PLANNING AND LAYOUT OF A RUN-OF RIVER HYDROPOWER SCHEME WITH PONDAGE - A CASE STUDY

A DISSERTATION

Submitted in partial fulfillment of the requirements for the award of the degree of

MASTER OF TECHNOLOGY

in

WATER RESOURCES DEVELOPMENT

By

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CANDIDATE'S DECLARATION

I hereby declare that the work, which is being presented in the dissertation entitled "**PLANNING AND LAYOUT OF A RUN-OF-RIVER HYDROPOWER SCHEME WITH PONDAGE – A CASE STUDY**" submitted, in partial fulfillment of the requirement for award of the degree of **MASTER OF TECHNOLOGY** in **WATER RESOURCES DEVELOPMENT** at **DEPARTMENT** of **WATER RESOURCES DEVELOPMENT AND MANAGEMENT,** of Indian Institute of Technology Roorkee, is an authentic record of my own work carried out for a period from July, 2005 to June, 2006 under the supervision of **Prof. Gopal Chauhan**, Professor, and **Dr. B. N. Asthana**, Ex-Visiting Professor, in the department of Water Resources Development and Management, Indian Institute of Technology Roorkee, India.

The matter embodied in this dissertation has not been submitted by me for the award of any other degree.

Date: 27th June, 2006
Place: Roorkee

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This is to certify that the above mentioned statement made by the candidate is correct to the best of our knowledge.

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AK Maurya

27th June,2006 **(ATUL KUMAR MAURYA)**

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SYNOPSIS

The estimated hydro power potential in India is about 84000 MW at 60 % load factor, out of which only 32326 MW has so far been harnessed. Its share in total energy generation is about 25.9 % whereas for efficient power system it shall be 40 % as per CEA norms. At present time the peak power shortage is of the order of 12.5 %, so for improvement of present power situation it is required to harness more and more hydropower potential of our country.

Hydro power generation can be possible either by storage schemes or by run-of-river schemes. There are lot of problems which are associated with storage schemes, hence run-of-river schemes are more appealing and out of 845 total identified hydro electric sites 514 are run-of-river schemes. This study deals with planning and layout of run-of-river schemes with pondage with a case study of Luhri hydro electric project.

The study gives the basic idea about planning of a run-of-river hydropower scheme, the data, the information, and the investigation required to develop a scheme to harness the potential of stream. Besides this, study deals with the layout of different component of project. There is no unique solution to the problems of any project, the solution are generally site specific.

There is no general criteria for energy planning, different criteria for planning energy generation from run-of-river schemes given by different authors (Mosonyi, G. Brown, Nigam) has been reviewed, and accordingly the energy planning is done for case of Luhri hydro electric project. As the pondage is associated with the case study, so valuable peaking energy assessment is also worked out which is supposed to be derived from this project. The study also

includes the design principles of various structures and these are illustrated with the dimensioning of structures of Luhri hydro power project.

INTRODUCTION

1.0. GENERAL

The complication of new power house is a homage to the well known scientist, Michael Faraday, who showed in the 19th century that when a coil of conductor is rotated in a magnetic field then electricity flows in the coil. This basic scientific principle was utilized by Thomas Alva Edison in his invention of first electrical generator which has become the basis for all generating equipment used in the different types of power houses already constructed throughout the world.

The type of prime mover utilized for the rotation of coil designates the type of power station. In a hydro electric power station, water which acts as a prime mover to rotate the turbine, which is coupled to the generator rotor.

Hydropower is a renewable, cost effective, nonpolluting and environmentally benign source of energy as compared to other conventional sources such as thermal and nuclear.

1.1. HYDRO POWER DEVELOPMENT SCENARIO

- First hydro power plant started in 1882 in WISCONSIN (USA).
- In India first hydro power plant was started in Darjeeling (2 X 65kW). In 1897, still in operation.
- In northern India, in 1913 at Upper Ganga Canal, at Pathree (Haradwar).
- In India, in 1950 total installed capacity of 1320 MW in which share of hydropower was 508 MW (38.48 %).
- In 1963, share of hydropower was 46%, which has declined since then to 25.9% as on date.

Consumption of electrical energy is an index of the economical and industrial development of the nation and the quality of life. The annual per capita power consumption (in kWh) in our country is about 606 (May-2006), which is lower than world average of 1000 and much more lower then developed countries (USA 13,800, Australia 9950, France 7500, South Korea 5552).

- The latest demand projection indicates a peak demand of about 1,57,000 MW and energy requirement of about 975 billion units at the end of 11th plan (2011-12)
- To meet this demand, total installed capacity of about 2,12,000 MW would be required at the end of 11th plan which means about 1,02,000 MW capacity is to be added without any retirement of unit[(11)].
- Presently the country is facing 8.3% shortage of energy and 12.5% in peak demand load.
- India is endowed with enormous economically exploitable and viable hydro potential equivalent to 1,50,000 MW of installed capacity (2,50,000 MW of installed capacity when pumped storage projects and small scale hydro-schemes are included) out of which only 32326 MW 21.55% has been harnessed.

A study made by Central Electricity Authority reveals that, out of 845 total identified hydro electric sites with a potential of 84044 MW at 60% load factor, 514 sites fall in the category of run of the river scheme.

The unfavorable hydro thermal mix reduces the operating plant load factor of thermal power plant, which not only adversely affects the efficiency of the power system and plants life but also necessitates burning of huge amount of valuable petroleum fuel.

Hydropower stations have inherent quality for quick starting, stopping, load variation and help in improving reliability of the power system, so the hydro stations are suitable for peaking stations. The study by CEA revels that for an efficient power system a share of 40% for hydro power in total energy generation is desirable for better grid/system efficiency and stability. Presently this share of hydropower is 25.9%, which is much far behind than required. Therefore there is great urge to accelerate the hydropower generation in our country. This development can be of run-of-river type of storage type.

The construction of a storage reservoir involves some major problem such as submergence rehabilitation, political interference, long gestation period etc.

So it is better option to go for development of run-of-the river hydro schemes, and as stated earlier that we are short in 12.5% in peak demand, if it is possibe to create pondage, with a run-of-river scheme, then peaking shortage may meet out up to some extent.

1.2. SCOPE OF STUDY

This study is associated with general planning and design for development of run-of-river scheme with pondage. The planning and design concepts are illustrated through a case study.

1.3. ORGANISATION OF DISSERTATION REPORT

Chapter 1: Gives an introduction to the dissertation work, describing the various aspects of the whole work.

Chapter 2: Gives the overview of present power scenario of India.

Chapter 3: Deals with the planning, investigations which are required for development of hydropower scheme.

Chapter 4: Throws light on the lay out of hydropower scheme, few ideas about the main component of a scheme are given.

Chapter 5: Highlights approach for energy planning based on different flow duration curves and also literature review for use of flow duration curve for energy planning.

Chapter 6: Gives brief idea about the Luhri hydro electric project, which is taken as a case study under this work.

Chapter 7: Deals with the hydrology of the project under taken, correlation of existing 10 daily data is done and different FDC's have been constructed by using 10 daily discharge data.

Chapter 8: Analysis of energy generation is done and different losses are calculated in this chapter, it has been described how to get the appropriate installed capacity for development of a hydro power scheme, power generation and peaking studies.

Chapter 9: Gives brief idea about the layout of different component of run-of-river scheme with pondage, and dimensioning of some main components.

Chapter 10: Conclusion and discussion.

POWER SCENARIO IN INDIA

2.0. GENERAL

Electricity is most sought after form of energy on account of evolution of more and more convenient and efficient processes of transmission of electrical energy over long distances from the place of production and development to its multifarious uses for service of human being. Per capita consumption has become the index of advancement and prosperity of any country or nation. In India this index has varied over the years as given in Table 2.1.

Table. 2.1: Per capita consumption of electricity energy

Year	Per capita electricity consumption
1947	14 KWH/ Year
1991	236 KWH / Year
2003	350 KWH/ Year
2006	606KWH/Year

(Source- Reference 11 & 26)

The annual per capita power consumption (in kWh) in the country is about 606 (May 2006, reference 26), which is lower than world average of 1000 and much more lower than in developed countries, i.e. in USA it is 13,800, Australia 9950, France 7500, Israel 6340, South Korea 5552 etc. The scenario of power and energy (April 2005 – Feb 2006) with reference to demand and supply is given in Table 2.2

Table. 2.2 : Supply and demand of energy in India

	Demand	Supply	Surplus/ Deficit
Energy	57,5384 MU	52,7539 MU	- 8.3 %
Peak Demand	92,968 MW	81,370 MW	- 12.5 %

(Source- Reference 26)

2.1. MAJOR SOURCES OF ENERGY

Main sources of energy which are being utilized for generation are of two types:

a) Non- renewable

b) Renewable

In non-renewable, electricity can be generated by fuels (in all forms – solid, liquid and gaseous).

In renewable source, we have water energy, sun, wind, and tides, but except water these have so far not used for generation of electricity to an appreciable extent. These except water energy are known as non-conventional source of energy. Development of power from tides has made noticeable start in France. In India a tidal power station of 900 MW capacity has been in planning stage for Gujarat (Kachha). Solar & wind energy development has made a start in India. Wind energy plants to an aggregate capacities of around 4000 MW have installed.

Different sources of energy as mentioned above are unevenly distributed in India and also in other countries of the world.

2.2. WATER RESOURCES IN INDIA

The available surface water resources of India have been assessed as 180 million ha-m. It has been estimated that on account of limitations of rainfall distribution, physiographic, topographic, geological, social, political constraints etc. only 69 million ha-m can be utilized, which is 38% of total available water resources. Out of which 31.2 million ha-m is used for run-of- river schemes for power generation which is 17% of total water resources of the country[12].

2.3. POWER DEVELOPMENT IN INDIA

The power sector since independence has gone a tremendous change and grown from 1364 MW in 1947 to about 1,24,827 MW in 2006. Development of hydro electric potential of India is being presently favoured due to its inherent advantage over thermal and nuclear power such as renewable resource, non-polluting, eco-friendly, low cost, immediate load variation.

Utilization of coal or any other fuel for generation of electricity will naturally be restricted to available resources. Nuclear energy will also depend on the particular type of mineral deposit which serves as raw material.

With the present rate of energy consumption, India and the whole world would not be left with any oil or gas by the 2050 AD. Even coal reserves are not infinite[11].

Effective handling of fly ash of thermal plant and disposal of solid radioactive waste of nuclear power plant are a great concern today. Thermal plants in India generates different type of waste annually as given in table 2.3.

Table. 2.3 : Type of waste generate

Sl No.	Type of Waste	Quantity (in million Tones)
1	Fly Ash	75
2	CO_2	290
3	SO_2	2.25
4	NO_2	1.71

(Source – Reference 11)

A speedy harnessing of vast eco-friendly hydro potential should has a preference over the thermal / nuclear options. An ideal hydro thermal mix of 40: 60 for optimum operation of the system is emphasised by C.E.A.. The present ratio of 26:74 needs to be corrected to meet peak load requirements as well as to achieve system and frequency stability.

The unfavorable hydro thermal mix reduces the operating plant load factor of thermal power plant, which not only adversely affects the efficiency of the power system and plant life but also necessitates burning of huge amount of valuable fuel. The contribution of different sources to power generation is given (May 2006) in table 2.4:

Table.2.4 : Contribution of different source of power

Sl. No.	Source of Power	Contribution	Percentage
1	Thermal Coal Gas oil	78491 MW 68519 MW 12690 MW 1201 MW	66 % 54.8 % 10.2 % 1.0 %
2	Nuclear	3900 MW	3.1 %
3	Hydro	32326 MW	25.9 %
4	Renewable	6191 MW	5.0 %
	Total	124827MW	

(Source – Reference 26)

2.4. ADVANTAGES OF HYDROPOWER OVER THERMAL

Besides the availability for unlimited period hydropower possesses a number of other inherent advantages over thermal and nuclear power such as:

(i) Hydropower stations can be started and stopped instantaneously and help in stabilizing the grid.

(ii) Hydropower development is eco-friendly. It does not have any adverse impact on environment unlike thermal and nuclear plants.

(iii) Hydro power possesses/ confirms non-consumptive use of natural and annually renewable source.

(iv) Operation and maintenance cost is less. Input cost is nil. Thermal has increasing input cost. Average cost of hydro power generation is 1/3rd to 1/4th of thermal[18].

(v) Life of the machines and powerhouse is more. The life of hydropower plant is taken as 60 years as compared to 35 years for steam power.

(vi) The coal based thermal plants consume about 10% of the power generation for its own power station auxiliaries and to that extent the load carrying capacity of the thermal unit is reduced and the same would therefore have the effect of increasing the capital cost of the thermal plant.

Recently concluded study by CEA indicates that reduction of 1 MW of hydro capacity in the optimal power plan, on an average would require addition of 1.6 MW of thermal power project which would increase the investment accordingly (source –reference 11).

2.5. HYDROELECTRIC POTENTIAL IN INDIA

2.5.1. Historical Development

In India first hydropower station was commissioned in year of 1897, at Darjeeling, with installed capacity of 2 x 65 KW[15].

The first power station with significant installed capacity of 4.5 MW was constructed as Sivasamudram in Karnataka in 1902. This power station is still in the operational stage, even more than 100 years elapsed.

The installed capacity of hydropower plant is 32326 MW accounting for 25.9% of total installed capacity.

The total assessed potential of hydropower at 60% load factor is 84,044 MW with probable installed capacity of 1,48,699 MW. Following table gives the break up of type of hydro power development

Table. 2.5 : Type of hydro schemes

Number of Schemes			Potential at 60 % load factor
Storage	Run of river	Total	
331	514	845	84044 MW

2.5.2. Future of Hydro Power Development

It is evident from above data that India has an enormous Hydro Electric Power potential of 84044 MW at 60% load factor assessed by CEA from a total of 845 hydroelectric schemes identified in various river basins.

These 845 schemes include 514 run-of-river schemes and rests are storage schemes. The high cost of construction, geological complexities large gestation period, environmental and rehabilitation problems as well as the resource crunch are the factors which have retarded the rate of development through storage schemes.

Thus, development of hydropower through run-of-the river schemes has to be expedited. These can be attractive to private sector also because of less problems and incentives by the Government. This is therefore the subject of this study.

PLANNING AND INVESTIGATION

3.1. PLANNING

Planning can be defined as the orderly consideration of a project from the original statement of purpose through the evaluation of alternatives to final decision on a course of action.

There may be several feasible sites for a proposed hydroelectric plant. Hence it often entails comparison of many alternatives. The steps involved are:

(a) Collect the hydrological data on the streams, and determine the amount of water available and its distribution throughout the year and from year to year.

(b) Make preliminary design for all installations which seem competitive in cost, and determine the most economic design at each site by comparison of costs and estimated power revenues, but if we want to harness more power from same project then we must go for less economic installation.

- Select feasible project sites as close to the load center as possible.
- Compare the best options from the several sites, and select the site or combination of sites which proves best for production of the required amount of power, often this selection is guided somewhat by estimated future requirements and the possibilities of expansion to meet them.

3.2. REQUIRED DATA FOR PLANNING

For planning of a scheme lot of data is required as described below:

3.2.1. Water Resources

(i) **Hydrology:** Precipitation, stream flow, evaporation, water quality. Water availability is the life line of any hydroelectric scheme. The success of the scheme depends on how accurate has been the estimation of total quantity of water available and is variability.

(ii) **Sediment and Soil Erosion :** In Himalayan region soil erosion is major problem for hydroelectric developments. Sedimentation reduces the storage capacity of dam. Sediment particles cause abrasion of turbine runner. The knowledge of type and composition of sediment and extent of soil erosion is necessary for planning and design of hydropower scheme.

(iii) Groundwater and soil survey and also cartographic maps.

3.2.2. Other Basic Resources:

(i) **Geology :** which type of minerals are deposited in proposed reservoir site, about there solubility in water.

(ii) **Ecologic :** The over all ecology of the region likely to be effected by construction and operation of hydroelectric project. It is there fore necessary to make at least surveys and investigations of vegetation, fish and wild life.

(iii) **Economic :** industry, transportation, markets, tourism, recreation. Such study gives the picture of region with reference to economic growth and economic growth is directly related to power consumption.

3.2.3. Constraints

(i) **Law** : water rights, pollution control, land zoning, land ownership, administrative patterns.

(ii) **Public Opinion:** Either the public is in favor of the project or in opposition of the project.

(iii) **Existing Projects** : How many projects exist in surrounding area and in which manner they effect, e.g. some time tail water level affects the FRL of proposed project.

3.2.4. Special Data

(a) Agriculture

(i) Land classification

(ii) Crop water requirements

(iii) Climatic limitations.

Above information is required to get the agriculture water demand if irrigation is also a component of project.

(b) Municipal Uses

(i) Industrial water needs – quantity and quality

(ii) Population water needs.

Such information is required for release of water (after construction of project) for industries and population of down stream.

(c) Hydropower

(i) Projected needs- if the project would be isolated then future projected demand of power is very important for planning.

(ii) Alternate sources.

(d) Flood mitigation

(i) Extent of past flooding and damages.

(ii) Local storm drainage requirements.

(e) Navigation

(i) Present water traffic patterns.

(ii) Alternatives – roads, rail roads, air ways.

(f) Recreation

Natural attractions.

(g) Pollution Control

(i) Existing waste discharge – location, time, and character of water.

(ii) Water pollution regulations or quality standard.

3.2.5. Projections

(i) Population – place and time.

(ii) Land use – place and time

(iii) Economic – market, tourism etc.

(iv) Agriculture

(a) markets

(b) crops

(c) technological development

(d) Water demand.

(v) Power

(a) market and demand

(b) growth of alternate sources

(c) technological improvements

(vi) Flood control

(i) Projected flood damage – place and frequency

(ii) Possibilities of flood warning.

(vii) Pollution

(a) Anticipated quantities and characteristics of waste.

(b) Technological advances.

3.3. SITE INVESTIGATIONS

The scope and extent of the site investigations depends partly on the availability of existing data, partly on the nature and size of the proposed development, and partly on the opportunities or difficulties posed by the existing topographical and geological features of the site. These in turn will affect the number of alternatives which have to be worked out.

