5. 4 Agricultural Economy

5.4.1 Methodology of Survey

The study aimed to identify the prevailing conditions in the Study area pertaining to the marketing of agricultural products (including potentials for development of market-oriented hill agriculture) and inputs, the rural credit network and linkages, and farm household economy.

The methodology adopted by the study consisted of a comprehensive study of 202 rural household samples based on the different sizes of land holdings, i.e. marginal (less than 0.2ha), small (0.2-0.5ha), medium (0.5-1.0ha) and large (over 1ha) households, field investigations and case studies at 15 survey spots of different settlements in the Study area, literature review and collection of the latest reliable data. As the data collection for rural credit was sometimes severely constrained by the lack of background information and published data on the present situations of the area, the case studies on rural credit delivery were conducted. The data collected from field investigations were substantiated by interviews with concerned officials from various line agencies as well as managers from the private sector.

The data and information obtained through interviews and data collection are summarized in Appendix 5.4.1-1.

5.4.2 Marketing System for Agricultural Products and Inputs

(1) Marketing System for Agricultural Products

In the Study area, a number of market centers can be seen in Devighat, Battar, Bidur, Dhunge and Trishuli. These play an important role as a consumer source for cereals, pulses, vegetables, fruits and livestock products, and in turn serve as a source of cash income for farmers.

Agricultural marketing, especially for agricultural products such as paddy, maize, millet and wheat is entirely controlled by 21 private traders (1 in Gerkhutar, 4 in Battar, 2 in Gangate, 3 in Inarpati, 8 in Devighat, and 3 in Phirkep Devighat) at 6 collection centers (see Appendix 5.4.2-1). Cereal crops purchased at the centres are famous fine paddy Pokhareli, maize, millet and wheat. In 1996/97, 2,990 MT of paddy, 188 MT of rice, 777 MT of maize, 913 MT of millet and 353 MT of wheat totaling 5,221 MT were purchased mostly from neighbouring VDCs such as Jiling, Belkot and Madanpur for shipment to Kathmandu and other districts. It has been reported that about 11.6% of the total volume was purchased from the Study area (see Appendix 5.4.2-1). While paddy, maize and wheat were shipped to millers/ feed industries for poultry (Quality Feed Industry and Star Feed Industry) in Kathmandu, millet was marketed to Pokhara and Bhairawa for brewing.

Almost all of the cabbage, carrot, radish and other vegetables cultivated in the Study area are consumed by the farmers themselves, with a small portion of surplus

vegetables being shipped to markets in Battar and Trishuli. Demand for vegetables in the area cannot be met through local production, and consequently the bulk of vegetable supply is brought into the area from nearby VDCs and Kathmandu. As the price of paddy generally drops during the harvest season, some distributors buy up rice at harvest time and store it until prices rise again at which time it is shipped to major markets like Kathmandu for maximum profit. Due to the shortage of storage facilities for fresh vegetables, price fluctuations are significant not only at farmgate markets, but also at wholesale and retail markets both in the Study area and in Kathmandu. Farm gate, wholesale and retail prices for cereals, pulses and vegetables are shown in Table 5.4.2-1.

Table 5.4.2-1 Farmgate, Wholesale and Retail Prices for Cereals, Cash Crops and Vegetables (1996/97)

Commodities	Unit	Farmgate	Wholesale	Retail (Study Area)	Retail (Kathmandu)
Paddy/Rice (Pokhareli)	Rs/kg	13.00	14.00	21.50	24.00
Paddy/Rice (Mansuli)	Rs/kg	10.25	11.00	16.00	16.00
Paddy/Rice (Mota)	Rs/kg	9.25	9.75	13.50	13.00
Maize	Rs/kg	8.50	9.00	9.00	-
Millet	Rs/kg	6.75	7.75	8.50	-
Wheat	Rs/kg	7.00	8.00	8.00	-
Lintle	Rs/kg	35.00	-	40.00	37.00
Brackgram (Whole)	Rs/kg	30.00	-	35.00	35.00
Brackgram (Dal)	Rs/kg	39.00	-	43.00	37.00
Soyabean	Rs/kg	16.00	-	21.00	32.50
Mustard Seed	Rs/kg	17.00	-	20.00	25.00
Sesame	Rs/kg	35.00	-	42.00	43.00
Cauliflower	Rs/kg	14.00	-	15.00	12.00
Cabbage	Rs/kg	5.00	-	8.00	7.50
Tomato	Rs/kg	13.50	-	14.50	15.50
Potato	Rs/kg	8.00	-	9.00	8.00
Eggplant	Rs/kg	-	-	15.00	10.00
Green Beans	Rs/kg	-	-	16.50	-
Green Peans	Rs/kg	11.00	-	17.50	12.00
Onion	Rs/kg	8.00	-	14.00	10.50
Garlic	Rs/kg	16.00	-	25.00	40.00
Ginger	Rs/kg	15.00	-	20.00	19.00
Radish	Rs/kg	3.00	-	4.00	6.00
Green Chilli	Rs/kg	22.00	-	30.00	23.00

Source: Interview survey.

(2) Marketing System for Agricultural Inputs

1) Fertilizers

In so far as farming practices are concerned, availability of credit by itself does not extensively promote agricultural production; however, the most important support services are adequate and smooth input supply and extension services. Fertilizer distribution is generally characterized by: (a) a near monopoly position by the Agriculture Inputs Corporation (AIC) in procurement and distribution of fertilizer; (b) heavy dependence on imports, facilitated by foreign assistance (grant or otherwise); (c) shortage of financial resources for the AIC to supplement external assistance for additional importation of fertilizer and for buffer stocking, resulting in uncertainty, inadequacy and untimeliness associated with such supplies; (d) lack of institutional credit support for distributors/retailers in the private sector despite the fact that privatization of fertilizer trade is promoted by the Government; and (e) a low level of credit support for fertilizer sales to farmers.

Currently, wholesale fertilizer supply in the Study area is carried out by the AIC main office in Bidur through a distribution network whereby fertilizer is imported at Calcutta Port and then dispatched to the office either via receiving centres located in Birgunj/Biratnagar or directly from the port. Retailing to farmers is mainly handled by 11 fertilizer retailers and partially by the cooperative societies (see Appendix 5.4.2-3) supplying 21.5% (1,121 MT in 1995/96) of the total fertilizer (5,210 MT) distributed at the field level in Nuwakot district. The 11 retailers supply fertilizers such as urea, DAP and MOP. Breakdown for the total sales volume in 1995/96 was 915.4 MT (81.7% of the total) of urea, 203.3 MT (18.1%) of DAP, and 2.5 MT (0.2%) of MOP. A major constraint appears to be unavailability of fertilizers on a timely basis.

Wholesale and retail prices in 1996/97 for chemical fertilizer are shown in Table 5.4.2-2.

Table 5.4.2-2 Wholesale and Retail Prices of Fertilizers (1996/97)

Type of Fertilizer	Unit	Wholesale	Retail
Urea (46,0,0)	Rs/kg	6.72	6.95
TSP (0,46,0)	Rs/kg	8.00	8.30
MOP (0,0,60)	Rs/kg	8.50	8.70
DAP (18,46,0)	Rs/kg	16.88	17.10
Complex (20,20,0)	Rs/kg	10.00	10.30
A. Sulphate (21,0,0)	Rs/kg	6.90	7.20

Source: Interview survey and AIC main office in Bidur.

With the removal of a major part of subsidies on all types of fertilizer (the Government is still providing a transport subsidy for fertilizer distribution), all

fertilizer prices have gone up. This has helped substantially to bring down the burden on the Government for providing subsidies. As of February 1997, the retailers and the cooperative societies obtain the same sales commission as shown in Table 5.4.2-3.

Table 5.4.2-3 Sales Commission of Fertilizer

Type of Fertilizer	Private Retailers & Cooperative Societies
Urea	Rs.196.00/mt
MOP	Rs.297.40/mt
DAP	Rs.437.40/mt
Others	Rs.310.00/mt

Source: AIC main office in Bidur.

2) Agro-chemicals

Pesticides and fungicides are primarily marketed to the farmer through 9 private dealers located in the Study area (see Appendix 5.4.2-3) and supplemented by the AIC main office. Most of these agro-chemicals are supplied by private agro-chemical and seed wholesalers in Kathmandu. Wholesale and retail prices for 1996/97 are in Table 5.4.2-4.

Table 5.4.2-4 Wholesale and Retail Prices of Agro-chemicals (1996/97)

Type of Agro-chemicals	Unit	Wholesale	Retail
BHC (Pesticide)	Rs/kg	9.10	10.00
Metacid (Pesticide)	Rs/100ml	65.00	75.00
Novan (Pesticide)	Rs/100ml	63.00	70.00
Forate (Pesticide)	Rs/kg	98.00	115.00
Thiodan (Pesticide)	Rs/100ml	50.00	60.00
Hinosan (Fungicide)	Rs/100ml	135.00	150.00
Diethane M45 (Fungicide)	Rs/kg	304.00	330.00
Blitox 50W (Fungicide)	Rs/kg	304.00	330.00

Source: Private dealers and AIC main office in Bidur.

3) Improved Seeds

Improved seeds such as cereal and cash crops, and vegetables are supplied to farmers mainly by the AIC main office in Bidur and 9 private agro-chemical dealers, and supplemented by fertilizer retailers in small quantities. However, a number of farmers engage in farmer-to farmer seed exchange, using old and degenerated seeds from their own previous production. Wholesale and retail prices for 1996/97 are shown below in Table 5.4.2-5.

Table 5.4.2-5 Wholesale and Retail Prices of Improved Seeds (1996/97)

Type of Seeds	Unit	Wholesale	Retail
Paddy (Pokhareli)	Rs/kg	18.00	20.00
Paddy (Mansuli)	Rs/kg	16.00	17.50
Paddy (Mota)	Rs/kg	13.50	15.00
Maize (Foundation)	Rs/kg	16.00	17.60
Maize (Certified 1)	Rs/kg	18.50	20.40
Maize (Certified 2)	Rs/kg	15.50	17.10
Wheat (Certified)	Rs/kg	14.75	16.20
Cauliflower (Certified)	Rs/kg	550.00	632.50
Radish (Certified)	Rs/kg	140.00	161.00
Okura (Certified)	Rs/kg	75.00	86.30
French Bean (Certified)	Rs/kg	165.55	190.40
Onion (Certified)	Rs/kg	225.00	258.80
Tomato (Certified)	Rs/kg	870.00	1,000.00
Cucumber (Local)	Rs/kg	3,480.00	4,000.00
Cowpea (Certified)	Rs/kg	87.00	100.00
Eggplant (Certified)	Rs/kg	435.00	500.00
Chilli (Certified)	Rs/kg	5,800.00	6,670.00

Source: AIC main office in Bidur and private dealers.

It is obvious that while provision of assured irrigation, fertilizers and improved seeds are essential for achieving higher yields, and assurance of reasonable prices to farmers is also important to motivate them to go in for better farming technologies.

(3) Post-harvest Facilities

In general, farmers are using traditional containers of various types and sizes, such as bamboo bins, earthen bins and sacks for storing food grains. Recently some farmers have been found using metal bins. These containers are not very moisture proof, and storage losses on account of insects and rodents stand at about 10%. Regarding processing of agricultural products, there are 26 small scale milling facilities in the Study area, which engage in milling of paddy, maize and wheat, as well as the extraction of oil from nigerseed and sesame. These processed items are for self-consumption by the farmers themselves (see Appendix 5.4.2-4). Some mills purchase paddy from the farmers for either wholesale to market center retail outlets, or direct sale to consumers.

(4) Present Marketing Conditions

The prevailing marketing conditions for agricultural products in the Study area are described below.

1) Geographic Location

Geographic location for marketing of agricultural products has been favourable given the fact that the largest consumption centre in Kathmandu is only 3-4 hours away (roughly 70km) by road.

2) Road Network

Extension of the road network from Kathmandu has essentially established Nuwakot district as a satellite sub-region of the Kathmandu Valley. The existence of the all weather road extending from the Study area to Kathmandu has facilitated trade and marketing of agricultural products, as well as transport of agricultural inputs even during rainy months. However, road surface conditions are not always good due to the fact that trucks overloaded with agricultural products and inputs, and consumer goods have caused road surface damage such as pot-holes, and at many locations pavement materials have been exposed. At present, the road between Kathmandu and Ranipauwa is undergoing improvements with funding by ADB, and the road between Ranipauwa and Trishuli is scheduled for 2 years of improvement works with funding by the World Bank from July 1997. Also, there exists a plan to widen the road between Trishuli and Galchi to allow for truck traffic. Should this project be implemented, the distance to Kathmandu will be shortened by 20 km thereby facilitating the flow of goods.

3) Food Supply Base for the Kathmandu Valley

Nuwakot district, due to its advantageous location and access, has become a food supply base for the Kathmandu Valley, which comprises a major consumption center for cereals, vegetables, fruits and livestock products produced in the district.

4) Trade of Agricultural Products

There are collection centers in the Study area at Gerkhutar, Battar, Gangate, Inarpati, Devighat, and Phirkep Devighat which purchase large amounts of paddy (particularly Pokhareli), maize, millet, wheat, etc. from farmers of nearby VDCs. With the exception of millet, shipping destination for these products is Kathmandu. The bulk of cereals shipped from the Study area is surplus produce from large farms, which crop high yield varieties in lowland areas where irrigation is possible even in the dry season. The collection centers serve as relay stations between villages and urban consumption centers, facilitating the collection and shipment of produce. Individual farmers are the basic operator units for sales to the traders, and transport of products to the centers is always on foot. Group collection is performed only at the Phirkep Devighat center.

As long as farmers are compelled to sell the products to the traders to meet the cash needs of their households, they are always price-takers and not price-setters.

5) Demand for Agricultural Products

Demand conditions exercise a significant influence on specialization and trade in agriculture, as farmers are not easily motivated to produce for the market without favourable demand. In the Study area, main market centres located in Devighat, Battar and Trishuli are responsive to the local demand of rural population. Local demand for agricultural products such as vegetables (cauliflower, tomato, cabbage,

onion and green chillies), pulses (lintle and blackgram) and oilseeds (mustard seed) is, at present, met through imports mostly from neighboring VDCs and Kathmandu.

Through the prevailing rural-urban trade and marketing linkages, the largest consuming area, Kathmandu, represents the most important potential for increased demand for agricultural products with increasing pace of urbanization and population pressure. Famous Trishuli fine paddy (Pokhareli and Mansuli) constitutes higher demand among urban consumers in Kathmandu due to its superior taste. If the Study area as a food production base is made more responsive to growing and diversified urban demand for such products, the impact on rural employment and income will be quite substantial.

6) Specialization and Commercialization of Agriculture

Nuwakot district, with its geographically competitive position as food production base for the Kathmandu valley, has already established itself as a specialized vegetable producing area responsive to consumer demand in Kathmandu. This is evidenced by the share accounted for by produce from Nuwakot out of the total transaction volume in vegetables at the Kalimati wholesale market. (see Table 5.4.2-6, and Appendix 5.4.2-5 for details)

Table 5.4.2-6 Transaction Volume of Vegetables in Kalimati Wholesale Market (1995/96)

Commodities	Share of Nuwakot District (%)
Cauliflower	10.7
Cabbage	10.8
Green Chilli	11.7
French Bean	14.5
Potato (white)	15.8
Potato (red)	18.9
Radish (white)	53.6
Radish (red)	46.5

Source: "Agricultural Marketing Information Bulletin, 1996", Marketing Development Division, Department of Agriculture.

Following specialization and commercialization of vegetables based on comparative advantages, farmers are likely to be better off through trading as compared to the prevailing subsistence production. Nevertheless, given the fact that there is strong competition with significant price fluctuations in the vegetable market, if the time advantages cannot fully be captured, vegetable trading will lose off-season advantages as supplies from other districts start arriving at the market.

7) Marketing Information

The information network for marketing activities operates poorly. Farmers have no adequate access to information on market prices of agricultural products across other markets. This despite the fact that marketing information on fruits and vegetables at the Kalimati Wholesale Market in Kathmandu from the Marketing Development Division of the Department of Agriculture is announced every morning on the radio.

8) Standardization and Grading

Standardization and grading of agricultural products are important for ensuring more reasonable and attractive prices to farmers, as well as a proper margin to traders and millers. However, there is no such practice at the farm level by traders and millers.

Based on the above, it is concluded that no serious marketing problems are found in the Study area which would constrain a shift from the prevailing subsistence agriculture, a situation promoted by relatively small land holdings, to specialized/commercialized agriculture and development of a market-oriented multiple cropping system best suited to the local environment through effective use of scarce land resources, improved agricultural technology and appropriate fertilizer inputs. This is essential for generating gainful employment and income opportunities for farmers, especially for the disadvantaged poor such as marginal and small farmers. This will, in turn, lead to further promotion of directly related agri-businesses and a diverse range of related agro-based industries.

5.4.3 Rural Credit

Rural credit institutions play a pivotal role in upgrading the economic standard of the rural population. A vast majority of the population lack productive resources to adopt improved farm technologies and generate income and employment opportunities. The 8th National Plan (1991/92~1996/97) has accordingly emphasized the need for a strong rural credits system which will help break the stranglehold of low income, saving and investment, and subsistence agriculture. The objectives of the rural credit program are to provide the necessary financial resources to (a) generate income and employment opportunities for small and marginal farmers and landless households under the poverty alleviation programs such as the Small Farmer Development Programme (SFDP), Intensive Banking Programme (IBP) and Production Credit for Rural Women (PCRW), (b) promote agri-businesses and agro-industries and maximize the use of indigenous energy resources, and (c) bring sustainability in the credit programs based on banking principles.

Rural credit facilities in the Study area can be broadly divided into three categories, i.e. institutional, non-institutional and semi-institutional credits as described below.

(1) Institutional Credit

The Agricultural Development Bank of Nepal (ADB/N) in Trishuli, Nepal Bank Ltd. (NBL) in Bidur, and Nepal Bangladesh Bank Ltd. (NBBL) in Battar are the major vehicles to provide institutional credit to farmers in the Study area, though NBBL was newly established in November 1996. While SFDP is implemented by ADB/N in 11 other areas besides the Study area (see Appendix 5.4.3-1), IBP is carried out by NBL in the Study area.

1) Loan Purposes and Interest Rates

ADB/N has classified its loan operation according to 14 purpose categories, including financing related to cereal, cash and special crops, farm equipment, irrigation, bio-gas, agricultural inputs marketing, agro and cottage industry, agri-business, horticulture, rural housing, livestock, etc., and in terms of loan period, i.e. short term for a period of 18 months, medium term for over 5 years and up to 7 years, and long term for a period of 10 years. The current annual interest rate charged (e.g. 15% for cereal, cash and special crops) ranges from 14% to 17% for individual loanees; however, cooperative societies can enjoy 2% less than the current rate (see Appendix 5.4.3-2).

Loans under IBP undertaken by NBL are broadly classified into three sub-sectors, i.e. agriculture, services and cottage industries. While the loan maturity period for agriculture and services is 2 years, that for cottage industries is 3 years. Presently, NBL charges an annual interest rate of 12% on loans up to Rs.15,000 and 14.5% on loans above that level (see Appendix 5.4.3-3).

2) Eligibility Requirements for Loans

Eligibility requirements for loans are will-defined. ADB/N generally makes loans against collateral security up to the limit of 70-80% of the value of the collateral such as land and building. On the other hand, NBL provides loans up to 50% of the appraised value with an additional guarantee made by the Credit Guarantee Corporation. Loanees are generally required to make equity contribution of 20% of the project cost. Penal interests of 4% and 6% per annum are charged on overdues and loans misused, respectively, by ADB/N, while a penal interest of 1-2% is charged by NBL.

3) Interest Rate on Deposits

The annual interest rate on deposits stands at 8% for savings, and 11% and 11.5% for fixed deposits of up to one year and two years, respectively (see Appendix 5.4.3-4).

4) Loan Procedure

Both ADB/N and NBL have a well-documented, comprehensive procedures for loan processing, appraisal, approval, disbursement, post loan supervision and loan recovery; the details of which are shown in Appendix 5.4.3-5 and Appendix 5.4.3-6,

respectively. In the case of both banks, penal measures for loan default can include ultimate public auction of collateral such as land or building.

