Nishatabad	11	Zegalo	0.07178	0.389490126	1.03923E-07
Liberty Power	Nishatabad	31	Rail	0.05969	0.385389537	1.02783E-07
220kV Mari (Daudkel)	132kV Mari-Daudkel CCT-1	5.5	Rail	0.05969	0.385389537	1.02783E-07
220kV Mari (Daudkel)	132kV Mari-Daudkel CCT-2	5.5	Rail	0.05969	0.385389537	1.02783E-07
220kV Mari (Daudkhel)	132kV Daudkhel-Kohat CCT-1	32.17	Lynx	0.1576	0.411544005	1.10055E-07
220kV Mari (Daudkhel	132kV Daudkhel-Kohat CCT-2	32.17	Lynx	0.1576	0.411544005	1.10055E-07
220kV Mari(JHP)	132kV Jinnah Hydel Power-Mari CCT-1	7.5	Lynx	0.1576	0.411544005	1.10055E-07

Descriptions		Length (Km)	Cond	R/km	X/km	Y/km
220kV Mari(JHP)	132kV Jinnah Hydel Power-Mari CCT-2	7.5	Lynx	0.1576	0.411544005	1.10055E-07
132kV Daudkhel	132kV Daudkhel-Wanbhachran CCT-1	58	Lynx	0.1576	0.411544005	1.10055E-07

132kV Daudkhel	132kV Daudkhel-Mianwali	41	Lynx	0.1576	0.411544005	1.10055E-07
132kV Mianwali	132kV Mianwali-Wanbhachran	32	Lynx	0.1576	0.411544005	1.10055E-07
132kV Daudkhel	132kV Daudkhel-Maple Leaf Cement Factory	4.2	Lynx	0.1576	0.411544005	1.10055E-07
132kV Daudkhel	66kV Daudkhel-Kalabagh-Makarwal CCT-1	42	Dog	0.2733	0.352796699	9.37211E-08
Daudkhel	66kV Daudkhel-Kalabagh-Trug CCT-2	34	Dog	0.2733	0.352796699	9.37211E-08
132kV Daudkhel	66kV Daudkhel-Mianwali	43	Wolf	0.1841	0.46	1.10055E-07
220kV Gatti	220kV Ludewala (New)	110	Double Rail	0.0311	0.2852	1.02783E-07
220kV Chashma Nuclear	220kV Ludewala (New)	145	Double Rail	0.0311	0.2852	1.02783E-07

LOAD DATA

For load, the following cases are considered:

(i) Peak load conditions

(ii) Off peak load (load is considered 60% of the peak).

All loads are considered to be fixed PQ load and 0.8 lagging power factor. The load detail (maximum) is also shown in the following table with usual units.

Type	Buses	Bus No	Active Load	Reactive Load	Shunt Capacitor	Shunt Capactior Rated MVAR	Nominal Voltage (kV)
PV	Chashma Hydel	1	13.91	10.43	0	0	132
Load	Wan Bhachran	2	17.04	12.8	0	0	132
Load	Chashma Left Bank	3	4.3	3	0	0	132
Load	Qaidabad	4	18.2	13.9	0	0	132
Load	Jauharabad	5	24	16	15	15	132
Load	Shahpur	6	17.16	12.3	6.62	6.62	132
Load	Ludewala(New)	7	11.36	8.11	0	0	132
Load	ABC Grout	8	34.78	25.5	20	20	132
	CJ HPP	9	0	0	0	0	132
Load	Piplan	10	24.47	19.71	10.8	10.8	132
Load	T Off Chasma N	11	0	0	0	0	132
Load	Chashma N	12	0	0	0	0	132
Load	T Paic	13	0	0	0	0	132
Load	T Off Poineer CF	14	0	0	0	0	132
Load	Poineer CF	15	24	17.4	0	0	132
Load	Zaman CF	16	28.98	20.87	0	0	132

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Load	Sardarpur-N-Bhalwal-Kuth	17	67.85	49.883	40	40	132
Load	Ludewala	18	16.11	13.9	6	6	132
Load	Kirana Hill	19	24.11	17.39	0	0	132
Load	Head Faqirian	20	11.59	9.27	8	8	132
Load	66 Ludewala	21	11.59	9.27	0	0	66
Load	66 Head Faqirian	22	11.59	9.27	8	8	66
Load	66 Pathan Kot	23	11.59	9.27	8	8	66
Load	66 Malakwal	24	5.5	4	0	0	66
Load	66 Bhabra	25	5.5	4	0	0	66
Load	T Off Kudlathi	26	0	0	0		132
Load	Kudlathi	27	23.2	17.4	12.58	12.58	132
Load	Bhamb	28	8.58	6.38	6	6	132
Load	Sargodha City	29	39.42	28.98	25	25	132
Load	Sargodha-2	30	23.19	17.39	0	0	132
Load	Chak 126 SB	31	25.5	18.55	0	0	132
PV	Liberty Power	32	0	0	0	0	132
Load	M3 Industrial	33	23.19	17.39	0	0	132
Load	Khadim Steel	34	23.19	17.39	0	0	132
Load	Millat Rd	35	23.19	17.39	0	0	132
Load	Nishatabad	36	500	350	0	0	132
Load	Mari Daudkel132	37	0	0	0	0	132
Load	Daudkel	38	0	0	0	0	132
Load	Mari Daudkel	39	15.7	11.1	0	0	132
Load	Mianwali	40	15.7	11.1	0	0	132

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Type	Buses	Bus No	Active Load	Reactive Load	Shunt Capacitor	Shunt Capactor Rated MVAR	Nominal Volt
Load	Maple Leaf CF	41	15.7	11.1	0	0	132
PV	ChashmaN220	42	0	0	0	0	132
Load	Ludewala(New)220	43	0	0	0	0	220
PV	Gatti220	44	0	0	0	0	132
PV	Jinnah Hydro	45	0	0	0	0	132
Load	220Mari(Daudkhel)132	46	0	0	0	0	220
Swing	220Mari(Daudkhel)220	47	0	0	0	0	220

TOTAL LOADS

Total PQ load of the area is 1120.19MW + j810.443MVAR. The PV buses have to be so adjusted that they provide the required load as well as losses of the network. The PV buses data is tabulated below

Bus Name	Bus No	Bus Voltage	Voltage (pu)	Power Input (MW)
Chashma Hydel	1	132	1.04	186
CJ HPP	9	132	1.03	25
Liberty Power	32	132	1.05	180
ChashmaN220	42	132	1.04	250
Gatti220	44	132	1.04	300
Jinnah Hydro	45	132	1.04	96
Total				1037

It is seen that these sources supply 1037MW, while the rest of the power input is supplied by the seventh source, which is taken swing bus. The swing bus is selected 220kV side of Mari (Daudkhel) grid station and designated as 220 Mari (Daudkhel) 220, and is set at 1.04pu voltage.

NEPRA GRID CODES FOR THE LOAD FLOW

NEPRA grid code requires the planning principles for a proposed interconnection as follows.

Sr. No	Description	Value
1	Voltage	0.95 to 1.05 of the rated
2	Voltage (N-1 Contingency)	0.9 to 1.1 of the rated
3	Frequency	50Hz continuous, 0.99 to 1.01 variation in steady state, 49.2 to 50.5 Short time
4	Power factor	0.8 lagging, 0.9 leading
5	132kV Equipment short circuit rating	44kA
6	Fault duration for Dynamic Transient stability normal clearance	100ms
7	Fault duration for Dynamic Transient stability delayed clearance	180ms

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1. LOAD FLOW STUDY

The analysis is carried out by ETAP software. For the load flow, system has been examined under different scenarios. Also, N-1 contingency criterion is checked for various cases. The cases considered are:

1.1 CJHPP NOT IN THE NETWORK

1.11 No contingency (All circuits intact)

1.12 132kV Jauharabad-Qaidabad circuit out

1.13 132kV Jauharabad-Shahpur circuit out

1.2 CJHPP CONNECTED WITH 132kV ABC GIROT-JAURABAD G/s IN&OUT (Alternative-1)

1.2.1 With CJHPP all circuits intact

1.2.2 CJHPP Jauharabad circuit out

1.2.3 CJHPP-ABC Girot circuit out

1.2.4 Jauharabad-Qaidabad circuit out

1.2.5 Jauharabad-Shahpur circuit out

1.3 CJHPP CONNECTED DIRECTLY TO 132kV JAUHARABAD G/s (Alternative-2)

1.3.1 With CJHPP all circuits intact

1.3.2 CJHPP Jauharabad circuit out

1.3.3 Jauharabad-Qaidabad circuit out

1.3.4 Jauharabad-Shahpur circuit out

CONCLUSION OF LOAD FLOW STUDY

The load flow study shows that there is a obvious improvement in the voltage levels at the adjacent 132kV grid stations. Without CJHPP, the voltage at 132kV Jauharabad and Girot grid stations are found 127.3kV and 125.8kV respectively while CJHPP (Alternative-1) the voltages raise to the levels of 131.6kV and 133.1kV respectively at these grid stations. The local load requirement at these grid stations is also catered by the new CJHPP. The improvement of voltage level at other grid stations is also noted. Similar improvement occurs in case of alternative proposal as well. The detailed load flow study cases have been given in the Appendices 1 to 6.

2. SHORT CIRCUIT STUDY

Short circuit study is carried out to find the fault levels before and after the interconnection of the 25MW CJHPP to the system. The fault levels at the adjacent substations are studied, for both cases, during three phase balanced fault and single phase to ground fault condition. The pre-fault voltage at all buses is set at 1.1 pu, and the source impedance of all the sources is considered as maximum i.e., at about 52kA (20,000 MVA short circuit level). The results of the short circuit study are tabulated below. The detailed results are however shown in the short circuit study reports in the Appendices 7, CASE-1, CASE-2 and CASE-3.

Sr. No	Grid station	3-Ph Fault Level Without CJHPP (kA)	1-Ph Fault Level Without CJHPP (kA)
1	132kV Jauharabad	8.562	4.466
2	132kV ABC Girot	4.062	1.874
3	132kV Shahpur	16.103	9.481
4	132kV Qaidabad	10.359	6.081
5	220kV Ludewala New (132kV Bus)	24.602	14.984
6	132kV Wanbhuchran	20.256	13.289

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Sr. No	Grid Station	3-Ph Fault Level With CJHPP (kA)	1- Phase Fault Level With CJHPP (kA)
1	132kV Jauharabad	9.186	5.866
2	132kV ABC Girot	5.692	4.13
3	132kV Shahpur	16.269	9.891
4	132kV Qaidabad	10.489	6.404
W	220kV Ludewala New (132kV Bus)	24.744	15.344
6	132kV Wanbhuchran	20.345	13.51
7	132kV CJHPP	5.507	4.45

Sr. No	Grid Station	3-Ph Fault Level With CJHPP (Alternate Proposal) (kA)	1-Phase Fault Level With CJHPP (Alternate Proposal) (kA)
1	132kV Jauharabad	9.36	5.913
2	132kV ABC Girot	5.525	3.028
3	132kV Shahpur	16.313	9.902
4	132kV Qaidabad	10.524	6.413
5	220kV Ludewala New (132kV Bus)	24.784	15.355
6	132kV Wanbhuchran	20.368	13.517
7	132kV CJHPP	4.687	4.073

CONCLUSION OF SHORT CIRCUIT STUDY

The results of the short circuit analysis demonstrate that the short circuit levels are well within the ratings of the switchgear, in all cases. However there is slight increase in the fault levels due to the addition of CJHPP which again do not endanger the system.

3. GENERATOR TRANSIENT STABILITY STUDY

Mechanical input to a generator is controlled by its governor according to the change of electrical load on the generator. However, in case of an abrupt change in the electrical load on a generator the input mechanical power is not adjusted quickly enough to cater the change in electrical load even by the most efficient governor response. This results in a shift of generator power angle to a new value. This new value is the steady state new value as per new load demand, but before reaching this new value, the generator shaft oscillates around this final steady state due to inertia. These oscillations can be large enough that the generator loses its synchronism. Due to this, the stability of the generator has to be checked against the worst electrical disturbance.

The worst disturbance for the generator is a three phase fault, right on the 132kV busbar. If this fault persists long, without being cleared by the protection relays and switchgear, the ultimate result is the loss of synchronism of the generator, which eventually may cause the severe damage to the generator as well as surrounding power system. The generator stability is checked with respect to the normal fault clearing time of the relays and the switchgear opening time.

The normal fault clearing time which consists of relay operation time plus the circuit breaker opening time is about 70ms for the modern relaying system and breakers. However NEPRA has set the criteria for stability check to take 100ms as the normal fault clearing time.

If the circuit breaker fails, then the delayed fault clearance occurs through breaker failure protection. The fault clearing time for the breaker failure has been fixed 180ms, following the occurrence of the fault.

Alternative No.1, CJHPP is connected to Jauharabad – Girot grid stations with line IN & OUT arrangement, has been studied for the generator stability. Though, Alternative-2 proposal has not been studied to the document length yet similar results are envisaged for Alternative-1

The generator stability is studied under the following cases:

3.1 GENERATOR MODELLING FOR TRANSIENT STABILITY

The generator parameters used in transient stability study have been taken from typical generator data available in ETAP software. Since per unit system is used, the values do not depend on the MW ratings of the machines, and the values of the actual machines lie in close vicinity of the values given in the typical data. For the stability study, Transient Impedance Model is used. The values are given in the following table with usual units.

Sr. No	Description	Symbol	Value
1	Generator Positive Sequence Sub Transient Reactance	Xd"	19%
2	Generator Positive Sequence Sub Transient Resistance	Ra	1%
3	Generator Negative Sequence Sub Transient Reactance	X2	18%
4	Generator Negative Sequence Sub Transient Resistance	R2	1%
5	Generator Direct Axis Transient Reactance	Xd'	28%
6	Generator Quadrature Axis Transient Reactance	Xq'	65%
7	Sub transient direct axis damping factor	Tdo"	0.035s
8	Sub transient quadrature axis damping factor	Tqo"	0.035s
9	Transient direct axis damping factor	Tdo'	6.5

10	Transient quadrature axis damping factor	Tqo'	1.25
11	Machine Inertia	H	2.5
12	No of Poles for Hydel generator	P	40
13	No of Poles for Thermal generator	P	4
14	Rotor Type		Wound
15	Governor		Without
16	Excitation		Fixed

3.1.1 CJHPP – JAUHARABAD LINE CIRCUIT BREAKER CLEARS THE FAULT AFTER 100ms

This case has been studied for many parameters, CJHPP generator speed, power angle, Excitation Voltage, Active Power, Reactive Power, Mechanical Power Input, and Excitation Voltage. Same quantities have been studied for the hydel and thermal power plants in the network, which are Jinnah Hydel PP, Chashma Hydel PP and Liberty PP. The results of the transient stability analysis of this case have been presented in the Appendix. 8.

3.1.2 CJHPP – GIROT LINE CB CLEARS THE FAULT AFTER 100mses

The transient stability analyses is repeated for a fault on the CJHPP-GIROT line, immediately after the circuit breaker and the fault is cleared in 100 msec. The results of analysis of this case are presented in Appendix 9.

3.1.3 CJHPP – JAUHARABAD LINE CIRCUIT BREAKER CLEARS THE FAULT AFTER 180ms

To study the stability in case of delayed fault clearance, the fault duration is set 180 ms. The results of the stability analysis are presented in the Appendix 10.

3.1.4 CJHPP – GIROT LINE CB CLEARS THE FAULT AFTER 180mses

To study the stability in case of delayed fault clearance, the fault duration is set 180 ms. The results of the stability analysis are presented in the Appendix 11.

CONCUSION OF TRANSIENT STABILITY ANALYSIS

All four cases of stability analysis show that the CJHPP generator maintains its stability after some initial oscillations of various parameters, which damp quickly to attain the same, or a new steady state value. The generators at Chashma Hydel, Jinnah Hydro, and Liberty Power Plants show some minor oscillation in speed. They attain the same active power and voltage levels after undergoing damped oscillations of these quantities, and settle down to the original values because these generators are set to operate in PQ mode. However new values of reactive power are attained after a period of damped oscillations.

Report No. PPI-7.1-Draft/08

PPI

INTERCONNECTION STUDY

for

44 MW Hydro Power Project At Chashma-Jehlum Link (Tail)

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Executive Summary

The study objective, approach and methodology have been described and data made available from PEPCO and ICS is validated.

Two circuits are required to connect a power plant with the network to satisfy the N-1 criteria of the Grid Code approved by NEPRA.

The load flow analysis has been carried out for on peak and off peak considering the targeted discharge flow of the CJ Link canal, for the dispersal of Load from CJ Hydro plant into FESCO grid at 132 KV level using the latest load forecast, generation and transmission expansion plans of NTDC and FESCO. The mentioned interconnection schemes has been evolved by performing the load flow studies testing the steady state performance for normal as well as contingency conditions fulfilling the Grid Code criteria of Hydropower plants. The grid facilities of FESCO are found adequate to absorb output power of CJ Hydropower plant at 44MW generation. Therefore, the grid facilities at FESCO are also adequate to handle 25MW generation from CJ Hydro plant.

The following two Alternatives of interconnection of Chashma-Jehlum HPP to evacuate its maximum power of 44 MW are envisaged and studied in detail:

1. Loop one circuit of Jauhrabad - ABCGirot 132 kV D/C OHL at CJ-HPP substation. It involves construction of double circuit of about 8 km length.
2. Install a direct double circuit of 132 kV from CJ-HPP to existing Jauhrabad 132 kV substation. It involves construction of about 36 km long double circuit plus addition of two line bays of 132 kV in the existing Jauhrabad substation.

Detailed load flow studies have been carried out for the peak load conditions of high water season of the year 2012 for both Alternatives under normal and N-1 contingency conditions to meet the Grid Code criteria.

Steady state analysis by load flow reveal that both the Alternatives I and II are adequate to evacuate the maximum power of 44 MW of the plant under normal and N-1 contingency conditions in terms of power carrying capacity (thermal rating) of the proposed and existing lines.

The sensitivity of off-peak conditions (60% of peak load) conditions have been studied for the Alternatives I and II, and we find that both fulfill the criteria of normal and contingency conditions.

The short circuit analysis has also been carried out for Alternatives I and II. The maximum fault levels calculated for three-phase and single phase fault conditions have been found within the ratings of the equipment of the substations of 132 kV located within the electrical vicinity of Chashma-Jehlum HPP.

The maximum short circuit level of 132 kV bus bar of CJ HPP substation comes out to be around 4 kA. Therefore the rating of switchgear for this substation may be an industry standard of either 25 kA or 31.5 kA. It is however preferred to go for 31.5 kA rating to accommodate future expansions of generation and transmission.

Different disturbances have been simulated to apply stress from the system faults on the CJ Link Hydro plant and vice versa and it was founded that plant dynamics characteristics and the grid connectivity is strong enough to maintain stability under all disturbances at 44MW. Hence, the plants characteristics and grid connectivity will also be sufficient to handle 25MW production instead of 44MW.

The configuration of 132 kV substation of Chashma-Jehlum HPP is proposed to have two single bus bars of 132 kV with a sectionalizer. Two line bays of 132 kV, one in each bus sections to connect the double circuit overhead line of 132 kV proposed in either of the Alternative-I and II.

The dynamic stability analysis of both the Alternatives of interconnection has been carried out. The stability check for the worst case of three phase fault right on the 132 kV bus bar of CJ-HPP substation followed by the final trip of one of the two 132 kV circuits emanating from this substation, has been performed for normal fault clearing of 5 cycles (100 ms) and for delayed clearance of 9 cycles (180 ms) due to breaker failure (stuck breaker) to fulfill Grid Code criteria. The system is found strong enough to stay stable and recovered with fast damping for normal and delayed clearing of fault. Both Alternatives successfully passed this dynamic stability check.

Both the Alternatives I and II have been proved technically feasible through load flow, short circuit and dynamic stability analyses. However the bill of quantities in Alternative – I is less than that in the Alternative-II. Therefore Alternative – I is obviously more economical.

Alternative – I is recommended to be adopted if there is no other concern or problem in looping in-out of one circuit from the existing direct double circuit line from Jauhrabad for dedicated supply to Army Base Camp Girot.

It is concluded that the study established that under the operating conditions discussed the proposed interconnection scheme of 44MW of CJ Link HPP would be enough to evacuate the power of the Hydro plant without any issue of state (Load Flow) or short circuit or dynamic performance (stability) or power quality issues related to this plant even when operated at 25MW.

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1. Introduction

1.1 Background

The site of Chashma-Jehlum Hydropower Project is located on the power channel to be constructed at the tail end of the Chashma-Jehlum Link Canal joining with river Jehlum about 6 kM south of small town of Girot located 30 kM south of Khushab/Jauhrabad. The location of Chashma-Jehlum HPP is shown in the Google map attached in Appendix-1. The alternative routes of power channel are shown in the sketches of Proposal-1 and Proposal-2 in Appendix-1. However the net output expected to be generated from the site remains around 44 MW of electrical power during high water season for either of the Proposals. The project is expected to start commercial operation by the year 2012. The electricity generated from this project would be supplied to the grid system of PEPCO through 132 kV grid of FESCO available in the vicinity of this project. To evacuate the power from this project, there could be different alternatives of interconnection at 132 kV level. The best technically feasible alternatives would be determined by the Study.

1.2 Objectives

The overall objective of the Study is to evolve an interconnection between Chashma-Jehlum Hydropower Project and PEPCO/FESCO network, for stable and reliable evacuation of 25 MW of electrical power generated from this plant, fulfilling reliability criteria of NEPRA Grid Code that requires two circuits to connect a power plant to fulfill N-1 reliability criteria. The specific objectives are:

1. To develop alternatives of interconnections at 132 kV for which right of way (ROW) and space at the terminal substations would be available.
2. To determine the performance of each alternative during steady state conditions of system, normal and N-1 contingency, through load-flow analysis satisfying the criteria of NEPRA Grid Code.
3. To check if the contribution of fault current from this new plant increases the fault levels at the adjoining substations at 132 kV voltage

levels 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 Chashma-Jehlum HPP.

4. To check if the interconnection withstands dynamic stability criteria of post fault recovery with good damping satisfying the NEPRA Grid Code.

1.3 Planning Criteria

The planning criteria required to be fulfilled by the proposed interconnection as enunciated in NEPRA Grid Code 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

Short Circuit:

132 kV Substation Equipment Rating 44kA

Dynamic/Transient:

The system should revert back to normal after dying out of transients without loosing synchronism with good damping

1. 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).

In case of failure of primary protection (stuck breaker case), the total fault clearing time from the instant of initiation of fault current to the complete interruption of current to isolate the faulted element, including the primary protection plus the backup protection to operate and isolate the fault, is equal to 180 ms (9 cycles).

2. Assumptions of Data

The data made available so far, to conduct the Study is attached in Appendix-2. There are two Options (I and II) having four Alternatives each for the sizes of generating units under different discharge conditions. The final selection of the sizes has not been made thus far. However for the purposes of this study, following assumptions have been made:

2.1 For Load Flow

Lump sum maximum generating capacity	= 44 MW
Power factor	= 0.8 lagging, 0.9 leading
Reactive power limits	= + 30 / - 19 MVAR

2.2 For Short Circuit Analysis

a) Generator

Lump sum MVA capacity	= 50 MVA (at PF = 0.8)
Sub transient reactance, X_d''	= 0.2 PU (+ve, -ve and 0 sequence)

b) Step-up Transformer

Lump sum MVA capacity	= 50 MVA
Impedance	= 0.12 PU (+ve, -ve and 0 sequence)

2.3 For Dynamic Stability Analysis

The sizing of each individual machine is important to be assumed for dynamic stability analysis. As an average and more likely size we have assumed three machines each of 14 MW sixe (Option-I, Alt-II), with following parameters as shown in the Tables in Appendix-2:

At full discharge	= 14 MW (3-units generating at 11kV, 0.8 pf)
Inertia Constant H	= 2.5 (MWs/MVA)
Speed	= 125 R.P.M
Synchronous reactance, X_d	= 0.12 PU

Transient reactance, $X_{d'}$	= 0.41 PU
Sub transient reactance, $X_{d''}$	= 0.2 PU
Open Circuit Transient Time Costant T'_{d0}	= 3.8 Sec
Open Circuit Sub-Transient Time Costant T'_{d0}	= 0.35 Sec

It is decided in the study established that under the assumptions of operating conditions discussed if the proposed interconnection scheme of 44MW of CJ Link HPP would be enough to evacuate the power of the Hydro plant without any Load Flow or short circuit or stability or power quality issues related to this plant it would be adequate to operate at 25MW as well.

2.4 Network data:

The 132 kV network available for interconnection to Chashma-Jehlum HPP is as follows, as shown in Sketch-1 in Appendix-4:

- 132 kV double circuit radial line from Jauhrabad to Army Base Camp Girot (ABCGirot)
- 132kV double circuit line between Ludewala and Wan-Bhuchran being looped in-out either of the circuits at Shahpur, Jauhrabad, T-Pioneer and Quaidabad.
- 132 KV single circuit radial from Ludewala to Bhamb via T-Kudlathi.
- The network data of PEPCO/FESCO have been assumed in the study as already available with PPI, and permitted to be used for this study by NTDC vide their letter No. GMPP/CEMP/TRP-300/4732 dated 26 August 2008, annexed with load projections, generation and transmission expansion plans for the year 2012.
- The normal continuous thermal rating of single conductor Lynx for 132 kV overhead lines is 112 MVA as per data provided by NTDC.

3- Study Approach and Methodology

3.1 Description of the Problem

In Pakistan, there is big hydropower generation potential in the Northern parts of the country whereas the big load centers are located mostly in the Central part of the country. The primary grid of 500 kV runs longitudinally from Peshawar in the North to Karachi in the South, with 220kV and 132 kV tributaries all along its way.

Chashma-Jehlum Hydropower Project is going to be a small hydropower project in the Central part of the country embedded in the distribution network of the load center of FESCO. There are two more medium sized run-of-river hydel power plants embedded in the 132 kV network of FESCO; these are Chashma Hydel and Jinnah Hydel (under-construction) with generating capacities of 186 MW and 96 MW respectively. These sources of power generation embedded in local distribution network provide great relief to the source substations of 220/132 kV at Daudkhel and Ludewala and also helps 132 kV network in terms of improving line losses and voltage profile.

Another typical feature of hydropower plants is that their output varies seasonally; they produce full power during high water season whereas their output touches to the lowest ebb during the low water period. A mix of thermal power located mainly in the Central and Southern parts, offsets these differences in the generation outputs of hydel power plants. It gives rise to different patterns of power flows between North and South in different seasons. Over and above that, lies the peak load and off- peak load power flow patterns during high and low water periods respectively.
The generation source of 44 MW at Chashma-Jehlum Hydropower Project has to be integrated with the distribution grid of FESCO/PEPCO in this overall perspective. The nearest available nodes of 132 kV network are ABCGirot, Jauhrabad and Kudlathi- Bhamb respectively that may be the choices to interconnect this generation. The adequacy of this system would be investigated in this study for absorbing and transmitting this power fulfilling the Grid Code criteria.

3.2 Approach to the problem

The consultant has applied the following approaches to the problem:

- A base case network model has be prepared for the year 2012, the commissioning year of Chashma-Jehlum HPP, comprising all 500kV, 220kV and 132 kV system, envisaging the load forecast, the generation additions and transmission expansions for that year particularly in the FESCO.
- Interconnection alternatives without any physical constraints, like right of way or availability of space in the terminal substations, have been identified.
- Performed technical system studies for peak and off-peak load conditions to confirm technical feasibility of the interconnections. Each alternative has been subjected to standard analysis like load flow and short circuit, whereas transient stability study would be performed to check the strength of the machines and the proposed interconnection alternatives under disturbed conditions.
- Determine the relevant equipment for the proposed technically feasible alternatives.
- Recommend the technically most feasible alternative/s of interconnection.

4. Development of Alternatives of Interconnection

4.1 The Existing and ongoing Network

The existing network available around Chashma-Jehlum HPP, as shown in Sketche-1 in Appendix-4 comprises of:

1. A double circuit of 132 kV from Jauhrabad to Army Base Camp Girot (ABCGirot)
2. A single circuit of 132 kV from Jauhrabad to Shahpur to Ludewala.
3. A single circuit of 132 kV from Jauhrabad to Quaidabad to Wan Bhuchran.
4. A parallel circuit of 132 kV on same towers as mentioned in 2 and 3 above, from Ludewala to Wan Bhuchran providing a T-Off connection to Pioneer on its way.
5. A 132 kV radial circuit from Ludewala to Bhamb providing a T-Off connection to Kudlathi on its way.

Keeping in view of the 132 kV network available in the vicinity of the site of the Chashma-Jehlum HPP, the interconnection alternatives have been developed.

4.2 Alternative-I

Loop single circuit of Jauhrabad-ABCGirot 132 kV of double circuit OHL

The nearest and quick option for interconnection may seem to be the looping in-out at Chashma-Jehlum HPP, of one of the two circuits of Jauhrabad - ABCGirot 132 kV as shown in Sketche-2 in Appendix-4. This would require

- Construction of about 8 km long double circuit overhead line of 132 kV from Chashma-Jehlum HPP switchyard to a looping point outside of ABCGirot substation on Jauhrabad - ABCGirot circuit.
- The proposed substation of 132 kV at Chashma-Jehlum HPP shall require adding two line bays to connect to a double circuit of 132 kV.

We may not face capacity constraint of the 132 kV circuits between Jauhrabad and ABCGirot because these circuits are built using Lynx conductor having the load carrying capacity of 112 MVA per circuit. The capacity constraints will be checked in the load flow analysis.

4.3 Alternative-II

Double Circuit of 132 kV from CJ-HPP to Jauhrabad

If there are concerns to loop and use the dedicated double circuit of ABCGirot – Jauhrabad providing direct power supply to Army Base Camp, then we have the next choice of connecting CJ-HPP directly to Jauhrabad through a double circuit of 132 kV as shown in Sketche-3 in Appendix-4.

This alternative would involve construction of:

- A double circuit of 132 kV of 36 kM length, from CJ-HPP to the existing Jauhrabad132 kV substation.
- The proposed substation of 132 kV at Chashma-Jehlum HPP shall require adding two line bays to connect to a double circuit of 132 kV.
- The exiting substation of 132 kV at Jauhrabad shall require adding two line bays to connect to a double circuit of 132 kV.

This would apparently be an expensive alternative and requiring to add extra capacity of transmission than required for the evacuation of 44 MW i.e. two circuits each with power carrying capacity of 112 MVA using Lynx conductor as per existing PEPCO practice. We cannot connect through just a single circuit because it would not fulfill the N-1 contingency criteria of reliability laid down in the Grid Code.

A third alternative could be connecting CJ-HPP to Kudlathi – Bhamb 132 kV single circuit. But it would not be worth studying as it would not be fulfilling the Grid Code's reliability criteria of N-1contingency.

4.4 CJ-HPP 132 kV Substation

There may most likely be the options of three or four hydro turbines to be constructed. We have proposed substation configuration for each of these options as follows;

4.4.1 For Option of Three Hydro Turbines

Single line diagram SLD-1 in Appendix-4 shows the main equipment of substation of 132 kV at CJ-HPP switchyard. It consists of;

- Tow bus bars of 132 kV with a sectionalizer

- Two breaker bays, one in each bus section, to connect two circuits of 132 kV that may be connected under the schemes of Alternative -I or II discussed above.
- Three breaker bays to connect the generating units, step-up transformers, two in one bus section and one in the other bus section.

The protection and relaying scheme may be designed accordingly.

4.4.2 For Option of Four Hydro Turbines

Single line diagram SLD-2 in Appendix-4 shows the main equipment of substation of 132 kV at CJ-HPP switchyard. It consists of;

- Tow bus bars of 132 kV with a sectionalizer.
- Two breaker bays, one in each bus section, to connect two circuits of 132 kV that may be connected under the schemes of Alternative -I or II discussed above.
- Four breaker bays to connect the generating units, step-up transformers, two in each bus section.

The protection and relaying scheme may be designed accordingly.

5. Detailed Load Flow Studies for High Water Peak

5.1 Base Case 2012, Without Chashma-Jehlum HPP

A base case has been developed for the peak load of high water season of the year 2012 using the network data supplied/authorized by the PEPCO. The peak loads of high water season of the year 2012 for FESCO have been modeled as per their forecast as 2900 MW. The results of load flow for this base case are plotted in Exhibit # 5.0 of Appendix-5. The network represented in this case comprises of entire 132 kV system from Ludewala up to Chashma-Hydel PP showing all the vital 132 kV bus bars of Shahpur, Jauhrabad, Quaidabad, Wan-Bhuchran, Pioneer and Zaman CFs and the vital radial double circuit from Jauhrabad to ABCGirot.

A 220/132 kV substation, Chiniot-Industrial, is included in the NTDC plans and is scheduled to be in service by the year 2012. Therefore it has been included in the network model for this study, though not shown plotted in the Exhibit, as it would have impact on power flows on 132 kV circuits emanating from Ludewala. It will be fed through looping of double circuit Ludewala-Gatti 220 kV.

The load flow results show that the power flows on circuits are within their normal rating and the bus voltages are also within the normal operating range of ± 5 % off the nominal.

N-1 outage contingencies have also been carried out to ascertain if the system has any constraints without its connection with CJ-HPP.

The following contingency cases are attached in Appendix – 5.

Exhibit 5.1	Jauhrabad – Shahpur 132 kV single circuit out
Exhibit 5.2	Jauhrabad – Quaidabad132 kV single circuit out
Exhibit 5.3	Jauhrabad – ABCGirot132 kV single circuit out

The results in these Exhibits show that the power flowing on the intact circuits of the system are well within their rated capacity; the bus bar voltages are within the acceptable operating limits.

We find that there are no capacity constraints in the 132 kV network available in the vicinity of CJ – HPP for its connectivity.

5.2 Alternative-I of Interconnection

Chashma-Jehlum HPP, with its full output of 44 MW in high water season has been modeled and added in the base case of peak load high water season of the year 2012 for the detailed load flow studies.

In Alternative-I, it is assumed to be synchronized with the system by looping in - out of one circuit of Jauhraabad – ABCGirot 132 kV double circuit. The power flow simulation results are shown in Exhibit 5.4, Appendix-5.

All the circuits of 132 kV including the circuits connecting ABCGirot to Jauhrabad show that they are loaded well within the rated capacity of 112 MVA of these circuits. The bus bar voltages are also indicated to be within the normal operating limits.

To fulfill N-1 criteria of reliability, we conducted the contingency analysis and attached the plotted results as follows in Appendix – 5;

Exhibit 5.5	CJ-HPP– Jauhrabad 132 kV single circuit out
Exhibit 5.6	CJ-HPP– ABCGirot132 kV single circuit out
Exhibit 5.7	Jauhrabad – Shahpur 132 kV single circuit out
Exhibit 5.8	Jauhrabad – Quaidabad132 kV single circuit out

The results in these Exhibits show that the power flowing on the intact circuits of the system are well within their rated capacity; the bus bar voltages are within the acceptable operating limits.

That means the full output of 44 MW can be easily evacuated from Chashma-Jehlum HPP without any capacity constraints or operational constraints by adapting to Alternative – I involving laying only a double circuit of 132 kV circuit of about 8 kM from the plant site.

5.3 Alternative-II of Interconnection

In this alternative we have laid a direct double circuit of 132 kV, 36 kM long, from CJ-HPP substation to the existing Jauhrabad 132 kV substation.

The results of load flow of the normal case have been shown plotted in Exhibit 5.9 in Appendix-5. We find that all the circuits of 132 kV including the newly proposed 132 kV circuits are well within their rated power carrying capacities. Also the voltage profile of 132 kV bus bars is within normal limits.

N-1 contingency analysis has been carried out and the plotted results are attached in Appendix – 5 as follows;

Exhibit 5.10 CJ-HPP– Jauhrabad 132 kV single circuit out

Exhibit 5.11 Jauhrabad – Shahpur 132 kV single circuit out

Exhibit 5.12 Jauhrabad – Quaidabad132 kV single circuit out

The results in these Exhibits show that the power flowing on the intact circuits of the system are well within their rated capacity; the bus bar voltages are within the acceptable operating limits.

This alternative though expensive, yet provides an independent network to evacuate the full capacity of 44 MW from CJ-HPP to Jauhrabad directly without involving to interfere with the independent supply of direct double circuit dedicated to supply to Army base Camp at Girot.

Technically, both alternatives are feasible so far as steady state performance has been checked by the above load flow analysis under normal and contingency conditions during peak load conditions of high water season.

6.3 H.W. Off Peak cases for Alternative -II

The 60 % off-peak case for Alternative-II for normal network conditions i.e. no outage has been indicated in Exhibit 6.6 of Appendix-6. Again we find, by comparing with the Exhibit 5.9 of Appendix-5 for same alternative for peak conditions, that the power flows on the 132 kV lines is higher in off-peak period, although within the normal rated limits of these circuits.

The one-line out (N-1) contingency cases are shown plotted in Exhibits 6.7, 6.8 and 6-9 for the following 132 kV circuits respectively:

Exhibit 6.7	CJ-HPP– Jauhrabad 132 kV single circuit out
Exhibit 6.8	Jauhrabad – Shahpur 132 kV single circuit out
Exhibit 6.9	Jauhrabad – Quaidabad132 kV single circuit out

The results in these Exhibits show that the power flowing on the intact circuits of the system are well within their rated capacity; the bus bar voltages are also within the acceptable operating limits.

The power flow results of off-peak cases for normal and contingency cases are found fulfilling all the criteria of planning and operation for both Alternatives – I and II.

6.4 Conclusion of Load Flow Analysis

From the analysis discussed in chapters 5 and 6, we conclude that both alternatives I and II are technically feasible. However the scope of work required in Alternative - I is less than what is involved in Alternative - II. Therefore obviously Alternative -I would be cheaper than alternative-II

7. Short Circuit Analysis

7.1 Methodology and Assumptions

The methodology of IEC 60909 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 60909:

- 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 2012 i.e. all the generating units have been assumed on-bar in fault calculation's simulations.

The assumptions about the generator and the step-up unit transformer are the same as mentioned in 2.2 of Ch.2 of this report.

7.2 Fault Current Calculations Without CJ - HPP

In order to assess the short circuit strength of the network of 132 kV without CJ - HPP for the grid of FESCO 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 without CJ - HPP and later on how much the contribution of fault current from CJ - HPP may add to the existing levels, but also we get a feel of the probable nodes to connect this Power Plant depending on their relative short circuit strength.

The results are attached in Appendix – 7.

The short circuit levels have been represented graphically on the bus bars of 132 kV along with fault current contributions from the incoming circuits, which are shown in the Exhibits attached in Appendix-7 as follows:

Exhibit 7.0.1 Maximum 3-Phase fault currents

Exhibit 7.0.2 Maximum 1-Phase fault currents

The fault currents in the Exhibits 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 whereas the contribution to the fault current from the adjoining sources is shown on the lines and transformers connected to that bus.

The tabular output of the short circuit calculations is also attached in Appendix-7 for the 132 kV bus bars of our interest i.e. the substations connecting in the 132 kV circuits lying between Ludewala and Chashma-Hydel. The total maximum fault currents for 3-phase and 1-phase short circuit at these substations are summarized in Table 7.1. We see that the maximum fault currents do not exceed the short circuit ratings of the equipment at these 132 kV substations which normally are 25 kA or 31.5 kA for older substations and 44 kA for new substations.

Table-7.1
Maximum Short Circuit Levels without CJ - HPP

Substation	3-Phase fault current, kA	1-Phase fault current, kA
Ludewala-N	15.81	12.15
Shahpur	5.62	3.67
Jauhrabad	4.79	3.13
ABCGirot	3.44	2.22
Quaidabad	7.61	5.49
Wan-Bhuchran	10.72	8.75
Liaqatabad	8.18	6.71
Chashma - Hydel	10.1	10.15

7.3 Fault Current Calculations for Alternative - I

Fault currents have been calculated for the electrical interconnection of Alternative-I. Fault types applied are three phase and single-phase at 132 kV bus bar of Chashma-Jehlum HPP itself and other bus bars of the 132 kV substations in the electrical vicinity of Chashma-Jehlum. The graphic results of are indicated as follows;

Exhibit 7.1 Maximum Three-Phase fault levels

Exhibit 7.2 Maximum Single-Phase fault levels

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

between Ludewala and Chashma-Hydel are placed in Appendix-7. Brief summary of fault currents at significant bus bars of our interest are tabulated in Table 7.2

Table-7.2
Maximum Short Circuit Levels for Alternative - I

Substation	3-Phase fault current, kA	1-Phase fault current, kA
Ludewala-N	16.1	17.39
Shahpur	5.99	4.41
Jauhrabad	5.51	4.54
ABCGirot	3.91	3.42
Chashma-Jehlum - HPP	3.97	3.76
Quaidabad	7.89	6.64
Wan-Bhuchran	10.97	9.68
Liaqatabad	8.29	7.36
Chashma - Hydel	10.24	10.64

Comparison of Tables 7.1 and 7.2 show the increase in short circuit levels for three-phase and single – phase faults due to connection of Chashma-Jehlum HPP on the 132 kV bus bars in its vicinity. We find that even after some increase, these fault levels are still very much below the rated short circuit values of the equipment installed on these substations. The short circuit level of the CJ – HPP 132 kV is quite low i.e. nearly 4 kA.

7.4 Fault Current Calculations for Alternative -I I

For the interconnection Alternative – II, the fault currents have been calculated same way as we did for Alternative – I. Fault types applied are three phase and single phase faults at 132 kV bus bar of Chashma-Jehlum HPP itself and other bus bars of the 132 kV substations in the electrical vicinity of Chashma-Jehlum. The graphic results of are indicated as follows;

Exhibit 7.3 Maximum Three-Phase fault levels

Exhibit 7.4 Maximum Single-Phase fault levels

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 between Ludewala and Chashma-Hydel are also placed in Appendix-7. Brief

summary of fault currents at significant bus bars of our interest are tabulated in Table 7.3

Table-7.3
Maximum Short Circuit Levels for Alternative - II

Substation	3-Phase fault current, kA	1-Phase fault current, kA
Ludewala	16.09	17.4
Shahpur	5.99	4.42
Jauhrabad	5.51	4.55
ABCGirot	3.8	2.86
Chashma-Jehlum - HPP	4.03	3.8
Quaidabad	7.89	6.64
Wan-Bhuchran	10.97	9.68
Liaqatabad	8.29	7.36
Chashma - Hydel	10.24	10.64

Comparison of Tables 7.2 and 7.3 shows that the fault levels for Alternative – I and II are not much different. We find that in both the Alternatives of interconnection, the fault levels are much below the rated short circuit values of the equipment installed on the substations in the vicinity of CJ - HPP. The short circuit level of the CJ – HPP 132 kV remains quite low i.e. nearly 4 kA.