It is, however, usual for both office studies and site investigations to be carried out in two main stages – preliminary and final and within these stages the investigations might be placed in four following broad categories.

i) Hydrological

ii) Topographical

iii) Geological

iv) Metereological

3.3.1. Preliminary Investigations

The purpose of the preliminary investigations is to provide sufficient information to confirm the feasibility of any proposed scheme of development, and to compare and choose between alternative schemes or arrangements, so that preliminary designs and estimates can be prepared and recommendations made with reasonable confidence. These preliminary investigations generally include the following studies on the existing documented data:

i) **Hydrological Studies:** overall rainfall and run off data, river flow data, flood characteristics etc.

ii) **Topographical Studies:** Tacheometric, aerial or other surveys depending on existing information and maps.

iii) **Geological Studies:** Overall geological characteristic and local features should be studied from available information and maps. Some sub-surface investigations by boring and by geophysical exploration; preliminary reconnaissance surveys for construction materials etc. The scope of investigations during preliminary stage is confined to the selection of the most suitable sites from the geological stand point, besides satisfying the engineering requirements. The investigation should proceed with 1:50000 available map to establish broad geomorphological features. Lithological characters and altitude of the host rock and its major jointing and shear zone pattern, the major structural and tectonic features such as folds, faults and thrusts should be recorded and their significance in terms of the seismicity of the area should be evaluated. After eliminating obviously unsatisfactory sites, reconnaissance stage explorations should be done to establish the nature and extent of overburden cover and major active or potential slide features along the slope. Preferably, thinly bedded fissile and highly fractured rocks should be avoided; slope configuration should be studied with reference to instability and availability of sound rock cover over the cavity.

3.3.2. Final investigations

The final investigations comprise the detailed exploration of the finally selected site (or sites) so as to establish beyond doubt their techno-economic suitability and to enable the final designs and contract documents to be prepared with the least chance of serious alteration after the contract has been let. The final investigations will generally be.

(a) Hydrological: Rain fall and run off data of the site for a considerable long period.

(b) Topographical: Preparation of accurate large scale maps for the site of all important structures.

(c) Geological: Detailed sub-surface investigation by excavation, boring, drilling etc; rigorous sampling and testing of materials; permeability and grouting tests, etc to give a complete picture of the geological features of the site.

(d) Meteorological: It include climatic data.

Cost: The cost of site investigations in relation to the total cost of the development is a matter on which no general rule can be given.

It is also necessary to remember that economy in the cost of site investigations may be completely lost later by delays and added construction cost arising from inadequate investigations. The investigation cost varies from project to project in the range of 0.5 to 2.5 % of the project cost.

3.4. HYDROLOGICAL INVESTIGATIONS

Run off data – Data of river flows observed or computed for a long period is essential to work out power potential of the selected site. It often happens that more data about the rainfall in the catchment area is available than the flow data in the stream or river.

Rainfall data, however, can be related to short period run-off data and used for extending the run-off series. However, run off data is obtained by flow-gauging of the river preferably at the proposed site of river diversion.

3.4.1. Water Availability Data for Power Studies

Long term discharge data at proposed site

10 day runoff (discharge) data i.e. mean discharge of 10 days at proposed site for the last 25-30 years is required to work out water availability for power generation.

Long term rainfall data for the proposed site

If direct observation of discharge at site is not available for long period, 10 day rainfall data for the last 30 years of the Indian Meteorological Department (I.M.D.) rain gauge stations influencing the catchments of the proposed site should be collected for computation of run off series to be used for working out power potential

- No rainfall and discharge data is available:

In such case the data of adjoining rivers/ catchment is used to develop the run off data at the proposed site.

- If discharge data of same river at other site is available:

In such case the data of other site is reduced in proportion to the area at both sites to obtain the discharges at the proposed site.

3.4.2. Direct Observation Method

When observed / computed discharge series at proposed site is available for last 30 years or so: The annual runoff is generally computed from 10 daily discharges and arranged in the descending order. The year for a particular dependability such as 90 %, 75 %, 50 % is calculated from (n+1) years where n is the number of years for which run off data is available.

3.4.3. Stage-Discharge Data

Once the basic details of the development scheme have been decided, it is necessary to determine, as accurately as possible, the stage discharge data is obtained either by direct observations or by computations, to work out the design of structures and the TWL for working out gross head.

3.4.4. Water Table

The ground water table and its fluctuations at the site of various structures are required for planning, design and construction of works.

3.4.5. Design Flood

Another important aspect of hydrological data is the estimation of peak discharge which has to pass over the structure without endangering its safety. A very cautions and judicious approach is required in selecting design flood for a hydraulic structure. If the selected design flood is too high, it will result in a conservative and costly structure and if low, it may cause danger to the structure. Thus the design flood is fixed depending upon the importance of the structure and the amount of damage that its failure may cause. The frequency analysis with the observed flow data is generally carried out to determine design flood. If data is not available other empirical or semi empirical method are adopted which are based on catchment characteristics.

3.5. GEOLOGICAL INVESTIGATIONS

Geological conditions largely influence the location and type of structures, and the reconnaissance survey should provide sufficient information to assure the designers that the sites chosen for diversion work, tunnels etc, are not only feasible, but that they will not involve unduly heavy construction cost. The survey should also include an assessment of valuable mineral deposits in the reservoir and existing and potential slide areas.

If diversion structure is in form of a dam, then the site and the entire reservoir area must be sufficiently water tight to avoid undue seepage losses.

The object of geological investigation is to provide the most complete and accurate picture possible of the character of the ground upon, or through which the work of proposed hydro-electric project may be constructed.

Geological surveying calls for imaginative and expert interpretation of data derived from various field reconnaissance, sub-surface exploration, geophysical methods, or aerial photographs. For this very close collaboration with, experts in geology and soil mechanics are required.

By geological investigations attempt is made to get the following essential data:

(i) Report on the overall geological structure and history of the area, with general geological plans and sections. This should indicate locations of faults slip-plans, crush-bands, buried river courses, and other potential sources of structural instability or leakage.

(ii) Record plans and field logs of all borings, shafts, adits, galleries, etc. Recorded data should include drilling speed; rate of water loss, standing water levels, percentage core recovery, etc. and all other pertinent information which will facilitate correct interpretations.

(iii) Laboratory test records: Chemical analyses, mechanical properties of test, permeability test.

(iv) Site test records, including: Loading test, permeability & grouting test.

(v) Construction material report: Sources of supply and quantities to available means of access, ownership, royalties, etc. Facilities for washing or processing, etc.

The geological report is most conveniently prepared in "preliminary" and "final" stages, since some amplification or modification is inevitable as the more detailed and site specific sub-surface exploration proceeds.

The preliminary stage report should, however, be prepared early and studied carefully before any large-scale sub-surface exploration works are undertaken.

3.5.1. Investigation for Different Structure

The geological investigation greatly facilitate comparison of alternative sites, and may serve as a basis for quantities used in preliminary cost estimates. Foundation investigation for earth / rock fill / masonry, concrete dams and other structures may be made as under.

3.5.1.1. Masonry and concrete dams

(i) Exploratory holes and / or drifts should cover the entire foundation and abutment area of the dam including energy dissipation structure. The location, spacing and depth of holes shall be decided according to the height of dam in consultation with an engineering geologist.

Description of logs for exploration should include ground elevation at the hole, location coordinates and sufficiently detailed remarks regarding the nature and type of rocks, geological structure, water loss etc. for a clear interpretation of the foundation conditions.

Contours of bed rock and geological structure of foundation strata should be presented.

(ii) Location and thickness of weathered, altered or otherwise softened zones and their characteristics and the structural weaknesses and discontinuities shall be investigated.

(iii) Tests for significant engineering properties of foundation rock such as density, absorption, permeability, compressive strength and strain characteristics (including the effect of moisture content) should be done and data presented. Where the type and / or structure of rock are such that its competency to ensure the stability of the dam against a sliding failure is in doubt, necessary in-situ shear tests should be done and data presented.

3.5.1.2. Barrages

In case of barrages the foundation investigations should be carried out for type of soil/ rock, bearing capacity, permeability etc under the area of the barrage and abutments.

3.5.1.3. Water Conductor System

(i) The L-Section of the water conductor system from intake structure to tail-race should be prepared. In power channel portion, trial pits of adequate depth should be put in at suitable intervals so as to indicate all changes of strata.

(ii) For tunnel, a geological section of the tunnel alignment and surge shaft and drill holes adequate to establish rock cover and important geological features should be drawn.

3.5.1.4. Power Station

(i) 2 to 4 drill hole details for the power station area may be given. The number, location, spacing and depth shall be decided in consultation with an engineering geologist of the Geological Survey of India.

(ii) The survey plan should cover an area sufficient to include switchyard and alternative plant lay-outs and should give contours at intervals of 5 m. Low water level, maximum observed flood level, rock out crops, sand shoals etc. at the power house site will be indicated therein.

(iii) Indications of slides and the possibility of rock fall in the hill slopes should be explored.

(iv) For underground power house, geological sections of power house, pressure tunnel, access tunnels and switchyard and sufficient drill holes / drifts to establish the geological features of the same are required.

(v) Ground water level at the power house site should be determined.

The following Table no 3.1 gives the minimum geological investigations required for different structures of a run-of-river project.

Table. 3.1: Location and depth of exploratory holes/ drifts / Pits etc.

	Structure	Pattern of Drilling	
		Spacing of drill holes / pits / drifts	Depth of drill holes / pits / drifts
	1	2	3
(a)	Earth and rock fill dam	Drill holes along the axis 150m or less apart, with intermediate pits to delineate weak and vulnerable strata with a minimum number of three to five holes in the gorge portion and additional two on each abutment parallel to the flow. Drift on each abutment at about 60m elevation interval with a min. of one on each abutment	Depth equals to half the height of dam at the elevation of the hole or 5m in the fresh rock (proved by the geophysical or any other suitable method) whichever is less. About two holes to be extended deep (equal to the maximum height of the Dam in the absence of rock at higher elevations), in the gorge portion and one each in abutments.

			Drifts to be extended 5m in geologically sound strata for keying the dam in the absence of rock.
(b)	Masonry and concrete dam	Drill holes along the axis at 100m interval or les apart to delineate weak and vulnerable strata with a minimum number of three to five holes in the gorge portion and additional two on each abutment parallel to the flow. Drifts on each abutment at about 60 m elevation interval, with a minimum of one on each abutment.	10 m in fresh rock (proved by geophysical or any other suitable method). About two holes to be extended deep (equal to the maximum height of the Dam in the gorge portion, and one each in abutment. 10 m in fresh rock (proved by geophysical or any other suitable method).
(c)	Tunnels	Drill holes one at each of the portal and adits sites and additional at least one every 1-5 km interval depending upon the length of the tunnel. Drift, one each at the portal and adit sites.	Drill holes 5-10 m below the tunnel grade of maximum possible depth. Wherever it is not possible to drill along the central line of the tunnel, the holes can be shifted. The explorations shall be so planned as to satisfactorily portray the geological structure and tunneling conditions. Drift shall be extended up to 10 m in fresh rock or up to tunnel face.
(d)	Barrage and Weirs	Drill holes along the axis, 150m or less apart with intermediate pits to delineate weak and vulnerable strata with a minimum of two additional	Drill hole 1.5-2 times of maximum head of wafer below the average foundation level or 5 m in the fresh rock whichever is less.

		holes on each abutment parallel to the flow.	.
(e)	Power house	Two to four or more drill holes and/or drifts covering the area to satisfatorcily portray the geological condition and delineate weak and vulnerable zones, if any.	Drill hole one to two times the maximum width of the structures or 5-10m in the fresh rock (proved by geophysical or any other method) whichever is less. For underground powerhouse, the strata shall be examined by the explorations, with adequate number of drill holes. If found feasible and necessary according to the site conditions, one drift with cross cut may be excavated at the roof level to prove fresh rock conditions along the length and breadth of the cavity structure.
(f)	Major Canal Structure	Sufficient number of drill holes with a minimum of three (one on each bank and one in the bed)	Twice the width of the foundation of the biggest component of structures below foundation level.
(d)	Canal and Water Conductor system	Drill holes or pits 500m or less apart to depicts the complete profiles details.	Equal to the full supply depth of canal or one meter below the design bed level in rock which ever is less.

Note:

1. A minimum pattern of drilling holes and excavation of pits and drifts has been suggested above. Additional holes shall be drilled and pits/drifts excavated in consultation with the Geologist/Research laboratory to bring out clearly the

foundation and abutment characteristics especially the weak zones requiring special treatment.

2. Disturbed and/or undisturbed soil samples, foundation of rock samples, etc. shall be collected and tested at an interval of 1.5 m depth or change of strata for laboratory tests. In situ permeability tests shall be carried out in the selected drill holes in different strata at different elevations. Other in situ tests, shear tests etc. shall be carried out in the hole or other suitable locations depending upon the nature of the strata and design requirements.
3. The bearings capacity test and in situ testing of the foundation rock shall be carried out for item (b) to (f) at average foundation level.
4. The plans and cross-sections shall be prepared on the scale as indicated in Table 3.2
5. The logs of the holes/pits/drifts shall be prepared as per I.S. Nos. 4453-1967 and 4464-1967.

In case the situation is near hilly slopes, stability of the hill slopes should be investigated. In situations subject to avalanche the extent of falling material should be studied. The creep of soil covered hill slopes should also be investigated.

In case of situation at high altitude, investigation should clearly bear out the suitability of foundation material with particular reference of the following conditions

(a) Permafrost;

(b) Stability of glacial and fluvoglacial material with a thin soil cap.

The presence and extent of artesian pressures below the foundation material should be investigated to determine whether the site is suitable for power house location or not.

3.6. TOPOGRAPHICAL INVESTIGATIONS

Survey of catchment, L-section of river and the site of important structures are essential for layout, planning, design and estimate of the structure.

Taking help of whatever maps already exist, it is desirable to make reconnaissance tours of the site for preliminary stage of investigation, but for final stage it is essential to carry out topographical surveys and prepare large-scale maps of selected sites for reservoirs, dams, and other important structures.

The following types of maps are generally required for planning & design of a scheme.

	Type of study		Type of map
a)	Alternative schemes of developments	(i)	General topography of catchments, scale between 1/100,000 and 1/50,000: level contours at 30 m or 15m intervals.
b)	Reservoir studies	(ii)	General purpose –local topography of selected valleys; scale about 1/10,000: CI = 3m or 6m.
		(iii)	Special purpose – detailed topography of areas affected by timber clearance, flooding or property, etc; scale about 1/1000: level contours at 2m, intervals or closer.
c)	Studies for dams, conduits power stations, etc	(iv)	Detailed topography of selected sites; scale from about 1/1000 to 1/250 : level contours at 2m or 1m interval

All the above maps may be produced either by ground surveying or aerial surveying methods. If a ground survey is adopted large scale maps such as (iii) and (iv) call for precise work with total station or by theodolite and level, while small –scale maps such as (i) and (ii) are often derived from less precise tachometer and plane-table surveys.

The main factors influencing choice between aerial and ground survey methods are

(a) Extent of area: In general, the greater the area to be surveyed the greater the opportunity for economy by aerial survey as compared with ground survey. This is particularly the case in undeveloped areas.

(b) Location and access: Distance to nearest habitable camp or supply base affects speed and cost of both ground and aerial surveys in general, the more dense the vegetations and difficult the access, the greater the case for adopting aerial survey, provided that this method will give an acceptable degree of accuracy.

(c) Climate- Seasonal extremes of temperature, rainfall, snowfall and ice, etc., limit the time available for survey work; while mist, low clouds, dust storm etc., may reduce visibility sufficiently to make aerial photography impossible at certain times of the year.

The details of topographical and geological surveying maps of various structures required for proper planning etc are given in Table 3.2

Table. 3.2:

	Area to be covered/Extent of surveys	Scale		Contour Interval	Remarks
		Horizontal	Vertical		
	1	2	3	4	5
1. (i)	**River Surveys (a) L- Section** Upstream L-section up to MWL+5 m or to a point up to which the backwater effect is likely to extend from the axis of the structure, whichever is less. In case of any headworks situated up-stream within MWL+5 m or the far these point affected by back water L-Section to be taken up to the headworks.	I: 10,000	1:100	-	Leveling at 50 m or less interval along the fair weather deep channel. Following items shall be indicated on the L-Section (i) Date of survey of the particular reach and water level on that day. (ii) Deep pools and rapids, rock outcrops etc. (iii) Maximum Historical observed HFL
(ii)	Downstream 10 km from the axis of the structure or up to nearest headwork whichever is less.	I: 10,000	1:100	-	-do-

(i)	**River Surveys (b) X-Section** **Upstream** X-Section @ 200 m interval up to MWL+5m or 1 km on either side of the firm bank which ever is less and for a distance of 2 km from the axis of the structure and thereafter at one km interval corresponding to the length of the L-Section.	1:2500	1:100	-	Leveling at 50 m or less intervals. Following items shall be shown on the cross sections – (a) Date of survey and water level on that day (b) Minimum Water Level (c) Maximum historical/Observed HFL (d) Rapids and Rock outcrops etc.
(ii)	**Down stream** X-Section @ 200 m interval unto historical/ observed HFL+1 m on either sides of firm bank for a distance of 2 to 5 km from the axis of the structure depending upon the meandering nature of the river.	1:2500	1:100	-	-do-
(ii)	Along the axis of the structure	1:2500	1:100	-	-do-
2.	**Reservoir** Contour Plan covering an area upto an elevation of MWL+5m.	1:2500	-	1 or 2	Contour interval for, slope less than 10^0 to horizontal – 1 m or less,

				or 3 m	slope 10^0 to 30^0 – 2 m and slope more than 30^0 – 3 m.
3.	**Dam and Dyke** Grid plan with contours of the site covering the area up to 250 m up-stream and 500 m downstream of the axis extending up to an elevation of MWL+5 m or more depending upon the site conditions, (tail channel area shall be adequately covered).	1:2500	-	0.5 to 1 m	Contour intervals as per item 2 above. Block leveling to be on 10 m grid basis.
4.	**Barrage/Weir** Grid plan with contours of the site covering an area up to 1 km on either side of the firm bank and 100m from the upstream/down stream tip of the guide bunds, parallel to the flow (tail channel area shall be adequately covered).	1:2500	-	0.05 to 1 m	Block leveling on 50 m or less grid basis depending upon the slope of the land.
5.	***Water Conductor System*** (i) L-Section (ii) Cross section at 50m interval (iii) Strip contour Plan cover 150m on either	 1:2500 1:2500	 1:100 1:100	 - -	 Leveling at 50 m or less interval. -do-

	side of the centre line of the canal or depending upon the requirement whichever is more.	1:1500	-	0.5	Block leveling as per item 4 above
6.	**Canal Structure**				
(i)	Grid plan with contours of the site to cover an area upto 300m on either side of the centre line of the canal -100m downstream of the point of exit of water and 100 m upstream of the point of water inlet.	1:2500	-	0.5	Block leveling as per item 4 above
(ii)	Cross section of the drain along the centre line of the canal	1:2500	1:100	-	Bed level/bank level and FSL of the canal and HFL of drain to be indicated on the cross-section.
(iii)	Drainage surveys for upstream and downstream of the centre line of the canal for adequate length as required for hydraulic Calculations.				
	For Plan	1:10000			Refer item 1 also
	Longitudinal and Cross sections	1:2500	1:100		Refer item 1 also

7.	***Power Houses, Switch Yard Surge Shaft, Tailrace etc.***				
	Contour plan of the site to cover full area of the component(s) alternative layouts.	1:2500	-	0.5 or 1 Or 2 or 3 m	Contour intervals as per item 2 above Block level as per Item 4 above
8.	***Plant and Colony*** Contour Plan of required area	1:2500	-	0.5	Block leveling as per Item 4 above
9.	***Tunnel and Adit***				
(i)	Contour plan of the area covering the length of the tunnel and 500m on either side of the centre line of the tunnel/adit including approach, portal and dump areas.	1:2500	-	1 or 2 Or 3	Contour interval as per Item 2 above Block leveling as per Item 4 above in case of ground surveys.
(ii)	L-Section	1:2500	1:100 or 1:200 or 1:500 or 1:1000	-	Vertical scale depending upon steepness of the slope and drop.
10.	***Penstocks***				
(i)	Contour plan of the area covering the length of the structures and 150m on either side of the centre line of penstocks.	1:2500	-	1 or 2 or 3 m	Contour interval as per Item 2 above. Block leveling as per Item 4 above.

