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JHIMRUK HYDRO ELECTRIC AND RURAL ELECTRIFICATION PROJECT IN NEPAL

Experiences from the Project Implementation

OFFICE OF INTERNATIONAL COOPERATION 1996

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Jhimruk Hydro Electric and Rural Electrificaton Project in Nepal Experiences from the Project Implementation	No. 6
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Abstract

The report summarizes the experiences gained from the implementation of the Jhimruk Hydro Electric and Rural Electrification Project in Nepal.

Besides being a documentation of the works carried out at Jhimruk, the report may hopefully be of some value for implementation of future projects.

Contributions to the report come mainly from the Norwegian Himal Asia Mission. The executive summary and chapters 6 (partly), 7 (mainly) and 8 are prepared by the Norwegian Water Resources and Energy Administration (NVE). Comments and conclusions expressed in these parts of the report are NVE's independent view on the project.

Subject Terms

Nepal
Hydropower Development
Experience

Responsible

Egil Skofteland

Cover photo: Headworks in Jhimruk valley
Photo by Ludvig Johan Bakkevig

MAIN CONCLUSIONS

From the viewpoint of the Norwegian Himal Asia Mission and the Norwegian Water Resources and Energy Administration the following main conclusions can be drawn:

I The Jhimruk hydro electric power project was carried out in accordance with project objectives.

II The central role of the United Mission to Nepal was to a large extent important for the success of the project implementation. The reason was the mission's general knowledge of Nepal and more than 30 years experience from the hydropower sector in the country.

III The project was carried out within the initial budget, which was considered to be reasonable. This was achieved in spite of money consuming design changes and some minor additional works.

IV Environmental and socio-economic matters should have been included in the project plans from the beginning. For example, no rules of operation were established in forehand. If it had been, the ongoing disputes about minimum water release could have been avoided. This issue still remains to be settled. To help reduce adverse impacts of the project, an environmental study was carried out during the construction period. Findings of the study resulted in recommendations of mitigative measures to be done.

V The project was not free from problems during implementation. Much concern was related to the unrest that occurred in Nepal in 1990 and caused strikes and delays at Jhimruk. Also, the serious delay in construction of the Bhalubang - Devistan road was a constant head-ache to the project. This road was absolutely necessary for bringing in the heaviest equipment.

These examples show that unexpected events might occur and cause serious problems for project implementation.

VI Problems occurred after short time of operation. Most serious was turbine wear due to high content of small quartz particles in the water. Sediment analyses dealing with possible adverse effects during operation were not carried out in the planning and design stage. This was a serious deficit. If being aware of the problems in forehand, precautions could have been taken to the extent possible.

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Abbreviations Used

ABB	Asea Brown Boveri
BPC	Butwal Power Company Pvt.Ltd.
BPCH	Butwal Power Company Hydroconsult
BTI	Butwal Technical Institute
HH	Himal Hydro & General Construction Company Pvt.Ltd.
HMGN	His Majesty's Government of Nepal
JHEREP	Jhimruk Hydro Electric and Rural Electrification Project
MOWR	Ministry of Water Resources
NEA	Nepal Electricity Authority
NHAM	Norwegian Himal Asia Mission
NHE	Nepal Hydro & Electric Pvt.Ltd
NORAD	Norwegian Agency for Development Cooperation
NVE	Norwegian Water Resources and Energy Administration
UMN	United Mission to Nepal

Salient Features

Project site:	Pyuthan District
River diverted	Jhimruk Khola
Catcment area	645 km^2
Long term average flow	25.32 m^3/s
Average minimum flow	3.2 m^3/s
Spillway design discharge	2500 m^3/s
Diversion weir type	Concrete gravity
Weir length / height	205 m / 3 m
Daily pondage with flashboard	82,000 m^3/s
Height of flashboards	0.8 m
Headrace tunnel	D-shaped concrete lined
Headrace tunnel length	1045 m
Headrace tunnel net cross section	5.5 m^2
Surge tank cross section	7 m^2
Penstock: Upper section, 45° shaft	265 m
Horisontal lower section, 1:12 tunnel	115 m
Penstock diameter	1.50 m
Gross head	210 m
Design head	205 m
Design flow	7 m^3/s
Turbines	3x4 MW Francis
Generators	3x5 MVA
33 kV transmission lines	162 km
132 kV transmission lines	41 km
Mean annual production capability (excl. of water release for irrigation purposes)	≈80 GWh
Project costs, actual	NOK 120 mill.

1. EXECUTIVE SUMMARY

1.1 Introduction

1.1.1 General

This executive summary is a brief summary of the report dealing with the experiences from the implementation of the Jhimruk Hydro Electric and Rural Electrification Project (JHEREP) in Nepal.

JHEREP followed a series of projects in Nepal funded by the Norwegian Agency for Development Cooperation (NORAD) through the Norwegian Himal Asia Mission (NHAM), which is a member of the United Mission to Nepal (UMN).

The main objectives of the project were:

1) To provide electricity to the national grid
2) To connect the centres in four hill districts to the electricity grid
3) To strengthen the Nepalese companies Butwal Power Company (BPC), Himal Hydro (HH) and Nepal Hydro & Electric (NHE) through their participation in the planning and construction of JHEREP

The implementation of JHEREP was special in many ways and it was based on a work that UMN started 30 years ago. Local expertise in hydro power was gradually built up in the three companies BPC, HH and NHE which were established by UMN in partnership with the Government. The implementation of Jhimruk therefore had a strong indigenous foundation.

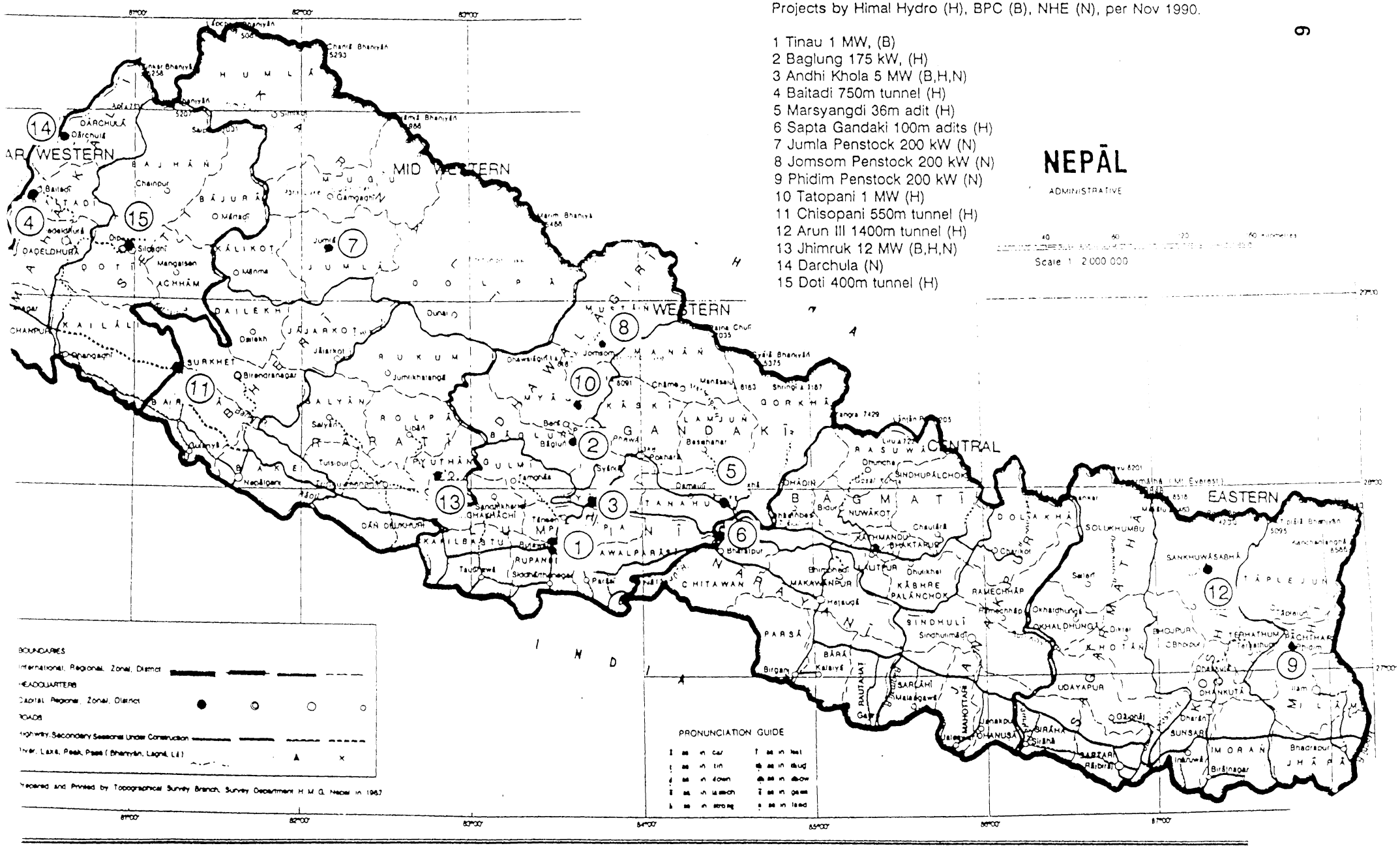
1.1.2 The Jhimruk Hydro Power Plant

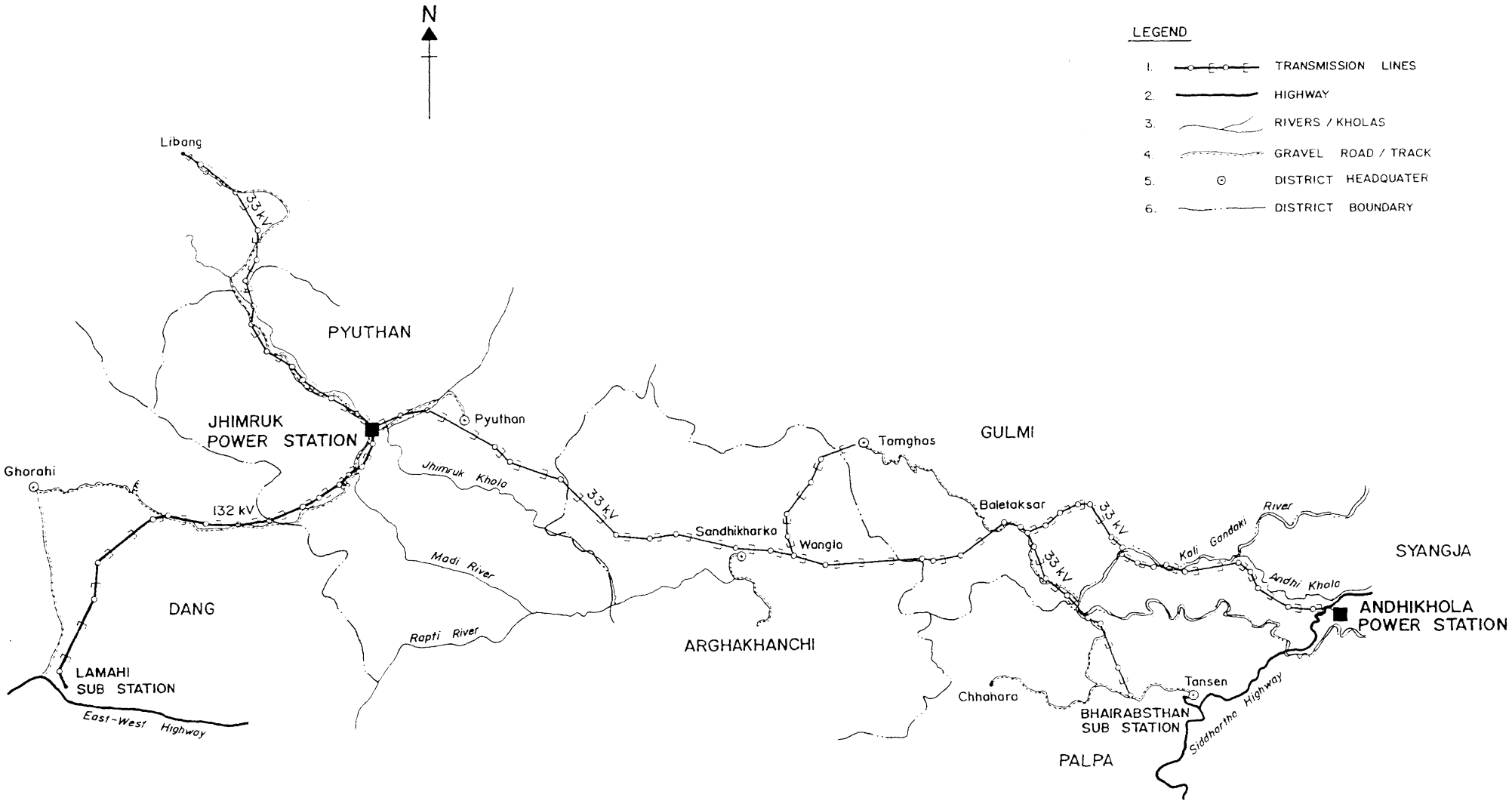
The Jhimruk project is located in Pyuthan district, in the mid western part of Nepal. The 12 MW power plant utilizes a head of approximately 200 m between the rivers Jhimruk Khola and Madi Khola. Main project components are a 205 m long and 3 m high concrete dam with gates and intake structures, a 1045 m long headrace tunnel, surge chamber, a 380 m shaft, mainly inclined, with penstocks, powerhouse with 3 x 4 MW Francis turbines and 3 x 5 MVA generators, and a short tailrace canal.

The power plant is connected to the national grid through a 41 km 132 kV transmission line to Lamahi. In addition, the project opens up for electrification of an area with a population of more than one million people by construction of 162 km of rural transmission lines, which is part of the project.

Projects by Himal Hydro (H), BPC (B), NHE (N), per Nov 1990.

1 Tinau 1 MW, (B)
2 Baglung 175 kW, (H)
3 Andhi Khola 5 MW (B,H,N)
4 Baitadi 750m tunnel (H)
5 Marsyangdi 36m adit (H)
6 Sapta Gandaki 100m adits (H)
7 Jumla Penstock 200 kW (N)
8 Jomsom Penstock 200 kW (N)
9 Phidim Penstock 200 kW (N)
10 Tatopani 1 MW (H)
11 Chisopani 550m tunnel (H)
12 Arun III 1400m tunnel (H)
13 Jhimruk 12 MW (B,H,N)
14 Darchula (N)
15 Doti 400m tunnel (H)





LAYOUT OF TRANSMISION LINES

1.2 Assessment

1.2.1 General

After NORAD responded favourably to a request from His Majesty's Government of Nepal (HMGN) for funding of the Jhimruk project, BPC was asked to take on the task of implementing the scheme. In fact, NORAD made it a condition that BPC should carry out the project, and that the grant should be channeled through NHAM/UMN.

Jhimruk was conceived as a straight-forward hydro power project. This was somewhat unlike earlier projects in which BPC had been involved, where also rural development aspects to a great extent had been present. Project plans were taken over from Nepal Electricity Authority (NEA), which had brought the plans up to feasibility level in cooperation with an expatriate technical adviser. The environmental and socio-economic aspects of the project had only to a very limited extent been included in the plans. After review of the plans by BPC Hydroconsult (BPCH), several modifications were made. The most important was the incorporation of a rural development component by including 162 km of rural transmission lines.

1.2.2 Contracts/Agreements

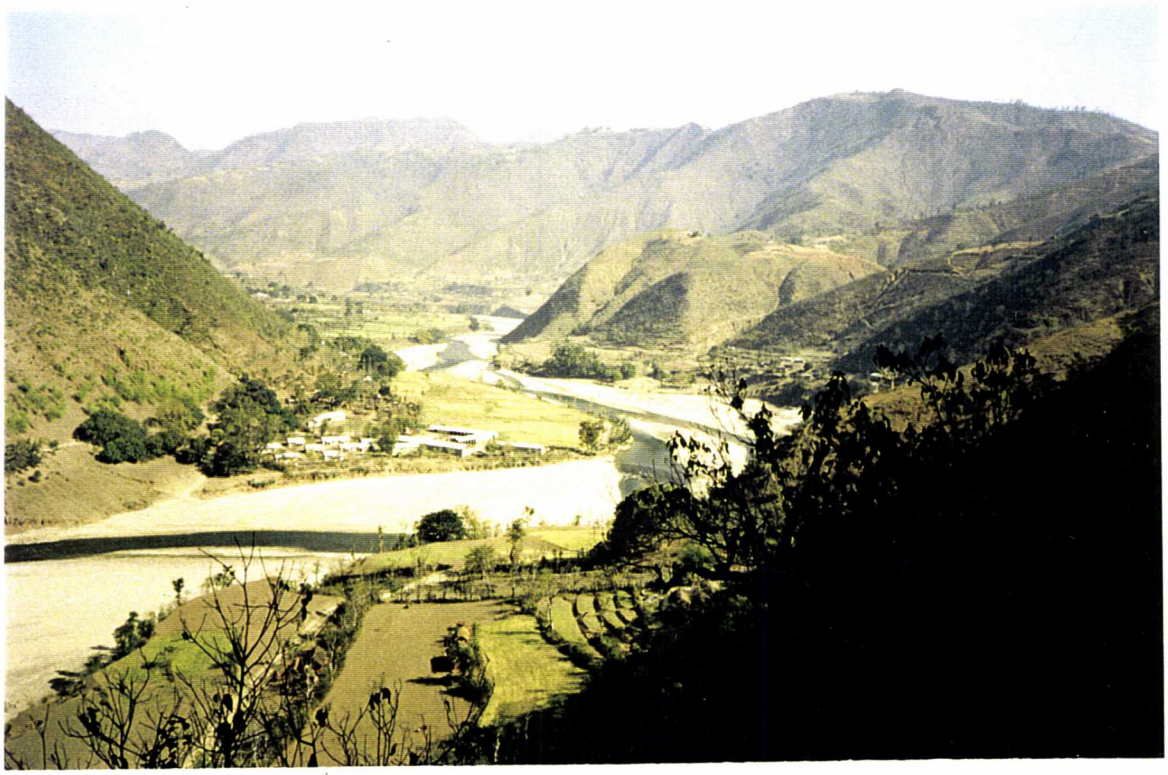
A contract between NORAD and NHAM was signed in 1989. This contract stated that NHAM was responsible towards NORAD for carrying out the project. A Project Agreement was made between UMN and HMGN. This agreement regulates the obligations and rights of the parties. It also points out BPC's responsibilities in carrying out the project.

The Jhimruk project was implemented without difficulties related to the contractual arrangements. One reason for avoiding disputes was probably the close relation between the companies involved. Another reason was that the project was technically successful and completed within drawn-up budgets.

1.2.3 Environmental and Socio-Economic Aspects

The environmental and socio-economic matters were not taken care of in the original project plans, which BPC took over from NEA. Possible environmental and economic impacts should have been evaluated and mitigation measures should have been included in the project plans in a satisfactory way before NORAD approved the application for funds. This is today's practice concerning projects financially supported by NORAD.

Jhimruk valley, upstream of the dam. (Photo by L. J. Bakkevig)



Madi valley, view upstream. Power house to the right, hidden by the hill in the foreground. (Photo by L. J. Bakkevig)

On the initiative of the Norwegian Water Resources and Energy Administration (NVE), an environmental project study was carried out. Possible impacts, especially on water supply, irrigation and fish habitats, were assessed. This study took place in 1990-91, and was based on fixed technical plans. The preferred practice would have been to incorporate the environmental and socio-economic parts into the technical planning at an early stage.

1.2.4 Training

One of the main purposes of the project, defined after BPC took on the task, was to strengthen the Nepalese companies BPC, HH and NHE, through training of staff on all levels with special emphasis on hydro power planning and construction. The programme included training on individual basis, but also covered project organization.

The training of personnel was mainly on-the-job training. Different kinds of special lectures and seminars were also arranged. A few key people were sent to Norway for practical training by the equipment suppliers.

The training at the Jhimruk site can be divided into two main groups:

1) Technical training, which was more or less directly related to the technical performance of the project, and considered necessary to do the job well.

2) General training, for personal development.

It appears that the aim of he programme was achieved, which was expressed this way by the Himal Hydro Project Manager when summing up his experiences: "During the life of Jhimruk Project, the skills and expertise of staff have been increased, and it is encouraging to see individual staff being able to take increased responsibility."

1.2.5 Project Implementation

In general, it may be concluded that the project has been successfully completed, although not completely free from problems. The main reasons for the good result may be identified as follow:

- Experience gained by the Nepalese companies from their involvement in the Andhi Khola Project, for example in organizing large number of workers.
- General knowledge of the Nepali society and the general setting. This knowledge could for example be very advantageous when purchasing materials for the construction works. In particular this knowledge was important in contacts and relations to the Nepalese authorities.
- Most of the expatriates within the companies had stayed in Nepal for a long time and were familiar with Nepali conditions.

- It should be mentioned that many of the staff had their basic technical education at the UMN related Butwal Technical Institute.
- Thorough planning and preparations were emphasized. Of special importance was the agreement and cooperation with the Norwegian Institute of Technology and the Norwegian Hydrotechnical Laboratory on the model studies. These studies provided the basis for a suitable design to secure the proper inflow of water into the intake structures, and also made it possible to use the latest available technology with regard to sediment flushing.
- The close cooperation between Kvaerner/ABB and NHE on the manufacturing and supply of mechanical and electrotechnical equipment.

1.2.6 Power Plant Operation

Problems occurred after short time of operation. Most serious was turbine wear due to high content of small quartz particles in the water. Sediment analyses dealing with possible adverse effects during operation were not carried out in the planning and design stage. The conclusion to be drawn is that this was a serious deficit. If such analyses had been carried out, the wearing problems that occurred could have been foreseen and precautions taken to the extent possible.

1.2.7 Project Economy

JHEREP was completed within the initial budget in spite of extra works being added later. The main reasons for this can briefly be said to be the same as for the successful implementation, since there is a close connection between implementation success rate and project economy.

2. BACKGROUND

2.1 History

It has been calculated that the size of the economically exploitable hydro power resources of Nepal are of the order of 25-30 000 MW. Of this less than 1 % has been developed up to now. The water power potential of the Nepali rivers is in fact one of the few but the more important natural resources of the country.

Mr Odd Hoftun (Electrical engineer, NTH 1952) had been working in Nepal since 1958 under the United Mission to Nepal (UMN), a Nepal based organization formed by 39 churches and mission organizations from 20 different countries to do social and development work in Nepal. From his home country Norway, like Nepal endowed with large hydro power resources, he brought with him a keen awareness of how important the exploitation of her water resources could be for the development and industrialisation of Nepal. It was also part of his thinking that the development of this potential as far as possible should be done by indigenous companies. To this effect he took initiative in establishing Nepali companies which could take on planning, building and equipping of water power projects.

As part of an industrial development and vocational training project, Butwal Technical Institute (BTI) in Butwal, Butwal Power Company Pvt.Ltd. (BPC) was registered in 1965. BPC received a licence for production and sale of electric power and started the electrification of Butwal, then a small town or market place, initially with diesel power. The building of a hydro power station started soon in the Tinau river. The narrow river valley made it necessary to locate the power plant in rock by tunnelling the hillsides of the valley, and it became the first underground powerplant in Nepal. The project was financially supported by NORAD.

Tinau was built in stages. A first stage for delivery of 50 kW was ready in 1970. Through further stages a capacity of 1050 kW was reached in 1978. The power plant was equipped with second hand machinery from Norway (from Fiskå Bruk, Øgreifoss, Bøylefoss and Vafoss) overhauled in Butwal with good assistance from Kvaerner. A mechanical workshop, later organized as a company known as Butwal Engineering Works (BEW), was established as part of the activity of BTI. BEW manufactured penstock pipes, gates etc., and undertook the erection work.

Based on the experiences gained from carrying out the civil works at Tinau, a separate construction company was formed in 1976: Himal Hydro & General Construction Company Pvt.Ltd (HH). The works at Tinau had been carried out by an unexperienced local work force under the guidance of engineers from UMN. They comprised a headrace tunnel of 1260 m length, an inclined shaft of about 50 m and a tailrace tunnel of 820 m length, besides a small power house cavern.

In 1978 BPC distributed electricity to 1156 consumers, and the streets of Butwal were illuminated by 306 lamps. The old bazar had grown remarkably and had now some small industries as a result of BTI's activity.

In 1982 BPC entered into agreement with HMGN to build a new project, the Andhi Khola Hydel and Rural Electrification Project (AHREP), which combined irrigation and power production. Part of the water coming through the headrace tunnel would be taken off for irrigation at the top of the hillside, while the rest was taken through a penstock to a power house with a capacity of 5.1 MW. The project comprised a good deal of tunnelling in partly very poor rock: Headrace tunnel approx. 1300 m, vertical shaft 240 m deep and 4 m diameter, tailrace tunnel 1050 m and a power house cavern to accommodate three pelton turbines with generators, valves and governors. NORAD supported the project with a grant of altogether NOK 25.4 mill.

Planning of Andhi Khola was initially carried out by the Development and Consulting Services (DCS), UMN's office in Butwal. However, in 1986 BPC established its own consultancy division, BPC Hydroconsult (BPCH) which took responsibility for detailed design of the intake structures and powerhouse. All civil works were executed by Himal Hydro, including the building of 50 km of 33 kV transmission lines. The electro-mechanical equipment for this project was also obtained second hand in Norway (from Mesna, Lillehammer). It was overhauled in Butwal by BEW. In the process a new company, Nepal Hydro & Electric Pvt.Ltd. (NHE), was established in 1986 with Kvaerner as one of the shareholders. NHE/BEW manufactured the penstock with bi-furcations for 250 m head, along with gates etc., and erected all the electro-mechanical equipment.