7.5 Conclusion of Short Circuit Analysis

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

The fault levels on the 132 kV bus bar of the substation of CJ-HPP are nearly around 4 kA. Therefore an industry-standard equipment of 25 kA or 31.5 kA would be fine to be installed at this substation. Preferably we would recommend installing the equipment of 31.5 kA rating in view of future additions and reinforcements in this area.

8. Dynamic Stability Analysis for Alternative - I

8.1 Assumptions & Methodology

8.1.1 Dynamic Models

The assumptions about the generator and its parameters are the same as mentioned in 2.3 of 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

8.1.2 System Conditions

We have used the system conditions of September 2012, which represent the high water i.e. high hydel and low thermal dispatch conditions. Most of the hydel generators in FESCO such as Chashma-Hydel and Jinnah-Hydel would be running at their full output.

All the power plants of WAPDA /NTDC from Tarbela to Hub have been dynamically represented in the simulation model.

8.1.3 Presentation of Results

The plotted results of the simulations run for the connectivity alternative – I are placed in Appendix-8. 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 the pre fault/disturbance conditions of the network under study were smooth and steady. Post fault recovery has been monitored for nine seconds. Usually all the transients due to non-linearity die out within 2-3 seconds after disturbance is cleared in the system.

8.1.4 Worst Fault Cases

Three phase faults are considered as the worst disturbance in the system. We have considered 3-phase fault in the closest vicinity of CJ -HPP i.e. right at the 132 kV bus bar of CJ – HPP substation, cleared in 5 cycles, as normal clearing time i.e. 100 ms, followed by permanent trip of 132 kV single circuit emanating from this substation.

Grid Code also mentions the extreme case of breaker failure (stuck breaker) to be considered for testing the stability of the system. The fault clearing time for this case would be 9 cycles i.e. 180 ms.

We have studied both; normal fault clearing and delayed clearing under breaker-failure (stuck breaker) case.

8.2 Dynamic Stability Simulations for Normal Fault Clearing

We applied three-phase fault on CJ-HPP 132 kV bus bar, cleared fault in 5 cycles (100 ms) followed by trip of 132 kV circuit between CJ-HPP and Jauhrabad. We monitored different quantities for one second pre-fault and nine cycles after clearance of fault (post-fault) conditions and plotted the results attached in Appendix – 8 and discussed as follows;

Fig. 8.1 Rotor Angles

The rotor angles of the generators of CJ – HPP, Chashma-Hydel, Jinnah-Hydel, Chahma-Nuclear, Nishatabad-SPS and Nishatabd-GTPS are plotted relative to machines at Mangla 132 kV. The results show that the rotor angle of CJ-HPP gets back after the first swing and damps down quickly. Similarly the rotor angles of other machines swing 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.

Fig. 8.2 Bus Voltages

The bus voltages of 132 kV bus bars of the substations of CJ-HPP, Jauhrabad, ABCGirot, Quaidabad, Ludewala and Wan-Bhuchran are plotted. The results show quick recovery of the voltages after clearing of fault.

Fig. 8.3 Frequency

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

Fig. 8.4 Speed of Generator at CJ-HPP

The speed deviation after clearing fault damps down quickly returning to normal speed as of before fault.

Fig. 8.5 MW Output of Generator of CJ-HPP

The pre-fault output of the generator was 13.5 MW and it gets back to the same output quickly after fast damping of the oscillations in its output.

Fig. 8.6 Field Voltage of the Generator of CJ-HPP

The EFD of the generator shoots up during fault duration and then gets back fast exponentially to the same level as of pre-fault value.

Fig. 8.7 MW Flow on CJ-HPP to ABCGirot 132 kV circuit

Followed by clearing of fault, the trip of the CJ-HPP to Jauhrabad 132 kV circuit caused the entire output of 44 MW to flow through the other circuit i.e. going to ABC-Girot. We see that the power flow on this circuit rises to 44 MW with power swings damping down fast settling to 44 MW level.

Fig. 8.8 MW Flow on 132 kV Circuits emanating from Jauhhrabad

The power swings settle quickly to almost the same levels as of pre-fault values.

8.3 Dynamic Stability Simulations for Delayed Fault Clearing

We applied three-phase fault on CJ-HPP 132 kV bus bar, cleared fault in 9 cycles (180 ms) followed by trip of 132 kV circuit between CJ-HPP and Jauhrabad. We monitored same quantities for one second pre-fault and nine cycles after clearance of fault (post-fault) conditions and plotted the results attached in Appendix – 8 and discussed as follows;

Fig. 8.9 Rotor Angles

The rotor angles of the generators of CJ – HPP, Chashma-Hydel, Jinnah-Hydel, Chahma-Nuclear, Nishatabad-SPS and Nishatabd-GTPS are plotted relative to machines at Mangla 132 kV. The results show that the rotor angle swings of CJ-HPP are a bit higher than normal clearing time yet it gets back after the first swing and damps down quickly. Similarly the rotor angles of other machines swing 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.

Fig. 8.10 Bus Voltages

The bus voltages of 132 kV bus bars of the substations of CJ-HPP, Jauhrabad, ABCGirot, Quaidabad, Ludewala and Wan-Bhuchran are plotted. The results show quick recovery of the voltages after clearing of fault.

Fig. 8.11 Frequency

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

Fig. 8.12 Speed of Generator at CJ-HPP

The speed deviation after clearing fault damps down quickly returning to normal speed as of before fault.

Fig. 8.13 MW Output of Generator of CJ-HPP

The pre-fault output of the generator was 13.5 MW and it gets back to the same output quickly after fast damping of the oscillations in its output.

Fig. 8.14 Field Voltage of the Generator of CJ-HPP

The EFD of the generator shoots up during fault duration and then gets back fast exponentially to the same level as of pre-fault value.

Fig. 8.15 MW Flow on CJ-HPP to ABCGirot 132 kV circuit

Followed by clearing of fault, the trip of the CJ-HPP to Jauhrabad 132 kV circuit caused the entire output of 44 MW to flow through the other circuit i.e. going to ABC-Girot. We see that the power flow on this circuit rises to 44 MW with power swings damping down fast settling to 44 MW level.

Fig. 8.16 MW Flow on 132 kV Circuits emanating from Jauhhrabad

The power swings settles quickly to almost the same levels as of pre-fault values.

The results of dynamic stability show that the system is very strong and stable for not only the normal fault clearing of 5 cycles (100ms) but for the delayed clearing of 9 cycles (180 ms) of breaker failure (stuck breaker) as well.

9. Dynamic Stability Analysis for Alternative - II

The dynamic stability analysis has been carried out for the interconnection Alternative –II with same assumptions and methodology as of Alternative – I discussed earlier.

9.1 Dynamic Stability Simulations for Normal Fault Clearing

We applied three-phase fault on CJ-HPP 132 kV bus bar, cleared fault in 5 cycles (100 ms) followed by trip of 132 kV circuit between CJ-HPP and Jauhrabad. We monitored different quantities for one second pre-fault and nine cycles after clearance of fault (post-fault) conditions and plotted the results attached in Appendix – 9 and discussed as follows;

Fig. 9.1 Rotor Angles

The rotor angles of the generators of CJ – HPP, Chashma-Hydel, Jinnah-Hydel, Chahma-Nuclear, Nishatabad-SPS and Nishatabd-GTPS are plotted relative to machines at Mangla 132 kV. The results show that the rotor angle swing of CJ-HPP gets back after the first swing and damps down quickly. Similarly the rotor angles of other machines swing 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.

Fig. 9.2 Bus Voltages

The bus voltages of 132 kV bus bars of the substations of CJ-HPP, Jauhrabad, ABCGirot, Quaidabad, Ludewala and Wan-Bhuchran are plotted. The results show quick recovery of the voltages after clearing of fault.

Fig. 9.3 Frequency

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

Fig. 9.4 Speed of Generator at CJ-HPP

The speed deviation after clearing fault damps down quickly returning to normal speed as of before fault.

Fig. 9.5 MW Output of Generator of CJ-HPP

The pre-fault output of the generator was 13.5 MW and it gets back to the same output quickly after fast damping of the oscillations in its output.

Fig. 9.6 Field Voltage of the Generator of CJ-HPP

The EFD of the generator shoots up during fault duration and then gets back fast exponentially to the same level as of pre-fault value.

Fig. 9.7 MW Flow on CJ-HPP to Jauhrabad 132 kV circuit

Followed by clearing of fault, the trip of the CJ-HPP to Jauhrabad 132 kV circuit caused the entire output of 44 MW to flow through the other circuit parallel circuit for Jauhrabad. We see that the power flow on this circuit rises to 44 MW with power swings damping down fast settling to 44 MW level.

Fig. 9.8 MW Flow on 132 kV Circuits emanating from Jauhhrabad

The power swings settle quickly to almost the same levels as of pre-fault values.

9.2 Dynamic Stability Simulations for Delayed Fault Clearing

We applied three-phase fault on CJ-HPP 132 kV bus bar, cleared fault in 9 cycles (180 ms) followed by trip of 132 kV circuit between CJ-HPP and Jauhrabad. We monitored same quantities for one second pre-fault and nine cycles after clearance of fault (post-fault) conditions and plotted the results attached in Appendix – 9 and discussed as follows;

Fig. 9.9 Rotor Angles

The rotor angles of the generators of CJ – HPP, Chashma-Hydel, Jinnah-Hydel, Chahma-Nuclear, Nishatabad-SPS and Nishatabd-GTPS are plotted relative to machines at Mangla 132 kV. The results show that the rotor angle swings of CJ-HPP are a bit higher than normal clearing time yet it gets back after the first swing and damps down quickly. Similarly the rotor angles of other machines swing 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.

Fig. 9.10 Bus Voltages

The bus voltages of 132 kV bus bars of the substations of CJ-HPP, Jauhrabad, ABCGirot, Quaidabad, Ludewala and Wan-Bhuchran are plotted. The results show quick recovery of the voltages after clearing of fault.

Fig. 9.11 Frequency

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

Fig. 9.12 Speed of Generator at CJ-HPP

The speed deviation after clearing fault damps down quickly returning to normal speed as of before fault.

Fig. 9.13 MW Output of Generator of CJ-HPP

The pre-fault output of the generator was 13.5 MW and it gets back to the same output quickly after fast damping of the oscillations in its output.

Fig. 9.14 Field Voltage of the Generator of CJ-HPP

The EFD of the generator shoots up during fault duration and then gets back fast exponentially to the same level as of pre-fault value.

Fig. 9.15 MW Flow on CJ-HPP to ABCGirot 132 kV circuit

Followed by clearing of fault, the trip of the CJ-HPP to Jauhrabad 132 kV circuit caused the entire output of 44 MW to flow through the other circuit parallel circuit for Jauhrabad. We see that the power flow on this circuit rises to 44 MW with power swings damping down fast settling to 44 MW level.

Fig. 9.16 MW Flow on 132 kV Circuits emanating from Jauhhrabad

The power swings settles quickly to almost the same levels as of pre-fault values.

9.3 Conclusion of Dynamic Stability Analysis

The results of dynamic stability show that the system is very strong and stable for both Alternatives I and II for not only the normal fault clearing of 5 cycles (100ms) but for the delayed clearing of 9 cycles (180 ms) of breaker failure (stuck breaker) as well. Therefore there is no problem of dynamic stability for any interconnection Alternative of CJ – HPP; it fulfils all the Grid Code criteria of dynamic stability.

10. Conclusions

The study objective, approach and methodology have been described and data made available from PEPCO and ICS is validated.

Two circuits are required to connect a power plant with the network to satisfy the N-1 criteria of the Grid Code approved by NEPRA.

The following two Alternatives of interconnection of Chashma-Jehlum HPP to evacuate its maximum power of 44 MW are envisaged and studied in detail:

I. Loop one circuit of Jauhrabad - ABCGirot 132 kV D/C OHL at CJ-HPP substation. It involves construction of double circuit of about 8 km length.

II. Install a direct double circuit of 132 kV from CJ-HPP to existing Jauhrabad 132 kV substation. It involves construction of about 36 km long double circuit plus addition of two line bays of 132 kV in the existing Jauhrabad substation.

Detailed load flow studies have been carried out for the peak load conditions of high water season of the year 2012 for both Alternatives under normal and N-1 contingency conditions to meet the Grid Code criteria.

Steady state analysis by load flow reveal that both the Alternatives I and II are adequate to evacuate the maximum power of 44 MW of the plant under normal and N-1 contingency conditions in terms of power carrying capacity (thermal rating) of the proposed and existing lines.

The sensitivity of off-peak conditions (60% of peak load) conditions have been studied for the Alternatives I and II, and we find that both fulfill the criteria of normal and contingency conditions.

The short circuit analysis has also been carried out for Alternatives I and II. The maximum fault levels calculated for three-phase and single phase fault conditions have been found within the ratings of the equipment of the substations of 132 kV located within the electrical vicinity of Chashma-Jehlum HPP.

The maximum short circuit level of 132 kV bus bar of CJ HPP substation comes out to be around 4 kA. Therefore the rating of switchgear for this substation may be an industry standard of either 25 kA or 31.5 kA. It is however preferred to go for 31.5 kA rating to accommodate future expansions of generation and transmission.

The configuration of 132 kV substation of Chashma-Jehlum HPP is proposed to have two single bus bars of 132 kV with a sectionalizer. Two line bays of 132 kV, one in each bus sections to connect the double circuit overhead line of 132 kV proposed in either of the Alternative-I and II.

The dynamic stability analysis of both the Alternatives of interconnection has been carried out. The stability check for the worst case of three phase fault right on the 132 kV bus bar of CJ-HPP substation followed by the final trip of one of the two 132 kV circuits emanating from this substation, has been performed for normal fault clearing of 5 cycles (100 ms) and for delayed clearance of 9 cycles (180 ms) due to breaker failure (stuck breaker) to fulfill Grid Code criteria. The system is found strong enough to stay stable and recovered with fast damping for normal and delayed clearing of fault. Both Alternatives successfully passed this dynamic stability check.

Both the Alternatives I and II have been proved technically feasible through load flow, short circuit and dynamic stability analyses. However the bill of quantities in Alternative – I is less than that in the Alternative-II. Therefore Alternative – I is bviously more economical.

Alternative – I is recommended to be adopted if there is no other concern or problem in looping in-out of one circuit from the existing direct double circuit line from Jauhrabad for dedicated supply to Army Base Camp Girot.

The load flow analysis has been carried out for targeted discharge flow of the CJ Link canal, for the dispersal of Load from CJ Hydro plant into FESCO grid at 132 KV level using load forecast, generation and transmission expansion plans of NTDC and FESCO. Different disturbances have been simulated to apply stress from the system faults on the CJ Link Hydro plant and vice versa and it was founded that plant dynamics characteristics and the grid connectivity is strong enough to maintain stability under all disturbances at 44MW. Hence, the plants characteristics and grid connectivity will also be sufficient to handle 25MW production instead of 44MW. It is concluded that the study established that under the operating conditions discussed the proposed interconnection scheme of 44MW of CJ Link HPP would be enough to evacuate the power of the Hydro plant without any major issues related to this plant even when operated at 25MW.

Volume – V
Environmental and Social Impact Assessment Report

25 MW HYDROPOWER PROJECT AT C-J LINK (TAIL)

FEASIBILITY REPORT

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25 MW HYDROPOWER PROJECT AT C-J LINK (TAIL)

ENVIRONMENTAL & SOCIAL IMPACT ASSESSMENT REPORT

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UNITS AND CONVERSION FACTORS

Length

1 inch	=	25.4 millimeters				
1 meter	=	3.281 ft				
1 mile	=	1609 meters	=	1760 yards	=	5280 ft

Area

1 sq. m	=	10.76 sq. ft	=	1.196 sq. yd		
1 hectares	=	2.47 Acres	=	10,000 sq. m		
1 sq. km	=	100 hectares				

Volume

1 US wet gallon	=	0.833 imperial gallon	=	3.785 liters
1 US dry gallon	=	0.967 imperial gallon	=	4.404 liters
1 cu. meters	=	35.28 cu. ft		

LIST OF ABBREVIATION

ACOP	Alluvial Channels Observation Program
Authority	Water and Power Development Authority
BOQ	Bill of Quantities
BC	Before Construction
CEnv	Contractor Environmentalist
Cfs	Cubic feet per second
CHASHNUPP-2	Chashma Nuclear Power Project 2
C-J Link	Chashma Jhelum Link
Cm	Centimeter
Cms	Cubic meter per second
CSR	Composite Schedule of Rates
CSCEnv	Construction Supervision Consultants Environmentalist
CTs, PTs	Compaction Tests, Penetration Tests
DC	During Construction
DISCO	Distribution Company
DSO	Dams Safety Organization
EA	Environment Assessment
EC	Electric Conductivity
E&M	Electrical and Mechanical
EHV	Extra High Voltage
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EL	Elevation
EPA	Environmental Protection Authority
EPD	Environmental Protection Department
ESIA	Environmental & Social Impact Assessment
Fig.	Figure
FIRR	Financial Internal Rate of Return
GIS	Geographical Investigation System
GoP	Government of Pakistan / Punjab
GTZ	German Technical Assistance
GWH	Giga Watts Hour
HV	High Voltage
IEE	Institute of Environmental Engineering
IRSA	Indus River System Authority

KESC.	Karachi Electric Supply Corporation
Km	Kilometer
kV	Kilo Volts
m	metre
MAF	Million Acre feet
masl	Mean average sea level
mm	Millimeter
MW	Mega Watts
NEQS,	National Environmental Quality Standards
NESPAK	National Engineering Services of Pakistan
NOC	No Objection Certificate
NTDC	National Transmission & Distribution Company
NWFP	Northern Western Federal Province
PAEC	Pakistan Associated Engineering Consultants
PID	Punjab Irrigation Department
PMO	Project Monitoring Office
PMOEnv	Project Monitoring Office Environmentalist
PPDB	Punjab Power Development Board
PSD	Particle Size Distribution
RAP	Resettlement Action Plan
RSC	Residual Sodium Carbonate
SAP	Social Action Plan
SAR	Sodium Absorption Ratio
SCADA	Supervisory Control and Data Acquisition
SFA	Social Framework Aggrement
SMO	Scarp Monitoring Organization
SPOT	Satellite Pour l'Observation de la Terre
	(Image of Earth Observation based in Toulouse, France)
SPTs	Standard Penetration Tests
STP	Standard Penetration Test
TOR	Terms of Reference
WAPDA	Water and Power Development Authority
WHO	World Health Organization

SUMMARY

Today the major problem of Pakistan is to meet the energy requirement of the country. The country's economy as well as the people living standard is suffering badly from the shortage of the energy. Keeping in view, the past trend and the future developments, WAPDA, in collaboration with energy wing, Planning & Development Division, Government of Pakistan made long term demand projections. The load forecast for the year 2011-12 is 22970MW. Whereas the total demand for the year 2007 is 15,838MW and generating capability of WAPDA (including Thermal, Hydel and IPPs) is 13,292MW respectively (WAPDA Annual Report 2006-07). In Pakistan, electricity is produced with four common ways i.e hydel, thermal, IPPs and Atomic Plant. Out of these, hydropower is the most environmental friendly and economical method of producing electricity.

To identify the potential sites for the development of hydropower projects, WAPDA along with German Agency for Technical Cooperation (GTZ) identified falls in the Indus Plain and ranked them in order of priority. Chashma-Jhelum (CJ) Link Tail site was ranked first amongst the recommended schemes on canals. A natural rated head of about 18m is available at the tail end of the CJ Link.

CJ Link Canal off takes from left bank of the Indus River at Chashma Barrage and out fall into Jhelum River. The approximate length of the canal is 108km which passes through the Thal Doab. The canal was constructed in 1971 under the program of Link canals system, after Indus Water Treaty, to divert water from western rivers to eastern rivers of Pakistan. It is an earthen canal. Khushab Atomic Plant raised the issue of severe waterlogging due to the seepage of water from the canal during early days of its operation. The crest level at the tail end regulator was trimmed down to 3ft to achieve the 6ft drop in maximum water level of the canal in 1981. This reduces the seepage of water and overcome the waterlogging problem to some extend. However, it is crucial to maintain the maximum water level in the canal during construction and operation phase of the power plant to avoid the return of the waterlogging problem.

The Powerhouse is proposed to be constructed at the right bank of the tail end of CJ Link Canal having the designed capacity to produce maximum 25MW. The Project includes constructing all the necessary items associated with the construction of powerhouse i.e. power channel, turbines, grid station, escape channel, siltation pond etc. A new road bridge,

relocation of a length of Khushab-Muzaffargarh road and a public park are also included in the scope of work.

Part of the site falls within the wildlife game reserve area which can be classified as environmentally sensitive area, under section 12 of Pakistan Environmental Protection Act 1997, it is therefore mandatory to prepare EIA and get NOC from EPA before the contractor mobilize at the site for the work.

The site is situated in the upper part of Indus basin in Thal Doab. The soil of Thal desert is predominately of alluvial nature with sandy texture and is generally free of salinity and alkalinity but some are deficient in nitrogen and humus contents. The land included in the project area is classified as 'Barani land' and only cultivates with rain water.

Groundwater can be found as shallow as 3m from ground level at certain places on site. Hand pumps and tube wells are the two most common sources of water within the area of influence (AOI) of the Project. Groundwater can be used as a source of water supply to the contractor's camp and batching plant. However, it is the contractor's responsibility to confirm the suitability and availability of the water to the site worker at an appropriate level. Surface water can be used for spraying on earth to minimize the dust pollution.

The climate of the area is arid characterized by long hot summer and short mild winter. It was found that ambient air is reasonably clean at present. The maximum temperature recorded during summer is about 48C^{o} and minimum reach to 0° in winter. The data indicates that the maximum average rain fall recorded in the area is 121.4mm in July and minimum average rain fall of 5.08mm in October. Normal wind velocity varies from 1 to 10 km per hour; however in the case of windstorm the velocity can be as high as 50 km per hour. The wind direction varies over the seasons of the year as follow:

- Wind from south and southwest during the summer months in the central and western parts of the area.
- Winds from the east and southeast during the summer months in the eastern and north-eastern parts of the area and;
- Winds from the north, northeast and northwest during the winter months over the major part of the area.

The biological environment of the site is typical Thal environment. The common trees and shrubs are the Van (Salvadora Abeoides), Karir (Capparis Aphylla), Jand (Prosopis Spicigera), Malla (Zizyphus Nummularia), Sarkanda (*Saccharum Munja)* together with growth in the uncultivated lands. Different types of grass species were found along the canal's banks and within the riverian track. Tahli (Dalbergia Sisso) and Kiker (acacia nilotica) are the common trees found along the canal and adjacent land of Jhelum river.

Canal and River water provide friendly habitate to hundreds of migrating birds including some rare species of duck and geese. Under the RAMSER Convention it is the responsibility of Pakistan Government to protect these rare species of birds. Other local game birds found in Thal environment include Gray Partridge (Tetar) and Hubra Bustard (Talor). Terrrestrial fauna including wolves, jackals, wild cats, foxes, badgers, wild bores, neel gai (blue bull), deer and the wild hill goats (Urial) are found in deep in thal forest. Occasional sighting of endangered species of Baz, Chankara (deer) have also been reported in the Project Area.

The main settlements near the project area is village Sharegareh, consist on approximately 50 houses. The neareast city is Khushab about 40km from the project site. The average house hold size in district Khushab is 6.2. The dominate brathery of village Sharegarh is Joya caste. Majority of the local population involve in farming activities other common occupation include milk processing, running grocery shop, daily wage work, transportation and working at Khushab Atomic Plant. The common type of crop cultivate in the project area is gram with a yield capacity of approximately 300 kg/acre. Hand pump is the common source of drinking water in the project area. Electricty supply is available on site.

There is sufficient WAPDA land available at site for setting up labour camp and batching plant and no private land is required for these activities. However part of the proposed power channel and relocated Khushab-Muzaffargareh road fall within private land. Approximate area of private land requires acquiring in this project is 121500m^2 (approximately 30acres). About 9000m^2 of cultivated WAPDA's land is identified within the power channel. Three houses (two use for living and one as medical dispensary) and a tube well are also interfering in the proposed power channel location, build in WAPDA's land. The private land owner and residents of the affected properties will be compensated and Social Framework Agreement (SFA) signed by concern parties. Majority of the local community involve in seasonal agricultural activities.

In net project will emplace significant positive social impacts in the area. Employment opportunity and training will be provided to a large number of unemployed youth. They will

receive life time benefit through skill training, capacity building and poverty alleviation. A large number of semi-skilled and unskilled workers in the Project area will be hired during construction. Greater awareness about Healthcare including HIV/AIDS and Hepatitis amongst the labour folk and the local community shall be created. At micro level, economic activities may reduce the cost of living down by making essential commodities available in greater bulks and at cheaper rates.

The potential environmental impacts of the Project have been analyzed and the mitigation measures and residual impacts are discussed in chapter 6 of the EIA Report. The nature and scope of the construction works and the environmental setting of the Project are such that there is no significant adverse environmental impact. No permanent adverse impact is anticipated in respect of sensitive habitat, wild life or cultural heritage. The Project does warrant acquisition of small area of private land and a resettlement of two families and a medical dispensary. But on the other side it is expected to produce 25MW power which can play vital role in the development of local and national economy. A public park will be developed at the right side of the canal under this Project which will provide a picnic spot to the local community and improve the aesthetic level of the area.

It is envisaged that about 56No. of trees will be required to cut for the construction of power channel. It is purposed to grow two plants at site for every one tree cut by the contractor and protect these plants until they are matured.

The Environmental Management Plan (EMP) has been developed in chapter 8 of the Report. This needs to be implemented and monitored at all the stages of the Project by the competent staff.

As no significant environmental or social issue is likely to be involved during construction and operational phase of the Project it could be safely concluded that the CJ Link Tail Hydropower Project is feasible for construction.

خلاصہ

آج پاکستان کی بڑی مشکلات میں سے ایک بڑی مشکل توانائی میں کمی کو پورا کرنا ہے۔توانائی میں کمی کی وجہ سے ملک کی معاشی حالت اور لوگوں کا معیار زندگی بُری طرح سے متاثر ہو رہی ہے۔واپڈا نے ماضی اور مستقبل کے ترقیاتی کاموں اور محکمہ پلاننگ اور ترقیاتی کی پیش گوئی کو مدنظر رکھتے ہوئے مستقبل کی توانائی کی ضرورت پیش گوئی کے مطابق 12-2011 تک ملک کی ضرورت 22970MW ہوگی۔جبکہ 2007 میں ملک کی ضرورت 15838 MW اور پیداوار 13292 MW تھی۔پاکستان میں بجلی تین طریقوں سے پیدا کی جاتی ہے ان میں پانی سے، ایندھن سے اور اٹامک انرجی سے ان میں سے پانی سے بجلی پیدا کرنا ماحولیات اور قیمت کے لحاظ سے سب سے بہتر ہے۔

واپڈا نے جرمن ادارا GTZ کے ساتھ مل کر وادی سندھ اور اس کے متعلقہ نہری نظام پر پانی سے بجلی پیدا کرنے کی ممکنہ جگہوں کا پتہ لگایا۔ان جگہوں میں چشمہ جہلم رابط نہر کی جگہ سب سے زیادہ مفید تھی۔تقریباً 18 میٹر کا قدرتی ھیڈ چشمہ، جہلم رابطہ نہر کے آخر پر میسر ہے۔

چشمہ جہلم رابط نہر دریائے سندھ پر چشمہ بیراج سے دریا کے بائیں کنارے سے نکلتی ہے۔اور دریائے جہلم میں گرتی ہے نہر کی لمبائی تقریباً 108 کلومیٹر ہے جو تھل دوآب میں سے گزرتی ہے۔نہر 1971 میں سندھ طاس معاہدے کے بعد رابط نہر سسٹم کے تحت تعمیر کی گئی۔رابط نہر تعمیر کرنے کا مقصد پانی مغربی دریاوں (چناب، جہلم، سندھ) سے مشرقی دریاؤں (راوی، ستلج، بیاس) کی طرف موڑنا ہے۔چشمہ جہلم رابط نہر ایک کچی نہر ہے۔نہر بننے کے ابتدائی دنوں میں خوشاب ایٹمی پلانٹ کی طرف سے زمین میں پانی کی سطح بلند ہونے کی شکایت کی گئی۔ 1981 میں نہر کے آخر میں لگے پانی کے بہاؤ کو کنٹرول کرنے والے دروازوں کی سطح 3 فٹ کم کرنے سے نہر کے پانی کی زیادہ سے زیادہ سطح میں 6 فٹ کی کمی ہوئی جس کی وجہ سے اردگرد کے علاقوں میں زمین میں پانی کی سطح بلند

ہونے کی مشکل پر قابو پالیا گیا۔ بہرحال بجلی کا پلانٹ بناتے ہوئے اور دوران استعمال پانی کی سطح میں تبدیلی کا خاص خیال رکھا جائے۔

44MW بجلی پلانٹ کی تعمیر کیلئے نہر کے دائیں کنارے پر جگہ منتخب کی گئی ہے۔ اس پروجیکٹ میں پاور ہاؤس تعمیر کرنے کے ساتھ ساتھ خوشاب۔ مظفر گڑھ روڈ پر پل اور پبلک پارک کی تعمیر بھی شامل ہے۔

پروجیکٹ زمین کا کچھ حصہ جنگلی حیات کے لئے مخصوص جگہ میں آتا ہے جو کہ ماحولیات کے نقطہ نظر سے حساس جگہ ہے اسلئے پاکستان تحفظ ماحولیات ایکٹ سیکشن 12 کے تحت پروجیکٹ کیلئے EIA بنانے اور EPA سے اس کی منظوری لینا ضروری ہے۔ پروجیکٹ کا ایریا وادی سندھ کے اوپر والے حصہ میں آتا ہے۔

تھل صحرا کی زمین ریتلی اور سیم اور تھور سے پاک ہے۔ کھیتی باڑی کا انحصار بارش کے پانی پر ہوتا ہے۔ پروجیکٹ ایریا میں زمینی پانی کئی جگہوں پر صرف 3 میٹر گہرائی پر واقع ہے اردگرد کے رہائشی علاقوں میں لوگ ٹیوب ویل اور ہینڈ پمپ کے ذریعے زمین کا پانی استعمال کرتے ہیں۔ زمینی پانی پروجیکٹ کے سٹاف اور مزدوروں کو روزمرہ کے استعمال کیلئے سپلائی کیا جاسکتا ہے۔ بشرطیکہ پانی کا معیار پینے والے پانی کے مطابق ہو۔ دھول مٹی کی آلودگی کم کرنے کیلئے دریا اور نہر کے پانی کا چھڑکاو کیا جاسکتا ہے۔

علاقے کا موسم لمبی گرمیوں اور مختصر سردیوں پر مشتمل ہے اس وقت علاقے کی آب وہوا کافی صاف ہے۔ گرمیوں میں زیادہ سے زیادہ درجہ حرارت 48 ڈگری اور سردیوں میں کم سے کم 0 ڈگری ہوتا ہے۔

سب سے زیادہ اوسط بارش جولائی میں 121.4mm اور کم سے کم اکتوبر میں 5.08mm ریکارڈ کی گئی۔ عام طور پر ہوا 10 کلومیٹر فی گھنٹہ کی رفتار سے چلتی ہے لیکن طوفان کی صورت میں رفتار 50 کلومیٹر فی گھنٹہ تک پہنچ جاتی ہے۔ ہوا کی سمت موسم کے مطابق بدلتی رہتی ہے۔ موسم گرما میں ہوا جنوب سے شمال کی طرف جبکہ سردیوں میں

شمال سے جنوب کی طرف چلتی ہے۔ پروجیکٹ ایریا میں پائے جانے والے اہم پودوں اور درختوں میں شیشم، کیکر، سفیدا، سرکنڈا وغیرہ شامل ہیں۔

نہر اور دریا کے پانی پر سینکڑوں کی تعداد میں ہجرت کر کے آنے والے پرندوں بسیرا کرتے ہے۔ پاکستان حکومت کی یہ ذمہ داری ہے کہ ہجرت کر کے آنے والے نایاب پرندوں کی حفاظت کرے ان میں کئی قسم کی مرغابیاں اور مقامی پرندوں میں تیتر، تلور اور باز نایاب نسل ہے۔ علاقے میں پائے جانے والے جانور میں نیل گائے، چنکارا، ہرن، ارڑیال، گیدڑ، لومڑی، سور وغیرہ شامل ہیں۔

شیر گڑھ گاؤں پروجیکٹ ایریا کے قریب واقع ہے جو تقریباً 50 گھروں پر مشتمل ہے جن میں زیادہ تر جوئیہ برادری سے تعلق رکھتے ہیں۔ قریب ترین اہم شہر خوشاب ہے جو کہ نہر سے 40 کلومیٹر کے فاصلے پر واقع ہے ضلع خوشاب میں اوسطاً تعداد فی گھر 6.02 ہے۔ مقامی آبادی کے زیادہ تر لوگ آبپاشی سے منسلک ہیں ٹرانسپورٹشین، دوکانداری، مزدوری اور کچھ لوگ اینٹی پلانٹ میں کام کرتے ہیں۔ چنا علاقے کی اہم فصل ہے جس کی پیداوار تقریباً 300 کلونی ایکڑ ہے۔

پاور پلانٹ کی تعمیر کے لئے منتخب کردہ جگہ کے اردگرد گورنمنٹ (واپڈا) کی زمین موجود ہے جس کی وجہ سے مزدوروں کی کالونی، کانکریٹ، مکس پلانٹ، پلانٹ اور میٹیرل سٹور روم وغیرہ کے لئے پرائیوٹ زمین کی ضرورت نہیں پڑے گئی لیکن خوشاب۔ مظفر گڑھ روڈ کی ری لوکیشن اور پاور چینل کیلئے پرائیوٹ زمین کی ضرورت پڑے گی جو کہ تقریباً 130 ایکڑ پر مشتمل ہے۔ تقریباً 9000m2 زرعی زمین پاور چینل کی تعمیر کے لئے درکار ہوگی۔ تین گھروں کو بھی دوسری جگہ پر منتقل کرنا پڑے گا جو اِس وقت پاور چینل کی منتخب کردہ جگہ میں آئے ہیں۔ متاثر ہونے والی پراپرٹی کا ازالہ پراپرٹی کے مالک کو دیا جائے گا پراپرٹی کے مالک اور حکومت کے درمیان فریم ورک معاہدہ میں پراپرٹی کی قیمت کو طے کیا جائے گا۔ مجموعی طور پر پروجیکٹ کے علاقے میں بہت ہی مثبت سماجی اثرات مرتب ہوں گے مقامی نوجوانوں کو روزگار اور تربیت کے مواقع ملیں گے جس کا انہیں پوری زندگی کا فائدہ ہوگا صحت کی

سہولت میں بہتری آئے گی۔ آمدورفت میں اضافے کی وجہ سے لین دین اور کاروباری زندگی میں اضافہ ہوگا۔ پروجیکٹ کے ماحولیات پر اثرات کے تجزیہ سے یہ ثابت ہوا ہے کہ تعمیری کاموں کے ماحول پر مستقبل میں کوئی بُرے اثرات نہیں پڑیں گے۔ تعمیری کاموں کے بُرے اثرات کو بتائی گئی تدبیروں سے ختم کیا جا سکتا ہے۔ پروجیکٹ ماحول دوستانہ ہے اور پانی کی صاف توانائی سے بجلی پیدا کی جائے گی۔

پبلک پارک بھی اسی پروجیکٹ میں بنائے جائیں گے جو علاقے کی خوبصورتی میں اضافہ کریں گے۔ ماحولیات کے اثرات کو تعمیری کاموں کے درمیان اور بعد میں بتائی گئی تدبیروں کے ساتھ کنٹرول کیا جائے گا۔

چونکہ پروجیکٹ کا ماحول دوستانہ ہے اسلئے ماحول اور سماجی نقطہ نظر سے پروجیکٹ پر تعمیری کام شروع کیا جا سکتا ہے۔

1. INTRODUCTION

Today meeting the requirement of electricity is one of the major problems of every single country of the world. Availability and cost of electricity is the most important factor of the development of the economy of any country. Pakistan is suffering from significant shortage of electricity. The estimated computed demand of the power in Pakistan is 15,838 MW When the total maximum production from is 13,292MW (collected from WAPDA annual report 2006/2007). Keeping in view the past trend and the future developments, WAPDA, in collaboration with Energy Wings, Planning & Development Division, Government of Pakistan developed long term demand projection based on electricity approach taking into account the category wise GDP and the impact of electricity price changes. The base year used for this forecast was 2002-03. This regression based load forecast now has been revised by replacing the base year figure by the actual demand of 15138MW in the year 2006-07 and playing the same growth rates each year as applied in the GOP MTDF load forecast. These projections of load forecast show an accumulated growth of 10.25% from the year 2008 to 2012. The calculated forecast is included in Appendix 1.

To identify the suitable sites for development of hydropower projects at barrages and canals Water & Power Development Authority (WAPDA) was assisted by a German Agency for Technical Co-operation, GTZ. Ten sites were identified for hydropower project at barrages and canals falls in the Indus Plain. As a result of the ranking study, Chashma-Jhelum Link Tail Hydropower Project was ranked first amongst the schemes on canals. This report comprises an Environmental & Social Impact Assessment (ESIA) of the project.

Environment Assessment (EA) is a process whose breadth, depth and type of analysis depend on the nature, scale and potential environmental impacts of the proposed project. EA evaluates a project's potential environmental risks and impacts in its areas of influence, examines project alternatives, identifies ways of improving project selection, sitting, planning designing and implementation by preventing, minimizing, mitigating or compensating for adverse environmental impacts and enhancing positive impacts and includes the process of mitigating and managing adverse environmental impacts through out project implementation. EA takes into account the natural environment (air, water and land); human health and safety. The study has been conducted by a qualified and experienced environmental engineer certificates are included in Appendix 2.

Social Assessment (SA) has been conducted to evaluate the project's potential positive and adverse effects on the affected people and to examine project alternatives where adverse effects may be significant. The breadth, depth and type of analysis in the social assessment

are proportional to the nature of the project and scale of the proposed project's potential effects on the affected people, weather such effects are positive or adverse.

1.1 PROJECT LOCATION

The proposed project is located in district Khushab of Punjab province. The project area lies at the tail end of the Chashma-Jhelum Link Canal and located between latitudes 31° and 32° 20' North and longitudes 72° and 72° 20" East. The project has been recommended on the right side of the canal

Main city of the Pakistan Lahore and Karachi are connected with site by road at a distance 312km and 1164km respectively. The nearest railway station is Khushab which is about 40km (25miles) from the site. The nearest village to the site is Share Gareh, which is about 800m from the site.

1.2 BACKGROUND

In an attempt to reduce power shortage in the country a great emphasis is being laid on the exploitation of short-gestation low-head hydropower utilizing the existing barrages and canal fall structures build for irrigation. To identify the potential sites for the development of hydropower, Water and Power Development Authority (WAPDA) was being assisted in this filed by German Agency for Technical Cooperation GTZ, as a result of the agreements between the governments on 13th October 1984. Accordingly WAPDA along with GTZ has identified in a ranking study ten sites at barrages and canals falls in the Indus plain. Chashma-Jhelum Link Tail Hydropower Project was ranked first amongst the schemes on canals.

The Chashma-Jhelum (CJ) Link Canal was constructed during 1967 to 1971 with a discharge capacity of 615m^3/s and normal depth 4.27m. In 1981 the crest level at the tail end of the Link canal was trimmed about 3ft because of the water logging problem arose in adjacent area of the canal.

The canal is a part of the link canals system to overcome the shortage of the water happen in result of the Indus Water Treaty in 1960 in eastern rivers (Ravi, Sutlej and Beas) of the Pakistan. Later on the Water Apportionment Accord between the four provinces was signed in 1991. A Schematic diagram of Indus basin is shown in Figure 1.1.