5) Loan Performance

While ADB/N disbursed loans totaling Rs.36, 422,000 to rural population in Nuwakot district in 1995/96, loans totaling Rs.28,984,000 were granted by NBL. Purpose-wise, agricultural inputs marketing accounted for 20.8%, agri-business for 19.3%, agro and cottage industries for 15.0%, cash and special crops for 13.4%, cereal crops for 13.0% and others for 18.5% of the total loans disbursed by ADB/N (see Appendix 5.4.3-7). IBP showed a very low share accounting for 9.9% of the total loans (see Appendix 5.4.3-8). This disbursement tendency is also prevalent in the Study area because of the largest share of the total disbursement by Bidur municipality.

The loan recovery performance of ADB/N improved from 35.4% in 1993/94 to 39.7% in 1995/96, with the exception of loans designated for cereal, cash and special crops, irrigation, bio-gas and horticulture for which the recovery rate deteriorated. Irrigation loans showed the highest overdue rate at 81.2% followed by horticulture (75.8%), cereal crops (73.2%) and cash and special crops (72.4%) in 1995/96 (see Appendix 5.4.3-7).

A major constraint appears to be that institutional credit is generally based on a collateral requirement; hence, the majority of the rural poor, who need credit, but face lack of collateral, do not qualify for institutional credit.

6) Small Farmer Development Programme (SFDP)

Two SFDPs were launched by ADB/N in 1974/75 as a pilot project at Tupche of Nuwakot district, located on the opposite bank of Gerkhutar in the Study area, and at Mahendranagar of Dhanusha district in the Terai with a view to experimenting the bankability and economic viability of the small and marginal farmers and other rural poor. Encouraged by the initial success, SFDP gradually expanded to cover all 75 districts. At present, 11 SFDPs are under operation in Nuwakot district (see Appendix 5.4.3-1 and Appendix 5.4.3-9).

The strategy of SFDP is to organize the small farmers, tenants and landless households into groups to strengthen their credit receivability, and foster self-reliant development on a group basis with group financing. They are assisted by the SFDP project office established at the VDC level in the planning and implementation of various socio-economic activities. Credit is provided by ADB/N to undertake income generating activities on either an individual or group guarantee basis. Under the program, the target group is provided with credit supports in crop production, livestock raising, irrigation, cottage industries, etc. The group lending approach of the program has appeared to be an appropriate mechanism to cater to the needs of the most disadvantaged segment of the rural population.

In general, small agricultural development projects are implemented according to the following procedure.

(a) A base survey of the project area is carried out by the Agricultural Development Bank of Nepal (ADB/N) with regard to topography, meteorology, land use patterns, natural resources, land ownership system, infrastructure, social structure, demography (distribution of ethnic groups), etc.

(b) On the basis of the above base survey, the branch of ADB/N with jurisdiction over the project area then selects the Panchayats (village level administrative units) which necessitate the implementation of the said project.

(c) Prior to actual project implementation, the group organizer responsible for the Project area carries out a household survey of the target Panchayats, in order to collect detailed data on assets, income, expenditure, employment, level of agricultural technology, literacy rate, health and sanitation, nutrition, etc. On the basis of this information, the group organizer identifies the small farmers to be targeted under the project.

(d) The targeted small farmers are then organized into groups to facilitate their participation in the project. One group consists of 5~25 farmers.

(e) Each group elects a group leader.

(f) Each group holds meetings to discuss problems of individual members as well as issues affecting the group as a whole. After identifying the funding needs of the group members, a "group project" is formulated to increase income and improve the daily living environment.

(g) The group then becomes eligible, upon the concurrence of the group organizer and the Small Farmer Development Project Office (administratively under the jurisdiction of the ADB/N branch office with authority over the project area) for receipt of funding without collateral, with liability for such loan to be borne by the group as a whole.

(h) Each group continues to hold regular meetings (at least once a month) to confirm project progress and formulate measures to resolve any outstanding problems.

(i) The group organizer monitors the activities of the groups for which he/she is responsible, and coordinates between groups and with the relevant agencies involved in the project. The group organizer also gives advice and counsel to the concerned groups with regard to project formulation and implementation, and makes arrangements for groups · group members to receive the necessary inputs, extension services, vocational training, etc. under the project.

Target activities for credit include, among others, cereals and cash crop cultivation, special crops production, livestock raising, agro and cottage industries, etc. Group financing based on group guarantee is eligible for a 2% discount in interest rate (see Appendix 5.4.3-2). However, despite this preferential discount, loans by the group to

the individual farmer member include a 2% surcharge for group operation and overhead expenses, thereby negating any benefit in terms of lower interest rate.

Loan performance in Nuwakot district in 1993/94 was around Rs 12 million, of which loans directed at livestock raising accounted for 30.3% of the total, followed by agricultural inputs marketing at 12.6%, cereals production at 10.6%, special crops production at 10.4%, and cash crop production at 9.2% (see Appendix 5.4.3-10). Loan recovery rate deteriorated from 42.4% in 1989/90 to 33.4% in 1993/94.

As discussed above, SFDP is a funding structure predicated on the needs of the small farmer, and is seen to have the following group financing advantages:

a) Group format allows the individual small farmer access to credit which would otherwise be impossible;
b) Simplified credit procedure; and
c) Reduced transaction cost for credit.

7) Intensive Banking Programme (IBP)

The establishment of NBL in 1937 marked the beginning of the institutional banking system in Nepal. Since its activities were confined to deposit mobilization and commercial lending only to commerce and trade, the agricultural sector remained unaffected by its lending operations despite the predominance of the sector in the economy. In these circumstances, the Nepal Rastra Bank (central bank of Nepal) initiated the IBP in 1981 as a strategy to boost priority sector lending.

The objectives of the IBP are: (a) to provide credit and supporting services to the population of specified geographical areas in order to help increase production, employment and income; (b) to motivate and assist them in making full use of their productive assets such as land, labour and skills; (c) to help make services and facilities available for social development through line agencies; and (d) to help develop institutions and institutional contacts which eliminate traditional dependence on non-institutional credit.

(2) Non-institutional Credit

Despite a sizable increase in the volume of rural credit supplied by institutional sources in conformity with national policy requirements, there are indications in the Study area that the actual access of rural households, especially the poor, to institutional credit is limited due to collateral requirements, and as a result the major part of their credit needs is still met by non-institutional sources such as local money lenders, landlords, traders, relatives and friends. Such credit generally involves higher interest rates ranging between 36% and 60%. Most of the lenders perform lending operations as an occasional practice when they have temporary surplus funds.

1) Landlord

The role of the landlord as a money lender is interlinked with land cultivation. His lending activity is not directed towards earning interest. His interest lies rather in the regular assurance of labour supply from landless and marginal farmers deprived of sufficient means of livelihood.

2) Trader

Traders sometimes advance cash credit to farmers on a pre-agreement basis to obtain repayment in kind. Loans are usually provided under verbal contract during the sowing period and recovered during the harvesting period.

3) Large or Medium Farmer

Large or medium farmers provide cash or in-kind loans to the landless or marginal farmers on a personal trust basis to ensure adequate labour supply during the sowing and harvesting periods. No interest is charged on such loans, but the repayment is made in terms of labour at a cheaper price.

4) Relatives and Friends

The role of relatives and friends has its own special importance in the non-institutional credit market. The mutual relationship and solidarity existing between parties leads to the continuation of this type of lending at a significant level. The loan tends to be smaller in size and shorter in duration, and usually without interest. The loan is provided on the basis of personal trust and mutual understanding.

(3) Semi-institutional Credit

The emergence of cooperative-type savings and credit groups can be seen at Pokhariphant and Gerkhutar, respectively. The former is a well-organized group which has been engaged in economic activities such as provision of credit to member farmers through its own bank (referred to as a community bank) located at Devighat, supply of consumers goods to members and non-members through its own shop located also at Devighat, and marketing of agricultural produce as well as livestock products. The annual interest rate is a uniform 18% regardless of the purposes of the loan, which is slightly higher than the institutional rate (see Appendix 5.4.3-11). The loan is only short term for a period from 6 months up to 18 months.

Source of loan capital comprises compulsory savings (interest at 9% p.a.) by group members, and membership dues. Monthly savings amounts are determined by the members themselves. Loan repayment is in principal on an installment basis, with penal interest rates levied on overdue loans (19% for the first month, and 20% for each month thereafter). Granting of loans is made according to both group and individual loanee criteria, taking into account factors of group savings performance, community service record of the individual applicant, the individual applicant's savings performance, etc. Loan application procedure is as follows:

a) The applicant submits an application form to his/her group of affiliation.
b) The general assembly (held between the 25th and 30th of each month) of the group discusses the application, and either approves or rejects it.
c) The approved application is submitted, along with minutes of meeting for the subject general assembly, by the group's treasurer to the community bank.
d) The bank management committee (which meets on the 11th or 12th of each month) discusses the application, and moves to approve or reject it.
e) The applicant is notified of the committee's decision.
f) A loan contract is entered into by the bank and the applicant (in cases where the loan amount is Rs 10,000 or less, 2 group members are required as guarantors; 3 guarantors are required for loans in excess of Rs 10,000)

The group at Gerkhutar is engaged primarily in such activities as community development (road construction and canal maintenance), health · sanitation · education (potable water supply, skill training, educational programs to increase child literacy rates, etc.), agricultural · livestock development (diffusion of high yielding varieties, introduction of improved breeds of livestock, etc.), environmental management (reforestation), income generating activities (vocational training), credit extension, etc. Interest rate on loans is a uniform 24% regardless of purpose. Loan repayment period is within one year, with some variation depending on loan purpose. A 12% penal interest rate is levied on overdue loans for a total rate of 36%. Source of loan capital is compulsory savings by group members.

The reasons behind the increasing popularity of this type of group financing are considered to be due to restrictions on loans by ADB/N or NBL, more specifically collateral requirements, and the cumbersome and time-consuming lending procedures.

This type of group lending system will continue mainly due to its simplicity in procedure compared to institutional credit, availability of money as per demand without any collateral, lack of restrictions as to the loan purpose, low interest and flexibility vis a vis repayment capacity of the loanee. Under the system members are likely to feel assurance of self-reliance.

In order to portray the actual borrowing practices of farmers, case studies have been made at 15 different settlements. 5 interesting instances are highlighted below.

(a) Non-accessibility to Institutional and Non-institutional Credit

Mrs. A, a Tibetan refugee, has a 7-member family and has been living alone from her family in Chandipokhari for 25 years on land granted by the Government. Her husband, a priest, and children are living in Kathmandu. She possesses a granted house, 10 ropanis of granted land, 3 buffaloes and 2 goats. These are her total assets at present. The land is used for cultivation of paddy, maize, wheat and niger by employing two Kumal share-croppers. She found it extremely difficult to access institutional credit. As a matter of fact, she has so far had no experience in institutional borrowings, because the legal status of her land was not guaranteed by the Government, and accordingly she was not a legal holder of a land ownership

certificate. She could not borrow any money even from local money lenders because of her economic and legal uncertainty. Whenever some amount of money was needed for emergency purposes, borrowings were made from her relatives living in Mustang district. She complained that her share-croppers were better off and richer than she. The latter are owner cultivators-cum-share-croppers and possess their land ownership certificates.

(b) Short-cut of Institutional Credit Procedure

Mr. B has a 9-member family, living in Maharani Dihi. He owns 2.5 ropanis of land for paddy, maize and millet cultivation. His first application for a loan amounting to Rs.22,000 for poultry raising was made directly to A bank. Nevertheless, he realized that his frequent visits to the bank were time-consuming practices causing him higher transaction costs. The next measure he undertook was an indirect application for such a loan via a poultry broker in Battar. All the loan procedures and formalities were undertaken by the broker on his behalf. It took only 3 days to disburse the loan in kind, i.e. a specified number of chicken, and feed materials. Surprisingly, this loanee did not know the interest rate.

(c) Large Amount Borrowed from Informal Sector

Mr. C has a 6-member family, living in Inarpati. He owns a house, 6.5 ropanis of land for cultivation of paddy, maize, vegetables and papaya, 2 buffaloes and 1 milk cow. He was a merchant supplying foodstuff to the army base in Dhunche. All the agricultural activities were performed by his wife and children because of his frequent absence from home. He borrowed Rs.600,000 in cash at an interest rate of 60% per annum for his business purposes from a local money lender who is an owner of a construction firm. Non-institutional loans are generally provided on personal trust, but this case was exceptional. A written agreement was exchanged between the parties in order to reduce risk as much as possible. The loan disbursement took a week after his first contract with the lender. His wife did not know the reason why he had not taken advantage of institutional credit where business loans were available. She was not worried, however, about loan repayment.

(d) Bitter Experience in Institutional Credit Delivery

Mr. D has a 9-member family, living in Pipaltar. He owns a house, 12 ropanis of land for maize, millet and niger cultivation, 2 buffaloes and 2 milk cows. He borrowed Rs.5,000 in cash for educational purpose at an interest rate of 36% per annum from his farmer friend in Jiling VDC on personal trust. It took 10 days to disburse the loan. He explained the main reason why he had not borrowed from B bank where a social loan was made available at the lower rate of 17%. The reason indicated was closely related to his past unfortunate experience regarding his younger brother's borrowing from B bank. His younger brother borrowed Rs.15,000 for business purposes from the bank. The actual amount disbursed was only Rs.14,000 and the balance of Rs.1,000 was used as lubricant. After his death in 1991, all his debts amounting to Rs.22,000, including principal and interest, had to be compulsorily taken over by his elder brother.

(e) Refusal to Pay Lubricant

Mr. E has a 4-member family, living in Majhitar. He possesses a house, 10 aana of his own land as well as 3 ropanis of share-cropped land for cultivation of maize, upland paddy and sesame, 1 brewing machine and 2 milk cows. His first approach for a buffalo raising loan was made to A bank, but some lubricant was asked for by the bank officer.

His refusal to pay such lubricant resulted in disapproval of his application stating that there is a budget constraint at the bank. With his disappointment in the prevalence of lubricant practices, he had to make an alternative visit to B bank. He was told that the bank would inform him if the budget in the bank was adequately secured. Nevertheless, no reply has yet come to him; he had been eagerly waiting for the last 2 months.

As can be seen from the above, farmers in the Study area exhibit a deep distrust of institutional credit. This coupled with the fact that collateral is required in the case of said institutional credit, reliance on high interest, non-institutional credit sources remains strong.

The following are the main constraints to the institutional credit:

(a) Compulsory collateral requirements;
(b) Complex, cumbersome and time-consuming loan formalities;
(c) No provision for emergent, consumption and social loans (except for NBL where such loans are made available by pledging gold or silver as collateral);
(d) Prevalence of lubricant practices to expedite the loan procedure; and
(e) Budget constraint and loan purpose-wise specific ceiling.

For the non-institutional credit, the following are the major advantages:

(a) No collateral requirements;
(b) Fast and easy procedure;
(c) Availability of loans for emergent, consumption and social purposes;
(d) Availability of loans at the desired time; and
(e) No fear of the auction of the mortgaged land and building due to repayment failure.

These evidences can explain the major reasons for the continued dominance of the non-institutional lending practices despite higher interest rates charged by them.

According to the results of household survey, number of households which have received credit in the past comprise 52% of total households. Breakdown by type of credit is 48.5% for institutional and semi-institutional credit, and 51.5% for non-institutional credit. Sources of institutional and semi-institutional credit are ADB/N for 68% of households, NBL for 27.5% and credit and savings groups for 3.9%.

Neighbors are the largest sources of informal sector credit, accounting for 48.1% of households availing themselves of non-institutional credit, followed by landlords at 20.4%, relatives at 18.5% and others at 13.0%.

5.4.4 Household Economy

The Study area is characterized by a predominantly subsistence agricultural economy and small land holdings with widespread poverty. Agriculture is largely traditional with low productivity. Disparities in income and employment opportunities are wide and persistent due to land holding size. Apart from the disadvantaged segment of the rural population, food security is guaranteed through higher income groups who are practicing a multiple cropping system in lowlying areas along the Trishuli and Tadi rivers, based on comparative area advantages. Smaller land holding households indicate increasing difficulties in supporting food requirements of their livelihood.

(1) Cash Income Sources

The main cash income sources of the farmers of different land holding size are summarized below.

1) Surplus Food Grains

The large farmers sell their surplus food grains to the local collectors and earn cash income required for household necessity. Similarly, the medium farmers also sell a limited quantity of food grains during the harvesting period of crops such as maize and millet to solve the household cash crisis and buy some needed quantity during the summer season.

2) Livestock Raising

Livestock raising is an important source of household income. Farmers domesticate cattle, buffaloes, goats, and chicken. Large farmers earn more income from raising livestock than smaller farmers. Milk production is popular among the farmers in Khadga Bhanjyang VDC where a milk processing center is set up. The processed milk is distributed to households of Bidur municipality. Thus, there may be a considerable scope as well as need for promoting livestock and poultry raising as an important source of income and employment, especially for the small, marginal and landless households, given appropriate credit support of ADB/N and NBL, and line agency support of DLSO.

3) Horticulture

Fruit growing is an important source of household income; and a few large farmers of Khadga Bhanjyang VDC and Bidur municipality area are growing fruits such as mango, papaya, banana, litchi, etc. in a separate patch of land. However, commercial fruit production is still insignificant due to poor marketing network and processing facilities. Much of the production, therefore, has to go for either home consumption or sale at the local markets like Battar and Trishuli bazars. A

great majority of the households traditionally own a few fruit trees, which are at no additional and visible cost to them, and whose produce is entirely used for home consumption.

4) Business

Business has been run mostly by the Newar large, medium and even small farmers in Bidur, Battar, Dhunge and Devighat areas. Drapery, grocery, utensils, drug stores, tea stalls, hotels/lodges, stationery, food grain shops are run by the richer households with large capital whereas small tea stalls and groceries are run by the relatively poorer households for their livelihood. Pottery production is the traditional occupation of the Kumals to maintain their livelihood.

5) Service

The service sector is the important sector after agriculture, both in terms of income and employment. Since most of the Study area is located in the municipality of the district capital, there are opportunities of getting low paid jobs as clerical staff or peons. This is evident from the class-wise distribution of household income size, which indicates that the annual income derived from this sector is even higher than that derived from crop farming.

6) Labour

Since the majority of the marginal and small farmers suffer a food deficit, they have to work as labourers to eke out their livelihood. They work as agricultural labourers during the peak agricultural season at the average daily wage rate of Rs.40 (average wages of male and female employment). If a ploughman comes to work together with his oxen, he is paid Rs.100 per day. Some poor people break stone for which they are paid Rs.15 per meter. Thus, agricultural labour is particularly important for the landless, marginal and small households, who are able to earn a higher income from provision of their agricultural labour force than from crop production. As agriculture becomes commercialized, it also creates a number of employment opportunities in the local labour market as an immediate impact of the project.

(2) Irrigation Block-wise Crop Incomes

Irrigation block-wise crop incomes are summarized in Table 5.4.4-1.

Table 5.4.4-1 Crop Incomes by Irrigation Block

Irrigation block	Gross income (Rs. 1,000)			Net income (Rs. 1,000)		
	Each block	Per household	Per capita	Each block	Per household	Per capita
A	616	17.6	2.26	280	8	1.03
B	1,227	19.79	3.03	620	10	1.53
C	1,715	5.77	0.93	906	3.05	0.49
D	1,931	17.88	3.89	1,027	9.51	1.54
E	2,585	20.68	3.67	1,290	10.32	1.83
F&G	1,541	8.66	1.36	912	5.12	0.81
H	778	5.02	0.89	407	2.63	0.46
I	886	6.66	1.21	598	4.5	0.82
J	1,043	20.45	3.37	606	11.88	1.97
K	1,450	20.14	3.52	842	11.69	2.04
L	3,438	15.01	2.48	1,631	7.12	1.18
Total:	17,210	11.91	1.97	9,020	6.24	1.03

Source: Household survey

Gross crop income per household for the Study area as a whole is Rs. 11,910. Adjusted to per capita income, this is Rs. 1,970. On a block-wise basis, E block exhibits the highest income at Rs. 20,680, while H block shows the lowest at Rs. 5,020. This represents roughly a 4 fold variation in income. Per capita income is again highest for E block at Rs. 3,670, which is 186% of the average for the Study area as a whole at Rs. 1,970. Per capita income is lowest in H block at Rs. 890.