UMN has directly or indirectly been the main shareholder in all the Nepali companies mentioned, with government agencies making up the rest of the share capital, apart from NHE, where Kvaerner has a part. Later on, the Norwegian company EB National Transformer, now ABB Energi, also became a shareholder of NHE.

Andhi Khola started production in 1991 and has since been generating about 35 GWhs a year. Only a small part of the energy is consumed by the about 1600 local consumers that have been connected so far. The bulk of the energy is sold to the national grid at the rate of NRs 1.60 (USc 3.2) a kWh as at present.

The next chapter in the history of BPC was opened in March 1987 when HMGN sent an official request to the Norwegian Government to help financing of the Jhimruk Project. A feasibility study (FS) made by Nepal Electricity Authority (NEA) together with expatriate technical advisers was completed in July 1987.

BPC looked upon Jhimruk as a relevant and suitable project for the continuing training and growth of the Nepali companies in the field of water power engineering and construction. The request from HMGN was therefore strongly supported by BPC as well as UMN.

BPC Hydroconsult brought the FS forward into a project proposal in October 1987. Some changes to the design were recommended:

- To move the desilting basin to the upstream end of the headrace tunnel
- To use a pressure shaft instead of a surface penstock
- To increase the effective head and thus the installed capacity from 10.5 to

12 MW
- To include 162 km of 33 kV transmission lines for local distribution in four districts with a population of more than 1 million.

It was suggested that these changes could be implemented within the proposed budget of USD 19 million.

In May 1988 the Norwegian Government informed Nepal of Norway's willingness to support the Jhimruk Project up to a total cost of USD 19 million on the condition that the project should be carried out by the UMN, who had indicated that they were agreeable to such an arrangement. In this way a more flexible and smooth implementation would be possible. NORAD wanted to channel the grant through the same organizations as had been used for Andhi Khola, i.e. NHAM, UMN itself, and also to follow more or less the same pattern for the execution of the project.

Nepal agreed to this in a letter dated 17.October 1988. All necessary formal agreements were ready by February 1989, and implementation of the Jhimruk Project could start. Planning, field investigations, design and tender documents took most of 1989. Actual work in field started around new year 1989/90.

2.2 Organization. Agreements/Contracts

Three main contracts constituting the framework of the project were:

a) Agreement between NORAD and NHAM.
b) Agreement between NHAM and UMN.
c) Agreement between UMN and HMGN.

In addition, an agreement was made between NORAD and NVE on the monitoring of the project.

The agreements are shown as Appendices to this report. They constitute BPC as the builder, owner and operator of the project until one year after commissioning. After this first year (the guarantee period) the project should be transferred to HMGN.

In line with the intentions as mentioned above the organising and contractual setup for the implementation of the Jhimruk project were arranged to provide for further training of the Nepali companies involved in hydro power development.

Acting as the owner and employer, BPC took care of the builder's duties and responsibilities. NORAD funds were transferred to BPC through NHAM.

Liaison with the Nepali government was taken care of by setting up a joint Project Monitoring Committee which in quarterly meetings would review the progress and be helpful in solving infrastructural problems.

Planning, design and supervision of the Jhimruk project was undertaken by BPCH.

The civil works were assigned to Himal Hydro in accordance with the objectives set out in the HMGN/UMN agreement, after tendering and contract negotiations.

NHE had the responsibility to produce, deliver and erect the hydraulic steel structures (penstock, gates, trashracks etc).

The electro-mechanical equipment consisting of three Francis turbines and generators, transformers and switchyard facilities (6 kV, 33 kV and 132 kV) were supplied by Kvaerner and ABB in close cooperation with NHE. NHE fabricated the major part of the turbines, panel boards for control, and installed all the equipment.

Due to import regulations BPC had to take care of all purchases from abroad. In addition to the normal Builder's responsibilities BPC had to take the full systems coordination responsibility for the project.

In order to solve any disputes that might come up, BPC, HH and NHE agreed on the appointment of a UMN expert to serve as an arbitrator whose decisions would be final and binding.

3. PROJECT DESCRIPTION

3.1 General

The Jhimruk Hydro Electric and Rural Electrification Project (JHEREP) is located in Pyuthan district in the central western part of Nepal.

The project included construction of a 12 MW power plant, 162 km of 33 kV rural transmission lines and 41 km of 132 kV transmission lines for connection to the main grid.

The main objectives of the Jhimruk project were:

1. To provide electricity for the national grid

2. To connect the centres in four hill districts to the electricity grid. These districts were Pyuthan, Gulmi, Arghakanchi and Rolpha.

3. To strengthen the Nepalese companies BPC, HH and NHE through participation in the planning and construction of Jhimruk.

3.2 Overall design

Project lay-out and design are shown in Appendix 5.

The Jhimruk hydro electric power scheme utilizes a head of approximately 200 m between Jhimruk Khola and Madi Khola at a point where the two rivers come within a distance of about 1 km from each other, 25 km upstream of their confluence.

The main project components are:
- Dam and intake structures, including desilting basin
- Headrace tunnel, surge shaft, inclined shaft with penstock
- Power station with 3 equal-sized units of 4 MW
- Tailrace canal

The dam is 205 m long and 3 m high, of concrete gravity type, constructed across the Jhimruk river. From the intake, the water is conducted through a 1045 m long headrace tunnel and 380 m long penstock to the powerhouse. A tailrace canal takes the water into the Madi river.

Design changes
When BPC took on the task of implementing the Jhimruk project, a thorough review of the existing plans was carried out. The main layout was kept unchanged without any further studies being carried out.The review resulted in a number of design changes, of which the most important were:

- Installed capacity was increased from 10.5 MW to 12 MW.

- The penstock was placed underground, in a 45° inclined shaft. The reason was that a surface penstock in the rather unstable hillsides was considered very insecure.

- Comprehensive river training works were carried out, mainly upstream of the dam, for the purpose of bringing the water smoothly into the intake structures.

- 162 km of 33 kV transmission lines were added to the project.

- As part of the mitigation measures, an approximately 20 km long 33 kV transmission line downstrem of the dam was also included .

3.2.1 Dam Construction, Intake

The dam

The 205 m long and about 3 m high dam is founded on a deep bed of alluvial material. Detailed model studies were carried out to decide the design of the dam.

The dam creates an 82 000 m^3 reservoir for daily pondage if flashboards are raised on the dam structure. An area of about 16 ha is flooded.

The dam crest can be used as a road across the river except during the highest floods.

Three gates with a total capacity of 300 m^3/s were installed in the dam, beside the intake structures. This is sufficient to take all the water away most of the time under monsoon conditions, and to flush bed load sediment in front of the intake, and from the channel upstream.

The intake

The intake structures are located at the right river bank. From a side intake the water is taken into a desilting basin and then into the headrace tunnel. The sediments in the desilting basin are removed through a recently developed 'serpent flushing system', which also has been installed and tested at Andhi Khola.

3.2.2 River Training Works

The intake is located in a wide braided river bed. The river thalweg meanders, and shifts during floods. A problem was foreseen in stabilizing the river so that water can always be taken out at the intake structure. Stabilization of the river upstream was achieved by the construction of a 1.6 km long channel between gabion lined banks, a concept which was fully tested by hydraulic model study.

Downstream of the dam river training works were carried out to concentrate the stream into a single channel and allow for sediment transport.

3.2.3 Waterways, Tunneling

The waterway system consists of a fully lined 1045 m long headrace tunnel with 5.5 m^2 net cross section, which conveys the water to a surge tank, and into a steel lined penstock with a diameter of 1.5 m. The underground penstock is 380 m long. The upper part is concrete embedded in a 265 m long shaft, inclined at 45°. The lower part is installed in a 115 m long tunnel at gradient 1:12, and ends in three bifurcations which conducts the water to the turbines in the surface powerhouse.

3.2.4 Powerhouse

The powerhouse is located at the foot of the steep hillside on the left bank of Madi Khola. Extensive excavation works in colluvium cemented river gravels and rock was carried out. The excavation was lined with concrete in the lower section and with masonry on the slopes behind the powerhouse.

The powerhouse is equipped with three Francis turbines of 4 MW each.

3.2.5 Transmission Lines

The Jhimruk project includes the following transmission lines:

1) An 85 km long 33 kV line from Tansen to Jhimruk which also links with Sandhikharka (Arghakanchi District Centre) and Khalanga (Pyuthan District Centre).

2) 104 km of other 33 kV lines linking up with Andhi Khola powerhouse, Tamghas (Gulmi District Centre), Libang (Rolpa District Centre) and Jhimruk valley downsream of the dam.

3) A 41 km long 132 kV line from Jhimruk to Lamahi for connection to the national grid

The Tansen - Jhimruk line provided electricity to the project during the construction period.

4. PROJECT IMPLEMENTATION

4.1 General

After the acceptance by Nepali authorities of NORAD's offer to finance Jhimruk in October 1988, BPC started the organizing of the implementation of the Jhimruk Project forthwith. This chapter of the report describes the implementation from the early planning of the project until completion and plant operation.

4.2 Organization

Main organization chart is shown on next page.

BPC's JHEREP organization was headed by a JHEREP Project Manager, who was responsible for the overall planning and implementation of the project. He was based in Kathmandu dealing directly with outside parties and agencies concerning JHEREP, reporting to the BPC General Manager.

A BPC site representative, the "Resident Engineer" , was responsible for the supervision of works at site. He reported to the Project Manager, but related directly to BPCH with regard to technical design.

A Deputy Resident Engineer was seconded to BPC by Ministry of Water Resources (MOWR), to assist in site administration and deal with matters related to HMGN and local authorities, particularly with regard to land acquisition.

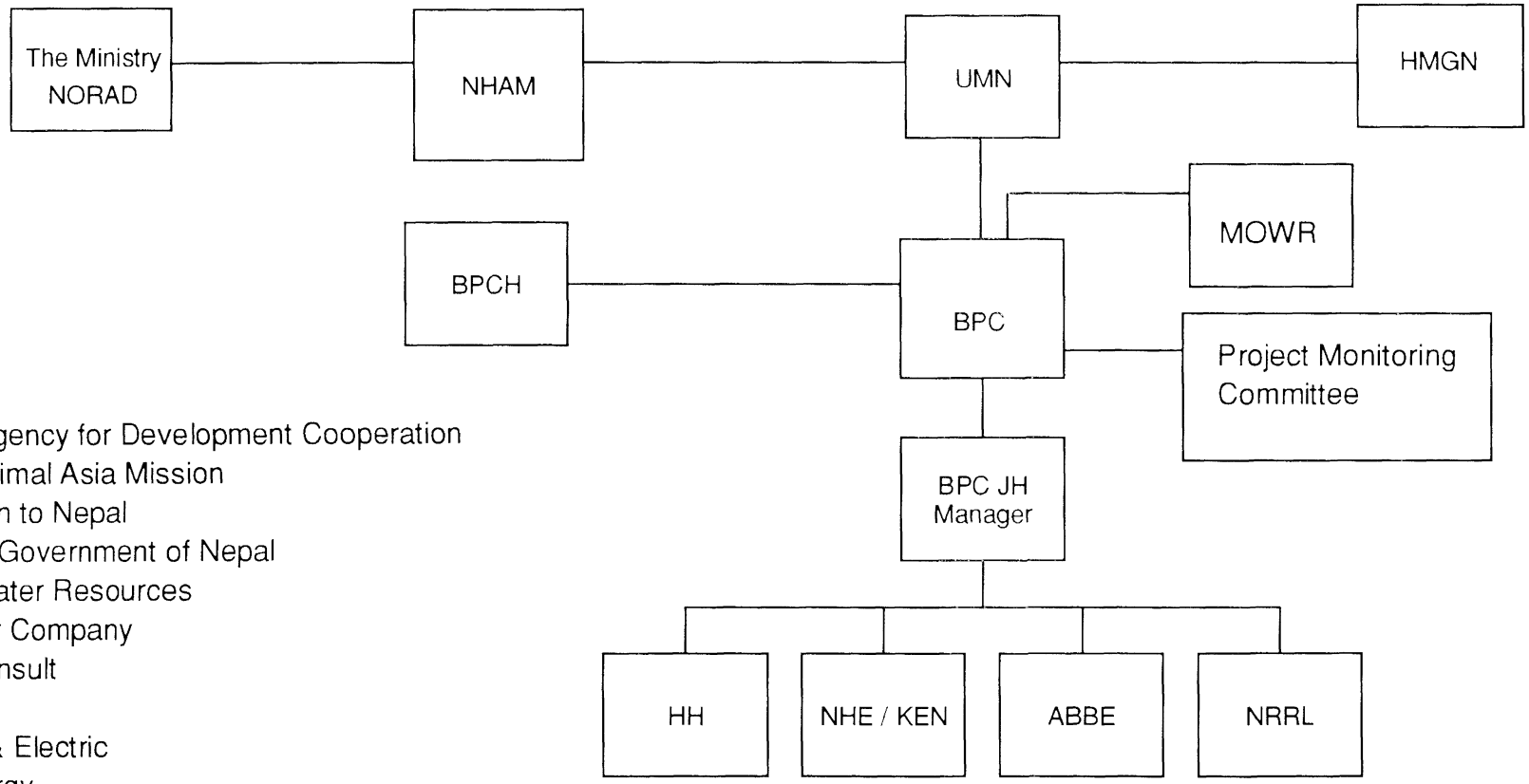
A varying number of surveyors, engineers and overseers and others were engaged in the BPC supervising team to monitor the civil and electro-mechanical works at the sites. Typically the site office staff would consist of one electrical engineer, two civil engineers, three overseers, one driver, two office workers and three helpers/ guest house staff. At times one community development officer, two drinking water technicans and one skilled water system worker were part of the team.

In addition BPC could have two engineers, 4 surveyors and 8 helpers on transmission line survey work, and one overseer with two helpers on transmission line operation and maintenance.

An outside expatriate quality auditor, Mr. Ludvig Johan Bakkevig, with long experience from hydro power development, was appointed by UMN to follow the works and to assist in drawing up the contracts and applying them in the course of construction.

Of all the staff mentioned above the "Resident Engineer" was the only expatriate BPC staff besides the quality auditor.

JHIMRUK PROJECT ORGANIZATION



Abbreviations:
NORAD : Norwegian Agency for Development Cooperation
NHAM : Norwegian Himal Asia Mission
UMN : United Mission to Nepal
HMGN : His Majesty's Government of Nepal
MOWR : Ministry of Water Resources
BPC : Butwal Power Company
BPCH : BPC Hydroconsult
HH : Himal Hydro
NHE : Nepal Hydro & Electric
KEN : Kvaerner Energy
ABBE : ABB Energy
NRRL : Nepal River Research Laboratory

4.3 Planning and Design

The planning was based on the NEA Feasibility Study (FS) which was further developed through detail design by BPC Hydroconsult. Comments to the FS were given by BPCH in October 1987.

From the preliminary work done by BPCH it was evident that some additional field investigations had to be undertaken. A physical model test at a hydraulic laboratory was also needed.

A programme for additional ground investigations was prepared by BPCH in consultation with NEA in December 1988. NEA took on the core drilling part of these investigations which were finalized in October 1989 after some delays due to shortage of diesel oil.

Through an agreement between The Norwegian Institute of Technology (NTH) and Institute of Engineering, Tribhuvan University, laboratory facilities were constructed at the University premises in Kathmandu and an agreement was made in January 1989 to undertake model tests for Jhimruk. The arrangement included training of Nepali students under the guidance of experienced Norwegian engineers. This project was funded by a special grant by NORAD.

As a result of field investigations and hydraulic model tests a canalization of 1.6 km of Jhimruk river was added to the project plans. The river had been meandering from year to year in the wide plains of the valley. A concentration of the river in this canal was also beneficial for protecting and developing the agricultural potential upstream of the dam, besides being necessary for a proper operation of the intake and for the sluicing of sediment bed load past the dam.

Other changes to the FS design were as follows:

- Dam: Due to the great depth to rock the headworks had to be founded on the alluvial river bed as proposed in FS. A 30 m wide impermable upstream blanket (HDPE) was added. The dam itself was constructed as a concrete weir with a two tier stilling basin. The upper tier would serve as a road across the river at all times except during very high floods. A sluiceway with three 2x5 m radial gates has enough capacity to divert all but the biggest floods during the monsoon.

- Intake: The FS proposed a bottom inlet (Tyrolian weir) as part of the dam. BPCH changed that to a side intake in the sluiceway wall leading the water into a desilting basin. It was felt that a bottom inlet would present problems like rapid silting up during the monsoon resulting in reduced discharge and extra maintenance problems. In addition, the high headloss of a bottom intake made it difficult to place desilting facilities close to the intake.

- Desilting basin: The FS proposed to locate the desilting basin in the hill side above the power house. This concept was changed to a desilting basin at the intake. The advantages of this were:
- problems of sediment transport and deposits in the tunnel are avoided.

- less headloss in the tunnel by changing from a free surface flow to a pressure tunnel flow.
- avoiding the flushing of silty water down the steep hillside.
- avoiding the hazard of having a big water basin in a steep hillside in an area where landslides are common.

- The tunnel was designed as a pressure flow tunnel with a net cross section of 5.5 m^2 and lined throughout by stone masonry lining of same type as successfully used at the Andhi Khola Power plant. Tunnel alignment was chosen with due consideration to the best location of the penstock and the powerhouse.

- Forbay/surge shaft. The forebay proposed in the FS was deleted and replaced by a surge shaft at the end of the headrace tunnel.

- Penstock. The surface penstock proposed by FS was replaced by a pressure shaft in rock. A surface penstock would demand digging a deep cut in the hillside with the risk of erosion damage and slides.

- Powerhouse: The FS came up with a plant that did not utilise the full head available. This was due to a possible future Naumuri Project which might raise the tailwater level by 15 m. The BPCH design uses the full head available taking into consideration a possible back pressure in the design of powerhouse and turbines. Together with reduced headloss at intake and in tunnel this brings about a net head increase from 180 m to 201 m. The installed capacity has been increased from 10.5 to 12 MW.

- Transmission lines: A 33 kV double circuit transmission line link with the national grid at Lamahi was included in the FS project. This 41 km line was upgraded to 132 kV. In addition 162 km of 33 kV rural lines were included in the project, linking 4 district headquarters to the grid. The transmission line from Tansen to Jhimruk power house, which was completed late 1991, made it possible to replace diesel generators at the project with construction power from Andhi Khola Power Plant.

All planning and design of civil works was done in BPCH's offices in Kathmandu by Nepali engineers under leadership of expatriate UMN engineers. For the electro-mechanical equipment planning and design was done in a co-operation between BPC in Kathmandu, Nepal Hydro and Electric in Butwal and the suppliers Kvaerner and ABB.

Gates, penstock, auxiliary installations and transmission line towers were designed and produced by NHE in Butwal in close consultation with BPC.

4.4 Time Schedule

A five years Implementation Schedule for the project was set up in 1989 (Appendix 4).

The schedule was conditional on timely granting of government licences, permits,

allowances etc. In addition the construction of a 45 km new road from Bhalubang to Devisthan by the Road Department was essential for the completion of the project. The much longer existing route via Lamahi-Ghorahi-Tiram hill was very poor and it was not possible to bring in the heavy electro-mechanical equipment over that road.

The starting up of the main construction work was in the beginning seriously delayed by some labour unrest and strikes. Nepal as a whole was in a state of unrest at that time, the spring of 1990, which brought about the revolution on the 9th of April. The unrest at Jhimruk was very much caused by outside political forces.

One result of this unrest was that the bridge across the Madi river to the power station site could not be completed before the onset of the monsoon which meant months of delay in starting up work on the inclined penstock shaft which was on the critical line for the timely completion of the entire project. The unrest continued with varying strength the whole year all over the country. In Butwal NHE was closed for a couple of months because of strikes, which caused delay in the completion of the Tansen-Jhimruk transmission line.

A revised time schedule was set up November 1990 stipulating 15.July 1994 as the target date for commissioning of the power plant. This schedule was modified a number of times, however, the stipulated completion time remained firm.

The Bhalubang-Devisthan road was opened in June 1994, and the heavy equipment including 32 ton transformers were successfully transported to the site over the new road. The road was soon afterwards closed due to land slides caused by the monsoon rains.

The Jhimruk Power Plant started commercial operation on 17. August 1994.

4.5 Tendering/Contracts

In an agreement between NORAD and NHAM it was decided that an overhead charge of 12 % on the direct implementation costs should be paid for administration, engineering and project management carried out by NHAM and BPC. This would cover all administration, planning, design and supervision costs on NHAM and BPC hands.

For the physical execution of the project the following contracts were agreed.

a) Civil works.

The civil works were split into three contracts in order to save time by tailoring the award of contracts to the progress of works.Thus the contractors could embark on mobilisation and infrastructure activities while tender design on the main project structures were still going on.

Tenders and contract documents were based on "Conditions of Contract (International) for Works of Civil Engineering Construction" as approved by

Federation Internationale des Ingenieurs-Conseils (Fidic) and other organisations (4th edition). Technical specifications, descriptions and drawings followed normal standards as used internationally. (Predominantly British). Payment was based on fixed unit prices and measured quantities. In addition the main civil works contract had an escalation clause related to the cost of major materials and labour.

It was decided in principle from the very beginning that Himal Hydro was to be the civil contractor, and that contract prices were to be fixed through tender negotiations with the expatriate Quality Auditor as the facilitator and if necessary serving as an arbitrator whose decisions would be accepted by both parties.

Tender documents for Lot C1 "Housing and Infrastructure" were issued November 1989, and works started at site at the end of November. Lot C2 "Access Road and Bridge" followed in January 1990.

Lot C3 comprising all the main civil works: dam and intake, river training, headrace tunnel, surge shaft, inclined penstock shaft and power house was issued in March 1990. It took, however, some time to finalise the contract negotiation due to changes in design of dam and river training works while waiting for the results of the model studies. In order not to delay the progress BPC issued a Letter of Intent whereby Himal Hydro was asked to start work on Lot C3 on a cost plus basis, aiming at incorporating such cost plus work in a final unit price contract later on.

The erection of transmission lines were covered by contracts based on cost plus. These contracts covered the complete works from surveying and planning to erection of the towers and stringing, inclusive transport, but exclusive of materials. Towers and line materials were provided by BPC. The towers were designed and produced by NHE under direct contracts with BPC.

b) Electro-mechanical works.

In principle it was clear that NHE to the extent possible would be the supplier of electro-mechanical equipment for JHEREP.

The contracts for supply and erection of the electro-mechanical equipment were made in a very different manner as compared with the civil works contracts. As a majority shareholder in NHE, BPC was in principle in a position to decide by itself what should be the terms and conditions according to which NHE would carry out its work as equipment supplier for JHEREP.

On the other hand, NHE depended very much on the support and technical know-how of its own collaborators to carry out the work. The terms of contract for the supply of major parts of the electro-mechanical equipment for JHEREP were therefore in reality determined through direct negotiations between BPC and NHE's collaborators in Norway.

The supply of electro-mechanical equipment for JHEREP falls into three categories, all to a larger or lesser degree involving NHE:

Supply of turbines and governors.
NHE entered into a consortium agreement with Kvaerner Energy (KEN) concerning equipment supply for JHEREP, with NHE as consortium leader. A contract was negotiated between BPC and this consortium for the supply of turbines and governors. The contract provided for fixed price supply ex NHE works in Butwal, with erection to be carried out on a cost-plus basis.

Supply of electrical equipment.
The contract for supply of electrical equipment was negotiated between BPC and ABB Energy AS without involving NHE directly. It was a fixed price contract for delivery ex works/ex stock Norway and for supply of engineering services. In addition, it provided for ABB to supply materials and personnel services at actual cost or fixed rates, on the assumption that NHE would carry out the manufacturing of panel boards etc. and supply manpower etc. for erection.

Supply of other equipment and services.
Penstock lining and furcations, radial gates, transmission line towers and poles, overhaul/modification of power house crane, turbine valves etc. and supply of erection services were generally undertaken by NHE on a cost plus basis, but to the extent possible with pre-negotiated prices for individual components. Foreign collaborators were not involved.

For all equipment supply and installation BPC itself carried the responsibility for system engineering.

The contracts for electro-mechanical works covered:

Poles and towers for transmission lines: Fixed rates	NHE
Penstock and Draft tubes: Partly fixed price and partly cost plus.	NHE
Gates and Valves: Partly fixed price and partly cost plus.	NHE
Power House Crane: Cost plus.	NHE
Turbines and governors: Fixed price ex works.	NHE/Kvaerner
Turbine erection: Cost plus.	NHE/Kvaerner
Generators, transformers, switchgear: Fixed price ex works.	ABB
Panel boards and electrical erection: Cost plus	NHE/ABB

Except for turbine runners, electronic governors, control cabinets and certain components, materials and supplies delivered by Kvaerner, the hydraulic machinery was manufactured, shop assembled and tested by NHE in Butwal under the guidance of Kvaerner specialists on periodic visits from Norway.

NHE produced all the hydraulic and other steel structures, transmission line towers and poles etc. in its Butwal workshop, according to specifications given by BPC and largely using materials provided by BPC who had all import licences and handled the logistics.

The erection work in the power house was done by NHE under the supervision of experts from the suppliers hired in and paid for by BPC according to fixed hourly rates.

4.6 Construction

4.6.1 Civil Works

Land acquisition was a necessary prerequisite for starting the works in the field. At an early stage (1989) Ministry of Water Resources (MOWR) seconded an engineer to work as a Deputy Resident Engineer with special responsibility for the land acquisition. Necessary Government permits were obtained, and land to be acquired was publically announced (13.09.89) by the Pyuthan Chief District Officer. The cadastral mapping was carried out by NEA and a Valuation Committee formed under the chairmanship of the Chief District Officer.

However, since decisions as to rates and payment took time, the project was allowed to move in and occupy the required land before legal formalities were completed and payment made. Land acquisition procedures went on through all of 1992, but the project was not hampered in any way by this slow process.