(ii)	L-Section	1:2500	1:100 or 1:200 or 1:500 or 1:1000	-	Vertical scale depending upon steepness of the slope.
11.	***Soil Conservation Survey***				
	Plan of area subject to erosion, slides and slips.	1:10000 or 1: 50000	-	10 m or less	Depending upon the location of the area.
12.	***Geological maps*** Reservoir and river valley structures (Dams, Barrage, Tunnel, Power House, Penstocks important structures on canal and water conductor system)	Same as recommended under each item above or otherwise stated in the text.			
13.	***Foundation investigation maps***				
	plan	1:2500	-	As speci-fied	Showing location of structures, bore-holes, trial pits, drifts and points

				above for the Correspo-nding structure	where in situ tests were conducted etc.
	Cross-section	1:2500	1:100	-	Showing logs of boreholes, trial pits, drift etc. and other features of the foundations.
14.	***Borrow Area and Quarries***				
	Plan	1:2500	-	0.5 or 1 m	Location of different materials of construction pit/drill holes.
	Section	1:2500	1:100	-	Showing profile along the grid lines up to the depth explored
15	***Soil Surveys***				
	Plan	1:10000 or 1:15000			

3.7. METEOROLOGICAL INVESTIGATIONS

When a proposal is found feasible, a water shed contoure plan should be prepared showing:

(a) The prominent orographical features.

(b) Normal annual isohyets.

(c) Location of rain gauge stations in and around the catchments area and discharge sites, (distinguishing between ordinary and self recording station).

(d) Sites of sediment observation.

(e) Location of pan evaporation stations.

(f) Inter State / International boundaries.

Meteorological Data for the following should be collected for the project area.

(i) Temperature records of the area, (daily minimum, average and maximum)

(ii) Daily wind velocity

(iii) Pan evaporation data.

(iv) Rain fall

3.8. OTHER IMPORTANT INVESTIGATIONS

3.8.1. Construction Material Investigations

Before the scheme is feasible it would be necessary to investigate whether right type of material is available in sufficient quantity.

3.8.2. Ecological Surveys

The over all ecology of the region is likely to be effected by construction and operation of major irrigation and hydro-electric project. It is, therefore, necessary to make at least surveys and investigation of the following.

3.8.2.1. Affected flora & funa

A survey plan of the areas likely to be submerged constituting as encroachment on wild life habitat as a result of the proposed structure should be incorporated in the report. The report should also indicate the area of reserve forests, wild life sanctuary, national park if any, that may come under submergence as also the estimate of the wild life population in the area proposed to be submerged. The quantum of the forest used as cover and grassland used for grazing by animals in the area proposed to be submerged should also be indicated, as also the details of such areas in the remaining parts of the sanctuary / park. The report should also discuss whether the area to be submerged is of any special importance to wild life in their annual / seasonal migration. Indication should be given of the size of any islands that may be created due to the formation of the lake as well as of the possibilities of alternative proposals for relocation of the effect wild life in the region. Wherever necessary, the cost of these should be provided in the project estimate.

3.8.2.2. Historical and cultural repercussions

Sites of great historical and cultural importance should be carefully looked for during investigations and where such sites can not be avoided; a complete inventory of these should be made. The feasibility of shifting such monuments to safe areas should be investigated in consultation with the Archeological Department.

If the area submerged is of outstanding scenic beauty, it should be investigated as to how best the damage to this amenity of natural heritage can be minimized

3.8.3. Special Surveys for Hydro Electric Project

The surveys of hydro electric project shall include:

(i) Present position of power supply in region, system loads, load factor, kWh generated per kW installed.

(ii) Details of major loads to be served, future peak and energy demands, and anticipated system load factor.

(iii) Investigation regarding earth resistivity in connection with sub station designs.

(iv) Power evacuation route survey.

LAYOUT OF A RUN-OF-RIVER HYDROPOWER SCHEME

4.0. GENERAL

Hydro power plants exhibit a great deal of variety. Almost every hydropower project has some special feature not common with other projects of the same type. In the case of run-of-river scheme, there is practically no storage to modify the river flow. Whatever flow of water is there in the river at a particular time, the same is diverted to the turbine for generation of electricity (except in the monsoon period).

4.1. LAYOUT OF SCHEME

Layout of hydropower scheme mainly depends on the topographical, geological considerations. Generally layout of every hydropower scheme is unique, and each project has different challenges due to topographic and geologic constraints. But the layout of every run-of-river scheme comprises of the following components/ structures.

(i) Diversion arrangement.

(ii) Intake structure

(iii) Water conductor system:- open channel or conduit/ Tunnel.

(iv) Fore bay / surge tank

(v) Penstock

(vi) Power house

(vii) Tail race system.

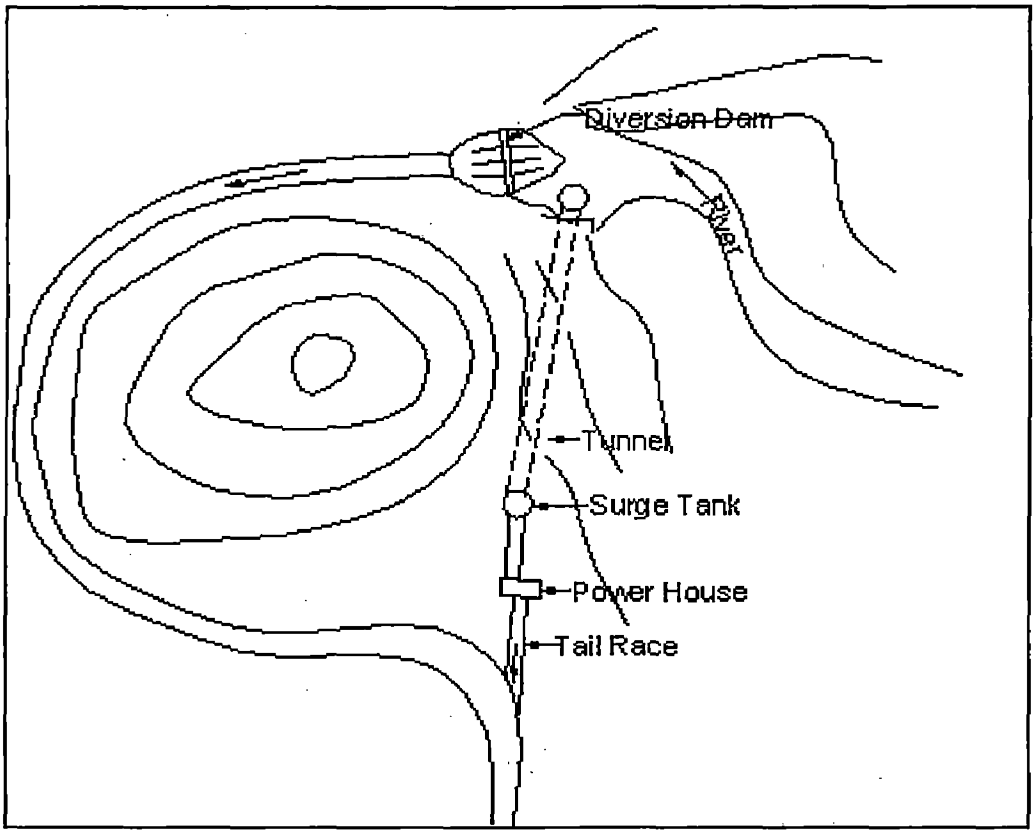


Fig.4.1 (a) : Typical layout of run-of-river scheme with pondage

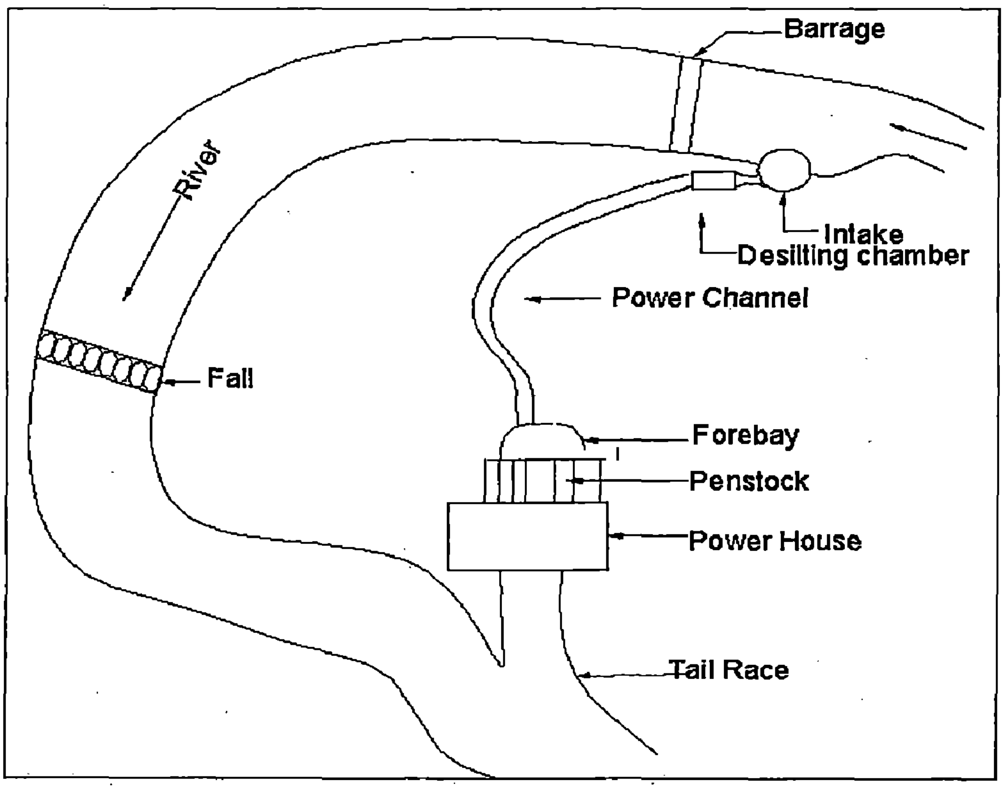


Fig. 4.1(b) : Typical layout of Run-of-river scheme

4.1.1. Diversion Arrangement

For run-of-river scheme, diversion arrangement may be barrage /weir or a low dam. In case of barrage or weir (generally built on foot hills) the gross head on turbine is elevation difference between FSL and tail water level but in the case of a diversion dam (generally made on non-perennial rivers or in mountainous terrain) there is additional head on turbine due to rising of water level on U/s of dam, so in this case the gross head on turbine is elevation difference between FRL and TWL. When there is a dam for diversion then initial cost for construction of dam is generally more than cost of barrage/weir. There is extra submergence also in U/s of dam.

The choice between dam and barrage can be decided by geology, topography and economy.

(a) Dam : two types of developments can be possible, in one case power house is sited at toe of dam (as shown in fig. 4.2) and in other case power house can be far away from the dam. In this case some additional head is available fig. 4.1.

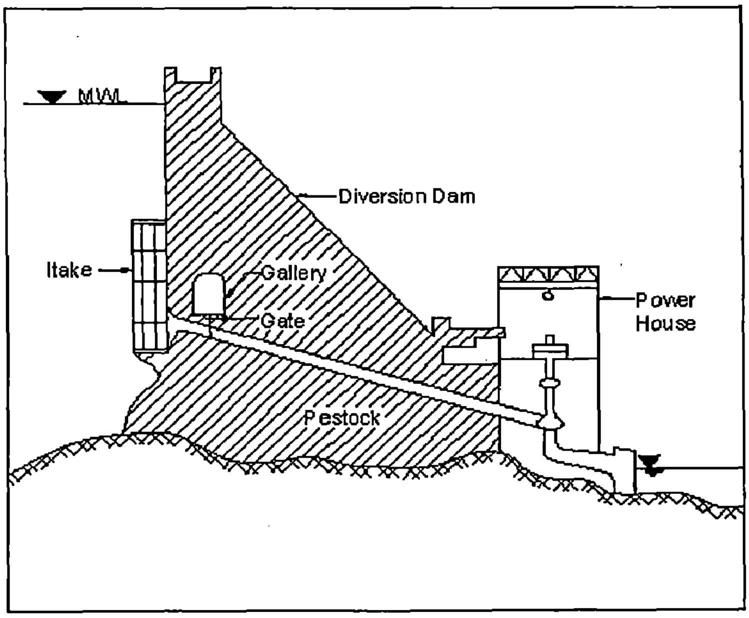


Fig.4.2: Power house at toe of dam

(b) Barrage / Weir: In this type of development power house is far away from the diversion arrangement fig. 4.1 (b). Silt excluders at the intake are provided to check the silt entry in water conductor system.

4.1.2. Intake Structure

Intake is a structure to draw water from the source and to let it pass into water conductor system in required quantity and quality. In hydro electric development general requirement for the quality of water will be that it should be free from debris, trash, ice and silt.

The intake structure has to perform the following functions:

(i) to minimise sediment entry

(ii) to prevent entry of trash and floating debris

(iii) To ensure and regulate the required quantity.

Intake should ensure smooth entry with minimum disturbance to minimize head loss. The requirement of assured water supply would fix the location of the intake in

(a) Plan so that water is always available,

(b) Elevation so that the invert level of the intake is at such location that the minimum water level is always above this invert level with some water seal, in case of under pressure conduit for carrying water

As already has been mentioned, the important thing in the location of an intake is to ensure that water is always available with minimum sediment at the intake.

4.1.2.1. Components of Intake

An intake structure should always have an arrangement by which it may be possible to control the flow of water. This arrangement is generally provided by introducing hydraulic gates and sometimes valves in the intake structure. Intake structure consists of several components to perform the following functions.

- The intake opening is provided with bell mouth entry.
- Regulating gates are provided. It is also fitted with stop logs or bulk head.
- The intake opening is also fitted with trash rack and its cleaning arrangement.
- The location and river approach to intake is so decided that sediment entry is minimised. Sediment exclusion and ejection devices are placed in the upstream and downstream of the intake.

Although the functional requirements of the intake remain the same as discussed but their shape, layout and operating heads vary according to the diversion structure and water conductor system.

4.1.2.2. Dam Intake

The dam intake being an integral part of the dam is possible only in masonry or concrete dams of either gravity or arch type (shown in figure 4.3).

In case of an intake required for an earth or rock fill type of dam the conveyance system will generally be tunnel and so it will come under the category of a tunnel intake. Tunnel Intake is meant to convey water from a natural tank or reservoir formed by a dam, to the tunnel.

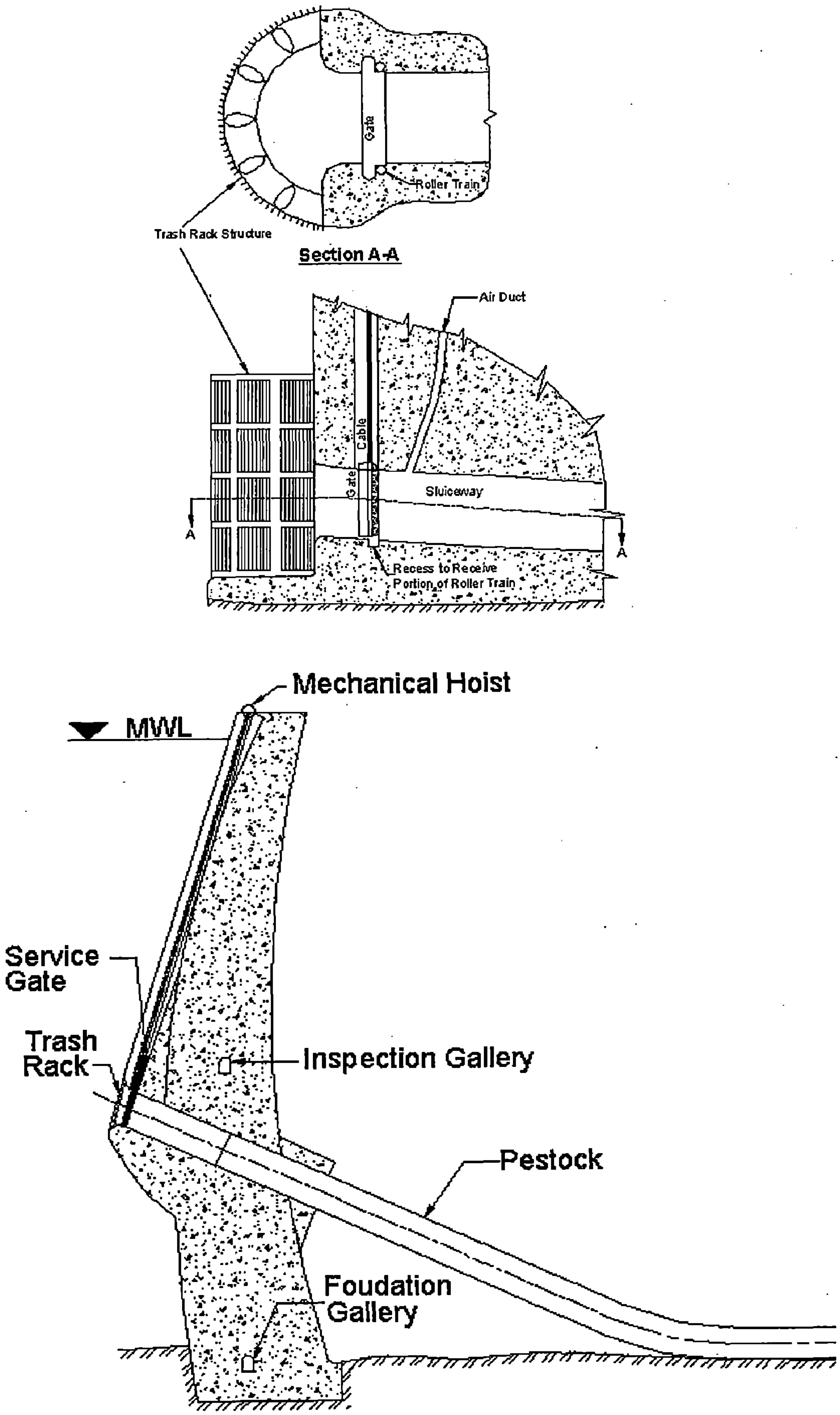


Fig.4.3 : Dam Intakes

4.1.2.3. Tower Intake

The tower intakes are normally on hill sides, not far off from the dam, when it is not convenient to provide the dam intake on the upstream face of the dam. A typical tower intake shown in Figure 4.4