(3) Farm Income

Farm incomes based on different land holding size, i.e. marginal (less than 0.2 ha), small (0.2~0.5 ha), medium (0.5~1.0 ha) and large (over 1 ha), are calculated in Table 5.4.4-2.

Table 5.4.4-2 Farm Incomes by Different Land Holding Size

Item	Unit	Marginal	Small	Medium	Large	Average
Average land size	ha	0.12	0.37	0.78	1.60	0.524
Average household size	no.	5.3	5.8	6.5	7.7	6.0
1. Farm income	Rs/year					
(1) Agriculture		10,177	14,714	24,143	38,167	17,757
- Crop		2,637	8,725	19,418	32,572	11,838
- Livestock and casual farm wage		7,540	5,989	4,725	5,595	5,919
(2) Non-agriculture		5,096	6,809	10,731	14,106	8,467
- Business and service		5,096	6,809	10,731	14,106	8,467
Total		15,273	21,523	34,874	52,273	26,224
2. Farm Expenditure	Rs/year					
(1) Agriculture		1,452	4,429	10,263	17,263	6,291
- Crop		1,257	4,158	9,246	15,502	5,635
- Livestock		195	271	1,017	1,761	656
(2) Household		13,639	16,724	22,391	28,417	19,188
- Food		10,625	11,891	15,917	18,841	13,642
- Others		3,014	4,833	6,477	9,576	5,476
Total		15,091	21,153	32,657	45,680	25,409
3. Net farm income	Rs/year	13,821	17,094	24,611	35,010	19,933
Agricultural income	%	66.6	68.4	69.2	73.0	67.7
Non-agricultural income	%	33.4	31.6	30.8	27.0	32.3
Per capita net income	Rs/year	2,608	2,947	3,786	4,547	3,322
Possible saving amount	Rs/year	182	370	2,217	6,593	815
Engel's coefficient	%	77.9	71.1	71.1	66.3	71.4

Source: DDC survey and household survey

Results of analysis by scale of farmer landholdings for the Study area are as follows:

1) Average annual income for large farmers (Rs. 52,000) is 3.4 times that of marginal farmers, and consists 73% of agricultural income.

2) Main source of income for marginal farmers is farm labor, accounting for 42.8% of total income. Crop income only accounts for 17.3% of total income.

3) Engel's coefficient for marginal farmers at 77.9% is the highest for all groups, and indicates that the average land holding of 0.12 ha for this group cannot produce sufficient food to support the average number of household members of 5.3. This situation applies to the small farmer group as well.

As the agricultural sector continues to be a major source of employment and income, and is overwhelmingly dominant in terms of labor force absorption, introduction of market oriented multiple cropping to the Study area constitutes a major potential for generating substantial employment and income opportunities especially for subsistence farmers.

5. 5 Irrigation and Drainage

5.5.1 System Assessment

(1) Battar Lift Irrigation Scheme in the Study Area

The Study area comprises about 630 ha (Zone A) between the Trishuli and Tadi River, and about 130 ha (Zone B) on the right bank of Trishuli River. Zone A (630 ha) encompasses a benefit area of 424 ha of Battar Lift Scheme.

The Lift Scheme was commenced in 1974/75 as a pilot project for lift irrigation for the country under the Rasuwa Nuwakot Rural Development Project by DOI, and was completed in 1978/79.

The Lift scheme was serving irrigation water to 424 ha of land belonging to Battar, Majhitar, Pipaltar, Maharani Dihi and Chandi Pokhari of Battar Municipality

Lifting of irrigation water was done from the main pump station from the left side of Trishuli River and was distributed to the command area through another 3 relay pump stations.

The project was formulated in 3 phases as mentioned below, with an initial benefit area of 582 ha. During phase III, due to rise in electricity tariff and lack of constant guaranteed voltage, DOI reduced the benefit area by 158 ha to a design benefit area of 424 ha (see table below).

Changes in Battar Lift Irrigation Benefit Area

Project Phase	Ward No.	Tar	Original Benefit Area	Final Benefit Area
Phase I	No. 6	Maharani Dihi	86 ha	86 ha
Phase II	No. 6	Chandi Pokhari	70 ha	60 ha
Phase II	No. 4	Battar	54 ha	54 ha
	No. 5	Majhitar	54 ha	54 ha
Phase III	No. 7	Pipaltar	270 ha	170 ha
	-	Padma Khadka	30 ha	-
	-	Gauri Gaon	18 ha	-
	Total		**582 ha**	**424 ha**

Source: Rapid Appraisal Report, Battar Irrigation Report 1988, by Water and Energy Commission Secretariat (WECS)

The Battar Lift Irrigation System is no longer functioning at present, and all 4 pump stations are out of order due to operational problems, silt entry, etc.

All the existing main canals have deteriorated, being filled up with soil and covered under newly built dwellings in some places. For this reason, existing irrigation facilities can not be reused in some places.

Moreover, the water in the river at the intake point of the main pump station is below the suction head during the dry season after construction of Devighat Power Station

by Nepal Electricity Authority (NEA) for hydropower production in 1984, which uses the tailrace water of the Trishuli hydropower station.

Thus the sustainability of lift schemes and their functioning are a source of doubt among user beneficiaries.

No channels exist in the command area for surface drainage. There is on evidence of water logging in the area. The surplus discharge during the rainy season is drained out through a natural drainage that crosses Maharani Dee.

The number and pumping capacity of the Battar Lift Irrigation pumps are given below.

Physical Characteristics of Battar Lift Irrigation Pumps

Pumps:	No. of pumps	Type	Motor power (hp)	Rated head (m)	Pumping capacity (m^3/s)	Pipe suction		Pipe delivery		Remarks
						Dia. (cm)	Length (m)	Dia. (m)	Length (m)	
Main pump	2	centrifugal	350	76.2	0.25 (each)	35.5 (each)	40	45.7		Electricity supply received at 400 volts from 2 × 500 KVA transformer
	1		250	76.2	0.17	30.5	40	(2 nos.)	350	
	1		100	70.7	0.07	(1 no.)				
Majhitar				48.8	0.17	25.5				Electricity supply received at 400 volts from 315 KVA transformer
	3	centrifugal	100	70.0	0.07	(3 nos.)	--	45.7	215	
	1		100	48.8	0.08	20.0		(1 no.)		
Battar	2	centrifugal	50	29.9	0.06	20.0	--	25.5 (1 no.)	27	Electricity supply received at 400 volts from 100 KVA transformer
Pipaltar	2	centrifugal	40	24.7	0.07	30.5	--	45.7	450	Electricity supply received at 400 volts from 100 KVA transformer
	1		40	24.7	0.11	30.5	--	(1 no.)		

Source: Rapid Appraisal Report, Battar Irrigation Report, 1988, WECS

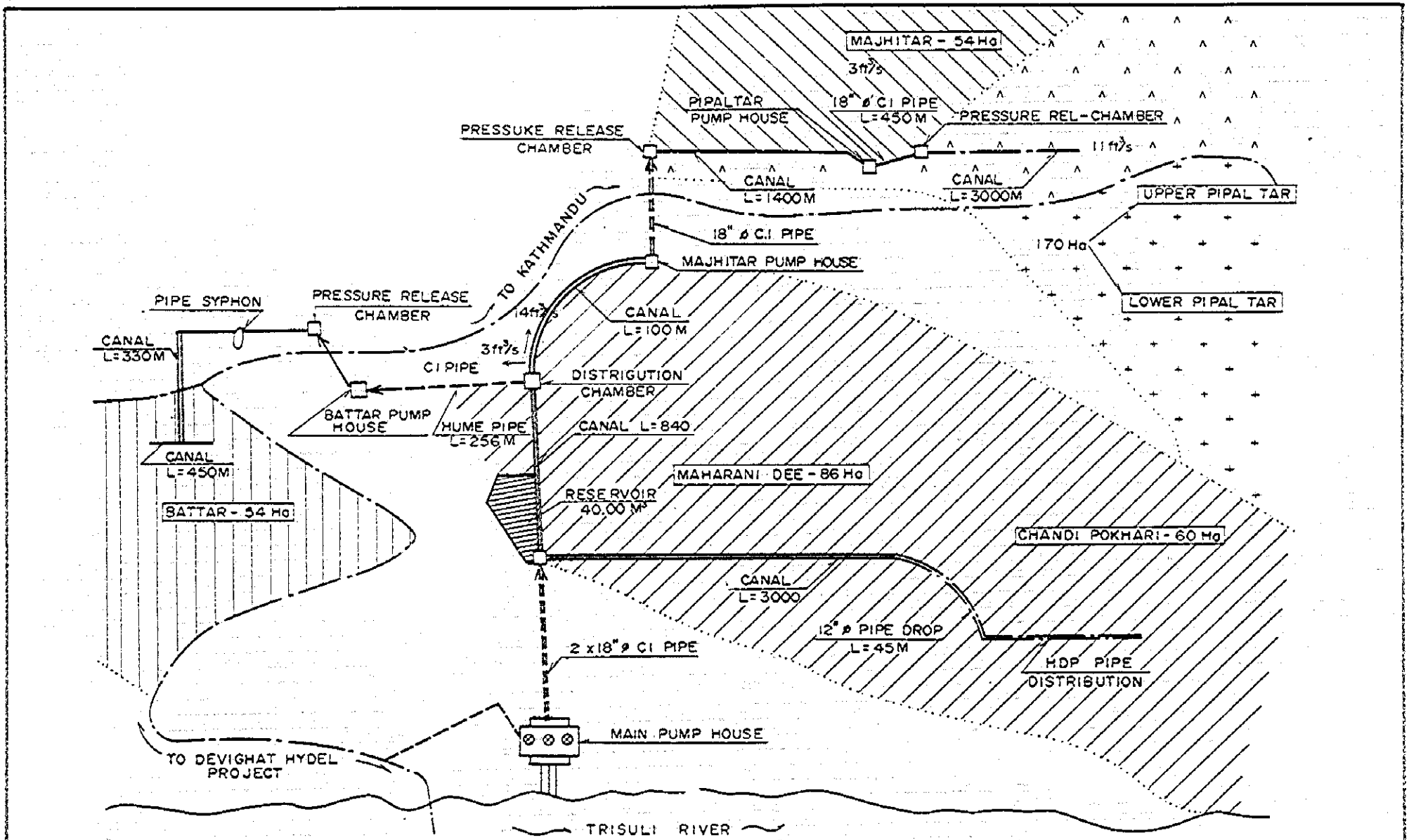


Fig. 5.5.1-1 Battar Lift Irrigation Scheme

(2) Trishuli-Devighat Hydropower Upgrading Project

The main water source under this Feasibility Study is the Trishuli River itself. The river flow is monitored since 1967 by the Department of Hydrology and Meteorology (DHM) at Betrawati gauging station (No. 447) and is utilized by NEA for Trishuli Hydropower at Trishuli Bazaar.

The Trishuli Hydropower Project was completed in 1970. It was originally targeted to generate power of 21 MW utilizing 31.15 m^3/sec of water from Trishuli River.

Similarly Devighat Hydropower Project was completed in 1984 using the tailrace water of the Trishuli Hydropower Project. The targeted electricity generation was 14.1 MW.

Since the economic life of the Trishuli Hydropower Project was finished, the Trishuli-Devighat Hydropower Upgrading Project under IDA was launched in May 1992 and was completed in December 1995.

Thus the generation of power from Trishuli Hydropower was targeted to 24 MW, 3 MW more than the original target to meet the demand of electricity in the country.

At present NEA requires 45.6 m^3/s of water for the power generation of 24 MW under the Trishuli Hydropower Project.

Simultaneously with this Upgrading Program, the Ministry of Water Resources formulated a plan to divert 3 m^3/sec of water for an irrigation project from the Trishuli-Devighat Hydropower Upgrading Project above aqueduct no. 2.

Thus the headrace canal was upgraded for a canal capacity of 48.6 m^3/s design discharge in 1995. Provision of 3 m^3/s of water was made for irrigation purposes. An opening was made at the upstream of aqueduct no. 2 on the left side of headrace canal in 1992.

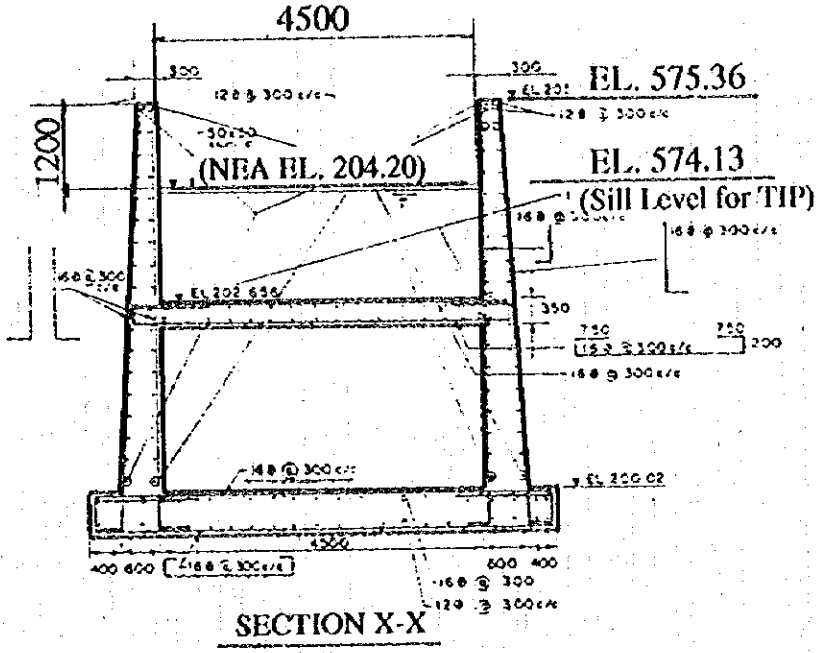
During the stay of the Study Team from early December 1996 to early March 1997, findings are made as follows;

1) There was a consent between DOI and NEA about the availability of 3 m^3/s of water during the wet season without affecting any power generation (refer to Volume II Appendices, Part A-8). It was understood that the decision was accomplished by the Honourable State Ministry of Water Resources dated 2048/12/9 (March, 1992). The Study Team could not find, however, any formal agreement between DOI and NEA in this regard. These facts were discussed in the Central Coordinating Group (CCG) meeting held on December 25, 1996 at DPTC Seminar Hall and it was recognized that further confirmation should be needed between DOI and NEA.

2) An opening sill level for irrigation use was made at aqueduct no.2 for discharge above 45.6 m^3/s, to be released for irrigation purposes.

Considering the available discharge, water availability is critical from January to March for 3 months, and the irrigation system can hardly expect any water from this constructed sill level (refer to Figure 5.5.1-2). During the 3 month stay of the Study Team, water level was always at least 40 cm below the sill level. Only during the wet season after the melting of snow, from April to December, water may be available at more than 48.6 m^3/s through this sill level (refer to Table 5.5.1-1).

3) 5 m^3/s of water is to be discharged to Trishuli bazaar for river maintenance. At present 5 m^3/s of water is not diverted to the Trishuli Bazaar for the maintenance purposes, thus the Battar Lift Scheme can hardly expect any water from the Trishuli river during the dry season.



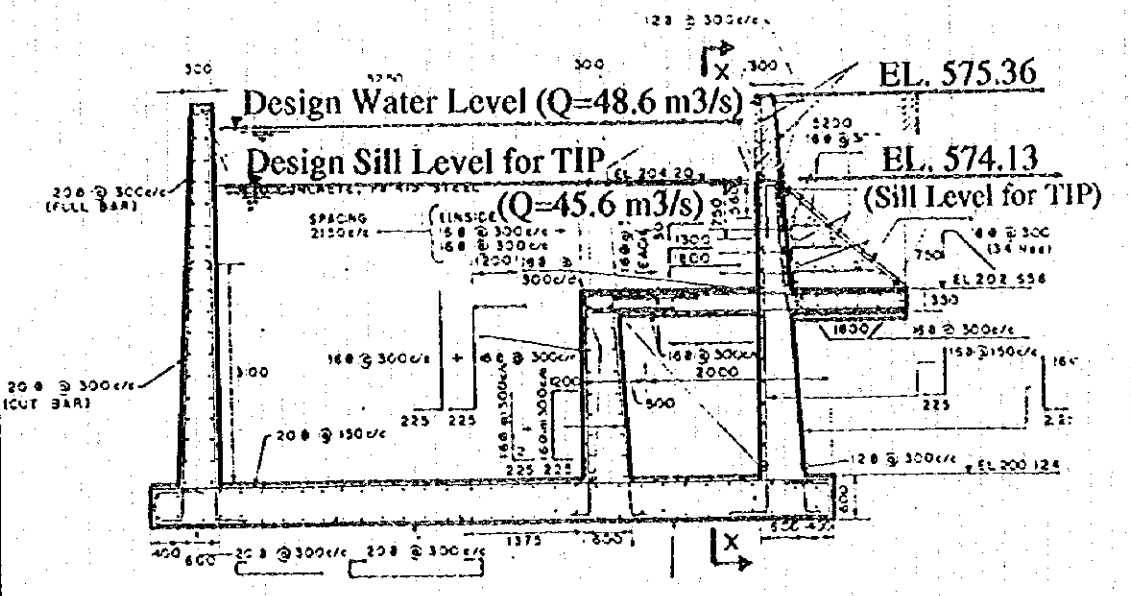


Fig. 5.5.1-2 Structural Section of Original Intake Point from NEA As-built Drawing

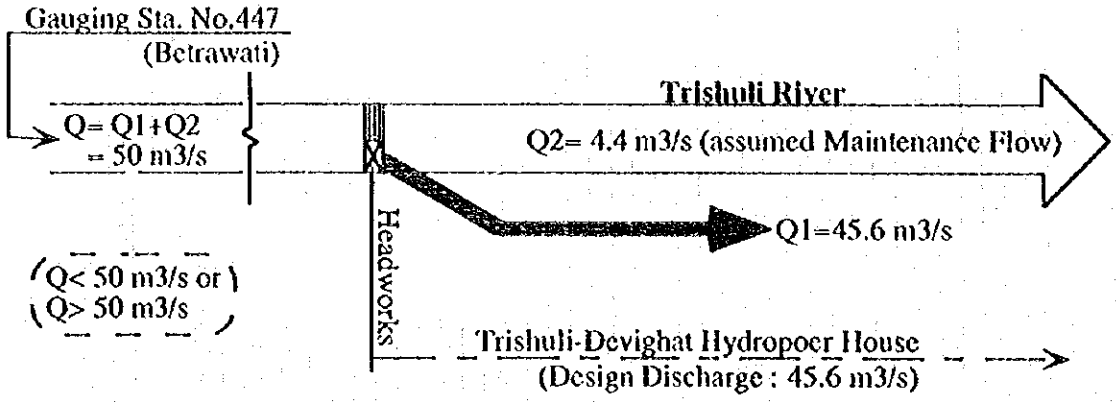
Table 5.5.1-1 Assumed Water Deficit Period for Irrigation in Dry Season

: Month of Water Deficit Period

Unit : Frequent Days/Month

Month	Nov		Dec		Jan		Feb		Mar		Apr		May		Jun	
Year	Q<50	Q>50	Q<50	Q>50	Q<50	Q>50	Q<50	Q>50	Q<50	Q>50	Q<50	Q>50	Q<50	Q>50	Q<50	Q>50
1977	0	30	0	31	23	8	23	5	21	10	28	2	0	31	0	30
1978	0	30	0	31	16	5	28	0	9	22	9	21	0	31	0	30
1979	0	30	2	29	13	18	28	0	31	0	15	15	0	31	0	30
1980	0	30	5	26	31	0	29	0	31	0	15	15	0	31	0	30
1981	0	30	7	24	31	0	28	0	31	0	15	15	0	31	0	30
1982	0	30	8	23	31	0	28	0	17	14	0	31	0	31	0	30
1983	0	30	1	30	31	0	28	0	31	0	28	1	8	23	0	30
1984	0	30	21	10	21	0	29	0	31	0	30	0	4	27	0	30
1985	0	30	0	31	31	0	28	0	31	0	25	5	15	15	0	30
1986	0	30	0	31	0	31	0	28	0	31	0	30	0	31	0	30
1987	0	30	0	31	1	30	0	28	0	31	0	30	0	31	0	30
1988	0	30	0	31	9	22	27	2	25	6	0	30	0	31	0	30
1989	0	30	22	9	1	30	27	1	24	7	0	30	0	31	0	30
1990	0	30	19	12	31	0	28	0	31	0	15	15	1	30	0	30
1991	0	30	29	2	31	0	28	0	31	0	28	2	1	30	0	30
1992	0	30	31	0	31	0	29	0	31	0	30	0	26	5	0	30
1993	0	30	30	1	31	0	28	0	31	0	27	3	0	31	0	30

Source : DHM, Hydrology Section



(3) Formulation of an Appropriate Project Cost and Sustainability of the Project

The Study Team targeted that availing of Japanese Grant Aid would be an option of the Nepalese Government in implementing the Project. Thus Project cost must be structured in such a way as to take into account the conditions prevailing in Nepal and be suitable for consideration under the Japanese Grant Aid Program.