The work in the field started end of November 1989 under contract C1 covering the civil contractor's mobilization, construction of 10 permanent staff quarters and a guest house, inclusive necessary water systems and electricity distribution from diesel generators, as well as offices for BPC administration across the Madi River. It was also agreed that the contractor should mobilize as for the main works including the contractor's camps, temporary staff houses, offices, work shops, stores etc. The main construction compound and housing areas were built up on the west side of the Madi Khola while offices were built on the east, the power house side.

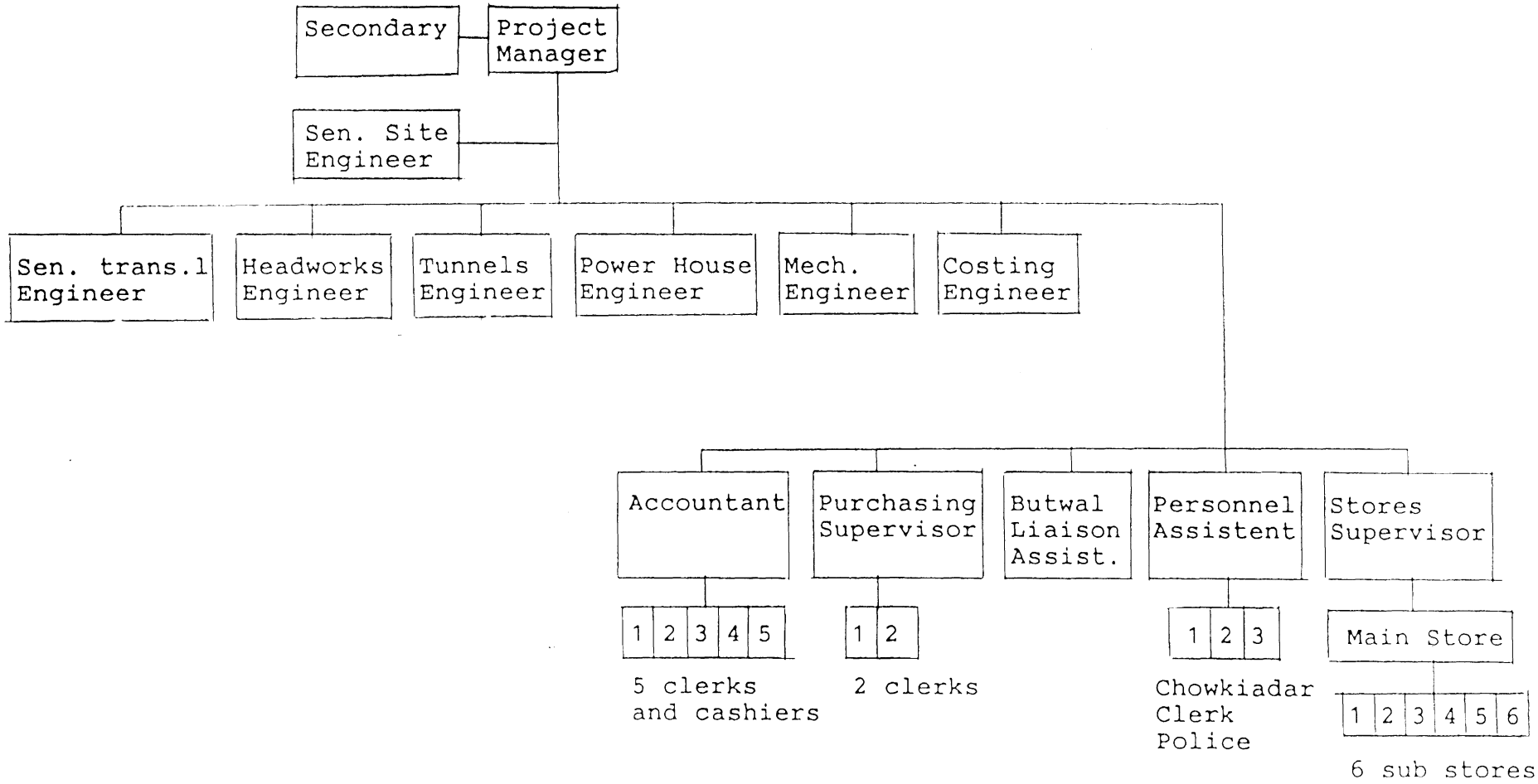
Work on contract C2 started in February 1990. It comprised the access road to the power house on the left bank of Madi River, about 2 km in length in a difficult terrain, and a 170 m long suspension bridge crossing Madi Khola.

A temporary bridge across Madi river with access road was constructed to allow easy access from the camp area to the construction site on the east bank. With the onset of the monsoon, that bridge was eventually washed away. Until the suspension foot-bridge was erected a simple ropeway was then used across Madi.

The works on these two first contracts were much hampered by labour unrest as mentioned earlier. Also problems in getting timber and roofing materials at this early stage added to a difficult start. However, in October the works of the main civil contract C3 could begin.

<u>Construction organization.</u>
Himal Hydro's overall organizational structure was modified during the life of the Project with the changing demands and challenges of the work. The top level structure was, however, set up as follows during most of the time:

Contractor's Site Organization



A Project Manager was in overall charge from the start up until the closing down.

Under the Project Manager there were four senior engineers, each of them having responsibility for a section of the main works:

a) the Headworks Engineer
b) the Tunnels Engineer
c) the Powerhouse Engineer
d) the Transmission Line Engineer

Also reporting directly to the PM were a senior Mechanical Engineer, a Business Manager, a Costing Engineer and a Training Coordinator, each of them heading one of the support sections.

Under each of the senior site engineers were from time to time one or two junior engineers to look after work going on in different areas (river training - dam/intake, headrace tunnel - penstock shaft), in addition to the overseers.

Including accountants, clerks, store keepers, nurses and others the project organization comprised 30-40 people among whom 7-8 were expatriates from UMN.

Labour force.
At the peak of construction (May 1992) Himal Hydro employed a total of 972 staff and workers inclusive about 200 working for sub-contractors. Out of HH's total were approx. 30 office staff and 60 technical staff. On the average through 1991-92 690 people were employed, all counted.

Skilled/semi skilled workers were mostly taken from earlier Himal Hydro projects while unskilled workers were recruited from the local area.

Very simple temporary housing was provided for skilled/semi skilled workers. Electric light was installed and water supplied to communal taps. Pit latrines were constructed and shared between 2-3 families.

Construction Equipment.
Major equipment which operated on the different sites is listed in appendix 6.

In addition to this equipment, the project had numerous items of minor workshop equipment including welding transformers, drilling machines, lathe, hand tools etc. Some of the major equipment items were earlier used at Andhi Khola, some were bought secondhand for this project (Mobile crane, Tower crane, Alimak, Cable crane, pumps, ventilation fan etc.), while others were new (Cat equipment).

From November 1991 construction power was supplied through the 33 kV line from Andhi Khola, initially via Tansen.

Construction materials and supplies.
Provision of construction materials and various supplies at the right time and the right price for a project like Jhimruk was a challenge both for the Purchasing Department and for the Logistic Department of the contractor. It is right to say that both Himal Hydro and BPC learnt a lot of purchasing during the construction period. It gave valuable information, training and experience for a potential next project.

Some problems in getting timber and roofing materials in time have been mentioned above. Other problems came up from time to time, but the construction work never stopped for lack of materials, although it happened that work was delayed waiting for deliveries which were late.

Regarding major materials and supplies this can be said:

Concrete aggregates: Sand and gravel were collected locally from the beds of the rivers. Washing of aggregates were normally done. In some cases, for special work, aggregates were crushed, but this being very expensive and with limited advantage over river gravel, natural gravel was used as a rule.

River boulders for masonry work were also taken from the beds of the rivers.

Cement: At the early stages of the project imported cement from Indonesia and Malaysia was used. After extensive testing of Indian cement, a supplier was found who could meet the requirements (Larsen & Toubro). Dealt with correctly, the Indian cement was also cheaper.

Steel was imported from India or from a re-rolling mill in Nepal.

Explosives. The explosives used for all the work were IEL SG80 25 mm ø, imported from India. The same supplier delivered also the short delay detonators. Average use of gelatine in the excavation of the headrace tunnel (8.5 m^2) was 1.37 kg/m^3.

Drill steel was supplied by Atlas Copco, India. Due to the soft nature of the rock, the wear on drill rods was small, a standard 35 mm ø rod lasting an average of some 620 drilled metres.

Spare parts obtainable in India, were taken from there normally. However, for plant not manufactured in India spare parts were often taken from Norway or Singapore. Cost and time lag were similar, but quality could be dubious on Indian goods.

Headworks.
The headworks consisted of 4 major structures:

- Dam
- Sluiceway
- Desilting Basin
- River Training

The construction of the headworks was a big challenge for Himal Hydro both in terms of programme and scale of the works. The river was there all the time crossing the construction site. The monsoon divided the year into two seasons, the rainy one and the dry.

Construction of the headworks structures mainly took place during dry seasons, although with the construction of substantial cofferdams, it was possible for some construction work to take place during the monsoon. Careful planning and programming was very much the key to meeting the requirements of the overal Time Schedule for each site and season. A total volume of 130 000 m^3 excavation and 11 000 m^3 of concrete had to be dealt with spread out over a widely extended site.

The river was channeled over to the left bank while working on the major concrete structures along the right bank: The desilting basin, the sluiceway and that part of the dam. During monsoons much of the river plain was flooded. When the concrete structures of desilting basin and sluiceway had reached sufficiently high level the river was diverted to the sluiceway canal, and the left part of the dam could be constructed. Three openings in the dam are provided at the left abutment for letting the river trough while erecting the radial gates in the sluiceway and for future maintenance.

Although involving a large volume to be excavated, the river training work did not offer any big problems. The new Cat E140 back hoe excavator managed the job well, digging both dry and under water.The gabion work was more labour intensive. A total of 21 300 m^2 of gabion mattresses were used for lining the embankments of the sluiceway canal. Specialist sub-contractors were engaged for weaving the wire mesh. (Gabions are very much used in connection with highway building in Nepal.) Some problems were encountered with badly annealed wire. Quite a substantial amount of wire had to be returned to the Indian supplier to be replaced with correctly annealed wire.

To meet the quality specifications for the concrete, the size and complexity of the structures, and the tight time schedule, the headworks represented a challenge and a training ground for Himal Hydro, a challenge they managed well, gaining experience and competence for future major works.

With the somewhat increased mechanization compared with earlier jobs Himal Hydro used for the first time big size shuttering panels, with a crane to handle them. Shuttering was mainly based on a system of plywood sheeting with wooden battens and aluminium or channel iron soldiers.

Very much work was done in the test laboratory to improve concrete quality and strength, so that the prescribed mixes could be produced as a matter of routine. The specifications (based on British Standards) were strict in requiring trial mixes and acceptance of a mix prior to commencement of actual concrete placing to the permanent works. Locally available aggregates were used for all the concrete mixes. Aggregates were generally collected and washed by sub-contractors before being placed in stockpiles.

Gate sections under construction. (Photo by L. J. Bakkevig)

Mounting of formwork at dam site. (Photo by L. J. Bakkevig)

Transportation of the wet concrete from the mixer to the formwork took place by a variety of means depending on site and type of structure. It ranged from skip and crane to wheelbarrow. Compaction was generally undertaken using pneumatically driven poker vibrators. Individual pour volumes varied from 4-50 m^3. Maximum volume of concrete poured in one month was 1158 m^3.

Curing of the concrete was generally carried out using wetting or ponding. In hot weather with big pours some special measures were taken to prevent flash setting. In addition to sheltering the aggregates from the heat of the sun and keeping the mixing water cool, the usual measure was to adjust the working day to avoid the hot hours.

The good surfaces of the concrete structures, together with the records of cube testing showing good strength, provides a good reference for the concrete work carried out by Himal Hydro at the Headworks site.

Headrace tunnel.

The excavation of the headrace tunnel was not on the critical line and presented no difficult problems for Himal Hydro. The geology of the tunnel was of the same nature as that of the Andhi Khola project, a fractured phyllite/slate rock with clay seams and minor faults. Having good experience from that project Himal Hydro decided to apply the same methods of excavation and lining as used at Andhi Khola.

Only about 60 m of the headrace tunnel was excavated from the Headworks site, the rest, approx. 1 km, was excavated from a short adit near the surge tank. The average progress for excavation, mucking and lining was approx. 10 m/week.

Excavation was by simple drill and blast techniques using hand held rock drills (Atlas Copco RH 656-4W) and pusher legs. The holes were charged with standard Indian gelatine (IEL SG80) and short delay electric detonators. The pull varied between 1 and 2 m, depending upon the rock conditions. The pull was also adjusted to fit the lining operation which followed each round of excavation.

Mucking was done by hand, initially using wheelbarrows for transportation. Later a rail mounted system with manually pushed 0.9 m^3 waggons was installed. A belt conveyer was used for filling the waggons. The mucking capacity was very low. However, the time schedule allowed for the use of this kind of labour intensive method.

The lining was carried out immediately after the mucking had been completed. With some adjustment to the pull of each blast a full cycle could be achieved within 2 shifts. Shift lengths were extended if necessary so that mortar to the masonry was allowed some 6-8 hours to set before the next blasting cycle.

The 350 mm thick stone masonry lining was constructed in two parts. Up to arch spring level open "shuttering" was used to contain the wall as it was being built up. After the masonry walls reached spring level, pre-fabricated concrete arch elements were installed as permanent formwork, and the masonry work continued to fill the cavity up to the crown of the tunnel. In case of larger overbreaks during the excavation, dry shotcreting was used to provide temporary support until the permanent lining could be installed. A 150 mm thick concrete flooring was applied after completion of the tunnel.

Surge Shaft.

The 3.5 m diameter and 28 m high surge shaft at the downstream end of the headrace tunnel was excavated from the top downwards, using a gantry crane for hoisting the muck out. The rock was very poor, only 10.6 kg of explosives were used for the total excavation of 216 m^3. The shaft was temporarily lined with shotcrete during the excavation. The permanent concrete lining was poured from bottom upwards, using a ready made steel shuttering which was moved 1.3 m upwards between each pour. The shuttering was manufactured locally by Himal Hydro.

Penstock Shaft.

The 265 m long shaft at 1:1 gradient was excavated from bottom up using an Alimak Raise Climber as a platform for drilling and charging. It was a first time use of this technique both for Himal Hydro and in Nepal. Excavation started after rigging up in February/March 1991 and a highly appreciated breakthrough came in June 1992. The rock quality was mostly very poor, average explosives use in this small bore of 3.4 m^2 was only 1 kg/m^3. A considerable amount of temporary shotcrete lining had to be applied.

Between the shaft and the branch tubes at the power house an inclined tunnel, 120 m long/gradient 1:12, had been excavated by conventional means before the works started on the 1:1 shaft.

The installation of the steel penstock pipes in the shaft and the inclined tunnel was another new and challenging task for Himal Hydro and also for Nepal Hydro and Electric in Butwal. NHE was responsible for the manufacturing of the pipes and for the welding in final position underground.

Starting the erection from the bend at the intersection of the 1:12 and 1:1 tunnels the 6 m long pipe sections had to be transported by different means through the surge shaft and the penstock shaft before aligning and welding, a cumbersome task. Then came the embedding of each separate pipe, concreting the space between steel pipe and rock. The installation of the steel lining started in January and was completed in October 1993.

Powerhouse.

The powerhouse construction involved bulk excavation of some 20 000 m^3 of soil and rock, one third of it rock, and some 900 m^3 of concrete. Most of the soils

Alimak Raise Climber for use in the penstock shaft. (Photo by L. J. Bakkevig)

Erection of penstocks in the inclined shaft. (Photo by L. J. Bakkevig)

excavation was done by manual means, while the rock was bench blasted and partly mucked manually. The rock face was stabilized with rock bolts and shotcrete. 1991 was the year of excavation.

The construction of the concrete structures was speeded up considerably by the use of a tower crane, which allowed an increase in the size of shuttering panels and eased the placing of concrete. Concrete work started in March 1992 and was finalized one year later. The switchgear and control building was completed June 1993.

Tailrace canal.

After finalizing the concrete works at the powerhouse late 1993/early 1994, the excavation of the tailrace canal was done. The short canal leading the tailwater from the powerhouse to the main course of the Madi river was lined with gabions. Total work comprised 5000 m^3 excavation and 2600 m^2 gabions.

Transmission lines.

JHEREP includes two types of transmission lines:

- A 132 kV line which connects the power plant to the national grid.
- 33 kV lines for supply of electricity to Pyuthan, Rolpa, Arghakhanchi, Gulmi and Syangja districts.

These lines were all surveyed and constructed by the Himal Hydro transmission line division under supervision of a senior expatriate engineer. The work was basically carried out on a cost plus basis. BPC provided most of the materials, such as poles and towers, insulators, ACSR conductors and GI earth line wire with necessary hardware.

The 132 kV line connects the Jhimruk power plant with the Lamahi substation which is on the main 132 kV line that runs through the length of the country from east to west and forms the backbone of the national grid. The 41 kms long Jhimruk line crosses a rugged hill area but ends in the Terai plains. It generally follows a motorable road which greatly facilitated the erection. The line is stringed with 50 mm^2 Cu equivalent ACSR, with 50 mm^2 GI earthline mounted on top of the towers. Conductors and insulators were purchased in India.

On the hill section there are several long spans, the longest near to 900 meters length, with towers, 10 to 15 meters high, placed on hill tops and ridges. On the plains spans are shorter and towers up to 25 meters tall. The towers are of a stayed modular lattice type, manufactured by NHE in Butwal, assembled at site by bolting together modular sections to the required height. The sections are fabricated in 2.5 meter lengths and galvanized after welding. Most towers have two legs, designed to take axial load only, hinged to a crossarm that is also similarly assembled at site from modular sections. The towers are held in position by means of stay wires which take up the horizontal forces.

Each modular section weighs no more than what can be carried by porters in rough terrain. These towers weigh less than half of self-supporting towers of conventional type, and do not require concrete foundations. The design and production of this type of towers was developed as part of the Andhi Khola project. They have been in use now for a number of years on spans of similar lengths as those on the Jhimruk line, carrying ACSR conductor of size equivalent to 95 mm^2 Cu. The cost per km of 132 kV line at Jhimruk amounted to NOK 210,000 approximately (USD 31,000).

33 kV line: The 162 kms of 33 kV transmission lines make up a significant part of the Jhimruk Project. When the term 'rural electrification' is mentioned in the name of the Project, it is because of the lines that are passing through hill districts with a population of more than one million people who have so far not had any supply of electricity. One of the lines, the 117 kms line from Jhimruk to Andhi Khola, does have other purposes also: It directly connects BPC's plant at Jhimruk with that at Andhi Khola, and it did supply construction power for the Project. But the main purpose of including the 33 kV lines as a part of the Project was to provide the basic infrastructure for rural electrification in these hill districts.

Generally these lines were built in roadless and rugged hill areas where materials had to be carried in by porters. Low weight galvanized conical tubular steel poles, manufactured by NHE in Butwal, were used. These poles are assembled at site simply by sliding one 2.5 m long section on top of another, as many as required to get the required height. Even the heaviest bottom section can be carried by one porter alone. The 33 kV lines are stringed with ACSR conductors of cross section varying from 25 mm^2 to 95 mm^2 Cu equivalent, with pin insulators except for dead end towers where disk insulators are used.

The surveying of these lines, the transport of materials and the construction supervision involved a lot of hardship for all involved due to the inaccessability along much of the route of these lines. But in the course of this work Himal Hydro has been able to build up and train a strong work force of skilled workers, supervisors and engineers, and has become the best equipped and most experienced transmission line contractor in the country.

Support facilities.

A civil engineering construction project in a remote area like the Jhimruk project, needs some support facilities to enable the construction work to take place. To provide these facilities was part of the civil contractor's mobilization work. Here only some of the arrangements should be mentioned.

Electro-mechanical support: All sites were supplied with electric power over a distribution net fed from diesel generators at the main compound at Madi river, later on from the incoming transmission line from Andhi Khola.

Compressed air for the works at surge tank and the headrace tunnel was taken from compressors located at the main compound.

Water supply to sites and housing areas was established.

Healthcare: With the assistance of a number of expatriate wives (2 doctors and three nurses) a main clinic was set up adjacent to the offices and a sub clinic at the Headworks. The clinics were able to deal with accidents, emergencies, vaccinations, first aid, healthcare training etc. During the construction period some Nepali staff were trained to work in the clinic.

4.6.2 Electro-Mechanical Works

As mentioned under # 4.5.b above the supply and erection of the electro-mechanical equipment for the Project were covered by different types of contracts:

- Electrical equipment: Mainly covered by a fixed price contract with delivery ex ABB works in Norway.
- Turbines and governors: Fixed price contract with a consortium of NHE and Kvaerner with NHE as Leader - delivery ex works Butwal.
- Other mechanical equipment including penstock and gates as well as transmission line towers and poles: Delivered by NHE ex works Butwal, partly on a cost plus basis, and partly with fixed price negotiated beforehand for specific components.
- Transport, storage, etc. was handled by BPC itself. Erection and commissioning was carried out under BPC's overall management with the help of suppliers' personnel as required - paid for as per fixed hourly rates.

BPC's role

The management of the contracts put heavy demands on BPC with regard to coordination and administration. It also loaded the Project with extra risks, even though risks related to transport, storage and erection were covered by insurance. In retrospect and generally speaking, it can be said that this setup worked out quite well, and resulted in considerable cost savings for the Project. It must also be noted that it could be done this way because the Project was grant financed. There were no lenders demanding risk coverage on bankable terms.

For future reference it may be worth while to consider these contractual aspects a bit further: What were the reasons for deciding to handle the supply and erection of the electro-mechanical equipment in this manner? And why did it work out the way it did?

Price negotiations - electrical equipment

Price negotiations for electrical equipment were not easy. ABB Energi's prices for equipment manufactured in Norway were high compared with prices quoted by foreign competitors. A significant difference in evaluated cost remained after hard bargaining, and even after taking into account the ease of communication and coordination having ABB Energi and Kvaerner working together as main suppliers.

The agreement with NORAD did not say that Norwegian suppliers should be given preference, but there was a case for buying Norwegian products when spending

NORAD grant money. In the end a more intangible factor influenced the decision: That was the element of trust which made it possible to agree on simple contractual terms, avoiding legal complexities, in the belief that any possible dispute could be settled amicably in a fair and reasonable manner.

Guarantees

The question of supplier's guarantees was the subject of much discussion, particularly with regard to the electrical equipment. In the end it was decided that the added costs of obtaining suppliers' guarantees were too high, particularly so since the guarantees were offered with so many conditions and reservations attached that the real coverage seemed doubtful after all.

Price negotiations - mechanical equipment

Supply of turbines etc. by the NHE/Kvaerner consortium was also governed by a fixed price contract. Since NHE had no basis for pricing its own input in a job of this kind, the overall contract price was actually negotiated by BPC with Kvaerner as if the equipment were to be manufactured by Kvaerner alone and delivered ex works Oslo. It was assumed that NHE's savings on production in Nepal, because of lower labour costs etc. would make up for the extra cost of having to pay for assistance from Kvaerner including foreign personnel for inspection and quality control in Nepal.

It was up to Kvaerner to decide whether the quality of NHE's work was acceptable, and to what extent Kvaerner personnel had to be present in Butwal, even though NHE had to pay whatever this might cost. From a legal point this would seem a hopeless arrangement. But it was a deal based on the trust that the relationship would be governed by a wish on both sides to be fair and reasonable. And this is the way it has worked out. In the end, NHE seems to have come out with a reasonable profit on the job, and has learned a lot in the process.

System responsibility

The two main equipment supply contracts with ABB Energi respective Kvaerner included engineering work directly related to the equipment they supplied. But the overall responsibility for design and coordination of the system as a whole rested with BPC. It was BPC as purchaser who had to determine the concepts and performance criteria which were to be met.

BPC worked out the hydraulic specifications for the waterway from the headworks through the penstock with furcations and branch tubes up to the main turbine valves. (These were obtained second hand and refurbished and modified by NHE with Kvaerner's help.) BPC had the complete responsibility for the detail design of the power house and switch gear/control building, including equipment installation and all auxiliary systems.

When BPC took on the responsibility as systems manager for the Project, its confidence was based on experience gained through its involvement over many

years in industrial and hydro power development in Nepal. BPC also wanted to gain more of that kind of experience which only comes when one has the sole responsibility for a project and is forced to consider all consequences when decisions are made. This type of experience is very important for institution building in a developing country like Nepal. It cannot be obtained by hiring outside consultants to make decisions.

Logistics

BPC took care of the logistics for all electro-mechanical works as well as a good deal of imported materials and equipment for the civil contractor through its branch office stores in Butwal. The BPC staff in Butwal consisted of one senior supervisor responsible for quality control and follow up on deliveries from NHE and other suppliers, and for onward transport to site. He was assisted by stock keeper, stock accountant and a varying number of helpers and labourers.

Another senior long term employee of BPC, serving as clearing and forwarding agent, was responsible for sea shipments through Calcutta. He had to stay in Calcutta for shorter or longer periods clearing shipping and import documents beforehand with port and customs authorities, overseeing the discharge and clearing of the cargo through the docks and customs, arranging the one thousand kilometer long road transport up to Butwal, and finally clearing the goods across the India-Nepal boarder some 50 kms south of Butwal.

Altogether about twenty consignments, a total of about 1400 tons of goods for the Jhimruk Project, were packed and shipped from Norway on Indian ships to Calcutta and transported by road to Butwal. In addition a number of shipments from Singapore and other Asian ports were handled in a similar manner, besides all the materials and equipment imported from India.