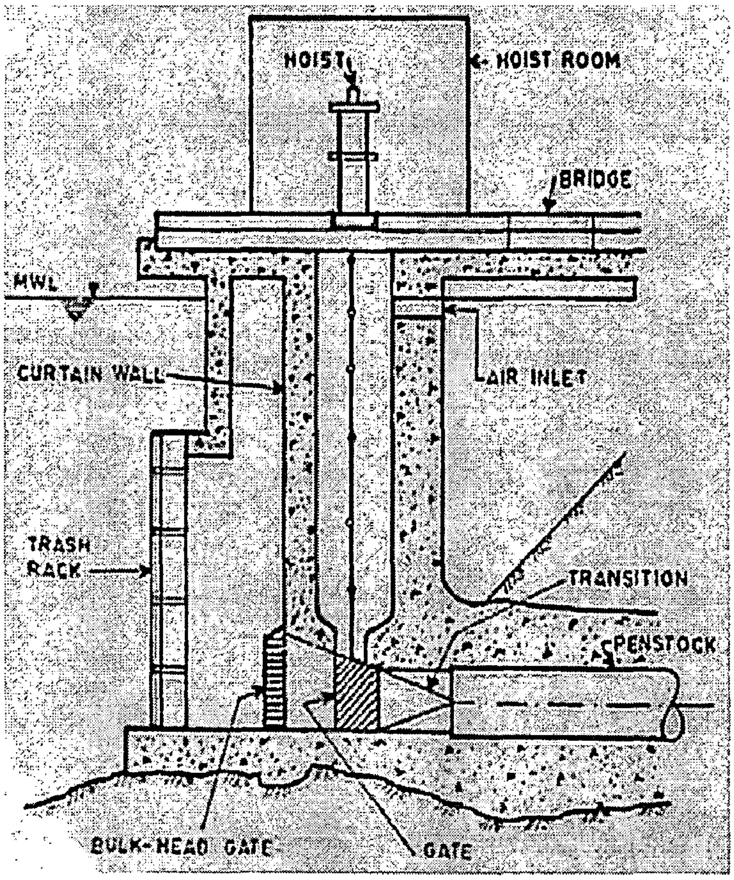


Fig. 4.4 : A typical tower intake

4.1.2.4. Shaft Intake

A vertical or near vertical shaft, driven at the reservoir site, carries water for desired use.

4.1.3. Head Race Channel / Tunnel

The water from the stream enters through the intake, into the power channel / power tunnel. In case of power tunnel, flow may be both under pressure or free flow.

4.1.3.1. Head Race Channel

Extra care has to be taken for the following points.

(i) The loss of water during conveyance in the channel is the least so that production of power is not reduced. For this reason the power channels are generally lined.

(ii) The slope of the channel is as flat as possible. A flatter slope would mean less head loss resulting in greater energy.

(iii) Due to flat slope, silt ejector is very essential, otherwise silting will occur in power channel.

4.1.3.2. Head Race Tunnel

The minimum diameter of the power tunnel is subject to the constraints of workability during construction. For mechanical construction the minimum diameter required is 3 m. Some important consideration for HRT.

i) Loss of head during conveyance through the tunnel shall be minimum, for this reason head race tunnels are normally lined.

ii) Minimum slope, so that the internal pressure does not increase too much along the length of head race tunnel.

iii) Level of HRT at surge tank location shall be such that the maximum down surge for critical reservoir level shall be above the HRT by a suitable margin, so that air will not be sucked into the penstock.

iv) For a given discharge, head loss is proportional to D^{-5}. Hence to minimise head loss and hence maximise power generation, diameter of HRT shall be large.

v) However, larger diameter will increase the construction cost. Based on this, lower possible diameter shall be preferred.

vi) Normally, a balance between investment cost and power generation loss is made, on the basis of equi-marginal annual cost and annual income from generation. Such a diameter is known as economical diameter.

vii) The design of free flow tunnel is like a open channel.

4.1.4. Fore Bay/ Surge Tank

In case of head race channel, a fore bay is provided at the down stream end. A fore bay is a reservoir which furnishes space, immediately available for the acceptance or delivery of water to meet the requirements of load changes, generally fore bays are provided for 2 minute of storage of water[1].

In case of H.R.T. surge tank is provided at junction of HRT and penstock. Usually surge tanks are necessary parts of medium and high head plants. This is particularly true when there is a considerable travel distance between intake and turbine i.e. through long conduits, considerable inertia effects arise from large mass of water due to motion.

This mass is of such magnitude that considerable force is required to accelerate or retard it. The pressure rises resulting from water hammer effects can be limited by use of relieve valves / deflectors in the case of reduction in load, however, for starting of the turbine, these are of no use. Hence, there has to be some provision for supplying the additional water required at the time of start and to store when load is reduced or turbine is fully stopped. This is achieved by providing a surge tank.

4.1.4.1. Functions of surge tank

a) Flow regulation.

b) Water-hammer relief of pressure regulation,and

c) Improvement in speed regulation.

The surge tank must be of such size and proportions that

(i) It shall contain the maximum possible upsurge for all reservoir levels and different load conditions.

(ii) The lowest down – surge for critical reservoir level and load change shall not allow air to be sucked into the penstock.

(iii) The range of surges shall not be so large as to cause undesirable governor movement or difficulty in picking up the load.

IS 7396, Part-I-1974 specifies the conditions as below.

a) Maximum upsurge corresponding to

(i) Full load rejection at max. reservoir level.

(ii) Where considered necessary specified load acceptance, followed by full load rejection at the instant of maximum velocity in HRT and higher of the two shall be adopted.

b) Minimum down-surge level corresponding to:

(i) Full load rejection at MDDL followed by specified load acceptance at the instant of maximum negative velocity in HRT.

(ii) Specified load acceptance at load or speed-no-load at the minimum reservoir level.

4.1.4.2. Types of surge tanks

These are basically of three types;

(i) Simple Surge Tank: in this type of surge chamber is a plain cylindrical shaft. It is usually connected to the conduit by a short connecting shaft or port. The simple surge chamber is a large and costly structure, commonly not used. Such type of surge tank is shown in Figure 4.5 (a).

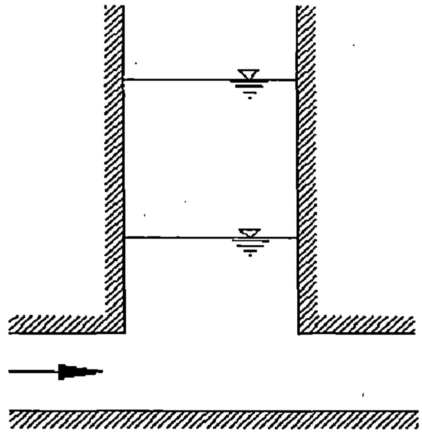


Fig. 4.5 (a): Simple Surge Tank

(ii) Restricted Orifice Type Surge Tank:- In such type surge tank, the entry of water to the tank is through a narrow (as compared to cross-sectional area of HRT) opening, leading to appreciable friction losse in the passage creating a deceleration head which retards the flow in head race tunnel. Restricted orifice type surge tanks are shown in Figure 4.5 (b).

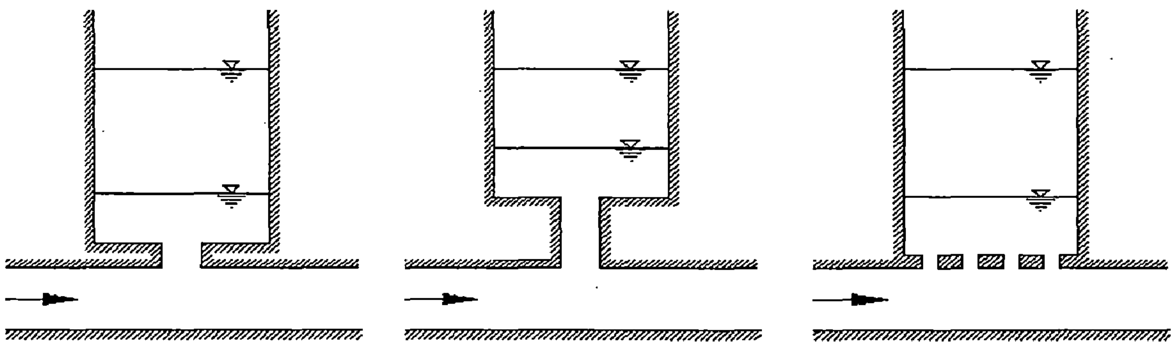


Fig. 4.5 (b) Restricted Orifice Type Surge Tank

(iii) Differential Surge Tank:- This type of surge tanks are much more efficient than simple surge tanks (shown in Figure 4.5 c). This type of surge tank has an additional internal riser pipe provided with annular ports connected with the chamber. These annular ports open into the outer surge shaft, thus, interlinking the riser pipe and surge shaft.

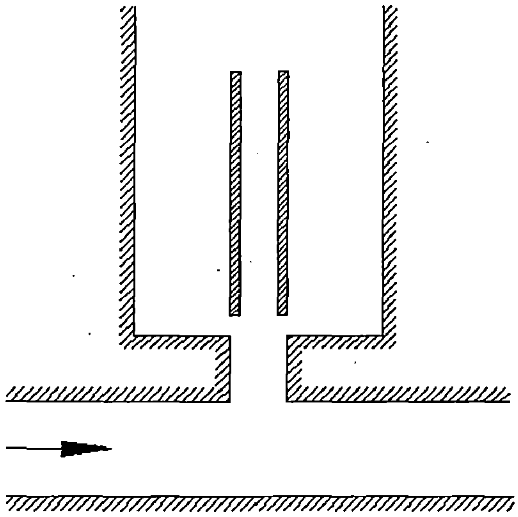


Fig. 4.5(c) : Differential Surge Tank

Surge tank /fore bay are always located as close as possible to the powerhouse in order to reduce the length of penstock to a minimum and preferably on high ground.

4.1.5. Penstock

Conduits carrying water from the surge tank or fore bay to the generating machine, are known as penstocks.

These are pressure conduits since they are subjected to appreciable internal pressure. Pressure will be varying from minimum at the upstream end to the maximum at the junction with scroll case.

Penstocks are generally of steel. Concrete pipes may be used for small heads.

4.1.5.1. Number of Penstock

One penstock may be provided for each machine or one penstock may serve more than one machine or all the machine in a power station. In case, one penstock serves more than one unit, at the tail end a suitable branching arrangement will have to be adopted. The choice of number of penstocks in a hydro power development will depend upon overall economy, fabrication and handling feasibilities and operational convenience.

4.1.5.2. Diameter of Penstock

Larger diameter will need greater thickness, since hoop stress in conduit section varies directly with the diameter. For welded penstocks the maximum wall thickness lies at about 60 mm, where as riveted penstocks are manufactured up to about 40 mm wall thickness [16]. Diameter of penstock is directly related to flow velocity in it. H.K. Barrows has suggested that the maximum velocity in penstock should not more than 6.4 m/sec, as per USBR criteria maximum permissible velocity is $0.125\sqrt{2gH}$ (in m/sec).

4.1.6. POWER HOUSE

In power house complex, turbines, generator, gantry crane and other accessories are housed. Sometimes inlet valve and transformers are also housed in power house complex.

A hydropower station, can be either surface or an underground power house. The choice depends on topography, geology and economy.

4.1.7. Tail Race

For discharging water after the generation of electricity in the power house, either a tail race channel or a tail race tunnel will be required (choice depends on the general topography of the area.

4.2. TYPE OF RUN-OF-RIVER SCHEMES

Run-of-river type development does not substantially alter the regime of the river. It implies that the water is diverted from the river without altering the pattern of flow. It also implies that no storage reservoirs are required. They are of two types

4.2.1. Run-of-River Scheme with Pondage

In this, pondage is provided at the diversion structure sufficient to store water for a few hours in a day to be used to supplement the river flows to meet the peaking demand of a few hours. The pondage in a run-of-river scheme is provided by putting high gates at the diversion structure. This is the usual practice at present and it meets the peaking requirement in the grid.

4.2.2. Run-of –River Scheme without Pondage

Diversion structure is provided across the flow of river, and whatever flow of water is available at any period of time is diverted to generate power. There is no modification in river flows.

POWER PLANNING

5.0. GENERAL

Power planning involves fixing of design discharge, design head, installed capacity, energy generation, pondage requirement for peaking etc. This chapter describes the procedure for fixing above parameters.

5.1. FIXING OF DISCHARGE

The power output of a hydropower plant depends directly on discharge and net head available on machine.

The year to year and month to month variations of the discharge are large and long term data gives the average, minimum and maximum discharges at any site for power generation.

During planning, assumption is made that in future years discharge will fall within the extremes of past records.

In case of run-of-river scheme, design discharge for power plant can be fixed with the help of flow duration curve (FDC) which can be prepared with available historical data.

5.1.1. Flow Duration Curve

The FDC represents the relationship between the magnitude of discharge (on Y-axis) and frequency of daily, weekly , monthly or some other time interval(on X-axis) for the project site, providing an estimate of percentage of time a given stream flow is equalled or exceeded over a historical period.

The flow duration curve can be plotted by two different methods. These are: (i) total period method and (ii) calendar year method. Both methods utilize the flow data available for the entire period for which records are available.

5.1.1.1. Total period method

The entire available record is used for constructing the flow duration curve. For example ten years record would produce 120 values of monthly average flows or 360 ten daily flows. These are first tabulated in the descending order starting from the highest discharge in the entire period and ending with the lowest value in the ten year duration. The resulting flow-duration curve would then be drawn.

5.1.1.2. Calendar year method

In this method, years of different dependability such as 50 %, 90 % are worked out then from 36 numbers ten daily discharge values, the FDC are made. Some times 90 % and 50 % dependable synthetic year FDC are also made. For construction of mean year FDC, each year's average monthly values are first arranged in descending order. Then the average flow values corresponding to the wettest month, second wettest month and so on up to the driest month are found out by taking arithmetic mean of all values of the same rank. These average values are then used for plotting flow-duration curve. Such a curve would have only twelve points (36 points if 10 daily flow data are used).

5.1.1.3. Shape of FDC

The shapes of flow duration curve (Fig. 5.1) which are the characteristics of the river have been categorized into following categories.

1. Steep drop FDC
2. Moderately flat FDC
3. Flat FDC.

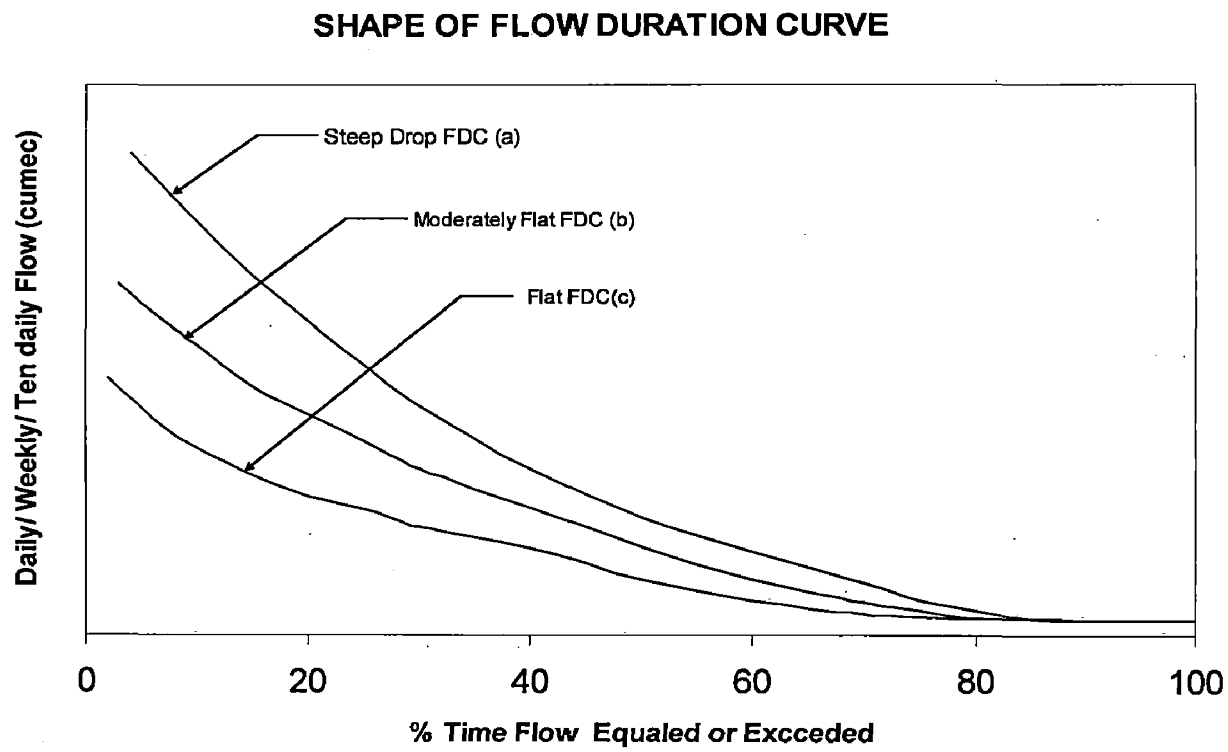


Figure. 5.1: Different shape of floe duration curve

The typical shapes of the above FDCs are shown as in Fig. 5.1(a), 5.1(b) and 5.1(c) respectively and described below.

In the first case for a certain change in the value of % time discharge is equalled or exceeded, we get a considerable gain in the magnitude of discharge as compared to that obtained in third case.

In the first case the large increase in discharge is available for a short period for energy generation whereas in third case same increase in discharge will be available for longer time for energy generation.

5.1.2 Review of Literature for use of FDC

Critical review of literature reveals that FDCs are universally used to estimate the planned energy generation from a run-of-river project. The hydropower generation from run-of-river project is generally based on 90% dependability.

In case of a run-of-river scheme, ten daily discharge of any particular dependability is found by arranging the discharge of any particular period in descending order with rank varying from 1 to n (where n is number of values). The exceedance probability i.e. % time the flow is equaled or exceeded is calculated by Weibull method (i.e. m/n+1). This can be adopted for drawing total or yearly FDCs. A synthetic flow year can be formed having a particular dependable flow in each ten day period. These flows will not correspond to any particular calendar year flows. This approach has been recommended by Nigam[19] and is on conservative side.