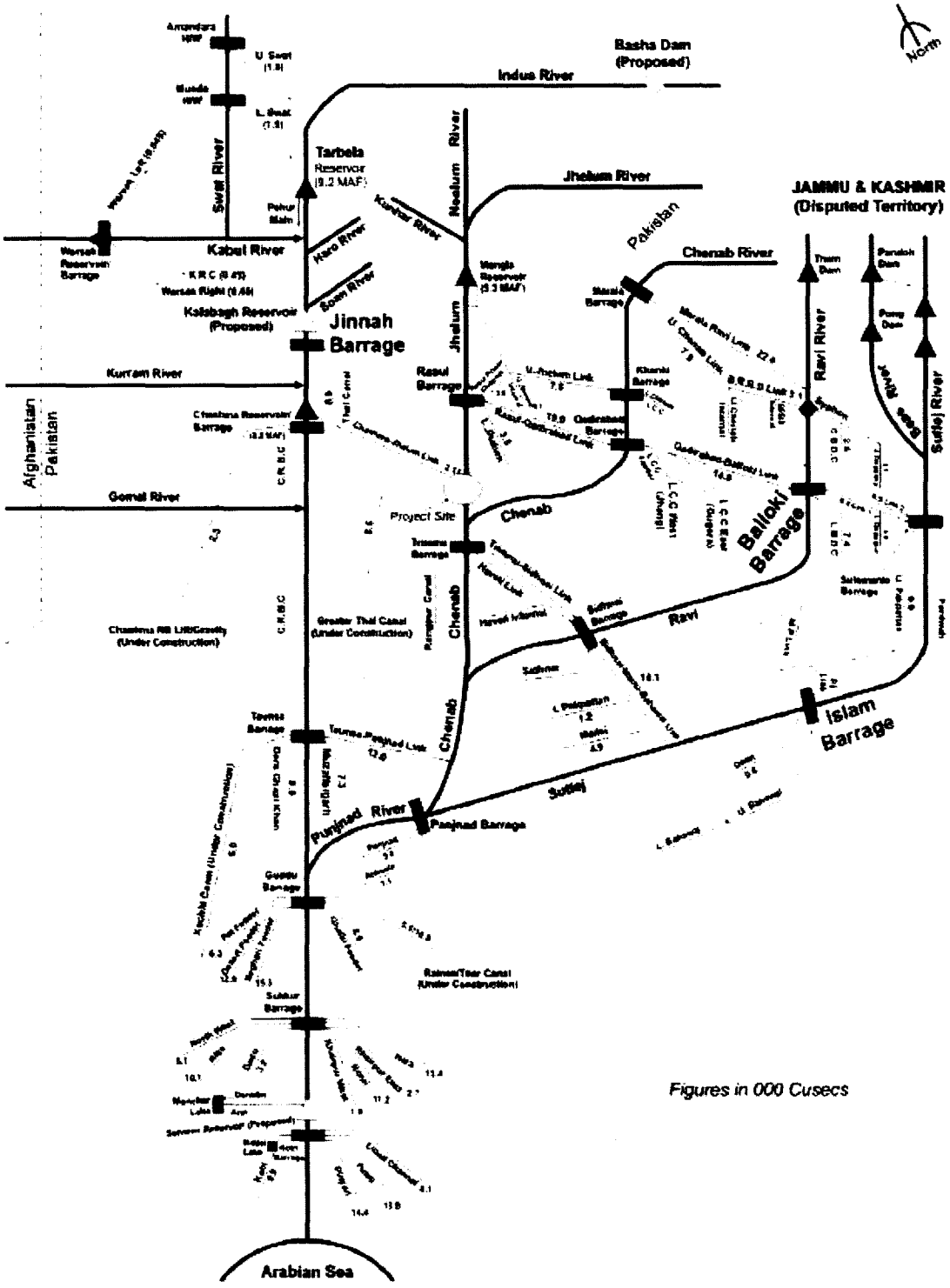


Figure 1.1: Schematic Diagram of Indus Basin Irrigation System

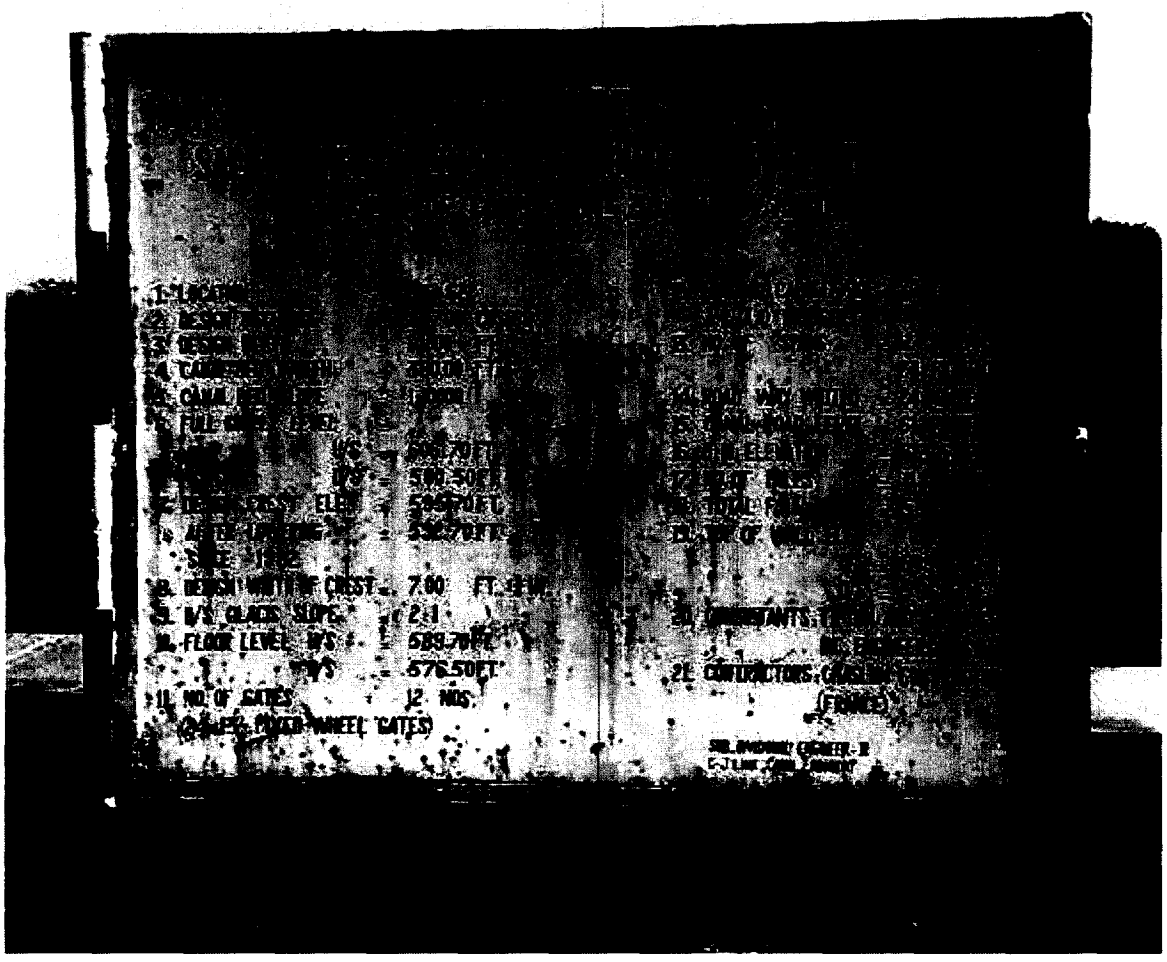


Plate 1.1: CJ Link Canal Construction & Discharge Details

CJ link canal off takes from the left bank of Indus river at the Chashma Barrage. The barrage is located along Indus River about 58 km downstream of Jinnah Barrage. The approximate length of the link canal is 108km and out fall into river Jhelum at about 97km upstream of Trimmu Barrage on river Jhelum. The canal is unlined earthen canal and the seepage losses is estimated to 26m^3/s at full discharge.

Two off takes from right side of CJ link canal are under constructions, the 240m^3/s Greater Thal Canal (GTC) off take at 58km and the 2.8m^3/s Ainu Minor off take at 90km. Both of these off takes are designed to supply irrigation channels that yet to be built. A provision of water for Greater Thal Canal during Kharif (summer) season is included in the Water Accord. It is proposed to supplement this allocation from Punjab's share in surplus flood supplies. The Punjab Government plans to provide perennial supplies to the canal by internal adjustment in water allocation of different canals within the province. The diversion of flows

to Greater Thal Canal will reduce the available flows at the tail of the C.J. Link and reduce both energy and power generation.

The Indus River System Authority (IRSA) is said to have agreed in principle to give permission to the Pakistan Atomic Energy Commission (PAEC) to use 25 cumecs of water daily to cool the Khushab Nuclear Power Plant. However, IRSA asked PAEC to install a proper system to gauge the water being released into the canal after being used for cooling.

The average natural ground surface on site is about 188.00m.a.s.l and subsoil groundwater level is about 174.25m.a.s.l near the gated structure and lowering down toward the river Jhelum. The natural ground surface in the surrounding area is about 183.00m.a.s.l which is lower than that of site. The marked difference in the ground level is due to the fact that at the time of construction of CJ Link the excavated material dumped near the site.

The low head hydroelectric potential in Pakistan has been recognized and is partly being utilized for the last three decades. Few low head power stations are already functional in the country approximately of the same head as available in this project.

This proposed project would produce 25 MW as compared to the existing projects having approximately the same head. Therefore, this project would be more productive and beneficial. This project is conceived to satisfy local or regional power requirements.

The power station of this project would contribute only a relatively small share of the total power requirements in the country, however due to relatively high reliability; the contribution in terms of the energy generated is quite significant.

1.3 OBJECTIVE OF THE REPORT

This report comprise the Environmental & Social Impacts Assessment (ESIA) of the Project, this include:

- Environmental and Social Assessment including the supporting administration.
- Baseline Data on Physical and Biological conditions of the Project.
- Assessment of Potential Environmental & Social Impacts.
- Mitigation Measure.
- Environmental Management Plan (EMP), including
  Prepare site layout plan of proposed construction site for labour camp and access road. Survey of the affected areas to determine whether any existing habitations or

livelihoods will be affected, including any encroachment on WAPDA's property. Prepare a Resettlement Action Plan/Social Action Plan in accordance with the World Bank guidelines. Strengthen the Environmental Management and Monitoring Plan, in particular detail guidance (including formats and frequencies). Ensure that the project design minimizes interruption to river and canal flows during the construction period and include measures in the EIA to mitigate any such interruption.

1.4 STRUCTURE OF THE REPORT

This report is divided into 8 following chapters.

Chapter 1 : Introduction
Chapter 2 : Legal and Administrative framework policy.
Chapter 3 : Project Description
Chapter 4 : Environmental and Social Baseline condition.
Chapter 5 : Analysis of Alternatives.
Chapter 6 : Impact Assessment, Mitigation and Enhancement Measures.
Chapter 7 : Public Consultation and Information Disclosure.
Chapter 8 : Environmental Management Plan.

1.5 APPROACHES ADOPTED FOR THE STUDY

Environmental and Social data were collected and analyzed for the overall environmental study area. Primary data was collected during site visits conducted from December 2007 to August 2008 by a competent team, led by an environmental specialist. Secondary data for the overall study area was clamed from other institutions e.g. Wildlife department, Fishery, Irrigation, SMO and land reclamation etc.

The base line data was developed and analyzed to identify the potential environmental impacts of the Project. Risk based methodology were adopted to identify the high risk activities and suggest their mitigation measures. Where possible, eliminating the risk by altering the work scope or method of execution of work was preferred rather than minimizing the risk with control measures. Public consultation was also undertaken including gender study to take into account the public point of view about the project.

1.6 REVIEW OF PREVIOUS STUDIES

The feasibility study report was prepared in 1995 by WAPDA in collaboration with GTZ for this project. The study concludes that there would be no major environmental impact on the

project area or surroundings due to construction and operation of CJ Link Tail Hydropower Project.

Historic daily flow data for a period of 12 years (1978-89) were analyzed to assess the flow availability for the feasibility study. From historic daily data, flow duration curves have been prepared on yearly basis and as a whole for the 12 years under analysis. The data from 1978-89 pertains to the period before signing of inter-provincial Water Accord of 1991 referred to as Water Accord. The report does not present analysis of the flow data of post period. However, it is mentioned that synthetic flow pattern on 10-daily basis obtained from WAPDA was analyzed to assess the post flow availability. Daily as well 10-daily flow data and water levels recorded at C-J Link tail regulator for the period 1978-89 were presented in the report. However, gauge data at head regulator was not presented.

Since CJ link canal is unlined throughout its entire length, therefore gains and losses along the canal influence the flow available at the tail regulator. This aspect had been addressed in the Inception Report dated April 2008. Daily flow data gauged at head regulator and as well as tail regulator was analyzed to determine the gains and losses by subtracting flows at tail regulator from flows at head regulator using data for the period 1985-89 (5 years). However, more data, especially the post Water-Accord flow data was required to collect and analyzed.

Sedimentation studies, as such required for the project had not been included in the feasibility study, except for some data on sediment sampling downstream of head regulator done by Alluvial Channel Observation Project (ACOP, WAPDA) during the course of studies for the period 1981-84.

In result of the review of feasibility study and as per TOR conditions the post Water-Accord flow and sedimentation data has been collected and analyzed in the Inception Report in April 2008. The data was collected from WAPDA, Punjab Irrigation Department (PID) and other organizations for the post period up to the recent years. This includes all the daily flow records gauged at head regulator, tail regulator/outfall structure.

A team of engineers visited the project site and offices at Chashma barrage to obtain the discharge and sediment data of C-J Link canal downstream of head regulator, at tail regulator outfall. The data includes discharge and gauge/elevation measurement at the following points for the period from 01-10-1987 to 29-02-2008:

- C.J Link at head regulator (RD 0+000)
- Thal Canal Aqueduct (Thal Complex) (RD 34+387)

- Dullewala Distributory Aqueduct (RD 105+722)
- Greater Thal Canal Regulator (Adhikot) (RD 180+722)
- Outfall/Tail Regulator of C.J Link (RD 315+622)

The inflows of Jhelum River down stream of Rasul Barrage and at confluence with C-J Link are being collected. The sediment concentration and particle size distribution (PSD) data will also be collected in due course of time from Dam Safety Organization (DSO), WAPDA office in Lahore.

1.7 SCOPE OF WORK

There is a desperate need of power generation projects to reduce the power shortage in the country. The proposed 25MW project was on the top the list in the ranking study carried out by the GTZ and WAPDA to identify the suitable sites for hydropower projects on existing canals & barrages. The main advantage of the work scheme is available head of about 19m, which could be utilized for power generation. WAPDA's land is available for the construction activities at the proposed site.

The main components of the project include

- Construction of new power channel
- Construction of Powerhouse
- Road bridge at the junction of power channel and Khushab Muzaffargarh road
- Alteration of the layout of Khushab Muzaffargarh road passing through the project area

The detail description of the project is included in Chapter 3.

1.8 AREA OF RESPONSIBILITIES

Under this contract National Engineering Services (Pvt) and Integrated Consulting Services (Pvt) as a joint venture will provide consultancy services including suitable personnel, plant and equipment to design the work.

HK Consortium is responsible and acting behalf of the employer for executing works of CJ Link Hydropower Project. The leading member of HK Consortium is Haseeb Khan & Company other member are Central China Power Group (CCPG) and ELBA International. This report comprises the Environmental & Social Impact Assessment of the proposed

scheme as a requirement under section 12 of Environmental Protection Act 1997. The key personnel involve in under taking this study are

Project Manager	:	Tariq Altaf / Farooq Qureshi
Principal Engineer	:	Mukhtar Ahmad
Environmental Specialist	:	Ahsan Iqbal Bela
Research Student	:	Annosha Tariq
Research Student	:	Samra Irem

2
LEGAL AND ADMINISTRATIVE FRAMEWORK POLICY

2. LEGAL AND ADMINISTRATIVE FRAMEWORK POLICY

2.1 GENERAL

This section provides an overview of the policy framework and national legislation that applies to the proposed Project. The Project is expected to comply with all national legislations besides World Bank Safeguard Policies relating to environment and social issues and to obtain all regulatory clearances required.

Government of Pakistan has framed regulations and legislation for keeping the environmental and social impacts of the project at minimal under the Pakistan Environmental Protection Act 1997 (Pak-EPA). It is mandatory to carry out detailed Environmental Impact Assessment (EIA) of the development projects depending upon the nature and magnitude of the impacts. Pak-EPA regulatory guidelines exempt a Hydropower project, from being put to EIA when

- The hydropower electric generation is less than 50MW.
- The capacity of transmission line less than 11KV and no grid station.
- The Project site is not classified as environmentally sensitive area.

The site is situated next to the Khushab Atomic Plant and part of the site comes within game reserve area, declared by Punjab Wildlife Department. Therefore this Project falls under the category of the projects requiring an EIA. This report comprises ESIA (Environmental & Social Impact Assessment) of the Project.

Appropriate engineering controls for environmentally friendly and safe systems of work will also be employed in accordance with the following relevant environmental and health & safety legislation, codes of practice and guidance notes:-

Pakistan Environmental Protection Act 1997
World Bank's Safeguard Policies
National Policy and Administration Frame Work
National Environmental Quality Standards
Provincial Department of Forests and Wildlife
Provincial Revenue Department
The Constitution of the Islamic Republic of Pakistan 1973
Pakistan Penal Code (PPC)
Canal Drainage Act 1873

The West Pakistan Fisheries Act 1961
The Punjab Wildlife (Protection, Preservation, Conservation and Management) Act 1974
The Forest Act 1927
The Antiquities Act 1975
The Public Health (Emergency Provision) Act 1954 Read with West Pakistan Epidemic Control Act 1958
Explosive Act 1884

2.2 REGULATORY REQUIREMENTS IN PAKISTAN

Under section 12 (with subsequent amendment) of 1997 Act, a Project falling under any category specified in Schedule I (S.R.O 339(1)/2000), requires proponent to file an IEE with concerned federal agency (Pak-EPA). Projects falling under any category specified in schedule II require the proponent to file an EIA with the federal agency. Within ten working days of the IEE or EIA having been deposited the federal agency will confirm that the document submitted is complete for the purpose of review. Subsequently, the federal agency shall make every effort to complete IEE review within 45 days and an EIA within 90 days of filing.

Pak-EPA regulation (SRO 339(1)/2000) states that an IEE is required for federal or provincial hydropower projects with a total generation of less than 50MW and/or transmission line less than 11KV and/or the project site is not lies in environmentally sensitive area. An EIA, on the other hand is required for all other federal or provincial hydropower projects and also for the projects are likely to cause adverse environmental affects.

The approximate total cost of this Project is around 4.5 billion rupee. The south west area of the site from Khushab – Muzaffargarh road comes under game reserve area therefore EIA is the essential document need to be prepared for this Project. All the Project activities should compliance with NEQS and establish monitoring and evaluation system, as required under Pak-EPA.

Recognizing that the Pak-EPA has delegated powers to provincial EPAs to enforce the provision of 1997 Act, an EIA must be submitted to the provincial agencies in whose jurisdiction the project falls which in this case is the Punjab Environmental Protection Agency. At the time of application, the Project proponent is also required to pay a specified fee to the concerned EPA.

2.3 WORLD BANK SAFEGUARD POLICIES AND GUIDELINES

The environmental and resettlement related polices and guidelines of the World Banks have been spelled out in the World Bank Operational Manual comprising documents relating to Operational Policies (OP) and Bank Procedures (BP). For the purpose of this report references have been made to Operational Policies. The applicable Ops are as follows:

- **Operational Policies (OP) 4.01**
  Besides defining the general policy of the World Bank about the environmental impact assessment (EIA), this document lays down the procedures and guidelines for conducting EIA of the projects including the aspects to be considered in EIA, public consultation and information disclosure procedures. It also provides environmental screening guidelines for classifying the projects into various categories (A, B, C and FI). This project can be classified as category C project as is likely to have minimal or no adverse environmental impacts.

- **Operational Policies (OP) 4.01 Annex A**
  This document provides definitions of terms that are frequently referred to in environmental assessment, as they appear in the Bank's perception and policy.

- **Operational Policies (OP) 4.01 Annex B**
  This document provides guidelines for the preparation of EIA report for Category "A" projects.

- **Operational Policies (OP) 4.01 Annex C**
  This document provides procedures and policies for the preparation of environmental management plan, including aspects like mitigation measures, monitoring requirements and institutional capacity development and training.

- **Operational Polices (OP) 4.12**
  The OP sets policies relating to involuntary resettlement of population disrupted by the project. Priority of the Bank's policy is to avoid displacement of the population; however, if it is unavoidable it should be kept to a minimal. For that matter Bank provides guidelines for considering alternative alignments of the project and making modification in the design. This document also provides guidelines for conducting census surveys, preparing resettlement action plan and reporting procedures.

- **Operational Policies (OP) 4.10**
  The document lays down the Bank's policy for the Indigenous Peoples, including natives, tribal groups and scheduled castes. As these people normally do not hold any title of land or other property, they are treated as vulnerable groups. Therefore, their issues are required to be addressed in special way.

- **Operational Policies (OP) 4.11**
  This OP deals with the Bank's policy on Cultural Properties, including sites, structures, and remains of archaeological, historical, religious, cultural, or aesthetic value.

Besides these OPs the Bank has produced three volumes of Environmental Assessment Sourcebook in 1991, which have been updated lately. The Sourcebook provides detailed discussion on Bank's policies, procedures, cross-sectoral issues, and sectoral guidelines for the preparation of EIA.

2.4 ENVIRONMENTAL INSTITUTIONS AND THEIR RESPONSIBILITIES

2.4.1 Provincial EPD

HK Consortium will be responsible for providing the complete environmental documentation required by the provincial EPD and remain committed to the approved project design. No deviation is permitted during project implementation without the prior and explicit permission of the EPD.

2.4.2 Provincial Departments of Forestry and Wildlife

The rehabilitation works are expected to involve some clearing of vegetation that exist on WAPDA's land where labour camp and batching plant are to be constructed. Constructing power channel and alteration of road layout of Khushab-Muzaffargarh road will also require removal of vegetation. The contractor will be responsible for acquiring permission from the Punjab Forest Department, even if these trees fall in the area of WAPDA before undertake any cutting.

2.4.3 Local Government and Municipalities

WPDA and its contractors must ensure that the project meets the criteria of district governments as related to the establishment of construction camps and plants, and the safe disposal of wastewater, solid waste, and toxic materials. WAPDA will coordinate and monitor environment-related issues.

2.4.4 Other Environment-Related Statutes

This section outlines statutes apart from the Pakistan Environmental Protection Act, 1997, which are relevant to the project.

- **The Forest Act, 1927 (and Provincial Acts and Rules)**

  The Act, *inter alia*, deals with the matters related with protection and conservation of natural vegetation/habitats. In that matter it empowers the concerned agency to declare protected and reserved forest areas and maintaining these. In spite of the fact that it recognizes the right of people for access to the natural resources for their household use, it prohibits unlawful cutting of trees and other vegetation. Cutting trees will require for provision of power channel and establishing labour camp and batching plant in this Project. The permission is required prior to undertake any tree cutting from the Forest Department of Punjab province.

  A survey has been conducted to cover the suggested area for Labour Camp and Batching Plant. The proposed site falls in WAPDA's land and no any tree cutting will require for establishing these facilities. However, 56 numbers of trees will be required uprooting for construction of power channel and associated structure.

- **Government of Punjab, Forestry, Wildlife, Fisheries and Tourism Department (Notification No. FOFT (EXT) VIII. 17/96 Dated 1998**

  In Punjab, should the number of trees to be felled for a project exceed 100, or if the project falls within the jurisdiction of more than one district, a committee comprising the Commissioner of the division covering the districts, the Conservator of Forests, and the Superintending Engineer of the HK Consortium must accord their approval. For this Project it is envisaged that the number of trees require to cut down is below the said limit.

- **Provincial Wildlife (Protection, Preservation, Conservation and Management) Act, Ordinances and Rules**

  In addition to empowering provincial wildlife department to establish game reserves, parks, and wildlife sanctuaries, these acts regulate the hunting and disturbance of wildlife. In this project part of the site comes within the game reserve area therefore this act will apply on the site. While reviewing the EIA, the provincial EPD may consult the provincial wildlife department in case the project has an impact on wildlife. The EPD may require HK Consortium to coordinate with the provincial wildlife departments for implementation of the project and monitoring of project impacts.

  Hunting, trapping and shooting within the project area by construction site workers will be prohibited and considered as a disciplinary offence.

- **Antiquities Act, 1975**

  The Antiquities Act relates to the protection, preservation and conservation of archaeological/historical sites and monuments. It prohibits construction (or any other damaging) activity within 200 m of such sites unless prior permission is obtained from the Federal Department of Archaeology and Museums. The Antiquities Act also binds the project proponent to notify the department should anything of archaeological value be excavated during project construction.

- **Provincial Local Government Ordinances, 2001**

  These ordinances, issued following the devolution process, establish regulations for land use, conservation of natural vegetation, air, water, and land pollution, the disposal of solid waste and wastewater effluents, as well as matters related to public health and safety. The ordinances will apply on this Project.

- **Regulation of Mines and Oil Fields and Mineral Development Act, 1948**

  This legislation provides regulatory procedures for the quarrying and mining of construction material on state-owned as well as private land. No any mine or oil field is spotted within the area of influence in this Project.

- **Factories Act, 1934**

  The clauses relevant to the project are those that are related with the health, safety and welfare of workers, disposal of solid waste and effluent, and damage to private and public property. The Factories Act also provides regulations for handling and

disposing of toxic and hazardous materials. Given that construction activity is classified as 'industry', these regulations will be applicable to the project.

2.5 NATIONAL CONSERVATION STRATEGY

The Pakistan National Conservation Strategy (NCS) was approved by federal cabinet in March 1992 is the Principal policy document on environmental issues in the country. The NCS outline the country's primary approaches towards encouraging sustainable development, conserving natural resources and management of resources. The NCS has 68 specific programmers in 14 core area in which policy intervention is considered crucial for preservation of Pakistan's natural and physical environment. The core areas that are relevant in the context of the proposed Project are pollution prevention and abatement, conserving biodiversity and preservation of cultural heritage.

2.6 NATIONAL ENVIRONMENTAL POLICY

The National Environmental Policy provides an overarching framework for addressing the environmental issues facing-Pakistan, Particularly pollution of fresh water bodies and coastal waters, air pollution, lack of proper waste management, deforestation, loss of biodiversity, desertification, natural disasters and climate change. It also gives directions for addressing the cross sectoral issues as well as the underlying causes of environmental degradation and meeting international obligations. The policy provides broad guidelines to the Federal Government, Provincial Government, Federally Administrated Territories and Local Government for addressing environmental concerns and ensuring effective management of their environmental resources. The policy will apply on this Project.

2.7 REGULATION FOR ENVIRONMENTAL ASSESSMENT

Under section 12 (and subsequent amendment) of 1997 Act, a Project falling under any category specified in Schedule I (SRD 339, 10/2000), requires the proponent to file an IEE with concerned federal agency (Pak-EPA). Projects falling under the category specified under the schedule II require the proponent to file an EIA with the federal agency. Within ten working days of the IEE or EIA having been deposited the federal agency will confirm that the document submitted is complete for the purpose of review. During this time should the federal agency require the proponent for revision, clearly citing those aspects that need further discussion. Subsequently, the federal agency shall make every effort to complete IEE review within 45 days and an EIA within 90 days of filing.

Pak-EPA regulation (SRO 339(1)/2000) States that an EIA is required for federal or provincial projects (except in the case of maintenance, rebuilding, or reconstruction case) with a total cost of Rs 50 million or more. EIA is also required in cases where projects are to be implemented in environmentally sensitive areas, or are likely to cause adverse environmental effects.

Recognizing that the Pak-EPA has delegated powers to provincial EPAs to enforce the provision of 1997 Act, an EIA must be submitted to the provincial agencies in whose jurisdiction the project falls which in this case Punjab Environmental Protection Agency, at the time of application, the Project proponent is also required to pay a specified fee to the concerned EPA.

In this Project a draft copy of the EIA report was submitted to HK Consortium for a view and after incorporating the comments of HK Consortium the final revision submitted to EPA Punjab for obtaining No Objection Certificate (NOC). A cheque of Rs. 30,000.00 will be raised by the consultant and submitted to EPA through HK Consortium for conducting a Public Hearing. The approval from EPA (NOC-No Objection Certificate) for the Project is mandatory requirement before commencing the work on site.

2.8 GUIDE LINE FOR ENVIRONMENTAL ASSESSMENT

The Pak-EPA has published a set of environmental guidelines for conducting environmental assessments and the environmental management of different types of development projects. The guideline relevant to the proposed Project are listed below:

i. Guidelines for the Preparation and Review of Environmental Reports, Pakistan Environmental Protection Agency, 1997

The guidelines, targeted at project proponents, specify:

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

The report must contain baseline data relating to the project area, an interpretation of the data and mitigation measures.

ii. Guidelines of Public Consultation, Pakistan Environmental Protection Agency, May, 1997

These guidelines deal with possible approaches to public consultation and techniques for designing an effective program of consultation that reaches out to all major stakeholders and ensure their concerns are incorporated in any impact assessment study.

2.9 NATIONAL ENVIRONMENTAL QUALITY STANDARDS (NEQS) 2000

The NEQS 2000 specify the following standards:

- Maximum allowable concentration of the Pollutants, (32 parameters) in emission and liquid industrial effluents discharge to inland water.
- Maximum allowable concentration of pollutants, (16 parameters) in gaseous emission
- Maximum allowable concentration of pollutants (two parameters) in gaseous emission from vehicle exhaust and noise emission from vehicles.
- Maximum allowable noise level from vehicles

These standards apply to the gaseous emission and liquid effluents discharged by batching plants, campsite and construction machinery. The standards for vehicles will apply during the construction as well as operation phase of the project. Precise standards for air quality are not available under NEQS, 2000. The National Environmental Quality Standards (NEQS) 2000 specify the following standards:

i. Discharge to inland waters, sewage treatment facilities and the sea:

The standard prescribes the maximum allowable concentration for 32 contaminants in the municipal and liquid industrial effluents being discharged to the environment.

Determinants which will be relevant to the contractor's activity and discharges to surface waters or surface water courses and their limits are listed in the following table 2.1.

Table 2.1: Effluent Discharge Standards Applicable to the Works

Determinant	Limit
Temperature	<40 deg Centigrade
pH	>6 and <10 pH
BOD	<80 mg/l
Chemical Oxygen Demand (COD)	<150 mg/l
Total Suspended Solid (TSS)	<200 mg/l
Total Dissolved Solids	<3500.0 mg/l
Grease and Oil	<10 mg/l
An-ionic detergents (as MBAS)	<20 mg/l
Ammonia	<40 mg/l
Chlorine	<1.0 mg/l
Chloride	<1000.0 mg/l
Sulphate	<600.0 mg/l
Manganese	<1.0 mg/l
Heavy Metals	(included in Appendix3)

There are no prescribed limits for the concentrations of microbiological determinants which will be required to be met by any wastewater discharged from the contractors work camps. Appropriate international standards will be considered in the Environmental Management Plan.

ii. Gaseous emission from industrial sources:

Maximum allowable concentration of pollutants at construction site are:

Table 2.2: Gaseous Emission Levels

Determinant	Limit
Carbon Monoxide (CO)	9 ppm (8 hours) 35 ppm (1 hour)
Sulphur Dioxide (SO_2)	140 ug/m^3
Nitrogen Dioxide (NO_2)	100 ug/m^3

iii. Environmental Noise Levels

While no environmental noise levels are currently in place, values have been submitted to the Expert Advisory Committee on NEQS for consideration. The levels which are being proposed are summarized in Table 2.3.

Table 2.3: Noise Emission Levels

Category	Daytime L_{eqd}dB(A) (06:00 – 21:00)	Night-time L_{eqd}dB(A) (21:00 – 06:00)
Residential Area	55	45
Commercial Area	65	55
Industrial Area	75	70
Silence Zone	50	40

The Standard prescribes maximum allowable noise levels for road vehicles and construction machinery is 85 dB (measured 7.5m from vehicle/machinery).

3
PROJECT DESCRIPTION

3. PROJECT DESCRIPTION

3.1 GENERAL

The Chashma-Jhelum Link Canal off takes from the Indus River at the Chashma Barrage. The canal head regulator is on the left bank of the Indus river immediately upstream of the Chashma Barrage. The link extends from its head regulator in a southeasterly direction for a distance of 108km to its outfall into Jhelum river. The upper 34km of the canal passes through the Thal irrigated area and lower part crosses the Thal Desert. The canal is unlined earthen canal with bottom width of 116m and a normal depth of 4.27m. The first 5km of the canal cross the left Indus river flood plain to the left river bluff, where the terrain rises 9m above the flood plain. The link canal runs in a deep cut with its full supply level below the surrounding terrain up to 51km where the level of the terrain falls below the link full supply level. The canal out fall into the Jhelum river at 40km downstream from the Khushab bridge on the river. The Access across the link canal is provided 27 roadway bridges, a footbridge and a railway bridge. Irrigation channels cross the link canal at three aqueducts, and small drainage channels are taken into the link through six small drainage inlets. The only active off take from the canal is for Khushab Atomic plant of about 24m^3 per day from at about 3km upstream from the tail end regulator.

The Powerhouse was proposed to be constructed on right bank at the tail of the C-J Link. The centerline of the powerhouse and C-J Link were kept about 180- 250m apart. The maximum design discharge for the power channel will be 320 m^3/s. The bed width is taken equal to the total width of the power house required for 3 horizontal tube turbines.

3.2 BACKGROUND

In 1960, under the agreement of Indus Water Treaty the right was given to India of the eastern rivers water, including Ravi, Sutlej and Beas. Consequent upon the construction of dams and barrages on these river by Indian government; the discharge in Sutlej and Ravi was reduced significantly. These rivers are bone dry when it enters into Pakistan, in most of the year. This generates a significant amount of work for transporting water from other rivers through link canals to overcome the shortfall of water in eastern rivers, Chashma-Jehlum Link Canal was constructed in 1971 under this program. The canal was designed to transfer of maximum 615m^3/s of water from Indus river to Jehlum river. The canal off take from left bank of Indus river at Chashma barrage and outfall in river Jhelum at about 97km upstream of Tarimu Headworks. The Water Apportionment Accord between the four provinces was signed in 1991. The Greater Thal Canal is presently under construction for utilizing Punjab's

share in the flood supplies. The canal off take from CJ Link at Adhikot and will have a capacity of 240.4 cms (8500 cfs). A provision of 1.874 MAF for the Greater Thal Canal exists in the Water Accord during the Kharif (summer) season. It is proposed to supplement this allocation from Punjab's share in surplus flood supplies. Post Water-Accord and Future Requirements have been assessed based on additional canal operation data of the post Water-Accord period in the Inception Report, dated April 2008.

3.3 PROJECT OBJECTIVES

The main objective of the project is to generate hydropower electricity up to 25MW by utilizing natural head available at the tail end of CJ Link Canal; this will involve the following main activities

- Construct power channel leading to the hydropower plant as shown in figure 3.1.
- Install hydropower turbines
- Construct road bridge at the junction of power channel and Khushab – Muzaffergareh road
- Develop Public Park to improve the aesthetic values of the area.

The works include Civil, Mechanical and Electrical works. The layout of work scheme is shown in Figure 3.1.

Civil Works

- Construct power channel & power house
- Escape Channel
- Construct a Road Bridge on Khushab-Muzaffergareh road
- Develop a new Public Park

Mechanical / Electrical Works

- Construction of Powerhouse

3.4 MATERIAL DEPOTS

The construction material would need to be staked within the area allocated for Batching Plant, as shown in drawing (land use map). As referred earlier, the WAPDA has ample space near the project site where along with Batching Plant and Equipment Yard the area would also be available for storage of the construction material, provided the change management process is followed as described in the EMP.

3.5 WORK BASES

The work base area proposed at the right side of the canal, as shown in drawing (land use map). The material will convey through the Muzaffargarh road and access roads to the construction point. The Work base area and all the access roads are located within the IPD's land therefore no any social problems are anticipated due to the establishing the work base area and access road. Modification and maintenance of the surface of the bunds and access roads to be done to ensure the dust free environment of the area.

3.6 APPROACHES TO WORK SITE

The Contractor's Camp, Labour Camp, machinery yard, material depots, batching plant and RE's office will all be located in and around Muzaffargarh Road and easily accessible to the work site. All constitute within IPD's land and no private land acquisition require. All the work activities will be within short journey of Labour Camp, Contractor's & consultant's offices and RE's office. These approaches are not likely to cause any significant environmental and social problems for the construction program.

3.7 CONSTRUCTION SCHEDULE

Construction schedule is included in Appendix 6.

3.8 PROJECT CATEGORIZATION

The World Bank Operational Policy OP 4.01 explains the environmental screening of each proposed project to determine the appropriate extent and type of EA. The bank classifies project into one of four categories A, B, C & F1 depending on the type location, sensitivity and scale of the project and nature and magnitude of its potential environmental impacts.

The proposed Project classified as category C project as is likely to have minimal or no adverse environmental impacts. Almost all the impacts are reversible and in most cases mitigatory measures can be designed more readily.

Accordingly to section 12 of Pakistan Environmental Protection Act 1997, EIA is required for the project if the area of influence (AOI) is classified as environmentally sensitive or project activities include the construction of transmission line (11KV and above) and grid station. The upstream area of CJ Link Canal from the tail end regulator (from Khushab-

Muzaffargareh road) classified as wildlife game reserve area therefore the requirement of EIA for this Project is mandatory.

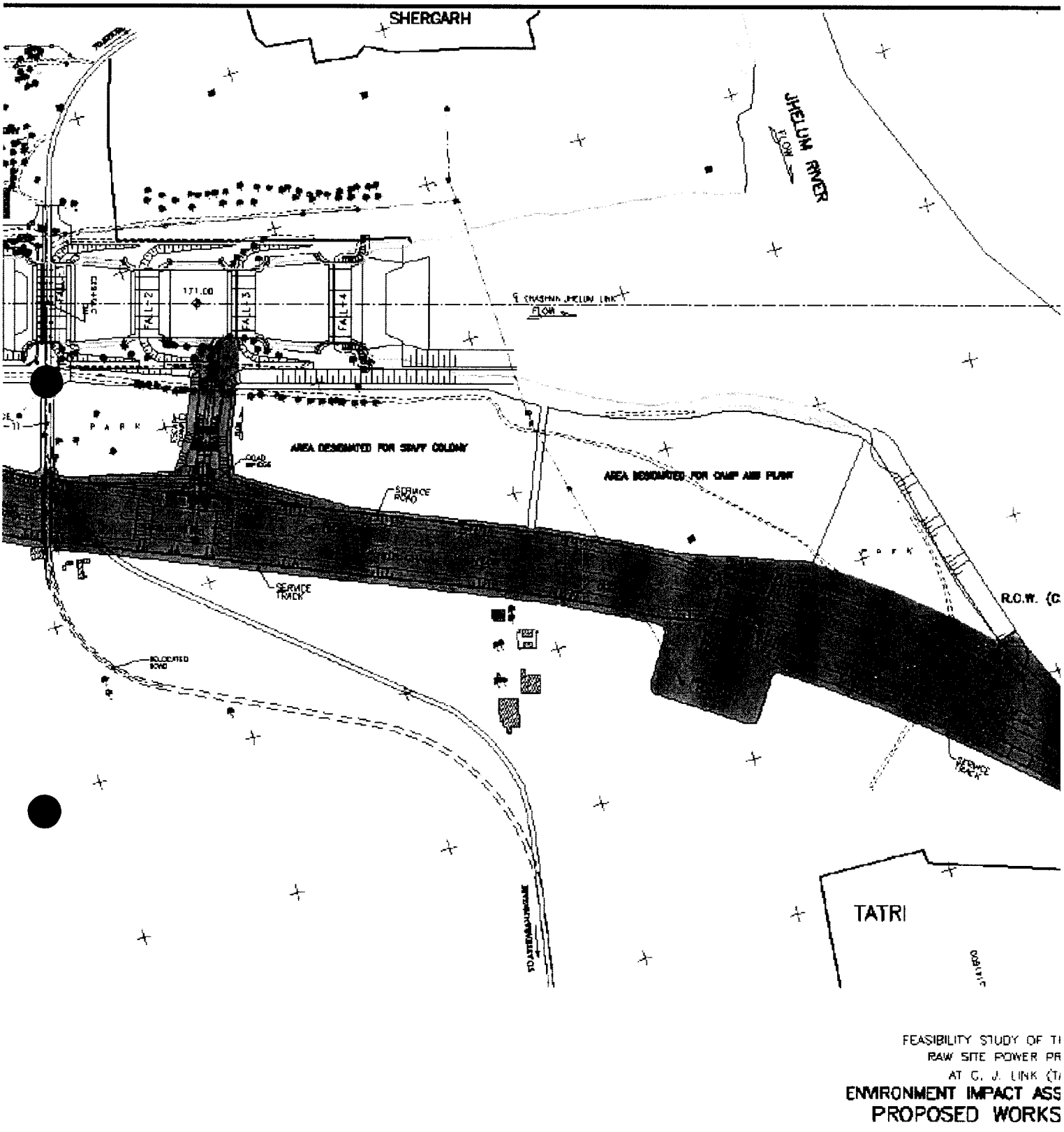


Figure 3 .1: Proposed Layout of Work Scheme

4
ENVIRONMENTAL BASE LINE CONDITION

4. ENVIRONMENTAL BASE LINE CONDITION

4.1 GENERAL

Data collected for ESIA study primarily pertain top infrastructure details, ecology of the area, flora and fauna and the results of information from other disciplines such as sedimentation, hydraulics, survey and imageries etc. Consultants adopted instrumental approaches for measuring land type, land use, water quality, air quality and noise pollution from the field. This chapter assesses the dimensions of the Area of Influence (AOI) and describes relevant physical, biological and socioeconomic conditions, including any changes anticipated prior to the project commencement. The study include current and proposed development activities within the Project area of direct and indirect connected to the project area also considered in this chapter. The data were collected regarding Physical Environment, Biological Environment and Social aspects of the study area. Primary data has been collected of the area very next to the proposed construction sites by using GIS technology and technical site surveys. Secondary data has been collected of the overall environmental study area from other institutions i.e. land Reclamation Office, Scarps Monitoring Organization (SMO), Punjab Wildlife Office, Fishery Department etc.

4.2 PROJECT AREA OF INFLUENCE

The area of project influence referred as "Area of Influence" (AOI) is the area likely to be affected by the project, including all its ancillary aspects such as power transmission corridors, pipelines, canals, tunnels, relocation and access roads, borrow and waste disposal areas and Labour camp as well as unplanned developments induced by the project.

Although the major construction activities remain restricted to the construction site, yet the situation in which construction related activities would extend beyond the construction site include:

- The Labour camp site, batching plant, material storage depots, equipment and machinery yards
- Borrowing & quarrying sites for soil materials
- Construction of haul tracks in order to transport construction material

The satellite image of the Project area and generalize land use of surrounding area is shown in Figure 4.1.