When BPC decided to take delivery of the electro-mechanical equipment directly from the suppliers in Norway, taking care of the packing and transport to site by itself, it was due to the long experience in handling shipments to Nepal which BPC had - along with a Norwegian agency: the Holm Development Aid Service (Holm U-hjelpservice) - a small low profile non-profit service firm affiliated with the NHAM.

Relationship between BPC and NHE

The relationship with NHE - for good and for bad - has been influenced by the fact that BPC is a majority shareholder in NHE. A guiding principle has been that business deals between the two should be negotiated at 'an armlength's distance'. But it has not always been felt that way by NHE who many times thought that the mother company was heavy handed in using its power as owner.

On BPC's side the feeling at times was that NHE expected BPC to do everything and demonstrated little independent initiative. The Project Agreement with HMGN gave certain import privileges to the Project as such. BPC was therefore responsible for purchase and import of materials, while NHE's own input was limited to manufacturing. This reduced NHE's turnover, but also its need of working capital.

The potential remained for making profit through efficient production in those cases where the price was fixed beforehand.

Much of NHE's work, particularly erection at site, was carried out on a cost plus basis, and required close cost control from BPC's side. This was not always easy to handle for the BPC Project Manager, a senior Nepali electrical engineer responsible for the management of purchasing and contracts.

NHE's performance as supplier

NHE had manufactured one Francis turbine before starting on the Jhimruk turbines - a 250 kW unit for 70 m head - located at Darchula - a remote place in the far West of Nepal. NHE had a turnkey contract for supply and installation of the complete electro-mechanical works for this plant. The turbine was designed by Kvaerner and manufactured according to Kvaerner's specifications. This job was successfully completed and a very good learning experience for NHE. It gave both NHE and Kvaerner the confidence that also the Jhimruk turbines could be manufactured in Butwal, even though these would be for 200 meter head and 4,000 kW each.

Turbines, governors, etc.

One Nepali engineer took part in the design of the Jhimruk turbines in Oslo. It was decided that the stay rings and the upper and lower covers should be manufactured in Norway. Semi-finished forged guidevanes were supplied from Norway, and machined to final shape in Butwal. The three runners plus one spare (designed for hydraulic pressure fit on the the extended generator shaft) were supplied by Kvaerner, as well as the electronic control cabinets and a number of hydraulic components for the speed governors.

The three spherical turbine valves were obtained second hand at a very reasonable price from the Tysse Power Plant where they became redundant because a new power station had replaced the old one. The valves had been put in fairly recently and were in excellent condition. The control system had to be modified to meet the requirements at Jhimruk. This was done with some design assistance from Kvaerner.

Otherwise, the manufacture of turbines and governors was carried out in Butwal, using materials which largely had been purchased through Kvaerner. The welding of the spiral casings - quality wise the most critical job - was subjected to x-ray and ultra sonic quality control, carried out by NHE personnel under the supervision of a Kvaerner NDT specialist in the course of a couple of two to three week long visits.

The machining of these casings was done in NHE's horizontal boring and milling machine. In spite of its age this machine turned out to be able to produce the necessary accuracy. Apart from some additional hand tools etc. the existing NHE turbine workshop with its complement of rather old secondhand machine tools proved to be sufficiently well equipped to handle the work without big problems.

Penstock, gates, poles, etc.
The fabrication of the 360 meter long 1.5 m diameter penstock tube designed for a head of 200 m was another big job for NHE, particularly the bottom bend and the furcations for the three turbine branchtubes. With the experience gained from manufacturing and installing the Andhi Khola penstock (1 m diameter and 250 m head) the NHE workers and staff handled this job without too much difficulty.

The penstock pipe was manufactured in Butwal in sections of 6 meters length. These sections were brought down through the inclined shaft on rails from the top. Site welding of the penstock by NHE welders continued over a period of about nine months from November 1992 to August 1993, followed by erection of the manifold with furcation and finally the branch tubes for each of the three turbines. This work was closely related to the civil contractor's schedule for embedding each penstock section in concrete. The same applied for the draft tubes embedded in the power house floor. The short tunnels for each branch tube from the main penstock tunnel into the power house were opened only after the 1993 monsoon.

The supply of galvanized steel poles and towers for 162 km of 33 kV and 41 km of 132 kV transmission lines was in terms of tonnage the largest job for NHE. The three 2 x 5 meter radial gates plus all other gates, trash racks, bulkheads, etc. for the headworks head race tunnel were also designed and manufactured by NHE.

Supply of embedded parts in time to meet the civil contractor's schedule did at times generate some friction. NHE was on several occasions behind schedule with their deliveries - usually because materials were not available in time. Lack of forward detail planning was the weakest point in NHE's performance. But in spite of these problems, NHE did not - as the main equipment supplier - really cause any significant delay in the overall completion of the Project.

Electrical equipment
NHE was also involved on the electrical side, although to a much lesser degree. All panel boards, except the electronic governor cabinets which Kvaerner supplied, were manufactured by NHE and wired up at the NHE Electric Section on the basis of detailed diagrams and drawings from ABB. The quality of the work proved to be satisfactory as determined by the ABB design engineer who provided guidance and advice during two visits in Butwal. NHE also supplied galvanized steel structures for the outdoor switching yards at both ends of the 132 kV line, and other necessary fixtures for the 6 kV and 33 kV switchgear installation.

The 33 kV switchgear section and its control panels were designed by BPC and NHE engineers jointly without any significant input from ABB. Control panels were manufactured by NHE, while switchgear and other components were picked up secondhand in Norway and overhauled or modified as necessary in Butwal.

4.6.3 Testing/Commissioning

Shop assembly and testing of turbines and governors took place in Butwal during

the last months of 1993 and early 1994 in the presence of a test engineer from Kvaerner. Thereafter the major turbine components were transported to site and erection began under the supervision of a Kvaerner erection supervisor along with the NHE engineer who had been responsible for turbine fabrication in Butwal. Erection of the turbine casings and valves had to be carried out in a certain sequence for one turbine at a time, involving the welding of the last sections of the inlet tube and draft tube, followed by the pouring of concrete in two stages. This work was completed over a period of about three months. During the same period the three generators were assembled one by one and placed in position to be lined up with the turbines before the foundation frame was concreted in its final position. At the same time the inside painting of the penstock pipe was going on. The tunnel and penstock was filled with water for the first time June 1994.

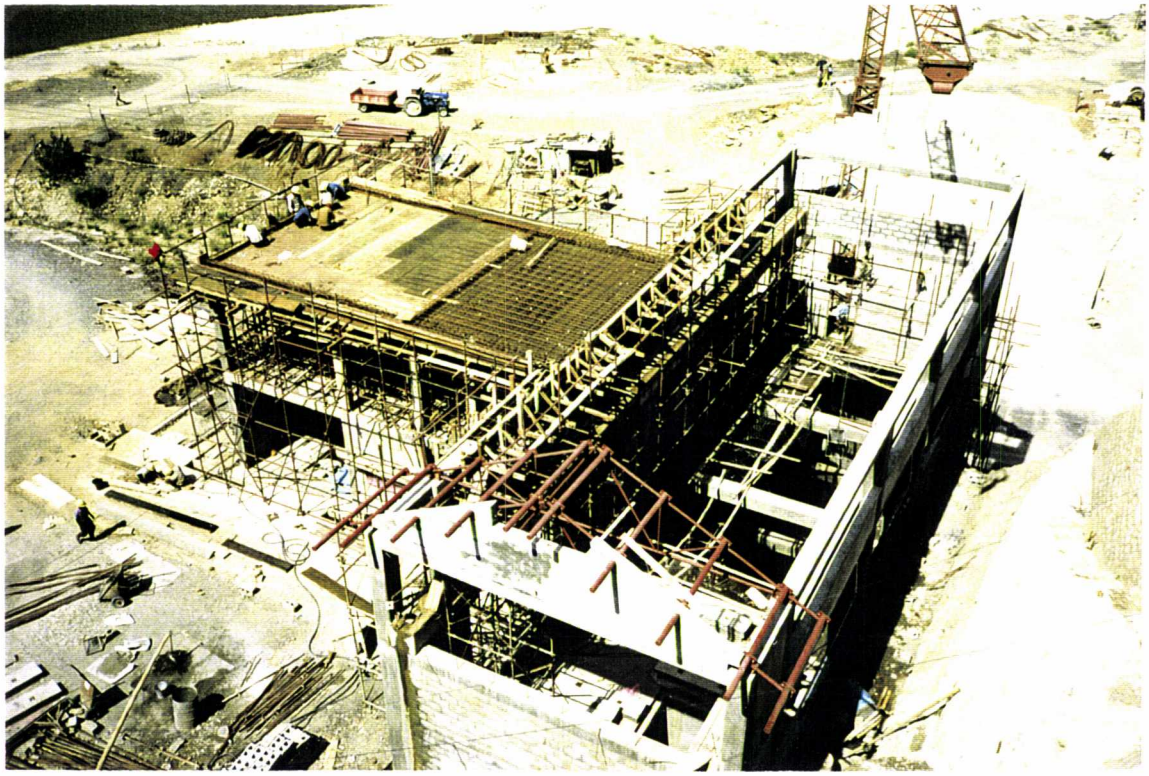
Erection of switchgear, laying of cables, etc started as soon as the building was completed in the fall 1993 under the supervision of BPC's electrical engineers at the site. Foundations and steel structures for the 132 kV switchgear were also put in by BPC at the Lamahi substation as well as at the power house site using own workers and contractors. An ABB erection supervisor spent two weeks checking the quality of this work and correcting mistakes.

By mid May the commissioning engineers, one from Kvaerner and one from ABB, arrived at site and stayed up to beginning of August when regular operation started. All electric circuits and control functions were tested (dry testing). Live testing of the first turbine began early July 1994. A specialist relay engineer came from Norway just for testing the impedance relay controlling the 132 kV cirquit breaker installed for the Jhimruk line at Lamahi.

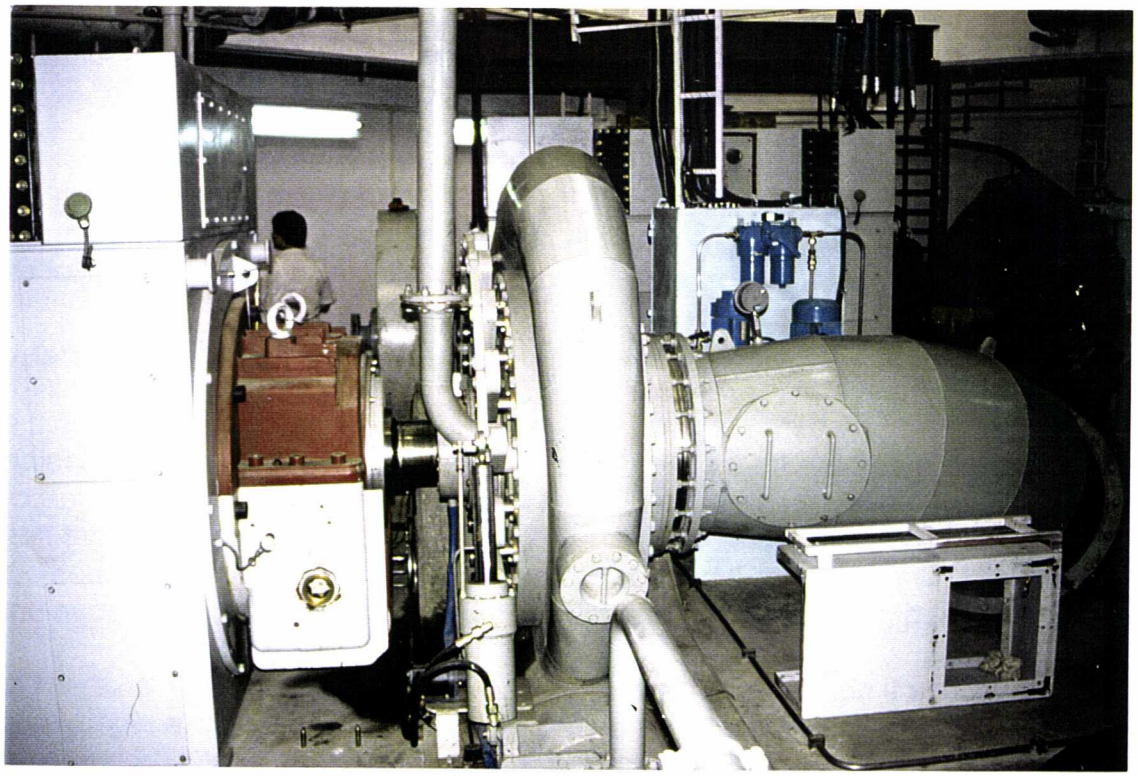
The main 15 MVA 6/132 kV transformer weighing 30 ton could not be transported over the old road across the hill. A new road along the Madi river had been under construction throughout the JHEREP construction period, and the big question was whether this road would be passable with a heavy load in time to bring in the big transformer. It just worked out. The transformer was brought in safely. And a couple of weeks later the road was closed again because of landslides after the first rain.

The last thing to be put into operation was the 132 kV transmission line itself, first because construction was behind schedule, and in the end because of problems at the receiving end. In the meantime testing with load had to be done over the long 33 kV line to Andhi Khola, and limited to the capacity of the 3 MVA 6/33 kV transformer at Jhimruk. Finally, the 132 kV was hooked up and permission given by Nepal Electricity Authority to carry out full load rejection test.

With this test also satisfactorily concluded, the erection, testing and commissioning of the Jhimruk power plant had been successfully completed just a couple of weeks after schedule.



Power house under construction. (Photo by L. J. Bakkevig)



4 MW unit at Jhimruk power plant. (Photo by T. Jensen)

c) The reason for the high bearing temperature therefore had to be insufficient cooling.

Generator bearings are lubricated and cooled by forced oil circulation. A separate unit contains the oil reservoir, pumps and a heat exchanger for oil cooling by running water.

The problem has since been solved by increasing the flow of water and doubling heat exchanger capacity. As a result, the bearing temperatures have come down to acceptable levels.

Also other teething problems were faced, particularly with regard to the functioning of electrical and electronic control equipment. All this happened during the holiday season in Nepal, and key members of the staff were away on holiday. The remaining rather inexperienced staff were left to cope with these problems, seeking advice by fax and telephone from ABB and Kvaerner in Norway. In the process, further mistakes were made which fortunately did not result in any damage or accidents.

Everything considered, the Nepali staff did cope with the problems as well as could be expected under the circumstances. What happened lends itself as cases to be studied and learned from in the follow-up training programme for the operating staff. One experience to be noted for future use is that the commissioning period should not be cut too short. On the other hand, staff having to cope with the problems on their own, rather than depending entirely on outside experts to sort out all difficulties, is certainly quite effective as 'on the job' training.

For more than a month, while investigations and repairs went on, the power plant was partly out of operation. In spite of these problems, the Jhimruk plant did generate about 35 GWhs of electric energy during its first 8 months of operation. At the going rate, this amounted to more than NPR 70 million gross income for HMGN.

The new energy source was very much appreciated by the Nepal Electricity Authority at a time with serious power shortage in the country. In fact, during the financial year 1994/95 the power plants at Jhimruk and Andhikhola together contributed more than 7 per cent of total production of electric energy in Nepal.

4.8 The Silt Problem

A serious problem remains at the Jhimruk power plant: The excessive turbine wear due to the high content of silt in the water. When the most affected turbine was opened up, it was confirmed that after only a couple of months of operation under monsoon conditions there was heavy wear not only on the bronze sealing rings, but also on the abrasion resistant stainless steel lining of the turbine covers, on the stainless steel guidevanes, and to a lesser degree on the runner.

The brief period of operation under monsoon conditions during the first year was insufficient as a basis for making final decisions about possible modifications in order to control and reduce the effects of the silt problem. It was decided that only

stop-gap repair work should be undertaken at this stage.

During the next monsoon season systematic monitoring of the silt content and the resulting wear should be undertaken. On the basis of these observations the situation would be reviewed and final decisions made concerning possible modifications.

The three turbines were taken out of operation one by one and reconditioned in NHE's workshop in Butwal. Worn surfaces were built up by welding and machined to original dimensions. This work was time consuming and labour intensive. It became even more evident how important it is to have a workshop of NHE's standard in Nepal. If this job should have been done in a workshop overseas it would have become prohibitively expensive.

In the meantime Kvaerner had studied the silt wear problem at Jhimruk - having also been faced with similar problem in other Himalayan rivers. One suggestion was to try a new method of surface treatment of wear parts known as nitrite hardening. In order to test this out at Jhimruk, one spare runner and four spare guide vanes were sent to Germany for treatment and thereafter installed in the last turbine to be overhauled. The outcome of this experiment is not yet known.

In any case, it is pretty clear that the silt problem is a thing which one in the future shall have to live with at the Jhimruk power plant. Besides the cost of repairs the main question is how to reduce the down-time of the turbines, and thereby the loss of production. One answer is to have a full set of spare parts which are continuously being reconditioned at the workshop in Butwal. After every monsoon, as a matter of routine, the turbines will be stopped one by one for replacement of worn parts. With certain modifications in the design of the upper turbine cover it is expected that the down-time per turbine may be reduced to 48 hours or less.
A full set of upper and lower covers with replaceable wear plates, and a set of semi-finished guide vanes for all three turbines has been ordered from Kvaerner at a price of NOK 2.1 million. In addition comes the cost of work to be done by NHE in Nepal.

At the time of reviewing this report another monsoon season has passed. During this second monsoon period an elaborate system for monitoring the operation of the headworks desilting basins etc. and for taking samples of siltladen water has been in place.

A Nepali engineer with specialist training in sediment control from NTH in Norway was stationed at the site through most of the monsoon period, supervising the operation of the headworks installations and a laboratory equipped for analyzing samples of suspended silt. Various devices have been installed to take out samples at different points under varying load conditions. This is carried out with assistance from and in continuing consultation with Haakon Støle from the Norwegian Hydrotechnical Laboratory, who was involved in the model study of the Jhimruk headworks from the beginning.

Samples taken in this manner show that the sedimentation chambers at the

headworks when correctly operated do remove particles larger than 0.2 mm which was the design criteria for the turbines. The problem is that the very fine silt, which remains in suspension, contains a large proportion of highly abrasive quartz. (See attached graph in Appendix 10.)

The possibility of trapping more of the silt by installing a by-pass sedimentation chamber at the lower end of the headrace tunnel is presently the subject of a model study carried out at the hydraulic laboratory in Trondheim. The idea is to divert water flowing close to the floor in the tunnel, which has a higher than average content of suspended silt, remove some of this silt in the by-pass chamber, and return the cleaner water into the tunnel.

It is worth noting that the Jhimruk power project is being used to carry out research and testing out innovations in sediment treatment which are of great potential value for future design of headworks installations and water treatment in Himalayan rivers.

One fruit of this is the establishment of the Nepal River Research Laboratory (NRRL) in Kathmandu which is meant to be a permanent and important instrument in the harnessing of Nepal's water resources. Another is the 'Serpent' concept for flushing of sedimentation basins. Still another is the study of possible remedies for further reducing the content of suspended abrasive silt.

This potential for research and innovation is a direct result of the manner by which the project has been financed, and the freedom given to the project management in the execution of the project.

For more detailed information on the silt problem see attached:
- 'Problems with Silt in Jhimruk Power Plant' by Suman Basnet. (Appendix 9)
- 'Sediment problems in the Jhimruk power plant'. BPC Hydroconsult 19.1.1996. (Appendix 10)

4.9 Ownership and Future Status

In accordance with the terms of the agreement between UMN and HMGN concerning JHEREP the income from sale of energy during the guarantee period belonged to the Government, while BPC was to be refunded for its actual expenses in operating the plant. A separate agreement was made to lay down the exact terms for the interim period, and the energy price to be paid by NEA to HMGN was fixed as a flat tariff of NPR 2.10 per kWh.

The JHEREP Agreement between UMN and HMGN said that BPC by the end of the one year guarantee period would hand over the project to HMGN without any compensation. This guarantee period would end on the 16.8.1995 unless extended by mutual agreement. BPC suggested that in view of the silt problem there might be reason for extending the guarantee period, but this was turned down by the Government.

The timing of the handover coincided with a politically very turbulent time, and the Ministry was late in making its final decision. When the decision was finally made, it

came more or less as a surprise for BPC and UMN.

The question of the future status of JHEREP had, of course, been debated for quite some time in view of the privatization drive taking place in the country. Already in July 1993 BPC raised the question in a letter to the Ministry by suggesting that HMGN might want to leave BPC as owner and operator of JHEREP against getting the value of the plant as preference shares in BPC.

At the same time it was suggested that BPC could take over the responsibility for rural electrification in the four districts covered by transmission lines built as part of JHEREP.

An alternative suggestion was made later: To set up a separate company to own JHEREP and lease it to BPC, and to sell the shares in the new company to private investors and give the proceeds from the sale to HMGN.

None of these suggestions were accepted by HMGN, even though Government officials continued to say that they wanted to strengthen BPC as a private operator in the power sector. This was understood to mean that JHEREP would remain in BPC's hands and that UMN's NORAD financed shares in BPC would be sold in the share market and the proceeds handed over to HMGN.

In spite of certain doubts concerning the ability of a privately owned utility to serve the public in a satisfactory manner, this was accepted to be the outcome of these deliberations - until HMGN's surprising decision was made known just a couple of weeks before the time of handover. HMGN's decision had three points:

a) To take over JHEREP as per the terms of the Agreement with UMN.
b) To give the project back to BPC as share investment in kind.
c) To demand that UMN turns over to HMGN a corresponding portion of its shares in BPC to HMGN.

The consequence of this was that HMGN would hold nearly 100 per cent of the shares. BPC would then become a 'Government Company' defined as a company where HMGN holds more than 50 per cent of the shares, and according to existing legislation is entitled to appoint the general manager and the members of the board. This was an outcome which all concerned had agreed should be avoided by all means.

The concerned officials in the Ministry still say that it is the intention of HMGN to sell a large part of its shares in BPC, and that non-Government people in the meantime will be appointed to serve as members of the Company Board.

At the time when this is written, there is still no indication of what action will be taken by HMGN in this respect. Neither has there as yet been issued a license to BPC giving the exact terms according to which BPC shall operate the power plant and defining the scope of BPC's involvement in retail distribution and rural electrification.

In the meantime BPC is operating the plant and selling the energy to NEA on the basis of the old agreement between the Ministry and NEA, receiving the income from this sale at the old price. On instructions from the Ministry BPC has submitted a first draft of long term power sales agreement with NEA. NEA has so far not been

willing to enter into negotiations on this subject.

With regard to BPC's own future several questions remain unanswered. UMN is now a minority shareholder in BPC. The Board has not yet been reconstituted, but it has been indicated from HMGN's side that UMN should continue to hold one seat on the Board.

Within the old Board there is a consensus that BPC under its new shareholder structure should be split into two companies: One company - by far the biggest in terms of assets and turnover - would hold the utility part of the present BPC. The other smaller company would take over BPC Hydroconsult and other development oriented activities. It remains to be seen whether this is actually going to happen.

The grant of NOK 130 million which was made available by NORAD for financing the JHEREP had not been fully used by the time the project was handed over to HMGN. About NOK 10 million was still in hand, out of which some NOK 5 million was earmarked for remaining mitigation works and for plant modifications due to the silt problem.

The remaining NOK 5 million is planned to be used to set up a centre for small scale industrial development and training. This centre will be accommodated in existing buildings which were used by the civil contractor during the construction period, and since have been vacant. The establishment of this centre is waiting for formal agreements with NORAD and other concerned parties to be finalized. The hope is that this will be accomplished within the current financial year which ends 15. July 1996.

5. TRAINING

5.1 Civil Construction

From what is said above it should be understood that institution building and staff training of the UMN related Nepali companies BPC including BPC Hydroconsult, Himal Hydro and NHE was to be an essential and integrated part of the project. Through the works at Tinau and Andhi Khola the lower grades of "company schooling" had been passed, now time had come for college level education! The target set by UMN for these companies was to make them independent and self-sustained indigenious institutions.

Such training is two fold: There is the need to develop the company as an organization, and there is the need to train the individuals in the company. Training within the companies is a vehicle to build them up as efficient organizations.

The framework for this process was laid down in the manner of contracting the works to the UMN companies. The works represented a step forward in scope from what the companies had undertaken before, with conditions and requirements being more strict and professional. In addition came the more specific staff training programmes within the companies.

The civil works contracts, based on Fidic rules and formats, required pricing of a full "Bill of Quantities" (BoQ) which for a project of this size left Himal Hydro with a challenge with regard to estimation they barely had data enough to meet. The negotiations with the "Employer" (BPC) were difficult. Some of the unit prices were too high, others too low in the opinion of BPC. A final BoQ was aggreed upon with BPC's guarantee that Himal Hydro should not suffer any loss on the contract. Further it was agreed that the contractor should establish a data collection system covering all the major components of construction work. As a result of the contract Himal Hydro came out of this project with a fairly extensive data bank.

In the separate data sheets for specific work items any input of manpower, materials etc could be quantified, but not in terms of costs. If recorded in terms of costs the data sheets would have been time related, i.e. tied to wages, cost of materials etc. as applied at the Jhimruk project and not valid straight away later on.

As a sub section of the data collection system, an extensive record of performance and cost data was set up for all heavy plant and machinery. In this area it is not enough to record manpower and materials only because of the high proportion of spare parts costs involved. Therefore all kinds of costs were recorded in order to give an hourly cost of operation.

With good help of computers a cost reporting system was also introduced. Basically two cost reports were produced each month,
a) Detailed Reports referring to each cost code: The expenditure, income and variance for the particular month, and cummulative as at the end of the month.
b) A Summary Report giving the overall picture of expenditure and income for each

site.

To set up this cost monitoring system and obtain the data in a timely way, was a struggle. However, once the system was set up, it operated well.