Given the fact that the degree of sediment inflow to the irrigation canal has a major impact on the sustainability of the envisioned irrigation system under the Project, the Study Team considered it imperative that selection of a suitable intake point instead of the originally agreed point at aqueduct no.2 would be carried out through the Study period.

In the meantime, the Study Team took into consideration the maximum use of inherent energy as determined by topographical conditions in the Study area. Mainly consideration was given to introduction of a gravity irrigation system which could be easily maintained and operated by users.

With regard to adopting an appropriate project cost and sustainability of the Project, the Study Team carefully studied cost aspects, sediment inflow and a gravity water distribution system.

During the Study, 2 intake points shown in Figure 5.5.1-3 were identified by the Study Team as follows:

Alternative plan	Location of Intake Point	Preliminary Assessment		
		Investment Cost	Influence of Sediment inflow	Gravity irrigation Aspects
Original	Aqueduct No.2	□	□	○
Alternative-1 (Option 3)	D/S of NEA Balancing Reservoir	○	○	○

Note: ○: Suitable, □: to be studied further

From points of view of appropriate project cost and sustainability of the Project, Alternative-1 (Option 3) appears to be most suitable as the intake point for this Study.

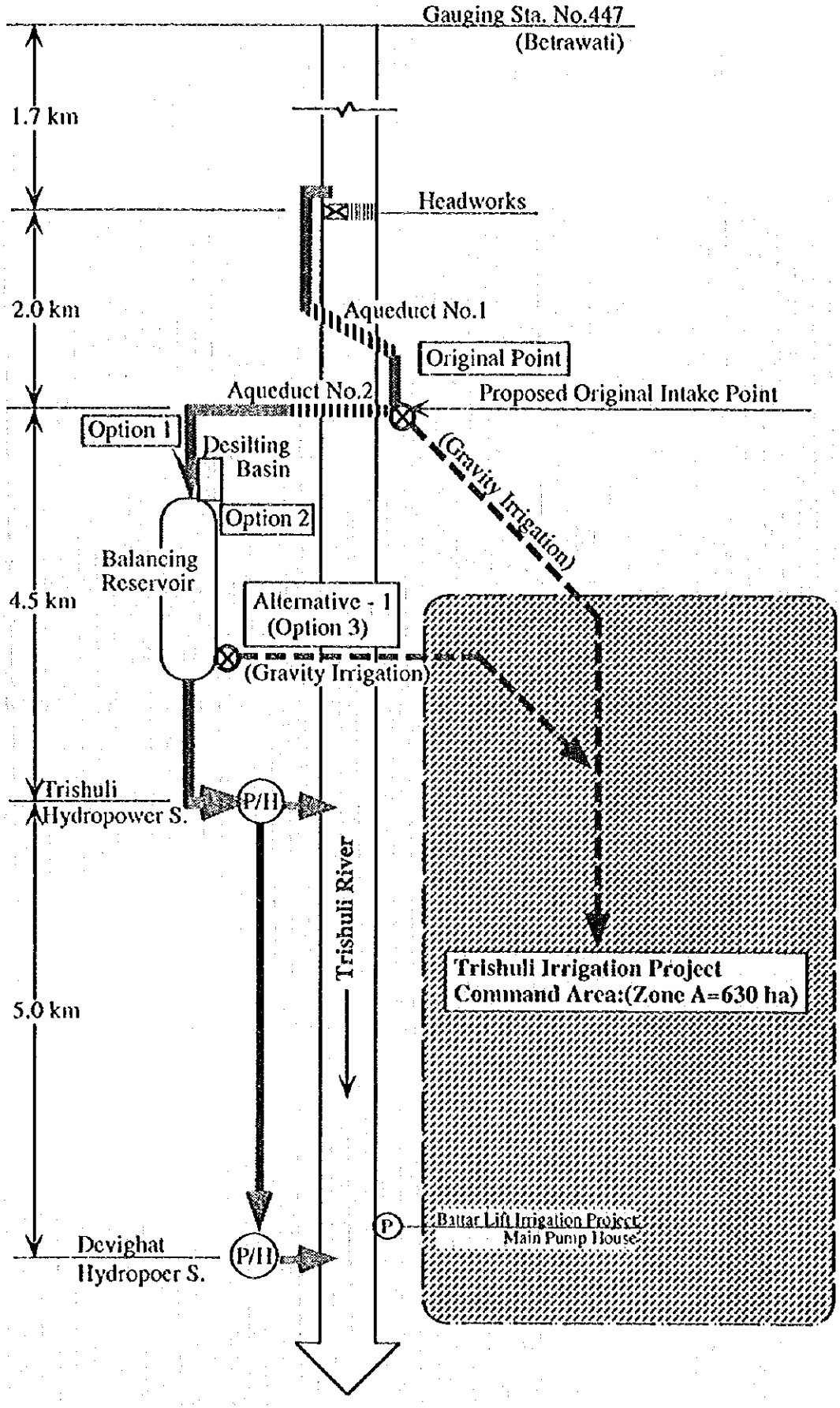


Fig. 5.5.1-3 Alternative Intake Points for Zone A of Trishuli Irrigation Project

(4) Balancing Reservoir

1) Introduction

① The balancing reservoir is located 1.635 km upstream of the penstock intake and downstream of the desilting basin

② The water conductor system of Trishuli Hydropower Project was designed for a maximum discharge for 31.15 m^3/s up to the balancing reservoir and 45.31 m^3/s beyond the balancing reservoir.

③ This balancing reservoir was not improved under the Trishuli-Devighat Hydropower Upgrading Project.

④ At present, this reservoir is filled with sediment. The live storage is almost completely lost and the reservoir does not accomplish the daily flow regulation needed to generate peaking capacity during the peak demand period of the day.

⑤ This live storage could supply an additional discharge of 14.51 m^3/s to the 31.15 m^3/s brought in by the upstream water conductor for a total discharge of 45.6 m^3/s.

⑥ This would provide a peak output of 19.5 MW for about 4 hours daily.

⑦ The water conductor downstream of the balancing reservoir, designed for a discharge of 45.31 m^3/s can carry this discharge to the powerhouse with no need for upgrading.

2) Features of Balancing Reservoir

<Reservoir>

Full supply level:	663.0 Ft = 202.65 m (=573.6 m)
Surface area:	1.58×10^3 km^2
Gross capacity:	765×10^3 m^3
Live storage:	255×10^3 m^3
Dead storage:	510×10^3 m^3

<Embankment>

Length:	1,219.50 m
Height:	16.15 m
Top width:	4.57 m

3) Condition of Sedimentation in Balancing Reservoir

The balancing reservoir constructed under the Trishuli Hydropower Project in 1970 has suffered progressive sedimentation. As a result, NEA commenced dredging of the reservoir in 1976. With cessation of dredging in 1986, cross-section survey of the reservoir was initiated to quantitatively ascertain degree of sedimentation. Again in 1995, mechanical removal of sediment was carried out. Trial calculations by the Study Team estimate present sediment content in the reservoir at 510,000 m^3. The history of reservoir sedimentation, and dredger features are described below:

<History of reservoir sedimentation>

Year	Sedimentation condition	Remarks
1970	Total reservoir capacity: V = 760,000 m^3 Live capacity: V1 = 250,000 m^3 Dead capacity: V2 = 510,000 m^3	Design discharge: Q = 31.15 m^3/s (up to reservoir) Q = 45.31 m^3/s (from reservoir)
1976~86	Dredger operation is only partial, with reportedly little dredging effect	Introduction of dredger with capacity of Q = 150 m^3/hr Sediment survey carried out over 1976~79
1986	Sedimentation amount confirved at V = 430,000 m^3	Cross-section survey carried out by NEA (16 sections)
1995	Partial removal of sediment (by backhoe and dump truck)	V = 146,000 m^3 of sediment removed (according to NEA interview)
Dec 1996 ~ Mar 1997	Sedimentation amount estimated at V = 510,000 m^3 as of Mar 1997	Amount estimated by JICA Team (on the basis of field survey and 1986 cross-sectional survey maps)

<Dredger features>

- A cutter-dredger was installed at the reservoir in 1976. Presently, it is not in working order, awaiting the arrival of spare parts (gear box and seal) from the manufacturer in the Netherlands.

- When the equipment was in order from 1976 to 1988, it was only partially successful in restoring the live storage of the balancing reservoir.

- During this period, the Trishuli power plant was reported to generate a peaking capacity of up to 15 MW, but never 18 MW as originally designed. It is understood that dredging was only done for one shift a day during this period.

- Equipment specifications are as follows:

Outer dredger of Trishuli:

Made in 1976 by N.V. Madhinefaereik de Holladsche Ussle - Oudewater, Holland

Dredging depth:	8.0 m
Dredging capacity:	150 m³/hr
Length:	13.56 m
Breadth:	5.39 m
Depth:	2.10 m
Discharge depth:	100.00 m (approx.)
Cabin weight:	1.2 t

(5) Sediment Data

1) Sediment Concentration in the main Trishuli River

Sediment concentration in the main Trishuli River, based on the 1990 Trishuli-Devighat Upgrading Project Feasibility Study and data (1977~79) collected by the JICA Team is summarized below. (see Table 5.5.1-2)

According to the tabulation, values for November~June are roughly the same, while river discharge and sediment concentration differ from year to year during the rainy season (July~October).

2) Sediment Concentration for Discharge into the Balancing Reservoir (rainy season)

Collected data has been collated in Table 5.5.1-3. According to the table, average sediment concentration of discharge into the reservoir is 360 mg/ℓ, which is equivalent to 38% of the sediment concentration for the main Trishuli river.

3) Sediment Load Inflow into the Reservoir

Observation data for May~September (1977~79) is collated in Table 5.5.1-4. According to this data, annual sediment inflow into the reservoir is 115,000 m³. Of this, 80% is fine sediment with particle size less than 0.075 mm.

Table 5.5.1-2 Sediment Data on Trishuli River (1977～1979)

1. Mean Monthly and Yearly Discharge - For Trishuli River At Betrawati (sta. No. 447) (unit: m^3/s)

Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Year
1977	48.1	46.5	49.8	54.9	77.8	192.0	591.0	609.0	368.0	164.0	94.0	61.7	197.2
1978	46.6	44.1	45.4	57.4	151.0	335.0	520.0	625.0	332.0	215.0	108.0	70.1	213.9
1979	51.3	43.5	43.9	52.4	91.9	185.0	468.0	504.0	280.0	137.0	83.0	55.6	167.5
AVG (77～79)	48.7	44.7	46.4	54.9	107.0	237.0	526.0	579.0	327.0	172.0	95.0	62.5	192.9

67～93	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Year
AVG	48.3	42.5	43.2	53.2	88.3	237.2	533.4	615.6	400.6	171.6	90.3	61.3	201.4
MAX	55.1	57.5	56.0	74.6	151.0	366.0	815.0	802.0	525.0	288.0	110.0	70.1	233.7
MIN	33.2	29.1	27.2	34.5	43.1	122.0	325.0	432.0	260.0	106.0	62.5	41.8	148.3

2. Summary of Mean Monthly Sediment Transport (m^3/day) at Betrawati

Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Year
1977	103	119	171	366	966	7,040	54,000	41,100	10,000	1,300	325	211	9,642
1978	144	119	149	360	7,080	20,300	18,100	20,500	7,370	26,200	512	288	8,427
1979	125	150	706	772	1,680	13,500	61,500	26,700	7,170	2,060	492	251	9,592
AVG (77～79)	124	129	342	499	3,242	13,613	44,533	29,433	8,180	9,853	443	250	9,220

3. Summary of Sediment Concentration (mg/L) at Betrawati

Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Year
1977	25	30	40	77	144	424	1,058	781	315	92	40	40	255
1978	36	31	38	73	543	701	403	380	257	1,410	55	48	331
1979	28	40	186	171	212	845	1,521	613	296	174	69	52	351
AVG (77～79)	30	34	88	107	299	657	994	591	289	559	54	46	312

4. Recommended Monthly Sediment Concentration in F/S Report on Trishuli-Devighat Hydropower Upgrading Project (August 1990)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Year
River Flow	44.0 (m^3/s)	38.4	39.6	49.3	83.0	226.6	498.7	548.4	368.0	165.4	85.8	57.8	183.8 (m^3/s)
Mean Monthly Sediment concentration	35.0 (mg/L)	51.0	80.0	96.0	351.0	778.0	1798.0	1231.0	757.0	272.0	79.0	65.0	466.1 (mg/L)

Table 5.5.1-3 Calculation for Sediment Concentration

1. In case of Q=31.15m³/s

<1977>

Month	①Trishuli River			②u/s of Desilting Tank			④To Balancing Reservior			④/①	④/②
	River Flow (m³/s)	Sediment (m³/month)	Concentration (mg/L)	Flow (m³/s)	Sediment (m³/month)	Concentration (mg/L)	Flow (m³/s)	Sediment (m³/month)	Concentration (mg/L)	(%)	(%)
JUN	192	21.12×10⁶	424	31.15	3.11×10⁶	385	31.15	1.15×10⁶	142	33	37
JUL	591	167.40×10⁶	1,058	31.15	7.34×10⁶	909	31.15	2.59×10⁶	320	30	35
AUG	609	127.41×10⁶	781	31.15	6.22×10⁶	770	31.15	2.12×10⁶	262	34	34
SEP	368	31.00×10⁶	325	31.15	5.30×10⁶	656	31.15	1.95×10⁶	241	74	37
AVG	440	86.73×10⁶	647	31.15	5.49×10⁶	680	31.15	1.95×10⁶	241	42.8	36

<1978>

Month	①Trishuli River			②u/s of Desilting Tank			④To Balancing Reservior			④/①	④/②
	River Flow (m³/s)	Sediment (m³/month)	Concentration (mg/L)	Flow (m³/s)	Sediment (m³/month)	Concentration (mg/L)	Flow (m³/s)	Sediment (m³)	Concentration (mg/L)	(%)	(%)
MAY	151	21.95×10⁶	543	31.15	2.38×10⁶	294	31.15	0.92×10⁶	113	21	38
JUN	335	60.90×10⁶	701	31.15	7.16×10⁶	886	31.15	2.73×10⁶	337	48	38
JUL	520	56.11×10⁶	403	31.15	15.28×10⁶	1,892	31.15	6.13×10⁶	754	-	40
AUG	625	63.55×10⁶	380	31.15	8.38×10⁶	1,035	31.15	3.15×10⁶	389	-	38
AVG	408	50.63×10⁶	507	31.15	8.30×10⁶	1027	31.15	3.10×10⁶	398	35	39

<1979>

Month	①Trishuli River			②u/s of Desilting Tank			④To Balancing Reservior			④/①	④/②
	River Flow (m³/s)	Sediment (m³/month)	Concentration (mg/L)	Flow (m³/s)	Sediment (m³/month)	Concentration (mg/L)	Flow (m³/s)	Sediment (m³)	Concentration (mg/L)	(%)	(%)
JUL	468	190.65×10⁶	1,520	31.15	11.09×10⁶	1330	31.15	4.23×10⁶	522	34	62
AUG	504	82.77×10⁶	613	31.15	8.10×10⁶	971	31.15	1.96×10⁶	240	39	32
AVG	486	136.71×10⁶	1067	31.15	9.60×10⁶	1151	31.15	3.10×10⁶	381	37	47

2. In case of Q=41.06m³

Month	①Trishuli River			②u/s of Desilting Tank			④To Balancing Reservior			④/①	④/②
	River Flow (m³/s)	Sediment (m³/month)	Concentration (mg/L)	Flow (m³/s)	Sediment (m³/month)	Concentration (mg/L)	Flow (m³/s)	Sediment (m³/month)	Concentration (mg/L)	(%)	(%)
MAY	107	-	-	41.06	11.2×10⁶	1,052	41.06	4.46×10⁶	419	-	40
JUN	237	-	-	41.06	9.85×10⁶	925	41.06	3.76×10⁶	353	-	38
JUL	526	-	-	41.06	19.32×10⁶	1,814	41.06	7.17×10⁶	673	-	37
AUG	579	-	-	41.06	13.34×10⁶	1,191	41.06	4.35×10⁶	408	-	34
SEP	327	-	-	41.06	8.24×10⁶	774	41.06	3.24×10⁶	304	-	39
AVG	355	-	-	41.06	12.39×10⁶	1,151	41.06	4.60×10⁶	431	-	38

Table 5.5.1-4 Sediment Data on Headrace Canal of Trishuli-Deright Hydropower Station (1977～1979)

1. Sediment Data in 1977～1979

<1977>

Month	①Trishuli River		Monthly Sediment (×10⁴m³/month)								
	River Flow	Monthly Sediment	②u/s of Desilting Tank			③Flush out through Desilting Tank			④To Balancing Reservior		
	(m³/s)	Transport(×10⁴m³/month)	Total	C+M	F	Total	C+M	F	Total	C+M	F
JUN	192	21.12	3.11	0.53	2.50	1.96	0.41	1.55	1.15	0.12	1.03
JUL	591	167.40	7.34	1.56	5.78	4.75	1.28	3.47	2.59	0.28	2.31
AUG	609	127.41	6.22	1.60	4.62	4.11	1.34	2.77	2.12	0.27	1.85
SEP	368	31.00	5.30	0.61	4.69	3.35	0.54	2.81	1.95	0.07	1.88
Total		346.93	21.97	4.3	17.67	14.17	3.57	10.60	7.81	0.74	7.07

<1978>

Month	①Trishuli River		Monthly Sediment (×10⁴m³/month)								
	River Flow	Monthly Sediment	②u/s of Desilting Tank			③Flush out through Desilting Tank			④To Balalancing Reservior		
	(m³/s)	Transport(×10⁴m³/month)	Total	C+M	F	Total	C+M	F	Total	C+M	F
MAY	151	21.95	2.38	0.32	2.06	1.46	0.22	1.24	0.92	0.10	0.82
JUN	335	60.90	7.16	1.54	5.26	4.43	1.06	3.37	2.73	0.48	2.25
JUL	520	56.11	15.28	3.69	11.59	9.15	2.20	6.95	6.13	1.49	4.64
AUG	625	63.55	8.38	2.88	5.50	5.23	1.93	3.30	3.15	0.95	2.20
Tial		202.51	33.20	8.43	24.77	20.27	5.41	14.86	12.93	3.02	9.91

<1979>

Month	①Trishuli River		Monthly Sediment (×10⁴m³/month)								
	River Flow	Monthly Sediment	②u/s of Desilting Tank			③Flush out through Desilting Tank			④To Balalancing Reservior		
	(m³/s)	Transport(×10⁴m³/month)	Total	C+M	F	Total	C+M	F	Total	C+M	F
JUL	468	190.65	11.09	3.40	7.69	6.86	2.25	4.61	4.23	1.15	3.08
AUG	504	82.77	8.10	4.36	3.74	6.14	3.90	2.24	1.96	0.46	1.50
Total		273.42	19.19	7.76	11.43	13.00	6.15	6.85	6.19	1.61	4.58

2. An Average Year Sediments (1977～1979)

Month	①Trishuli River		Monthly Sediment (×10⁴m³/month)								
	River Flow	Monthly Sediment	②u/s of Desilting Tank			③Flush out through Desilting Tank			④To Balalancing Reservior		
	(m³/s)	Transport(×10⁴m³/month)	Total	C+M	F	Total	C+M	F	Total	C+M	F
MAY	151	21.95	2.38	0.32	2.06	1.46	0.22	1.24	0.92	0.10	0.82
JUN	264	41.01	5.14	1.04	4.10	3.20	0.74	2.46	1.94	0.30	1.64
JUL	526	138.05	11.23	2.88	8.35	6.92	1.91	5.01	4.31	0.97	3.34
AUG	579	91.24	7.57	2.95	4.62	5.16	2.39	2.77	2.41	0.56	1.85
SEP	368	31.00	5.30	0.61	4.69	3.35	0.54	2.81	1.95	0.07	1.88
Total		323.25	31.62	7.80	23.82	20.09	5.80	14.29	11.53	2.00	9.53

Note①

River Flow : Mean Monthly Discharge(×10⁴m³/month)

Monthly Sediment Transport : Mean Monthly Sediment (m³/day)×30 or 31

Note②,③,④

C+M = Coarse Sediment (d>0.2mm) + Medium Sediment (0.075<d<0.2mm)

F = Fine Sediment (d<0.075mm)

5.5.2 Water Resources

(1) Introduction

The main source of water for this irrigation project is the Trishuli river. It originates from the Himalayas and is perennial.