Figure 4.1: Generalize Land Use Map

The project area falls in Khushab Districts. It lies between 31° to 32°-20' latitudes north and 72° to 72°-20" longitudes east. The project area lies in the upper part of the Indus Basin, in Thal Doab, extends from the foot hills of salt range in the north to the confluence of Indus and Chenab river. The project is located at tail (RD 316+622) of Chashma Jhelum Link Canal, which off takes from Chashma Barrage. It conveys Indus River water to Jhelum River at point about 97km upstream of Trimmu Barrage, and about 42km downstream of Khushab Bridge. Survey during field visits suggested that water of the canal in the project area is not consumed for human drinking but is consumed occasionally by livestock. However the extended canal closure over long time could affect the water quality of hand pumps and tube wells along the canals, as the canal water also recharge the ground water. A social survey will be conducted to evaluate the effects due to extended canal closure within the project area and reported under Social Action plan (SAP) including the mitigation measures. The project area and its surrounding come within the Thal Canal command area. In this study, secondary data for the Thal Canal Command area has been used to establish the groundwater quality and land salinity of the project area.

4.3 PHYSICAL ENVIRONMENT

Physical environment include soil condition, water quality (surface water and groundwater), ambient air quality and climate.

4.3.1 Soil

Physiography

Physiography mainly includes systematic identification, description and mapping of different land forms existing in the study area. In alluvial landscapes, like the Indus Basin, major land form units are: Active/Recent flood plains, sub recent flood plains and Pleistocene river terraces. These are further subdivided into: bars/levees, basins/channels infills and level to nearly level areas of numerous local topographical inequalities which are one of the major causes of soil salanization followed by sodication.

Pakistan is divided into three major geographic areas: the northern highlands; the Balochistan Plateau and the Indus River plain with two major subdivisions corresponding roughly to the provinces of Punjab and Sindh. The project area lies in the upper part of the Indus Basin, in Thal Doab. The Doab is a part of Indus basin which is bounded on the west by river Indus and on the east by Jhelum and Chenab rivers. The word Thal is considered to be derived from Sanskrit word "Marus Thal" meaning "sea of sand" which is very descriptive

of the area. The soils of the huge Thal desert belt are alluvial with sandy textured sand dunes. The site location is indicated on Pakistan's Physiography map in Figure 4.2.

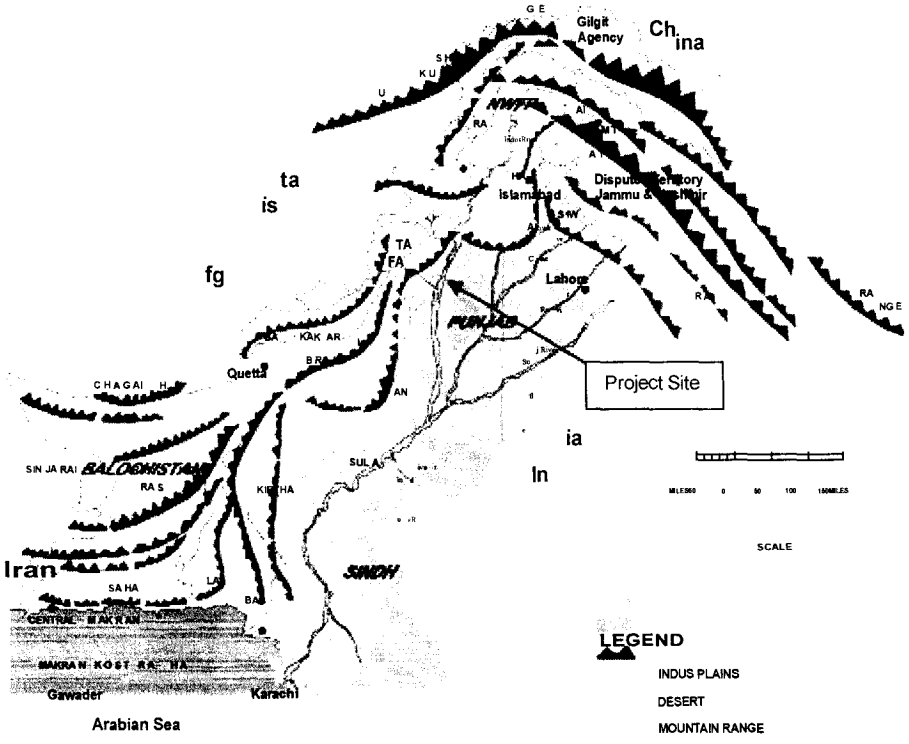


Figure 4.2: Physiography of Pakistan

Soil Type

Physiographically "Thal Doab" can be divided into two major groups.

1. Piedmont
2. Alluvial Plain

Piedmont material has been derived from fan deposits at the foot of salt-range and has undergone many cycles of erosion and redeposition by hill torrents and small meandering streams. The piedmont deposits generally become fine-grained in southerly and easterly direction.

The alluvial plain of Thal Doab consists dominantly of un-consolidated fine to coarse sand with minor clay and silt. The sediments were deposited in a subsiding trough by the river Indus and its tributaries.

Land form profile around the project area are indicated on Figure 4.3

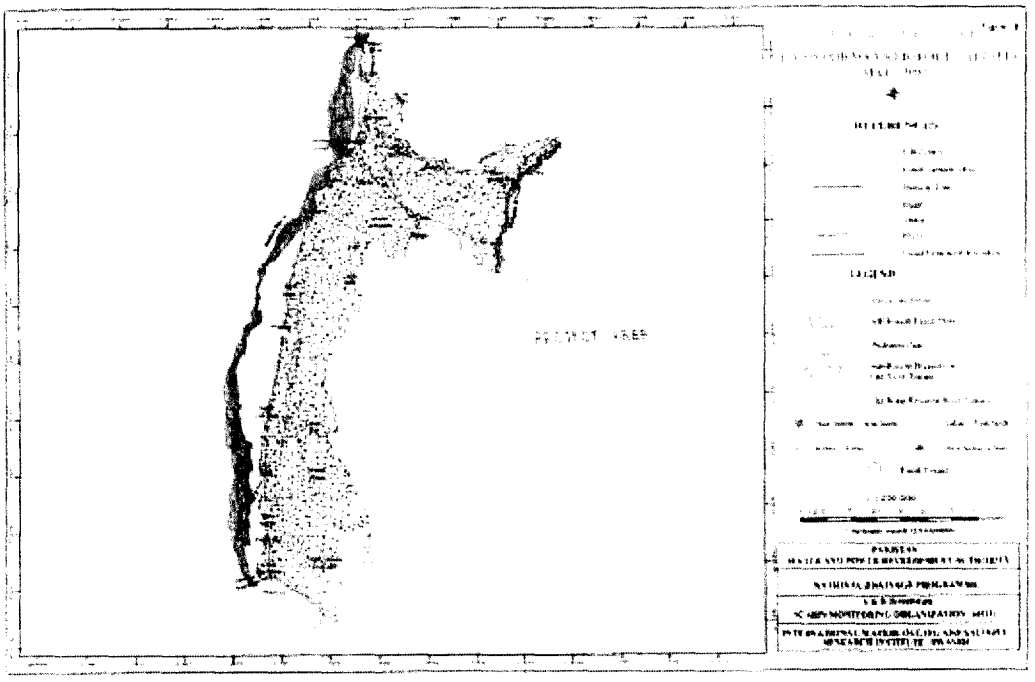


Figure 4.3: Land Forms Profile

Land Use

The power plant is proposed on right side of the CJ Link Canal, left side of the canal is occupied by Khushab Atomic Plant. The average natural ground surface at site is about 188.00 m.a.s.l and subsoil water level is 174.40 m.a.s.l. Eastern part of the site near the village Sharegareh cultivate with tube wells water remaining land of the site is Barani. The land use of AOI is indicated on Figure 4.1.

Surface Salinity

Surface salinity has been appraised by visual assessment of amount of salts accumulated at the surface in the form of crust/salt puff, apparent adverse effects on existing crops/natural vegetation; determination of EC (1:1 suspension) in the field using portable digital EC meter.

The study was undertaken by SMO department and summarized in their report. Four categories namely non saline, slightly saline, moderately saline and strongly saline were recognized and mapped as shown in figure 4.4. The four categories of salinity represent EC values (in dS/m) are up to 4, 4-8, 8-15 and above 15 respectively. 1,751 surface (0-15cm) soil samples were tested in the field for EC and pH, whereas in order to confirm field appraisal 836 surface soil samples were analyzed in laboratory for pH, ECe and SAR.

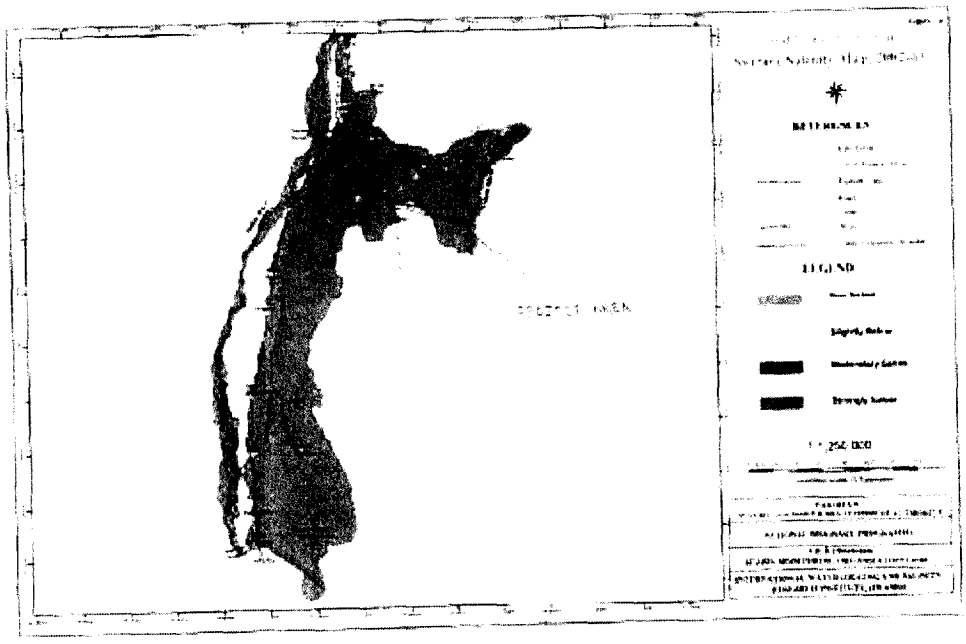


Figure 4.4: Soil Salinity Map of Thal Canal Command area

4.3.1.2 Seismicity Data

Earthquake in non-cohesive soil may cause serious problems. In extreme cases liquification can occur if

- Relative density is low
- Initial confining pressure (overburden) is low
- Earthquake intensity is high
- Duration of ground shaking is long

It is recommended that important components of the project should be designed for PGA of 0.20g to avoid economic loss due to earthquake hazard. Other less important structures could be designed to withstand PGA of 0.17g.

Review of active faults classified by A.H.Kasmi ("Geodynamics of Pakistan". Farah and Dejong 1979) indicates that Kalabagh fault and Uchhali fault zone may extend through alluvial complex towards the project area. During seismotectonic studies of Kalabagh dam project, it has been established that very late quartnary and probably Holocene deposits have been broken by those faults in repeated displacements. Seismotectonic analysis of Kalabagh region has indicated that quite a number of earthquake epicenters have been located on Kalabagh fault as shown in Figure 4.5. This fault is capable of producing MCE of magnitude 7 with acceleration of 40% g.

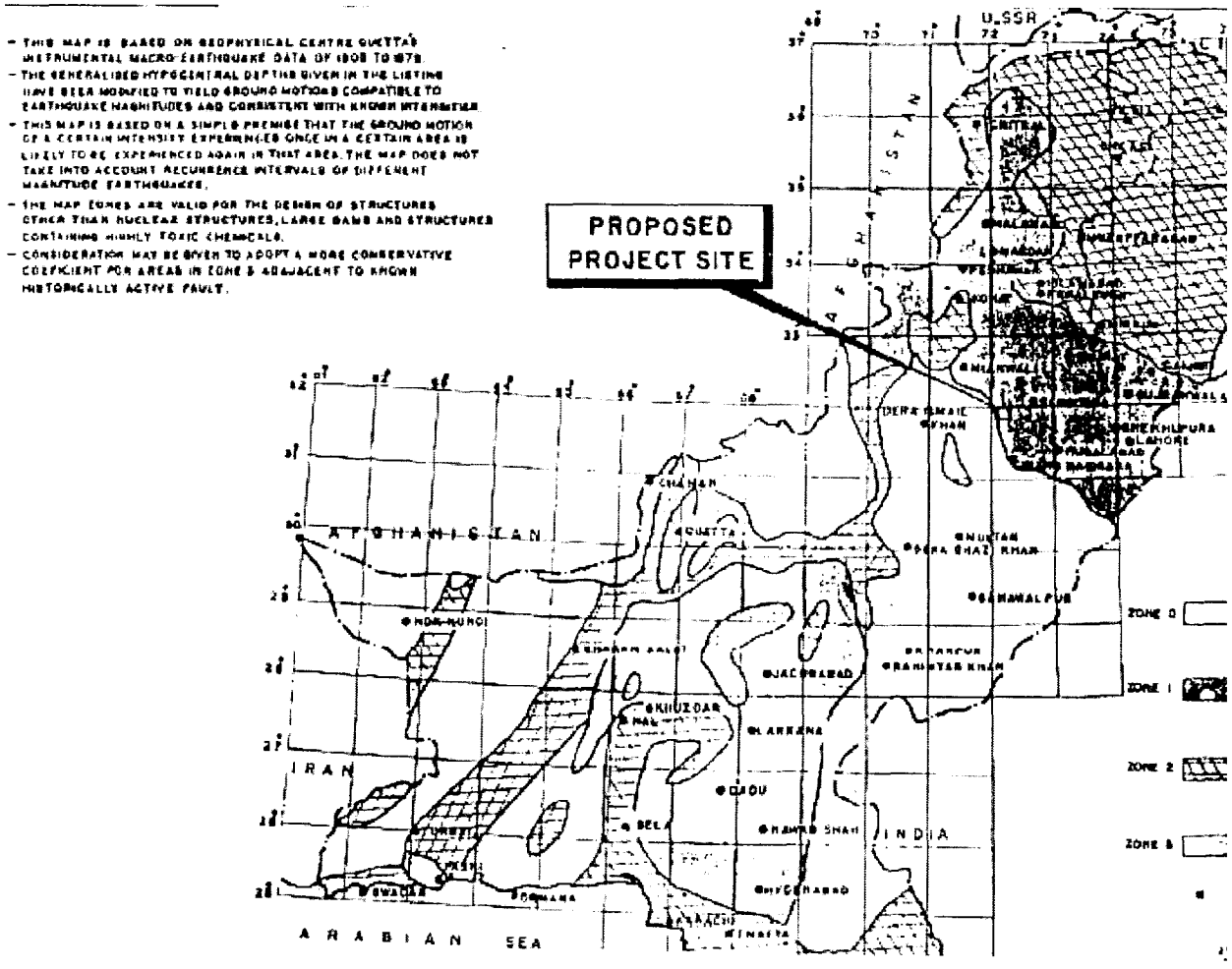


Figure 4.5: Seismic Zones of Pakistan

Meterological Department Geophysical Centre Quetta has developed a map indicating the Seismic Zones of Pakistan, as shown in figure 4.5. The Project area lies quite far away from this fault, yet a safety factor against the seismicity should be taken into account. The area located in an area of Minor Seismic Danger for which the seismic factor is between g/15 to g/20 for ordinary buildings.

4.3.2 Water

Control water can be divided into surface water and groundwater.

4.3.2.1 Surface Water

The natural surface water resources of the project area include Jhelum River and Chashma-Jhelum Link Canal. River Jhelum is a major tributary of River Indus. The salient features of the river are;

Approximate length	820km
Total Catchment Area	62,720km^2
Average Annual Flow (at Mangla)	28,815MCM

(Source: The Indus Basin, History of Irrigation, Drainage and Flood Management, H.Fahlbusch, Bart Schultz, C.D Thattle)

The Chashma-Jhelum Link off takes from Indus River at the new Chashma Barrage. The barrage is located along Indus River about 58km downstream of Jinnah Barrage. The link head regulator is on the left bank of Indus river immediate upstream of the Chashma Barrage. The link extends from its head regulator in a southeasterly direction for a distance of 108km to its outfall into Jhelum river at a point 97 km upstream of Trimmu Barrage. The Link Canal was designed as an unlined regime channel based on Lacey's approach. Taking into account various factors relating to the hydraulic design of alluvial channels in regime, link was designed for the following parameters;

Parameter	*Units*	*Lacey Section*	*Adopted Section*
Discharge	m^3/s	615	615
Area	m^2	494	540
Velocity	m/s	1.24	1.14
Bed Width	m	114	116
Unit Discharge	m^3/s/m	5.29	4.85
Silt Factor	-	0.98	0.98
Manning's Coefficient	-	0.020	0.022
Slope	m/m	10000	10000
Berm Width	m	7.6	7.6
Max. Water Level	ft.a s.l	600	600

It has been found, during the site surveys, that there is one inlet of waste water discharge into the canal in the project influence area, at about 100m downstream from tail head regulator. The waste water generate from the cooling process at Khushab Atomic Plant. It was also found that canal water and river water within the project area is not consumed for drinking purpose.

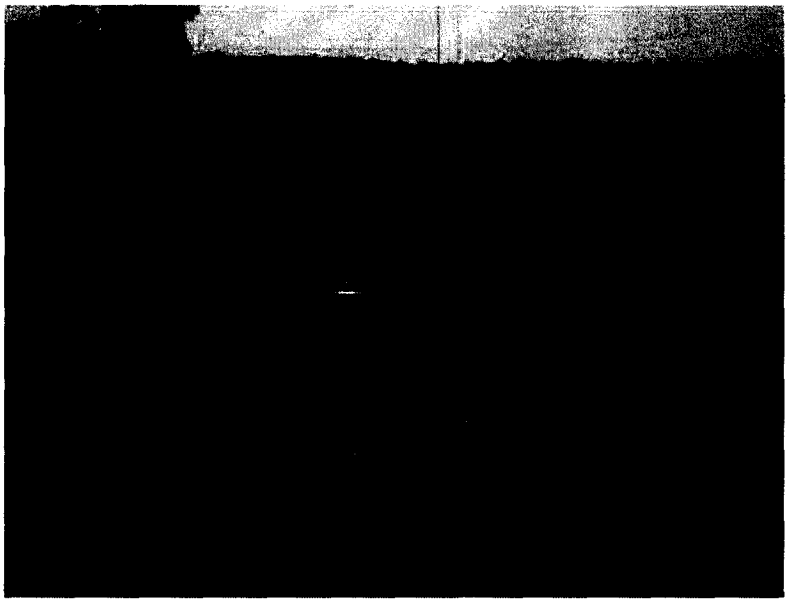


Plate 4.1: Wastewater Discharge into CJ Link

For evaluating the suitability of water for irrigation, a number of parameters such as salinity, alkalinity, soil chemistry, types of crops, leaching requirement etc are to be considered. However, initially the salinity of water in terms of salt contents is considered as the prime indicator. Water quality is usually assessed on the basis of three parameters called Electric Conductivity (EC), Sodium Adsorption Ratio (SAR) and Residual Sodium Carbonate (RSC).

Table 4.1: WAPDA's Standard

Category	Parametric Limits		
	EC (µS/cm)	RSC (meq/l)	SAR
Useable	Less than 1500	Less than 10	Less than 2.5
Marginal	1500 – 3000	10 – 18	2.5 – 5
Hazardous	More than 3000	More than 18	More than 5

Many studies have been conducted to provide the general idea of the chemical composition of various river water. Most of the samples were collected at gagging stations in order to co-relate the chemical composition of total dissolved solids with concurrent level of stream flow.

In previous studies, it has been observed that the dissolved mineral contents remained fairly constant during winter flow in the rivers but large variation in quality were observed during the monsoon months.

A study conducted under Environmental Monitoring of Land and Water conditions of NDP to determine the water quality of River Indus and its Tributaries. A regular water sampling was undertaken under this study during 1999 to 2004. The samples were analyzed in the SMO's laboratories. Electric conductivity and pH were determined on site and also in the laboratories for confirmation.

The sampling locations and test results obtained for EC, RSC, SAR and type of salts present in the sample for Jhelum River are summarized in Table 4.2.

As shown in the table more than 90% of the results indicate that the river water is non hazardous and fit for recreation purpose. Calcium hydroxide is the most common type of salt found in the river water.

Table 4.2: Jhelum River Water Quality

Sampling Site	No.ofSamples Collected	Water Quality During 2001-04										
		Usable		Marginal		Hazardous		$Ca(HCO_3)_2$	$Mg(HCO_3)_2$	$Na(HCO_3)_2$	NaCl	Na_2SO_4
		No	%	No	%	No	%	W/S (%)	W/S (%)	W/S (%)	W/S (%)	W/S (%)
Mangla Dam	4	4	100	-	-	-	-	4 (100)	-	-	-	-
Rasol H/W	26	26	100	-	-	-	-	23 (88.46)	3 (11.54)	-	-	-
Girot	3	3	100	-	-	-	-	2 (66.67)	-	-	-	1 (33.33)
Khushab Railway Bridge	25	21	84	2	8	2	8	15 (60.00)	-	1 (4.00)	9 (36.00)	-

Source: Scarps Monitoring Organization (SMO)

The proposed power house structure will be protected from flood water. Under Second Flood Protection Sector Project (FPSP-II), flood risk maps for 5 year and 50 year return period

were developed for Jhelum River, as indicated in Figure 4.6. This map will be used to prepare the flood protection plan for this project.

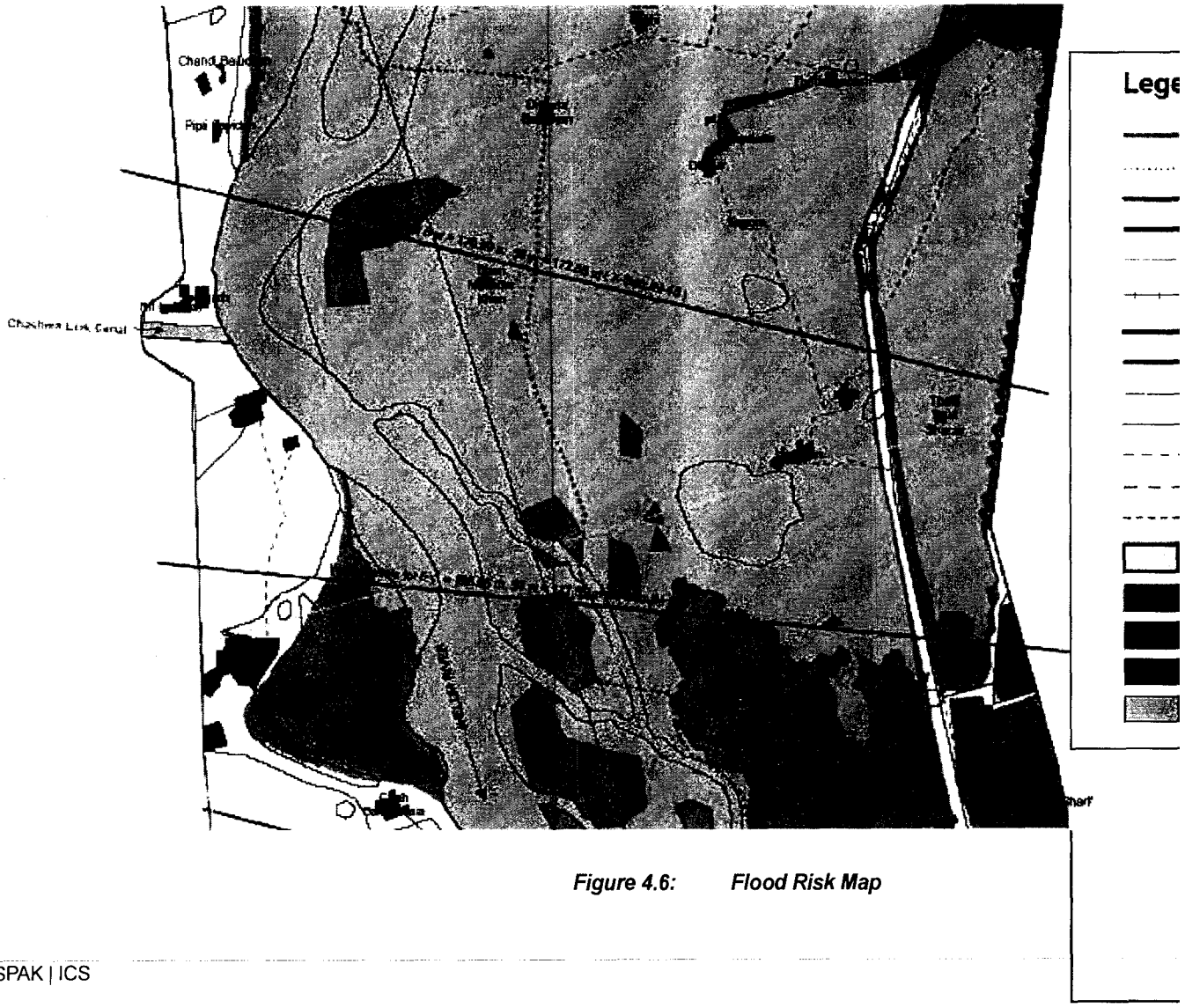


Figure 4.6: Flood Risk Map

4.3.2.2 Groundwater

Source of Groundwater

A major aquifer can be found as shallow as 300cm depth from ground level on site. Hand pumps and Tubewells are the two most common types of the source of groundwater within the project area.

Groundwater Quality

The Project site located at the tail end of Thal Canal Command area. The secondary data of groundwater quality included in this section is obtained from the report for Thal Canal Command Area prepared by Land Reclamation and SMO. The data presented herein is based on chemical analysis of the groundwater wherever samples could be collected within a depth of 300 cm during profile augering or deeper to 45 meters depth of hand pumps or tubewells. The ground waters were classified on the basis of laboratory analysis run for Electrical Conductivity (EC), Sodium Adsorption Ratio (SAR) and Residual Sodium Carbonate (RSC). For ease in description, the groundwater have been expressed as usable, marginal and hazardous for irrigation as determined by the adverse value of any of the above mentioned three parameters. The classification criteria used is not intended to be hard and fast' in relation to the effects of irrigation waters on soil and crop growth which can be truly adjusted according to environmental factors such as climate, type of soil, crops grown and management practices.

For appraisal of shallow groundwater quality of the area pH and EC were tested in the filed by using digital pH and EC meters. All the water samples were sent to the laboratory for detailed chemical analysis. The samples were analyzed for:

- pH
- Soluble cations such as Ca^{++}. Mg^{++}, Na^{+} and K^{+} in meq/l
- Soluble anions like CO_3^{-}, HCO_3^{-}, Cl^{-} and SO_4^{--} in meq/l
- Dissolved salts (ppm)
- EC (uS/cm) at 25°C
- Residual sodium carbonate (RSC) in meq/l
- Sodium Adsorption Ration (SAR)

Limits of these parameters namely EC, SAR and RSC used for classification of water samples as usable, marginal and hazardous are given in Table 4.4.

Using the above parameters water samples have been classified as usable, marginal and hazardous categories and presented in Fig 4.7.

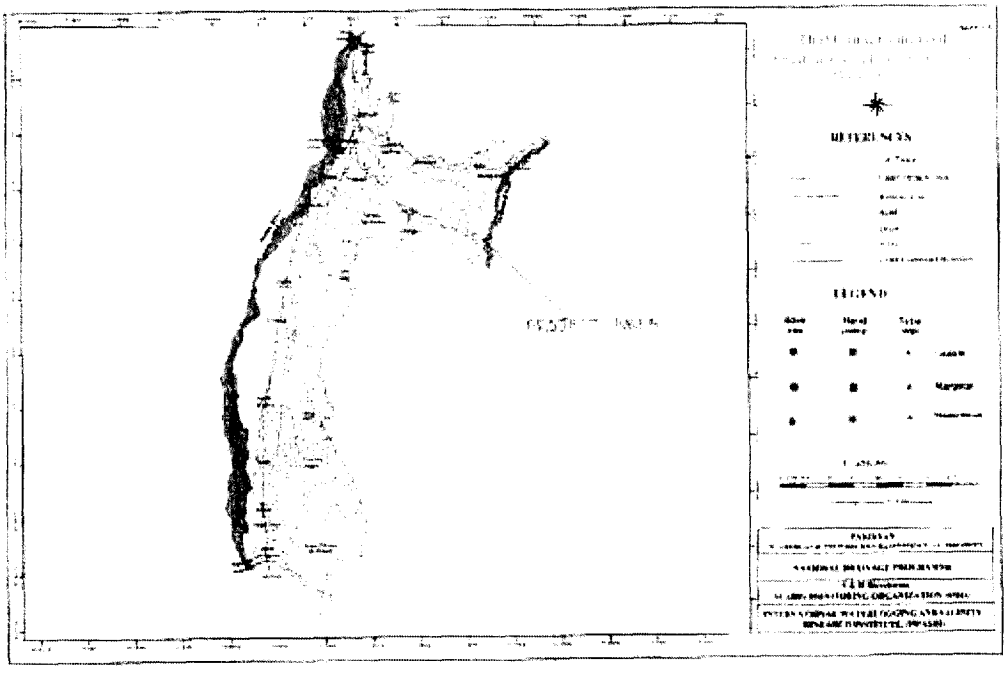


Figure 4.7: Thal Canal Command Groundwater Quality

It appears that overall groundwater quality around at project area is non-hazardous but there are few samples from adjacent site, classified as hazardous. Water quality of tubewells is relatively better than that of hand pumps.

Depth of Water Table

In order to determine the water table depth in canals command area. Every fourth profile was augered up to 300 cm or sloughing material whichever was shallower. In all auger holes were made for water table depth measurement. Water table was encountered within 300 cm depth at the site. This is attributed to bring conditions prevailing in the country for the last more than 5 years and excessive pumpage by private tubewells for irrigation purposes.

SCAPRs Monitoring Organization (SMO) is engaged in monitoring the water table depth in Indus Plain bi-annually i.e. during pre-monsoon and post- monsoon through a network of piezometers and tubewells. On the basis of data collected by SMO, water table depth maps have been prepared by using GIS technology, shown in Figure 4.8.

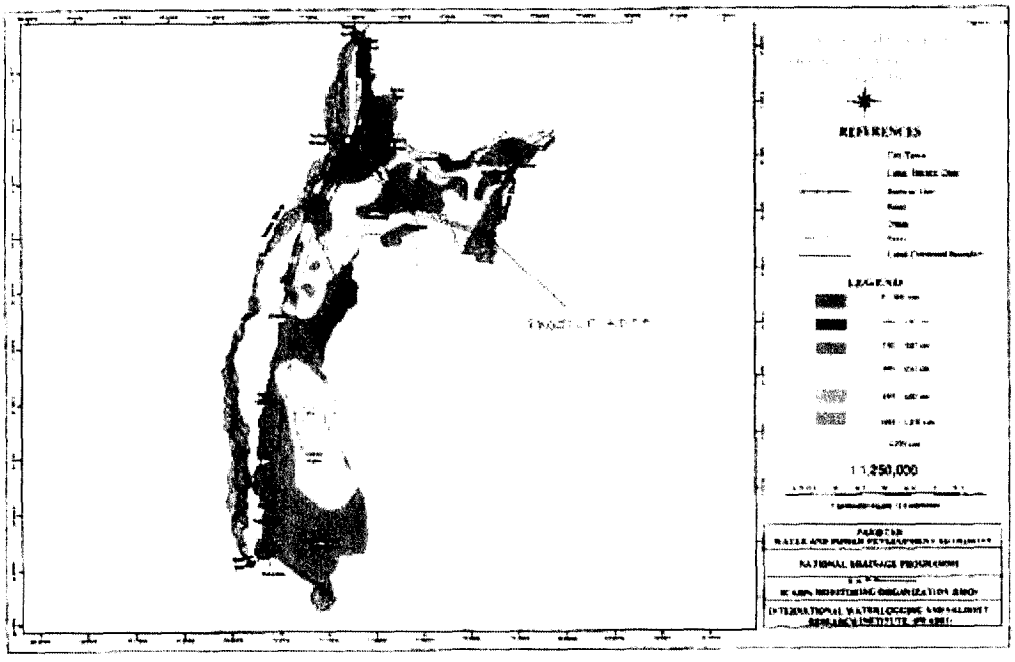


Figure 4.8: Water Table in Thal Canal Command Area

4.3.3 Air

It was found that the ambient air is reasonably clean at present. Air quality studies around Chaubara, Mankera and Nurpur showed that the air is well within the quality standard. It is anticipated that during excavation work the particulate matter is somewhat on the higher side due to dusty atmosphere.

Keeping in view the traffic level, present and expected, no significant change is anticipated in the air quality after the completion of the construction work. However Air quality could be deteriated during the construction phase from the plant & equipment emission. Air standard for Pakistan have not yet been standardized but up to 5,000 vehicles per day are considered below the critical level.

4.3.4 Climate

The climate of the area is arid characterized by long hot summer and short mild winter. The summer extends from April to October. Summer start from April and persists up to September. Monsoon season arrive on site during July to September. The climate data collected and described below is from the control centre at Joharabad.

Temperature

The maximum mean temperature during June, the hottest month of the year, and January, the coldest month of the year, are 41.36°C and 21.25°C respectively. May and June are the hottest months during which maximum temperature may rise up to 48°C. The winter lasts from December to February with minimum temperature could be as low as 0°C. Table 4.3 describes the average temperature recorded during year 2007.

Table 4.3: Average Monthly Temperatures of Joharabad for year 2007

Month	Ave. minimum Temperature	Ave.maximum Temperature	Ave. Temperature
January	3.32	21.25	12.28
February	7.56	22.06	14.81
March	10.51	25.66	18.08
April	17.73	37.99	27.86
May	23.63	40.93	32.28
June	25.52	41.36	33.25
July	24.78	36.59	30.68
August	26.33	37.24	31.78
September	22.95	34.91	28.93
October	17.78	34.08	25.93
November	9.51	28.23	18.87
December	5.3	21.15	13.22

(Source: Regional Meteorological Centre)

Rainfall & Humidity

Long term rainfall data (1975 through 1982) is available from Jamali Baluchan Station in the immediate vicinity of project area. The data records an average monthly rainfall ranging from minimum 5.08 mm in October to maximum 121.4 mm in July.

Wind movement controls the amount and distribution of rainfall. Three quarters (about 77%) of the total annual rainfall is during the summer months as a result of monsoon air movement from the Arabian Sea and the Bay of Bengal. The northeastern Thal also benefits more from rain bearing winds from the Asian landmass during winter.

A study of agroclimatology in semi-arid and arid zones of the near east by F.A.O, UNESCO and W.H.O (1962) suggests the following rainfall limits for various named climatic zones.

Zone	Average annual rainfall
Arid	Less than 200 mm
Semi-arid	200 mm – 500 mm
Sub-humid	More than 500 mm

The semi-arid zone is further subdivided into "true semi-arid" (300 – 500 mm) and "very dry semi-arid", (200 – 300 mm). In accordance with the above classification the project area consists of arid, very semi-arid and true-arid area.

Table 4.4: Annual Precipitation of Joharabad City for year 2007

Month	Mean monthly precipitation (mm)
January	Negligible
February	2.89
March	2.36
April	0.08
May	0.45
June	3.38
July	6.25
August	2.16
September	1.9
October	Negligible
November	Negligible
December	0.07
Total	**19.54**

(Source: Regional Meteorological Centre).

The average annual rainfall in the area is 150 to 180mm. Nearly 60% of the Precipitation is received during July August whereas the rest is unevenly spread over the remaining months. On the whole the rainfall is too scant and unreliable to be of any agricultural use. The general evapo-transpiration are very high and the irrigation requirements are met through the well organized (weir controlled) canal irrigation system. The relative humidity is generally low except during monsoon period.

Wind

The climate of a country is dominated by monsoon winds (seasonal winds) blowing from sea to land in summer and from land to sea in winter. During the summer months the landmass of Asia rises in temperature, the air above it, heats up and rises. As a result low pressures areas are formed over the landmass in contrast to high-pressure areas over Arabian Sea

and Bay of Bengal. The predominant wind direction during the summer months is therefore to the northeast and north from the Arabian Sea. Additionally, the Bay of Bengal monsoon air stream from the southeast markedly influences the northeastern parts of the country. In the winter months, the temperature of the Asian landmass decreases and high-pressure area is created in the northeast of the country resulting in land winds blowing towards the south and southwest. Hill masses such as Suleman Range and Salt Range locally modify wind movements in Thal area, which could be summarized as follow.

- Wind from south and southwest during the summer months in the central and western parts of the area.
- Winds from the east and southeast during the summer months in the eastern and north-eastern parts of the area and;
- Winds from the north, northeast and northwest during the winter months over the major part of the area.

Unedited records from Jamali Baluchan wind recording station compiled by Surface Water Hydrology Project, WAPDA shows that average daily wind speed at Jamali Baluchin (1975 through 1981) ranges from 0.927 km (0.5 nautical miles) per hour minimum to 10.562 km (5.7 nautical miles) per hour maximum during year. At the event of windstorm the wind velocity can be as high as 50 km per hour. Winds in the northeastern side of the project area are stronger and more uniform in direction than in the southern part. This change is presumed due to the Bay of Bengal monsoon stream influence. Wind is the principal eroding force. Unchecked wind continually causes landscape deterioration of the surface and destruction of existing vegetation through sand blasting.

Table 4.5: Monthly average wind speed (knots) for year 2007

Month	Wind speed at 8:00am (knots)	Wind speed at 5:00pm (knots)
January	0.58	1.41
February	1.60	0.0
March	1.61	2.03
April	1.2	1.7
May	1.8	2.70
June	1.26	2.46
July	1.54	1.61
August	0.8	1.41
September	1.06	1.86
October	1.09	1.48
November	1.6	1.6
December	1.64	1.54

(Source: Regional Meteorological Centre).

4.4 BIOLOGICAL ENVIRONMENT

Biological environment can be divided into Flora and Fauna.

4.4.1 Flora

The surrounding area of the site classified as barani land. The part of the Thal desert comes in district Khushab has almost disappeared over time. The characteristics trees and shrubs of the bar uplands are the Van (Salvadora Abeoides), Karir (Capparis Aphylla), Jand (Prosopis Spicigera), Malla (Zizyphus Nummularia), Sarkanda (*Saccharum Munja)* together forming jungle with which the uncultivated lands are generally covered. The van or jal (Salvadora Abeoides) with the leaves some things like the mistletoe, often forms a dense bush. In the river valleys the most common trees are the Kikar (Acacia Arbica) and Tahli (Dalbergia Sissoo) which are very largely grown especially on cultivated land.

There is no wooden area (forest) in the project area. In detail the flora of site can be divided into two parts:-

1. Riverian Track & marsh area along the canal banks
2. Adjacent Area

Riverian Track

In riverian track, especial in five years flood return area the succession of vegetation, first colonizes are grasses and Typha followed by Tamarix riverbed serut as the soil become consolidated and is raised by the new silt deposition in the scrub, so that the vegetation is no longer completely submerged and erect tree growth becomes possible. Marsh area along the canal banks provide a habitat for Typha and grass species.

As long as the edaphic condition remain unstable, Tamarix and Poplar remain dominant. As the soil gets stabilized and drained the forest community normally progresses to Acacia Nilotica and Dalbergia Sisso.

Plate 4.2: ***Thick Vegetation along the Banks of CJ Link (looking upstream at tail head regulator)***

Plate 4.3: ***Lippia Species (found along river bank)***

Plate 4.4: Saccharum Munja (Sarkanda)

Plate 4.5: Calotropis Proccra (Aik)

Plants

Frash (Tamarix articulate)
-Babool (Acacia Nilotica)
Shisham (Dalbergia sissoo)
Beri (Zizyphus Yujuba)
Habd (Prosphis spicigera)
Bhen/Poplar (Populus enphratica)
Khabbal (Cynodon Dactylon)
Kanwal (Melolotus oralifolia)
Munj (Erianthus Munja)
Kia (Sacchrum spontaneum)
Kunder (Typha elephantine)

Whereas the trees provide a habitat for birds the solid ground below houses the mammals. The margin line of Typha and grasses along the water bodies and Shrubs(s) on sand dunes becomes a good habitat for reptiles while the fish occupy the adjacent waters.

Adjacent Area

Adjacent area provides a typical thal environment. The natural flora of inland area is as follows:-

Plants

Jand (prosopis spicigera)
Karir (capparis aphylla)
Van (salvadora oleoides)
Kikar (acacia nilotica)
Lana (suda ruiteesa)
Beri (zizyphus jujube)
Khardar (Alhaji camelorum)
Khabbal (Cynodon dactylona)
Phog (Calligonum polygnoides)
Malla (Zizphus numularia)
Date Palm (phoenix rubicola)

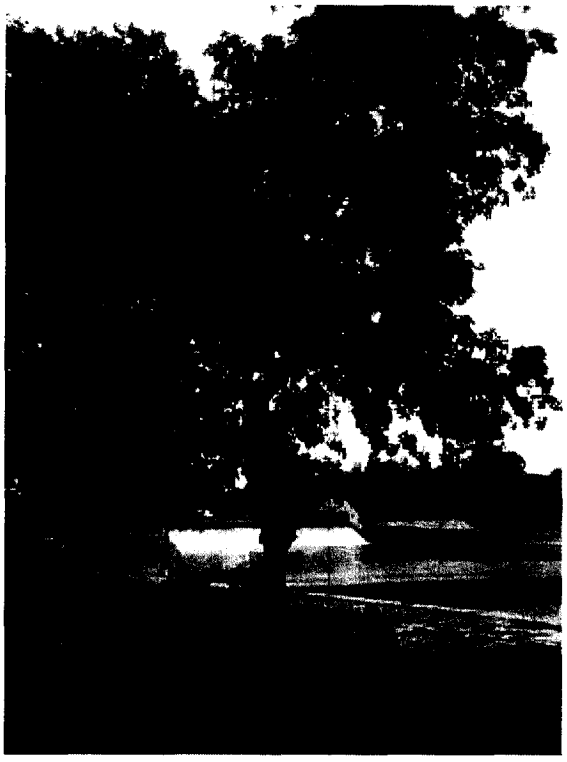


Plate 4.6: Dalbergia Sisso (Tali)

Plate 4.7: Eucalyptus (Sufaida)

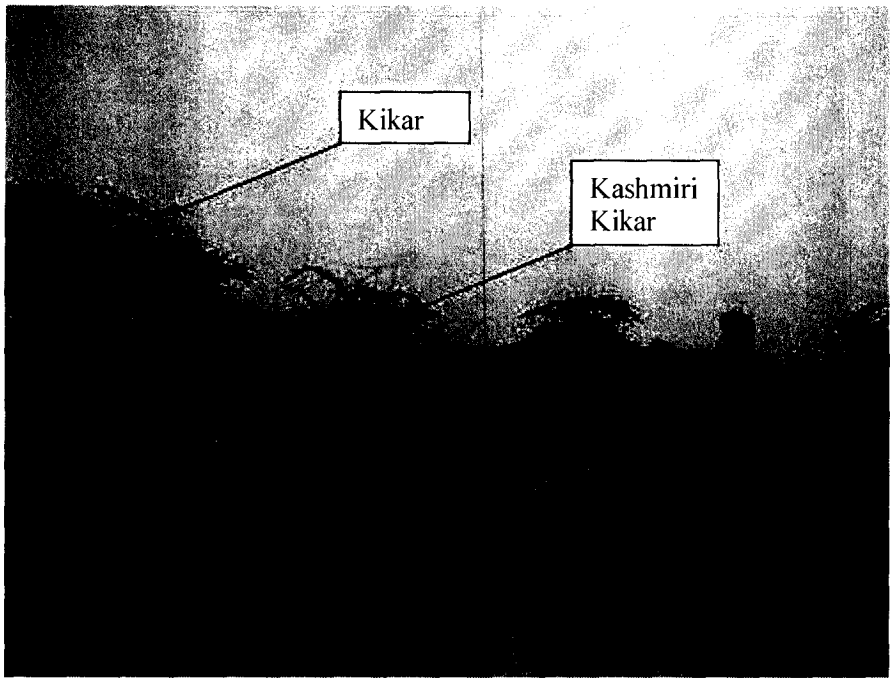


Plate 4.8: Kikar (acacia nilotica)

Plate 4.9: Phoenix Dactylifera (Date)

Plate 4.10: khagal

Kiker, Tali and Tarmail were the main type of trees found along the canal.