Introducing systems as mentioned above required individual training. A whole series of training programmes were established under the organization and leadership of a part time Training Coordinator.

Main areas of training included:

- New techniques
- Use of new machines (Heavy Plant, Alimak etc.)
- Use of computers

- Management training
- Report writing
- English language

- Healthcare/sanitation
- Nutrition
- Use of money

The Himal Hydro Project Manager, summing up his experiences, says:
"During the life of Jhimruk Project, the skills and expertise of staff have been increased, and it is encouraging to see individual staff being able to take increased responsibility."

A full report on the training in Jhimruk is given in Appendix 7.

5.2 Training in BPC/BPC Hydroconsult

Most of the training in the offices in Kathmandu has been done on the job, by having one experienced person working together with two or three assistants. A small library has been built up on hydro power engineering, and some international technical periodicals subscribed to. On special subjects lectures have been presented either by senior staff or by outside visitors.

Courses have been given in English language and in use of computers.

Each year one or two engineers have received scholarships to the one-year course in Hydro Electric Engineering at the Norwegian Technical Institute at the University in Trondheim.

5.3 Training in NHE

NHE came into being as a fruit of the Andhi Khola Project and was set up in

collaboration with Kværner's Sørumsand Verksted (now part of Kværner Energy AS). The purpose of this collaboration was to manufacture turbines and other hydraulic/mechanical equipment for hydro power development, and to offer repair and maintenance service for the hydro electric power industry in Nepal.

Later ABB National Transformer AS joined as a shareholder in NHE, and helped establish a workshop in Butwal for quality repair of distribution transformers. With Jhimruk another company in the ABB group, ABB Energi AS, came into the picture, not yet as a shareholder, but in technical collaboration related to local manufacture of panel boards and erection of electrical equipment supplied by ABB for Jhimruk.

The same may be said for NHE as mentioned above in the case of Himal Hydro: While Andhi Khola was like primary education for the Company, Jhimruk has been like secondary school. For NHE this has especially been training of staff and workers in specific fields.

Over the years nearly 20 employees of NHE have been in Norway for periods of one to six months or so for getting on the job training with Kværner: The chief design engineer has worked on the design of Jhimruk turbines at the Kværner engineering office in Oslo for periods of several months each time. Three welding technicians have been working at Sørumsand for getting practical experience in non- destructive testing and quality control of welding. One of these has obtained official certification as welding quality control inspector.

Similarly, Kværner specialists have been giving on the job training in different areas to NHE workers and supervisors for two to three weeks at a time during their visits in the NHE workshop in Butwal in connection with the fabrication and shop assembly of Jhimruk turbines and governors.

A considerable amount of training was carried out also on the electrical side. Two electrical engineers (one from NHE and one from BPC) had three months training in Norway organized by ABB Energi. This training continued on the job in Butwal when an ABB engineer made a couple of two weeks long visits to inspect the manufacture and wiring of instrument cabinets for Jhimruk in Butwal.

Probably the most valuable form of training on the mechanical as well as the electrical side took place during the time of erection at the power plant in Jhimruk. This was especially true for NHE workers and engineers who had a golden opportunity to learn the trade from Kvaerner's experienced turbine erection supervisors and commissioning engineers.

On the job training by foreign experts who come to Nepal is expensive when one has to pay hourly rates equal to one or two weeks' salary for a Nepali engineer. But if the foreign experts are of the right kind, this sort of input can be very efficient, even when it must be limited to two or three weeks at a time due to the high cost.

5.4 Training of Power House Operators

At an early stage steps were taken in consultation with Himal Hydro to recruit people from the local area who as employed at the various construction sites had demonstrated personal qualities and ability to learn new skills. When erection started, these were engaged as helpers for the erection crew from NHE in order for them to pick up some understanding concerning the equipment being installed.

A deputy plant supervisor from Andhi Khola, trained at Butwal Technical Institute (BTI), was transferred to become chief plant supervisor at Jhimruk. Other BTI trained technicians with practical experience were picked to become supervisors at Jhimruk, one on the electrical and one on the mechanical side. One electrical and one mechanical engineer made up the rest of the technical staff. Several of these had been involved in BPC design work and had taken part in manufacturing and shop assembly of Jhimruk equipment in Butwal, and all of them were present and more or less actively involved during the erection, testing and commissioning at site.

BPC's Operations Manager, a Nepali electrical engineer responsible for the operation of the Andhi Khola plant and distribution system who had been involved in the design and erection of the Andhikhola power plant, was charged with the additional responsibility of overseeing the starting up and operation of the Jhimruk plant.

The rather complex Jhimruk headworks installations required also well trained personnel who under critical monsoon conditions can operate the system with necessary skill and understanding. Engineers and operators have been trained on the job by the engineers from the Norwegian Hydrotechnical Laboratory (NHL) in Trondheim, among these Haakon Stole who carried out the model testing and provided the conceptual design of the Jhimruk headworks. He and other experts from NTH and NHL were instrumental in setting up the Nepal River Research Laboratory in Kathmandu where Jhimruk model study was carried out. This laboratory, intended to serve Nepal's future needs in its field, can by itself be counted as a valuable by-product of the Jhimruk Project.

The plan is to continue the training of the operating staff at Jhimruk. Part of this training is integrated with the preparation of a complete operation manual, partly written in the Nepali language. The operators are being involved in this process of trying to express complex technical matters in practical terms understood by people without higher academic education.

In addition, a regular two year training programme for power house operators and maintenance personnel is being planned by BTI. Primarily this is to meet the training requirements for the new Khimti Project, but it will also be open for BPC personnel at Andhi Khola and Jhimruk. Part of the training will actually take place at these two power stations by trainees being rotated to learn the practical side of what they are taught in the classroom.

6. PROJECT COSTS

Project budget, actual project costs and deviation from the budget for the main activities are shown on next page. Further cost breakdown and comments to the Financial statement are shown in Appendix 8.

Initial budget (= NORAD grant) for the Jhimruk project was USD 19 mill., which equals NOK 129.2 mill.based on an exchange rate of 1 USD = NOK 6.80.
NOK 0.8 mill. was added later. In addition came USD 1.170 mill. (= NOK 7.956 mill.) to be paid by HMGN, mainly to cover expenses for land aquisition, taxes etc.

Expenses were paid partly in NOK and partly in NPR. Financial statement as per 16.08.95 (Appendix 8) is based on the average actual exchange rates during the construction period which turned out to be 1 USD = NOK 6.58 = NPR 40.30.

BPC kept the overall budget unchanged in spite of several cost consuming design modifications, and also adding new parts to the project. To be especially mentioned is the construction of the 33 kV rural transmission line from Tansen to Jhimruk.

Actual project costs ended up with NOK 120.420 mill (as per 16.08.95), which was NOK 17.5 mill. below the budget. Mean annual production capability at Jhimruk is approximately 80 GWh. Investment costs will then be 1.50/kWh. Dependent on the amount of water to be released for irrigation purposes, and also to what extent possibilities for electricity sales during monsoon season are present, actual production might vary between 60 and 80 GWh/year.

Some small works still remained after 16.08.95. The final project costs will therefore be slightly higher. The approximately NOK 10 mill. of the funds saved will be spent partly on remaining mitigation works and repair works due to the silt problem and partly on a centre for small scale industrial development and training. These works will be organized as a separate project, JHEREP II, (ref. # 4.9).

JHIMRUK HYDRO ELECTRIC and RURAL ELECTRIFICATION PROJECT

BUDGET and ACTUAL COSTS, MAIN ITEMS

	Project budget, NOK x 1000	Actual costs, (as per 16.08.95) NOK x 1000	Deviation from orig. budg., NOK x 1000
Support Services	7,820	5,257	- 2,563
Civil Works	39,168	40,281	1,113
Electro-Mechanical Works	43,146	38,019	- 5,127
132 kV Transmission Line	5,780	9,117	3,337
33 kV Rural Lines	11,118	9,684	- 1,434
Extra Works (Mitigation)		1,422	1,422
Financial costs		0,218	0,218
Land and Taxes	7,956	3,942	- 4,014
Direct Costs	114,988	107,940	- 7,048
12 % Engineering/Management *)	13,929	12,480	- 1,449
Contingencies	9,039	0	- 9,039
TOTAL COSTS	137,956	120,420	- 17,536
FUNDS RECEIVED:			
NORAD	130,000	130,000	0
UMN	0	1,240	1,240
HMGN	7,956	3,942	- 4,014
Adjustment reg. rate of exchange **)	0	- 3,289	- 3,289
Total net received ***)	137,956	131,893	- 6,063

*) The fee for administration, engineering and management (E&M) was fixed as 12 % of direct costs (+ contingencies, but excluding cost of land and taxes paid by HMGN).

**) Actual costs have been converted into NOK at the average weighted rate of exchange of NPR against NOK throughout the project period (NOK 1.- = NPR 6.12). At the current rate of exchange of about USD 1.- = NPR = NOK 6.50 (i.e. NOK 1.- = NPR 8.815) the value in NOK of NPR funds held in Nepal is reduced by NOK 3,289,000.

***)

Net funds received	NOK 131,893,000
Less total costs	" - 120,420,000
Less part of E&M fee	" - 1,449,000
Available balance in hand	NOK 10,024,000

7. ENVIRONMENTAL AND SOCIAL ASPECTS

7.1 General

One shortcoming of the project planning was that the environmental and socio-cultural aspects were poorly taken care of from the beginning.

At an early stage (1990) the Norwegian anthropologist dr. Harald Olav Skar made a review of aid through Norwegian non governmental organizations in Nepal (/3/). Skar's report also dealt briefly with the Jhimruk project. One of Skar's objections to the project was that it did not include a rural development component, as had been the case at Andhi Khola, for example. The response from BPC was that the project was taken on as a hydro power project only, and had to be carried out according to that.

One issue mentioned in Skar's report is, however, very important. That is the information to the local population of what was going to take place. According to Skar the information aspect had been almost completely neglected, at least at the very early stage. This again led to uncertainty among the people.

The Jhimruk valley is a densely populated area where almost all the people make their living from agriculture. Most of the fields are located in the hills surrounding the valley, but there are also considerable areas of cultivated land on the valley floor. Most of these fields are completely dependent on irrigation water from the Jhimruk river. Many of the villages are also dependent on the Jhimruk river for supply of water for drinking and washing.

According to the project plans, all the water would be taken away from the river when the flow is less than the operation flow of the power plant.

When NORAD approved the government's application for financing of the Jhimruk project, no conditions were made as to possible environmental measures. In retrospect it was obvious that environmental studies should have been carried out, preferably in close connection with the technical/economic planning of the project, but at least based on fixed technical plans.

In 1990 it was therefore decided to carry out an environmental study. The Nepalese firm GEOCE Consultants (P) Ltd. was engaged to do the job, and the final report was completed September 1991 (/4/). NVE made an assessment of the report in January 1992, refered to under item 7.2.5.

7.2 Findings of the Environmental Study

The environmental study concentrated on three fields:

- Irrigation
- Water supply
- Fish

The main emphasis was put on fish.

7.2.1 Irrigation

General
The first tributary of the Jhimruk river which contributes with water in the dry season is Chappe Khola, located 13 km downstream of the headworks. The total lowland areas between the weir and Chapppe Khola is 164 ha. The farmland is intensively utilized, giving three crops per year. Paddy is grown twice a year, pre-monsoon and monsoon, while wheat is grown in winter. As the agriculture land is limited, these productions are for local consumption only. The total diversion of Jhimruk Khola would affect the cultivation of pre-monsoon paddy, as the crop water requirement for paddy is fairly high and the cultivation period falls in the dry period. Instead of pre-monsoon paddy, crops such as maize and mong beans could be grown as substitute.

Water release.
There are irrigation canals on both sides of the river, with offtakes upstream of the weir and command areas immediately downstream of the weir. In addition, there are many places further downstream where local farmers' cooperatives take water from the river for irrigation.

During the monsoon season July to September and the first couple of months afterwards there is more water in the river than the power plant can use and the question of minimum water release in the Jhimruk river does not affect the operation of the power plant. But for the rest of the year the generation is very much dependent on how much water has to remain in the river.

7.2.2 Water supply

There are 23 villages between the weir and the confluence with Chappe Khola. Only three of these had their drinking water from pipes. The rest had their water supply from flowing streams, of which eleven drew their water from Jhimruk. This was in fact a very poor source of drinking water. It was therefore recommended that water supply to the villages should be included in the project.

7.2.3 Fish

Jhimruk Khola harbours a wide range of local and migratory fishes. The total diversion of the water would have a significant impact on the local fishes and on the spawning and nursery beds of the migratory fishes. The local fishes being only supplementary food for the local people, impact would be minor. It was, however, concluded that impact on spawning and migratory fishes would be serious as it would disturb the behaviour of the fishes.

7.2.4 Other non-tecnical issues

Land requirements

An issue which was outside the scope of the environmental study, was the acqusition of land. Nevertheless, this is an issue of extremely importance for the people affected. Land had to be acquired for the following main purposes:

- Camp and accomodation
  (Compensation was given by providing irrigation of larger areas of previously dry farmland, which remained untouched by the project)
- Powerhouse
- Dam and intake
- River training, upstream and downstream of the weir
- Areas for infrastructural purposes, mainly roads

Total demand for land was approximately 20 ha. However, due to the river training works, a large area that was earlier often flooded was reclaimed, but is probably not useful as farmland. Planting trees in the area could be a possibility. The net effect in the headworks area was therefore land gain, although of different quality. One problem was, however, that the land lost and the land gained belonged to different people. The handling of land acqusition and other land related issues were dealt with by the government through the Chief District Officer. People losing their land because of the project were paid money as compensation.

7.2.5 NVE's comments

NVE made an evaluation of the GEOCE report, presented in a memo in January 1992 (/5/). Comments from the Norwegian institutions Directorate for Nature Management and NORAGRIC were also included in the memo, on request from NVE.

NVEs main conclusion was that the study was comprehensive, thorough and of high quality. GEOCE's recommendations were supported. NVE highlighted the following points:

- Financial support should be given for construction of new pipebased water supply systems in the affected villages downstream of the dam.
- People losing their land should be secured new land.
- A flow sufficient to secure irrigation and aquatic life at an acceptable level should be released through the weir. The amount of water to be released should be decided based on a 5-year monitoring programme.
- A fish ladder should be built in connection to the dam
- People affected by the construction works at Madi river should be compensated according to the intention in NORAD's environmental guidelines.

7.2.6 Mitigative measures

Mitigative measures were recommended in the fields of irrigation, water supply and fish. The recommendations have to a large extent been followed up by the project.

Irrigation

Physical arrangements have been provided at the dam so as to make it possible to release water into the downstream irrigation system. The decision on the volume of water that has to be released will be taken later. A leakage in order 250 - 500 l/s through the dam is expected.

The Government has not yet issued a license to BPC for the operation of the power plant or otherwise given any directives regarding minimum water release. It has been left to BPC to work it out directly with the farmers. This has not been easy because opinions vary widely with regard to the amount of water which is necessary for the farmers to irrigate their fields.

BPC has employed a full time agricultural specialist to study these questions together with the farmers, in the hope that some mutually acceptable conclusions can be drawn. Several small projects have been initiated, involving plots made available by farmers where seed and fertilizer is provided free by BPC, for demonstrating alternative crops and farming methods. This work will continue at least for one more year.

BPC is also studying lift irrigation from wells in the river bed and other ways of making irrigation more effective with less use of water.

On the basis of a monitoring of the downstream water flow, the necessary or wanted release can be found. A temporary agreement was decided for the first year of operation, before the monitoring results are in hand. According to this agreement, all the water would be released in the driest priod, when the rice was planted and the need for water was high. For the second driest month, half of the water flow would be released.

BPC had in any case to close down the plant for a few weeks because of necessary work, and it was possible to schedule this to coincide with the farmers' needs of irrigation water.

Recently, another one year agreement has been made to cover the 1996 dry season. This provides for more or less the same amount of water to the farmers. One new aspect is the installation of flash boards on the dam for daily pondage. The farmers have accepted this if they get their water when they need it. Supply of energy at peak hours should command a higher energy price for BPC, and to some extent make up for loss of water released for irrigation. The trouble is that NEA so far is not willing to pay anything extra for peaking power.

BPC is in a very weak position to negotiate with the farmers as well as with NEA without Government support. And so far the Ministry has not been ready to take any

stand on the delicate issue of water release, but preferred to let BPC sort it out on its own.

Water supply

It was decided to include in the Jhimruk project piped water supply systems in the downstream villages that was dependent on Jhimruk river for drinking water. Water technicians were employed by the project to assist in this work. Drinking water systems for fourteen villages have been constructed.

In the Madi valley a pipeline is to be constructed to supply farmers close to the powerhouse with irrigation water, and a drinking water system has been constructed as well. Many people in this area were affected by land acquisition for the project.

Fish

A fish ladder was constructed at the right side of the dam, close to the gates. This arrangement will secure free passage for the migrating fishes. As to the water flow considered necessary to release for the fish purpose, this issue will be postponed until experience is gained through the monitoring system. For the first two years sufficient water flow was secured.

Local transmission line

Electrification is a priority need. It was therefore decided to include in the project a 22 km long 33 kV transmission line downstream of the dam, which has now been constructed. The expectation is that low tension distribution will follow, and people are generally happy. It has also helped on relations that it has been decided that BPC will continue to own and operate the project.

Future plans

Plans for a second phase of JHEREP involving a community and small industry development centre are still unknown to the local people (because NORAD financing of the project is not yet formally approved). When this programme gets going, it is expected that relations between BPC and the public may further improve.

8. COMMENTS AND CONCLUSIONS

8.1 General

The three main objectives of the Jhimruk project were:

1) To provide electricity, including peak power, to the national grid. This could be achieved by providing daily pondage by means of flashboards mounted on the dam crest.

2) To connect the centres in four hill districts to the electricity grid. These districts were Pyuthan, Gulmi, Arghakhanchi and Rolpa

3) To strengthen the Nepalese companies BPC, HH and NHE through the planning, design and construction of Jhimruk

According to these objectives and the achieved results, it could easily be concluded that the project has been successfully carried out. However, the above mentioned objectives do not cover all the different aspects and complexity of a hydro power project. Some issues of obvious importance should in this context be mentioned. These are, for example, project costs, impacts on the environment and impacts on the local population.

It has therefore been considered valuable to make some comments on the different aspects of the Jhimruk project.

8.2. Background for the Project

The implementation of JHEREP was in many ways special, and can hardly be directly compared with "ordinary" projects in developing countries. The development of JHEREP was based on a work that started 30 years ago. Under the leadership of UMN, a hydropower expertise had gradually been built up in Nepal by establishing the companies BPC, HH and NHE. The implementation of Jhimruk therefore had a strong domestic foundation, which often is not the situation in developing countries.

The strength of the UMN companies was also the reason why NORAD made it a condition for funding the project that these companies should be responsible for the implementation. This was obviously a right decision, for many reasons:

- As mentioned above, the companies had achieved the necessary experience through earlier projects.

- As Nepalese companies, they were familiar with the Nepali society, and could probably operate more effectively than for example foreign companies.

- NHAM has a very strong position within UMN, with regard to hydro power development. NORAD's relationship with the project went through the NHAM.

This very close contact to the parties responsible for the project implementation, obviously improved NORADs possibilities of project steering and control.

The Jhimruk project came, however, up in a rather unusual way. NORAD was requested by the Nepalese authorities to support the project financially. The request was based on a feasibility study (FS) prepared by the Nepal Electricity Authority with assistance from expatriate technical adviser. The project, as presented in the FS, was a straight forward hydropower project, with few or none development aspects included. Of most importance was, however, that environmental and socio-cultural aspects also were almost completely missing. In spite of this very essential shortcoming of the FS, NORAD approved the application without making any conditions relating to environment. This was obviously a mistake, and not in accordance with NORAD's own procedures, at least not as they appear today.

Organization

According to the agreement between HMGN and UMN, BPC should take on the task of carrying out the Jhimruk project. The task comprised planning, detail design, construction, supervision and commissioning of the project. It was further said in the agreement that HH and NHE should be given contracts on civil works and mechanical/electrotechnical works respectively. This was in line with one of the main objectives of the project - to strengthen the companies BPC, HH and NHE.

The project organization was established on the basis of this agreement and has proved to work satisfactorily. It could be objected that the close relations between the parties involved might be a weakness. For example, independence, control, follow up etc. could be questionable. However, at Jhimruk the feeling is that the strong company relations have been an advantage for the performance of the project. One example is the possibility to "plan as you go". Although the final project design was not completed in all respects, the work could easily go on under the certainty that no unnecessary risk was taken.

NORAD has been relating directly to NHAM, with NVE as an adviser on technical/economic and environmental issues. This arrangement has worked satisfactorily.

8.3 Project Layout - Project Design

The approval of financing the Jhimruk project was based on an existing feasibility study. This meant that the overall project layout was already fixed when BPC took on the task. Other alternatives had been considered at an early planning stage, but found less favourable than the chosen one. We therefore find no reason to comment on other alternatives in this project evaluation.

BPCH made several modifications to the initial project plans. These modifications were all based on thorough studies and considerations. The design changes and the reasons for doing them are described in chapter 4.3, Planning and Design. All the changes were obviously beneficial for a successful project implementation. Of

special importance was the including of the rural transmission line from Tansen and Andhikhola to Jhimruk, with a branch line to Libang. This line opens up for the possibility of electrifying an area of 1 million people. In addition, it was of direct advantage through supply of electricity during the construction period.

In retrospect it has, however, to be concluded that the lack of sediment analyses was a serious deficit. If such analyses had been carried out, the wearing problems that occurred after short time of operation could have been foreseen and precautions taken to the extent possible.

8.4 Project Implementation

The description of the project implementation (chapter 4) covers the whole period from early planning to project completion.

Design work
The design changes are described above. Important is the increase of engineering competence this task meant to the Nepali engineers within BPCH, who were responsible for the project design under leadership of expatriate UMN engineers.

Time schedule
Concerning the time schedule, the conclusion is that unforseen events have to be accounted for. The main reason for the half year delay of completion date compared with the initial time schedule, was a nation-wide unrest which at that time came up in the country. The consequences for the project were unrest and strikes. In retrospect, it is difficult to see how the problems that occured could have been avoided. The impression is that the project staff were dealing with the problems in a professional way.

Contracts - project management
BPC took on a quite substantial responsibility (and some risk) by handling the supplies included transport, storage and equipment erection to a large extent on its own. Questions are raised under #4.6.2 about the reasons for doing it this way, and also why it worked out the way it did. One obvious reason was the possibility of saving money. BPC had the necessary, may be also the best, qualifications to do the job at this spesific site. It was therefore a natural choise to try to do as much as possible on its own. The good result showed that this decision was right.

Construction
Himal Hydro was the contractor for the civil works. The company's organization at Jhimruk put much emphasis on training. It could therefore seem as if the project was somewhat heavy staffed. The contractor's experience was, however, good, also regarding efficiency. In addition came the obviously valuable training effect.

As to the performance of the construction works, it was successfully carried out.

Various reasons for this can be identified:

- Experience gained by the Nepalese companies from their involvement in the Andhi Khola Project, for example in organizing large number of labour.
- General knowledge of the Nepali society and the general setting. This knowledge could for example be very advantageous when purchasing materials for the construction works.
- In particular this knowledge was important in contacts and relations to the Nepalese authorities.
- Most of the expatriates within the companies had stayed in Nepal for a long time and were familiar with Nepali conditions.
- A good personnel policy including training, giving Nepali engineers and other staff in leading positions responsibility. It should be mentioned that many of the staff had their basic technical education at the UMN related Butwal Technical Institute (BTI).
- Thorough planning and preparations. Of special importance was the agreement and cooperation with the Norwegian Institute of Technology (NTH) and the Norwegian Hydrotechnical Laboratory (NHL) on the model studies. These studies provided the basis for a suitable design to secure the proper inflow of water into the intake structures, and also made it possible to use the latest technology with regard to sediment flushing.
- Good cooperation between Kvaerner/ABB and NHE on the manufacturing and supply of mechanical and electrotechnical equipment.

Much of what is mentioned above is a continuation and result of the work that has been done by the UMN-companies for several years. From a development point of view, it seems to be quite unique, and can hardly be compared with "ordinary" projects in developing countries.

However, the importance of establishing strong domestic competence, as in Nepal by building the hydropower companies, is maybe the most essential experience from Jhimruk and the previous project Andhi Khola.

8.5 Training

Training of the Nepali companies and personell was one of the main objectives of the project. Usually, training has its own separate budget in NORAD supported projects, to secure that this important part is taken satisfactorily care of. The need to handle the training aspect specially is first of all important when the recipient country has none or only little experience in forehand and foreign companies have the complete project responsibility. This was not the case in Jhimruk, where Nepali companies were responsible for project implementation. Therefore, the training was there all the time, above all as on-the-job training, but also through special courses considered necessary to do the job well.

8.6 Costs

Costs were kept within the initial budget in spite of extra works being added to the project. The reasons for this can briefly be explained by what is said in # 8.4 above, as there is a close relation between implementation success rates and project costs.

8.7 Environmental and Social Aspects

It was obviously a deficit by the project planning that the environmental and socio-cultural aspects were not included from the beginning. For example, no operating manual was established in forehand. If it had been, the ongoing disputes about minimum water release could have been avoided. This issue still remains to be settled.

Considered in relation to the baseline conditions, the impression is that the environmental and socio-cultural issues have been satisfactorily handled, and that necessary mitigative measures have been, or will be, set in force. With BPC continuing as owner and operator of JHEREP, further development will take place in the area through a new project.

The conclusion is, however, that possible environmental and economic impacts should have been evaluated and mitigation measures should have been included in the project plans in a satisfactory way before NORAD approved the application for funds.