The Study area comprises 2 zones along the left and right bank of the Trishuli river, respectively.

During the Study period, field survey, data collection, field investigations and review of pervious studies were conducted. Collected data on hydrology and meteorology are as follows:

1) Climatological Records in and around the related stations (1976 to 1990, 14 years). General meteorological data (precipitation, air temperature, relative humidity) at Nuwakot station for 1985~90 is given in Table 5.5.2-1.
2) Monthly rainfall records in and around the related stations (1971 to 1990, 20 years) (refer to Table 5.5.2-2)
3) Mean monthly and yearly discharges for Trishuli river at Betrawati station (1967 to 1993, 27 years) (refer to Table 5.5.2-3)
4) Mean daily discharges for Trishuli river at Betrawati station (1977 to 1993, 17 years. From 1994 onwards, data are not yet available from DHM) (refer to Table 5.5.2-4)
5) Daily Generation Report at Trishuli powerhouse (Jan. to Apr. 1995, Dec. 1995, Jan. to Dec. 1996, Jan. 1997) (refer to Table 5.5.2-5 and Figure 5.5.2-1)

(2) River Systems

The Study area is located at the tail end of the Trishuli river basin. Catchment area and available water source of the related Study area are as given below;

Zone	Study Area (ha)	River Basin	Catchment Area (km^2)	Available Water Source
Zone A		Trishuli R.	4,640.0	Trishuli Hydropower
(L/B of Trishuli R.)	630 ha	Betrawati ~ Weir Point	4.1	Project: headrace
			Total: 4,644.1	water
Zone B		Bhorele Khola		Trishuli-Devighat
(R/B of Trishuli R.)	130 ha	Sere Khola		Hydropower Project:
		Judi Khola	Total : 4.5	tailrace water

Note; Zone A: Comprises Gerkhutar, Simbutar, Bidur, Battar, Pipaltar, Maharani Dihi and Chandi Pokhari
Zone B: Pokhare Phant only

(3) Available Water Source for the Study area

1) Zone A

The main source of irrigation water for Zone A is from the Trishuli river diverted at the weir which was raised 1.52 m above the previous 1.32 m, giving a total crest

height of 2.8 m to accommodate the canal capacity of 48.6 m^3/s of water under the Trishuli-Devighat Hydropower Upgrading Project.

The headrace canal has a capacity of 48.6 m^3/s water just upstream of aqueduct no. 2. An opening made at aqueduct no.2 is the diverting point for irrigation use of 3.0 m^3/s water.

At present, irrigation water is not used from the opening located at 2 km downstream of the headworks. Therefore, all diverted discharge from the weir goes to the Trishuli powerstation and is being utilized for hydropower production.

Diversion discharge records for this headrace canal were collected by the Study Team as follows (see Table 5.5.2-5~6 and Figure 5.5.2-1):

Trishuli Hydropower Headrace Canal Discharge Records (Unit: m^3/s)

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1995	Min	10.6	22.6	16.1	30.7	-	-	-	-	-	-	-	20.7
	Max	42.5	44.1	48.7	48.7	-	-	-	-	-	-	-	56.6
1996	Min	37.4	31.0	28.3	34.0	28.3	24.4	29.6	25.5	28.3	28.3	28.3	34.0
	Ave	44.6	36.1	38.2	43.5	45.1	46.5	45.1	44.1	43.0	45.2	44.1	40.3
	Max	53.7	39.6	48.1	50.9	50.9	50.9	48.1	48.1	48.1	48.1	49.5	50.9
1997	Min	41.6	N.A.	N.A.									
	Max	46.7	N.A.	N.A.									

Source: Daily Generation Report, NEA; Station: Trishuli Power House

2) Zone B

Runoff of the 4.5 km^2 of catchment area seems to be not enough for year-round irrigation as compared with the extent of 130 ha command area.

During the survey 2 options for off take points were identified.

Option 1 : D/S of Zone A main canal across the Trishuli River
(9 months irrigation by gravity system together with lift system in some isolated area)
Option 2 : Devighat hydropower station tailrace water
(Year round irrigation by overall lift system)

Above all, beneficiaries of this area expressed a desire for a year-round irrigation system through the 1st and 2nd FLAG meeting held by the Study Team, and declared their intention to maintain the lift irrigation system by themselves after hand over. Thus, Option 2 was to be adopted for the system design during the subsequent Study.

Table 5.5.2-1 Precipitation, Air Temperature and Relative Humidity
(Average of 6 years; 1985 ~ 1990)

Station: Nuwakot

		Dry Season				Wet Season						Dry Season			
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	
Precipitation	(mm)	2	22	25	64	112	287	583	499	260	101	6	29	1990	June to Sept.
Ratio	(%)	0.1	1.1	1.3	3.2	5.6	14.4	29.3	25.1	13.1	5.1	0.3	1.5	100.0	81.9%
Air Temperature	(°C) Max.	14.2	15.6	18.1	25.3	31.7	31.4	30.1	30.4	24.8	23.8	21.2	18.3	23.7	
	Min.	7.9	8.9	11.7	17.7	19.3	21.4	21.5	21.4	20.8	17.7	13.3	9.9	16.0	
	Daily	11.0	12.3	14.9	21.5	25.5	26.4	25.8	25.9	22.8	20.7	17.2	14.1	19.8	
Relative Humidity	(%) mor.	70	67	62	71	75	84	89	90	89	85	81	79	78	
	eve.	62	55	51	62	65	77	87	86	85	82	78	80	72	
	mean	66	61	57	66	70	81	88	88	87	84	79	80	75	

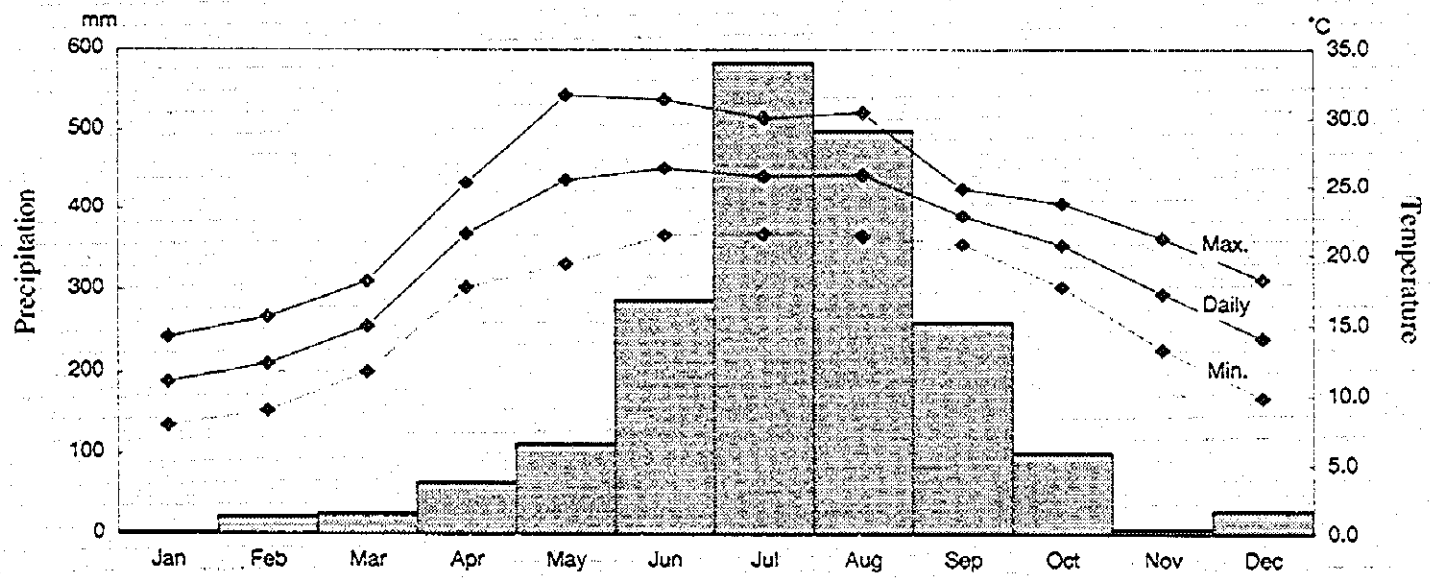


Table 5.5.2-2 Precipitation Summary (1971 ~ 1990 : 20 Years)

1003 : Trishuli
1004 (IMD) : Nuwakot
1004 : Nuwakot (mm)

Year	Station No.	Dry Season				Wet Season						Dry		
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yearly
1971	1003	2	5	16	76	163	561	321	358	93	147	2	0	1,744
	1004	0	4	18	99	96	687	377	321	96	170	5	0	1,873
1972	1003	7	25	62	16	70	283	379	422	204	82	15	0	1,565
	1004 (IMD)	11	26	62	21	81	282	456	422	256	84	17	0	1,718
	1004	16	26	61	22	76	233	468	417	272	93	20	0	1,704
1973	1003	40	30	34	39	128	348	280	425	359	110	21	0	1,814
	1004 (IMD)	16	32	44	21	225	445	244	504	327	137	12	0	2,007
	1004	24	38	51	17	190	448	325	421	400	99	13	0	2,026
1974	1003	19	4	14	20	141	121	374	485	392	76	0	7	1,653
	1004 (IMD)	23	19	15	6	102	178	481	482	422	70	0	7	1,805
	1004	24	9	41	45	71	319	452	490	529	55	0	29	2,064
1975	1003	26	4	-	24	110	294	407	93	394	338	10	6	(1706)
	1004 (IMD)	16	14	0	31	139	-	460	340	447	17	0	0	(1464)
	1004	30	12	12	37	130	368	602	393	470	19	2	0	2,075
1976	1003	8	0	12	6	98	283	336	489	211	20	0	0	1,463
	1004 (IMD)	-	4	0	24	42	391	361	459	181	13	0	0	(1475)
	1004	29	5	0	50	68	432	416	538	197	5	0	0	1,740
1977	1003	-	-	-	-	-	-	-	-	-	-	-	-	-
	1004	4	0	18	142	159	305	480	574	198	69	24	54	2,027
1978	1003	-	-	-	-	-	-	-	-	-	-	-	-	-
	1004	0	29	91	8	104	448	674	782	269	132	3	2	2,542
1979	1003	2	32	0	20	11	221	744	399	47	100	10	51	1,637
	1004	2	9	0	22	28	241	716	257	155	114	32	26	1,602
1980	1003	0	39	40	15	56	671	780	743	158	41	0	3	2,546
	1004	0	43	25	16	37	420	529	562	65	36	0	0	1,733
1981	1004	44	6	54	161	110	287	463	600	235	2	24	0	1,986
1982	1004	14	20	52	92	23	259	512	695	172	22	16	2	1,879
1983	1004	34	31	58	99	74	249	469	663	290	156	0	43	2,166
1984	1004	12	4	9	70	89	214	482	349	526	16	0	6	1,777
1985	1004	10	4	0	85	81	175	691	381	248	167	0	55	1,897
1986	1004	0	19	22	71	113	546	763	468	364	121	5	56	2,548
1987	1004	2	29	11	78	30	337	692	484	276	142	17	17	2,115
1988	1004	0	11	27	26	97	322	551	401	227	0	0	-	(1662)
1989	1004	-	-	-	-	209	167	394	708	317	46	0	11	(1852)
1990	1004	0	47	65	59	140	173	404	553	130	131	13	6	1,721

Station No : 447
River : Trishuli
Station Name : Betrawati

Table 5.5.2-3 Mean Monthly and Yearly Discharges for Trishuli River at Betrawati

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
1967	47.4	38.0	35.6	41.2	63.7	137.0	429.0	518.0	326.0	199.0	66.9	48.2	156.9
1968	37.9	32.1	31.0	38.7	64.9	220.0	486.0	479.0	281.0	170.0	75.8	51.0	164.8
1969	40.5	35.5	33.2	38.1	62.3	133.0	398.0	451.0	335.0	126.0	67.7	47.4	148.3
1970	36.7	31.9	29.9	40.5	65.3	162.0	468.0	512.0	290.0	152.0	83.6	57.9	162.1
1971	45.0	38.6	36.8	46.5	65.1	348.0	448.0	549.0	320.0	154.0	81.5	54.8	183.3
1972	42.9	37.3	38.9	42.9	101.0	163.0	431.0	473.0	283.0	106.0	62.5	43.0	152.8
1973	37.3	36.8	40.2	60.4	96.6	366.0	510.0	663.0	525.0	288.0	100.0	65.7	233.7
1974	50.8	39.7	36.2	53.8	82.2	200.0	546.0	640.0	390.0	106.0	86.4	60.6	199.6
1975	51.2	46.2	44.2	60.2	91.6	264.0	548.0	561.0	516.0	222.0	110.0	69.8	216.5
1976	49.3	41.9	40.3	46.6	85.2	207.0	367.0	487.0	372.0	165.8	99.0	65.5	169.4
1977	48.1	46.5	49.8	54.9	77.8	192.0	591.0	609.0	368.0	164.0	94.0	61.7	197.2
1978	46.6	44.1	45.4	57.4	151.0	335.0	520.0	625.0	332.0	215.0	108.0	70.1	213.9
1979	51.3	43.5	43.9	52.4	91.9	185.0	468.0	504.0	280.0	137.0	83.0	55.6	167.5
1980	43.5	40.2	40.8	59.4	80.6	276.0	663.0	678.0	390.0	162.0	91.0	58.9	216.4
1981	42.5	36.4	37.2	50.0	85.0	290.0	714.0	619.0	369.0	140.0	87.1	56.0	212.2
1982	43.8	39.8	56.0	74.6	81.4	212.0	407.0	596.0	393.0	120.0	77.5	54.1	180.6
1983	40.1	34.8	36.3	38.5	69.9	161.0	377.0	506.0	438.0	200.0	94.9	60.4	172.4
1984	46.6	33.4	34.2	34.5	107.0	298.0	619.0	517.0	417.0	117.0	69.5	48.9	196.0
1985	35.6	33.8	41.9	46.3	54.6	156.0	486.0	432.0	369.0	200.0	91.7	69.1	169.1
1986	55.1	54.5	53.9	64.6	77.1	319.0	694.0	595.0	454.0	169.0	96.4	67.9	226.0
1987	54.2	50.1	48.8	56.7	69.9	177.0	396.0	-	-	116.0	78.7	61.8	-
1988	52.2	48.5	49.3	59.7	86.3	178.0	488.0	566.0	260.0	109.0	71.8	58.8	170.0
1989	53.8	47.5	48.4	57.2	105.0	188.0	356.0	441.0	282.0	120.0	65.1	-	-
1990	-	37.1	36.1	47.9	91.2	315.0	815.0	650.0	452.0	167.0	77.1	49.1	-
1991	38.5	32.5	32.5	38.0	86.4	210.0	448.0	802.0	-	-	-	45.1	-
1992	35.4	29.1	28.6	34.6	43.1	122.0	325.0	709.0	410.0	140.0	66.5	41.8	166.0
1993	33.2	30.5	27.2	38.2	84.5	192.0	446.0	728.0	422.0	166.0	67.7	42.1	191.0
AVG	48.3	42.5	43.2	53.2	88.3	237.2	533.4	615.6	400.6	171.6	90.3	61.3	201.4
MAX	55.1	57.5	56.0	74.6	151.0	366.0	815.0	802.0	525.0	288.0	110.0	70.1	233.7
MIN	33.2	29.1	27.2	34.5	43.1	122.0	325.0	432.0	260.0	106.0	62.5	41.8	148.3

Table 5.5.2-4 Monthly and Yearly Discharges

River: : Trishuli
Station Name : Betrawati, No. 447

MEAN MONTHLY AND YEARLY DISCHARGES (in Cumec)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yearly
1977	48	47	50	55	78	192	591	609	360	164	94	62	196
1978	47	44	45	57	151	335	520	625	332	215	108	70	212
1979	51	44	44	52	92	185	468	504	280	137	83	56	166
1980	44	40	41	59	81	276	663	678	390	162	91	59	215
1981	43	36	37	50	85	290	714	619	369	140	87	56	211
1982	43	40	56	75	81	212	407	596	393	120	78	54	180
1983	40	35	36	39	70	161	377	506	438	200	95	60	171
1984	47	33	34	35	107	298	619	517	417	117	70	49	195
1985	36	34	42	46	55	156	486	432	369	200	92	69	168
1986	55	55	54	65	77	319	694	595	454	169	96	68	225
1988	52	49	49	60	86	178	488	566	260	109	72	59	169
1989	54	48	48	57	105	188	356	441	282	120	65	49	151
1990	42	37	36	48	91	315	815	628	452	167	77	49	230
1992	35	29	29	35	43	122	325	709	410	140	67	42	165
1993	33	31	27	38	85	192	446	728	422	166	68	42	190
Average	45	40	42	51	86	228	531	584	375	155	83	56	190

MAXIMUM MONTHLY AND YEARLY DISCHARGES

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yearly
1977	52	51	58	78	155	432	772	820	505	262	125	74	820
1978	52	49	55	87	248	620	652	918	424	540	141	85	918
1979	59	52	46	83	123	404	1,040	790	468	194	97	75	1,040
1980	49	45	43	105	110	667	1,040	1,080	575	265	110	70	1,080
1981	50	39	40	73	127	678	862	784	760	218	116	66	862
1982	47	46	75	81	129	364	662	838	667	167	94	61	838
1983	48	37	39	52	108	400	520	662	601	355	123	81	662
1984	57	35	37	45	221	382	808	820	748	188	81	61	820
1985	41	41	46	73	86	423	667	596	656	525	116	75	667
1986	60	58	58	83	93	832	922	856	970	247	123	81	970
1988	55	53	54	62	190	324	655	758	508	148	86	69	758
1989	82	53	55	63	324	512	512	592	440	214	79	54	592
1990	46	42	46	67	152	552	1,330	840	737	266	99	59	1,330
1992	38	34	32	43	61	285	600	1,360	630	229	86	50	1,360
1993	37	33	30	73	116	320	832	1,850	645	276	91	51	1,850
Extreme	82	58	75	105	324	832	1,330	1,850	970	540	141	85	1,850

MINIMUM MONTHLY AND YEARLY DISCHARGES

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yearly
1977	44	44	46	49	55	109	440	436	245	117	78	52	44
1978	43	41	43	43	85	170	376	364	225	141	83	59	41
1979	44	42	42	43	73	93	195	307	159	99	70	49	42
1980	41	38	36	42	62	99	405	247	261	110	72	49	36
1981	38	34	34	35	60	97	500	463	188	118	68	47	34
1982	40	37	45	68	69	133	167	477	167	92	62	47	37
1983	35	33	35	35	43	86	244	382	275	110	76	49	33
1984	34	32	32	31	34	196	409	347	199	83	61	41	31
1985	32	31	37	38	43	73	373	343	221	118	77	60	31
1986	52	51	51	52	64	81	432	436	247	125	80	59	51
1988	48	46	47	55	61	95	256	400	158	87	63	54	46
1989	50	45	44	51	58	102	235	332	220	80	54	46	44
1990	38	35	34	34	50	158	472	488	273	102	60	42	34
1992	32	27	27	27	35	54	146	456	210	86	49	37	27
1993	31	28	25	26	59	110	262	468	288	92	46	35	25
Extreme	31	27	25	26	34	54	146	247	158	80	46	35	25