The location of the Labour Camp and Batching Plant were selected such that no tree cutting or uprooting require.

4.4.2 Terrestrial Fauna

Khushab district is quite rich as far as various animals, birds, reptiles and amphibioxus are concerned. About a century ago, the forest within the district had tigers, leopards, hyenas, wolves, jackals, wild cats, foxes, badgers, wild bores, neel gai (blue bull), deer and the wild hill goats (Urial). During the last three or four decades some of the ferocious animals have become extinct due to hunting and killing, changes in the climate, soil changes after the colonization of Thal and diminishing of forests and jungles.

Inside or adjacent to the project area there is no wildlife sanctuary, however part of the project area is classified as wildlife game reserve area as shown in drawing 4.2. The Fauna of project area summarized as follow:

Mammals

Species	*Scientific Name*	*Status*
Jungle cat	Felis chaus	Common
Mongoose	Herpestes edwardsi	Rare
Mongoose	Herpestes anropunctatous	Rare
Porcupine	Hystrise indica	Common
Hedge Hog	Hemiechinus spp.	Common
Fox	Valpes bengalensis	Endangered
Jackal	Canis aureus	Common
Wild Boar	Sus scrofa	Rare
Armo Delo		Rare
Hare	Lepus nigricollis	Common

Reptiles & Amphibian

Species	*Scientific Name*	*Status*
Marsh crocodiles	Crocodylus palustris	Extinct
Gavial	Gavialis gangeticus	Extinct
Chequared keel back Snake	Natrix piscator	Common
Dark-bellied marsh Snake	Xenochrophis cerasogaster	Common
Striped river Snake	Enhydris pakistanica	Rare
Indian Python	Python molurus	Extinct
Dhaman	Ptyas mucosus	Rare
Striped Keel back	Amphiosma estolata	Rare
Indian Cobra	Naja naja	Rare
Indian Monitor Lizard	Veranus bengalensis	Common
Khapra snake	Viper	Common

Turtles – Hard shelled

Species	*Scientific Name*	*Status*
Brown River Turtle	Kachuga smithin	Common
Brahminy River Turtle	Hardella thurgi	Common

Flap Shells

Species	*Scientific Name*	*Status*
Indian Flapshell Turtle	Lissymes punctata	Rare
Spotted Pond Turtle	Geochlemys hamiltoni	Rare

True Soft Shells

Species	*Scientific Name*	*Status*
Narrow Headed soft shell turtle	Chitra indica	Rare
Indian soft shelled turtle (Sunworshippens)	Trionysc gangeticus	Rare
Common Tortois		Common

4.4.3 Birds

Resident Birds of Prey

Species	*Scientific Name*
Fishing Eagle	Haliaeetus leucroryphus
Brahminy Kite	Haliaster Indus
Red Kite	Milvus Milvus
White breasted kind Fisher	Heleyon sinyrnensis

Seed Eating Birds

Species	*Scientific Name*
Dove	Streptopelia dacaocta
Dove	Streptopelia tranquenbarica
Dove	Streptopelia senegalensis
Weaver birds	Ploceus philippinus
Weaver birds	Ploceus manyar
Indian Sand Martins	Riparia paludicola
Indian River tern	Sterna auranlia
Common Babbler	Turboides candatus

Common Terrestrial Birds

Species	*Scientific Name*	*Status*
Grey Partridge	Pyeronotus zynthopygos	Common
Jungle Pigeon	Teron Walia	Common

House sparrow	Passer spp.	Common
Crow	Corcias abyssinicus	Common
Raptor	Falconiformes	Endangered
Warblers & Song Birds	Passeriforms	Endangered
Shikra	Elanus Calruleus	Endangered
Baaz	Circus Aeruginosus	Endangered

Migratory Birds (Water Fowls)

Species	*Scientific Name*	*Status*
Black Headed goose	Anser indicus	Rare
Black headed gull	Larus ridibundus	Rare
Black-necked grebe	Podicepa nigricollis	Rare
Black stork	Ciconia niger	Rare
Black tailed godwit	Limasa limosa	Rare
Common Shelduck	Tadorna ladoran	Rare
Common snipe	Callinago gallinago	Rare
Curlew sand piper	Calidns ferruginea	Rare
Ferruginous duck	Aythya nyroca	Rare
Great cormorant	Phalacrocorax carbo	Rare
Great crested grebe	Padiceps cristatus	Rare
Great egret	Egretta alba	Rare
Shag	Phalacrocorax fuscicallis	Rare
Red crested pochard	Netta rufina	Rare
Tufted duck	Aythy fuligula	Rare
White spoon bill	Platalea leucorodia	Rare
White tailed plover	Vanellus leucurus	Rare
Black Winged stilt	Himantopus himantopus	Common
Cattle egret	Bubulcus ibis	Common
Common coot	Fulica atra	Common
Common pochard	Aythya ferina	Common
Common sand piper	Actitis hypaleucus	Common
Common teal	Anaz crecca	Common
Common Tern	Sterna hirundo	Common
Eurasian wigeon	Anaz Penelope	Common
Gardwal	Anaz strepera	Common
Green shank	Tnnqaa nebulana	Common
Grey heron	Ardea comerea	Common

Pond heron	Ardeola Grayti	Common
River tern	Sterna aurantia	Common
Intermediate egret	Egretta intermedia	Common
Lesser Whistling teal	Denrocygna bicolor	Common
Little cormorant	Phalacrocorax niger	Common
Little egret	Egretta garzetta	Common
Little grebe	Tackybaptus ruficollis	Common
Little ringed plover	Charadrius dubius	Common
Mallard	Anas platyrhynchos	Common
Moorhen	Gallinula chlaropus	Common
Lapwing	Vanellus vanellus	Common
Pintail	Anas acuta	Common
Shoveler	A.clypeata	Common
Pheasant tailed jacana	Hydrophasianus chirurgus	Common
Purple gallinule	Porphyrio parphyrio	Common
Purple heron	Ardea purpurea	Common
Red shank	Tringa tetanus	Common
Cotton teal	Nettapus Coromandelianus	Endangered
Snake Bird	---	Endangered

4.4.4 Fish

One hundred and twenty seven species of fresh water fish have been recognized in Indus River and its tributaries, comprising 59 cyprinids, 33 slurries, 2 clupeids and 33 others. Of these most important are Palla (Tenua losa ilisha) and Mahasheer (Torputitora spp.) which are an exceptional species and powerful game fish. But due to construction of a series of barrages Palla cannot migrate from sea upwards and is almost extinct from river waters. Upward breeding movement of Mahasheer is also restricted due to barrages.

The data included in this part is collected during the site visits from the fishing contractors and Fishery Department office in Jauharabad. It has been reported that the fishery department lease out the net fishing activities in CJ Link Canal for year 2007/2008 on Rs. 51,000.00. However under this contract the contractor are not allowed to carry out fishing activities within 100ft of the head regulator or any ongoing construction activities at the canal. The length of the Jhelum River, passes near the project site, also leased for fishing for 2007/2008 year for Rs. 5,00,000.00. Mainly the fish is exported to close by cities and towns like Khushab, Sargodah etc. However small quantity of fish also sold by the vendors at

Chashma barrage. The most common type of fish found at the head regulator are Mali, Gulfam, Gulbam, Sangari, Raho, Mori, Soul, Khaga and Pari.

Plate 4.11: Fisherman Preparing his Fishing Rod at Tail Head Regulator

Fishes Commonly Found in River Jhelum & CJ Link Canal

Local Name	***Scientific Name***
Daula	Channa marulius (Ham)
	Channa punctatus (Block)
	Channa triatus (Block)
Dumbra	Labeo rohita (Ham)
Dumbro	Labeo rohita (Ham)
Gulfam	Cyprinus carpio
Jhalli	Eutropiichthys vacha (Ham)
	Eutropiichthys murplus (Ham)
Khagga	Mystus (Mystus) bleekeri (Day)
Khagga	Rita rita (Ham)
Morakha	Barilius Vagra (Ham)
Morakhi	Barilius Vagra (Ham)

Local Name	*Scientific Name*
Mori	Barilius Vagra (Ham)
Mullee	Wallago attu (Bloch And Schn)
Rohu	Labeo rohita (Ham)
Saul	Channa marulius (Ham)
	Channa striatus (Bloch)
Singhara	Mystus (Osteobagrus) seenghala (Sykes)
Singhari	Mystus (Osteobagrus) aor)Ham)
Singhi	Heteropneustes fosslis (Bloch)
Theil	Catla Catla (Ham)
Thaila	Catla catla (Ham)
Theili	Catla catla (Ham)

It can be concluded from the above data that as long as there is no drastic change in the general river habitat there cans hardly any impact on Wildlife or Fish habitats. In anyway, the biological interbalance in the ecosystem is healthy that all minor changes do not cross the limits of ecological shock absorbers. It is also envisaged that the development of new Public Park could attract more visitors and therefore seasonal fish shops at the project site.

4.5 SOCIO-ECONOMIC STUDIES

4.5.1 General

The objectives of the study is to update prevailing socio-economic conditions of the related community and to assess the effects of envisaged project works cover all the possible options of work scheme, as discussed in chapter 5. To achieve the project objectives, it is imperative to study the prevailing socio-economic and socio cultural aspects of their livelihood. For this purpose a survey based on rapid rural appraisal was conducted to assess the socio economic conditions of the people and the cultural practices of the area. The study was completed by end of July 2008.

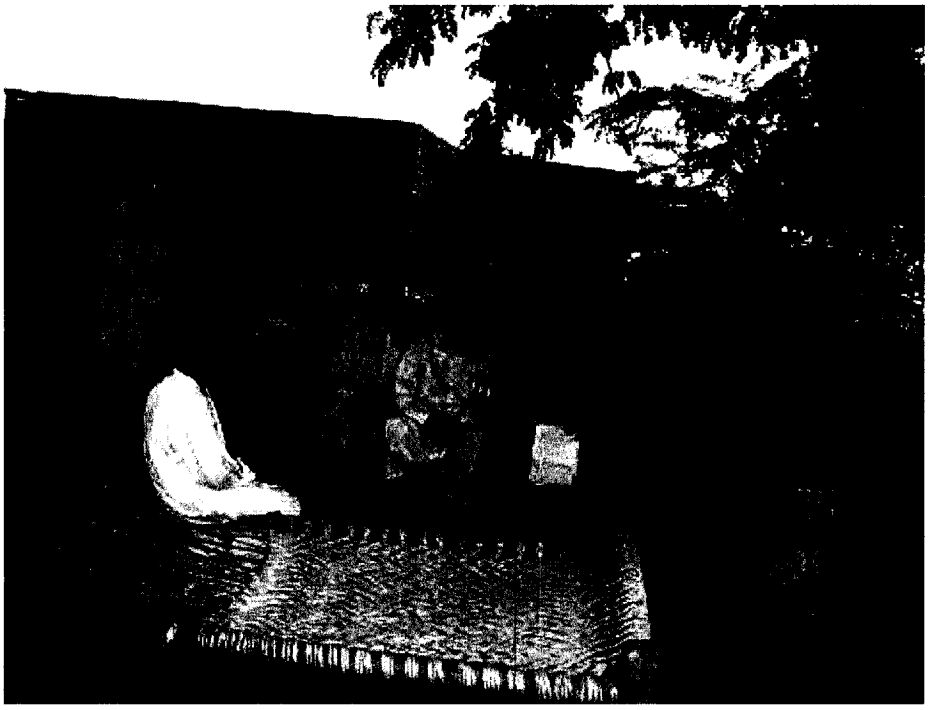
4.5.2 Study Area

The areas to be affected by the construction of power channel and relocated road have been considered for socio-economic study. The study area is indicated in Figure 4.7, falls in district Khushab, is situated in the Thal Doab which extends from foothills of 'Salt Range'.

Historically, Thal Doab existed as a flourishing state, with its capital at Taxilla, in times before Christ. In 326 B.C when Alxender the Great attacked India, Raja Ambhi of Sindh Sagar offered him eighty elephants and porters to help him to take his armies to across Jhelum. Thal Doab supported a good cover of natural vegetation even up to the times when the Moghal King Baber attacked India. His success at Shikar of big animals near Khushab attracted him to go head. But it appears that lower apart of Thal Doab is used only as transit. Greater Thal tract has little or no remnants of the earlier time except a vast sandy desert as a result of heavy deforestration b y various communities at different times. Recently the tropical thorn forest cover was destroyed by the occupants to clear the sand dunes to grow grams. The communities currently living in Greater Thal tract are Jat, Pathan, Awan, Baloch, syed, Qurashi, Joia and Sheikh. Most of the communities are agricultural but some are there to avail commerece opportunity available amongst the agricultural based economy.

4.5.3 Data Source / Methodology

The required secondary data was obtained from the latest published sources. Baseline survey was conducted to collect the deficient data related various social characteristics of the farm/nonfarm households by interviewing the representative of affected properties. It was found, during the social survey, that three properties and a tube well (indicated on figure 4.9) is located at the proposed location of the power channel. The details about the properties are described below



Plates 4.12: Interviewing with Local Community

SOCIO-ECONOMIC STUDY AREA
Khushab Atomic Plant
Sher Garh
Scale: 1:4,000

The details of representative of houses/property are

Property A (consist on 3 rooms & back garden)

Name:	Muhammad Zufar
Father Name:	Dost Muhammad
Occupation:	WAPDA's Employee
Marital Status:	Married
Total No. of Household:	7

Property B (consist on 7 rooms & back garden)

Name:	Muhammad Jabar
Father Name:	Dost Muhammad
Occupation:	Employee at Khushab Atomic Plant
Marital Status:	Married
Total No. of Household:	12

Property C (Medical Dispensary)

Name:	Syeed Nur Muhammad Shah
Father Name:	Syeed Muhammad Mangia Shah
Occupation:	Retired Assistant Medical Officer
Marital Status:	Married

The findings/write-up based on the results of survey and secondary data collected from various agencies are as follows:

4.6 SOCIO-ECONOMIC CHARACTERISTICS

4.6.1 Demographic Characteristics

Household size may also effect the economic situation of the household. Bigger household size may mean more hands to do farm work or non farm work. It can also mean more mouths to feed. Table No. 4.6 reveals that the average household size 6.2 and 6.9 in rural part of Khushab District and Punjab province respectively is almost the similar.

The relative proportion of two sexes in the total population is an important demographic feature. Sex composition profoundly affects the social and economic behavior of population.

It gives the proportion of males to females and is commonly expressed as the number of males per 100 females. The male female ratio in the study area is 99.4:100, which is lower as compared to the ratio in Punjab province (Table 4.6).

Table 4.6: Demographic Characteristics of Local Population

	H.H Size	Sex Ratio
Khushab District	6.2	99.4
Punjab Province	6.9	106

Source: Khushab Census Report 1998.

4.6.2 Caste/Biratheries

The word caste comes from the Portuguese casta, meaning lineage. The male respondents belong to different castes. Majority of the people living in village Share Garh belong to Joya biratheries. Tiwanas are the dominant tribes of the Thal others major castes find in district Khushab are Awan, janjua, Baloch.

4.6.3 Education

A study of educational status not only provides guidelines to policy makers but also help in understanding the demographic behavior of the population (Malik 1967). The literacy level is one of the factors which determine the quality of the human resources. The low percentage of literacy gives the indication of cultural barriers to the spread of innovations and scientific methods. The literacy rate in rural area and urban area in Khushab district are 36.7% and 51.6% respectively. The data given in Table 4.7 indicates the education level in the of district Khushab, according to 1998 Census.

Table 4.7: Education Level in Khushab District

(Percent)

Below Primary	Primary Pass	Middle	Matric	Intermediate	Graduates
22.3	33.9	22.7	14.3	3.8	1.8

Information regarding educational facilities in the district is as under:

Table 4.8: Educational Institution by their type and number

Type	College	Higher Secondary School	High School	Middle School	Primary
Boy	2	4	56	63	470
Girl	1	2	20	39	355

Source: Khushab Census 1998.

4.6.4 Occupation

It is useful to have information about occupational distribution of members of the sample households. The rural community in the Project area and surrounding consists of two groups. Farmers and those who are landless / non farm households. Farmers, who either own or lease/encroach land derive their living, by cultivating the farm land. This community may also supplement the farms income by raising animals and off farm work. The members of non farm community generally do agriculture labour, business, services, transportation, operating small shops, daily wage work, milk processing, working at Khushab Atomic Plant and sales and other services to earn the income to fulfill their living necessities. They conduct such business in their own village and nearby villages and in urban areas. Due to small land holding and Barani environment, the farmers have to engage in other activities such as livestock raising, goat/sheep breeding and working as labour. Table 4.9 describes the percentage of employed rural population engaged in different occupation

Table 4.9: Percentage of Employed Population by Occupation Rural Areas, 1998

Occupation	%
Legislators, Senior Officials and Managers	0.1
Professional	2.4
Technicians and Associate Professionals	2.0
Clerk	0.8
Services Workers and Shop and Market Sales Workers	3.8
Skilled Agricultural and Fishery Workers	51.8
Craft and Related Trades Workers	2.3
Plant and Machine Operators and Assembles	4.2
Elementary Occupations	32.0
Armed Forces	0.6

4.6.5 Drinking Water

The main cause of most of the communicable and abdominal disease is non availability of clean drinking water. Bradley (1976) has dwelt on a number of tropical diseases relating to water supply. About 20-30 different diseases may be caused by water supply for example, viral, bacterial, protozal and helminthic diseases. According to him these diseases may be water borne (infectious) water – based (due to lack of water) and water related (from insects in water).

From the above, it can be concluded that suitable safe drinking water is important factor promoting human health and productivity.

All the three houses come within proposed power channel location are facilitated with hand pumps inside the house.

According to 1998 Census 60.2% housing units in rural area of district Khushab have facility of source of drinking water inside the house, table 4.10 summarized the source of drinking water in rural area of District Khushab.

Table 4.10: Housing Units Percentage by Source of Drinking Water in Rural Area District Khushab, 1998

Source	% of Houses
INSIDE	60.2
Pipe (Nul)	12.9
Hand Pump	46.5
Well	0.8
OUTSIDE	39.8
Pipe (Nul)	9.8
Hand Pump	11.2
Well	6.3
Pond	5.3
Others	7.2

4.6.6 Source of Light

Energy is vital for socio-economic development. All the three houses come within the proposed power channel location have access to electricity.

Percentage of housing units by source of light in rural areas in district Khushab is summarized in table 4.11.

Table 4.11: Housing Units Percentage by Source of Lighting by Rural Areas

Source	%
Electricity	51.0
Kerosene Oil	48.6
Others	0.4

4.6.7 Health

Good health is a basic social value of great importance to individuals and to society. When ill health prevails, most of other ills of society also flourish as poor health takes a heavy toll in term of economic productivity, loss of earning and cost of treatment.

A medical dispensary was found within study area, running by a retired assistant medical officer from health department. The dispensary needs to be relocated as the local community use this facility on regular basis.

Other available medical facilities found in District Khushab are as follow:

D.H.Q Hospital	:	2 (one at Khushab and one Jauharabad)
T.H.Q Hospital	:	2 (one at Noorpur and one at Naushera)
Civil Hospital	:	2
Rural Health Centers	:	2
Basic Health Units	:	37
Civil Dispensaries	:	5 of Government
Rural Dispensaries	:	22 (Zila Council) Khushab
M.C.H Centers	:	3 of Government
M.C.H Centers	:	3 of Zila Council
Sub Health Centre	:	4

4.7 AGRICULTURAL ASPECTS

4.7.1 Size of Holding & land Value of Sample Farms

Sharif *et. al* (1986) have argued that land is the major determinant of farm income. They have further stated that under the prevailing socio-economic conditions of rural areas in Punjab. Control over land has a direct bearing on farmers ability to earn.
The land value ranges from Rs. 100,000 to Rs. 500,000 per acre for various land categories, an average of 175,000 per acre in sample survey area.

4.7.2 Livestock

Livestock rearing is second source of income in the study area. Almost all the farm/non-farm households maintain livestock because of its many advantages i.e. milk selling, meeting milk requirement, providing farmyard manure and the cash income at the time of financial difficulties. Almost all the living animals like buffaloes, cows, goat, sheep and poultry are present in the study area. It was found that poultry birds were not maintained on commercial basis. There number per household suggests that they are kept only for meeting household's egg and meat requirements. In the Study area, relatively very smaller numbers of bullocks are held per farm due to tractor farming.

4.7.3 Cropping Pattern

Agriculture is the main stay of the people in the district. More than 70% population is directly or indirectly engaged or dependent upon agriculture. Total cultivated area during 1998 was 1,160,903 acres which may not be accounted good as compared to the total area of the district (1,627,688 acres). Cropping pattern in a certain region is determined by the interaction of socio-economic and biological factors over a considerable period of time. It reflects a constantly shifting equilibra of these factors which are often subject to change overtime. The details of cropping pattern is summarized in Table 4.12.

Table 4.12: Area and Production of Main Crops and Yield, 1998

Name of Crops	Area Under Cultivated (in acres)	Yield (in 000 kg)
Gram	586,900	170,000
Wheat	205,000	115,920
Rice	30,000	22,612

Sugarcane	20,900	348,000
Oil Seed	7,500	2,500

4.7.4 Irrigation Status

Considerable development has been made in irrigation sector since 1947. Muhajir and Dullewala branches of Thal Canal and diesel/electric tubewells are major source of irrigation in the district. Out of 1,243,196 acres of cultivated area 231,551 acres are irrigated by this canal.

During 1995-96, 2,679 tubewells were installed by ownership, the most of which were run by diesel. Details is as under:

Table 4.13: Tubewells by ownership and type , 1995-96

Type	Total	Private	Government
Diesel	2,328	2,328	-
Electricity	351	290	61
Total	2,679	2,618	61

4.7.5 Horticulture

Main fruits are citrus fruit: Mussami, Kino, Red Blood and fruiter earlier are some of best varieties and are grown in abundance. Other fruits are mango, falsa, ber, loquate, jambolan, lemon etc.

4.8 GENDER ANALYSIS

4.8.1 Role of Woman

Gender problems are critical issues and are connected to a sustainable development process, which is usually perceived as women specific issues. In order to assess socio-economic conditions of women of the area, a gender component surveys conducted by taking a sample of women. A total 15 women from the study area were interviewed.

Plate 4.13: Interviewing with Local women

4.8.2 Age Composition & Education

Age is another important demographic characteristic which has a bearing on the employment and mobility. A study of distribution of heads of households by age will throw some light on the type of strategies which may be helpful in raising their income and employment. The data about age of household head (respondent) in Study area as presented in Table 4.14 indicates that relatively more sample respondents fall in age group of 20-34 years.

Table 4.14: Age Distribution of Sample Respondents by Household Categories (Percent)

Age Group Years	No of respondents	Percentage
Upto 24	5	33.3
25-34	5	33.3
35-25	4	26,6
45-54	0	0
55-64	1	6.7
65 & above	0	0

4.8.3 Women Marriage Age

It is common trend in the study area to marry the daughters at early age specially when they grow up/reach at working age. Table shows that 26.66% of the woman married at the age of

15 years and below, 60% at the age group of 16-20 years, and 13.33% at the age group of 21 to 25 years.

Table 4.15 Women Age Distribution at the Marriage Time

Age Group (Years)	Percentage
Upto 15	26.66
16 to 20	60
21 to 25	13.33

4.8.4 Women Participation in Agriculture

Women of the study area, undertake much of the work in the fields. Only one respondent does not participate in the farm activities due to old age but she does non farm economic activities to supplement her house income. Women undertake a number of activities concerning various farming operations. These include seed preparation, irrigation, land preparation, applying manure, sowing, weeding, hocking, and collecting chaff and hey etc fodder cutting and livestock rearing.

4.8.5 Participation in Livestock Related Task

Many of the livestock caring jobs are also considered women's work especially cutting/chopping of fodder, feeding, watering, cleaning the shed, bathing, milking and churning of milk.

4.8.6 Woman in Non Farm Activities

In addition to farming activities, women have to spend their time in non farm activities such as cooking, cleaning the house, washing the clothes and looking after the family and children. Repairing and maintaining of mud walls of the kacha houses is another responsibility of the females. Women also spend time in sewing or knitting activities which are carried out either for her own family or, in rare cases to earn cash. Women of the study area especially amongst small farm families are over worked compared to men.

4.8.7 Special Needs of Women

The survey data shows that females showed their interest in the education of women, and specially interested in vocational/technical training activities such as sewing, embroidery, and carpet weaving. In fact, the activities that they could carry out from the home and so not disturb the male patriarchy.

Plate 4.14: Interviewing with Local women

4.8.8 Women in Household Decision Making

All the respondents said that none of women was head of their household in the study area. Respondents were also asked how much decision making power women had in their household. It is clear from their replies that women have very little influence in major decision making in the house.

5
ANALYSIS OF ALTERNATIVES

5. ANALYSIS OF ALTERNATIVES

The main objective of this section is to provide a sustainable solution regarding location and layout of the whole project. For the selection of appropriate layout, under existing site conditions, the following environmental and social precautions have been considered.

Minimum environmental adverse impacts
Minimum resettlement and land acquisition, particularly private land
Cost effective solution

Following options/alternatives were analyzed for strength and weaknesses:

1. No project option (worst case scenario option)
2. Power Channel Layout Option 1
3. Power Channel Layout Option 2
4. Power Channel Layout Option 3 (Selected Option for Detail Design)

5.1 NO PROJECT OPTION (WORST CASE SCENARIO OPTION)

Analysis

Strength and Opportunities

- The efforts and investments shall be saved and would be available for diversion to another project in case the Project is not taken up at all.
- No social conflict issue shall develop, due to acquiring land from private/settlers and immigrating new settlers.
- The recurring cost of the Project would be avoidable.
- The Link Canal flow shall not interrupt due to the project activities.
- Loss of the agriculture land through which the power channel has to pass and construct a contractor's camp, shall be avoided.

Weakness and Threats

- Deny the power generation of up to 25MW from clean source of energy.
- The people of the area shall be denied employment during the project construction and later through escalated economic activities.

- No improvement in the aesthetic values of the area, as a development of public park will be carried out under this project.

5.2 POWER CHANNEL LOCATION OPTION 1

The layout of this option is shown on figure 5.1.

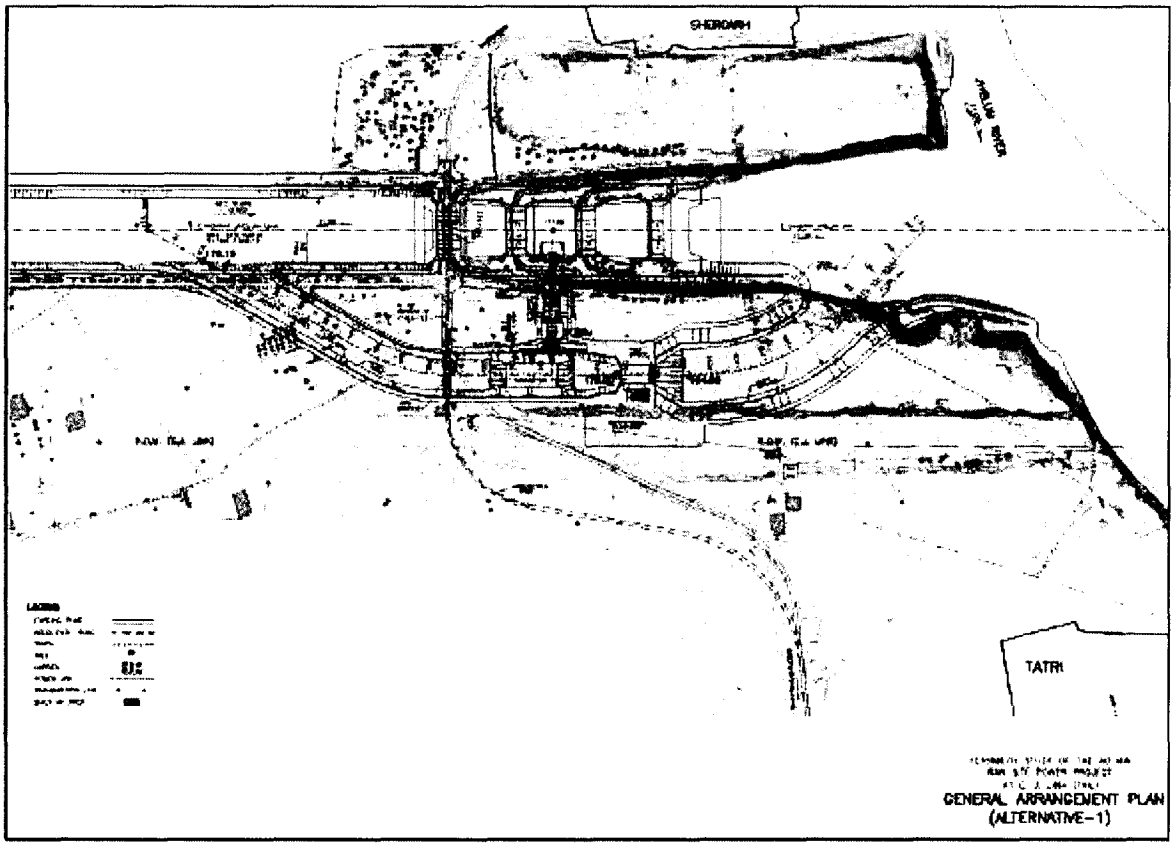


Figure 5.1: Power Channel Layout of Option 1

Analysis

Strength and Opportunities

- Less adverse social impact.
- Less land acquisition.
- Minimum impact on cultivated land.
- Smaller power channel length therefore cheaper in cost.

Weaknesses and Threats

- Bend in the proposed power channel will initiate soil erosion without any protection.
- About 59No. of trees comes within the purposed power channel location.
- 2 houses, a medical dispensary and a tube well need to be relocated.
- Soil erosion protection structure will be required at the sharp bend of the channel.
- Arrival of hundreds of workers in the area will emplace extra burden on existing services i.e. health, transport, education etc.

5.3 POWER CHANNEL LOCATION OPTION 2

The layout is indicated on figure 5.2.

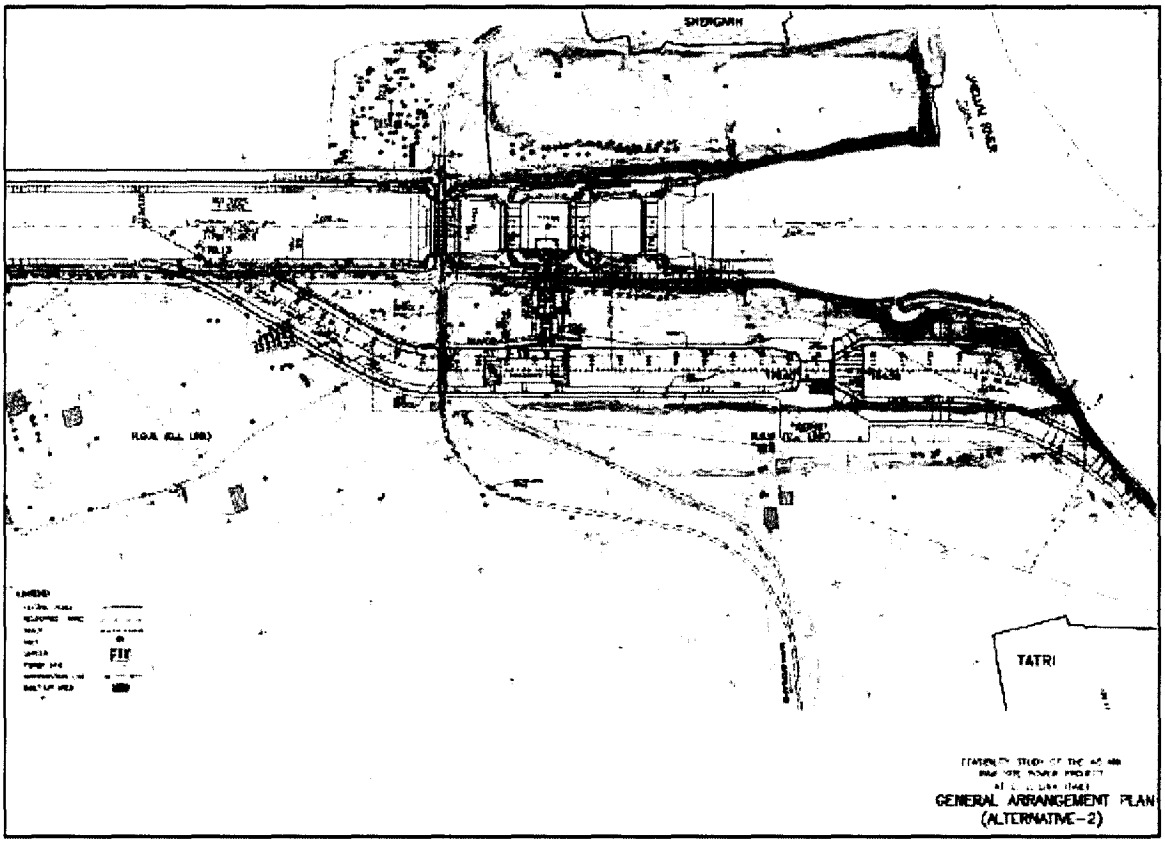


Figure 5.2: Power Channel Location for Option 2

Analysis

Strength and Opportunities

- Less soil erosion is anticipated as no bend in the proposed power channel length.
- Marginal increase in available head for power production.

- Larger area available for the proposed public park.

Weaknesses and Threats

- Higher land acquisition requires.
- An establish boat service station will be required to relocate as it conflict with the location of outlet of the proposed power channel.

Plate 5.1: Existing Boat Service Station

- Three houses (including a medical dispensary) and a tube well will be required to relocate.
- Length of power channel is longer than option 2 therefore higher construction cost.
- Adverse impacts on the local available services.

5.4 POWER CHANNEL LOCATION OPTION 3 (SELECTED OPTION)

The layout of selected layout of Power Channel is indicated on figure 3.1.

Analysis

Strength and Opportunities

- Less social impacts as compare to option 2 because of the existing boat service station may no need to be relocated with this set up.
- The option will allow utilizing additional head generated in Jhelum River along its length.
- The power generation capacity with this scheme will be higher than other options and therefore enhance positive impacts on local economic.
- The larger area available for proposed Public Park in this scheme.

Weaknesses and Threats

- Higher land acquisition, including some private land.
- Longer length of the power channel, therefore higher construction cost.
- More excavation work involves which could deteriorate the ambient air quality during construction phase.

Plate 5.2: Proposed Power Channel Crossing at Khushab-Muzaffargareh Road

Plate 5.3: Centre Line of Proposed Power Channel for Option 1, 2 & 3

Table 5.1: Comparison of Different Options

	Positive Impacts			Adverse Impacts		
	Physical	Biological	Social	Physical	Biological	Social
No Project Option	Avoid loss of agricultural land. Avoid air, water and land pollution from construction activities.	Avoid tree cutting. Avoid disturbance of habitat of flora & fauna from the construction activities.	No social conflict issue shall develop due to acquiring land from settlers and immigrating new settlers.	Deny the production of electricity from available clean source of energy.	Public Park development will involve plantation of new trees and improve the aesthetic value of the area.	Deny opportunity of employment for local population during the project construction and later through escalated economic activities.
Option 1 (Alternative Location of Proposed Power Channel)	Less land acquisition. Only IPD land is required for project activities. Lower project cost. Production of about 35MW from clean source of energy.	Develop Public Park to improve the aesthetic values of the area. Less tree cutting.	Employment opportunity for local population.	Land acquisition will require. Excavation work will deteriorate ambient air quality.	About 59No. of trees will be required cutting. Construction activities within the game reserve area.	Three properties need to be relocated. Private land acquisition will require for the relocation of the road layout.
Option 2 (Alternative Location of Proposed Power Channel)	Less soil erosion is anticipated as no bend in the proposed power channel. Production of 37MW power from clean source of energy.	Bigger area for public park available.	Employment opportunities for local population.	Higher land acquisition requires. Require some private land acquisition as well.	59No. of trees will be required cutting. Disturb the habitat of flora & fauna of the area.	A boat service station will require relocating. Three properties are located in the proposed location of power channel.

	Positive Impacts				Adverse Impacts		
	Physical	Biological	Social		Physical	Biological	Social
Option 3 (Selected Option)	Production of up to 25MW power from clean source of energy.	Public Park will be developed on site which will include plantation of hundreds of tree on site.	Employment and learning opportunities for local community. The arrival of additional persons in the area and larger market activities will reduce the profit margin and price.		About 32 acres of private land will be acquired.	56No. of trees will be cut.	Relocating three houses. Extra Burdon on existing services i.e. transport, health, etc

5.5 CONCLUSION

Pakistan is facing chronic shortage of energy since its inception. With the passage of time the gap between demand and effective capability of the power stations is widening. WAPDA is trying to fill the gap by installation of thermal power stations with steam and gas turbines as well as combined cycle units. The power generation at these stations is not environmentally friendly and generates harmful emission. Pakistan is endowed with hydroelectric potential available along rivers and irrigation system and it is very crucial to use these clean resources of energy for the development of the country. It can be concluded that the weakness and threats outweigh the strengths and opportunities of NO Project option and therefore no project option is rejected.

In other three options the alternative routes of the proposed power channel was considered. The environmental and social impacts of options 1,2 and 3 are quite similar. However, option 3 allows generating about 4 to 5 MW more than option 1 and 2, which could make a notable difference in respect of positive economical impacts on the area. More land acquisition will require under option 3 but is not agricultural land and impact is mitigable. The overall cost of the project may be on higher side of option 3 but the positive environmental, social and economical impacts significant. The positive impacts outweigh the weakness and threats of option 3 therefore the option is recommended for the detail studies.

6
IMPACT ASSESSMENT, MITIGATION AND ENHANCEMENT MEASURES

6. IMPACT ASSESSMENT, MITIGATION AND ENHANCEMENT MEASURES

This chapter identifies the potential impacts of CJ Link Tail Hydropower Project on the physical, biological and socio-economic aspects.

6.1 POTENTIAL IMPACT SOURCES

Environmental impacts and social impacts attributed to the Project can be broadly classified into three main groups

- Impact during design phase
- Impacts during construction phase
- Impacts during operational/post construction phase

Some of the impacts can be anticipated and avoided at design stage with appropriate adjustment in the Project Design some can be mitigated by good implementation technique and other by following the operational manual.

6.2 IMPACTS ASSOCIATED WITH THE DO NOTHING SCENARIO

This act would result in no production of power supply and result to wastage of available natural hydraulic head at the tail end of CJ Link canal. The no action option would also have a significant negative impact on the regional economy.

6.3 IMPACTS AND MEASURES ASSOCIATED WITH THE IMPLEMENTATION OF THE PROJECT

The following impacts are anticipated in case of the implementation of the Project

- The project will not have any significant adverse impact on the environment other than on a result of increase in noise and dust levels and movement of the additional machinery and traffic.
- There will be no major loss or damage to livelihood. Temporary employment to the local communities will be given. This will be a significant positive impact.
- The project area is free from the historical monument so there is no impact on such component.

- As far as tree cutting is concerned. The survey of the existing tree on site shows that 56No. of trees will required to be cut on site (see figure 6.1) for execution of work.
- There will be no impact on the aquatic ecology of the canal and river as seasonal flow regime will remain almost unchanged.

Potential adverse environmental impacts of selected work scheme on physical, biological and socio-economic environment have been identified, measures to mitigate these impacts and their residual impact are discussed below.

Environmental impacts can be broadly classified into three broad categories: a) impacts during Design Phase, b) impacts during construction Phase c) impacts during operation/post construction. The potential impacts can be avoided during planning, design, implementation or construction and execution of the Project. Environmental Management Plan (EMP) is useful to address the impacts during design, construction and operation/post construction period.

Potential impacts of the proposed Project under design, construction and operational phases have been studied under following categories.

(i) Physical Environment
- Land Resources
- Hydrology and Water Resources
- Air Quality
- Noise level

(ii) Biological Environment
- Flora
- Fauna
- Fish
- Endangered species

(iii) Culture and Heritage

(iii) Socio-economic

Table 6.1 summarized evaluate the environmental and social impact assessment of the Project. The generalize land use of the Project is shown in Figure 6.1.