APPENDICES

THE ROYAL NORWEGIAN MINISTRY OF DEVELOPMENT COOPERATION

C O N T R A C T

between

THE ROYAL NORWEGIAN MINISTRY OF DEVELOPMENT COOPERATION

and

THE NORWEGIAN HIMAL-ASIA MISSION (DEN NORSKE TIBETMISJON)

concerning

THE JHIMRUK HYDRO ELECTRIC PROJECT

The Royal Norwegian Ministry of Development Cooperation (hereinafter referred to as "the Ministry") and the Norwegian Himal-Asia Mission (hereinafter referred to as "the Organization") have agreed as follows:

1. The Ministry's obligation:

The Ministry shall, subject to Parliamentary appropriations, furnish the Organization with a sum of up to USD 19.000.000 (United States dollars nineteen million) (hereinafter referred to as "the Grant") which shall be utilized to finance the implementation of the Jhimruk Hydro Electric Project (hereinafter referred to as "the Project") which is described in Appendix I to this Contract.

2. The Organization's obligations:

The Organization shall be responsible towards the Ministry for the carrying out of the Project, and to this end the Organization undertakes:

2.1 To make sure that the Project is carried out on the basis of the Project plans, time schedule and budget contained in Appendix I, as well as the annual workplans and budgets referred to in section 2.2 below. Revision of the plans for the Project may be proposed by either party to this Contract in the event of this being indicated by the experience gained or by changes in the assumptions on which the Project plans are based:

2.2 to forward an annual workplan and budget for approval by the Ministry within 1 November each year. The approved annual workplans and budgets shall be attached as appendices to this Contract:

2.3 to effect purchases for the Project in such a manner as to obtain the most favourable terms in regard to price, quality, delivery date and maintenance facilities:

2.4 to keep the Project insured as laid down in Appendix I,4;

2.5 to deposit funds advanced from the Grant in a separate interestbearing bankaccount in Norway. Withdrawals from this account shall be used solely for the purpose of meeting Project expenses within the budget in Appendix I, and the annual budgets. Transfer of funds to the Project in Nepal shall take place as required in order to carry out the work in an efficient manner without unnecessary cash build up in Nepal;

2.6 to keep the Ministry informed as to the name of the auditors for the Project. Norwegian and/or non-Norwegian auditors are to be chartered or registered accountants;

2.7 to carry out Project operations in such a manner as to benefit the local inhabitants irrespective of race, creed or opinions;

2.8 to inform the Ministry as quickly as possible of any unforeseen events or developments which may have detrimental effects on the Project;

2.9 to arrange for full operation and proper maintenance of the Project until hand-over to His Majesty's Government of Nepal (see section 5.1 below);

2.10 to submit to the Ministry reports and statements of accounts in accordance with section 4 below.

3. Disbursements

3.1 The Ministry will disburse the amount needed for Project implementation by 1 January and 1 July each year (or as soon as possible thereafter) upon reception of a request containing:

- summarized accounts for expenses incurred in the preceding six months' period

- a specification of the estimated expenses in the next six months.

3.2 The Organization may apply to the Ministry for permission to use interest earned for project-related expenses. Interest earned may not be used without obtaining the Ministry's approval in advance. After the Project is completed, any funds not used (including interest) shall be repaid to the Ministry by the Organization.

4. Control - Reports - Statements of accounts

4.1 The Organization shall assist the Ministry in carrying out such control measures as the Ministry thinks fit in order to appraise the use to which the Grant is put,

and to appraise Project operations.

4.2 The Organization shall forward to the Ministry quarterly progress reports.

4.3 Within 9 months after the end of the Nepalese financial year (i.e. 15 July), the Organization shall submit annual reports along with audited statements of accounts to the Ministry.

5. Organization - Cooperation

5.1 The Project shall be carried out in agreement with the authorities in Nepal. To this end, an Agreement between His Majesty's Government of Nepal and the United Mission to Nepal concerning the Project shall be entered into. A copy of this Agreement shall be forwarded to the Ministry for information.

5.2 A memorandum of understanding between the Organization and United Mission to Nepal shall be entered into. A copy of this memorandum shall be forwarded to the Ministry for information.

5.3 A list of the Nepali companies involved in the Project is given in Appendix I,1. The organizational relationships shall be regulated in the agreements referred to in section 5.1 and 5.2 above, and contracts to be entered into during Project implementation.

5.4 The Norwegian Water and Electricity Board will represent the Ministry at a professional level in an advisory capacity, and shall be kept informed on the progress of the Project by receiving a copy of all reports submitted to the Ministry (ref. section 4) as well as additional information when asking for it.

5.5 In November each year, representatives of the Ministry, the Norwegian Water and Electricity Board and the Organization shall meet in order to review the progress of the Project and discuss the proposed annual workplan and budget for the following year.

6. Breach of Contract

The Ministry will demand repayment of all or part of the Grant if the Organization wilfully or negligently fails to fulfil its obligations under this Contract.

7. Disputes - Entry into force - Termination

7.1 If any dispute arises relating to the implementation of this Contract, there shall be consultations between the parties with a view to securing a successful realization of the purpose of this Contract.

7.2 This Contract shall enter into force on the date of its signature and shall remain in force until both parties have fulfilled all obligations arising from it.

7.3 Notwithstanding 7.2 above, this Contract may be terminated by either party at six months' notice in writing before the end of the months of June and December respectively, provided that the parties to this Contract shall make a mutually acceptable arrangement with regard to the completion of the Project, taking into consideration the Organization's obligation towards His Majesty's Government of Nepal in connection with the Project.

This Contract is drawn up in duplicate, one for each party.

Oslo, 7 feb. 1989

For the Royal Norwegian Ministry of Development Cooperation

Oslo, 7 februar 1989

For the Norwegian Himal-Asia Mission

A G R E E M E N T

between

HIS MAJESTY'S GOVERNMENT OF NEPAL

MINISTRY OF WATER RESOURCES

and

THE UNITED MISSION TO NEPAL

on

THE JHIMRUK HYDRO ELECTRIC AND RURAL ELECTRIFICATION PROJECT

Whereas His Majesty's Government of Nepal (hereinafter referred to as "HMG/N") and the United Mission to Nepal (hereinafter referred to as "UMN") in 1965 established the Butwal Power Company Pvt. Ltd., registered on 14, Poush 2022, (hereinafter referred to as "BPC") to serve as an executing agency for carrying out Hydro-electric Development Projects,

Whereas HMG/N and UMN have been undertaking various hydropower and irrigation development projects within the Kingdom of Nepal,

Whereas HMG/N and UMN are desirous to further confirm their co-operative efforts by undertaking new projects in the field of hydropower and irrigation development,

Now, therefore, His Majesty's Government, Ministry of Water Resources (hereinafter referred to as the "Ministry"), and the UMN have agreed to implement the Jhimruk Hydel and Rural Electrification Project (hereinafter referred to as the "Project") detailed out in the attached schedule, as follows:

Article I.
THE PROJECT

1.1 The Ministry and the UMN agree to cooperate in the implementation of the Project and that the project during the period of its implementation (planning, design, construction and commissioning) shall be owned and managed by BPC of which HMG/N and UMN shall during this period remain the major shareholders.

1.2 At the end of the period of implementation (as defined in the attached Schedule or as subsequently revised by mutual agreement) BPC shall hand over the Project with all its assets and liabilities to HMG/N without any compensation, and HMG/N shall be obliged to take over the Project and thus relieve BPC and its shareholders from any further responsibilities with regard to the Project.

Article II.
FINANCING OF THE PROJECT

2.1 The total cost of the Project has been estimated to be US$ 19 millions and Nepalese Rupees 30 million.

2.2 HMG/N shall contribute the cost of acquisition of land, electricity for construction, part of the cost of additional ground investigations and model study, taxes and duties in Nepalese Rupees and UMN shall contribute the balance.

2.3 The contributions by either HMG/N or UMN may be in cash, in kind or in service. Such contributions shall be received by BPC as the respective party's share investment, and be used for the implementation of the Project.

2.4 Any dividend earned by UMN on its shares in BPC shall be reinvested in the BPC.

2.5 The accounts of BPC relating to the Project shall be open for inspection at any time by person(s) appointed for this purpose by either HMG/N or the UMN.

Article III.
RESPONSIBILITIES OF UMN

3.1 A major part of UMN's financial contribution to the Project will be provided by the Royal Norwegian Ministry of Development Cooperation (NORAD), with the understanding that UMN, during the period of implementation of the Project, shall remain the majority shareholder of BPC and through its representatives on the BPC Board of Directors and at the General Meetings of BPC shareholders, will see that the implementation of the Project is properly carried out by BPC.

3.2 UMN shall to the extent possible make available qualified expatriate personnel to fill such posts in BPC and its related sister organizations mentioned in 6.1 as may be required in order to carry out the Project in a professionally satisfactory manner, and for the training of Nepali personnel at all levels and in all positions. The service rendered by UMN expatriate personnel shall be accounted for as a part of UMN's contribution to the Project as per clauses 2.2 and 2.3 above.

3.3 UMN shall make BPC technically responsible for planning, detail design, construction, supervision and commissioning of the Project, and cause BPC to obtain necessary expert service in Norway with regard to the design and execution of

the Project, and to submit plans and design to the Ministry for its review and comment prior to commencement of construction work.

Article IV.
RESPONSIBILITIES OF HMG/N

4.1 HMG/N shall issue or cause to be issued promptly the licenses and permits which are required for the implementation of the Project, particularly with regard to the supply of materials and equipment which are needed, whether to be obtained within the country (timber, cement, etc.) or imported from abroad.

4.2 HMG/N shall make available to BPC the necessary land and access rights, temporary or permanent, including access to and right to take out stone, sand, etc., as may be required for the construction of the hydropower plant and the transmission and distribution lines.

4.3 Completion of the partly finished motor road from Bhalubang along the Madi river to the Project site, with necessary bridges, would greatly facilitate transport to the Project, especially of heavy power machinery. HMG/N shall endeavour to programme through the concerned Department of HMG/N to have this road completed at the earliest possible time.

4.4 HMG/N shall through the concerned Agency supply electric power for construction from a suitable point in the existing net.

4.5 HMG/N shall give permission to BPC for use of telephone radio communication equipment needed for maintaining contact between the various work sites and BPC' offices in Butwal and Kathmandu.

4.6 HMG/N by itself or through Nepal Electricity Authority (NEA) shall, to the extent possible and practical, make available qualified personnel who will be deputed to serve in BPC under BPC' regulations, as may be desirable in the course of implementation of the Project, and its future operation and maintenance.

4.7 HMG/N shall as deemed necessary issue non-tourist visas for all expatriate personnel (and their dependents) of BPC and related companies mentioned in Article 6.1 who are working for the project.

4.8 HMG/N shall bear the expenses towards the operation and maintenance of the Project from the date when commercial generation starts up to the date of hand-over as per Article 1.2.

Article V

FACILITIES TO BE GRANTED BY HMG/N

HMG/N shall grant the following facilities to BPC and companies mentioned in Article 6.1 in connection with the implementation of the Project:

5.1 Exemption from payment and/or deposit of Import Licence Fee, Customs Duty, Sales Tax, premium and any other import duties or taxes in connection with the import of machinery and equipment (including trucks, motorcycles and upto five nos. passenger-vehicles), materials and supplies for use in connection with the execution of the Project.

5.2 Construction equipment leftover after the completion of the Project will be turned over to HMG/N free of charge, with the understanding that HMG/N will hand over the same to

Himal Hydro and General Construction Company Pvt. Ltd as HMG/N's share investment in kind.

5.3 Exemption from payment of Sales Tax, Excise Duty or royalties on goods purchased directly from the manufactures within the country for use in connection with the execution of the Project.

5.4 Exemption from payment of local taxes or royalties of all sorts in connection with the execution of the Project.

5.5 Issuance of visas free of charge for the expatriate personnel who are required for the execution of the Project.

Article VI.
MISCELLANEOUS

6.1 HMG/N and UMN agree that it is an important objective of the Project to give contracts to Himal Hydro and General Construction Pvt. Ltd. and Nepal Hydro and Electric Pvt. Ltd. of whom HMG/N and UMN are major shareholders in order that these two companies may become viable instruments for serving Nepal in the development of Nepal's hydro power resources. Such contracts will be awarded on the basis of terms and prices negotiated by BPC.

6.2 Quarterly progress reports concerning the Project, will be submitted by BPC to the Ministry and to UMN, and BPC shall inform the same immediately of any event or development likely to delay the completion of the Project.

6.3 A Project Monitoring Committee consisting of representatives of the Ministry, NEA, UMN and BPC shall be constituted to review the progress of the Project on a regular basis.

6.4 Any of the provisions of this Agreement may be amended when mutually agreed upon by the parties of this Agreement.

6.5 Any difference between the parties arising out of the implementation of this Agreement shall be settled amicably by consultation between the parties.

6.6 This Agreement shall come into force from the date of its signing, and shall remain valid throughout the period of implementation of the Project.

6.7 This Agreement shall be subject to the terms and validity of the General Agreement between HMG/N and UMN dated 26th May 1985, or to any subsequent Agreement between HMG/N and UMN extending or replacing it.

6.8 This Agreement shall in all respect be construed and subject to the prevailing law of Nepal.

Done in Kathmandu on February 23, 1989 in two originals in English.

For and on behalf of
HMG/N Ministry of
Water Resources

(B. K. Pradhan)
Acting Secretary

For and on behalf of
United Mission to Nepal

(Howard Barclay)
Executive Director
and Chief Executive

Letter of Agreement

JHIMRUK HYDRO ELECTRIC PROJECT, NEPAL

Summary of the Project:

The Jhimruk hydel project in Nepal is a high head scheme of 12 MW capacity. The scheme consists of a 275 m diversion dam on Jhimruk River, a 1 km long headrace tunnel, an underground powerstation, a 45 km long 33 KV transmission line connecting the power plant to the central grid and 135 km of 33 KV distribution lines for rural electrification. The estimated cost is US $ 20 million, of which US $ 19 million is to be financed by a grant from Norway. The project is planned to be implemented in the period 1989-1994.

Organizational Arrangements:

The contract between the Norwegian Agency for Development Cooperation (NORAD) and the Norwegian Himal Asia Mission (NHAM) concerning the project is attached as Appendix 1. Section 5 of this contract specifies the organizational arrangements for the project. These are summarised in the organization chart attached as Appendix 2. As stated in Sections 5.4 and 5.5 of this contract the Norwegian Water Resources and Energy Administration (NVE) shall represent the Ministry on a professional level and, together with the Ministry, participate in annual meetings. NVE shall also be kept informed on the progress of the project by receiving a copy of all reports submitted to NORAD (ref. section 4 of the contract).

Cooperation between NVE and NHAM:

NVE may provide relevant services in Norway with regard to the design and execution of the project - either on request from NHAM or at NVE's initiative if NVE judge it professionally necessary.

To provide these services NVE may also call upon technical/ economical/environmental expertise which is not available within NVE.

In addition to the above, site visits by NVE will also be necessary. These visits shall be carried out in agreement with NHAM.

Expenses connected directly to NVE personnel will be paid by NORAD. Expenses related to experts engaged from outside NVE may (if these are large) be charged to the project, subject to agreement with NHAM.

We would be grateful if you would indicate your agreement to these terms by signing the enclosed copy of this letter which we kindly ask you to return to NVE.

Oslo, 1. August 1989
place date

Egil Skofteland
For
The Norwegian Water Resources and Energy Administration

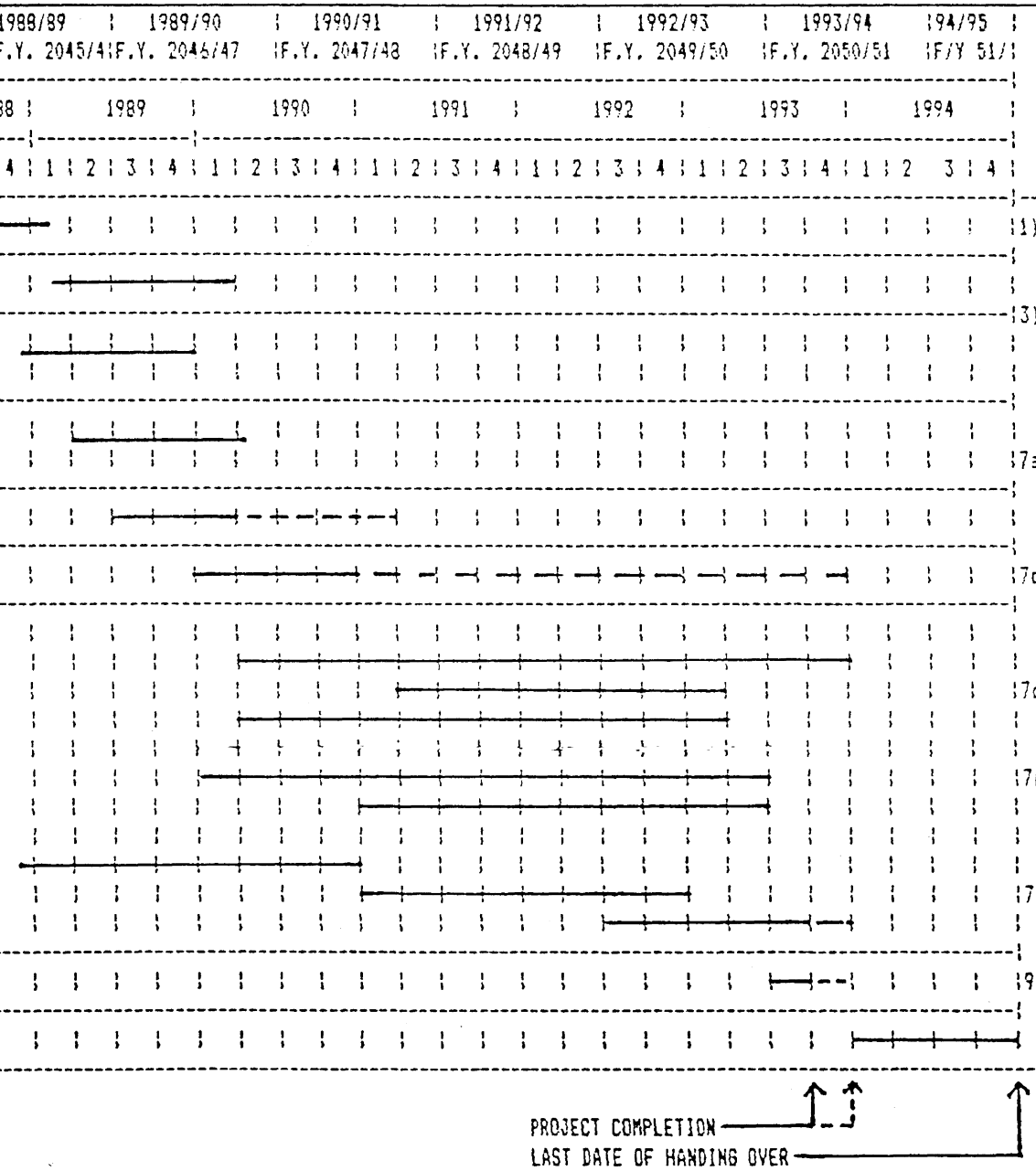
Oslo, 1st August 1989
place date

Einar Kippenes
For
The Norwegian Himal Asia Mission

SCHEDULE - 3
IMPLEMENTATION SCHEDULE
(PROPOSED)

PROJECT: JHIMRUK HYDRO ELECTRIC

S.	Description of Activities	DURATION IN MONTHS
1	Process Agreement	2.5
2	Preparatory Works	15
3	Field Investigation & Model Study Finalise Design Concept & Revision	12
4	Prepare Specification Document and Item-Rates of Wroks	9
5	Contract Negotiation & Award	9
6	Detailed Design and Supervision	51
7	Construction	
	a) Dam and Intake	45
	b) Tunnel and surge shaft	24
	c) Penstock, Power House & T/race	36
	d) Equipment Supply & Erection	
	i) Power House	45
	ii) Penstock, Gates & T/racks	30
	e) 33 kv line Supply & Erection	
	i) Tansen - Jhimruk	27
	ii) Jhimruk - Lamahi	24
	iii) Jhimruk - Libang	18
9	Testing commissioning	3
10	Finishing & Moving Out	12



NOTES

1) Important to start Project activities

3) Basic concept of Dam and Headrace depends on results of model study. Dam and intake are major cost items.

7a) Work on dam goes on right to the time of starting generation.

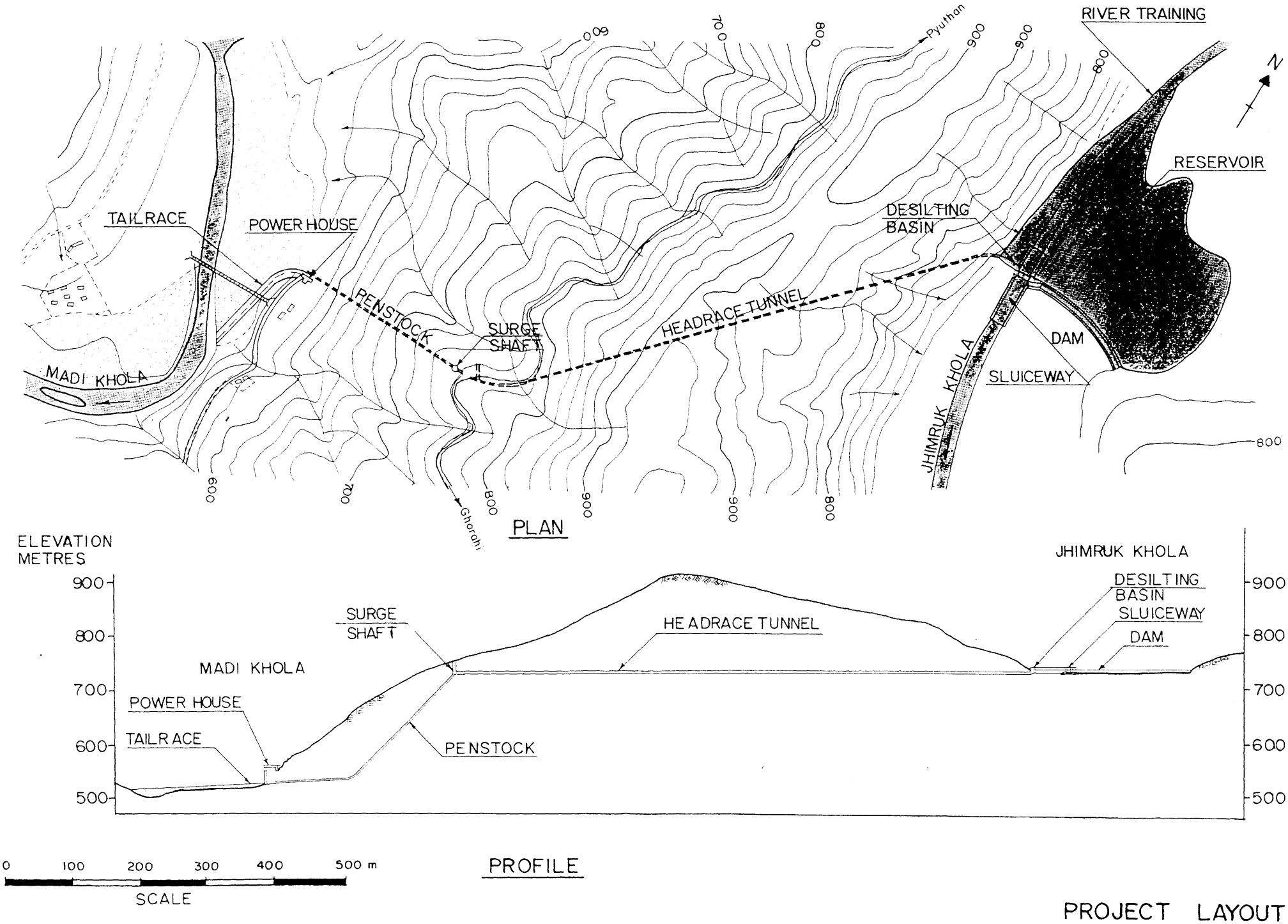
7c) If underground shaft, co-ordination with Power House construction important.

7d-i&ii) Including manufacturing time as well.