Table 5.5.2-5 (1/2) Daily Headrace Canal Discharge and Generation in 1996

Date	JAN Headrace Canal (cumec) Max	Mini	Ave	T.E.G (kwh)	FEB Headrace Canal (cumec) Max	Mini	Ave	T.E.G (kwh)	MAR Headrace Canal (cumec) Max	Mini	Ave	T.E.G (kwh)	APR Headrace Canal (cumec) Max	Mini	Ave	T.E.G (kwh)	MAY Headrace Canal (cumec) Max	Mini	Ave	T.E.G (kwh)	JUN Headrace Canal (cumec) Max	Mini	Ave	T.E.G (kwh)
1	53.8	51.0	51.6	428,430	37.4	36.8	37.0		35.4	35.4	35.4	353,110	39.6	34.0	36.9	328,920	51.0	45.3	45.1	421,460	49.0	31.1	40.0	375,150
2	53.8	48.1	51.0	420,200	36.8	36.8	36.8	380,790	36.8	35.4	36.1	349,670	39.6	36.8	37.4	360,620	45.3	34.0	44.8	419,300	48.1	45.3	47.3	472,540
3	51.0	51.0	51.0	429,180	36.8	31.1	36.6	354,390	36.8	34.0	35.3	344,140	36.8	36.8	36.8	362,490	48.1	45.3	46.2	421,900	51.0	24.4	47.0	449,290
4	51.0	51.0	51.0	435,390	36.8	36.8	36.8	368,780	34.0	34.0	34.0	340,800	38.2	36.8	36.9	358,910	48.1	34.0	43.2	295,210	51.0	45.3	48.4	464,390
5	51.0	49.6	50.7	428,890	36.8	36.8	36.8	374,660	36.8	34.0	36.1	343,730	39.6	39.6	39.6	361,520	36.8	28.3	33.2	290,580	51.0	45.3	47.4	464,150
6	49.6	49.6	49.6	424,600	36.8	36.8	36.8	372,930	36.8	31.1	34.2	333,070	39.6	39.6	39.6	356,250	42.5	31.1	38.7	354,610	48.1	45.3	47.8	446,120
7	49.6	49.6	49.6	416,500	36.8	36.8	36.8	370,240	34.0	31.1	33.4	321,120	39.6	39.6	39.6	362,860	42.5	39.6	41.9	371,770	49.6	45.3	47.2	468,930
8	49.6	48.1	49.0	414,620	36.8	36.8	36.8	370,280	34.0	34.0	34.0	328,440	42.5	34.0	40.0	352,820	45.3	42.5	43.2	386,700	48.1	42.5	46.7	479,030
9	48.1	48.1	48.1	414,550	36.8	36.8	36.8	364,750	34.0	34.0	34.0	326,000	39.6	39.6	39.6	356,190	45.3	45.3	45.3	397,910	48.1	45.3	46.8	467,820
10	48.1	48.1	48.1	400,600	36.8	36.8	36.8	374,570	39.6	36.8	35.4	336,950	42.5	39.6	40.2	374,170	48.1	45.3	45.9	409,100	48.1	45.3	47.5	472,960
11	48.1	39.6	45.6	384,910	36.8	36.8	36.8	385,950	41.1	36.8	39.0	365,940	45.3	42.5	44.3	397,960	51.0	28.3	44.2	356,970	49.6	48.1	48.4	454,620
12	48.1	48.1	48.1	410,740	36.8	36.8	36.8	375,840	48.1	41.1	41.8	376,160	45.3	45.3	45.3	407,840	51.0	42.5	45.9	422,770	50.4	45.3	46.8	480,550
13	48.1	48.1	48.1	408,590	36.8	36.8	36.8	352,260	45.3	39.6	41.9	378,800	45.3	45.3	45.3	398,880	45.3	45.3	45.3	420,910	48.1	45.3	47.5	461,490
14	48.1	48.1	48.1	407,510	36.8	35.4	36.3	364,160	42.5	39.6	40.9	382,910	45.3	45.3	45.3	408,020	45.3	45.3	45.3	417,090	48.1	42.5	47.4	445,470
15	48.1	39.6	41.9	419,290	35.4	35.4	35.4	364,650	42.5	28.3	41.6	311,800	45.3	45.3	45.3	403,110	45.3	45.3	45.3	424,240	48.1	45.3	47.5	457,380
16	48.1	42.5	47.6	449,490	35.4	35.4	35.4	354,760	42.5	39.6	40.5	361,740	45.3	42.5	44.7	401,760	45.3	39.6	45.1	413,130	48.1	42.5	47.5	474,900
17	48.1	41.8	46.3	417,190	36.8	35.4	35.8	346,790	42.5	36.8	39.3	374,710	45.3	45.3	45.3	410,760	45.3	45.3	45.3	418,160	48.1	48.1	48.1	466,390
18	41.8	41.8	41.8	437,900	35.4	35.4	35.4	343,650	42.5	42.5	42.5	383,580	45.3	45.3	45.3	394,180	45.3	45.3	45.3	432,660	48.1	45.3	47.8	485,140
19	41.8	41.8	41.8	416,720	35.4	35.4	35.4	336,060	42.5	42.5	42.5	389,090	45.3	42.5	44.1	395,390	48.1	45.3	45.6	425,670	48.1	42.5	46.7	469,180
20	41.8	41.8	41.8	414,990	39.6	35.4	36.9	371,900	42.5	42.5	42.5	386,990	48.1	42.5	45.9	403,390	48.1	48.1	48.1	454,260	49.8	42.5	45.8	462,600
21	41.8	41.1	41.3	419,320	36.8	34.8	35.8	347,940	42.5	39.6	41.5	383,730	48.1	34.0	47.5	410,970	48.1	48.1	48.1	457,070	48.1	45.3	46.3	438,410
22	41.1	41.1	41.1	414,400	35.4	34.8	35.2	343,800	39.6	39.6	39.6	377,420	48.1	45.3	47.7	428,230	48.1	48.1	48.1	468,040	48.1	39.6	46.3	431,710
23	41.1	39.1	40.0	401,370	35.4	34.0	34.7	345,460	41.1	39.6	39.9	386,590	48.1	45.3	46.2	410,040	51.0	48.1	49.4	486,290	48.1	39.6	42.4	440,570
24	39.1	39.1	39.1	400,430	34.0	34.0	34.0	350,120	42.5	39.6	40.3	367,850	45.3	45.3	45.3	420,860	51.0	51.0	51.0	491,500	48.1	39.6	45.3	417,110
25	39.1	39.1	39.1	400,240	34.8	34.0	34.1	349,270	39.6	39.6	39.6	364,710	51.0	45.3	48.3	425,880	51.0	28.3	46.5	398,450	48.1	42.5	45.8	441,500
26	39.1	39.1	39.1	389,290	34.0	34.0	34.0	367,190	42.5	36.8	39.5	356,620	51.0	42.5	47.2	431,990	48.1	28.3	38.5	317,680	48.1	45.3	46.0	439,050
27	39.1	39.1	39.1	392,900	36.8	34.0	36.1	364,100	39.6	36.8	38.5	360,720	48.1	45.3	45.7	440,150	51.0	42.5	46.4	457,310	48.1	48.1	48.1	458,830
28	39.1	39.1	39.1	395,020	36.8	36.8	36.8	365,340	39.6	36.8	37.3	362,550	45.3	45.3	45.3	429,240	51.0	45.3	48.4	477,300	48.1	39.6	45.1	463,930
29	39.1	37.4	38.4	387,480	36.8	35.4	36.3	357,180	36.8	28.3	33.8	181,140	51.0	45.3	47.1	427,140	51.0	39.6	47.5	389,780	46.7	39.6	44.4	438,600
30	37.4	37.4	37.4	388,050					39.6	31.1	35.6	337,210	51.0	45.3	48.1	438,490	46.7	45.3	45.8	411,900	46.7	42.5	44.0	463,920
31	37.4	37.4	37.4	388,350					39.6	36.8	37.2	329,780					49.0	42.5	46.2	476,880				
	53.8	37.4	44.6	411,521	39.6	31.1	36.1	361,350	48.1	28.3	38.2	351,518	51.0	34.0	43.5	395,301	51.0	28.3	45.1	412,471	51.0	24.4	46.5	455,058

Table 5.5.2-5 (2/2) Daily Headrace Canal Discharge and Generation in 1996

Date	JAN Headrace Canal (cusec) Max	JAN Mini	JAN Ave	JAN T.E.G (kwh)	FEB Headrace Canal (cusec) Max	FEB Mini	FEB Ave	FEB T.E.G (kwh)	MAR Headrace Canal (cusec) Max	MAR Mini	MAR Ave	MAR T.E.G (kwh)	APR Headrace Canal (cusec) Max	APR Mini	APR Ave	APR T.E.G (kwh)	MAY Headrace Canal (cusec) Max	MAY Mini	MAY Ave	MAY T.E.G (kwh)	JUN Headrace Canal (cusec) Max	JUN Mini	JUN Ave	JUN T.E.G (kwh)
1	1,900	1,800	1,822	428,430	1,320	1,300	1,307		1,250	1,250	1,250	353,110	1,400	1,200	1,304	328,920	1,800	1,600	1,594	421,460	1,730	1,100	1,413	375,150
2	1,900	1,700	1,800	420,200	1,300	1,300	1,300	380,790	1,300	1,250	1,275	349,670	1,400	1,300	1,321	360,620	1,600	1,200	1,583	419,300	1,700	1,600	1,671	472,540
3	1,800	1,800	1,800	429,180	1,300	1,100	1,291	354,390	1,300	1,200	1,248	344,140	1,300	1,300	1,300	362,490	1,700	1,600	1,633	421,900	1,800	860	1,661	449,290
4	1,800	1,800	1,800	435,390	1,300	1,300	1,300	368,780	1,200	1,200	1,200	340,800	1,350	1,300	1,302	358,910	1,700	1,200	1,526	295,210	1,800	1,600	1,708	464,390
5	1,800	1,750	1,790	428,890	1,300	1,300	1,300	374,660	1,300	1,200	1,275	343,730	1,400	1,400	1,400	361,520	1,300	1,000	1,175	290,580	1,800	1,600	1,673	464,150
6	1,750	1,750	1,750	424,600	1,300	1,300	1,300	372,930	1,300	1,100	1,208	333,070	1,400	1,400	1,400	356,250	1,500	1,100	1,367	354,610	1,700	1,600	1,688	446,120
7	1,750	1,750	1,750	416,500	1,300	1,300	1,300	370,240	1,200	1,100	1,179	321,120	1,400	1,400	1,400	362,860	1,500	1,400	1,479	371,770	1,750	1,600	1,667	468,930
8	1,750	1,700	1,730	414,620	1,300	1,300	1,300	370,280	1,200	1,200	1,200	328,440	1,500	1,200	1,413	352,820	1,600	1,500	1,525	386,700	1,700	1,500	1,650	479,030
9	1,700	1,700	1,700	414,550	1,300	1,300	1,300	364,750	1,200	1,200	1,200	326,000	1,400	1,400	1,400	356,190	1,600	1,600	1,600	397,910	1,700	1,600	1,654	467,820
10	1,700	1,700	1,700	400,600	1,300	1,300	1,300	374,570	1,400	1,300	1,250	336,950	1,500	1,400	1,421	374,170	1,700	1,600	1,621	409,100	1,700	1,600	1,679	472,960
11	1,700	1,400	1,610	384,910	1,300	1,300	1,300	385,950	1,450	1,300	1,379	365,940	1,600	1,500	1,563	397,960	1,800	1,000	1,561	356,970	1,750	1,700	1,709	454,620
12	1,700	1,700	1,700	410,740	1,300	1,300	1,300	375,840	1,700	1,450	1,477	376,160	1,600	1,600	1,600	407,840	1,800	1,500	1,621	422,770	1,780	1,600	1,654	480,550
13	1,700	1,700	1,700	408,590	1,300	1,300	1,300	352,260	1,600	1,400	1,478	378,800	1,600	1,600	1,600	398,880	1,600	1,600	1,600	420,910	1,700	1,600	1,679	461,490
14	1,700	1,700	1,700	407,510	1,300	1,250	1,283	364,160	1,500	1,400	1,446	382,910	1,600	1,600	1,600	408,020	1,600	1,600	1,600	417,090	1,700	1,500	1,675	445,470
15	1,700	1,400	1,480	419,290	1,250	1,250	1,250	364,650	1,500	1,000	1,468	311,800	1,600	1,600	1,600	403,110	1,600	1,600	1,600	424,240	1,700	1,600	1,678	457,380
16	1,700	1,500	1,680	449,490	1,250	1,250	1,250	354,760	1,500	1,400	1,429	361,740	1,600	1,500	1,578	401,760	1,600	1,400	1,592	413,130	1,700	1,500	1,679	474,900
17	1,700	1,475	1,634	417,190	1,300	1,250	1,265	346,790	1,500	1,300	1,388	374,710	1,600	1,600	1,600	410,760	1,600	1,600	1,600	418,160	1,700	1,700	1,700	466,390
18	1,475	1,475	1,475	437,900	1,250	1,250	1,250	343,650	1,500	1,500	1,500	383,580	1,600	1,600	1,600	394,180	1,600	1,600	1,600	432,660	1,700	1,600	1,688	485,140
19	1,475	1,475	1,475	416,720	1,250	1,250	1,250	336,060	1,500	1,500	1,500	389,090	1,600	1,500	1,558	395,390	1,700	1,600	1,609	425,670	1,700	1,500	1,650	469,180
20	1,475	1,475	1,475	414,990	1,400	1,250	1,304	371,900	1,500	1,500	1,500	386,990	1,700	1,500	1,621	403,390	1,700	1,700	1,700	454,260	1,760	1,500	1,617	462,600
21	1,475	1,450	1,459	419,320	1,300	1,230	1,266	347,940	1,500	1,400	1,467	383,730	1,700	1,200	1,679	410,970	1,700	1,700	1,700	457,070	1,700	1,600	1,635	438,410
22	1,450	1,450	1,450	414,400	1,250	1,230	1,243	343,800	1,400	1,400	1,400	377,420	1,700	1,600	1,683	428,230	1,700	1,700	1,700	468,040	1,700	1,400	1,635	431,710
23	1,450	1,380	1,412	401,370	1,250	1,200	1,225	345,460	1,450	1,400	1,408	386,590	1,700	1,600	1,630	410,040	1,800	1,700	1,746	486,290	1,700	1,400	1,496	440,570
24	1,380	1,380	1,380	400,430	1,200	1,200	1,200	350,120	1,500	1,400	1,423	367,850	1,600	1,600	1,600	420,860	1,800	1,800	1,800	491,500	1,700	1,400	1,600	417,110
25	1,380	1,380	1,380	400,240	1,230	1,200	1,204	349,270	1,400	1,400	1,400	364,710	1,800	1,600	1,704	425,880	1,800	1,000	1,642	398,450	1,700	1,500	1,617	441,500
26	1,380	1,380	1,380	389,290	1,200	1,200	1,200	367,190	1,500	1,300	1,396	356,620	1,800	1,500	1,667	431,990	1,700	1,000	1,361	317,680	1,700	1,600	1,626	439,050
27	1,380	1,380	1,380	392,900	1,300	1,200	1,275	364,100	1,400	1,300	1,358	360,720	1,700	1,600	1,613	440,150	1,800	1,500	1,638	457,310	1,700	1,700	1,700	458,830
28	1,380	1,380	1,380	395,020	1,300	1,300	1,300	365,340	1,400	1,300	1,317	362,550	1,600	1,600	1,600	429,240	1,800	1,600	1,710	477,300	1,700	1,400	1,592	463,930
29	1,380	1,320	1,355	387,480	1,300	1,250	1,281	357,180	1,300	1,000	1,193	181,140	1,800	1,600	1,663	427,140	1,800	1,400	1,677	389,780	1,650	1,400	1,567	438,600
30	1,320	1,320	1,320	388,050					1,400	1,100	1,257	337,210	1,800	1,600	1,700	438,490	1,650	1,600	1,617	411,900	1,650	1,500	1,554	463,920
31	1,320	1,320	1,320	388,350					1,400	1,300	1,313	329,780					1,730	1,500	1,633	476,880				
	1,900	1,320	1,574	411,521	1,400	1100	1,274	361,350	1,700	1000	1,348	351,518	1,800	1200	1,537	395,301	1,800	1000	1,594	412,471	1,800	860	1,641	455,058

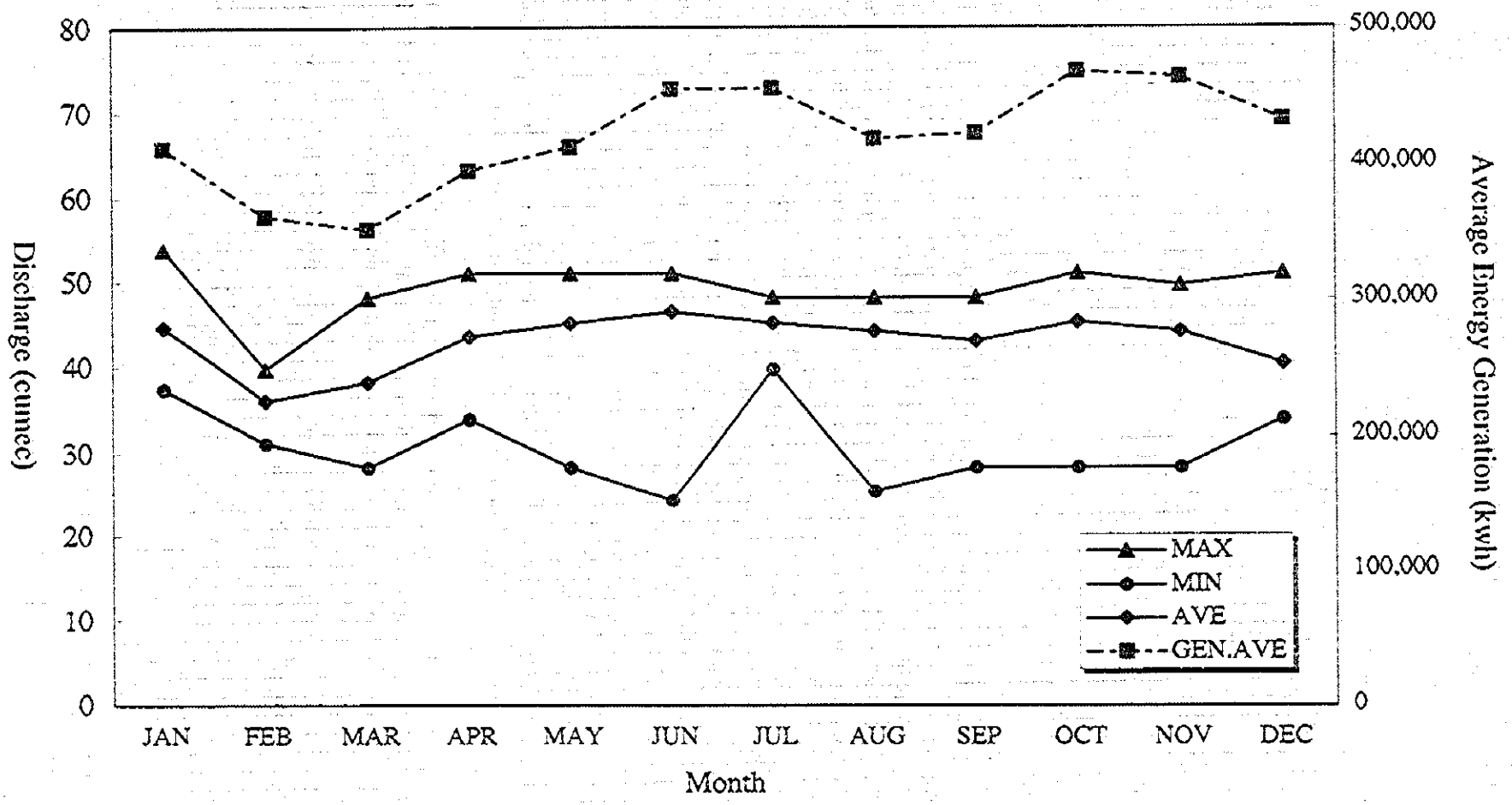


Fig. 5.5.2-1 Daily Discharge and Energy Generation Records at Trishuli Power House in 1996

5.5.3 Main Canal Alignment

(1) Topographic Conditions along Survey Route

With the original intake at aqueduct no. 2 the main canal alignment has to pass through various geologically fragile stretches of land at the left bank of the Trishuli river at the initial portion for about 4 km. The topographic condition varies from steep to gentle slope towards the cross-section of the alignment. Compared to a piped canal system, the open canal system encounters more in case of rock outcrop, forest lands, steep slopes, weathered and fractured rocks at its beginning.