Table 6.1 (sheet 1): Evaluation of Environmental & Social Impacts

Evaluation of Environmental and Social Impact of CJ Link Hydropower Project

Category	Impact Assessment		Impact									
			Slight			Moderate			Significant			NES PAK ICS
			1*	2**	3***	1*	2**	3***	1*	2**	3***	
1. Design Phase												
	1.1	Water logging the adjacent area							/			
	1.2	Limitation developed due to silt deposit at upstream the canal							/			
	1.3	Damage to ecology							/			
	1.4	Damage to fish							/			
	1.5	Adverse Social Impact							/			
	1.6	Impacts of Retrogression				/						
2. Construction Phase												
Physical Environment Land Resources	2.1	Site Location of Labour Camp & Batching Plant					/					
	2.2	Waste Disposal					/					
	2.3	Quarries & Borrowing Area					/					
	2.4	Road Bridge Construction		/								
	2.5	Damage to Paths, Access Roads and Cross Drains					/					
	2.6	Impacts of Crushed Stone Transport					/					
	2.7	Contamination from Diesel and Other Spill etc from Machinery					/					

* Avoidable through design
** Mitigation through contractor's obligation or by communities through social framework agreement (SAF)
*** Non-reversible, Permanent change (to be adopted)

Table 6.1 (sheet 2): Evaluation of Environmental & Social Impacts

Evaluation of Environmental and Social Impact of CJ Link Hydropower Project

Category	Impact Assessment		Impact								
			Slight			Moderate			Significant		
			1*	2**	3***	1*	2**	3***	1*	2**	3***
2. Construction Phase											
Physical Environment	2.8	Drinking Water & Wastewater					/				
Hydrology and Water Resources	2.9	Impacts of Electrical/Mechanical Work		/							
	2.10	Impact of Extended Canal Closure		/							
	2.11	Source of Water for construction activities		/							
Air Quality	2.12	Impacts of Batching Plant on Air Quality					/				
	2.13	Smoke from Burning of Waste material or Burning Firewood		/							
	2.14	Impact on Air Quality from Road Bridge Construction Activities					/				
	2.15	Impact on Air Quality of Earth work Activities		/							
Noise	2.16	Noise Pollution from Construction Activities		/							
Biological Environment Flora	2.17	Labour Camp & Batching Plant Impacts on Biological Resources					/				
Terrestrial Fauna Fisheries	2.18	Impacts from Construction Activities of Power Channel					/				
Endangered Species	2.19	Impacts from Wastewater disposal		/							

* Avoidable through design
** Mitigation through contractor's obligation or by communities through social framework agreement (SAF)
*** Non-reversible, Permanent change (to be adopted)

Table 6.1 (sheet 3): Evaluation of Environmental & Social Impacts

Evaluation of Environmental and Social Impact of Construction of Islam Barrage

Category	Impact Assessment		Impact								
			Slight			Moderate			Significant		
			1*	2**	3***	1*	2**	3***	1*	2**	3***
2. Construction Phase											
Socio Economic	2.20	Land Acquisition		/							
	2.21	Social Impact on Local Population due to Migrating Labour from other Part of the Country					/				
	2.22	HIV/AIDS and other Communicable Diseases					/				
	2.23	Tourism		/							
3. Post Construction											
Monitoring and Evaluation as per Operational Manual and Monitoring Plan	3.1	Strict application of the prescribed O&M plan							/		
	3.2	Continous evaluation of design efficiency							/		
	3.3	Environment Annual Audit							/		
	3.4	Regular Maintenance							/		
	3.5	Continue Public Consultation				/					
	3.6	Refresher courses for the operational staff				/					

* Avoidable through design
** Mitigation through contractor's obligation or by communities through social framework agreement (SAF)
*** Non-reversible, Permanent change (to be adopted)

ENVIRONMENT STUDY AREA PORTION

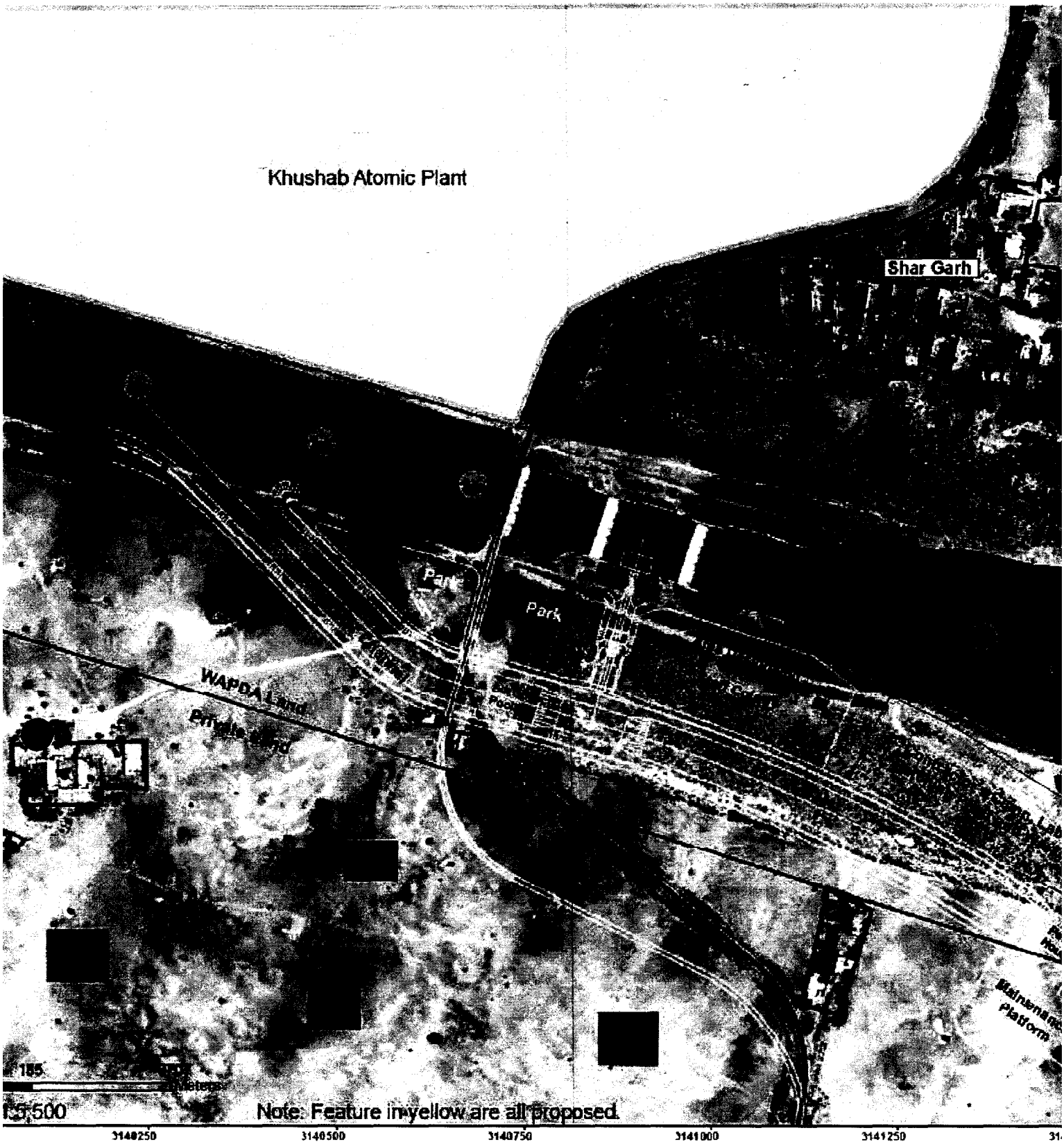


Figure 6.1: Environment Study Area Portion

6.4 DESIGN PHASE

6.4.1 Water Logging the adjacent area

Adverse Environmental Impacts

CJ Link Canal is an earthen canal and has direct impact on groundwater level through the seepage of the canal water. During the early times of the canal operation a water logging issue was raised along the middle and tail reaches of the canal. To reduce the menace it was considered to that trimmed off the tail regulator crest to reduce the maximum water level in the canal. The first stage of knock off of 3 feet was completed in August 1981 and dropped the maximum water level in canal to approximately 600ft.a.sl. from 606ft.a.s.l. A study was conducted in 1984 by WAPDA to observe the channel behavior after knocking off the crest of the tail regulator. It was concluded in study that water logging problem was solved by stage one trimming of crest of tail regulator and there is no requirement of stage two trimming.

The proposed work scheme should be carefully designed to avoid any raise in maximum level of canal water and subsequently water logging issue, during construction and operation phase.

Mitigation Measures

- Maximum water level of CJ Link canal considered in design calculation should not be more than 600ft.a.s.l.
- Any temporary work (cofferdam or sheet pile etc) design for execution of the work should not raise the water level of the canal above 600ft.a.s.l.

6.4.2 Reduction in Discharge Capacity Due to Silt Deposit

Adverse Environmental Impact

Because of the diversion of canal water to power channel the phenomena of siltation could happen at upstream of canal. This would reduce the discharge capacity of the canal.

Mitigation Measures

Design the work with care, including temporary work, to maintain the minimum flow in the canal and avoid any siltation.

6.4.3 Damage to Fish

Adverse Environmental Impact

Power generating turbine could damage the fish in the attempt to migrate from river Jhelum to Link Canal.

Mitigation Measures

A physical barrier should be installed to stop fish swimming into the powerhouse.

6.4.4 Retrogression Erosion

Adverse Environmental Impact

Accompanied by pulsating Hydraulic jump, damage to canal bed and upstream floor of the tail end regulator.

Mitigation Measures

Undertake detail analysis of Hydrological and Sedimentation impact by a competent person to confirm no-erosion no-deposit condition maintain during and after completion of proposed work scheme.

6.5 CONSTRUCTION PHASE

Construction phase of the project can be divided mainly on following activities.

- Labour Camp
- Batching Plant & Material Storage Yard
- Road Bridge
- Barrage Structure Repair Work
- Increasing Embankments Height and Construction of Wetting Channel

6.5.1 Physical Environment

6.5.1.1 Land Resources

Site Location for Labour Camp & Batching Plant

General:

The project will attract large number of skilled & unskilled labour. It is a principal contractor's responsibility to build a contractor's camp to accommodate the contractor's employee near

the construction site. The camp should be a permanent structure so it can be used by other institute e.g. Irrigation, WAPDA, Police, tourism, education, Defense forces etc, once the construction phase of the project is completed.

The camp will include but not limited to the following items.

- Mosque
- Welfare facilities
- Leisure facilities
- Waste water treatment / disposal system
- Waste containment area

Adverse Environmental Impact:

About 5 acres of land will be requiring for the construction of labour camp. There will be cost application if the land acquired from the private land owner.

Mitigations Measures:

- The camp should be located in the Government (WAPDA) Land in the close vicinity of the construction site.
- A recommended location for the camp within the WAPDA's land is indicated on Figure 6.1.
- Maximum unskilled labour and where possible skilled labour should be arranged locally.

Waste Disposal

Adverse Environmental Impacts:

The waste not handled properly could cause nuisance and diseases. Domestic waste contains high percentage of readily degradable hydrocarbon which on decomposition release bad smell and leachate of high BOD, especially in hot and humid environment, which could contaminate the adjacent land. Construction waste classified as inert waste which could be a problem to dispose of.

Mitigation Measures:

- All the waste generated at Labour Camp and site offices should be collected and temporarily store at the designated bonded area within the labour camp.
- The area should be prepared, maintain and visually inspected on regular basis by the principal contractor to make sure the adjacent land is not contaminating with dumped waste.

- It is a responsibility of Principal contractor to arrange the waste collection from the temporary waste storage area with local authority or waste disposal cooperation on regular basis.
- Construction waste should not be mixed with domestic waste as the construction waste could be recycled (e.g. packing waste etc) or use as a fill material (e.g. crushed concrete, brick pieces etc).
- Implement resource conservation and recover recyclable waste e.g. paper, steel cane, glass bottles etc from the collected waste and divert the filtered waste to the area landfill site. This will reduce the total volume of waste need to dispose off at the Landfill site or disposal site.
- Encourage all future residential developments in to participate in the existing curbside recycling and yard waste collection programs.
- Provide a burning pit on site where the combustible waste could be burn. The recommended dimension of the burning pit in feet are 15 x 12 x 4 (length x width x height)
- The detail waste management plan is included in chapter 8.

Residual Adverse Impact:

- The area for temporary storage of waste will attract the animals and cause the foul smells in the surrounding area.

Impacts of Earth Work

Adverse Environmental Impact:

Significant amount of work of soil excavation from the proposed location of power channel and it surrounding will be required. Other activities of the work mainly based on balance cut and fill. The excavating activities could place significant impact on environment including soil erosion, drainage problem, existing structure stability and health and safety of the workers.

Mitigation Measures:

- Quarrying and cutting land is not likely to be requiring in this project. If is needed a controlled methods of cutting and blasting shall have to be adapted to mitigate the negative impacts anticipated in such activity.
- If cutting and blasting of stone undertake on site then it is a Contractor's contractual obligation to carry out the cutting and blasting of stones in a highly controlled manner. The Contractor will mark the anticipated danger area and will keep the public away during such operations by evacuation procedures.

- The Earth required for revamping of retired embankment and other works would be used out of the available excavated soil during power channel construction. When earth is required to be lifted from private owners land, then the owner(s) would be compensated for temporary hire of land and crop (if apply) by the contractor. Social Frame Work Agreement will be completed by the contractor
- The contractor should not leave the borrow pits or dumped area in such a condition that they are unstable and filled with rain water and cause the problems for the community.
- Ensure that selected borrow areas and areas for dumping excavated soil are clearly demarcated, including the allowed depth of the excavation or height of dumped, before starting any soil removing/dumping.
- No soil removal or dumping should be undertaken from private land.
- The edges of the pits should be given flat slopes and area should be leveled as far as possible.

Residual Adverse Impact:

- Excavation and earth movement activities will generate the dust and affect the air quality of the surrounding area.

Road Bridge

Adverse Environmental Impact:

A road bridge will be constructed on Khushab - Muzaffargarh road at the junction of proposed power channel and relocated road, as shown in figure 6.1. The land along the proposed bridge location will be acquired to execute the construction activities and possibly providing the temporary route for the road traffic during construction activities. Relocating the length of the Khushab-Muzaffargarh road will involve acquiring of private land.

Mitigation Measures:

- The adjacent land on both side of the road at the suggested location of the road bridge belongs to WAPDA, however certain length of the existing road, need to be relocated, falls in private land. Minimum private land should be acquired to undertake the work.
- The private land owner should be compensated for land and crop (if apply).
- Principal contractor should provide a temporary route during the bridge construction.
- The temporary route should be adequate for the existing traffic plus the site traffic and designed and build by a specialized contractor.

- The rural roads leading to or passing near the construction site could be used to convey men and materials to the construction sites.
- It is a Contractor's contractual obligation to use the roads and paths carefully and in case of any damage, repair the damaged roads or paths.

Damage to Paths, Access Roads and Cross Drains

Adverse Environmental Impact:

Local transportation infrastructure could be damage through carelessness of the heavy machinery drivers/operators. Such carelessness can cause considerable damage to paths, road and drains if the drivers/operators are not made aware, trained and bound to be careful.

Mitigation Measures:

- An effective signology should be in place to reinforce the instructions to the drivers for example maximum load limit, type of vehicle allowed, speed limit etc to avoid any physical damages of the roads and paths.
- It is a Contractor's contractual obligations to impose strict control over operators and drivers of all types of vehicles.
- Should any damage take place due to the project activities, the contractor must be bound to carry out the repair immediately.
- Enforce the maximum speed limit for site traffic to 20 km/hour.

Impacts of Crushed Stone Transport

Adverse Environmental Impact:

Stones shall be brought from Sargodha District or Margalla hills. So, no quarrying has to be done locally. But the vehicles carrying the stones shall exert additional traffic load on the roads leading to the project area. By keeping the road dust free and repaired even the slight impact shall stand mitigated.

Mitigation Measures:

- It is a Contractor's contractual obligation to use the roads and paths carefully and in case of any damage, repair the damaged roads and paths immediately.

Graveyard and Burials

No graveyard is identified within area of influence (AIO). However if unrecorded graveyards and/or burials are found during the courses of construction activities, the supervising agency

will contact and work with local religious authorities within the immediate Project area to allow for possible identification of the remains and where appropriate, properly undertake relocation and burial.

Contamination from Oil & Diesel and other Spill from Construction Machinery

It is inevitable and may exceed the maximum permissible limit. The dumping site will be permanently damaged along with allied physical, biological and social losses. This impact is mitigable through effective application of the maximum spill regulations. General criteria for oil and breakage at construction sites, as per standards set forth by "Oil Spill Contingency Plan of PKP Exploration Ltd." And "Guidelines for Oil Spill Waste Minimization and Management" issued by International Petroleum Industry Environmental Conservation Association" as follows:

(i) Minor Spills

Soil contaminated by minor spills/leakages (defined as leaks from vehicles, machinery, equipment or storage containers such that the area and depth of soil contaminated is less than one (1) sq.ft and three (3) inches respectively) is to be scraped and send to a burn pit (incinerator).

(ii) Moderate Spills

Moderate spills are defined as spills of volume less than or equal to 200 liters. These are to be contained and controlled using shovels, sands, absorbing mat and native soil. These equipments and materials are to be made available at camp sites during the operation (Spill Kit). The contaminated soil will be excavated and send it to the treatment site such as bioremediation or solidification/stabilization (S/S). The excavated area will be lined with an impermeable base before fill with clean soil.

(iii) Major Spills

Major spills are defined as spills of volume much greater than 200 liters. This would require indication of Emergency Response Procedure and Oil Spill Contingency Plan to be prepared by the Contractor in consultation with the Engineer. These spills are to be handled and controlled by a specialize contractor to clean the site.

Mitigation Measures:

- All the oil based material should be stored in the designated bounded area.
- Spill Kit should be available on site to handle the small spill on site.
- Good house keeping will minimize the accidental drip or spill.

- All loading and unloading of material should be supervised and carried out with appropriate plant.
- Empty drums of the fuel should be handle with care as some material may left over in the drums or container.
- All the liquid material or fuel should be stored well away from any control water source, river or wetland etc.

6.5.1.2 Hydrology and Water Resources

Drinking Water & Wastewater

Adverse Environmental Impact:

Pumping groundwater from the major aquifer for water supply for the labour camp shall neither cause any significant change in the groundwater reservoir, nor in the river and canals which recharge it. The impact can be considered as slight and mitigable. The contractor should tap the underground reservoir and install hand pumps or tube wells with overhead water tank to supply drinking water to the labour and workers at appropriate pressure. As the groundwater on site could find as shallow as 3m depth at some places of the site, there is a possibility that shallow groundwater not fit for human consumption.

It is envisaged that a considerable value of wastewater will be generated from labour camp. There are plenty of examples of successful systems of using wastewater for agriculture. Domestic wastewater is expected to be contaminated with pathogens. Many factors affect the degree to which the potential risk due to the presence of pathogen in wastewater can become actual risk of disease transmission and pose a risk to health of consumers and workers (farmers). The following conditions are therefore recommended to be satisfied.

1. Either an infective dose of an active pathogen reaches the field or pond or the pathogen multiplies in the field or pond to form an infective dose.
2. The infective dose reaches a human host.
3. The host become an infected
4. The infection causes disease or further transmission.

The risk merely a potential if condition (4) is not satisfied.

Mitigation Measures:

- It is the responsibility of principal contractor to test and confirm the suitability of the groundwater before its supply to the contractor camp.

- The depth of the extraction well should be increased until the quality of ground-water meets the WHO standards, the guidelines are included in Appendix 2.
- Four main measures are recommended to be considered to protect health, wastewater reuse, wastewater treatment, crop restriction, control of waste waster application and exposure contract and promotion of hygiene of those waste water treatment.
- It is the responsibility of the principal contractor to set up a suitable and appropriate wastewater collection and disposal system.
- Method and level of treatment of waste water obviously depend upon the anticipated use of effluent. In the view of expected use of treated water for agriculture purposes, treatment at primary level will be cost effective. It is therefore proposed that waste stabilization ponds or underground septic tank with bypass arrangement for rainwater be provided in the labour camp with about three days storage capacity of waste water.
- If the waste water discharge into the control water body i.e. river, canal, groundwater etc then it is a contractor obligation to confirm the effluent meets the NEQS level. Provision of underground septic tank is a preliminary treatment and reduce the total suspended solid concentration (TSS) to the acceptable level however it may not reduce the BOD level up to the required level. Therefore it is suggested to provide the aeration treatment of the effluent (if require) to meet BOD level before discharge into the river or canal. Aeration can be achieved from number of treatment methods including mechanical aeration, providing steps in the open channel, aerobic stabilization pond (maximum depth up to 4feet) etc. The selection of treatment method depends on the availability of space and initial concentration of the BOD.
- The treated sewage should be tested on regular basis and confirm the NEQS levels are met before it is pumped into the river, canal or used for agricultural purposes.

Residual Adverse Impact:

- It is envisaged that in the long run of pumping groundwater for water supply system will have some adverse effects on groundwater quality of the area in terms of salinity.
- Bacterial removal with three days retention of wastewater in stabilization pond will only be sufficient to reduce but not completely eliminate the risk to consumers of vegetable crops. Crops restriction will therefore be essential.
- Stabilizing pond could cause the ordour and nuisance problems of the surrounding area.

- Consistent and higher rate of groundwater pumping will drop the groundwater level locally and could affect the water quality of existing hand pumps and tube wells.
- Drop in groundwater level will accelerate the seepage from the link canal, which means losses in available discharge for power channel.

Impacts of Electrical/Mechanical Work

Adverse Environmental Impacts

The type of soil found on site is loss to medium dense sand and major aquifer which is very permeable. The depth of groundwater is as shallow as 5m from ground level therefore any accidental spill of hazardous material could contaminate the groundwater very quickly and subsequently damage the river environment.

The work may also involve of building the temporary structure like **cofferdam, scaffolding** etc. Failure of the temporary structure could cause the serious injuries or fatality and pollute the control water.

Mitigation Measures

- All temporary structure should be designed and build by a specialized contractor.
- The temporary structure should be approved by a competent person before its use.
- Daily Inspection should be carried out of work area before the start of every working shift.
- Good house keeping should be maintained to avoid any accidental spill or falling objects in to the canal.
- Oil based material should be kept in bunded container.
- Electrical equipment should be handled with extra care.
- Provide proper PPE (personal protected equipment) for all the workers as a precaution against any mishap, and interlink various parts of the construction complex.

Impacts of Extended Canal Closure

Adverse Environmental Impacts

Canal closure could adversely affect the groundwater and water quality from existing hand pumps and tube wells along the canal. However during the site visits it has been observed that the people living within the Project area do not use the canal water for drinking purpose.

There is an off take of about 25m^3 of water from link canal by Khushab Atomic Power Plant at about 2km upstream from the site. Canal closure could impact the power production from the Atomic Plant.

Mitigation Measures:

- The work should be planned and schedule such that the canal closure may be avoided.
- Caffordam or sheet piling can be mounted to ensure the canals running during the execution of work.
- The saline groundwater area along the link canal is indicated in figure 4.7. The people living in this area will be the most vulnerable in case of any accidental extended canal closure. The sufficient and suitable water supply will be arranged by the Principal Contractor for the affecties in the form of water tank or pipe line from other area during the extended canal closure period.

Source of construction Water

Ordinarily the canal or tubewell water is suitable for construction work. If it is obtained from any other private source, it must be compensated.

Contractor could use canal water as a source of water for construction activities, sprinkling on kacha path for dust control and for vehicle washing purpose.

Groundwater could be used for drinking water supply. The contractor should tap the underground reservoir and install hand pumps or tubewells with overhead tank to supply drinking water to the Labour Camp and site workers. Drawing water for drinking from aquifer shall not cause any significant change in the under water reservoir, nor the river and canals which recharge it. The impact can be considered as slight and mitigable.

Mitigation Measures:

- Contractor's contractual obligation to pay for water obtained from private source.
- Contractor's contractual obligation to supply running tap water, flush latrines and wastewater disposal system near the camp. It should be ensured that wastewater should not be discharged into the river or canal system without achieving the NEQS level.
- All the wastewater generated from the vehicles washing and construction activities should be tested and ensure that the disposal should not put any adverse environmental impacts.

6.5.1.3 Air Quality

Batching Plant

Adverse Environmental Impact:

From previous work experience, it has been observed that the emission from the batching plant can be very harmful for the site worker and the local population. The emission could cause skin disease e.g. skin rashes etc. The plant will raise the traffic level around the plant area and dust may be the issue because of heavy traffic.

Mitigation Measures:

- It is recommended that the **Zero Emission Plant** should be set up for this project. This will include using washed aggregate and enclosed cylose with automatic injection system of material in to the mixing chamber.
- Recently a zero emission plant has been established and working successfully at Jinah Barrage power project.
- Air quality should be monitored on regular basis near the plant.
- The plant should be located at least 200m away from any major living area.
- The plant should not be operated outside the working hours.
- Water sprinkling should be carried out on regular basis during the operational phase to control the dust pollution.

Residual Impacts:

- The Plant's traffic might leave some adverse impacts on road works in the area.
- Deprivation of the air quality.
- Although the recommended plant consists on enclosed cylose the plant activities will generate some dust especially in consistent dry weather.

Smoke from Burning Of Waste Material or Burning Firewood

Adverse Environmental Impacts

A large number of big and small fires in the labour camp can produce smoke and smog which can cut off visibility, reduce traffic ability and cause suffocation along with causing diseases of respiratory tract.

6.5.1.3 Air Quality

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- The plant should be located at least 200m away from any major living area.
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- Although the recommended plant consists on enclosed cylose the plant activities will generate some dust especially in consistent dry weather.

Smoke from Burning Of Waste Material or Burning Firewood

Adverse Environmental Impacts

A large number of big and small fires in the labour camp can produce smoke and smog which can cut off visibility, reduce traffic ability and cause suffocation along with causing diseases of respiratory tract.

Mitigation Measures:

- Contractor's contractual obligation to use clean and smoke free fuel in the labour camp.
- Cutting and burning trees or shrubs for fuel shall be prohibited.
- Gas Cylinders should be used in the labour camp for cooking purposes.

Road Bridge

Adverse Environmental Impacts

Air quality could be depreciated due to the construction activities.

Mitigation Measures

- Regular spraying of water should be undertaken to minimize the dust pollution.
- All vehicles, machinery, equipment and generators used during construction activities will be kept in good working condition to minimize the exhaust emissions.

Earth Work

Adverse Environmental Impacts

Excavating activities will generate dust and pollute the surrounding area. The emission from the plants use in earth work activities will also degrade the air quality of the site.

Mitigation Measures

- Regular spraying of water should be undertaken to minimize the dust pollution.
- All vehicles, machinery, equipment and generators used during construction activities will be kept in good working condition to minimize the exhaust emissions

6.5.1.4 Noise

Power Channel construction

Adverse Environmental Impact:

Currently the ground level at part of the proposed power channel location is well above the design bed level of the channel, therefore significant amount of excavation work will require executing. The marked difference in the ground level is due to the fact that at time of the construction of CJ Link, the excavated material was dumped on site. However the top 3 to 4 m consist on uncompacted fill which will not require powerful machinery for excavation. The part of the power channel passes through the wildlife game reserve area, as shown in figure

6.1. The game reserve area is a heaven for many rare species of migrated birds. Noise generated from the plant & equipment during the construction phase will adversely impact the natural habitat of many wildlife species of the area.

Mitigation Measures:

- Suitable equipment and plant should be used to execute the work to minimize the noise pollution.
- All vehicles, machinery, equipment and generators used during construction activities will be kept in good working conditions and properly tuned and maintained in order to minimize the noise emission and minimum land disturbance.
- It is a contractor's obligation to stop unnecessary movement of traffic and worker in game reserve area.
- All working activities should be restricted within the allowed working hours.
- Enforce the maximum speed limit to 20km/h for vehicles using embankments and access road.

Residual Adverse Impact:

- Movement of the site traffic and tree cutting will generate some noise.

6.5.2 Biological Environment

The anticipated biological impacts can be on the following:

- Damage to Flora
- Damage to Fauna
- Damage to Endangered Species
- Damage to Fish

The bird life in general shall be benefited by extension of the water body through link canal system.

Endangered species have been reported in the Project area including occasional sitting of Chinkara and Baz.

6.5.2.1 Labour Camp & Batching Plant

Adverse Environmental Impacts

About 10 acres of land will be acquired to build a Labour Camp & Batching Plant. Some tree cutting may also require for the construction purpose. Natural habitat of the game reserve area would be under the threat of new development (Labour Camp & Btching Plant).

Mitigation Measures

- The location of the camp should be selected such that the minimum cutting of trees are required. The suggested location for labour camp and batching plant will not require any tree cutting.
- The outside boundary of the camp should be fenced or walled for security reasons.
- 24 hours security should be provided by the contractor at Labour Camp and Batching Plant.
- It is contractor obligation to ensure that unnecessary and out of bound activities/movements are not done outside the campus allotted to him for setting-up the labour camp, material depots and machinery yard.
- No fire arms are carried by any of the worker.
- All forest, wildlife and fisheries laws are fully respected and abide by the Contractor and his work force.
- Limits and norms of wildlife game reserve are fully respected and implemented.
- Necessary sign boards are displayed to make labour, visitors and members of public to remind them of their obligations towards Biota.
- Inspection by wildlife, forest and fisheries officers are facilitated in camps to facilitate a proper implementation of relevant laws.

6.5.2.2 Construction of Power Channel

Adverse Environmental Impacts

The approximate total numbers of trees need to be uprooted for the power channel construction is 56, as shown in Figure 6.1. Part of the channel located inside the game reserve area which accommodates many rare species of migrated birds and local wild life. There is a risk of destruction of the natural habitat of the area due to the noise and dust generated from the movement of site traffic and work activities.

Mitigation Measures

- It is recommended that the minimum cutting of the trees should be undertaken in executing the work.

- Every tree cut on site should be replaced with the plantation of minimum two new trees.
- All vehicles, machinery, equipment and generators used during construction activities will be kept in good working conditions and properly tuned and maintained in order to minimize the exhaust emission and minimum land disturbance.
- Communities are given awareness and are involved in proper protection of the Biota inside and around the Project side.
- No unauthorized tree or bush cutting should be allowed. Should it be necessary, it must not be done without permission of the "The Engineer" and follow the change management process.
- If possible nests of bird be shifted to other nearby trees.

Residual Impacts

- Nests of some of the birds shall be destroyed when the trees and bushes are cleared along the proposed power channel.

6.6 SOCIO-ECONOMIC IMPACTS

The overall impacts of the Project on social and economic activities in the project area will be positive. About 32 acres of private land will be required to acquire in this project. The adverse environmental impacts and their mitigation measures are discussed as follow:

6.6.1 Land Acquisition

Adverse Environmental Impacts

Land acquisition will require undertaking the work activities including power channel construction, access road, Labour Camp, Batching Plant, work base area and Contractors Camp. Most of the land need to acquire belongs to WAPDA. Private land owner and livelihood of the concern people could adversely affect due to the land acquisition.

Mitigation Measures

- Maximum Project activities require land acquisition should be planned within the WAPDA land. All the private land acquires must be compensated for land value and crop value (if apply). A Social Framework Agreement should be completed and signed by all the concern parties.
- Shifting allowance will be calculated and granted to the affecties living on WAPDA's Land.

6.6.2 Adverse Social Impact on Local Population

Adverse Environmental Impacts

There is a risk of adversely affecting the social life of local population due to the arrival of huge number of labour from outside the area. Extra burden on the local infrastructure e.g. medical facility, shops, restaurants, mosque, public transport etc. is also anticipated.

Mitigation Measure

- The outside boundary of the camp should be fenced or walled for security reasons.
- Locating a labour camp at least 500 m or ideally 1 km away from the villages or major build up area (local settlement).
- Leisure facilities including play grounds, restaurant etc should be provided inside the labour camp.
- All the unskilled labour and where possible skilled labour should be arranged locally.
- The camp should be located within WAPDA land, such that there is no any private land acquisition require for this activity.

6.6.3 HIV/AIDS and other Communicable Diseases

The Labour Camp, their interaction with truck drivers and alike personnel are potential places for spread of HIV/AIDS if the incidence exists. Majority of the people living in the surrounding of the Project, and potential labour are not aware of the source, mode of communication or consequences of HIV/AIDS. Although their religious and cultural value system, to a large extend exclude the outbreak or rapid communication of HIV/AIDS, yet its occurrence in such a situation cannot be precluded. It is necessary that along with other communicable diseases like Cholera, Typhide and Tuberculosis, awareness and preventive campaigns are run from time to time in the Labour Campus and the field offices of the Project on Communicable diseases.

Mitigating Measures:

The Contractor shall:

- Put up temporary but prominent sign boards all of the Project activity area warning people against likely hazards which can be caused due to certain activities.
- Arrange to run a proper campaign the labour camp, to make people aware of the cause, mode of transmission and consequences of HIV/AIDS.
- Strengthen the existing local health & medical services for the benefit of labour as well as the surrounding villages.

- Ensure proper cleanliness and hygienic conditions at labour camp by ensure a clean mess, proper drainage and suitable disposal of solid waste. Inoculation against Cholera will be arranged at intervals recommended by Health Department.
- Keep all the camps, offices, material depots, machinery yards and work site open for the inspection of health and safety measures, and related documents.

6.6.4 Positive Social Impacts of the Project

The economic analysis shows high economic benefits compared to costs. Salient economic benefits of the project are:

- Availability of electricity of surrounding villages
- Improved service area and opportunities for employment, education, healthcare, especially for women and children shall improve.
- Employment during construction phase shall employ and train large number of unemployed youth. They will receive a life time benefit through skill training, capacity building and poverty alleviation. A large number of semi-skilled and unskilled workers in the project area will be hired.
- Greater awareness about Healthcare including HIV/AIDS and Hepatitis amongst the labour and the local community shall be created.
- At micro level, economic activities may bring the cost of living down by making essential commodities available in greater bulks and at cheaper rates. This combined with better employment opportunities will bring poverty line rate lower.
- The new public park will raise the aesthetic values of the area and will provide a picnic spot to local community.

6.7 OPERATIONAL AND MANAGEMENT (O&M) PHASE

At operational phase of the proposed Project a comprehensive Operational and Management Manual (O&M) shall be prepared by Project Manager at the completion of the work as per ISO Standards. An effective Monitoring and evaluation has to be done as per O&M and monitoring plan. Mistakes at operational level or handling the operations by untrained staff can prove very risky and costly. Important points to be attended at operational stage are as follows:

(i) Develop comprehensive O&M Rules
(ii) Strict implementation of prescribed Environmental Management Plan (EMP).
(iii) Continuous evaluation of design efficiencies and water level monitoring

(iv) Understanding and training of staff on Operation and Maintenance Manual
(v) Annual Environmental Audit
(vi) Regular maintenance of engineering works
(vii) Continued public consultation and feed back on it
(viii) Continued attention towards gender issues and women consultation
(ix) Irrigation system to run up to its design capacity and not beyond
(x) Refresher Training Courses for operational staff.

7

PUBLIC CONSULTATION AND INFORMATION DISCLOSURE

7. PUBLIC CONSULTATION AND INFORMATION DISCLOSURE

This chapter describes the public consultation process. The consultation was conducted with different stakeholder groups that may be affected by the Project according to the World Bank Operational Policy (OP 4.01).

A stakeholder is any person, groups or institution that has an interest in the Project. This definition includes intended beneficiaries and intermediaries, winners and losers and those involved or exclude from decision – making process.

Objective of the consultation of stakeholder is to get participation both institutional players and services users.

A set of meetings were held with the local population from different occupation. The local community was briefed about the Project activities and their point of view regarding the environmental & social impacts were recorded.

7.1 MEETING WITH LOCAL AND REGIONAL OFFICIALS

A series of meetings were held with local and regional officials (see the list of officials contacted in table 7.1)

Meetings with officials provided multiple and diverse objectives such as

- Provided a forum for the initial definition of critical environmental and social issues.
- Established their interpretation of the key sector development issues and linkage confirmation of the environmentally sensation sites like game reserve area etc.
- Planning of field work.

Table 7.1: List of Officials Contacted

Sr. #	Official Name	Title	Phone #
1	Gulam Yasin Yasir	Assistant Director Fishery Johra Abad	0300 6080782
2	Khalid Mahmood	Wildlife District Officer	0300 6058674
3	Dr. M Azaher Javed	Assistant Land Reclamation Officer	042-9250181
4	Abdul Jabar Memon	Director SMO	
5	Rizwana Anjum	Deputy Director SEMU	042-9250183
7	Miss Azma Khan	Manager Conservation WWF	
8	Miss Sadia	Research Associate WWF	

7.2 MEETINGS WITH PUBLIC MEMBERS

In second phase of public consultation member of public and their representatives were consulted to introduce the Project formally to the local community and take on their opinion about the Project.

Table 7.2: Member of Public Contacted

Sr. #	Name	Occupation	Phone
1	Muhammad Zafar	Bail Dar, WAPDA	0301 7673720
2	Muhammad Jabar	Employee at Atomic Power Plant	0325 6896830
3	Syeed Nur Muhammad Shah	Assistant Medical Officer	
4	Muhammad Bakhesh Kalo	Game Warden, wildlife	0301 5692365
5	Muhammad Rafiq	Private Driver	03004700882
6	Ghulam Muhammad	Security Guard	
7	Tariq Pervaz Malik	Principal DPS Joharabad	0300 8115677

Objectives Achieved with the Public Consultation

- Confirm that people living along the Link Canal do not use the canal water for drinking purpose.
- Eliminate the scare that the canals will remain closed during the execution of work. It was clarified that due measures will be taken that canals would run as per usual program.
- No change would ordinarily be made in existing capacity of canals during construction phase, so no any adverse impact is anticipated in the surrounding area of the canal. It was explained that project is aimed to produce electricity and very important for the country development.
- It was clarified that all the private land and properties acquire for this project will be compensated.
- Social Action Plan and /or resettlement plan (if require) will be prepared and any affecties because of the Project activities including encroachers, squtters, will be facilitated accordingly to the above plan.
- Eliminate the fears that the large number of workers and labour will be brought by the contractor from outside the project area and ensure them that an opportunity of employment generated by the project shall be availed by the people of the area.
- It was clarified that no access roads or public paths damage or alter because of labour camp, material depot, machinery yard etc.

- It has been ensured to the local community that maximum employment will be offered to the local labour/workers.
- Fishermen of the community believe that the construction activities would not put adverse effects on fishing industry as the fishing activities is prohibited within 100feet of ongoing construction activities at the canal. The Project activities schedule within half kilometer of upstream and downstream of the Link Canal Tail regulator.
- Question was passed by the community that presence of large number of male members of labour from general locality of project will not only restrict the chances of women employment, but also cause moral and social problems for the free movement of local women folk in the area. It was clarified that strict discipline would be exercised on the labour force by providing stringent clauses in the contract document. To cull out the possibility of any moral issues or HIV/AIDS spread, a well organized campaign shall be run.
- Road and kacha paths within the project areas would expose to the heavy traffic due to Project activities. This could raise the road accident and deteriation rate of the roads. It was clarified that due sinology and traffic management plan would be put into operation to minimize the impacts.
- With arrival of additional persons in the area, the price of accommodation in project area and surrounding towns and villages would go up, and price index would go unfriendly for the local villagers. It was clarified that a Labour Camp will be constructed to accommodate the maximum number of workers. It was also explained to the local community by same trade oriented people that instead of rise in price those would fall because larger market activities reduce the profit margin and price.

The following points came up in open acceptance of the project.

- Greater employment opportunity was most welcome.
- Greater economic activity will alleviate poverty.
- Additional production of electricity in result of completion of this project will emplace positive impacts on local and country economy.
- Present level of services i.e. electricity, communication, schooling, water supply etc. is likely to improve.
- New Public Park will attract visitors and tourism in the area and put positive effects on the local economy.

Plates 7.1: Public Consultation

7.3 SOCIAL FRAMEWORK AGREEMENT (SFA)

A Social Frame Work Agreement (SFA) will be signed through mutual open consent between the local village leaders and designated official of I&P Department. At least two confirmed leaders/elders will be chosen from each of the villages situated adjacent to the area were constructions activity would take place. These leaders/elders will constitute a villager's Committee and they will choose a Chairman from among themselves. The SFA shall be signed by an official from I&P Department and by the Chairman of villager's Committee. SFA shall be drafted on the lines of legal agreements signed between two parties and should preferably be on a stamp paper to be provided by I&P Department at the project cost. All the mitigation measures where reference to SFA has been made in the Environmental Management & Monitoring Plan (EMMP) shall be included in the SFA. The I&P Department obligations and affecties social obligations shall be listed separately. SFA shall be considered as a natural follow up of the public consultation and public hearing and an indication that I&P department and the local people are mutually facilitating the project. Following draft SFA is suggested.

Social Framework Agreement

1. This is a Draft Social Framework Agreement between an official representing the Irrigation and Power Department (Wapda Department), Government of Punjab and the villagers' Committee, whose names have been inscribed below in their presence and full consent.

Sr. No. of Village	Village	Name (Two from each Village)	Father's Name
1.			1.
			2.
2.			1.
			2.
3.			1.
			2.
4.			1.
			2.
5.			1.
			2.
6.			1.
			2.
7.			1.
			2.
8.			1.
			2.
9.			1.
			2.

2. We the committee of village leader/elders have agreed unanimously to nominate _____ S/O _____ as our Chairman and authorize him to enter into an SFA with Wapda on our behalf. We understand and pledge that this SFA will be a binding on us and Wapda throughout the currency of the construction work as well as the operational phase.

   Signatures or Thumb Impression (TI) of the Chairman and the Members of the Villagers Committee.