According to Masonyi[16] for estimating the total energy of a stream or river system as the first step using the average flow duration curve based on 30 to 40 years hydrological data. This will be total area under the average year flow duration curve and will be the gross energy potential of the river at that site assuming that head will not materially change with discharge since harnessing of this energy would not be techno-economically feasible, a reducing factor may be applied. In some case the energy generation may be 0.75 to 0.80 of the gross energy. The two probable extreme shapes of flow duration curves are shown in Fig. 5.1 (a) & 5.1(c). High reduction factor may be applicable to the shape of FDC indicated by curve shown in Fig. 5.1(c).

Masonyi[16] has further stated that range of technically utilizable power can possibly be selected on the basis of economic considerations. In the earlier years the water power capable of being developed was characterized by the discharge available for 85 to 90% of duration i.e. the discharge available for 325 days in a year. In many cases, however, the lowest cost of energy production can be attained by utilizing the flow available approximately 50% of time i.e. 182 days in a year.

In the interest of more effective utilization of undeveloped hydro potential, in recent years there has been a trend to increase the degree of utilization towards shorter duration. With the advent in long distance transmission lines, integrated power grid system, the plant discharge has been selected as high as Q^{34} (flow equaled or exceeded for 34% time).

Masonyi[16] has recommended construction of average year FDC and the selection of discharge for installed capacity in a range of Q^{34} and Q^{50} based on economic considerations.

J.G. Brown[3] described the selection of design discharge, which can be intercepted from streams with wide and erratic varying flow conditions, on the basis of economic consideration. To begin with, mean / average discharge is calculated. As a general rule the maximum discharge which can be intercepted will be several times the mean discharge depending upon the shape of FDC. Economics of power generation shall be calculated considering the multiple of mean flow. In U.K. this multiplying factor is generally 3. The design discharge and installed capacity are fixed at which the cost of unit generation is minimum.

Literature review has revealed that design discharge with an exceedance probability on flow duration curve (FDC) as low as 10 to 20% depending on the shape of FDC has been adopted in some of the run-of-river hydro electric schemes in European countries (Masonyi[16]). This is decided on the basis of techno-economic analysis.

The design discharge in the schemes of Ganga Valley corresponds to an exceedance probability of approximately 30 to 45% on FDC. Some examples are given in Table 5.1

Table. 5.1: Exceedence probability of some existing project

Name of project	Exceedence probability i.e. % time the flow is equaled or exceeded
1. Maneri Bhali hydro project stage I (3 x 30.0 MW)	46
2. Maneri Bhali hydro project stage II (4 x 76.0 MW)	33
3. Chilla Hydro project (4 X 36.0 MW)	46 before Tehri dam 33 after Tehri dam
4. Srinagar hydro project (6 x 55.0 MW)	21

(Source-Reference 12 & 22)

5.2. FIXING OF HEAD

Head depends on the topographical and geological characteristics of site. Existing natural head must be properly appraised and must be utilized to the optimum.

The gross head at any instant is the difference between the water level in the barrage or dam pond or the foe bay and in the tailrace. The gross head is usually dependent on the variation in reservoir level. Tail water level variations are small. Hence there will be a range of maximum, minimum, and mean gross head. In run-of-river schemes the pond level in the diversion structure is practically constant, hence the gross head is also constant.

The net head at any instant is the gross head minus the losses. These losses vary with the flow depending on the load through the conduit, so that the net head varies. During planning stage frictional losses in conduit/ channel are accounted for as other losses are quite insignificant in comparison with friction losses.

5.3. INSTALLED CAPACITY

When design discharge through FDC procedure has been fixed and design head is also ascertained the power out put is worked out by

$$P = 9.81\ Q\ H\ \eta$$

The installed capacity is based on economic considerations or feasible maximum generation. According to J. G. Brown(3), economics of power generation shall be calculated considering the multiple of mean flow. This multiple can be up to 3, and the maximum flow through the head race tunnel will be somewhere between 1.0 to 3 times the mean flow.

Masonyi(16) has recommended that discharge for installed capacity in a range of Q^{34} and Q^{50} based on economic considerations of average year flow FDC.

The procedure to work it out is to select four or five discharges in the proposed range. For each discharge there will be an installed capacity and for that work out the total energy generated and the cost of scheme. In this way for each discharge one gets the cost of generation per unit of energy. The discharge and corresponding capacity which gives the minimum cost of per unit generation is selected as design discharge. Alternative the capacity at which incremental energy per MW increase in capacity falls sharply, should be selected as optimum capacity and corresponding to it will be the design discharge.

A procedure which is currently being followed in preparing the feasibility report of run-of-river hydro schemes is as follows.

- Work out unrestricted annual energy generation for all the years for which discharge data is available.

- Arrange the annual energy generation for all the years in descending order.
- Select 90% and 50% dependable years.
- Select a range of installed capacity for 90% dependable year
- Workout with the 90% dependable year discharges and the energy generation for 4 or 5 installed capacities in the selected range.
- Work out the incremental energy per MW increase in installed capacity and select the capacity beyond which the increase in incremental energy falls sharply.
- While selecting installed capacity it is to be ensured that it will generate energy for at least 25 to 30 % of time in a year.
- With the selected installed capacities the annual energy generated in 90% and 50% dependable years is worked out for financial studies.
- The discharge corresponding to the selected installed capacity is worked out for design of scheme.

5.4. ENERGY GENERATION

For all hydropower installation, the foremost requirement is to generate maximum power at the possible minimum cost. It is worked out for 50% and 90% dependable flows using the installed capacity decided earlier. The financial aspects are generally worked out for energy availability at 90% dependability.

5.5. PONDAGE

As per Mosonyi[16] " pondage is that rate of storage in run-of-river developments which can cover daily peaks only".

"Over short periods, such as a day or a week, the natural flow may be at a uniform rate, high enough to meet the average demand, too high for the hours of low demand, and not high enough for the peak demand. Limited storage will enable the rate of flow to be varied to suit the variation of demand; short term storage of this nature is sometimes described as pondage" by J. G. Brown[3].

H. K. Barrows[2] define pondage as the holding back and releasing later of water at the dam/ barrage of a water power development (1) to equalize daily or weekly fluctuations in river flow or (2) to permit irregular hourly use of water by turbines to accord with fluctuations in load demand.

As per Nigam[19] by pondage , some modifications in the withdrawals of water for generation of electricity is possible.

Pondage takes care of the hour-to-hour fluctuations over a day or occasionally, day-to-day fluctuations over weekly cycles[6].

Any plant is said to have ample pondage if the capacity of the pond above the intake is sufficient to take care of hour to hour fluctuations of the load on the plant throughout the period of a day[5].

Hence pondage in run-of-river schemes can be of help to meet the peak demand for few hours in a day.

LUHRI HYDROELECTRIC PROJECT - A CASE STUDY

6.1. THE PROJECT

Luhri Hydro Electric Project is proposed to harness the hydroelectric potential of river Satluj between KEPU and BINDLA villages in Shimla district of Himachal Pradesh (fig. 6.1). The proposed project is a run of river type development. A low dam can be constructed at the site and pondage can be provided to run the scheme as a peaking station. A water conductor system of about 30 Km length gives a gross head of about 202 m when a dam of about 80 m high is built.

6.2. BACKGROUND INFORMATION

Satluj river rises from Rakas Tal fed by Mansarover lake (at about 4570m above mean sea level) in Nari Khorsam province of Tibet and after flowing in West direction for a distance of about 300 Km., it enters India near Shipkilla in District Kinnaur. The Satluj descends from about 2590 meter at Khab to ± 936 meters at Rampur Town, in Distt. Shimla, the main supply station to Distt. Kinnaur. The Satluj flows in this whole reach between narrow cliffs and therefore there is no open ground worth describing all along its banks, thus excluding the possibility of making any storage Dam.

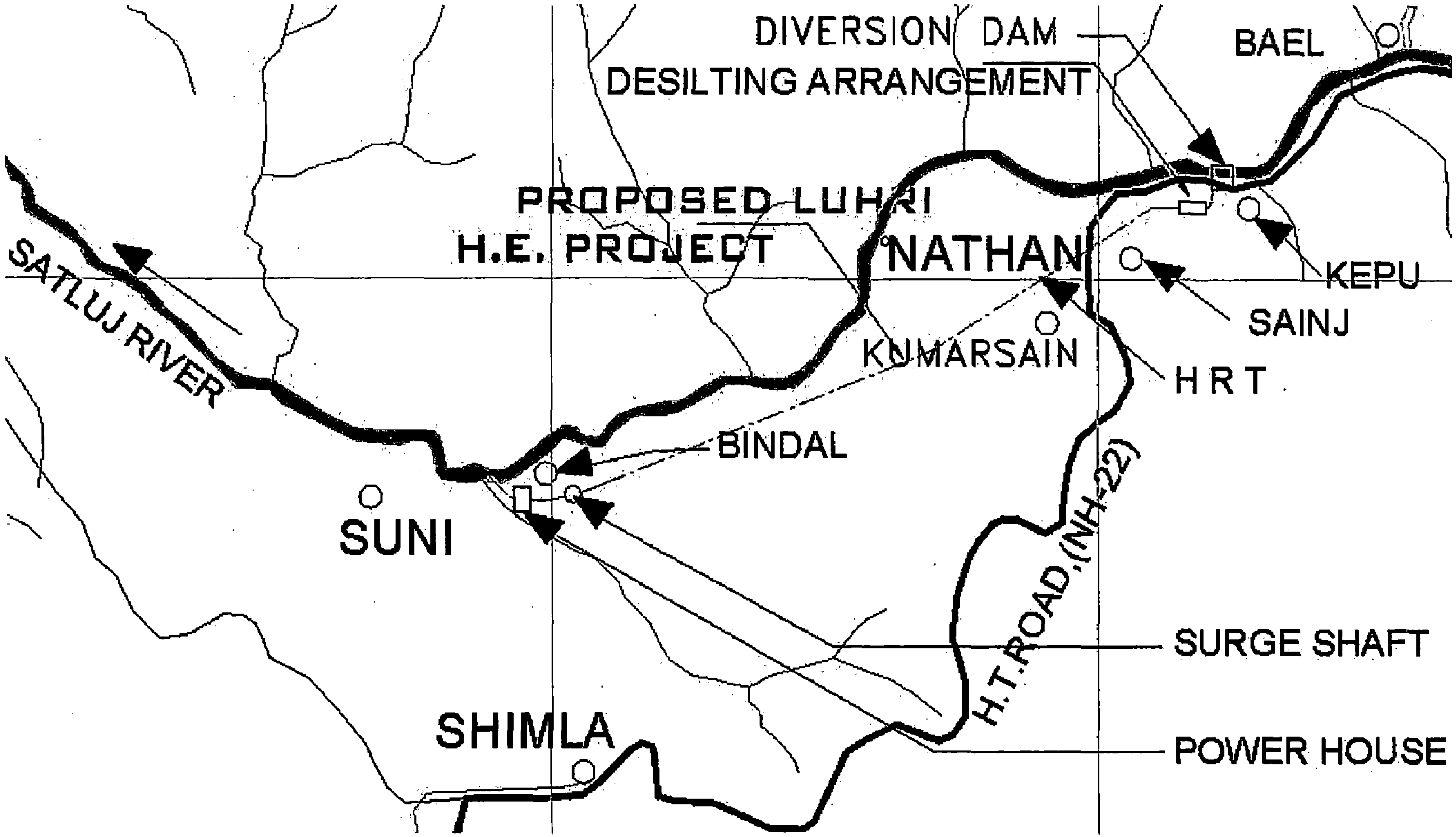


Fig. 6.1: Satluj river and Luhri H. E. Project

The water of the river is more or less discoloured. Cultivated fields in terraces are generally at considerable heights from its bank and are thus immune from the turbidity of the water, which is largest in summer months. Within the limits of the District Kinnaur the river is not navigable owing to the rapidity of flow and presence of boulders. After it leaves the boundary of the District Kinnaur near village Chaura it enters Shimla District.

The Satluj is joined by several tributaries in Nari-khorsam such as Changchu, Drama Yankti, Chonak, Manglan, Transuo, Summa, Trap etc. Immediately after entering the Indian territory near Shipkilla, the river takes a south-westerly direction on its way to Bhakra gorge about 320 Km away after crossing, which it emerges into the plains of the Punjab

The significant tributaries streams and rivers that flow into the Satluj river from south or along its left bank are successively the Tidong, Hogis, Gyamthing, Baspa, Duling, Sholding, Manglad etc. Likewise those entering from the north or its right bank are the Spiti River, Ropa, Kirang, Kashang, Pangi, Choling, Bhaba, Sorang, Kut and Ganwi Khud. In between there are many seasonal streams that meet the Satluj river and its tributaries. At Khab it receives the Spiti river where the bed of the stream is still about 2590 meter above the mean sea level.

The fall of Satluj from its source to the plains of India is very uniform. The height of the bed is about 4570m near Rakas-Tal, 2530m near Shipkilla, 915m at Rampur, 416 m at Bilaspur and 350m at the Bhakra Dam site.

The total catchment area of the Satluj above the Bhakra dam site is about 56875 Sq.km and above the Nathpa diversion site is about 49820 Sq.km from Bhakra to Nathpa, 148 Km on a straight line and 193Km by river, the drainage area is comparatively narrow with an average width of about 35km. This part of catchment has an area 7055 Sq.km and above Nathpa the catchment is considerably wider than below it.

The total catchment area of the Satluj above the Bhakra dam site is about 56875 Sq.km and above the Luhri diversion site is about 52403 Sq.km The river Satluj drains an area of about 50880 Sq.km at Rampur discharge site and 52915 sq. km at Sunni discharge site.

The tail water elevation is 859 m of proposed Rampur hydroelectric project, which is upstream development to Luhri project. The FRL of Kol dam hydro electric project is 642 m ,in figure 6.2 adjacent H.E. projects to Luhri H.E. project are shown[21].

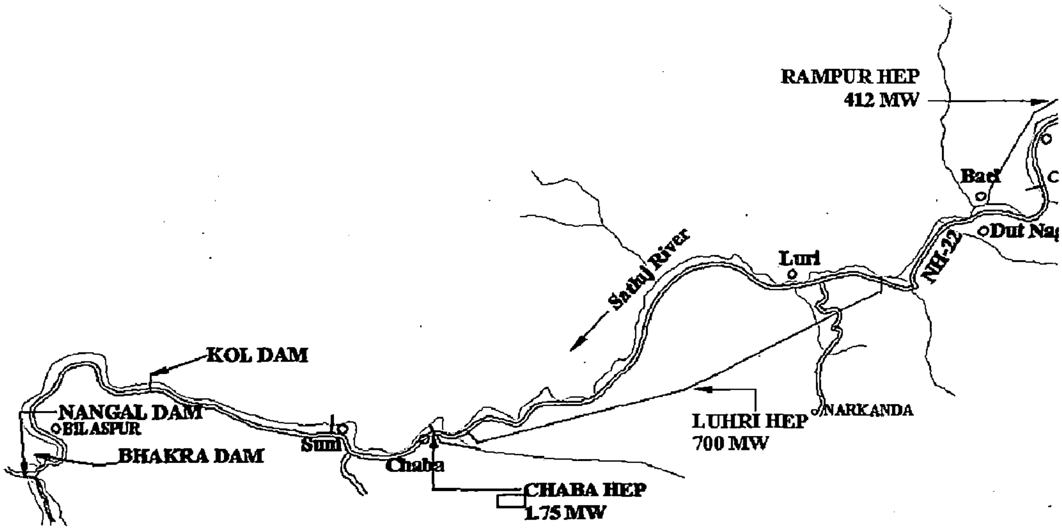


Figure.6.2: Adjacent H.E. projects to Luhri H.E. project

6.2.1. PROJECT AREA

Himachal Pradesh is located in the western portion of the Great Himalayan Mountain Range of northern India, bounded by the State of Jammu-Kashmir to the North, Tibet to the East, and the plains of northern India to the South and West. The Satluj river is one of the major rivers draining this region. It rises in the Tibetan Plateau, passes via steep valleys and gorges through the Himalayan

Mountains and foothills and meets the Arabian sea across the plains of Northern India.

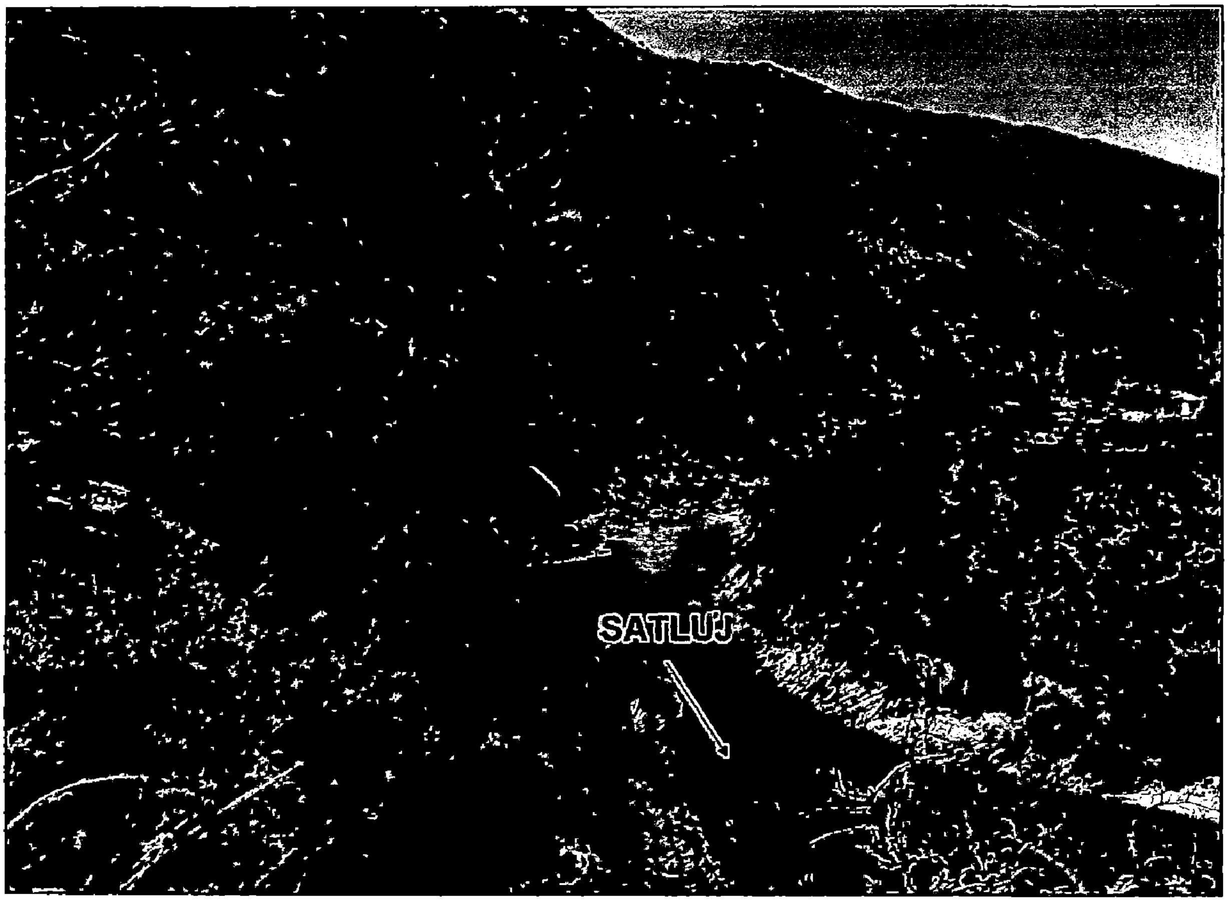


Fig. 6.3: Dam site view at river Satluj

The project site area is located about 100 km from Shimla, the State capital, and is an upstream development of the proposed Kol dam Electric Project (800 MW) on the Satluj river. While the power house will be located near village Bindla ropeway bridge in Karsog Tehsil of Mandi District., the Dam will be located near village Kepu, 1.5km upstream of Sainj on NH-22(Fig. 6.3). The reservoir will extend upto Tail Race of Rampur Hydel Project near Bael village opposite Duttnagar.