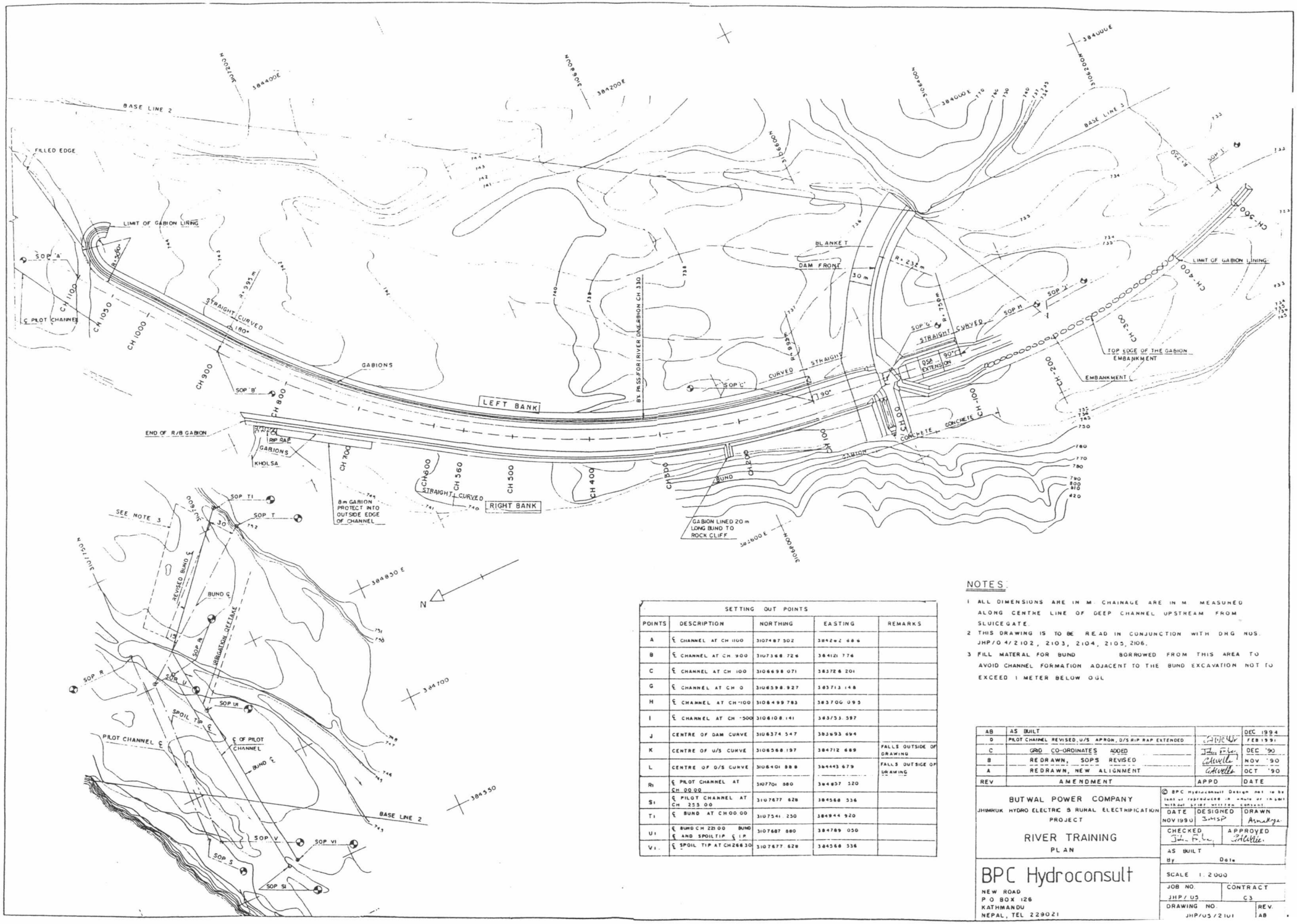
7e-i) Construction power needed diesel will be as standby only. Includes manufacture of towers and poles.

7e-ii) Needs to be ready in time of start of generation

9) Commissioning time includes 3 months extra time for unforseen problems



PROJECT LAYOUT



SETTING OUT POINTS				
POINTS	DESCRIPTION	NORTHING	EASTING	REMARKS
A	℄ CHANNEL AT CH 1100	3107487.302	384242.686	
B	℄ CHANNEL AT CH. 900	3107368.726	384121.776	
C	℄ CHANNEL AT CH 100	3106698.071	383728.201	
G	℄ CHANNEL AT CH 0	3106598.927	383713.148	
H	℄ CHANNEL AT CH -100	3106499.783	383700.095	
I	℄ CHANNEL AT CH -500	3106108.141	383753.597	
J	CENTRE OF DAM CURVE	3106374.547	383693.694	
K	CENTRE OF U/S CURVE	3106568.197	384712.689	FALLS OUTSIDE OF DRAWING
L	CENTRE OF D/S CURVE	3106401.888	384443.679	FALLS OUTSIDE OF DRAWING
R1	℄ PILOT CHANNEL AT CH 00.00	3107701.880	384857.520	
S1	℄ PILOT CHANNEL AT CH 253.00	3107677.628	384568.336	
T1	℄ BUND AT CH 00.00	3107541.250	384944.920	
U1	℄ BUND CH 221.00 ℄ BUND AND SPOILTIP ℄ TP	3107687.880	384789.050	
V1	℄ SPOIL TIP AT CH 266.30	3107677.628	384568.336	

NOTES:

1. ALL DIMENSIONS ARE IN M. CHAINAGE ARE IN M. MEASURED ALONG CENTRE LINE OF DEEP CHANNEL UPSTREAM FROM SLUICE GATE.
2. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH DWG NOS. JHP/04/2102, 2103, 2104, 2105, 2106.
3. FILL MATERAL FOR BUND BORROWED FROM THIS AREA TO AVOID CHANNEL FORMATION ADJACENT TO THE BUND EXCAVATION NOT TO EXCEED 1 METER BELOW OGL

REV	AMENDMENT	APPD	DATE
AB	AS BUILT		DEC 1994
D	PILOT CHANNEL REVISED, U/S APRON, D/S RIP RAP EXTENDED		FEB 1991
C	GRID CO-ORDINATES ADDED		DEC '90
B	REDRAWN, SOPS REVISED		NOV '90
A	REDRAWN, NEW ALIGNMENT		OCT '90

BUTWAL POWER COMPANY

JHIMRUK HYDRO ELECTRIC & RURAL ELECTRIFICATION PROJECT

RIVER TRAINING

PLAN

DATE	DESIGNED	DRAWN
NOV 1990	JMSP	Asmalya

CHECKED: John Finley — APPROVED: Schlettie

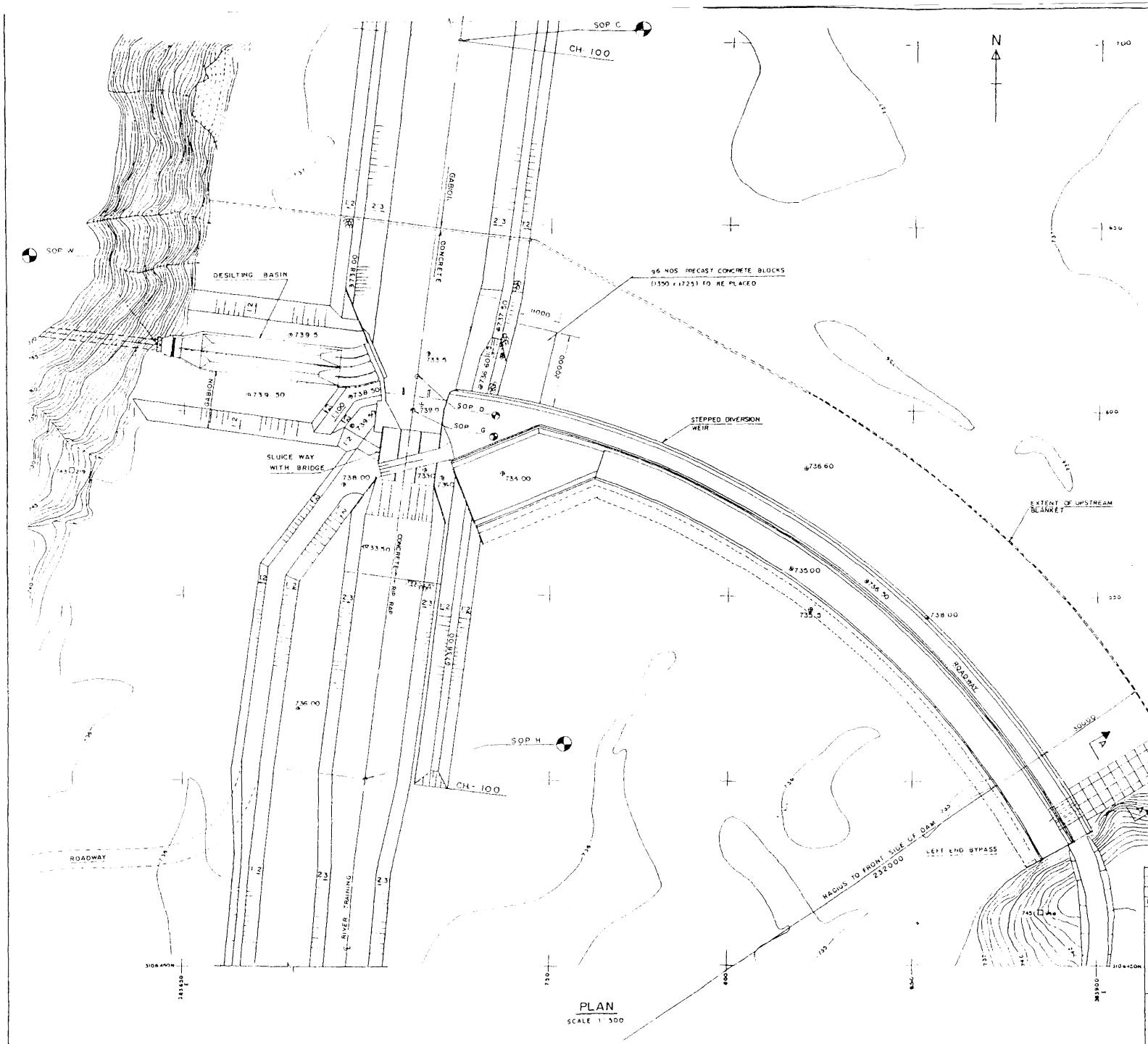
AS BUILT By Date

SCALE 1:2000

JOB NO. JHP/03 — CONTRACT C3

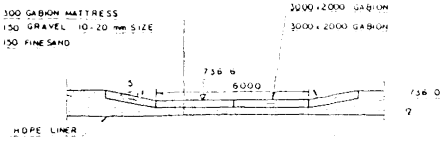
DRAWING NO. JHP/03/2101 — REV. AB

BPC Hydroconsult
NEW ROAD
P.O BOX 126
KATHMANDU
NEPAL, TEL 229021



PLAN
SCALE 1:500

SETTING OUT POINT			
SOP	DESCRIPTION	NORTHING	EASTING
W	JHIMRUK KHOLA TUNNEL PORTAL	3108918.820	383642.881
C	℄ CHANNEL AT CH. 100 m	3106898.071	383724.400
D	DESILTING BASIN ℄ & CHANNEL ℄ IP	3106809.089	383714.486
G	℄ CHANNEL AT CH. 0.00 m	3108588.927	383713.148
H	℄ CHANNEL AT CH. -100.0 m	3108498.783	383700.093
J	CENTRE POINT OF DAM CURVATURE	3108374.547	383695.634



SECTION A-A
SCALE 1:100

NOTES

1. CHAINAGE ARE M, LEVELS ARE M ABOVE M.S.L.
2. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH DRG NOS JHP/04/2101, 2102, 2103, 2301
3. THE EXACT LOCATION OF GABION MATTRESS SHALL BE AS PER HEADWORKS ENGINEER'S DECISSION

REV	AMENDMENT	APPD.	DATE
C	PRECAST CONCRETE BLOCK U/S OF DAM ADDED		NOV 94
B	BERMS AT DESILTING BASIN U/S. APRON REVISED		FEB 1990
A	DAM CROSS SECTION SLUICEWAY REDESIGN		OCT 1990

BUTWAL POWER COMPANY

JHIMRUK HYDRO ELECTRIC & RURAL ELECTRIFICATION PROJECT

HEADWORKS

GENERAL LAYOUT

BPC Hydroconsult
NEW ROAD
P.O. BOX 126
KATHMANDU
NEPAL, TEL 229021

DATE	DESIGNED	DRAWN
OCT 1990	JMSP	
CHECKED	APPROVED	

ISSUED FOR CONSTRUCTION
By Date

SCALE 1:500

JOB NO	CONTRACT
JHP/04	C3

DRAWING NO	REV
JHP/04/2201	C

A5-3

Construction equipment

a) at Headworks

1x Cat E140 Hydraulic Excavator
2x Cat 916 Wheeled Loader
2x MF 245 Tractor
1x Belarus 611 Tractor
2x Tata 1210 SAK/32 Dump Truck
1x Grove RT 60 Mobile Crane
2x Volvo 860 Dump Truck (part time only)
1x Brøyt X20T Hydaulic Excavator - " -
2x Ford Tractors - " -
1x Poclain Hydraulic Excavator (hired one season)
2x Hino Dump Trucks - " -

1x RB 33 generator 25 KVA
2x Atlas Copco VT 250 Diesel Compressors
2x Kirloskar MF 20-25 Water pumps
4x Mody submersible pumps
5x Various water pumps
2x Winget 400R concrete mixers
1x Argawali rock crusher
1x HMV cable crane 250 m span, 2.5 tonne capacity.

b) at Headrace tunnel

Atlas Copco RH 656-4W Rock drills
Atlas Copco BMK 62-SA Pusher legs
Wheelbarrows
Rail Wagons (0.9 m3)
1x ZPG Dry shotcrete machine
2x Ashok 10/7 concrete mixer
1x Flakt ventilation fan.
1x Belarus 611 Tractor (Part time)

c) at Powerhouse/Penstock shaft:

1x Alimak STH 5EE Raise Climber (Shaft)
1x Cadilon 1021 Tower crane (Powerhouse)
1x Belarus 611 Tractor (Part time)

d) at Main Compound:

1x Kirloskar/cummings NT 495G Generator set 110 KVA
2x Kirloskar RB 66 - " - 55 KVA
1x Kirloskar RB 22 - " - 20 KVA
1x Atlas Copco XA280 Diesel Compressor 17 m3/min
2x Atlsa Copco VT250 " - " - 7 m3/min
1x Atlas Copco DT4 Electr. _ " - 1.6 m3/min
1x Pytzmeister P11 Shotcrete machine

2x Tata 120 Truck
1x Belarus 611 Tractor
1x Toyota Land Cruiser
2x Toyota Hilux
2x Honda XL 185 M/C
2x Honda CT 110 M/C

REPORT ON TRAINING IN JHIMRUK PROJECT

1. INTRODUCTION:

From the very beginning of the project, efforts have been made to facilitate good training opportunities for staff and workers. Training has been seen as a vehicle to build up effective companies, make the work challenging & attractive and give employees opportunities for personal growth.

Most of the training in Jhimruk is done "on-the-job" for all levels, where experienced people work alongside less experienced people. For some work, we have called experts from outside to teach. Training has happen also, when staff/workers have tried, perhaps failed, tried again and learnt. However, this report will deal with the training activities "off-the-job", where employees have been called out of work to participate in seminars, discussions, lectures etc.

Most training of employees has been done within work hours.

Some training has also been given to people relating to project, like staff and workers wives and local people.

Some training is strictly work related and necessary to successfully complete the work. Other training activities are more life skill training, for personal development and better life standard.

2. TRAINING PERSONNEL:

Senior staff, especially Project Manager, Senior Site Engineer and Site In Charges have conducted most of the training.

Outside expertise has been called upon when necessary and available.

A Training Coordinator (with educational background) has worked part time.

3. AIM GROUPS FOR TRAINING ACTIVITIES:

The different aim groups have been:

1. SENIOR STAFF (Nepali Engineers, Overseers, higher administrative staff) is the main group.

2. LOWER STAFF (Storekeepers, foremen, mechanics and other administrative staff)

3. WORKERS have mainly received "on-the-job" training, but sometimes also have been called for special sessions.

4. FAMILIES of Staff and Workers have received "life skill" training

5. LOCAL PEOPLE have taken part in some "life skill" training.

4. TECHNICAL TRAINING:

By technical training we mean work related training, training needed to do the job well, to use new machines and equipment and/or new methods.

4.1 REGULAR TECHNICAL STAFF MEETINGS:

As well as general discussion about the work situation, these monthly meetings have been a place for lectures and discussion on special technical subjects, like use of equipment, concrete mix design, management skills, report writing, temporary works design, formwork, falsework details, Company's Administration Manual etc.

Senior Staff have been responsible for presentation of short lectures in the group. This has given them good training in gathering and ordering of information and presentation in English.

4.2 SPECIAL LECTURES:

Lectures on different technical subjects have been presented by outside visitors/experts on themes like:- Ropeways, History of the UMN Companies, Use and Maintenance of Cranes, Welding, X-Ray testing of welds, HDPE liner installation, Dealing with people and various other topics.

4.3 COMPUTER TRAINING:

All senior staff have participated in an introductory course in the use of computers.

Word Perfect 5.1 and Lotus 1-2-3 has been taught to groups of staff who will use these programmes in their daily work.

Training has been done, mainly within project, by Senior Staff and by an outside Consultant. Also few of the staff have been trained outside project.

4.4 REPORT WRITING:

Several lectures have been held for Senior Staff, and practical tasks given to increase the skill in report writing. Lots of follow-up is needed to reach a satisfactory level.

Some staff have been sent for training courses outside the project.

4.5 MANAGEMENT TRAINING:

Themes dealt with are: planning, organizing, communication, evaluation and leadership.

Most Management training is done "on-the-job", but some Management training has been carried out, when groups of staff are called for seminars, or in regular staff meetings.

A Workshop for Senior staff on Management issues is planned to take place in a few weeks time, with assistance from an outside Consultant.

4.6 ENGLISH:

Much efforts has been put into English training, as it becomes more important for staff to be able to use English in their daily work.

Activities have been:

- English classes in the evenings. Expatriates have been teachers.
- Conversation classes (five times a week for one month) small groups.
- "Speakers Club" one evening a week (time to time).
- English Speaking Days in the offices.
- English films have been shown and English literature has been made available.

5. TRAINING FOR SPECIAL GROUPS:

5.1 FOREMEN:

A key group in the Company is the Foremen. They have usually little formal education, but long experience. All training of the Foremen must be in Nepali language.

A Foreman is usually leading a group of 20-25 men, in their daily work.

The main themes dealt with in Foremen's meetings and in seminars are :

- Foremen's role as a leader and supervisor. (motivation, organising, planning, communication etc).
- Technical subjects as reading drawings, safety, first aid understanding of equipment and electricity etc.
- Relation to other departments like store, purchasing and mechanical.

5.2 STORE STAFF:

Stores efficiency is important for all work, at sites. Store staff are relating to many departments and people in their daily work, as well as, they are responsible for handling costly materials.

One eight hours seminar has been held about efficiency, cost and communication.

5.3 TRANSMISSION LINE STAFF:

Transmission Line staff are most of the time far away from main site of the project, and can not usually take part in training activities within the project.

Once a year they are called for a two days seminar on subjects relating to their work, like electricity, maintenance of survey instruments, costing, management, first aid, construction operations etc.

When working close to the project, they are called for other training activities, when possible.

Some of the staff have been trained for shorter periods in Norway.

5.4. MECHANICS:

With increased mechanisation in the Company, more training in operation, preventative maintenance and repair has been necessary. As much as possible, it is done at site, by Senior staff or outside experts.

Some staff and workers have participated in training outside the project, to learn about the use and maintenance of diesel powered machinery, in India and about heavy construction plant in Norway.

5.5 TRAINEES:

3 Trainees from the vocational school (Butwal Technical Institute) had their practical work and theory classes in the project for one year.

Mainly senior Nepali staff were teachers and supervisors, while over all coordination was done by Training Coordinator.

6. "LIFE SKILL" TRAINING:

It has been an unique opportunity for our workers, and their families as well, to gain knowledge and skills that will change their lives and help them to achieve better living standard. This would not only for duration of the project, but for the rest of their lives, as well.

No resources were allocated for this kind of training when the project started, but observation of the needs has led to some limited activities.

6.1 MONEY USE AND SAVING HABITS SEMINAR:

The Seminar was run for about 80 workers only, as a trial.

Themes covered were:

1) Money (its use, benefits and danger)

2) Debt (focusing on personal experience).

3) Saving concept (use of money in a meaningful way, importance of planning)

4) Cooperation (make use of skills learnt and working together)

We learnt: - for 80 - 90 % of the participants "loans are the worst enemy".

- workers consuming habits change (not only to the better) when they have regular income.

- many workers could tell how they had utilized income to increase the family living standard.

- surprisingly few workers were able to make up an account for their expenditure and income.

- regular income for a period is beneficial for the family, only when workers know how to spend wisely their hard earned income.

- a period with regular income might even make the family situation more difficult, if their habits change in a negative way.

6.2 KITCHEN GARDENING SEMINARS:

Many workers and staff bring their families to the project. They live mainly in quarters built by the Company.

Small kitchen gardens give needed and nutritious vegetables, and can help families to keep their expenses lower. A kitchen garden may also help in the process of settling, feeling at home and thriving as a family. It also gives meaningful tasks and activities.

About 75 workers/staff wives and local women took part in a Seminar where they learnt preparation of a garden, lay out, use of manure, planting, watering, making simple climbing frames, pit for waste water and protection against animals.

6.3 NUTRITION SEMINARS:

Workers wives, staff wives, local women, cooks in the project, single staff members, school children in Jhimruk area, have taken part in nutrition sessions.

Subjects covered/touched were:

- local food resources in relation to nutrition
- feeding techniques for infants
- variety of food
- malnutrition
- nutritious snacks
- demonstration of Oral Rehydration Solution
- nutritious porridge for children
- sprouting of beans
- good diet for pregnant women
- cost awareness

We believe that if this knowledge is put into practice, employees living standards will change to the better, and they will also later take knowledge and experience with them to their respective home villages, the day they do not work in the Company, any longer.

6.4 PREVENTIVE HEALTH:

In connection with the clinic set up, for [1]"security" and treatment of employees, teaching sessions for wives and local women has been done in subjects like:-

- prevention of diseases
- danger of smoking and use of alcohol
- use of medicines
- cleanliness and sanitation
- care during pregnancy
- dehydration and diarrhoea
- dental care
- danger of early (child) marriage
- First Aid
- Aids

First Aid and safety teaching has been done at all sites.

6.5 INFORMATION TO LOCAL PEOPLE ABOUT THE PROJECT:

A Drama was shown to local people close to project in November 1990 as part of our efforts to inform them about the project and make good relationships between the project and the local community. This was particularly in response to problems and misunderstandings in the early days of the project. The Drama was made also, to reach children and illiterate people. We hoped to answer some questions that we knew were being discussed in the community and also to open up the project for more contact.

7. CONCLUSION:

Much effort has been made to train staff and workers in Jhimruk Project.

We have accomplished a lot, and do have a much better trained staff and workforce, who are able to take on more work and responsibility. The life skill training we do believe, will benefit employees and people related to the project for their life times.

The main limitations have been that these activities were not programmed into the project time scale, nor were specific personnel (apart from the Training Co-ordinator (½ time)) included in the staffing of the project.

[1]"Security" meaning to give a sense of closeness/availability of medical facilities in a remote area.

8. RECOMMENDATION:

Training and development need to be given high priority, or else the urgent day to day work will prevent good training happening. Budget, time and personnel for training, must be included in the overall planning of a similar project.

Planning and coordination of training efforts in the companies as a whole, are also necessary.

DOROTHEA VESTOL
TRAINING COORDINATOR

January 1993

Jhimruk Hydro Electric and Rural Electrification Project

Financial Statement as per 16.8.1995 (1)

based on BPC's Nepalese Rupee Accounts
converted to NOK as per average actual rate of exchange
USD 1.- = NOK 6.5825614 = NPR 40.30605
NOK 1.- = NPR 6.1231559 (2)

	Actuals NPR	Actuals NOK	Budget NOK
Support service	32.190.841	5.257.230	7.820.000
Civil works	246.646.915	40.281.011	39.168.000
Electro-Mechanical equipmt (3)	232.794.380	38.018.692	43.146.000
132 kV transmission line (4)	55.823.093	9.116.719	5.780.000
33 kV rural lines	59.297.985	9.684.219	11.118.000
Extra works (mitigation) (5)	8.710.047	1.422.477	0
	635.463.261	103.780.348	107.032.000
Less donated value (6)	-7.591.831	-1.239.856	0
NORAD financed direct costs	627.871.430	102.540.492	107.032.000
Stock balance (7)	11.243.459	1.836.220	0
Fund balance in Nepal (8)	58.372.162	9.533.019	0
Total BPC received from NORAD	697.487.051	113.909.732	107.032.000
Accounted for in Norway only:			
Fee for adm/engg/mgmt. (9)		13.928.571	12.852.000
Interest paid in Norway (10)		217.888	0
Contingencies incl. added budget		0	10.116.000
Funds held in Norway (11)		1.943.809	0
		130.000.000	130.000.000
HMGN grant for land/taxes (12)	24.135.126	3.941.815	7.956.000
Grand total JHEREP I	721.622.179	133.941.815	137.956.000

Notes - see next page.

Notes:

(1) This statement follows the format of the original NORAD approved budget. The same format has been used for interim statements submitted annually during the construction period. A more detailed statement of project costs, with a breakdown of the main headings, is attached.

(2) The transfer of funds in cash and in kind from Norway to Nepal has been recorded with reference to current rate of exchange of USD against NOK respective NPR for each individual transaction.
The recorded amounts in USD have been checked and reconciled by the auditors on both sides, as confirmed in the Auditors' reports in Norway and in Nepal.
The weighted average rate of exchange (NOK 1.00 = NPR 6.1231559) for all transactions throughout the whole length of the construction period has been used to bring the total costs in NOK and NPR together in one consolidated statement of account as presented here for comparison with the approved budget.

(3) Most of the electro-mechanical equipment was procured and paid for in Norway under contracts with Kværner Anergy respective ABB Energi.
The amounts paid in NOK against these contracts have been recorded in Nepali currency according to the rate of exchange on the date of each such transactions. When these cost items are brought back into NOK as per overall average rate of exchange, the amounts will obviously not be identical with the orginal payments.
The last installment of the turbine contract (10 % guarantee amount retained) was due for payment after 16.8.1996 and is therefore additional to the cost of electro-mechanical equipment recorded in the present statement.
The same is true concerning cost of extra spareparts and modifications of the turbines (which have become necessary in order to cope with the heavy wear of turbines because of very abrasive silt content in the water).
These additional costs will be included under the budget for the proposed follow-up project named JHEREP IIA.
Cost of some items has been reduced as they were obtained as 'Donated equpment' as explained in note (5) below.

(4) Purchase and installation of switchgear at Lamahi sub-station (required for connecting the line from Jhimruk to the national grid) is included under the cost of the transmission line rather than under 'Electro-mechanical Equipment' as was budgetted.
This is one of the reasons why the cost of this 45 km long 132 kV transmission line has gone higher than budgetted.