Sr. No.	Name	Signatures/TI
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

3. By mutual consent it is agreed the Wapda Department

   i) Shall not occupy any agriculture land or acquire any other land during the construction of the project.
   ii) Shall not cause any damage or reduction in the water supply in the canals during the construction period of the project, except in case of force majeure e.g. high floods, strong storms or any other act of God
   iii) Shall not cause any disturbance to the wildlife sanctuary, archeological heritage or a place of worship
   iv) Shall not interfere in the social political or tribal balance of the area.
   v) Shall wherever possible, facilitate better services and supplies to the area e.g. schooling, health, awareness on epidemic diseases, HIV/AIDS, electricity and road/rail communication

4. Also, by mutual consent it is agreed that all the villagers residing in the area influencing project (name of the villages listed in para 1 above), collectively and severally:

   i) Shall not interfere in the location of labour camps, material depots, equipment yards and all the approach roads to be used during project construction phase, all of which will be located on the lands of I&P department

ii) Shall not interfere if the Wapda department decides to shift the construction of works elsewhere on a more suitable site as long as the activity remains on I&P department's own land

iii) Shall not receive any discharge of water slurry or oil spills to any graveyard or archaeological site

iv) Shall not cause any damage to wildlife or forest resources of any wildlife sanctuary and no villagers will be involved in killing, poaching or illegal hunting

v) Shall not allow reduction or official interference in our existing services and facilities e.g. education, health, electricity, drinking, water supply, religious and social congregations

vi) Agree that in case the contractor wishes to obtain some material from the private lands or wishes to make use of any piece of land outside the I&P department land that would invoke a new agreement between the villagers and the contractor and Wapda department or Govt. of the Punjab shall not be involved in that in any way

vii) Agree to respect and observe the cautions on the signed boards displayed by project authorities and shall not remove or cause to be removed any signboards or installations put up by Wapda or their representatives

(Add more conditions if required as per the prevailing circumstances).

This SFA has been signed this _____ day of _____, at _____

Signatures	Signatures
Resident Engineer (Full name and address)	Chairman Villagers' Committee (Name and Address)

Counter signed

Signature
Designated Official of WAPDA, Punjab
(full name and address)

7.4 PUBLIC HEARING

The place and time will be announced in the press and through local publicity methods e.g. personal contacts, beat of drums, announcement on mosque loudspeakers fifteen days before the Public Hearing of the Islam barrage Rehabilitation Project. Director EPA Punjab will chair the meeting representatives of all relevant Departments of District Government, members of the press, the representative of Irrigation & Power Department, local formers and any person interested in the welfare of the project area joined the gathering.

The discussion should include but not limited to the following points and the replies should be registered after completion of the hearing:

Topic	Replies
Obstruction of flow of Canal and Jhelum river during construction phase which may cause drainage problems	
What is the need of a wildlife game reserve? Why local fish, birds and animals are being refused to locals?	
The connection between water logging of surrounding area and water level in the Link Canal.	
Source of Drinking water and confirmation its suitability.	
What is the guarantee that the local labour would not be ignored?	
Will presence of large number of labour and constructing new hydropower plant improve the road net work?	
State never makes mistakes. It is expected that all social values shall be duly conserved.	
Problems related to operational phase of hydropower plant.	
Will water fowl, flora and fauna of wildlife and game reserve site would be disturbed due to partial closure of canal during construction?	

Appropriate answers were provided by satisfied the people the Irrigation and Power Department to all above questions.

7.5 PUBLIC DISCLOSURE

The Public Hearing should be carried out as explained above and copies of EIA will be placed at the office of EPA Punjab, at the Project Site i.e., C-J Hydropower Project office and the Punjab Public Library Lahore so as to be accessible to project beneficiaries, local NGOs and general public.

7.6 EPA APPROVAL

The EIA report will be submitted to the HK Consortium for a view and after incorporating the comments the report will be submitted to EPA Punjab for obtaining No Objection Certificate (NOC). A cheque of Rs. 30,000.00 will be raised by the consultant and submitted to EPA through HK Consortium for conducting a Public Hearing. The approval from EPA (NOC-No Objection Certificate) for the Project is mandatory requirement before commencing the work on site.

8
ENVIRONMENTAL MANAGEMENT PLAN

8. ENVIRONMENTAL MANAGEMENT PLAN

This chapter comprises a detailed Environmental Management Plan (EMP) for the project. The EMP will propose an effective and plan of action that will indicate responsibilities and required measures to minimize the negative environmental impact at various stages of the project.

Present study is of detail design level and the Environmental Management Plan (EMP) will be further refined when detail design is completed and Tender/Contract Documentation are prepared. Following sections describe the Environmental Management Plan for the Project. It has been discussed under three main components:

- Mitigation Plan
- Monitoring Programme
- Institutional Arrangements

Most of the mitigation activities proposed in the EMP will be assured under provisions in the construction contract and necessary agreement with the communities.

8.1 MITIGATION PLAN

The mitigation plan includes measures to mitigate potential negative impacts and enhance its positive impacts during initial physical works and normal operation of Irrigation System. These are summarized in this section and later are given in a comprehensive EMP wherein, under the institutional arrangements a "Check List" has been provided assigning responsibilities for the implementation and monitoring of EMP.

8.1.1 Mitigation of Adverse Impacts at Design Phase

Majority of negative impacts can be avoided (eliminated) through the use of adequate and environmentally sound technical design. Usually the planners find a compromise somewhere in between to adjust with available finances. The Project has however been designed on the basis of the lessons learnt from similar projects and major design initiatives undertaken to avoid any major negative impacts are as follows:

1. Necessary measures should be taken to exclude any big deposits or erosion of soil or debris anywhere.
2. Improve the aesthetic value and Flora & Fauna of the site by developing a park on site.

3. Ensure the Project activities during construction and operation phase would not raise water level of the canal and cause the water logging in area of influence (AOI).
4. As far as possible appropriate indigenous technology and knowledge has been utilized while planning and designing the project.

8.1.2 Mitigation Adverse Impact at Construction Phase

There are specific measures required to be taken by the contractor and the proposal for monitoring contractor's compliance/performance during construction phase, to reduce the potential impacts of physical works.

The contract document will contain requirements for:

(i) Proper management of construction waste.
(ii) Control measures for waste fuel.
(iii) Reduction of oil/lubricants, spill or leakage, noise and dust level.
(iv) Rehabilitation of areas used for construction detours and sites used for temporarily storage of construction materials.
(v) Proper use and maintenance of equipment with appropriate noise and smoke abatement.
(vi) Restoration of borrow areas (whether on state land or private land).
(vii) Other requirements as obligation of the contractor emanating from the Mitigation Plan and the EMP.
(vii) Specific provisions will also be included to make it mandatory to use formal health and safety measures including protection against HIV/AIDS and Hepatitis. Group insurance measures to minimize accidents and avoiding fatalities during the construction process.
(viii) Advisory element to address a number of other issues will also be included in the contract. These will include:

↕ Road Closure

For transporting construction material or conveying heavy machinery to the site, the rural roads passing near or through village(s) may have to be closed temporarily and access of public for certain period may have to be blocked. The dates, timings and duration of such period will need to be agreed with authorities and communities.

↕ Cultural and Historical Resources

Communities shall be requested to identify in the field, all known sites of cultural and historical value that may be affected by the Project, for protective actions by the contractor.

- Archaeological Field Support

  The Government of the Punjab will make available (on demand) a qualified archaeologist to conduct field investigations when important search work and new material sites area opened. No such site is yet in view but just in case it does, the services of archeologist will be obtained.

- Graveyard and Burials

  If unrecorded graveyards and/or burials are found during the courses of construction activities, the supervising agency will contact and work with local religious authorities within the immediate Project area to allow for possible identification of the remains and where appropriate, properly undertake relocation and burial.

- Local Employment

  The contractor is advised that unskilled labour and skilled masons/mistries/ stone workers are easily available from local communities as and when required. There is no obligation to hire local labour but it is desirable that maximum employment benefits are made available to local communities.

- Land Acquisition and other Compensations

  During the community consultation, in the Project area, it was made clear by the communities that they would expect due compensation, if their buildings, trees or land were affected or destroyed during construction activities or any of its allied structures. Social Action Plan will be prepared separately to address the social impacts of the Project.

- Resource use Agreement – Construction Materials

  Earth is available in the form of fill material at the location of proposed power channel. Stones are available from District Sargodha and Margalla hills. Yet there may be a need for additional agreement with public to obtain certain materials. In that case the farmland should be given the last priority in procuring the fill material when inevitable, however, due compensation should be paid. Whenever the borrow pits are dug, considerable care should be taken in their location. The site may invariably be rehabilitated after use. Ideal situation would be that the site is made good to a condition similar to that prior to the project. It will be helpful if photographs of pre-project condition are used for the purpose of comparison.

- Resource Use Agreements – Water

  Although ample quantity of groundwater is available in the Project area, yet the contractor will be required to confirm the quality and demand detail and indicate source of water prior to the start of construction. Disposal plan for waste water without

polluting the land, clean waters or ambient air, shall be produced by the contractor for approval of The Engineer/Project Director.

8.2 MONITORING PLAN

Monitoring Plan is an essential component of the Environment Management Plan (EMP). Implementation of the EMP shall be the contractual obligation of the Contractor. For that the Contractor shall engage full time technical staff capable of carrying out the suggested measures under of the EMP as contractual obligations under the contract agreement. The engineering supervision team shall also have a full time professional level Environmental Expert to provide an overall professional cover to the environmental monitoring process and the procedures and initiate required reports and point out any gaps in the implementation of the mitigation measures or enforcement of the measure of the EMP. Environmental unit (EU) under Principal Contractor will Monitor and Evaluate (M&E) application of environmental measures at detailed design, bidding and construction stages. The result of M&E activities will be included as routine element of reports prepared by the Project Manager.

The Parameters, frequency, responsibility and mitigation measures for monitoring have been described in comprehensive Environment Monitoring Management Plan (EMMP) describe in section 8.10.

It is also anticipated that additional inspection will be required in response to any complaints by local communities. So another two visits per quarter may be budgeted for M&E Units. All officers concerned with M&E shall prepare their own M&E Implementation Plans for information of all concerned. All M&E units shall be given optimal mobility and flexibility to implement their M&E implementation plans.

8.3 INSTITUTIONAL ARRANGEMENT

8.3.1 Management Responsibilities

Overall responsibility for environmental management will rest with Principal Contractor.

i.	The Executing Agency	:	WAPDA
ii.	Supervising and Monitoring Agency	:	Environmental Unit under HK Consortium (Principal Contractor) on regular basis.
iii.	General Assistance to all above agencies in their	:	The Project Director, WAPDA will facilitate communications, logistics and data collection

	respective tasks		as and when required.
iv.	Logistic Support	:	The Project Director, I&P Department shall provide the logistic support and shall be the focal point for the construction activity.

(i) The Executing Agency

Executing Agency for the Monitoring Plan will assume overall responsibility for ensuring:

- That while executing the contract and undertaking the construction all environmental norms, regulations and requirements promulgated by Environmental Protection Council (EPC), Pakistan Environmental Protection Agency (PEPA) and Environmental Protection Agency (EPA) Punjab, with respect to the work site and adjacent areas are fully respected and implemented.

- Overall responsibility for implementation of EMP.

All mitigation and precautionary measures prescribed in EMP shall be implemented meticulously and well in time and duly reflected in the progress reports. Consulting Engineers and Environmental Specialist will assist and advice the Executing Agency in implementation of EMP. Executing Agency will ensure that the Contractor is complying with various clauses related to environment in Contract Documents.

(ii) Supervision and Monitoring Agency

- It is intended to create an Environmental Unit (EU) with in HK Consortium to monitor Project performance. The EU may consist of experts on Environment and Sociology along with their support staff. The function of this Unit will be a timely and sound execution of activities given in an acceptable sequence under the project.
- Post construction maintenance activities will be implemented in accordance with the Barrage Maintenance Manual and rules & regulation of those institutions which will be responsible for its Operation and Maintenance (O&M).
- The EU will function in coordination with the Consultants and will receive reports from Contractor on behalf of HK Consortium.
- EU will prepare and submit periodical Progress and Monitoring Reports to WAPDA as per their schedules. In this task they will seek assistance/ guidance from supervision Consultants as and when required.

(iii) Logistic Support

The Project Director shall provide or arrange the logistics including communication, transport and accommodation to all visiting persons/teams experts from any of the above monitoring units and shall coordinate with the contractor(s) to facilitate the visits/inspections. For all Monitoring and Evaluation activities in the field the Engineer's Representative shall act as a focal point.

8.3.2 Institutional Strengthening

A Project Monitoring Office (PMO) is proposed to be created to manage and monitor the Project during construction. As part of the PMO, an Environmental unit (EU) has been proposed. At operational phase a suitable recurring arrangements shall be made. Institutional strengthening activities will be necessary to facilitate implementation of the EMP. The staff of EU will receive training before commencing their full scale work. The EU staff will carry out in-house training on Environmental Management to technical staff and Contractor's staff. Exhibition 2 indicate the organizational structure for the environment management activities.

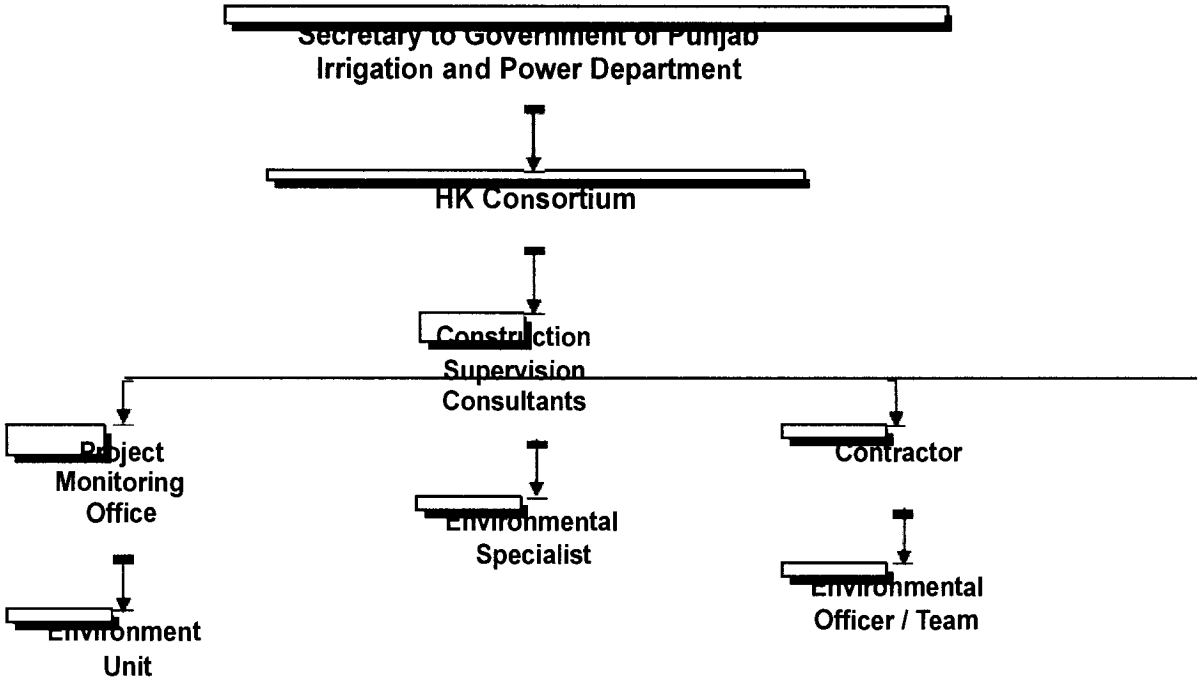

Exhibit -2: Organization Chart for Environment Management / Monitoring Implementation

8.4 CHANGE MANAGEMENT

An environmental assessment of the proposed project has been made at the time of EIA was prepared. However it is possible that change in project design may be required when the project is implemented. This section describes the mechanism for to handle Changes that might affect the project environmental impact. The changes in the project design may be:

First Order Change is one that leads to a significant departure from the project described in the EIA such change in location, design of the project. The project will be submitted to EPD for approval of change.

Second Order Change is one that is not significantly different from those described in the EIA such as;

Increase in project personnel by 25%

Changes in the documentation and communication, stakeholders consultation program

Third Order Change is one that is of little consequence to the EIA findings, such as;

Re-aligning a particular section of road to avoid cutting a tree

8.4.1 Changes in the EMMP

The possible categories of changes have been discussed above. The changes in the project design or result of the environmental monitoring may necessitate changes in the EMMP. In this regard the following actions will be taken:

Bidding between HK Consortium, contractor and consultants representatives

Based on the discussion during the meeting a change report will be produced collectively which will include the additional EMMP clauses

A copy of the report will be sent to the head offices of HK Consortium, the Contractor and the Consultants

All relevant project personnel will be informed of the additions. These additions will be reported in the Consultants monthly environmental reports.

Mid term review of the EMMP to review any changes that might affect the project environmental impact.

8.5 COMMUNICATION AND DOCUMENTATION

Communication and documentation is an essential feature of EMMP. The key features of such mechanism are:

8.5.1 Data recording and maintenance:

All forms to be used for recording information during the environmental monitoring will follow a standard format which will correspond to the data base in to which all the gathered information will be placed. Check boxes will be used as much as possible to facilitate data entry. Tracking system will be developed for each form.

8.5.2 Storage of information:

The database may include the following information

- Training programs;
- Staff deployment;
- Non-compliance;
- Corrective actions
- List of environmental data and
- List of environmental data to be maintained:
  - Soil and land pollution
  - disposal of excavated silt and earth
  - disposal of waste
- water resource
  - quality
  - quantity
  - fuel oil and chemical spills
- vegetation record
- record of wildlife
- Noise pollution
- Air and dust pollution
- Socio-economic data

8.5.3 Meetings:

The following environmental meetings during the project will take place

Kickoff meetings
Daily meetings

The purpose of the meeting will be to discuss the conduct of the operation, non – compliances noted by the consultant's environmental team and measures for their remedy. The meeting will be recorded in the form of a daily environmental report.

8.5.4 Reports

The Environmental Expert of the proposed EU shall produce periodical reports as well as inspection notes based upon the visits to the Project site. This information shall make a basis for EU for their further reporting or visiting the site. All reports shall be location and activity specific. The reports shall especially identify areas of contractor's non-compliance with the EMP and provide guiding remarks on actions to be taken. The significance of the non-compliance shall also be noted. Copies of these reports shall be sent to the Project Manager who shall forward them to the Resident Engineer, WAPDA and the Contractor for their action(s).

The Project Manager will include in his routine reports a summary status of activities relating to the EMP. Supplemental reports on issues should also be prepared as and when required.

The consultant's environmental team will produce daily, monthly, and annually reports, as well as a final report of the project based on the information collected. The list of distribution reports is given in **Exhibit-3**.

8.5.5 Photographic record of the project area:

This will include:
Identifying key locations for taking photographs
Using digital camera to photograph of the project area before the construction start and Recording the following information for each short on a form

- Short number
- Camera

- Name of photograph
- Date
- Time
- Featured photograph
- Other observations

Repeating the above after completion of all activities for selected location

8.5.6 Social complaints register:

The consultants ' environmental team will maintain a social complaint register at camp site office to document all complaints received from the local communities the register will also record the measures taken to mitigate these concerns. The final report will be communicated to EU.

8.5.7 Record Register:

A designated person should be kept updated records in site office. The results from environment monitoring and sampling program should be fully documented and recorded. The results will be available for inspection by the regulator, authorities and other concern parties on site. The record should provide the following quality assured monitoring and sampling information.

- Determinants monitored and sampled
- Specified details of measurements/samples to support analytical and QA requirements e.g. dates, times, location, other relevant parameters
- Results of measurements/sample analysis, with error limited.
- Interpretation and review of results against specified trigger level.

This will be maintained at a site to document any change in the project design as well. These changes will be handled through the change management mechanism if any. The final report will be communicated to Env.PMO

Exhibit-3 Periodic Reports

Report	*Timing*	*Prepared by*	*Reviewed by*	*Distribution*
Daily	--	Environmental team of the Construction Supervision Consultants	Reviewed by PMOEnv.	Resident Engineer HK Consortium
Monthly	--	Environmental team of the Construction Supervision Consultants	Reviewed by PMOEnv.	Resident Engineer HK Consortium
Annually	--	Environmental team of the Construction Supervision Consultants	Reviewed by PMOEnv.	Resident Engineer HK Consortium WAPDA EPD
Change Management	--	Environmental team of the Construction Supervision Consultants	Reviewed by PMOEnv. & EPD	Resident Engineer HK Consortium WAPDA EPD
Final	--	Environmental team of the Construction Supervision Consultants	Reviewed by PMOEnv.	Resident Engineer HK Consortium WAPDA EPD

8.6 WASTE DISPOSAL PLAN

This component describes the waste disposal plan that will be employed during the construction & operational period. The main types of waste to be disposed off will be:

- Waste generated during construction
- Fuel, oils, and chemicals;
- Sewage;
- Campsite waste ;
- Medical waste;
- Demolition waste; and
- Packing waste Excess construction material.

Domestic waste and construction waste will be the main type of waste generated from Labour Camp and construction activities. As there is not any demolition work involve in the scope of work, the volume of construction waste will be nominal. Domestic waste contains high percentage of readily degradable hydrocarbon which gives bad smell on decomposition, especially in hot and humid environment. Construction waste classified as inert waste which could be a problem to dispose off. It is recommended to collect the domestic waste and construction waste separately.

8.6.1 Domestic Waste

- All the waste generated at Labour Camp should be collected and temporarily store at the designated bonded area within the labour camp.
- The area should be prepared, maintain and visually inspected and recorded on regular basis by the nominated person from Principal Contractor.
- The waste storage area should be fenced to stop animal's direct contact with the waste. The site must be decontaminated to keep the building free from foul smells, spreading of diseases and healthy working environment.
- It is a responsibility of Principal contractor to arrange the waste collection from the Labour Camp with local authority or waste disposed cooperation on regular basis.
- Waste Chute should be provided within the Labour Camp. Chute will enable the collection of thrown solid in the covered storage site.
- Bags should be provided to the occupants and resident of the Labour Camp for collecting their waste.
- Implement resource conservation and recover recyclable waste e.g. paper, steel cane, glass bottles etc from the collected waste and divert the filtered waste to the area landfill site.
- A burning pit should be built on site to burn the combustible waste on site. The suggested dimension of the pit is 15 x 12 x 4 (length x width x height)

The waste disposal system is summarized in **Exhibit-4** below:

Exhibit-4 Waste Disposal Plan

Types of waste	Description	Operation phase	Disposal methods
fuel, oils, and chemicals spills contaminated soil or waste	Contaminated soil or water	All phases	Soil contaminated by minor spills / leakages (defined as leaks from the vehicles, machinery, equipment, or storage containers such that the areas and depth of soil contaminated is less than 1sqft and 3 inches respectively) will be scraped and sent to the burn pit (incinerator) where it will be burned along with other combustible wastes. Contaminated water will be dispersed with pressure. Moderate spills defined as spills of volume less than or equal to 200 liters will be contained and controlled using shovels, sand, and native soil. These materials and equipment will be made available at campsite and construction site during operation. The contaminated soil will be excavated and stored in a bonded area lined with impermeable base.

Types of waste	Description	Operation phase	Disposal methods
			Depending on the volume of the contaminated soil /water will be either disposed of by burning limited volumes of the soil in burn pit or by specialized treatment such as bioremediation or solidification/stabilization (s/s) Major spills of volume exceeding 200 liters will require the initiation of PMO emergency response procedures. These spills will be handled and controlled according to the specialized measures and special treatment as suggested by the spills removal experts.
Sewage and gray wastewater	Waste water from kitchen and washing areas, sewage	Construction / operation phase	Sewage to be disposed of using septic tanks and sock pits, solid residue to be disposed of in sewage treatment facilities in dg khan. waste water from kitchen and washing areas to be disposed of in sock pits
campsite waste	Animal, fruit or vegetable residue, domestic garbage	Construction / operation phase	Recyclable waste to be given away for recycling; non recyclable, combustible waste to be burned at burn pit and non combustible waste to be buried in designated landfill as agreed by PMO
Medical waste	Syringes, glass bottles, soiled bandages, expired drugs, dressing	Construction / operation phase	To be incinerated at nearby hospital incinerator, if any, or an equivalent facility
Workshop waste, and fluid waste	Used oil, ferrous /non ferrous materials, batteries, oil etc	Construction / operation phase	Collected by certified recycling contractor
demolition waste	Concrete, bricks, other building materials	construction / operation phase	Reusable material to be given away for use. remaining waste to be buried in designated landfill
Packing waste	Paper, plastic, textiles, cardboard, rubber, wood, glass, tin, cans, aluminum cans	Construction / operation phase	Combustible waste to be burned in burn pit, recyclable waste to be handed over to recycling contractors-
Excess construction material	Sand, aggregate, cement, bricks, reinforcement steel bars, paints and other construction materials	Construction / operation phase	To be sold back or given to the supplier or other users

8.7 GAME RESERVE MANAGEMENT

The common wildlife species find in game reserve area indicated on figure 6.1, a copy of the declaration by Wildlife Department is included in Appendix 3. As shown on the figure the

recommended location for the labour camp and batching plant are within the game reserve area therefore the Wildlife of the game reserve area will be under the threat of construction activities. Similarly workers will be under the risk from the attacks of dangerous animals. Wildlife Department issued the shooting permits on request. The shooting activities near the working area and Labour Camp could cause the serious accidental injuries or fatality.

8.7.1 Control Measures

Following control measures are suggested to manage the working activities within the game reserve area.

- It is strongly recommended that the shooting permit should not be given by the Wildlife Department for the area near the project site during the construction phase of the project for the safety reason and distraction of the workers from their tasks.
- The unnecessary movement of workers in game reserve area should not be allowed and minimized by the principal contractor, depending on the requirement of the work activities.
- All vehicles, machinery, equipment and generators used in execution of work will be kept in good working conditions and properly tuned and maintained in order to minimize the exhaust emission, noise and minimum land disturbance.
- Workers should not be allowed to carry fire arms with them within the game reserve area.
- A well equipped laboratory should be set up to safe and treat the workers from the bites of snakes and other poisoness insects.
- It would be worthwhile to prepare the area with suitable machinery before commencement of the detail work. The construction activity should be schedule keeping this in view.

8.7.2 Protection of Biological Resources

The Principal Contract will ensure that:

a) Unnecessary and out of bound activities/movements are not done outside the area agreed by "The Engineer" with him for setting-up the labour camp, material depots and machinery yard.

b) No fire arms are carried by any of the employees or labour.

c) All Forest and Wildlife Laws are fully respected and abided by the Contractor and his work force.

d) The Biodiversity is respected and saved on its terrestrial, aquatic and aerial habitats.

e) Necessary sign boards are displayed to make labour, visitors and members of public to remind them of their obligations towards Biota.

f) Inspections by Wildlife and Forest Officers are facilitated in camps to facilitate a proper implementation of relevant laws.

g) Communities are given awareness and are involved in proper protection of the Biota inside and around the Project site.

8.8 OUTLINE OF EMERGENCY-RESPONSE AND CONTINGENCY PLAN

If any of the results of the environmental monitoring / sampling exceed specified trigger levels for the determinant, the appropriate actions will be undertaken to prevent hazard to human life, property and the environment outside the operating site bounding control and minimize any immediate risks of pollution of the environments, ensure the immediate initiation of necessary investigation and management actions to identify, mitigate and remediate the cause of the accidence. Initiate training and periodic testing when necessary. Exhibit 5 summarized the emergency environmental contingency plan

The probabilities of accident such as oil spills, accidental habitat destruction, water or air pollution are very low. However, such accidents can occur and overall environmental emergency response method may be used:

- Obtain an early warning of the emergency conditions so as to avoid adverse impacts on the environment.
- Safeguard personnel to prevent injuries or loss of life
- Minimize the impact of such event on the environment and facilities by mitigating the potential for escalation and containing of the hazardous.

It is a responsibility of the contractor to provide at least one First Aider during working hours.

8.8.1 First Aid Provider

First Aid Provider will perform the following duties.

i. Keeping all necessary first aid medicines and bandages in the first aid box at on site.

ii. Replace the medicines before their expiry dates to avoid any health hazard to the people.

iii. Provide first aid to the wounded person.

iv. Report any accident / incident to the environmental manager immediately for necessary action.

v. Call ambulance in case of any serious emergency.

An outline of an environmental contingency plan is shown in **Exhibit – 5**

Exhibit-5 Environmental Contingency plan

Step	Diesel spill	Chemical and Oil Spill
Alert / Mobilize	Alert emergency coordinator and team	Alert emergency coordinator and team
Initial action	Start log of event Determine appropriate strategy Notify PMO Notify relevant authority	Start log of event Determine appropriate strategy Notify PMO Notify relevant authority
On-going actions	If there is a containment breach, use earth moving equipment to construct ditch or berm to contain spill .Use pump / absorbent to recover the product. Reuse product if possible,	Start log of event Determine appropriate strategy Notify PMO Notify relevant authority
Stand Down	Once the incident has ended the emergency team and authorities will stand down and commence as full investigation	Once the incident has ended the emergency team and authorities will stand down and commence as full investigation
Waste disposal	Incinerate the collected product at a controlled –access area at the burn pit. Collect all contaminated soil and incinerate it at the burn pit.	Incinerate the collected product at a controlled –access area at the burn pit. Collect all contaminated soil and incinerate it at the burn pit.

8.9 ENVIRONMENTAL MANAGEMENT COST

8.9.1 Environment Monitoring Cost

Canal water should be tested on quarterly basis at the tail regulator during construction phase, installation of automatic gate operating system and excavation activities. Samples should be collected from upstream and downstream of the barrage during the operational phase. The approximate cost of monitoring 2 years during construction phase is Rs. 300,000.00. Dissolve Oxygen, pH and Electric Conductivity (EC) of the river water should be monitored on monthly basis the approximate cost of the equipment are

DO meter = Rs. 50,000.00
EC meter = Rs. 5,000.00
pH meter = Rs. 5,000.00

Groundwater should be tested at quarterly basis. Testing is also required at the start of the project before using the groundwater as a drinking water. The samples should be collected from all the sources of groundwater use for the water supply system on site i.e. hand pumps, tubewell etc. The approximate cost of monitoring the groundwater over 2 years of construction

phase is Rs. 300,000.00, this include 2 samples every three months, including upstream and downstream of groundwater from Project Site.

Air quality should be monitored on quarterly and when require basis at the upstream of the wind at work activity. The approximate cost of Ambient Air Monitoring over 2 years during construction phase is Rs. 125,000.00. Noise should be monitored on monthly basis. The approximate cost of the Noise meter is Rs. 50,000.00.

The all above monitoring should be analyzed and reported on regular basis. The cost of Report writing based on 2 man month of environment engineer is Rs. 100,000.00.

8.9.2 Social Impact Cost

Most of the project activities are schedule within the WAPDA land. However a part of the proposed power channel and relocating Khushab-Muzaffargarh road falls in private land. Social Action Plan (SAP) will be prepared to address the social impacts and their cost i.e. compensating private land owner and restoration of the livelihood of the affecties. Similarly shifting allowance is calculated and awarded to the squatter come within the working area.

The total social estimated cost is Rs. 1,000,000.00.

8.9.3 Training Cost

Training is considered to be an important part of environment awareness and all site management and work supervisors should undertake periodic training.

Principal contractor should arrange to run a proper campaign among the workers to make people aware of the causes, mode of transmission and consequences of HIV/AIDS.

Briefing should be given to all workers regarding the biological resources and game reserve area. It should be cleared to the worker that unnecessary and out of bound activities / movements are strictly prohibited in the game reserve area. No fire arms are carried by any of the worker.

All forest and fisheries laws should be explained and added by the workers.
The approximate cost of training the site managers and supervisors is Rs. 300,000.00. The cost includes 8 session of environment awareness course each cost Rs. 37,500.00.

8.9.4 Environmental Audit Cost

Environmental Audit should be carried out on regular basis by the independent consultant. The approximate cost of the Environmental Audit is Rs. 400,000/-. The cost includes two man months of environmental specialist and one man month of Sociologist.

8.9.5 Plantation Cost

Construction of proposed power channel (as shown in figure 4.8) will require some tree cutting. GIS technology was used to estimate the number of trees come within the proposed location of power channel. 56 numbers of trees were found within the proposed power channel location which will require cutting, as shown in figure 6.1. Therefore it is a responsibility of the Principal contractor to plant 112 new plants and look after them until their maturation. The approximate cost of the plantation along the channel is Rs. 5000/-.

It is proposed to plant 200 No. fruit trees, 200 No. woody trees and 200 No. of flower plants at Public Park location. The approximate cost of the above are Rs. 25,000/-, Rs. 10,000/- and Rs. 25,000/- respectively.

The total estimated cost of the plantation is Rs. 60,000/-.

8.9.6 Cost of Implementation of Emergency Plan

The cost of the Emergency Plan explained in section 8.10 should be included in the Bill of Quantity as rate only. Half million rupees should be allocated for the implementation of the Environmental Contingency Plan during construction phase if require.

8.9.7 Waste Disposal Cost

Daily production of domestic waste by contractor's camp on site is approximately 500kg. The approximate cost of disposal of domestic waste for 2 years of construction phase including the preparation and maintenance of the temporary storage area and burn pit is Rs. 500,000.00.

Specialize contractor should be hired to dispose off the special waste i.e. cement bags, clinical waste, electric batteries etc. The approximate cost of the disposal of special waste is Rs. 200,000.00.

8.9.8 Water Supply & Wastewater Treatment Cost

It is Contractor's obligation to install a new tube well with overhead water tank to supply drinking water to the site workers at appropriate pressure. The approximate cost for installing water supply system is Rs. 200,000/-.

It is proposed to treat the domestic wastewater generated from the labour camp should be treated with provision of three chamber Septic Tank connected in series. The capacity of each chamber should have minimum one day waste water discharge which is 100000 litres. The approximate construction and maintenance cost of the Septic Tank is Rs. 500,000/-.

Effluent should be tested and confirmed that the treatment meets with NEQS standard before use for agriculture purpose. The quarterly testing is recommended of the treated wastewater. The cost of testing is Rs. 150,000/-.

8.9.9 Site Visits by Authorities & Regulators

Inspections by stakeholder for example Wildlife and Forest Officers etc should be facilitated in camps to facilitate a proper implementation of relevant laws. The approximate cost of this item is Rs. 100,000/-.

8.9.10 Traffic Management Cost

The approximate cost of traffic management, including alteration of road layout, provision of temporary route during the bridge construction activities and appropriate signology is Rs. 1,000,000/-.

8.9.11 Extended Canal Closure Cost

Cofferdam and sheet pile methodology should be used to avoid the canal closure. However in case of the accidental extended canal closure the damages to the stakeholder or property should be quantified with the social survey conducted in affected areas and the compensation should be given to the affecties in terms of arrangement of alternative water supply, installation of tubewells etc. One million rupee should be allocated as a rate only in the BOQ for this item.

8.9.12 Public Park

The development of Public Park to raise the aesthetic value of the area is also included in this Project. The approximate cost of this item is Rs. 1,000,000/-.

8.9.13 Restoration Cost

The area being under the use of contractor during construction time should be restored at the completion of the project to the original level without any additional cost. However any additional improvement should be paid to the contractor for example converting kacha path into metal road etc.

Table 8.2: Environmental & Social Cost

Activity	Cost (Rs.)
Environment Monitoring Cost	904,000
Social Impact Cost	1,000,000
Training Cost	300,000
Environmental Audit Cost	400,000
Plantation Cost	60,000
Emergency Plan	500,000 (rate only)
Waste Disposal Cost	700,000
Water Supply & Wastewater Treatment Cost	850,000
Site Visits by Regulators & Authorities	100,000
Traffic Management Cost	1,000,000
Extended Canal Closure Cost	1,000,000 (rate only)
Public Park	1,000,000

8.10 ENVIRONMENTAL MANAGEMENT & MONITORING PLAN (EMMP)

The mitigation plan is a key component of EMMP. This section outlines the potential impact of rehabilitation works on the physical, biological, and socioeconomic environment and their associated mitigation measures as already identified in EIA report of the Chashma-Jhelum Link Canal Hydropower Project. It also assigns responsibility for implementing these measures. Now the guidelines for the implementation of mitigation plan indicated in EIA of the Project will cover:

- Lists of only those mitigation measures which will be directly covered by the environmentalist and not those mitigation measures which are covered under civil or mechanical work.

- The person(s) responsible for ensuring the implementation of the measures
- The person(s) responsible for the monitoring
- The parameters to be monitored for the effective implementation of measures
- A time scale for the implementation of measures to ensure that the objectives of mitigation plan are fully met

The Mitigation and Monitoring Plan for the activities likely to have a direct impact on the environment is presented in **Exhibit-6**

Compliance Monitoring:

Compliance with the requirement of EMMP will be checked by monitoring the activities of the contractor on daily basis by the environmental specialist of the consultants. The objectives of EIA compliance monitoring will be:

- Systematically observe the activities undertaken by the contractor in the civil and mechanical works.
- Verify that the activities undertaken are in compliance with the EIA and other conditions identify time to time by HK Consortium, WAPDA, Consultants and Donors.
- Document and communicate the observations to the concerned persons so the corrective action, if required, can be taken timely.
- Maintain a record of all incidents of the environmental significance and related action and corrective measures.
- Prepare periodic reports of the environmental performance for PMO.
- Develop an environmental issue tracking system for an effective monitoring and ensuring that all environmental concerns are identified and addressed in a timely manner.

The Environmental Management & Monitoring Plan will be used as a management and monitoring tool for compliance monitoring. Inspection will be done using checklists, samples of which are included in appendix 5. The remaining checklist will be developed by the environmental specialist of the Construction Supervision Consultants on the basis of mitigation plan. The responsibility of compliance monitoring is laid on all organizations such as HK Consortium, consultants and the contractor.