6.2.2. SEISMICITY

The project area lies in an active seismic region, zone IV of the Seismic Zoning Map of India. Available data on seismcity within a radius of 150 kms of the project shows that earthquakes having a magnitude greater than 5 on the Richter scale occur at frequent intervals. Important seismic events which have taken place in the past 150 years and caused *significant* damage include the 1905 Kangra quake (magnitude 8 +), the 1908 Kullu quake (magnitude 6.0), the 1945 and 1947 Chamba quakes (magnitude 6.5 & 6.6), 1975 Kinnaur quake (magnitude 6.8) and the 1991 Uttarkashi quake (magnitude 6.6).

6.2.3. HYDROLOGY

At Luhri diversion dam site there is no gauging station. The ten daily discharge data of Sunni discharge site (D/s of Luhri dam site having catchment are of 52915 Sq KM, Annexure-VII/1) and Rampur discharge site (U/s of Luhri dam site having catchment are of 50880 Sq KM, Annexure-VII/2) is used to generate the ten daily discharge data for Luhri dam site (having catchment area of 52403 Sq KM) on the basis of catchment area at Rampur & Sunni gauging site.

6.2.4. GEOLOGY

The project area lies in the formation of Kullu and Shali formations. The Kullu Group mainly comprise of gneiss with quartzite bands, carbonaceous and graphitic phyllite and schist with limestone bands. The Shali formation comprises of slate, dolomite, limestone and quartzite with shale partings. All the rocks are well foliated. The general trend is N-S with moderate dips toward East. These are transacted by a number of joints of which the foliation and strike joints are the most predominant followed in frequency by steeply dipping transverse joints. Rocks are generally covered by glacial deposits, rock debris, alluvial terraces and fans. The soils of the Satluj valley are relatively poor sandy loam and exposed bed rock. In the valley bottom there is virtually no soil.

HYDROLOGICAL STUDIES

7.0. GENERAL

Discharge Data at Luhri dam site is not available, but ten daily discharge data is available at two gauging stations on same river in the vicinity of the project site.

7.1. AVILABLE FLOW DATA

Ten daily discharge data is available at downstream of proposed dam site i.e. at SUNNI on same river. This data is available from Jan 1972 to May 2005.Sunni discharge site has a catchment area of 52915 KM^2. (Annexure –VII/1).

Ten daily discharge data of another site is also available which is upstream of proposed dam site i.e. at Rampur , from this site ten daily discharge data is available from Jan 1972 to May 2004.(Annexure –VII/2).. Rampur site has a catchment area of 50880 KM^2.

7.2. ANALYSIS OF FLOW DATA

After analysis and applying consistency check to above ten daily data of Sunni and Rampur discharge site, it is established that linear relation exists between data of both sites, the correlation is given below, and graphically shown in figure 7.1.

$$Q_{Rampur} = 0.8828 \text{ X } Q_{Sunni} + 3.8384 \qquad (7.1)$$

r = 0.9915

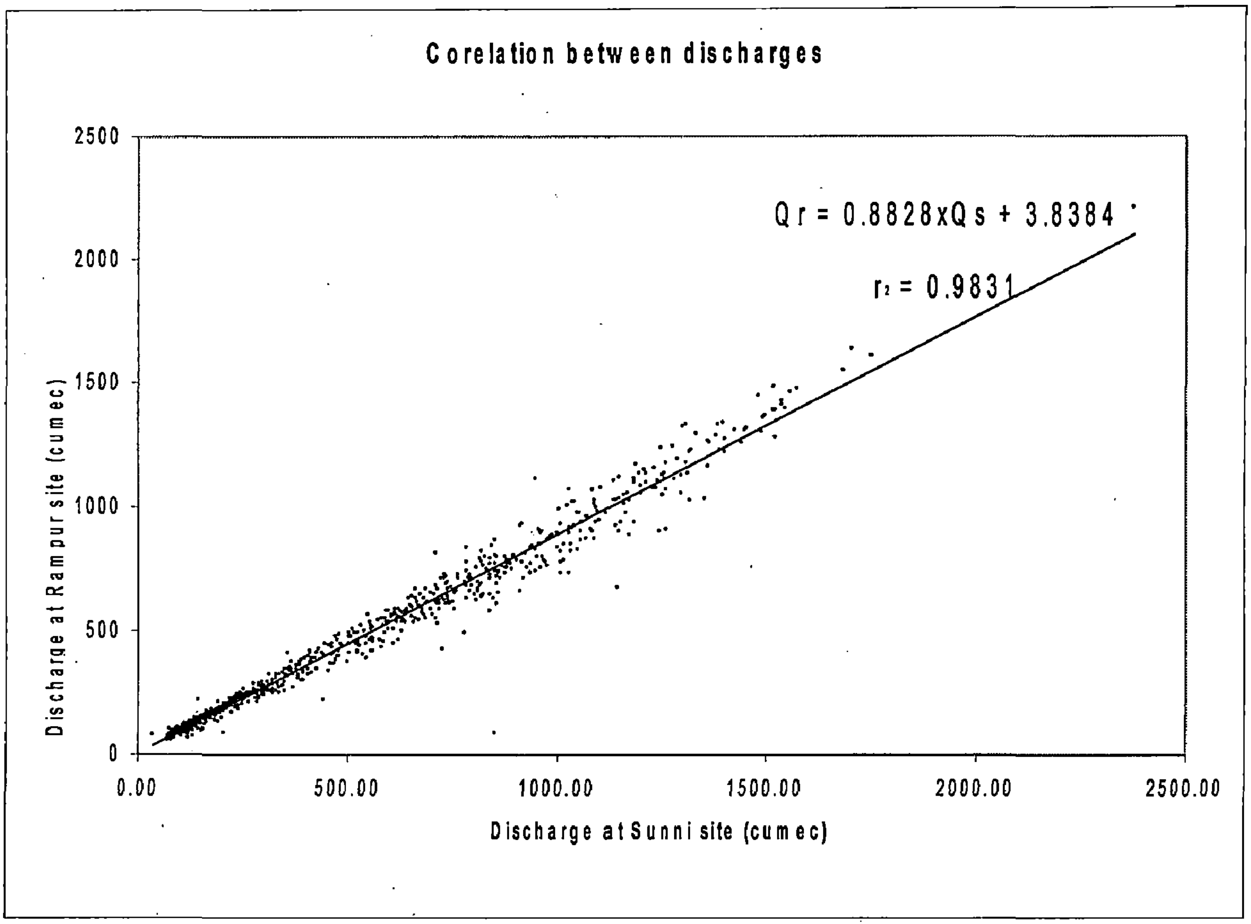


Figure.7.1: Correlation between discharge data of Rampur and Sunni

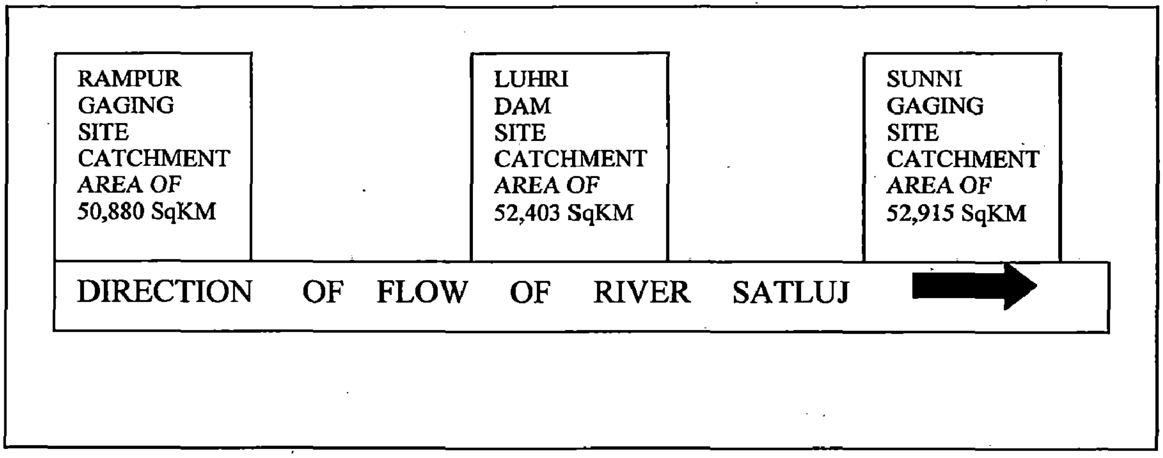
Validation of equation no 7.1 is done. The ten daily discharges are generated by above equation and comparison is done between generated and observed ten daily discharge data, the error has been negligible (annexure -VII/3).

7.2.1. Generation of Data

7.2.1.1. For Rampur site

Ten daily discharge data of Rampur site is available from Jan1972 to May 2004. Form Jun 2004 to May 2005 ten daily discharge data is generated by equation 7.1. (Annexure-VII/2).

7.2.1.2. For Luhri dam site



By above line diagram, it is clear that the additional catchment area between Rampur and Sunni is 2,035 Sq KM. Similarly catchment area between Luhri dam site and Rampur is 1,523 Sq KM. The difference between catchment area of Luhri and Sunni is only 512 SqKM, (approximately 1 % of total catchment area of river Satluj at Luhri dam site)

The long term series at Luhri dam site has been developed on the proportionate catchment area basis, by using the discharge data at Rampur and Sunni discharge site.

$$Q_{Luhri} = Q_{Rampur} + (Q_{Sunni} - Q_{Rampur}) X k$$

$$\text{Where } k = \frac{Al - Ar}{As - Ar} = 0.7484$$

Al = catchment area of Luhri Dam site (52,403 KM^2)

As = catchment area up to Sunni (52,915 KM^2)

Ar = catchment area up to Rampur (50,880 KM^2)

The ten daily discharge data at Luhri dam site is given in Annexure –VII/4

7.3. CONSTRUCTION OF FLOW DURATION CURVE

Flow Duration Curves is discussed in section 5.1.1.The flow duration curve, relates flow rate with duration , does not give any sequential information regarding the flow .It has discharge plotted on the Y-axis and the percentage of time duration for which that magnitude (or more) is available plotted on X-axis. Since there is considerable difference of opinion on the FDC to be used in power studies, a comparative study of various FDCs in a case is made and describe below.

7.3.1. FDC for total Duration

All ten daily discharge values of entire period are used for plotting FDC of total duration, shown below in Fig. 7.2

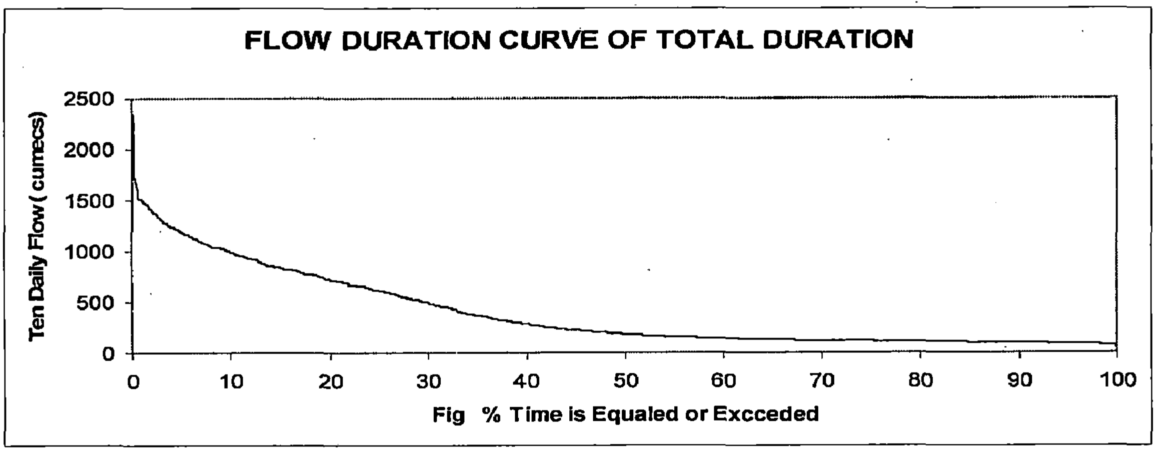


Fig. 7.2: FDC of total duration

7.3.2. FDC for Mean Year Flow

Ten daily discharge of same block/month is summed up for all the years and then divided by total number of years, then this average discharge for ten daily block is used for FDC. So we get 36 ten daily average flows and they are arranged in descending order. (Annexure-VII/5). It does not relate to any particular year data (Fig 7.3).

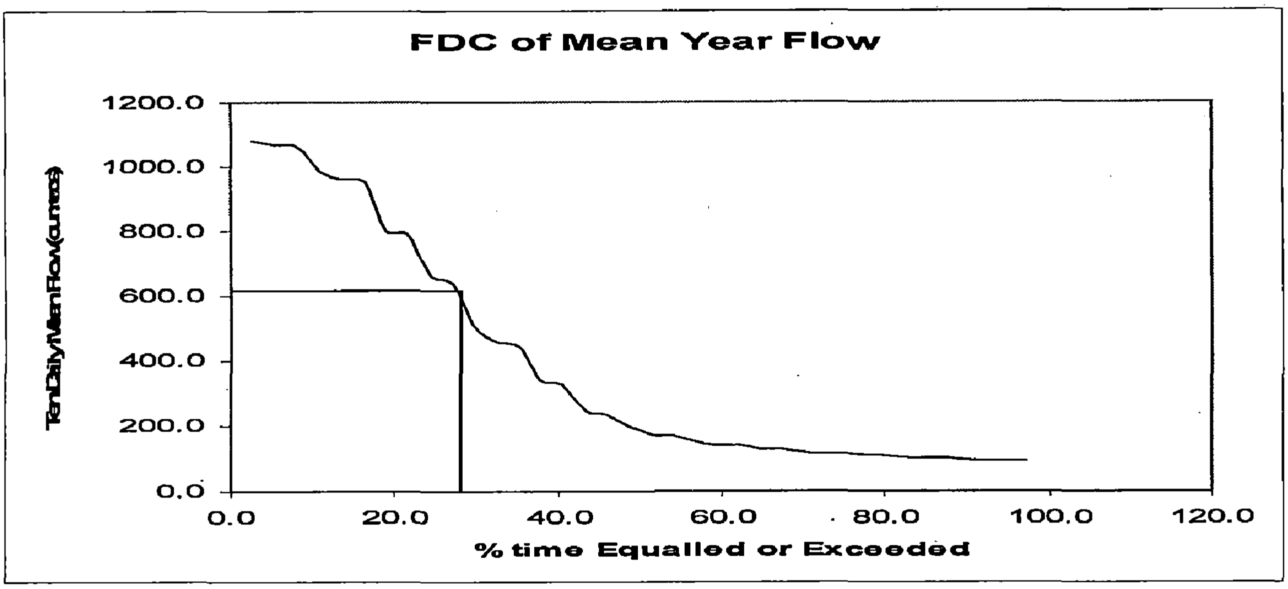


Fig.7.3: FDC of mean year flow

7.3.3 FDC for 90 % Dependable Year

Total energy generated for entire period is calculated, then these energy are arranged in descending order . The yearly energy of (n+1)x0.9th rank gives the 90 % dependable year . In our case n equals to 33 years (as we are having flow data of 33 years). When the yearly energies are arranged in descending order then from top 31st row gives the 90 % dependable flow year and that particular year which corresponds to this , is known as 90 % dependable year. In our study year 2001-02 is 90% year and ten daily discharge data of this year ie 2001-02 is arranged in descending order and with this data we get FDC for 90% dependable year. (shown in fig. 7.4, related ten daily flows are given in Annexure-VII/6)

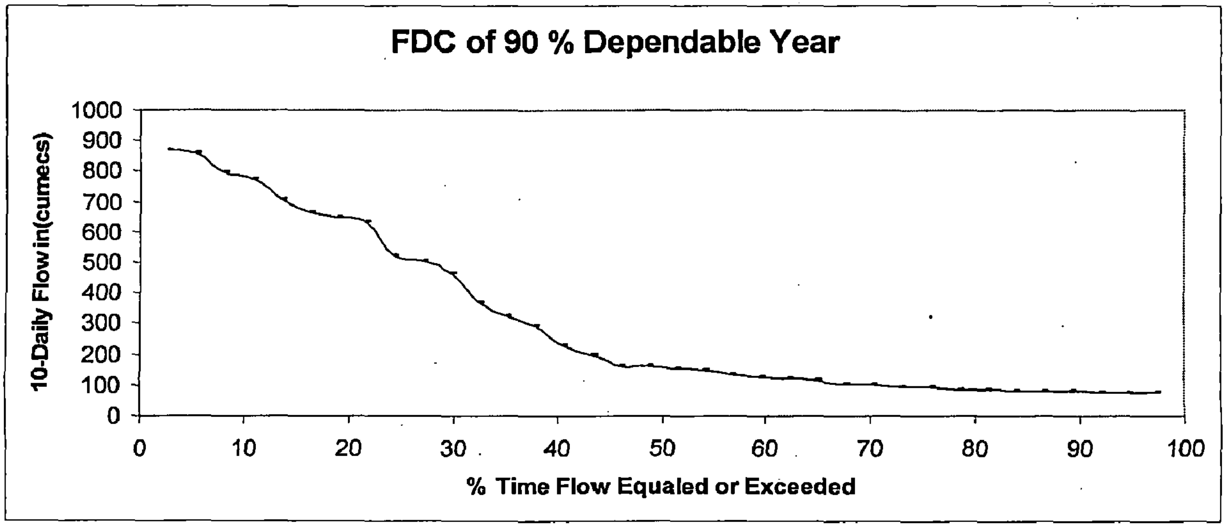


Fig.7.4: FDC for 90% dependable year flow

7.3.4 FDC for 50 % Dependable Year

As describe in 7.3.3 ,if we use (n+1)x0.5 =(33+1)*.5=17th year flow data then we get FDC of 50 % dependable year similarly as described in above paragraph. (Annexure-VII/6)