The remaining portion is generally alluvial deposit and occasionally colluvium gravel mixed soil.

(2) Geological Conditions in the Project Site

The left bank of the Trishuli river in the upstream part of the command area is very steep and unstable with huge rock outcrop and thick alluvium and colluvium deposits containing coarse cobbles and boulders. Soil of the area is sandy and gravelly in nature, and permeable. The command area of the Project has different levels of ancient and recent alluvial terraces. Upper terraces such as Majhitar and Pipaltar are made up of lateritic soil, whereas the lower terraces mainly contain reddish grey sandy to silty soil layers with fine pebbles. Geologically the area is very fragile. Gullies with deep soil erosion can be found in the right bank of Tadi river from Majhitar to Devighat. This is because of rapid river cutting and local scale faulting passing through at SW~NE direction in the area. Similar to the Tadi river, bank cutting and old landslide with gullies can be observed towards the intake site of the canal alignment on the banks of the Trishuli river.

(3) Methodology and Works Done

The Study Team made a preliminary reconnaissance of the main canal alignment from the original intake point of the hydropower headrace canal to the Study area.

Prior to this route surveying, the Team and counterpart officials executed 8 km of longitudinal survey along the existing road in the Project area, so as to identify the hydraulic gradients to know the possibility of shifting the canal alignment.

With reference to this gradient obtained, the Team identified the difference of level between the intake point and the Study area.

The Study Team used aerial photos together with the longitudinal survey for identifying the boundary of the command area.

Based upon the findings of the survey and existing topography, alternatives were sought namely for;

Canal system	Location of intake site
1) Open canal system	upstream of aqueduct no. 2
2) Piped canal system	-do-
3) Alternative canal system (Option 3)	downstream of balancing reservoir

1) Open Canal System

It was found that the open canal system will be very expensive requiring a number of aqueducts, siphons, tunnel, and road cutting works at many places, with hill cutting affecting the environment.

The proposed open canal system passes through many rock outcrops near the intake site, at Gerkhukhola, Simutar and Dhunge. In other places the colluvium and alluvium deposits are predominant along the alignment. Besides this, it is necessary to cross many wide lateral streams coming from above river scouring areas. To pass the canal along this alignment requires high rock cutting, long tunnel construction and well lined canal to protect against seepage and leakage of water. Although there are no existing, large landslides there will be chance of sliding during and after implementation because of steep slope, loose soil deposit and soft and weak rock outcrop.

2) Piped Canal System

The pipe canal alignment runs through the left bank of the Trishuli river the same as the open canal up to Simutar, and then crosses the river two times to reach the command area. In this system, rock excavation and length of tunnel construction is less. But to cross the Trishuli river, it is necessary to construct two aqueducts through sandy soil with gravel.

In case of piped line canal the alignment avoids the geologically fragile fractured rock outcrops and passes mainly through the alluvial deposits of cultivated terraced lands, fallow lands and some portions of forest lands. These alluvial deposits are generally gravel, boulder, sand mixed silty clay.

The alignment passes through forest land around 200 m and requires a tunnel of 200 m at ch.1+950m. The alignment crosses the Trishuli river at ch.3+500 m and then passes along the right bank of the river.

On the right bank of the Trishuli river, the alignment mainly passes through cultivated land of alluvial silty soil with large boulders at its foot hill. Then it crosses beneath the Trishuli bridge at Trishuli Bazaar. At ch.4+200 m it crosses the Trishuli river via an aqueduct and the alignment then follows the left bank of the river just downstream of Dhunge.

At Dhunge the texture of the soil is grey to reddish silty clay, and the area comprises moderate to gentle slope cultivated terrace.

The alignment passes over two deep valleys at both sides of the army camp from ch.6+110 m to ch.6+390 m. All along the alignment, the alignment passes through reddish gray soil. The main control tank would be proposed at ch.7+900 m. It will be the ending point of the main canal.

3) Alternative-1 Canal System (Option 3)

The proposed Alternative-1 (Option 3) alignment starts from the tail end of the NEA balancing reservoir about 1.7 km downstream of the other two alignments on the left bank of the Trishuli river. This alignment mainly runs through gentle alluvial river terraces except an existing landslide and rock outcrop at one place and crosses the river as in the case of the other alignments.

With the intake for Alternative-1 (Option 3) at the downstream of the NEA balancing reservoir (refer to Figure 5.5.1-3), the alignment meets the original alignment from aqueduct no. 2 at ch.3+500 m. The chainage for the new alignment at this point will be ch.1+450 m.

The new alignment from the downstream of the balancing reservoir will reduce main pipeline length by around 2 km. Here the soil is loose gray silty soil to silty clay mixed with gravel, cobble, boulder.

5.5.4 Comparative Study on Main Canal System

(1) Comparative Study

Based on the main canal alignment survey, the Study Team estimated preliminary construction costs for three (3) different alignments, using the latest unit construction rates from related agencies, in cooperation with Nepalese counterparts.

Preliminary construction costs of each alignment are shown in Table 5.5.4-1 up to the proposed main control tank (see Figure 5.5.4-1). Related unit costs of construction works are shown in Table 5.5.4-2.

Cost estimate criteria are as follows:

1) Estimates do not include the downstream portion of Zone A from the proposed main control tank, nor any of Zone B.

2) Design discharge is assumed at Q = 1.50 m³/s.

3) Open canal cross-section is assumed at W = 2.00 m, H = 1.50 m.

4) Pipe is 1,250 mm dia. steel pipe.

The following table summarizes the above construction costs compared with canal length and total construction cost for three (3) different systems of main canal.

Comparative Study of Canal System

Length up to Proposed Control Tank

Systems	Length of Main Canal Alignment (m)					Construction Cost Million Rs. (US$/ha)
	Open Canal	Piped Line	Aqueduct /Siphon	Tunnel	Total Length	
(1)Open Canal	5,130m	220m	650m	1,010m	7,010m	650 (US$ 18,000/ha)
(2)Piped Canal	1,380m	4,870m	920m	140m	7,310m	370 (US$ 10,300/ha)
(3)Alternative-1 Canal (Option 3)	1,380m	3,305m	840m	0m	5,525m	250 (US$ 6,800/ha)

Note: Unit construction costs (US$/ha) are calculated on the basis of 630 ha of Zone A command area, not including Zone B.

(2) Adoption of Alternative-1 (Option 3)

The Study Team discussed with the Department of Irrigation construction costs and methods for the above 3 alternatives. DOI personnel (both central government and district level) and Study Team members reconnaissanced the entire canal alignment in the field and identified both level of construction difficulty and any adverse environmental impacts.

On this basis, it was agreed that Alternative-1 (Option 3) should be adopted for the main canal under the Project. With regards to intake location (balancing reservoir), discussions are to be pursued with the responsible agency, NEA.

Table 5.5.4-1 Comparison on Preliminary Construction Cost of Three(3) Different Canal Systems

(1) Open Canal System				(2) Piped Canal System				(3) Alternative Canal System			
No. Works	Length (m)	Unit Cost (N.Rs.)	Amount (N.Rs.000')	No. Works	Length (m)	Unit Cost (N.Rs.)	Amount (N.Rs.000')	No. Works	Length (m)	Unit Cost (N.Rs.)	Amount (N.Rs.000')
1. Open Canal	560	73,192	40,987	1. Pipe Aqueduct	180	74,863	13,475	1. Pipeline	780	25,993	20,274
2. Open Canal	500	20,384	10,192	2. Pipeline	1,060	25,993	27,552	2. Siphon	200	39,988	7,998
3. Open Canal	440	73,192	32,204	3. Pipeline	200	25,993	5,199	3. Pipeline	490	25,993	12,736
4. Tunnel	200	200,000	40,000	4. Pipeline	140	26,801	3,752				
5. Siphon	175	39,988	6,998	5. Pipeline	95	25,993	2,469				
6. Open Canal	450	73,192	32,936	6. Tunnel	140	200,000	28,000				
7. Siphon	75	39,988	2,999	7. Pipeline	560	25,993	14,556				
8. Open Canal	525	20,384	10,701	8. Pipeline	130	25,993	3,379				
9. Open Canal	215	73,192	15,736	9. Pipeline	650	25,993	16,895				
10. Tunnel	150	200,000	30,000	10. Pipe Aqueduct	100	158,585	15,858				
11. Pipe Aqueduct	105	74,863	7,861	**Sub-total**	**3,255**		**131,136**	**Sub-total**	**1,470**		**41,008**
12. Tunnel	450	200,000	90,000								
13. Pipe Aqueduct	75	74,863	5,615	11. Pipeline	95	25,993	2,469	11. Pipeline	95	25,993	2,469
14. Tunnel	210	200,000	42,000	12. Pipe Aqueduct	395	74,863	29,571	12. Pipe Aqueduct	395	74,863	29,571
15. Open Canal	560	73,192	40,987	13. Pipe Aqueduct	100	158,585	15,858	13. Pipe Aqueduct	100	158,585	15,858
16. Siphon	75	39,988	2,999	14. Pipeline	625	25,993	16,245	14. Pipeline	625	25,993	16,245
17. Open Canal	500	20,384	10,192	15. Pipeline	90	25,993	2,339	15. Pipeline	90	25,993	2,339
				16. Pipeline	500	25,993	12,996	16. Pipeline	500	25,993	12,996
				17. Pipeline	35	25,993	910	17. Pipeline	35	25,993	910
				18. Pipeline	470	25,993	12,217	18. Pipeline	470	25,993	12,217
Sub-total	**5,265**		**422,408**	**Sub-total**	**2,310**		**92,606**	**Sub-total**	**2,310**		**92,606**
(Common)											
19. Syphon	85	39,988	3,399	19. Siphon	85	39,988	3,399	19. Siphon	85	39,988	3,399
20. Pipeline	220	25,993	5,718	20. Pipeline	220	25,993	5,718	20. Pipeline	220	25,993	5,718
21. Siphon	60	39,988	2,399	21. Siphon	60	39,988	2,399	21. Siphon	60	39,988	2,399
22. Open Canal	1,380	20,384	28,129	22. Open Canal	1,380	20,384	28,129	22. Open Canal	1,380	20,384	28,129
Sub-total	**1,745**		**39,646**	**Sub-total**	**1,745**		**39,646**	**Sub-total**	**1,745**		**39,646**
Total	**7,010**		**(1)=462,054**	**Total**	**7,310**		**(2)=263,389**	**Total**	**5,525**		**(3)=173,261**

(1) Open Canal System : N.Rs.462,054 x 1.4 =647Million (US$ 18,014/ha)
(2) Piped Canal System: N.Rs.263,389 x 1.4 =369Million (US$ 10,269/ha)
(3) Alternative Canal System: N.Rs.173,261 x 1.4 =243Million (US$ 6,755/ha)

Table 5.5.4-2 Tentative Unit Cost for Preliminary Construction Works

Materials/Works		Unit	Unit Cost (NRs)	Remarks
1. Excavation				
Common	Machinery	m^3	90	assumed cost using DOI projects
Rock	Machinery	m^3	1,500	assumed cost using DOI projects
Removal of excavated		m^3-km	90	assumed cost using DOI projects
2. Fill Placement				
Backfill at structure	random	m^3	90	assumed cost using DOI projects
Grass Sod		m^2	30	assumed cost using DOI projects
3. Gabions				
Gabion Box		m^3	3,909	NEA 1992, Esca.20%
Mattresses	t=500mm	m^2	1,202	NEA 1992, Esca.20%
4. Formwork				
Straight formwork		m^2	1,200	assumed cost using DOI projects
Curved formwork		m^2	1,200	assumed cost using DOI projects
5. ReinforcingSteel				
Reinforcing Steel	Tor steel	kg	48	NEA 1992, Esca.20%
6. Cast-in-place Concrete				
Class M150	PCC	m^3	5,134	NEA 1992, Esca.20%
Class M200	RCC	m^3	6,187	NEA 1992, Esca.20%
7. Plastering				
Mortar Plastering	t=25mm	m^2	300	assumed cost using DOI projects
Shotcreting		m^2	1,000	assumed cost using DOI projects
8. Materials				
Sand		m^3	324	KTM Valley 1992, JICA Study
9. Stone Masonry		m^3	3,200	assumed cost using DOI projects
10. Truss Bridge	Q=1.5m^3/s	m	186,141	NEA 1992, Esca.20%
	D=1.25m	m	100,000	bidded by class A Pipe Maker
11. Pipeline Fabrication				
from Japan, Korea	D=1.25m	m	10,873	bidded by class A Pipe Maker
from Norway	D=1.25m	m	25,630	bidded by class B Pipe Maker
from India	D=1.25m	m	27,464	bidded by class B Pipe Maker
Adopted Cost		m	18,000	discussed with DOI counterparts
12. Tunnel		m	200,000	assumed cost using NEA projects

Fig. 5.5.4-1 COMPARISON STUDY C

(1) Open Canal
(2) Piped Canal
(3) Alternative

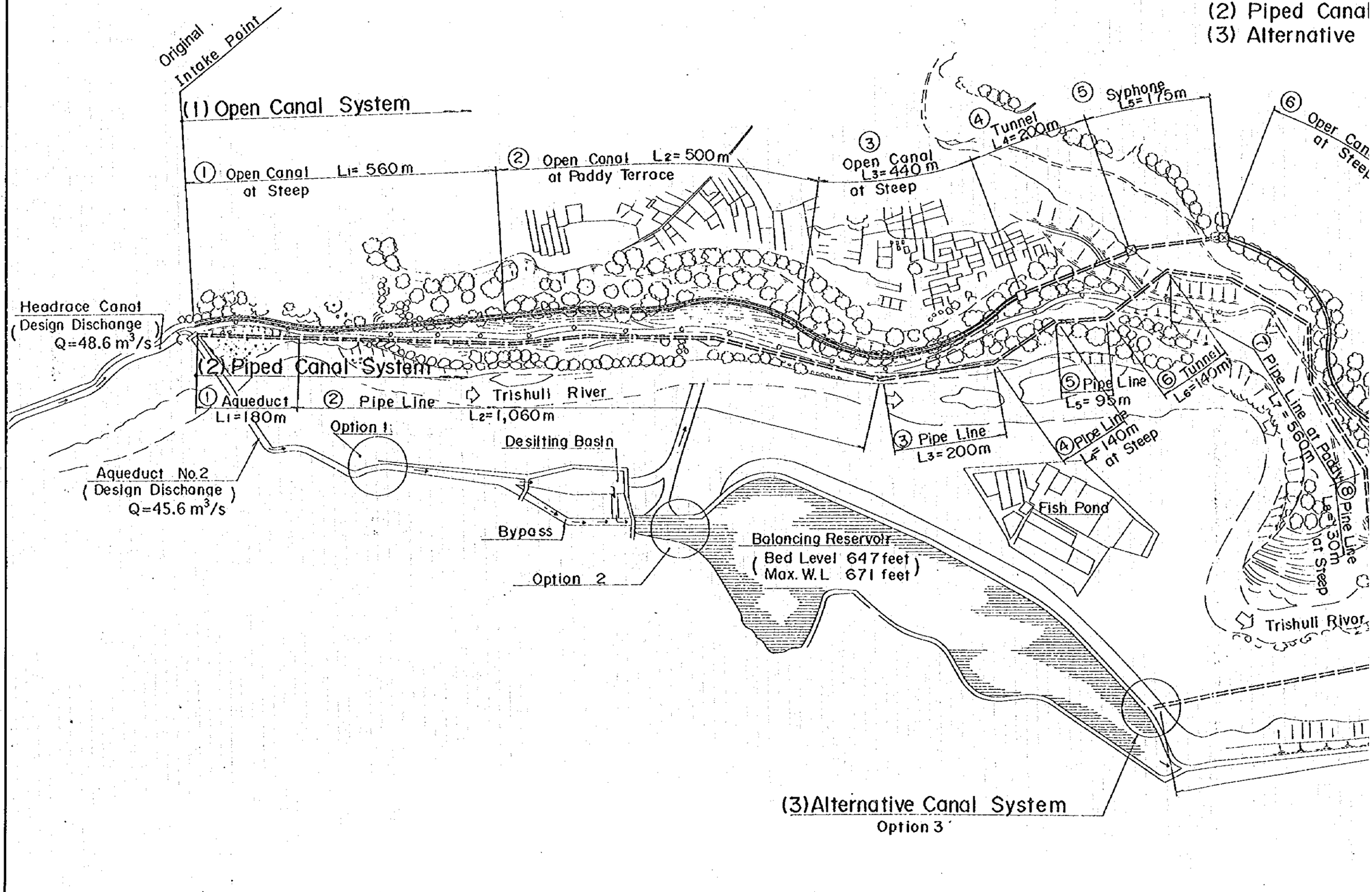
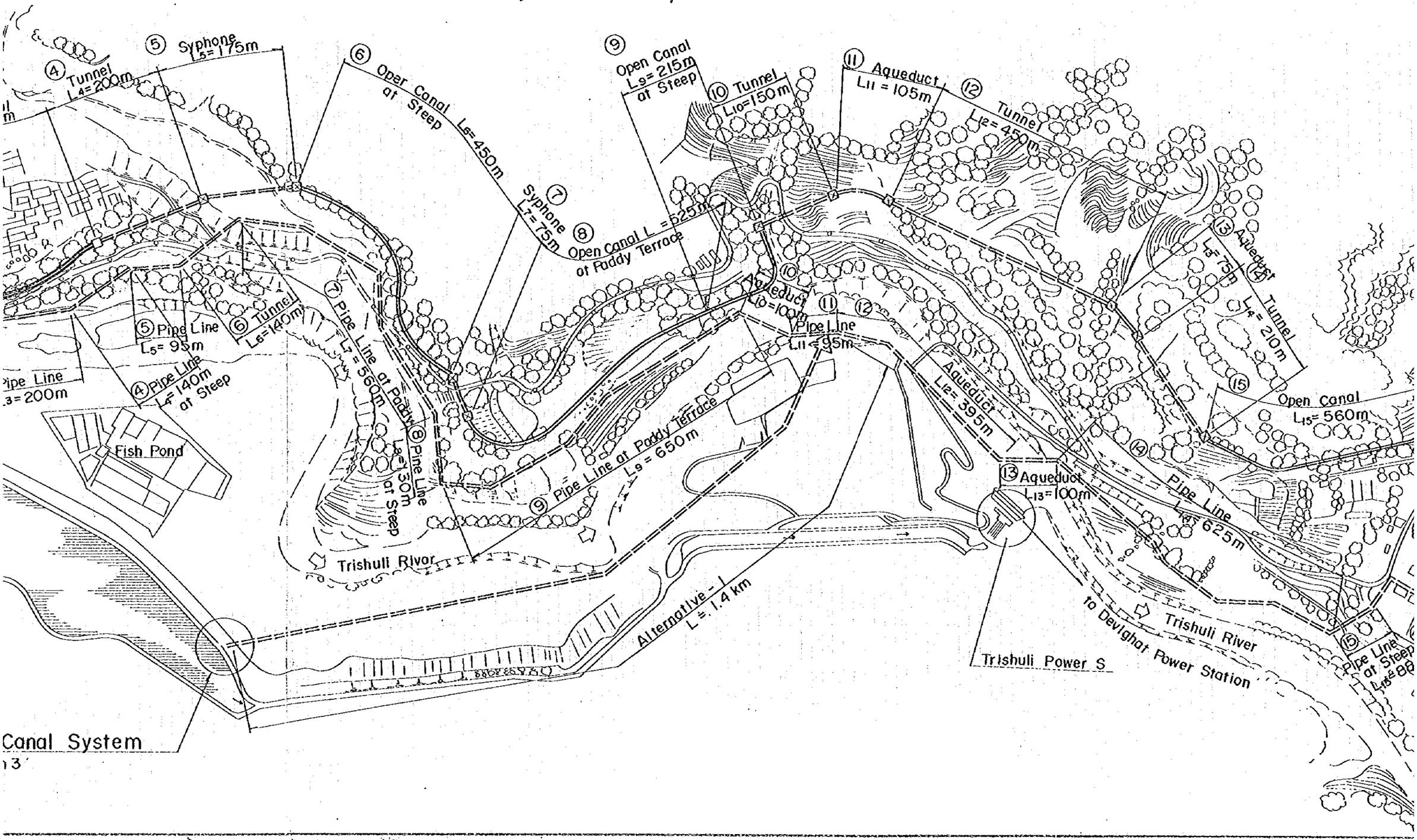