- EU will be environmental implementer / coordinator
- Environmental team of Construction Supervision Consultants will be field monitors

Exhibit-6 Mitigation and Monitoring Plan

Sr .#	Project component	Description	Measures /Actions	Responsibility		Paran Monit
1				Executor	Monitor	
	A. Land resources					
	Borrow materials from earth borrowing site.	**- Borrow Material:** Material to be used for the construction of the coffer dams will include silt for core filling, soil material for random filling.	1.1 Ensure that selected borrow areas are clearly demarcated before starting any soil removing and no soil removal is undertaken outside the demarcated area.	CEnv	CSCEnv PMOEnv.	Records boundar demarke
			1.2 Ensure that photograph are taken of the Borrow area	CEnv	CSCEnv PMOEnv.	Photogr records
			1.3 Ensure that the fill material take is restricted to specific limit.	CEnv	CSCEnv PMOEnv.	No work markers
			1.4 Ensure that the surface drainage is provided to control the surface run off during rainy season	CEnv	CSCEnv PMOEnv.	Control i Effective surface case of
			1.5 Ensure that the movement of lifting	CEnv	CSCEnv PMOEnv.	compliar

			machinery and vehicles is limited to the work area.		
			1.6 Ensure that Erosion protection measures are taken, such as retaining wall, avoidance of steep cut and fill	CEnv.	CSCEnv PMOEnv.	Visible s soil eros
			1.7 Detailed checklist for Management and Monitoring of barrow area will be Established	CEnv.	CSCEnv. PMOEnv.	A detail in check
			1.8 Ensure that the barrow area to be leveled and top soil restored	CEnv.	CSCEnv PMOEnv.	Photogr
			1.9 Ensure that complete documentation for the borrow areas used for the project will be maintained.	CEnv.	CSCEnv PMOEnv.	Records

2	**Construction of Road Bridge**	- A road bridge will be constructed on Khushab-Muzaffergarh road at the intersection of the road and proposed power channel . If the part of the road needs to be closed down to carry out the construction work then it is the responsibility of the main contractor to provide the suitable temporary alternative route.	2.1 Ensure that the traffic management plan prepared and must be implemented in order to control the traffic by the Contractor.	CEnv.	CSCEnv PMOEnv	Complia
			2.2 Ensure that the temporary rout should be adequate for the existing traffic plus the site traffic.	CEnv.	CSCEnv PMOEnv	Complia specifica
		-The general mobility of both local and residents and their livestock as well as the operators of residence business and their clientele in and around the construction area is likely to be hindered. -Unchecked speeding may cause human and livestock injuries and fatalities as a result of Highway accidents.	2.3 Ensure that regular water sprinkling must be carried out to control the dust pollution.	CEnv.	CSCEnv PMOEnv	Complia Records
			2.4 Ensure that the traffic sign board (speed breaker & speed limit) should be placed at least one Km from the diverting rout.	CEnv.	CSCEnv PMOEnv	Complia
			2.5 Ensure that the alternative route	CEnv.	CSCEnv PMOEnv	Complia

			should be designed on the basis of the traffic survey conducted by the contractor.			
			2.6 Ensure that mobility of the men and animal should not be hindered due to the construction activity.	CEnv	CSCEnv PMOEnv	Site Insp

3	**Site for Disposal of waste material of the coffer dam:**	- It has generally been observed that after construction is over the waste material is dumped at the site without proper planning. The material from the coffer dams may be of huge quantity. This needs proper disposal.	3.1 Ensure that the selected disposal site is demarked before starting the work	CEnv	CSCEnv PMOEnv.	Demarc
			3.2 Ensure that photographs are taken of the area	CEnv	CSCEnv PMOEnv.	Photogr
			3.3 Ensure that all trucks used for the transportation of waste construction material will be airtight and watertight	CEnv	CSCEnv PMOEnv.	System i
			3.4 Ensure that contractor obligation define in contract document and SFA are followed	CEnv	CSCEnv PMOEnv.	Complia
			3.5 Ensure that the movement of lifting machinery and vehicles is limited to the work area.	CEnv	CSCEnv PMOEnv.	Complia

		3.6	Ensure that soils properly disposed of in a manner that does not affect the natural drainage	CEnv	CSCEnv PMOEnv.	Complia
		3.7	Ensure dumping and leveling on site only as agreed in SFA	CEnv	CSCEnv PMOEnv.	Complet

4	**Installation of Batching Plant**	**- Land** **Requirement:** WAPDA will provide land near Project site to Establish batching plant. So no private land will require for this item.	4.1 Ensure that no private acquire to establish the batching plant.	CEnv	CSCEnv PMOEnv.	Complia
			4.2 Ensure that the batching plant has zero emissions and also the location of the batching plant must be at least 500 m from the village (local settlement)	CEnv	CSCEnv PMOEnv.	Complia specific
		- Land Contamination Land may be contaminating from concrete from the batching plant due to spill and during transportation and dumping of the waste concrete.	4.3 Ensure that land contamination from the batching plant, during transportation and dumping of the waste concrete will be controlled through careful working of the Contractor's crews to avoid spillage of fresh concrete and dumping of waste concrete on private land.	CEnv	CSCEnv PMOEnv.	System
			4.4 Ensure that Contractor will adopt good engineering practices to control	CEnv	CSCEnv MOEnv.	Compli

		land contamination.			
	- Raw material: Raw material for the construction of structure include cement, sand, aggregate, steel, water lubricants, fuel and additives. The material will be stock pilled at the area provided by WAPDA near the batching plant.	4.5 Ensure that leak /spill record is maintained for each vehicle and repairs done at the earliest. Leaking vehicles will not be operated unless repaired.	CEnv	CSCEnv PMOEnv.	Comp
		4.6 Ensure that the material should be stock and pilled at the area provided by WAPDA near the project site.	CEnv	CSCEnv PMOEnv.	Complia specifica
		4.7 Ensure that surface drainage should not block due to the pilling of the raw material.	CEnv	CSCEnv PMOEnv.	System
	- Wind direction While installing the batching plant the care of the direction of the wind should be considered.	4.8 Ensure that height of the pile should not exceed from specification.	CEnv	CSCEnv PMOEnv.	Complia specifica
	- Land Requirement: WAPDA has ample space where contractor camp and workshop will be	4.9 Ensure that the location of the batching plant should be such that the wind direction may be opposite from the	CEnv	CSCEnv PMOEnv.	Complia

		accommodated. There is high risk of affecting the social life of local population due to the arrival of huge number of labour from outside the area.	settlement			
			5.1 Ensure that no private land will be used to construct the contractor camp and workshop.	CEnv.	CSCEnv MOPEnv.	Complia
			5.2 Ensure that the location of the camp should be at a distance of 500m from the nearest local settlement.	CEnv.	CSCEnv PMOEnv.	Measure
5	**Contractor's Camp Location and Workshop.**		5.3 WAPDA will provide space near the site to establish contractor's camp and workshop etc.	CEnv.	CSCEnv PMOEnv.	Complia
			5.4 Ensure that photographs of camp site and other features are taken prior to any activity which will be used as a reference when restoring of site	CEnv.	CSCEnv PMOEnv.	Photogra
			5.5 Ensure that room size is as per standard	CEnv	CSCEnv PMOEnv.	Complia specifica

		specifications.			
		5.6 Ensue that washing areas are demarcated and water from washing areas and kitchen is released in sumps	CEnv	CSCEnv PMOEnv.	System
		5.7 Ensure septic tank of appropriate design are used for sewage treatment and outlets released into sumps	CEnv	CSCEnv PMOEnv	System
		5.8 Ensure that latrines, septic tanks, and sumps are built at a safe distance from water hole, stream, or dry streambed and the bottom of the sump is above the ground water level.	CEnv	CSCEnv PMOEnv	Complia
	- Utilities: Contractor will share with	5.9 Ensure that Sumps are: - In absorbent soil - Down –slope and away from	CEnv	CSCEnv PMOEnv	Complia specifica

	WAPDA for the facilities of water supply and electricity on payment basis.		the camp - Downstream from the camp water source and above the high watermark of any nearby water body (if any)			
		5.10	Ensure that effective drainage is in place at site	CEnv		System i
		5.11	Ensure that existing system may not be overstressed.	CEnv	CSCEnv PMOEnv	System i
		5.12.	If existing capacity may not cope with the demand in that case the contractor has to make separate arrangement.	CEnv	CSCEnv PMOEnv	complair
		5.13.	Contractor make assessment and carry out renovation /expansion works in	CEnv	CSCEnv PMOEnv	System i

		consultation with WAPDA. WAPDA to assist the contractor in this regard			
	- Disposal of Waste (water and solid) Unmanaged disposal of solid or wastewater generated by contractor's activities will contaminate land.	5.14 Ensure solid waste disposal: - Material suitable for recycling stored separately in three bin system and disposed off. - Combustible waste burnt at burn pit only - Non- combustible, non recyclable garbage sent to the designated landfill site in the specified area. - Medical waste transported to any hospital incineration plant - Solid residue from the septic tank will be transported to municipal sewage facilities at the nearest place - Contaminated soil sent to burn pit or	CEnv	CSCEnv PMOEnv	Waste d

			landfill.			
			5.15 Ensure wastewater disposal: - Ensure that waste water collected in the septic tank & sump is disposed off into water ways after its proper treatment	CEnv	CSCEnv PMOEnv	Complia System
6	**Relocation of Camps, Material and special approaches routes and roads.**	If private land acquire for these facilities; contractor obligations defined as per SFA agreement and contract documents	6.1 No specific action is required except that the contractor has to remain vigilant that the moving machinery should remain within the boundary of WAPDA Department land	CEnv	CSCEnv PMOEnv	Complia map
	Access Tracks	**- Land Requirement:** Construction sites are accessible through Khushab-Muzaffargareh road; tracks marginal bunds and guide banks, therefore no addition land will be required. However access tracks have to	6.2. All section of the access track that are prone to dust emission and where sensitive receptor are located within 500 m should be identified and marked on the map of the project area.	CEnv	CSCEn PMOEnv	Complia

	be constructed for batching plant and labour camps. **- Damage paths roads and linear fixtures crossed/damaged by moving machinery moving to and from the construction site:** Heavy traffic may damage the existing roads. Contractor will carry out necessary repair work.	6.3. Ensure that the access track which are prone to dust emission and marked on the map should be maintained by water spraying daily	CEnv	PMOEnv CSCEnv	Complia contract obligatio
		6.4 Ensure that gravel is dumped only on locations allowed by the Consultants and dumping of gravel does not result in blocking of traffic or damaging vegetation.	CEnv	PMOEnv. CSCEnv.	Complia
		6.5 Ensure that construction corridors along the access road is marked	CEnv	PMOEnv.	Complia drawing
		6.6 Ensure that the access roads does not block the natural drainage and culverts are constructed where necessary	CEnv	CSCEnv. PMOEnv.	Complia
		6.7 Ensure that surface run-off controls are installed and maintained so as to	CEnv	CSCEnv. PMOEnv.	Control i

		minimize erosion			
		6.8 Ensure adherence to the speed limit of 30 km/hr at the access road	CEnv	CSCEnv. PMOEnv.	Control ir
		6.9 Ensure that construction corridor is monitored and repairs are undertaken where required	CEnv	CSCEnv. PMOEnv	Compliar contractu obligatior
		6.10 Ensure that vegetation clearing is minimized and no trees are uprooted without prior permission.	CEnv	PMOEnv CSCEnv.	Compliar EIA/EMM
		6.11 Ensure that cleared vegetation if any, is not disposed off in a manner that may affect the natural drainage	CEnv	PMOEnv CSCEnv.	System ir
		6.12 Standard safety procedures for handling explosive	CEnv	PMOEnv.	Compliar

			will be used to protect the staff, community and the environment		CSCEnv.	
			7.1 Ensure that the selected disposal site is demarked before starting the work	CEnv	PMOEnv CSCEnv.	Complia
			7.2 Ensure that photograph of area are taken.	CEnv	CSCEnv PMOEnv	Photogr
			7.3 Ensure that all the waste generated from different location must be disposed of according to the waste Disposal Plan.	CEnv	CSCEnv. PMOEnv	Photogr
7	**Waste Disposal Site.**	- This component describes the waste disposal plan that will be employed during the construction and restoration period. The main types of waste to be disposed of will be: ▯ Waste generated	7.4 Ensure that all trucks used for the transportation of waste construction material must be airtight and watertight	CEnv	PMOEnv CSCEnv	Waste D Plan
			7.5 Ensure that contractor obligation define in contract document and SFA are followed	CEnv	CSCEnv. PMOEnv	System SFA

		during construction - Fuel, oils, and chemicals; - Sewage; - Campsite waste ; - Medical waste; - Demolition waste; and - Packing waste, - Excess construction material.	7.6 Ensure that the movement of lifting machinery and vehicles is limited to the work area.	CEnv	CSCEnv. PMOEnv	Compli
			7.7 Ensure that contaminated soils are properly disposed off in a manner that does not affect the natural drainage.	CEnv	CSCEnv. PMOEnv	System
			7.8 Ensure dumping and leveling on site only as agreed in SFA	CEnv	PMOEnv CSCEnv.	Compli SFA
			7.9 Ensure that factious medical waste is disposed of after proper autoclaving or incineration.	CEnv	PMOEnv CSCEnv	Compli

8	**Land contamination due to spill of lubricants, fuel , chemicals and other waste material**	**- Construction Machinery:** The construction machinery including trucks, loaders/ dumber and batching plants will be used during the construction period. There are chances of contamination of the land due to release of contaminated effluents.	8.1Ensure that no contaminated effluent is released in the environment.	CEnv	CSCEnv. PMOEnv.	The em effluent handlec conforn EP Act with the standar Compli
			8.2Ensure that the maintenance of vehicle and other equipment takes place only in designated areas underlined with concrete slabs and a system to catch runoff, and that washing of vehicle is minimized	CEnv	CSCEnv. PMOEnv.	System
			8.3 Ensure rig wash and other potentially contaminated effluents are released in mud pit	CEnv	CSCEnv. PMOEnv	System
			8.4 Ensure that fuels, oils, and other hazardous substances are handled and stored according to standard safety practices such as secondary containment. Fuel tanks should be labeled	CEnv	CSCEnv PMOEnv.	Compli

		accordingly			
		8.5 Ensure that fuels, oils, and chemical are stored in areas lined by an impervious base and containing dykes.	CEnv	CSCEnv PMOEnv	System
		8.6 Ensure spills are avoided during fuel and oil transfer operations through appropriate arrangements, such as use of concrete base or drip pans,	CEnv	CSCEnv PMOEnv	System
		8.7 Ensure fuels, oil and chemical storage are daily checked for leakage	CEnv	PMOEnv. CSCEnv	Arrange place
		8.8 Ensure that shovels, plastic bags and absorbent materials, are kept available near fuel and oil storage areas.	CEnv	PMOEnv. CSCEnv	System
		8.9Ensure that refueling of vehicles is planned on daily basis to minimize travel and chance spills	CEnv	PMOEnv CSCEnv	System
		8.10 Ensure that operating vehicles are checked for any fuel, oil,	CEnv	PMOEnv CSCEnv	Arrang place

			or battery fluid leakage regularly			
			8.11Ensure that leak /spill record is maintained for each vehicle and repairs effected at the earliest opportunity. Leaking vehicles will not be operated unless repaired.	CEnv	PMOEnv CSCEnv	Syster
			8.12 Soil contaminated by minor spill (covering an area up to 0.1 m² and 75 mm² deep) will be collected and disposed at burn pit.	CEnv	PMOEnv CSCEnv	Record maintai
			8.13 Ensure that soil contaminated by moderate spills or leaks (up to 200 liters) is contained using shovels, sand and soil., The contaminated soil will be removed from the site and disposed off at landfill or burn pit as	CEnv	PMOEnv CSCEnv PMOEnv	Contra contrac obligati
9	**Agricultural land and crop destruction.**	- No agricultural land is involved anywhere in the project implementation. Sometimes such a	9.1 Ensure that damage to agricultural land should be avoided.	CEnv	CSCEnv PMOEnv	Compli

		situation may arise due to mistake of contractor's vehicle driver or labour. If there are chances of losses of crop in the project area it should be compensated.	9.2 If it is absolutely unavoidable, it must be dully compensated	CEnv	CSCEnv PMOEnv	Contrac obligati
10	**Any discharge or diversion of water to a graveyard or archeological site.**	- No graveyard / archeological site are found in the project area so no such situation may occur in the area.	10.1 If during construction such sites are found and discharge or diversion of water happened then it must be contractor's obligation not to let it happen.	CEnv	CSCEnv PMOEnv	SFA
			10.2 Solve the problem by collaboration with the communities as per social framework agreement. No action is required	CEnv	CSCEnv	Compli
11	**Electric & Mechanical Works.**	- Renovation of electric and mechanical installations of the Power House will be carried out in situ within WAPDA land so there will be no private land acquisition.	No action is required	----------	----------	----------

12	**Extended Canal Closure.**	- All the construction activities will be scheduled in such a way that minimum canal closure is required in normal canal closure and avoided extended canal closure. The canal is a link canal and does not supply water for agriculture or drinking purpose within the project area of influance. In case of extended canal closure there might be the following environmental impacts. - Deteriate the water quality of tube wells or hand pumps situated along the canal. - Effect on biodiversity and endangered	12.1. Ensure that the extended canal closure must be avoided. 12.2 Ensure that arrangements for the supply of drinking water in the saline zone area or people living along the canal well before in time in case of the groundwater quality is affected due to extended canal closure. 12.3 Ensure that there must be a provision in the contract and SFA to cover the extended canal closure. 12.4 Ensure that there must be a vigilant monitoring for any endangered species and water levels in the canal. 12.5 Ensure that a separate budget must be formulated in order to mitigate the social issues emerged during the	CEnv CEnv CEnv CEnv CEnv	CSCEnv CSCEnv PMOEnv CSCEnv PMOEnv CSCEnv PMOEnv CSCEnv PMOEnv	Complia Contract & SFA Complia Complia Contract contract obligatio

		species of migrated birds.	extended canal closure.			
	B. Water resources					
13	**Construction of Coffer Dams.**	**- Contamination:** Contamination of the river water from soil material during construction and removal of the coffer dams consequently affecting the aquatic life, particularly downstream fisheries. Good engineering practices will be applied to minimize contamination of the river water.	13.1 Ensure that soil material during construction of the coffer dam should not contaminate the river water so much which effect the aquatic life, particularly downstream fisheries	CEnv.	CSCEnv PMOEnv.	Complia
			13.2 Ensure that the soil material during removal of the coffer dam should not contaminate the river water.	CEnv.	CSCEnv PMOEnv.	Complia
			13.3 Ensure that contractor use good engineering practice to minimize contamination of the river water.	CEnv.	CSCEnv PMOEnv	Complia contract obligatic
		-Use of water: The contractor will require water for sprinkling the earth material for	13.4 Ensure that contractor keep the daily water use tanks record and also include in the monthly progress report.	CEnv.	CSCEnv	Complia

		compaction. For this purpose river water or canal water will be used. The quantity to be used will be small as compared to the water available in the river and canal. Consequently no significant effect is foreseen.			PMOEnv.	
14	**Rehabilitation of the Subsidiary weir & associated structure)**	**-Use of water:** Preparation of concrete at the batching plant would need water free from sediments and high salt concentrations, particularly sulphates. Ground water in vicinity of the river will meet this requirement. Therefore, the contractor will install tube well at the site to meet this requirement. Water may also be needed for curing the concrete. For this the	14.1 Ensure that pumping of the ground water will not effect the private or public tube well in the near vicinity 14.2 Ensure that contractor use the water free from sediments and high salt concentration for the preparation of concrete at the batching plant. 14.3 Ensure that waste water generated from the batching plant should not enter in the river or canal without any treatment. 14.4 Ensure that major portion of the pollutants	CEnv. CEnv. CEnv. CEnv.	CSCEnv PMOEnv. CSCEnv PMOEnv. CSCEnv PMOEnv. CSCEnv PMOEnv.	Compla Compli Compli Compli contrac

		contractor will use river water. **-Disposal of waste water:** Waste water generated from the batching plant will be loaded with cement and fine aggregate. Disposal of this water into the river will affect the water quality and consequently affecting the aquatic life.	should be removed through impounding before this is disposed off in to the river.			obligatic
			14.5 Ensure that Engineer to oversee that the contract clauses are complied by the contractor.	CEnv.	CSCEnv PMOEnv.	Compli
15	**Construction Camp & Workshop**	**-Water Consumption:** The contractor will need water at the camp for consumptive as well as for the use at work shop for washing and otherwise. This may be required from the existing resource available with IPD for the use at the colony or install a new tube well. The arrangement will be made in consultation with Consultant and	15.1 Ensure water consumption for domestic use is monitored at camp site and aquifer/well.	CEnv.	CSCEnv PMOEnv.	System
			15.2 Ensure that drinking water standard should be maintained while supplying water to the labour in the camp and also regular water testing and monitoring should be done.	CEnv.	CSCEnv PMOEnv	TDS/ E(Complia
			15.3 Ensure that community is compensated for the water if extracted from the community.	CEnv.	CSCEnv PMOEnv.	SFA

		PMO. **- Disposal of Waste water and other waste effluents:** The construct camp will generate wastewater from two sources, viz., residential area and workshop. Both the wastewaters will have different types of contaminants, i.e; former will contain human excreta while the latter will have oil and grease. Disposal of untreated waste water in to the river will pollute river water thus may effect the aquatic life.	15.4 Ensure that sewage and other waste effluents is handled to avoid contamination of surface and ground water 15.5 Ensure that contractor arranged wastewater treatment facilities separately for both type of wastewaters. .	CEnv. CEnv.	CSCEnv PMOEnv. CSCEnv PMOEnv.	
16	**Electrical & Mechanical Work**	Electrical and mechanical work of installations of the power house will be carried out in situ	No impact on the water resources	----------		----------

	C. Air Quality and Noise Pollution					
17	**Dust, smoke and other potential pollutants from construction machinery**	- A lot of machinery consisting of bulldozers, dumpers generators, Batching plants and vehicles will be used during the construction phase. This construction machinery will generate lot of dust, smoke and other potential pollutants in the air. Using strict standards for maintenance of construction's machinery and regular sprinkling of water the dust pollution can be minimized.	17.1 Ensure that all equipment, generator and vehicles used during the project are properly tuned and maintained in good working condition, in order to minimize the exhaust emissions	CEnv.	CSCEnv PMOEnv.	Gaseou rates fro generat key equ
			17.2 Ensure that the batching plant should be installed with zero emission.	CEnv.	CSCEnv PMOEnv.	System
			17.3 Ensure that dust emissions due to vehicular traffic are minimized by reduced speed, vehicular traffic minimized through good journey management and water sprinkling when required.	CEnv.	CSCEnv PMOEnv	Visible c Visible c of size c clouds
			17.4 Ensure that dust emissions at the construction sites are minimized by implementing good house keeping and sound management practices.	CEnv.	CSCEnv PMOEnv	System

			17.5 Ensure that periodic ambient air quality measurements /monitoring will be taken to assess the concentration of Carbon Monoxide (CO), Carbon Dioxide (CO_2), Nitrogen Dioxide (NO_2), Sulphur Dioxide (SO_2), Oxygen (O_2) and Particulate Matter / (PM_{10}) in the atmosphere.	CEnv	CSCEnv PMOEnv	Complia
18	**Smoke from burning of waste material or burning of firewood in the labour camp**	During the construction the labour will try to use the wood as fuel and also burn the solid waste in their camps. So it is the duty of the contractor to provide gas to the labour and not to allow them to use fuel wood.	18.1 contractor obligations is to provide gas to the labour camp and not allow them to use wood as fuel.	CEnv.	CSCEnv PMOEnv	Complia contract obligatic
			18.2 Ensure that all the combustible material should be burnt in the burn pit.	CEnv.	CSCEnv PMOEnv.	System
			18.3 Ensure that the quantity of waste burnt at one time is managed so as to minimize smoke emission	CEnv.	CSCEnv PMOEnv.	Maintair
			18.4 Ensure fuel consumed during project is monitored	CEnv.	CSCEnv	Complia

					PMOEnv	
19	**Noise from use of old or outdated other machinery**		19.1 Contractor obligation is to use appropriate and fit for purpose machinery 19.2 Ensure prohibition of use of vehicle horns near the health care units or game reserve area 19.3 Ensure that drivers are discouraged from keeping vehicles running in parking lots 19.4 Ensure that periodic noise measurements are undertaken to monitor noise level during day and night	CEnv. CEnv. CEnv. CEnv.	CSCEnv PMOEnv CSCEnv PMOEnv. CSCEnv PMOEnv. CSCEnv PMOEnv	Complia the cont Complia Complia Complia
	D. Biological Resources					
20	**Damage to biological resources during construction.**	- The west side of the project area has been classified as a game reserve area for all the wildlife species. All the construction activities	20.1Ensure that all routes are designed such that minimize vegetation loss and no tree fell, when aligning the access road	CEnv.	CSCEnv.. PMOEnv.	Comp

	are down stream and away from the protected area. Only the contractor will clear vegetation from the areas to be used for: - Borrowing soil material - Establishing Construction Camp - Erecting Batching Plant - Haulage Tracks Including Guide banks There are chances for cutting of trees/bushes by the crew for fuel.	20.2 Ensure that endangered plant/animal species (as quoted in EIA) and their habitat are protected. 20.3 Ensure fuel wood and shrubs are not used as fuel during construction or operation 20.4 Ensure camp waste/food waste is disposed off in such a way that animals are not attracted 20.5 Ensure that there is no open defecating in the vicinity of camps or construction site. 20.6 Ensure that no fire arms are carried by any of the employees or labour within Project AOI. 20.7 Ensure that safe driving practices is observed so that the accidental killing of human being and animals crossing the road could be avoided	CEnv. CEnv CEnv. CEnv. CEnv.	CSCEnv.. PMOEnv CSCEnv.. PMOEnv CSCEnv. PMOEnv CSCEnv. PMOEnv CSCEnv. PMOEnv CSCEns.	Comp envir laws EIA/E Comp EIA/E Comp Wild Prote Comp Wast Plan Comp EIA/E Comp Envir prote

			20.8 Ensure that damage to the natural topography and landscape is kept minimum as possible	CEnv	CSCEnv. PMOEnv	Comp Envirc protec
			20.9 Ensure that no-hunting, no trapping, no harassing wildlife and policy in this regard will be strictly observed.	CEnv.	CSCEnv PMOEnv	Comp Wildlif Comp EIA
			20.10 Ensure that fishing in the river/canal by the project staff is avoided	CEnv.	CSCEnv PMOEnv	Site In
			20.11 Ensure that the general awareness of the crew is enhanced regarding the game reserve, through environmental training, notices board.	CEnv	CSCEnv. PMOEnv	Comp Envirc and W Protec
			20.12 Ensure that no project vehicle or staff is allowed to access any protected place in the project area except the project fenced areas and the road approved.	CEnv	CSCEnv. PMOEnv	Comp contra obliga
			20.13 Ensure that shooting permit should not be issued covering Project	CEnv	CSCEnv. PMOEnv	Comp Wildlif

			AOI by the Wildlife Department during the construction phase.			
			20.14 Ensure that workers should be protected from harmful species of animals.	CEnv	CSCEnv. PMOEnv	Comp
			20.15 Ensure that river ecological monitoring will be carried out prior to the start of the project during construction and post construction	CEnv	CSCEnv PMOEnv	Comp
	E. Socio-economic and cultural issues					
21	**Adverse effects on Local population**	**-Disruption of population:** There are settlements come within the proposed location of power channel. Although the land belongs to WAPDA the compensation need to be paid for structure relocation. **-Population at Risk:** Settlement being	21.1 Ensure that there will be no disturbance of local population due to the movement of manpower and machinery.	CEnv	CSCEnv PMOEnv	SFA
			21.2 Ensure that the contractor to impart to the training to the workers on safety matters.	CEnv.	CSCEnv. PMOEns	As pe
			21.3 Ensure Community Compliant Management	CEnv.	CSCEnv.	Comp

	located near the site, there will be safety and health hazards for the local population. Moreover there will be safety and health hazards for the work force.	Register is maintained at Camp site office.			
		21.4 Ensure no machinery is left unattended on site in the field	CEnv.	PMOEns CSCEnv.	Comp with c
		21.5 Ensure PMO representative visits monthly or quarterly to gather complaints from Social/Environment Complaints Management Register and provide feedback to the community on the status of the previous complaints to the community elders.	CEnv.	PMOEns PMOEns	Comp with c
		21.6 Ensure blowing unnecessary horns is prohibited	CEnv.	CSCEnv. PMOEns	Comp
		21.7 Ensure all entry points in to the construction area are to be staffed 24 hours a day, 7 days a week.	CEnv.	CSCEnv. PMOEnv	Site I Comp
		21.8 Ensure that safe driving practices are	CEnv.	PMOEnv CSCEnv.	Comp

			adopted, particularly while passing close to settlements. This includes a speed limit of 30Km/h if passing within 100 m of settlements anywhere in the site area.			
22	**Existing service facilities like education, health, electricity, drinking water supply and public gathering, religious congregations etc.**	- Social consultation will be done and all impacts influencing the communities will be defined and all these factors will be added and incorporated in the contract document of the contractor and SFA of the communities	22.1Service facilities may be regularized through SFA.	CEnv	PMOEnv CSCEnv.	Comp SFA
			22.2 Ensure that women are adequately informed and consulted regarding the project activities and community development projects.	CEnv CEnv	PMOEnv CSCEnv. PMOEnv CSCEnv	Contra obliga Comp
			22.3 Ensure that religious congregations must be observed carefully in order to avoid conflicts with local communities.	CEnv	CSCEnv. PMOEnv	Comp
			22.4 Ensure that all matters to be attended by the contractor, to be made his contractual obligation.	CEnv	CSCEnv. PMOEnv	Comp

23	**Tribal tension ,local rivalries on running canals and use of aquatic life**	- Just one month before the start of the construction work social frame work agreement will be done between the community members and the resident engineer. In order to avoid conflicts with tribal leaders and local communities mutual consents will be discussed in SFA.	23.1Ensure that polices with direct bearing on project activities are culturally sensitive, in order to avoid conflicts with tribal leaders and local communities and to offset any impact on the local social structure.	CEnv	CSCEnv. PMOEnv	Compl SFA
			23.2 Ensure women are informed through traditional means of communication of the presence of foreign men (if any) in their area	CEnv	CSCEnv. PMOEnv	Compl
			23.3 Ensure that individuals holding titles to private property used in the project are compensated in accordance with the market rates and all payment are recorded	CEnv	CSCEnv. PMOEnv	Compl SFA &
			23.4 Ensure that focus group meetings are conducted with both men and women to identify any water related and other issues related to project	CEnv	CSCEnv. PMOEnv	Compl

			implementation			
24	**Adverse effects on archaeological sites any grave yards and burial sites**	- No important on cultural and archaeological site has been found or reported in the AOI of the Project	24.1 Ensure that no adversely is affected to any site(s) of historical, cultural, religious and archeological significance. 24.2 Though no such site is indicated in the project area currently. Ensure that if any such sites are found during the construction stage informed to the concerned department immediately.	CEnv CEnv	CSCEnv. PMOEnv CSCEnv. PMOEnv	Com with I indic EIA/E Site F
25	**Health & safety of labour and near by population at construction site.**	- Due precautions shall be taken by the contractor, and at his own cost, to ensure the safety of his staff and labour and, in collaboration with and to the requirement of the local health authority to ensure that medical staff headed by qualified medical doctor, first add equipment stores, sick bay and suitable	25.1Ensure Community Compliant Management Register is maintained at Camp site office. 25.2 Ensure no machinery is left unattended on site in the field 25.3 Ensure that a proper Ambulance (preferably a four-wheel drive vehicle should be available at site 24-on hour basis.	CEnv CEnv CEnv	CSCEnv PMOEnv CSCEnv. PMOEnv CSCEnv PMOEnv	Com Com Com

	ambulance service are available at the campus , housing, and on the site at all times through out the period of the contract and that suitable arrangements are made for the prevention of epidemics and for all necessary well fare and hygiene requirements.	25.4 Ensuring that all materials, gears and equipment (including personal protective equipment) needed to carry out the job safely is provided prior to commencing work.	CEnv	CSCEnv PMOEns	Comp
		25.5 Ensure that employees must have access to cool potable water in summer at their place of work and also shaded area be provided for rest period.	CEnv	CSCEnv PMOEnv	Syste
		25.6 Ensure PMO representative visits monthly together complaints from Social/Environment Complaints Management Register and provide feedback to the community on the status of the previous complaints to the community elders.	CEnv	CSCEnv PMOEnv	Comp with c
		25.7 Ensure blowing horns is prohibited, except when necessary.	CEnv	CSCEnv PMOEnv	Comp

			25.8 Ensure all entry points in to the construction area will be staffed 24 hours a day 25.9 Ensure that safe driving practices are adopted, particularly while passing close to settlements. This includes a speed limit of 30Km/h if passing within 100 m of settlements anywhere in the site area.	CEnv CEnv	CSCEnv PMOEnv. CSCEnv PMOEnv	Com Com
26	**Employment opportunities**	- The project will open new jobs opportunities which the local population could avail. IPD may request the contractor to hire labour from the local community. It is believed that substantial amount of unskilled work force for construction could be recruited from the local population near the project site. Therefore construction will have	26.1 Attempt 100% of unskilled, up to 50 % of semi skilled employment and as much as possible of skilled jobs are to be provided to people from local communities, provided the person with required qualifications are available. 26.2 Ensure project staff interaction with local community is minimized 26.3 Ensure that inter tribal balance is maintained	CEnv CEnv	CSCEnv PMOEnv PMOEnv. CSCEnv PMOEnv.	Com with in co docu Com with

	a positive impact on the socio-economic fabric of the local society. The Contractor will evaluate the available manpower taking into consideration the level (skilled or unskilled) and numbers of the workers who could be inducted in the labour/ work force of the Project. The Contractor will give preference to employing suitable personnel living within 150 miles of the Project area on the conditions which will be in accordance with the National Law ensuring that the working conditions for the labour/ work force at the site take due care of the health, safety and ambient conditions conducive to appropriate	when giving employment to the local population. Preference to be given to the people directly affected by the project.	CEnv	CSCEnv	Com
		26.4 Ensure that guidelines are prepared and implemented to sensitize non-local labour to local norms and customs in order to minimize cultural tensions	CEnv	PMOEnv. CSCEnv	Com
		26.5 Ensure that field crew is medically screened before employed on site	CEnv	PMOEnv CSCEnv	Com with

		working/living standards applicable to a work site.				
27	**Communicable Diseases.**	-The labour camp, their interaction with truck drivers and alike personnel are potential places for spread of communicable diseases if the incidence exists. Almost 100% of the people of project area and the potential labour are not aware of the source, mode of communication or consequences of Hepatitis, HIV/AIDS etc. Although their religious and cultural value system, to a large extent excludes the out break or rapid communication of HIV/AIDS, yet its occurrence in such a situation cannot be precluded. It is necessary that along with other	27.1 Ensure that periodic awareness campaign for Hepatitis and HIV/AIDS are undertaken for the project staff. 27.2 Ensure that a risk assessment of the spread of HIV/AIDS is undertaken in the project area on the basis of data from the Punjab HIV/AIDS program. 27.3 The medical staff ensure periodical checks of the cooking staff particularly for symptoms of hepatitis B.	CEnv CEnv CEnv	CSCEnv PMOEnv. CSCEnv PMOEnv. CSCEnv PMOEnv	Com with Com Com

	communicable diseases like Cholera, Typhoid, Hepatitis and Tuberculosis, awareness and preventive campaigns are run from time to time in the labour camps and the field offices of the project on HIV/AIDS			

28	**Restoration/rehabilitation**	- It will be the requirement of the contract document that restoration of borrow areas (weather on site land or private land) will be done well before in time. All borrow areas will be leveled, graded and brought in a level form resembling to natural condition prior extraction / borrowing. Campsite and temporary facilities will be restored in accordance with contractual obligations and requirements. All the community roads and bridge roads which were under contractor use will be restored to its original shape or better. * Borrow pits and other landscape depressions if left open, may prove	28.1 Ensure that all borrow sites are remediate as per contract requirements 28.2 Camp site is restored and changed to tourist resort if possible and agreed by WAPDA 28.3 All waste products, solid and liquid will be disposed of in accordance with the requirement of the EIA / EPA and contract document. 28.4 All fencing and access gates will be removed 28.5 All pits (including burn pits, sumps and depression) will be backfilled 28.6 The portion of the access track likely to be of no use for other activities will be restored by removing culverts and gravel topping	CEnv CEnv CEnv CEnv CEnv CEnv	CSCEnv PMOEnv. CSCEnv PMOEnv. CSCEnv PMOEnv. CSCEnv PMOEnv. CSCEnv PMOEnv. CSCEnv PMOEnv.	Com Com Com with Disp Com with guide Com Com with guide

	hazardous to human beings, livestock and wildlife. Open pits containing water are potential sources of Mosquito breeding if left stagnant, and can create health hazards. -Potential conflicts may emerge with landowners regarding the restoration of the borrow areas.	28.7 While abandoning sumps and extra cap of soil will be placed over them to allow for compaction. 28.8 Ensure that no potential conflicts should emerged with landowners during the restoration of the borrow areas. 28.9 Ensure that proper documentation should be done during the restoration of the borrow area e.g. completion certificate.	CEnv CEnv CEnv	CSCEnv PMOEnv CSCEnv PMOEnv CSCEnv PMOEnv	Com SFA Com

BC: Before construction; DC: During Construction; CEnv: Contractor Environmentalist; PMOEnv. Project Monitoring Office Environmentalist; CSCEnv. Construction Supervision Cons

8.11 CONTRACTOR'S OBLIGATION

Contractor's Obligations

The following conditions should be included in the Tender Document followed by the Contract Document as essential clauses:

- **Clause regarding disposal of waste construction material**
  The Contractor shall in consultation with and with the approval of Resident Engineer (RE) of the Project, select and abide by the selection, a site for disposal of waste construction material as well as the material used for construction of coffer dam. Contravention to this clause may tantamount to contravention to contract and the Contractor will be responsible of removing the material dumped on a wrong site, at his own expense and pay a fine for his negligence.

- **Clause regarding adjustment with unstable locations appearing during construction especially the foundation**
  In case an unstable location appears during construction, especially the foundation, the contractor shall immediately inform the Resident Engineer expressly providing full technical details about the problem. The RE will inspect the site; preferably the same day the report is received and will, if necessary, agree to make modifications and changes in the design to stabilize the situation such as change in the depth of foundation. Contractor will not make any changes in the specification without express approval of RE. Contravention to this provision will mean unauthorized construction carried out for which RE will issue dismantling orders.

- **Clause regarding Location of Labour Camps, Material Dumps / Depots, Equipment and Machinery Yards, approach roads and routes**
  WAPDA land is available for location of Labour Camps, Material Depots, Equipment and Machinery Yard, Link Road or other activities related to these matters and proposed sites have been shown on the project map. The Contractor will choose particular sites within the overall campus indicated in consultation with RE. These activities shall not be allowed outside the WAPDA land adjacent to project area. If the Contractor chooses to locate his facilities on a private land, he will himself be responsible for any compensation, resettlement or rehabilitation process and costs and RE or WAPDA shall not be involved in acquiring or using the land in making any payments for doing so.

- **Clause regarding Rehabilitation of Construction and extraction sites**

  The Contractor shall carry out construction work exactly on the same site and according to the same design as provided in the Tender Documents. Also the camps site, the material depot, the machinery and equipment yard, link roads, borrow areas and coffer dam shall, after the completion of construction, be restored and rehabilitated and brought to at least the same condition, in which these were handed over to the contract. A set of photographs or a video tape film shall be prepared to show the pre-construction sites and post construction rehabilitated sites. For any contravention of this clause the final payments and the securities deposited shall not be released.

- **Clause regarding drainage, paths, roads, Linear Fixtures crossed/damaged by Machinery moving to and from the construction sites**

  During the construction, if the Contractor's vehicles moving to and from the construction site(s) cause any damage or disruption of services pertaining to drainage systems, paths, roads linear fixtures e.g., transmission lines and fences, the Contractor shall get the damage repaired and services restored within 24 hours of the damage clause failing which the RE will get an assessment of the damage and losses and debit that amount to Contractors account and the next payment shall be made to Contractor after deducting the debited amount.

- **Clause regarding earthen embankments or Concrete Work vicinity scouring on the Protection Bunds or on the main sill structure**

  All such spots where there is a possibility of scouring of earthen embankments or concrete work edge as mentioned in the Tender Document and quality included in this Construction Contract, the Contractor shall protect by protection walls and stone rip-rap work, failing which the payment of the Contractor shall be with-held.

- **Clause regarding discharge spill or dumping on any building, House, graveyard, archaeological site (established or newly Found), unstable slopes, uncompacted embankment or leaking into construction area**

  The Contractor shall be contractually bound to not to allow or cause discharge spill or dumping on any building house, graveyard, archaeological site (established or newly found), unstable slopes, uncompacted embankment or leakage into the construction area. Any such failure shall be duly noted by RE during site inspections and contractor shall immediately remedy the situation failing which the payment of the contractor shall be with-held and the damage so caused shall be debited to contractor's account under the contractual provisions.

- **Clause regarding Diesel and other fluids spilling over to River water from construction machinery**

  The Contractor shall ensure that his construction machinery is always in first class working order and no spilling of Diesel or any other fluids into the River, is caused by the defective machinery of the Contractor. For any such spill the Contractor shall pay the environmental compensation to be assessed by RE in consultation with EPA Punjab and the said amount shall be debited towards the payment of the Contractor.

- **Clause regarding protection of construction work from floods**

  The Contractor shall, throughout the construction work, manage to keep an eye on the flood position of the river and shall remain in touch with Flood Control Centre and remain equipped with means and equipment for taking protective measures to protect the works under construction. WAPDA shall not be responsible for any damage caused by floods and any works washed away shall be reconstructed by the Contractor at his own cost within the tenure of the contract.

- **Clause regarding providing proper diversion of water from downstream**

  The Contractor shall, in consultation with RE provide proper diversion to water flowing downstream and by requesting the Tail Regulator Management opening and closing the main barrage gates and by collaboration with local communities especially the Fishermen community as per SFA and preparing them for any such diversions or closures. Losses caused to construction work due poor or mismanaged canal flow diversion shall be considered as negligence on the part of contractor any damages or losses caused due to this negligence shall be borne by the contractor.

- **Clause regarding control on air quality by not allowing Machinery to cause dust, smoke or noise pollution**

  The Contractor shall not cause deterioration of air quality by using old or ill maintained machinery which raise excessive dust, produce excessive smoke or cause excessive noise pollution. The Contractor shall follow strict standards of maintenance of machinery, provide qualified and trained drivers and operations for the vehicles. The Contractor shall also sprinkle water on kacha roads to be used as link roads, and sites where the earth is to be dumped. And the Contractor shall provide protective masks to his work force. Failure to do so shall be taken as serious contravention of the contract and shall cause the payment to be deferred till the correction of the situation.

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- **Clause regarding control of dust or other pollutants from Stored materials, material depots or spoil heaps**

  The Contractor shall:-

  (a) locate his material depots and spoil dump as far away from the villages/community "Deras" as possible.

  (b) keep all such materials covered for effective control of the fugitive dust.

  Failing to do the Contractor will bear the cost which may have to be incurred on arranging remedy to defaults.

- **Clause regarding use of outdated machinery**

  The Contractor shall obtain a certificate from Vehicle Examiner working under the RE but paid by the Contractor, that all the machinery employed is either new or in first class fitness condition so as not to cause smoke or oil leakages. RE will not allow the use of any outdated machinery.

- **Clause to Protect the Biological Resources**

  The Contract will ensure that:-

  Unnecessary and out of bound activities/movements are not done outside the campus allotted to him for setting-up the labour camp, material depots and machinery yard.

  a) No fire arms are carried by any of the employees or labour.

  b) All Forest, Wildlife and Fisheries Laws are fully respected and abided by the Contractor and his work force.

  c) The Biodiversity is respected and saved on its terrestrial, aquatic and aerial habitats.

  d) Necessary sign boards are displayed to make labour, visitors and members of public to remind them of their obligations towards Biota.

  e) Inspections by Wildlife, Forest and Fisheries Officers are facilitated in camps to facilitate a proper implementation of relevant Laws.

  f) Communities are given awareness and are involved in proper protection of the Biota inside and around the Project site.

g) Any contravention to any of the above sub-clauses will be considered as breach of contract and lead to disqualification of the Contractor.

- **Clause regarding respect for Socio-economic and Cultural Values and heritage**

The Contractor shall be bound to:-

(a) Ensure that no damage or disruption is caused to the social infrastructure or public services being provided to the people e.g., education, health, electricity supply, drinking water supply facilities for public gathering or religious congregations.

(b) Ensure the Contractor or his employees remain above the local Tribal tensions especially the strife's over distribution of canal water and use of aquatic life.

(c) Ensure that existing ownership of land around the Project is respected.

(d) Ensure that if some construction material has to be procured from or through a member of local community, it must be by a proper Social Framework Agreement social communities.

e) Ensure that no damage or adverse effect is caused to archaeological (present or chance find) sites, graveyards and burial places.

- **Clause regarding Public Safety, Health and Safety at Construct Site, including measures against HIV/AID and Life insurance.**

The Contractor shall:-

a. Put up temporary but prominent sign boards in all of the project activity area warning people against likely hazards which can be caused due to certain activities. (Also to be reflected in SFA).
b. Arrange to run a proper campaign in the labour camp, to make people aware of the causes, mode of transmission and consequences of HIV/AIDS.
c. Strengthen the existing BHU for the benefit of the labour as well as the surrounding villages.
d. Ensure proper cleanliness and hygienic conditions at labour camps by ensuring a clean mess, proper drainage and suitable disposal of solid waste. Inoculation against Cholera will be arranged at intervals as recommended by Health Department.

e. Keep all the camps, offices, material depots, machinery yards and work site open for the inspection of health and safety measures, and related documents and include in the contract document the text regarding accessibility to the camps etc.

f. Provide proper overall, helmet and field boots and earplugs to work as a precaution against any mishap, and interlink various parts of the construction complex with local wireless telephones also fitted the vehicles.

g. Provide a group insurance cover to the workers and labour on study on site or in the camp, against accidents, mishaps or loss of life on duty.

- **Clause regarding employment of Locals in the construction work**

  The Contractor as an obligation of the Contract will employ, subject to availability and work ability, maximum number of local labour for construction work.

Note:

The above clauses have been suggested from technical point of view. These may be got vetted by qualified law officer before incorporating them into the Tender Document or the Contract Documents.