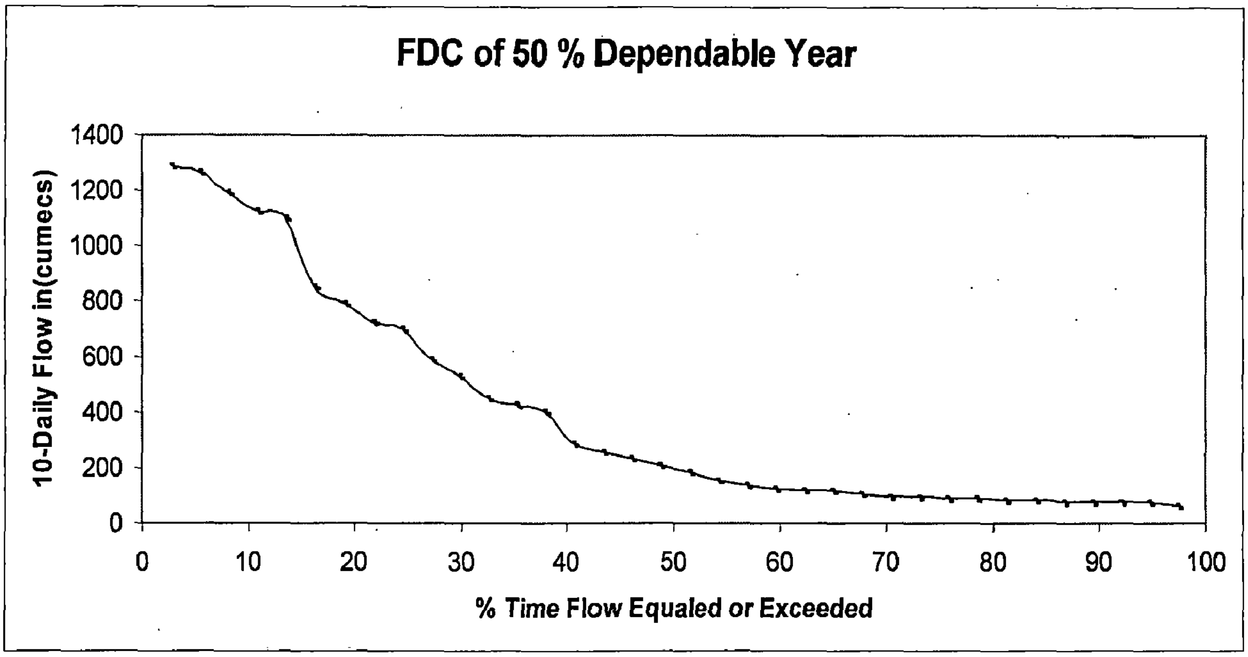


Fig.7.5 : FDC for 50% dependable year flow

7.3.5 FDC for 90% and 50 % Synthetic Year Flow

All ten daily discharges of each year are arranged in descending order. In our case we have 33 years data so we have 33 rows and 36 columns, then we take 31st rows data for 90% and 17th row data for 50 % synthetic year flow. The FDC by such discharge data are known as FDC for 90% synthetic year & FDC for 50% synthetic year, and are shown in fig 7.6 & fig. 7.7 respectively. (Annexure-VII/7).

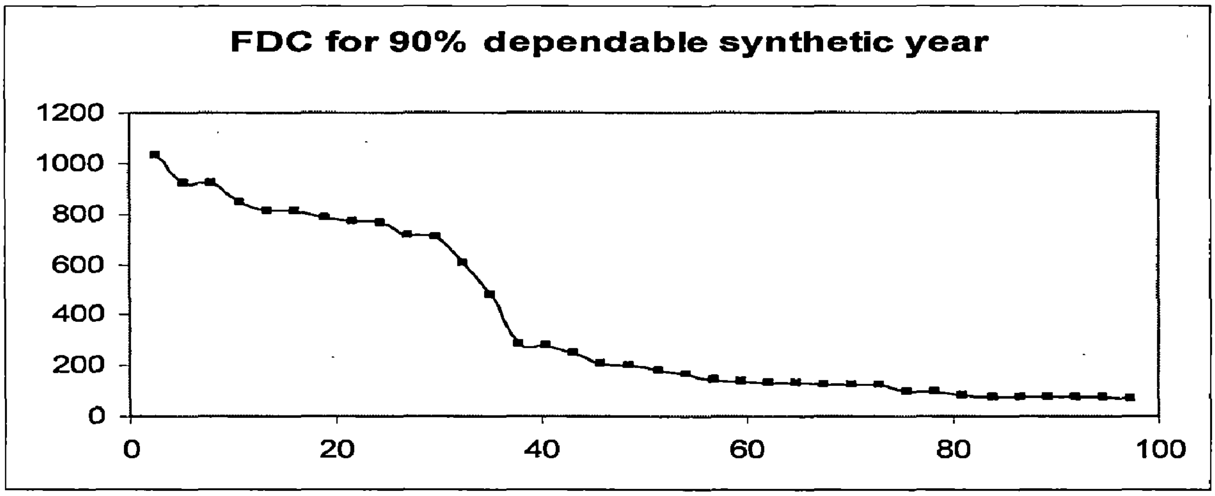


Fig.7.6: FDC for 90% synthetic year flow

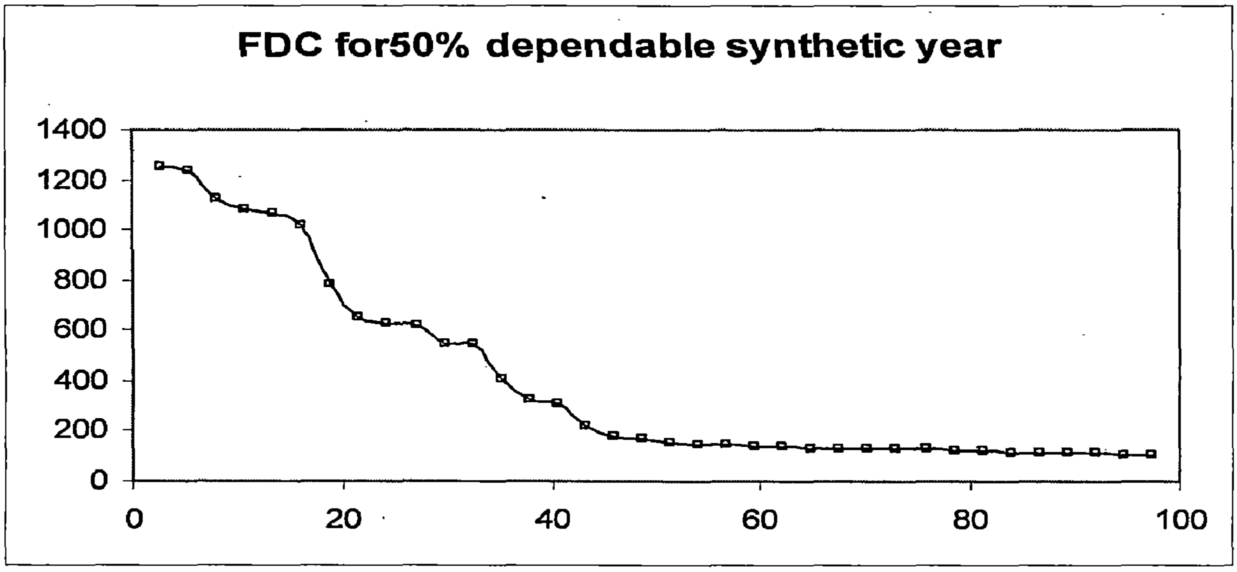


Fig.7.7: FDC for 50% synthetic year flow

7.4 COMPARISON BETWEEN DIFFERENT FDCs

FDC drawn with total duration flow data gives the actual picture of past, in this case for FDC of total duration is constructed with the help of 1188 data in number.

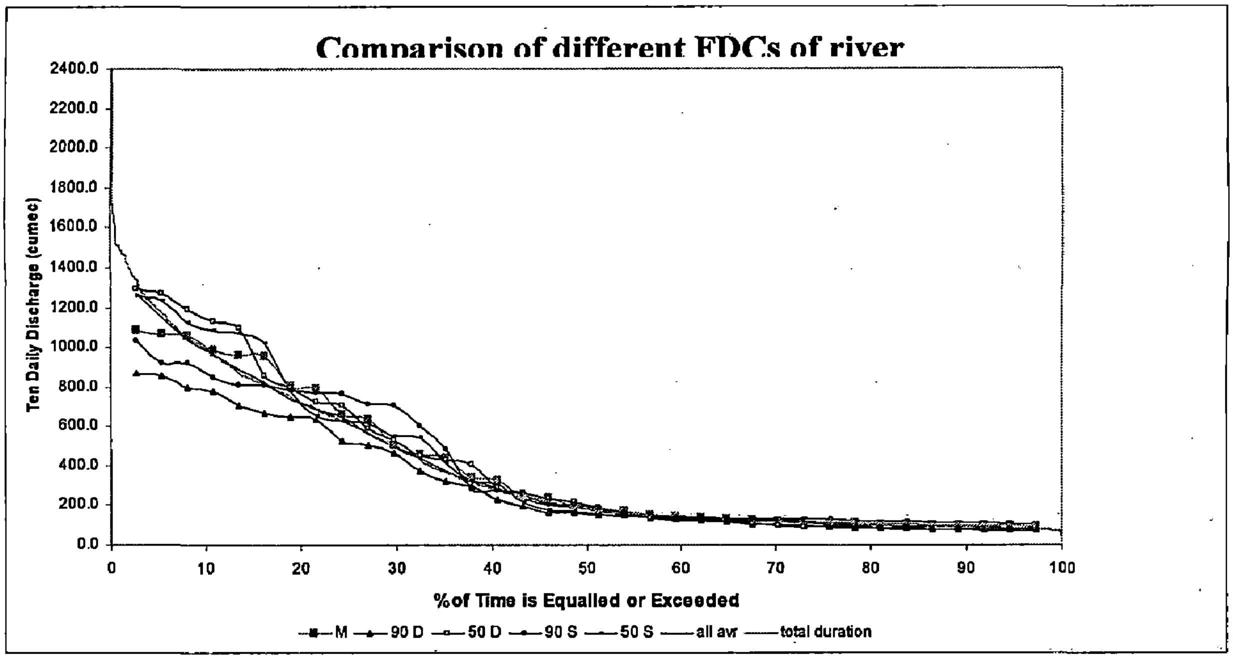


Fig.7.8: Superimposition of different FDC of river Satluj

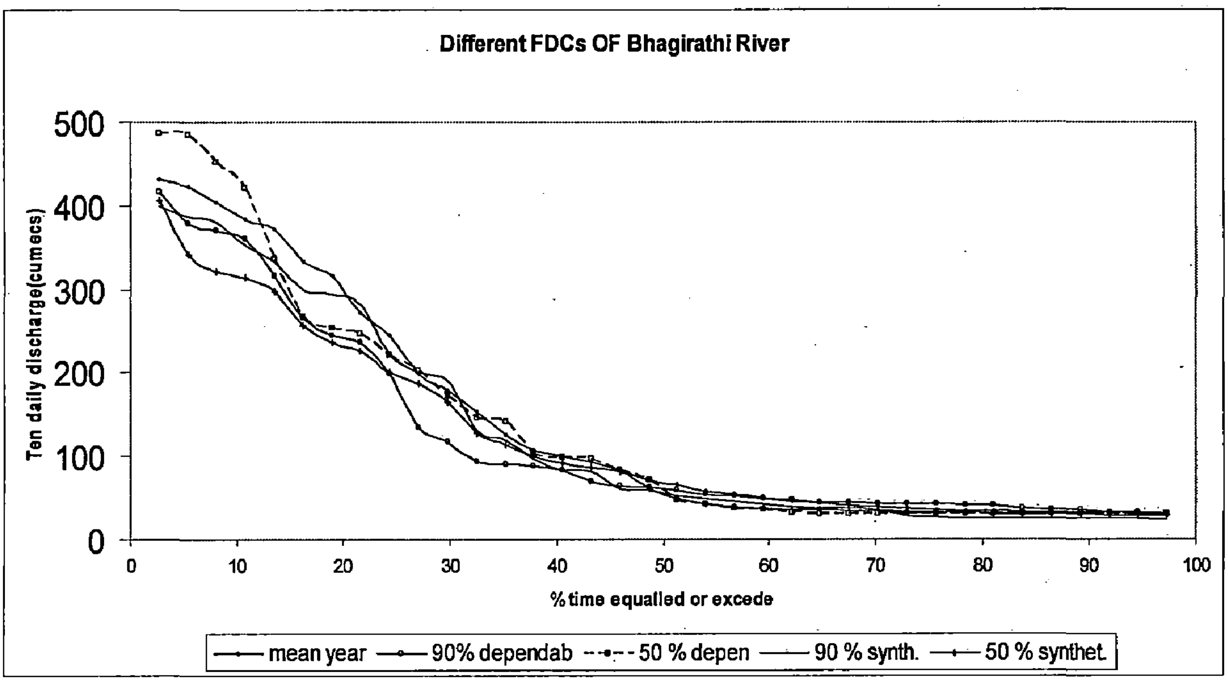


Fig.7.9: Superimposition of different FDC of river of Ganga basin

From above it is evident that there is difference of opinion regarding selection of the year of FDC to be used. Some suggest 90% dependable synthetic year, some 90% dependable year and some (Mosonyi & Brown) advise the use of average year FDC for deciding the design discharge and installed capacity. In one case on river Satluj various FDCs have been worked out and superimposed on each other in the enclosed fig. 7.8. It can be seen that the lower limb of FDCs from 40% of time to 100% of time it is practically same for all the FDCs, but these differ in the upper limb between 0 to 40%of time, but average year FDC is found the near average of all the cases. Similar trend has been observed at one site of river in Ganga basin. Hence it is suggested to use average year FDC for planning the scheme. So in our energy studies we have used mean year FDC.

7.5 DESIGN FLOOD ANALYSIS

As stated earlier, no discharge data is available at Luhri dam site. However 24 years (from 1979 to 2004) record of annual maximum discharge in respect of Satluj river at Sunni site are available, and 42 years (from 1963 to 2004) record of annual maximum discharge at Rampur site is also available. The two methods have been used for computing the flood discharge of different return periods.

(i). Gumbel's method,

(ii). Log-Pearson type III

7.5.1. Flood Analysis with Sunni Data

Maximum discharge at Sunni site is worked out by above both methods (Annexure-VII/8). The maximum flood discharge at Luhri dam site is deduced as given below, and are given in Table 7.1.

$$Q_{Luhri} = Q_{Suni} (CA_{Luhri} / CA_{Suni})^{3/4}$$

7.5.2 Flood Analysis with Rampur Data

Maximum discharge at Rampur site is worked out by above both methods (Annexure-VII/9). The maximum flood discharge for 1000 years return period, at Luhri dam site is deduced as given below,and are given in table 7.1.

$$Q_{Luhri} = Q_{Rampur} (CA_{Luhri} / CA_{Rampur})^{3/4}$$

Table.7.1: Maximum flood discharge at Luhri dam site

Description	Gumbel's method	By Log-Pearson type III
By Rampur Data	7439 cumecs	5427 cumecs
By Sunni Data	8234 cumecs	10284 cumecs

So we adopt maximum flood of 10284 cumecs .

POWER POTENTIAL STUDIES

8.0. GENERAL

It is a run of the river scheme with pondage to harness the hydropower potential of river Satluj. The 33 year discharge data fo Luhri dam site is generated (Annexure –VII/3).

8.1. POWER STUDIES

Discharge data for 33 years from 1972 to 2005 in ten daily blocks are available. Energy generation for each year (June to May) has been worked out. The gross head is taken as 202 m, after calculation of losses (Annexure –VIII/1) the net head is 162 m.For such head Francis Turbines are proposed to be use for this project. The efficiency of the generating unit is taken as 92 %. The environmental releases is taken as 15 % of the minimum ten daily discharge of mean year. This work out to be 14 cumecs. The unrestricted energy computed are enclosed. (Annexure –VII/6).

8.2. DISCHARGE DATA

The ten daily discharges reduced at the project site for the 12 months in ten daily blocks for mean year(Annexure-VII/5), for 50 % dependable year(1980-81), and those of 90 %dependable year(2001-02) enclosed in Annexure –VII/6.

8.3. INSTALLED CAPACITY ANALYSIS:

As per Mosonyi[16], Q_{34} is around 452 cumec and Q_{50} comes around 182 cumec, which corresponds 662 MW and 266 MW respectively.

J. G. Brown[3] recommends that maximum flow for power generation can be taken upto 3 times of mean flow, so by this approach our discharge is worked out equal to 1161 cumec, so we can fix our installed capacity upto 1700 MW by this criteria.