Fig. 5.5.4-1 COMPARISON STUDY ON 3 SYSTEMS OF MAIN CANAL S = 1:12,500 (Based on Scale 1 to 25,000 Aerial Photo)

(1) Open Canal System : ΣL = 7,010 m
(2) Piped Canal System : ΣL = 7,310 m
(3) Alternative Canal System : ΣL = 5,325 m



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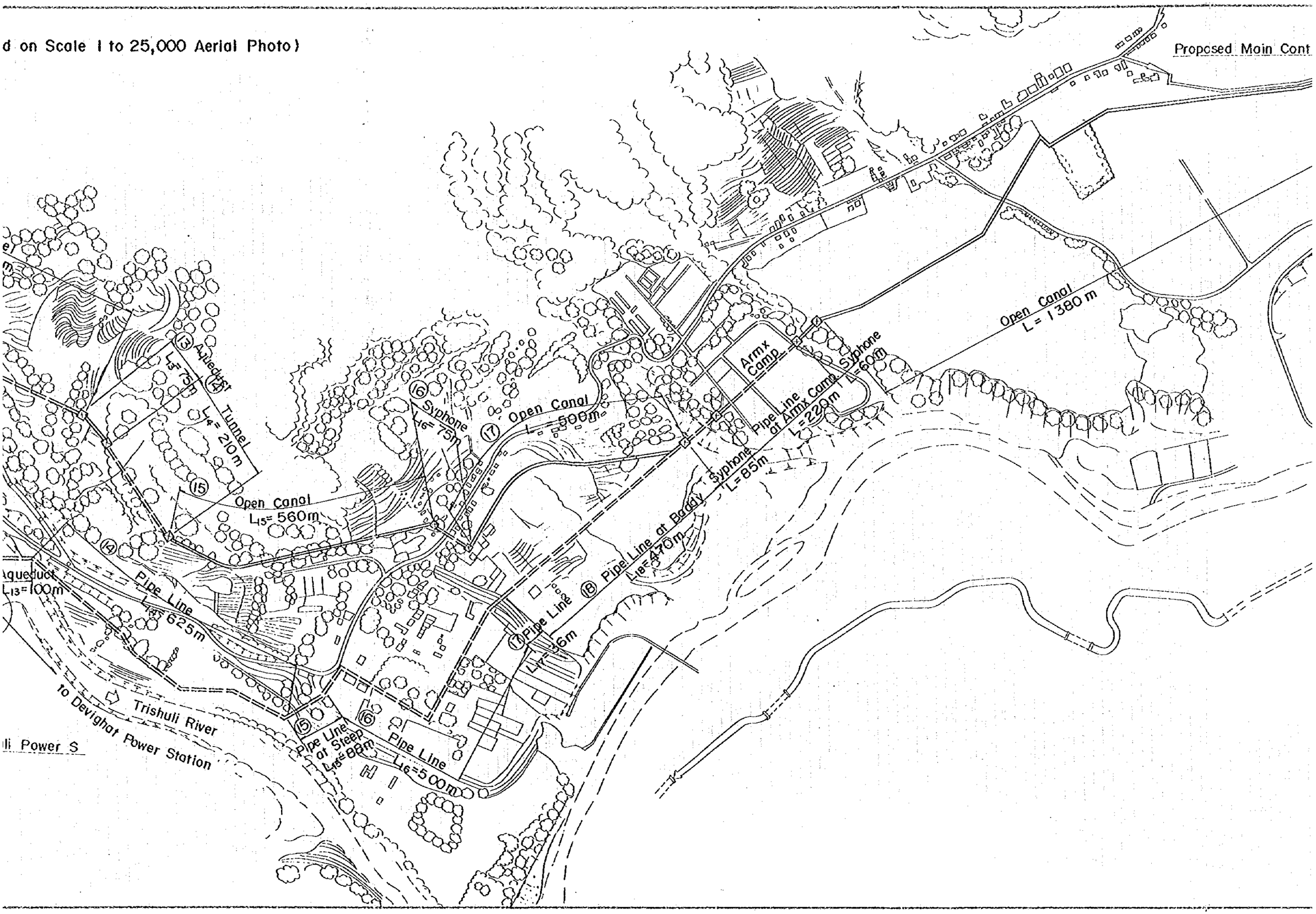

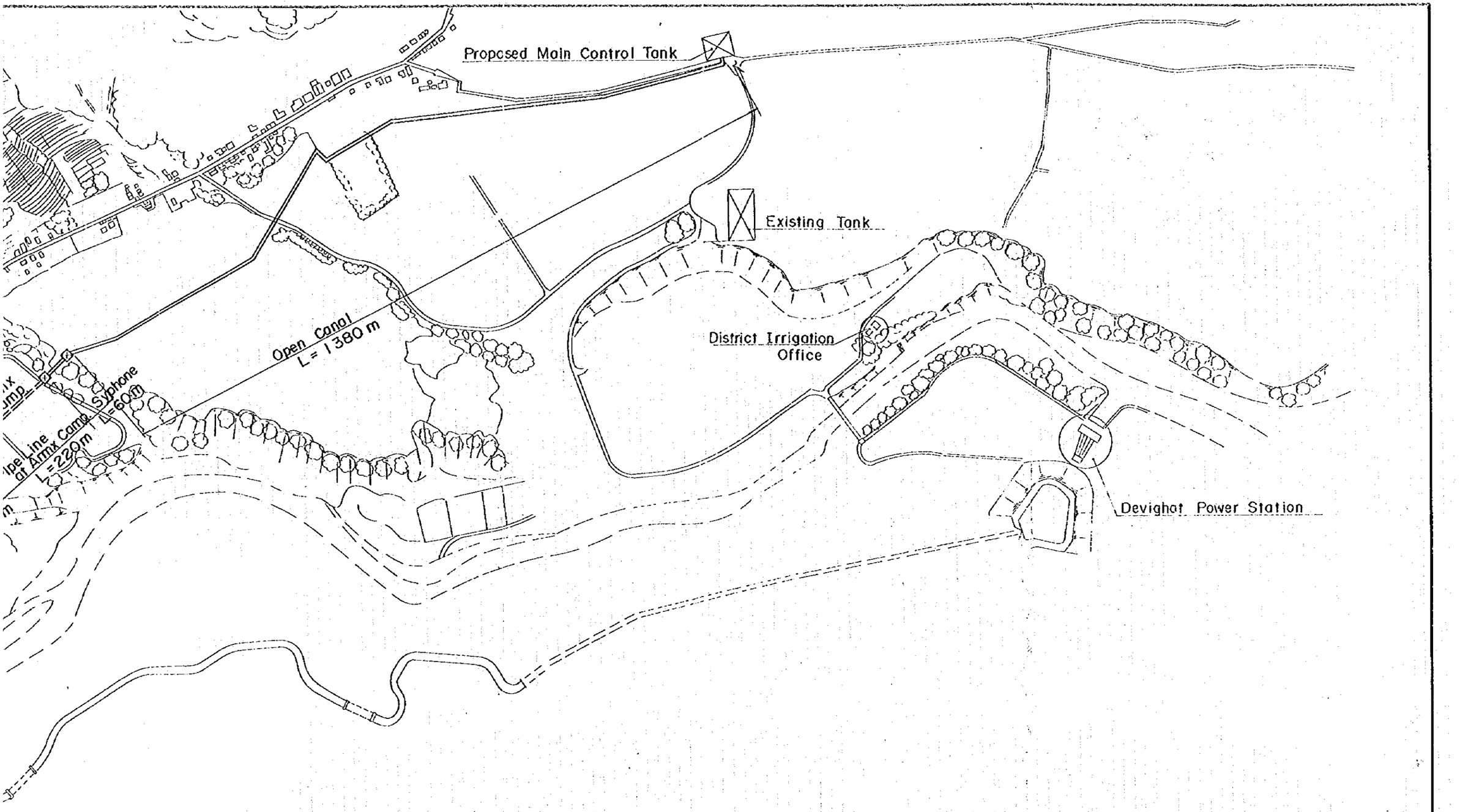

Fig. 5.5.4-1 Comparison Study on 3 Systems of Main Canal

5.5.5 Identification of Command Area

(1) Net Command Area

The command area during the initial proposal was 1000 ha but based on the topographic map (S=1:5,000) made by the JICA Study Team in February 1997, the command area was calculated at 758 ha including Pokhare Phant (Zone B) on the tailrace at the right bank of the Trishuli river.

The command area of the Study area proposed by DOI was identified by the Study Team as follows:

Name of Area	Proposed by DIO (Gross, ha)	Identified by the Study Team (Net, ha)
Zone A (L/B of Trishuli R.)		
1) Gravity Area	570	447.2
upper block	200	145.6
down block	370	301.6
2) Lift Area	230	182.0
Total 1)+2)	**800**	**629.2**
Zone B (R/B of Trishuli R.)		
	200	**128.5**
Total: Zone A+B	**1,000**	**757.7**

Note: Net command area blockwise and sub-block wise is shown in Table 5.5.5-1

(2) Irrigation System

Layout of the Proposed Irrigation System in 12 Blocks (A ~ L)

Some modifications were carried out by the Study Team for the case of gravity system and lift system based on present site conditions and topography.

Through the site survey, the Study Team divided the design irrigated area into 12 blocks (A to L), as shown in Figure 5.5.5-1.

The gravity irrigation system was adopted to the extent possible in consideration of the ease in operation and maintenance for the beneficiaries. In the case of the old Battar Lift Irrigation Scheme, areas such as Lam Bagaicha, Tallo Pipaltar, Devighat had been designed as pumped schemes. The Study Team identified and proposed to supply water through a gravity system for the above areas.

Six lift irrigation schemes including isolated areas above the intake water level were identified in the Study Area as follows:

Pump Station	Tar	Command Area (ha)	Actual Pump Head (m)	Located Block
P1	Majhitar	46	35	I
P2	Pipaltar	136	45	J, K
P3a+P3b	Pokhare Phant	129	50+30	L
P4	Battar	17	30	C
P5	Bidur	8	5	B
P6	Dhansar	12	15	D
Total		348 ha		

Table 5.5.5-1 Net Command Area in Blockwise

	Irrigation Block	Sub-block	Location	Municipality/VDC	Command Area (ha) Sub-block Gravity	Lift	Block Total	L:Lift G:Gravity
Zone A	<Gravity Area>							
	A	A1	Gerkhutar	Gerkhu VDC	8.56			G
		A2	Simbutar	Bidur-1	5.58			G
		A3	Gerkhutar+Simbutar	Bidur-1	9.17		23.31	G
	B	B1	Dhunge	Bidur-1	2.17			G
		B2	Horticulture Farm	Bidur-1	11.93			G
		B3	Trishuli Hotel	Bidur-3	3.99			G
		B4	Bidur	Bidur-4	10.76			G
		B5	Bidur	Bidur-4	11.25			G
		B6	Bidur	Bidur-3		7.89	47.99	L
	C	C1	Battar + Damaki	Bidur-3 & 4		17.59		L
		C2	Sukumbasitol (Battar)	Bidur-4	21.04			G
		C3	Battar Campus	Bidur-4	11.67			G
		C4	Battar	Battar-4	11.20			G
		C5	Battar	Bidur-4	12.80		74.30	G
	D	D1	Inarpati	Bidur-6	22.98			G
		D2	Inarpati	Bidur-6	17.50			G
		D3	Gangate & Ghadigaon	Bidur-6	8.27			G
		D4	Ghadigaon	Bidur-6	7.00			G
		D5	Ghadigaon	Bidur-6	9.06			G
		D6	Chwadi Kuwa	Bidur-6	4.00			G
		D7	Dhansar	Bidur-5		12.55	81.36	L
	E	E1	Dihigau	Bidur-6	8.00			G
		E2	Maharanidihi	Bidur-6	17.00			G
		E3	Maharanidihi	Bidur-6	7.67			G
		E4	Dihigaon	Bidur-6	12.40			G
		E5	Maharanidihi	Bidur-6	19.47			G
		E6	Chandipokhari	Bidur-6	14.82			G
		E7	Chandipokhari	Bidur-6	11.76			G
		E8	Chandipokhari	Bidur-6	10.04			G
		E9	Chandipokhari	Bidur-6	3.05		104.21	G
	F	F1	Chwadi	Bidur-6	4.22			G
		F2	Chandipokhari	Bidur-6	8.31			G
		F3	Lambagaicha	Bidur-7	10.28			G
		F4	Lam Bagaicha	Bidur-7	7.09		29.90	G
	G	G1	Tallo Pipaltar	Bidur-7	22.00			G
		G2	Tallo Pipaltar	Bidur-7	12.20			G
		G2	Tallo Pipaltar	Bidur-7	17.34		51.54	G
	H	H1	Deurali	Bidur-7	3.61			G
		H2	Devighat	Bidur-7	3.00			G
		H3	Devighat	Bidur-7	13.72			G
		H4	Devighat	Bidur-7	14.26		34.59	G
	<Gravity Area>Total (Block A ~H)				409.17	38.03	447.20	
	<Lift Area>							
	I	I1	Majhitar	Bidur-5		7.40		L
		I2	Majhitar	Bidur-5		17.80		L
		I3	Majhitar	Bidur-5		9.00		L
		I4	Majhitar	Bidur-5		12.00	46.20	L
	J	J1	Thulogaon (Pipaltar)	Bidur-5		9.30		L
		J2	Majhagaon (Pipaltar)	Bidur-5		12.40		L
		J3	Thulogaon (Pipaltar)	Bidur-5		9.75		L
		J4	Thulogaon (Pipaltar)	Bidur-5		5.66		L
		J5	Majhagaon (Pipaltar)	Bidur-5		15.00		L
		J6	Chwadi (School)	Bidur-5		4.69	56.80	L
	K	K1	Tallogaon (Pipaltar)	Bidur-5		6.30		L
		K2	Tadi bank	Bidur-5		9.85		L
		K3	Tallogaon (Pipaltar)	Bidur-7		9.10		L
		K4	Pipaltar	Bidur-7		14.64		L
		K5	Pipaltar	Bidur-7		17.17		L
		K6	Pipaltar	Bidur-7		10.16		L
		K7	Pipaltar	Bidur-7		11.80	79.02	L
	<Lift Area>Total (Block I, J, K)				0.00	182.02	182.02	
	Zone A Total (Block A ~ K)				409.17	220.05	629.22	
					Low Head	High Head		
Zone B	L	L1	L1-1	Philkep-Devighat Khadgabhanjyang	7.63			L
			L1-2	Pokharephant Khadgabhanjyang	31.12			L
			L1-3	Dhodeni Khadgabhanjyang	21.68			L
			L1-4	Sirkhali Khadgabhanjyang	20.98			L
			L1-5	Kumaltar Khadgabhanjyang	13.59			L
		L2	L2-1	Majhigaon Khadgabhanjyang		8.79		L
			L2-2	Pokharephant Khadgabhanjyang		9.81		L
			L2-3	Sirkhali Khadgabhanjyang		11.52		L
			L2-4	Kumaltar Khadgabhanjyang		3.40		L
	Zone B Total (Block L)				95.00	33.52	128.52	
Net Command Area Grand Total (Zone A + B)							757.74	

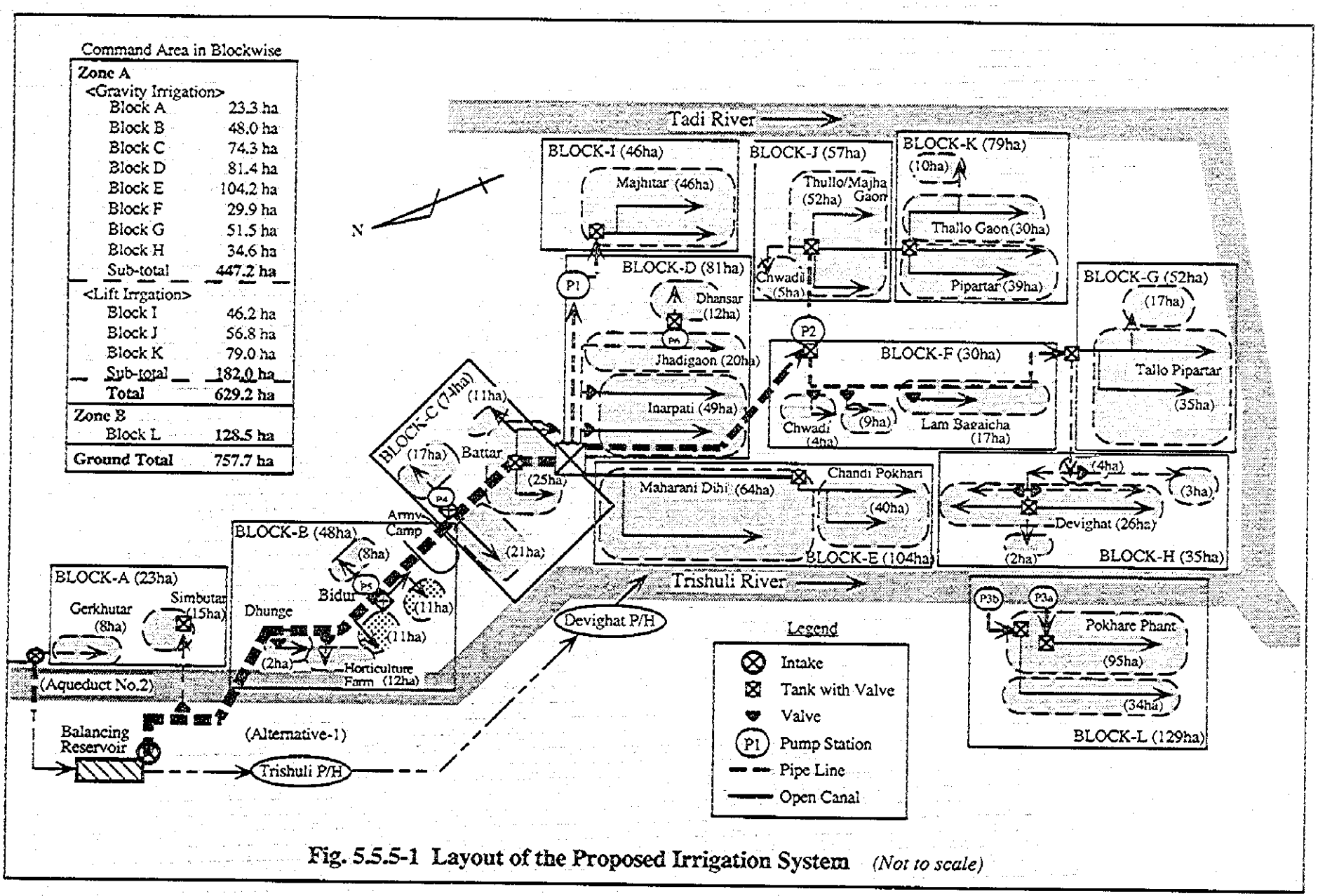

Fig. 5.5.5-1 Layout of the Proposed Irrigation System *(Not to scale)*