(5) Extra works (mitigation) amounting to NOK 1.422.477 covers a number of mitigation measures related to drinking water schemes, rural electrification and projects related to irrigation and agriculature in the area downstream of the dam which is affected by the reduced flow of water in the river.
These items where not specified in the orginal budget, and has been funded out of the provision for contingencies.
Some of these mitigation projects were not completed as per 16.8.1995, and are expected to be continued as separate schemes under a proposed JHEREP II agreement between NORAD and NHAM.

(6) The NOK 1.239.856 shown as donated value is accounted for as UMN share investment in kind. It is deducted here since it has not been financed by NORAD.

This investment is made up of (i) 3 main turbine valves (high head spherical valves); (ii) a 30 ton power house crane; (iii) a large part of 6 kV and 33 kV switchgear; and (iv) various smaller items installed/used at JHEREP.

The values listed for these items (approved by BPC's Board of Directors) are considerably below the cost of similar new equipment.

(7) 'Balance stock of materials' includes line materials which have not yet been charged out, mainly related to the 33 kV were not completed by 16.8.1995 (the Libang line and the line for supply of the area downstream of the dam).

Also still included in the stock are some spareparts for the 132 kV transmission line, and other items related to the JHEREP project which remained in stock on 16.8.1995.

All these will be accounted for as part of the follow-up project JHEREP IIA.

Some goods in stock may also be sold and the proceeds added to 'Funds in Transit' (see (7) below).

(8) This NPR 58.372.162 'Fund balance' held by BPC in Nepal as per 16.8.1995, consisted partly of outstanding receivables in the form of customs deposits and other refundables, partly in local current bank deposits, and was otherwise temporarily tied up as part of BPC's working capital.

Some of these funds have since been spent on the ongoing project works referred to above, such as additional turbine spares and modifications, unfinished rural transmission lines and other mitigation works. These funds are to be accounted for under JHEREP II.

It should be noted that the equivalent fund balance shown as NOK 9.533.019 is calculated using the overall average rate of exchange over the construction period, and does not reflect correctly the value of the funds in NOK today, which is considerably lower.

(9) The fee for administration, engineering and project management was fixed in the JHEREP contract Between NORAD and NHAM at 12 per cent of direct construction costs.

Assuming that all available funds will be used, either under JHEREP I or JHEREP II, the amounts to NOK 13.928.571 (being NOK 130.000.000/1.12 x 0.12).

One third of this (i.e. 4 per cent) amounting to NOK 4.642.857, is compensation to NHAM's for personnel and administrative expenses in Norway.

The remaining two thirds (i.e. 8 per cent), amounting to NOK 9.285.714, are held by NHAM in a separate fund in Norway.

Out of this NOK 3.228.681 is payable to BPC for Engineering and Project Manage ment services as per billing up to 15.7.1995. There will be additional bills coming. The remaining balance rest will continue to be held by NHAM and used to finance other projects related to BPC and hydro-electric power development in Nepal.

(10) An amount of NOK 217.888 was paid in interest for short term loan taken in order to cover project funding needs during a critical period while waiting for next installment of NORAD grant money to be made available. NORAD has agreed that this can be counted as part of project costs.

Norway, which according to the JHEREP Agreement is refundable to NORAD.

(11) Funds held in Norway NOK 1.943.809 represent the net total of bank deposit and short term payables and receiveables in Norway. Interest due to NORAD is not included in this.

(12) HMGN's investment by definition is whatever may be required to cover (i) actual cost of land purchases and compensation to land owners affected by the project; (ii) taxes and customs duty levied by the Nepal Government; and (iii) charges by the Nepal Electricity Authority for supply of construction power.

End.

Jhimruk Hydro Electric and Rural Electrification Project

Financial Statement as per 16.8.1995

Detailed breakdown (1)

		Actuals NPR	Actuals NOK	Budget NOK
Support services	Total	32.190.841	5.257.230	7.820.000
Road, bridge, ropeway		9.173.418	1.498.152	
Camp		17.079.140	2.789.271	
Equipment		5.938.283	969.807	
Civil works	Total	246.646.915	40.281.011	39.168.000
Field investigations		684.589	111.803	
River training		24.765.721	4.044.601	
Dam and headworks		145.144.035	23.704.121	
Tunnels		45.648.028	7.454.984	
Power house		30.404.542	4.965.502	
Electro-Mechanical	Total	232.794.380	38.018.692	43.146.000
Turbines (2)		61.508.866	10.045.288	
Valves, crane (3)		11.512.927	1.880.227	
Plumbing, wiring, etc.		2.210.461	361.000	
Penstock (excl. civil)		16.620.895	2.714.433	
Gates etc.		6.152.392	1.004.775	
Generators, transformers (4)		77.897.275	12.721.753	
Switchgear (5)		35.345.670	5.772.460	
Erection (6)		8.711.968	1.422.790	
Training (7)		12.833.926	2.095.966	
132 kV transmission line (8)		55.823.093	9.116.719	5.780.000
33 kV rural lines (9)		59.297.985	9.684.219	11.118.000
Mitigation etc. (10)	Total	8.710.047	1.422.477	0
Agricultural Programme		22.485	3.672	
Irrigation etc.		343.059	56.027	
Drinking water		3.001.944	490.261	
Electrification		5.342.559	872.517	
Land, taxes, etc. (11)		24.135.126	3.941.815	7.956.000
Total direct costs (12)		659.598.387	107.722.163	114.988.000

Notes on next page.

Notes:

(1) This statement must be seen together with the general financial statement which gives the complete picture of JHEREP financing and costs as per 16.8.1996.

(2) This is the fixed price contract with Kværner/NHE for delivery of turbines and governors ex NHE workshop in Butwal. The amount includes about NPR 3 million (NOK 500.000) paid to NHE for repair of turbine parts which worn down during the guarantee period.
In addition comes the cost of extra spareparts and modifications to turbines etc. required in the future for handling the heavy turbine wear due to excessive content of abrasive silt in the water. This will be covered under the proposed continuation project JHEREP IIA.

(3) Valves and cranes were obtained secondhand. The amount given here includes payments made in Norway, freight etc.; cost of overhaul and modification mainly done by NHE in Butwal; and the estimated donated value invested by UMN.

(4) Fixed price contract with ABB ex works Norway plus cost of freight etc.

(5) Includes 132 kV switchgear etc. purchased from ABB at fixed price contract ex works Norway, as well as secondhand 6 kV and 33 kV switchgear, along with expenses towards freight etc. Also included is the estimated donated value contributed by UMN as investment in kind.

(6) Erection was basically carried out by NHE on 'cost plus' basis, under supervision of foreign experts at hourly rates.

(7) Services of foreign experts at hourly rates involved in training. A clean distinction between supervision and training is not possible. The training involved NHE staff and workers as much as, or more than BPC staff.

(8) Includes 132 kV switchyard and control equipment installed at NEA's substation at Lamahi.

(9) The full cost of the 33 kV line to Libang is not included, mainly because final billing for materials from project stock is lacking. This cost will come off the stock balance of NOK 1.836.220 (shown in the main statement) and will be covered by the budget for JHEREP IIA.

(10) The mitigation works are expected to continue up to 15.7.1997, and the additional costs will be covered under the proposed JHEREP IIA.

(11) Government investment covers all expenses related to land purchase; compensation for felling of trees for transmission lines; taxes and duties levied in Nepal; and electricity charges for construction power supplied by NEA.

(12) The following items are not included under total direct costs: (i) remaining balance of goods in stock; (ii) administration, engineering and project management fee; (iii) costs of extra spareparts and modifications to turbines etc. required for handling the heavy wear due to excessive content of abrasive silt in the water. It is expected that all remaining costs will be covered by funds in hand at the time when the project was taken over by HMGN on 16.8.1995.

PROBLEMS WITH SILT IN THE JHIMRUK POWER PLANT

Paper presented at the symposium on ENERGY MANAGEMENT IN NPS IN THE PRESENT CONTEXT organized by the O & M Directorate of the Nepal Electricity Authority at Trisuli HP Division from 4 to 6 December 1995.

by Suman Basnet, Butwal Power Company Limited

1. INTRODUCTION

The Jhimruk power plant which is owned and operated by Butwal Power Company Limited (BPC) began regular operation from 17th August 1994 (1st Bhadra 2051). During its first year of operation, the power plant generated about 45.1 GWh of energy, giving a plant factor of about 43%. Looking at the running hours and the down time of the three units cumulatively, the percentage of down time (45%) is high. There are several reasons for this, many of which are "teething problems" that crop up in any new power plant.

When we further analyse the various reasons for the down time, we see that the highest percentage of down time (43.7%) is because of problems related to high sediment load in the water.

One of the major problems related to the development of water resources specially in the Himalayan region is the extremely high sediment load in the rivers, mainly during the monsoon period. The Jhimruk power plant has also fallen victim to it.

2. DESIGN ASPECTS

2.1 Sediment load study

We know that sediment in the river water creates many problems in the operation of hydro power plants. But adequate study of this problem is usually not done in the planning and design stages of hydro power plants. The report on the Jhimruk power development feasibility study highlights the importance of assessing the river sediment load for calculating the loss of active storage capacity of a dam. However, it does not mention the adverse effect it has on the operation of the power plant. The report predicts that the Jhimruk river may expect considerable sediment load. It goes on to say that because of lack of sufficient data, accurate calculation of the sediment load was not possible.

2.2 Headworks

The headworks for the Jhimruk power plant is designed for a flood discharge of 2000 m^3/sec (1 in 100 year flood). The desilting chamber is designed to trap quartz particles larger than 0.2 mm. The sediments are flushed out by the "Serpent Sediment Sluicing System". The design of the headworks is based on a physical model

study carried out in the Institute of Engineering, Pulchowk Campus.

2.3 Turbine

The material used for the parts of the turbine that come into contact with water is stainless steel containing chromium (Cr) and nickel (Ni). Cr and Ni provide toughness, ductility, wear resistance and hardness to the steel. The runner and the guide vanes are of stainless steel whereas the turbine covers have a three mm thick stainless steel layer on the surfaces in contact with water. The turbine sealing rings are made of nickel aluminium bronze. The equipment supplier claims that wearable parts are easily accessible for repair and replacement. The components are designed to withstand most adverse conditions, e.g. runaway conditions, pressure vibrations etc. The supplier guarantees the turbine against cavitation pitting but not damages due to chemical composition of water or abrasion by solids in water.

3. OPERATIONAL EXPERIENCE

3.1 Headworks

The sediment concentration in the Jhimruk river during floods varies considerably, and is often not a direct function of the river discharge. Therefore, the operation of the headworks and the recruitment and training of staff to carry out the necessary sediment control procedures have received much attention. To continuously check the performance of the headworks, a sediment sampling programme has been set up. The analysis of the samples is carried out in a field laboratory at the site.

The first year's operation has shown that the desilting basin has trapped most of the silt particles larger than 0.2 mm. However, most of the finer particles are quartz. Sampling results show that there is a higher concentration of silt in the water near the headrace tunnel floor. When the tunnel was emptied during the monsoon silt was found on the tunnel floor.

2.2 Turbines

Soon after the power plant began regular operation, there was a rapid increase in the temperature of the driving end thrust bearing. Investigation of this problem led us to the measurement of the gap between the turbine sealing rings and the runner. This gap which during commissioning was between 0.35 and 0.7 mm had increased to over 1 mm. This heavy wear on the sealing rings brought to our attention the possibility of wear on the other turbine parts because of sediment in the water.

When flow in the Jhimruk river decreased to a level when a unit had to be shut down, the turbine of unit 3 was dismantled for inspection in mid January 1995. Similarly unit 2 was dismantled in May 1995 and unit 1 in August 1995. The wear on the turbine covers, sealing rings and the guide vanes of all three units was very severe.

There were deep grooves on the stainless steel layer of the turbine covers and at some spots the mild steel base had been revealed. There were grooves formed at different positions of the guide vanes, but the deepest grooves were at the fully open position of the vanes.

There was severe wear on the blade sides, the blade ends that are against the turbine covers and on the ears of the guide vanes. The shaft had also worn down.

There were some grooves on the runner at the foot of the blades at the inlet and outlet sides of the runner. The wear on the blade thicknesses was up to 1.5 mm at some spots. The average wear was about 0.5 mm.

These matters were reported to the equipment manufacturer, and extensive discussions were held. It was decided to ship the worn parts to the Nepal Hydro and Electric (NHE) workshop in Butwal for repairs.

2.3 Overall operation

The above discussion suggests that the fine silt that goes through have a high concentration of quartz. Quartz, a very hard mineral, is very abrasive. When the power plant is shut down or is operating with very small loads, the velocity of water in the tunnel is so low that the silt settles in the tunnel. When there are drastic increases in velocity of water in the tunnel, e.g. when there is sudden increase in load and when the tunnel is being emptied or filled up, the silt in the tunnel is picked up and carried to the turbines. This may be causing heavy wear on the turbine parts.

Certain improvements in the desilting process and the operating procedures may reduce this problem to some extent. However, indications seem to point towards the problem being something one must learn to live with. This may mean the overhaul of turbine parts every year and additional investment in a full set of replaceable parts for all three turbines to reduce the down time of the plant. The shutting down the plant at times of extreme sediment concentrations may help to lessen the problem.

3. REPAIR OF TURBINE PARTS

After extensive discussions between BPC, NHE and the equipment manufacturer, it was decided that the turbine covers and guide vanes would be repaired at NHE, that the runners would not be repaired, and that the bronze sealing rings would be replaced by stainless ones.

The worn down areas in the turbine covers were built up using electrodes that were supplied from Norway. The welding was done with extreme care to keep the deformation of the covers to within acceptable limits and to prevent damage to the guide vane bearings. The turbine covers were bolted back to back and welding was done in short bursts in one area and then on an area diametrically opposite to the first. The covers were turned over frequently to be able to work on both sides. They were then machined according to prescribed drawings. The tolerance in the turbine cover is as small as 0.04 mm.

The worn surfaces of the guide vanes were built up by welding. Five guide vanes were welded simultaneously. Each of them was preheated to 150^{0}C. The welding was done in short bursts consecutively on the five guide vanes. Extreme care was taken to avoid deformation of the guide vanes. The tolerance for the guide vanes 0.02 mm. The guide vane shafts were then machined and the blades ground according to prescribed drawings. The repaired guide vanes were then lapped with the respective turbine covers. In spite of the extreme care taken during welding some guide vanes were deformed more than what was allowable. These were straightened by carefully controlled heating and cooling process.

The nickel aluminium bronze sealing rings were too "soft" for the sediment laden waters of the Jhimruk river during the monsoon. So, stainless sealing rings were designed by the equipment manufacturer that would better withstand the monsoon wear. This sealing ring had mild steel as the core material with a layer of stainless steel welded on the surface coming into contact with water. To avoid the risk of seizing, the gap between the ring and the runner was increased to 0.7 mm thereby compromising on efficiency.

The repairs carried out at NHE were seen to be "stop-gap" repairs that needed to be done to bring the turbines back into operation within a short period. But the workmanship of NHE's technicians has shown that complex repair work requiring high degree of accuracy and skill can be done by them.

4. FUTURE DIRECTIONS

Assessment of the silt problems in Jhimruk indicates that we need to work on several areas.

4.1 Sediment sampling and control

In this area we are reinforcing our sediment sampling programme, mapping the sediment load under different seasonal load conditions and analysing and interpreting the records. We are thinking of installing real time sediment concentration measurement instruments, so that power house operators can immediately reduce the load or shut down the plant at preset sediment concentrations.

We are designing a flushing outlet at the end of the headrace tunnel to flush out water in the lower portion of the tunnel during the start up of turbines after long periods of standstill, during emptying and filling of the tunnel, and during drastic changes in output when silt concentration in this volume of water may be very high. We are also considering installing a gate to control the flow of water into the penstock. This gate will prevent the silt that may be deposited in the tunnel from entering the penstock during emptying or filling of the penstock.

4.2 Operation procedures

We are revamping our operation procedures by reviewing our procedures for flushing of the penstock and tunnels so that as much of the silt as possible is removed before the water passes through the turbine.

4.3 Turbine parts repair and replacement

We are considering having a complete set of spare guide vanes for all the three turbines. After the end of the monsoon season, the worn guide vanes will be replaced by reconditioned ones, and the former will be sent to the NHE workshop for repairs so that it is ready for the next year.

The lower turbine covers are easy to dismantle. So we are considering having spare lower covers for all the three units which will be replaced and repaired as for the guide vanes. The upper turbine cover is more difficult to dismantle because we need to move the generator to remove this cover. We are considering bolting wear plates on the inside of these turbine covers. These "use and throw" plates will be replaced after each monsoon season. These plates can be replaced by simply dismantling the runner and without moving the generator.

We are considering having bronze sealing rings for the dry season when the water is clear and high efficiency of the turbine is

required. During the monsoon we could use the stainless ones which are designed for rough use, with relatively higher losses, since high efficiency is not important when there is plenty of water. The lower sealing ring is boltable but the upper one is press fitted. We are working towards making both of them boltable for easy replacement.

All the above measures will drastically reduce the down time of the power plant during the time of the year when energy is most required in Nepal.

4.4 Hard facing by plasma nitriding

One of the methods for hard facing critical turbine components exposed to heavy wear is called plasma nitriding. This process takes place in a furnace containing nitrogen gas at very low pressure. The gas is ionized and accelerated in an electric field. These nitrogen ions then hit the surface of the component at high velocity and get implanted into the material to a depth of about 0.15 mm after about 30 hours of treatment at about 550^{0}C. This process does not change the dimension of the component being treated and no distortions occur.

One spare runner and four spare guide vanes have been treated with this process. These have been installed in turbine no. 1 in Jhimruk which has just come into operations after being repaired at NHE. We will monitor their performance over the next monsoon and evaluate whether this may be a suitable method of hard facing the turbine components.

5. CONCLUSIONS

The past year has been very challenging for the Jhimruk power plant. We have not been able to run the plant to the satisfaction of NEA/LDC. On the other hand we have had valuable experience and learnt some important lessons regarding the operation and maintenance of hydro power plants built on Himalayan rivers.

The importance of studying sediment load characteristics of a river and the effect it may have on the operation of the power plant has been reinforced. This will not only be useful for the design of sediment removal systems but also for the design of turbines that are best suited for the Himalayan rivers.

We have also learnt the need to have suitably qualified personnel for all aspects of power plant operation and maintenance, and the need to constantly review our operational procedures to look for ways to make the power plant operation more efficient.

Sediment problems in the Jhimruk power plant.

Design parameters of the desilting basin of Jhimruk power plant;

- Trap all the particles larger than 0.2 mm (as mentioned in model study report).
- Intermittent flushing (normally), but could be operated continuously in accordance with the sediment load in the river.
- Continuous operation of the power plant while the flushing is in progress by installation of the serpent sediment slucing system (a movable pipe float system)

Each desilting basin - Effective length 36 m, width 5.5 m. Two basins only.
Designed total power flow 7.1 cu. mec.

* Physical model study of desilting basin was carried out only to study hydraulics of the flow pattern inside the basin.

Sediment load and the turbine wear.

The power plant having 3 Francis turbine units (each 4 MW) was commissioned from about middle of August 1994 and then had a chance to run in the monsoon season (i.e. up to the end of September), when the sediment load becomes high in the river. The highest recorded sediment load then was 8486 ppm in the river at the headworks, otherwise in August '94 power plant had run at the average sediment concentration level of 1500 PPM measured at the end of the headworks tunnel, but also had sediment concentration recordings of about 2500 to 5000 ppm, on several days too in August '94.

From August '94, until middle of September 1994 all three turbines were in alternate operation most of the time, each turbine carrying 2.35 m^3/s of flow. Total power discharge was about 4.7 m3/s. From November '94 to end of January '95 all three units were in operation at full capacity and during this time there was negligible sediment load. After that in January '95 one unit was dismantled after running 3019 hours (20% in 1994 monsoon. The other unit was dismantled in middle of May after running 4212 hours (10% in 1994 monsoon). These two units were reassembled again in August '95 after extensive repair works on wear caused by sediment mixed water during monsoon period.

At the same time in August '95, the remained 3rd unit was also dismantled after running 4185 hours (26% in monsoon time) and was repaired and reassembled in November '95. At present all 3 units are running well.

The worst wear caused by abrasion had appeared to the turbine which was dismantled in August '95. Since commissioned, it had ran 26% of the total run-hours (4185) in sediment loaded condition of the river including part of the monsoon time of 1995. Description about the wear on the turbines is outlined below:

Deep grooves had been cut on the stainless steel layer of the turbine covers and at some spots the mild steel base had been revealed. There were grooves formed at different positions of the guide vanes, but the deepest grooves were at the fully open position of the vanes.

There was severe wear on the blade sides, the blade ends which are against the turbine covers and on the ears of the guide vanes. The shaft had also worn down.

There were some grooves on the runner at the foot of the blades at the inlet and outlet sides of the runner. The wear on the blade thicknesses was up to 1.5 mm at some spots. But the average wear was about 0.5 mm.

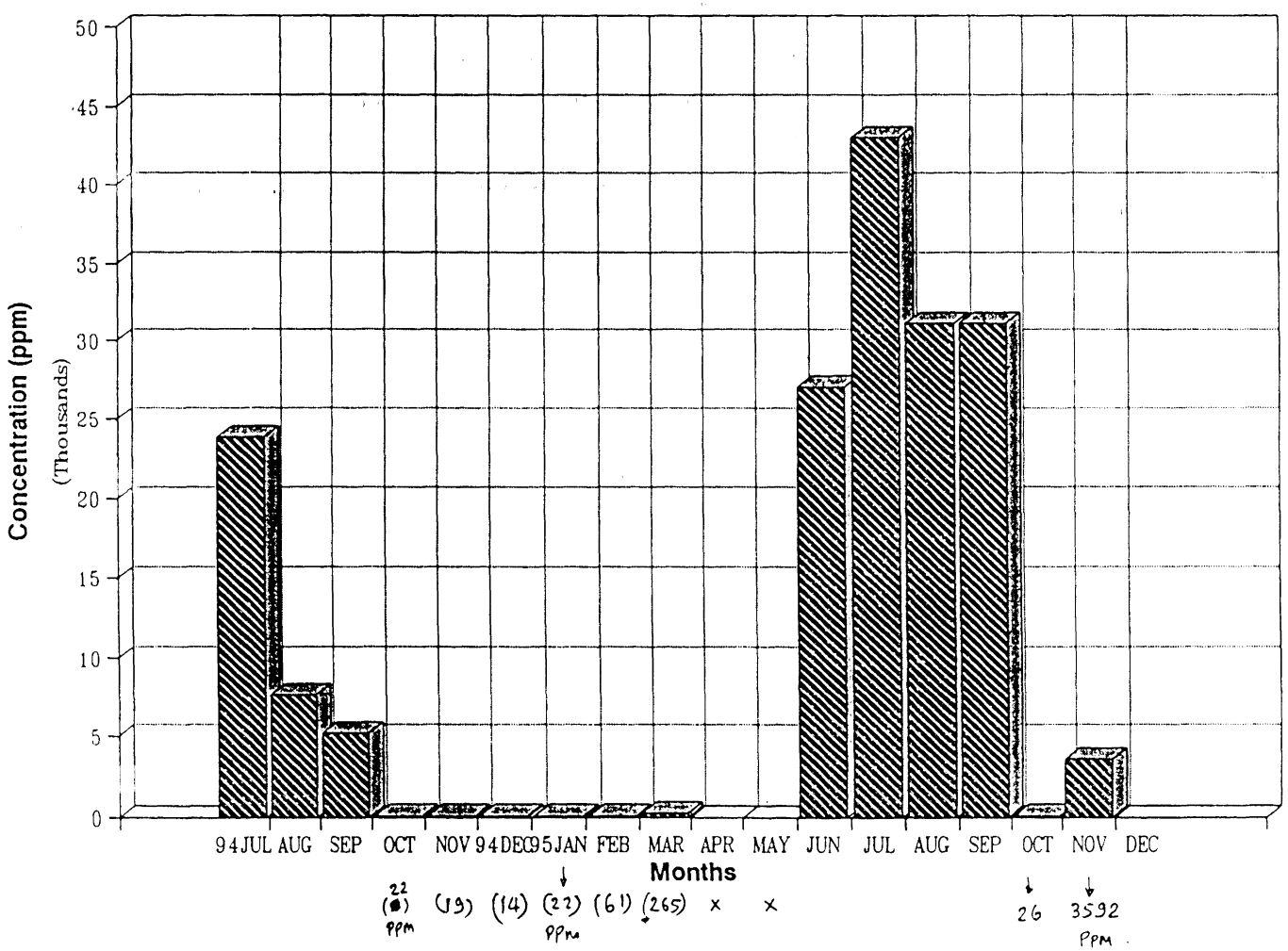
The main cause of the heavy wear in the turbines is due to the fine particles entering the tunnel and penstock which has high content of quartz minerals.

The sieve analysis of the samples taken at the end of the headrace tunnel in monsoon '95 revealed that about 83 % of the particles entering the penstock are smaller than 0.09 mm and about 16.85 % of the particles are between the range 0.2 mm to 0.09 mm. A very small percent about 0.15 % is between the range 0.5 mm to 0.2 mm, and did not existed any sediment particles in the tunnel larger than this range.

The sieve analysis has revealed that the particles entering into the headrace tunnel and finally into the turbine do not contain any significant percentage of coarse particles larger than 0.2 mm and should have been trapped and flushed by the desilting basin. However finer particles as mentioned above do enter into the headrace tunnel. Mineralogical analysis has to be done yet to know the % of quart content of the finer particles that has deposited in the Headrace tunnel.

At present further precaution and remedial measures are under consideration to lesser the wear on the turbines.

JHIMRUK RIVER
Highest Recorded Concentration1994-95



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