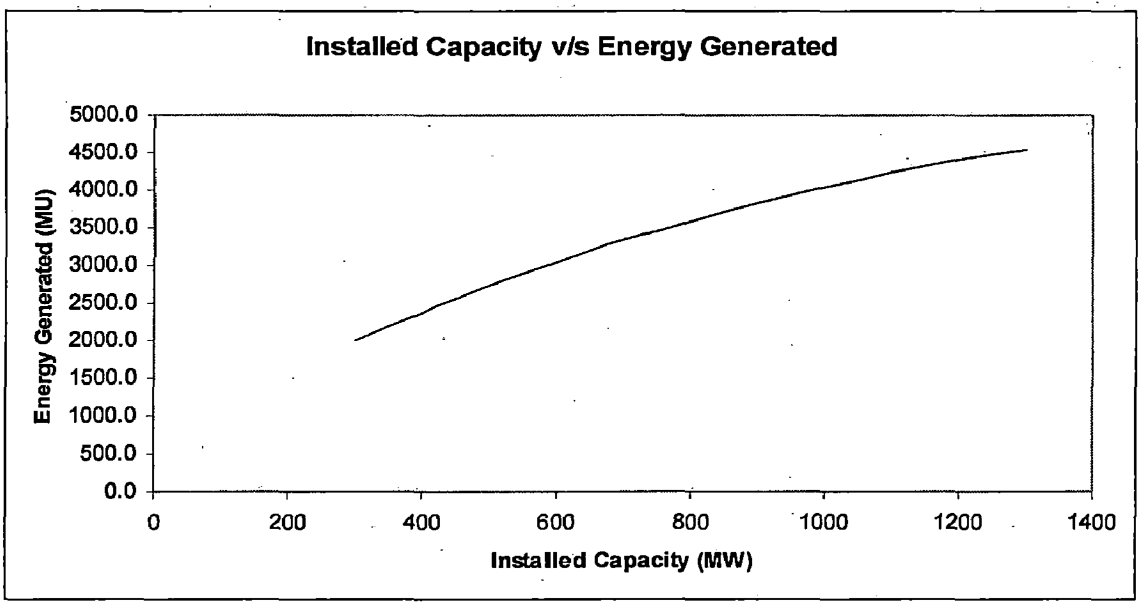


Fig.8.2: Installed capacity v/s energy generated

Considering the inflows of different years, annual energy generated has been worked out for different installed capacities (300MW to 1300 MW , with increment of 50MW and are worked out in Annexure-VIII/2 for mean year flow and in Annexure-VIII/3 for 90% dependable year flow. It is seen from these Annexure that the annual energy generation increases from 1996 million units to 4626 MU for mean flow, 1837 MU to 3774 MU for 90 % dependable flow, 1904MU to 4499 MU for 50 % dependable flow, 1927 MU to 4572 MU for 90 % synthetic year flow, 2006 MU to 4568 MU for 50 % synthetic year flow respectively, as the installed capacity increases from 300 MW to 1300MW. For different installed capacities energy generated, incremental increase in energy and incremental increase in energy per MW for different flows are tabulated in Annexure-VIII/4. The graph of installed capacity V/s energy generated for mean year flow is shown in Figure 8.2.

8.4. INSTALLED CAPACITY SELECTION

Annexaure-VIII/2 shows the total annual energy generated against different installed capacities for mean flow. It is seen that with increase of installed capacity the annual energy generation increases. Installed capacity Vs incremental increase in energy per megawatt graph is plotted for different flows (Fig 8.3). For installed capacity of 600 MW, 700 MW, 800 MW and 900 MW, energy generated, discharge required, corresponding exceedence probability for different flows are given in Annexure -VIII / 5.

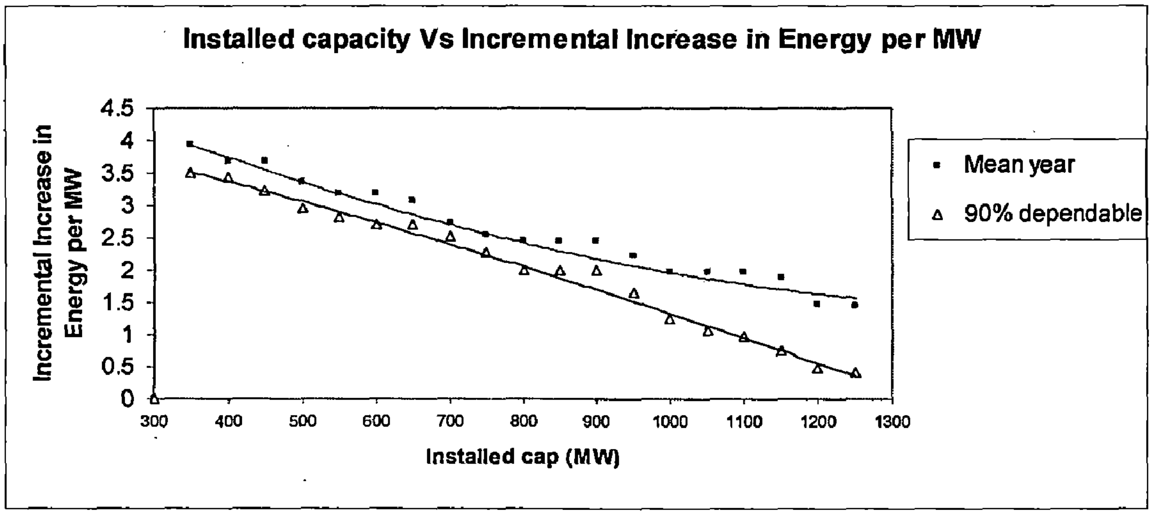


Fig.8.3 : Installed capacity v/s incremental increase in energy

Considering the incremental energy/MW increase in MW in all FDCs as well as the period of minimum 100 days for which the power house can run on installed capacity, the installed capacity is fixed at 900MW. For 900MW, 615 cumecs of discharge will be required having exceedance probability of 29 % on Mean Year flow FDC (reference- Fig: 7.3) and which gives 3832 MU of energy.

At the installed capacity of 900 MW the power and energy in ten daily blocks of the 12 months of the mean year is shown in Annexure-VIII/2. The comparison between annual energy generated (for installed capacity of 900 MW) for different ten daily flows are given in Annexure-VIII/6, for mean year and 90 % dependable year it is 3832 MU and 3347 MU respectively.

8.5. UNIT SIZE

For the mean year flow, in ten daily blocks the power generated is given in table 8.1

Table: 8.1 Range of power and number of days

Power range(MW)	No of 10 day block
<100	0
100-150	10
150-300	9
300-450	2
450-600	2
600-750	3
750-900	0
>900	10

From Table it is clear that 900 MW power will be generated for 100 days in a year while 100 to 150 MW will be generated for about 100 days. It is therefore, proposed to install 6 units of 150 MW each. During this 100 days period when less than 150 MW power is available, only one unit will be run at 70% of load.

8.6. ENERGY GENERATION

At the installed capacity of 900 MW, power and energy in ten day blocks of the 12 months for mean year flow and 90 % dependable year is shown in Annexure-VIII/2 and VIII/3.

Energy generation 100% and 95 % plant availability for different ten daily flows are given in Annexure –VIII/6 and VIII/7 . For installed capacity of 900 MW and for different flows corresponding plant load factors and generated energy is given in Table 8.2

Table.8.2:Generation of energy for different ten daily flow

	Type	Generation for 100 % of time		Generation for 95 % of time	
		Energy generated in MU	Plant Load Factor	Energy generated in MU	Plant Load Factor
1	Mean Year Flow	3832	0.48605	3741	0.475
2	90 % dependable year flow	3444	0.43683	3347	0.425
3	50 % dependable year flow	3747	0.47527	3659	0.464
4	90 % synthetic year flow	3834	0.4863	3765	0.478
5	50 % synthetic year flow	3844	0.48757	3737	0.474

8.7. PEAKING

The useful live storage capacity is taken as 12 MCM from Pre Feasibility Report for 80 m high dam. Area elevation and area capacity curves are not available, so in absence of such information in this study net head is taken as 162 m (gross head = 202m , losses =33 m and elevation difference between FRL and MDDL is 20 m , so net head = 202-33-20 x 1/3=162.33 m).

Minimum discharge for mean year flow is only 81 cumec. If we provide peaking for 3 hours, then

Required volume of water = (615 – 81) x 3 x 3600 = 5.767 MCM

In flow of 20 hours duration = 81 x 21 x 3600 = 6.124 MCM

Required amount is less than available, Hence 3 hour peaking is possible in this case during minimum 10 daily discharge. In other 10 daily discharge it will be more.

CONCEPTUAL LAYOUT

Conceptual layout of main components of the project are as following:-

9.1. RIVER DIVERSION WORKS

9.1.1. Diversion Tunnel

The river diversion is proposed for the construction of the dam and appurtenant work , through a diversion tunnel, located on the right bank of the river Satluj. It is proposed to adopt design diversion discharge as 550 cumecs for LHEP because the ten daily average flow during the working season (Oct.- Apr.) at dam site is about 387 cumecs .For Rampur HEP design discharge for river diversion has been fixed as 540 cumecs which is up stream development of Luhri Hydro Electric Project.

9.1.2. Diversion Dam

It is proposed to construct a straight gravity type concrete dam 78m high (above river bed level) near Kepu village, 1.5 Km u/s of Sainj Village, to divert 769 cumecs of discharge. Out of this, discharge of 154 cumecs is meant for flushing of sediments through the desilting arrangement. The dam shall be founded on sound rock below the river bed level. The dam at the top shall be app.342.5m long. The top of dam, FRL and MDDL are 848m, 845m and 825m respectively. The distribution of sediment in a reservoir is a complex phenomenon and is govern by a number of factors relating to the characteristics of the catchment , geometry of reservoir, the sediment inflow and the operation of reservoir[23]. Live storage is app. 12 Mcm after taking into account siltation of reservoir. The cross-section of river Satluj at proposed dam site is shown in fig. 9.1

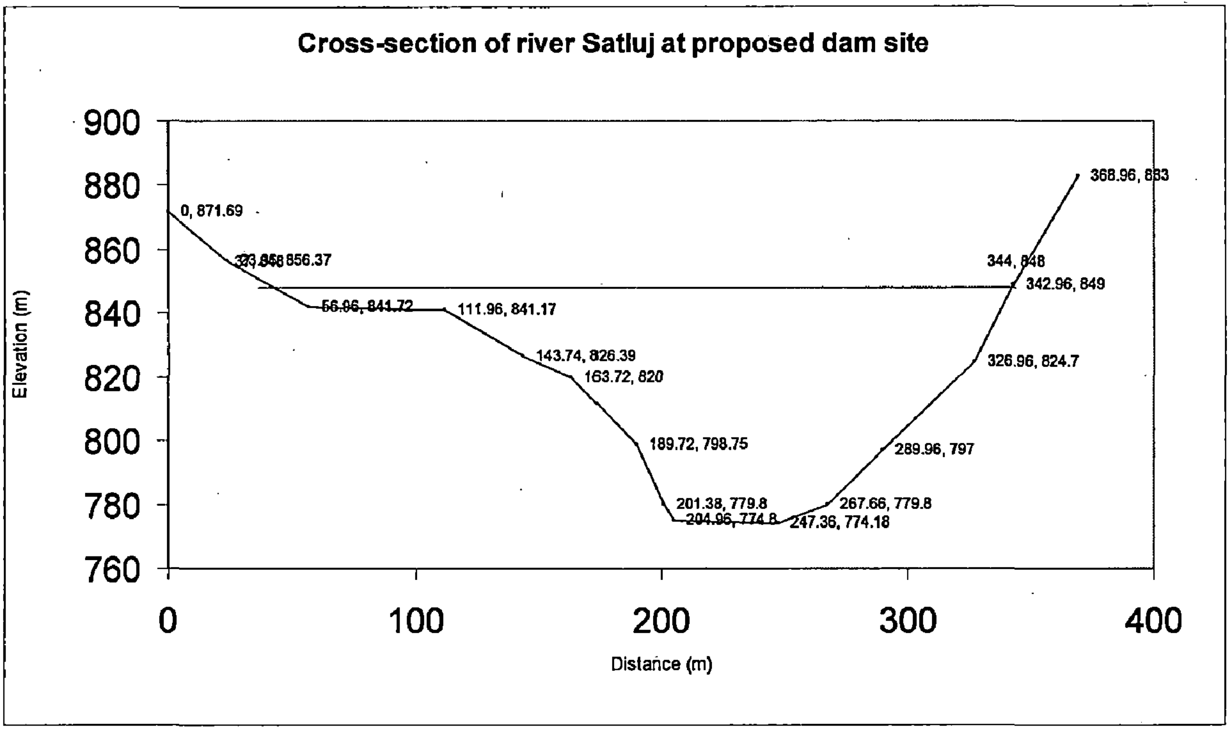


Fig.9.1: Cross-section of Satluj river at dam site

To flush the reservoir periodically under sluice should be provided at invert level of El. 790m. The sluices will be controlled by radial gates from the control room located at top of the dam itself.

9.2. INTAKE STRUCTURE

The intake structure comprising six no. intakes, proposed in the dam body itself shall be designed to handle a total discharge of 769 cumecs (615 cumecs for power generation and 154 cumecs for requirement of silt flushing. The invert level at El. 811.25m. Each intake should pass 128 cumecs of flow. The rectangular opening of 10.15m X9.40 m (h) at the start of the intake shall be reduced to 7.2 x6.0(h)m through a suitable bell mouth transition. Vertical lift gates shall be provided to control the flow of water into the desilting chambers. A suitable transition is provided to convert the rectangular opening into a 7.10m dia horse shoe tunnel. The intake tunnels shall lead the water into the desilting chambers.

A row of trash rack piers having trash racks up to FRL is proposed to be provided in front of intake blocks.

9.3. DESILTING ARRANGEMENT

The sediment load is only a fraction of a gm/lit. during low flows, but increase to an average of 10- 12 gm/lit. in high flow periods[25]. To remove sediment a cut & cover surface desilting arrangement has been proposed on the left bank of river to arrest the silt particles greater than 0.20mm size from the water before it enters the head race tunnel. The arrangement comprises six parallel compartments each 510 m long, 28m high and 15 m wide. The surface desilting chambers would be of RCC and designed to resist full internal pressure. Each chamber shall have a 3m wide collection trench in the center. The sediments from the collection trench will flow down to the flushing tunnel below this trench, and ultimately flushed out to the river through main flushing tunnel.

9.4. WATER CONDUCTOR SYSTEM:

9.4.1. Head Race Tunnel

The length of head race tunnel, from d/s of desilting tank to the main surge tank is 29 Km. having 12.50 m finished diameter and circular in section. The tunnel diameter is designed for discharge of 615 cumecs at a flow velocity of 5.01m/sec. The friction loss in HRT is 31.22 m.

The head race tunnel shall be concrete lined with sections fully supported/partially supported with steel ribs, besides necessary rock bolting as required by geological considerations.

9.4.2. Surge Shaft

The main surge tank, located at 29 Km from the 0 RD of head race tunnel, will be of 36m dia and 164m height. The dia of restricted orifice shall be 5.0 m.

Detailed calculations are worked out in Annexure-IX/1, and relative elevations are shown in figure 9.2

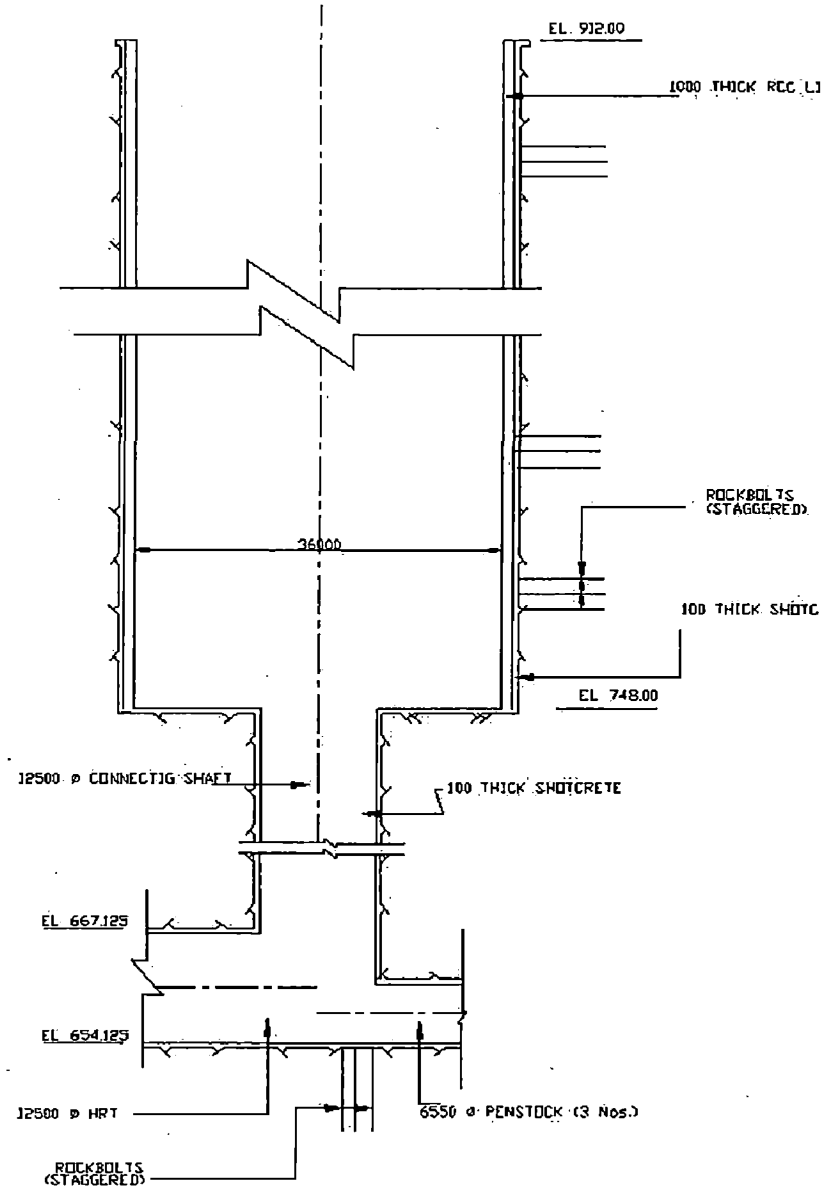


Fig. 9.2: Surge Shaft

9.4.3. Pressure Shaft

Three penstocks, each 175m long and 6.10m dia would take off from the surge tank. These would be lined with high tensile ASTM steel of thickness varying from 30mm to 40mm . Each of the three penstocks will bifurcate (of 4.65 m diameter unit penstock) to feed the six generating units. A butterfly valve has been provided in each penstock d/s of surge tank to enable closing of penstock whenever required.

9.4.4. Tailrace Tunnel

The tail race tunnel, 12.50m circular section, about 250m long will be provided to carry the discharge from the draft tube tunnels emanating from the power house. The invert level of this tunnel at its portal end has been kept at El. 626.25 m. The mouth of tail race tunnel is proposed to be kept submerged by constructing a weir with crest elevation as 639m.

9.5. POWER HOUSE

An underground power house of size 125m (L) X 25m(W) X 43m(H) would be located sufficient below the natural surface level. The power house will have an arched roof with concrete lining and shall house six generating units each of 150 MW capacity. The transformers & GIS would be accommodated in another parallel cavity located d/s of power hose cavern. Two overhead cranes each of 250 T capacity with crane girders supported on rock at either end will be provided in the main power house cavity.

9.6. DIMENSIONING OF DIFFERENT COMPONENTS

9.6.1. Dimensioning of Intake

There are six intakes are provided in concrete dam itself. The invert level at RL 811.25m. Each intake should pass 128 cumecs of flow. The rectangular opening of 10.15 m X9.40 m (h). Calculations are work out in Annexure-IX/2).

9.6.2. Dimensioning of Desilting Chamber

River Satluj carrying large quantities of harmful sediment during monsoon, so it may pose serious abrasion to different components of the scheme, which will require frequent repairs and maintenance and during such period there should loss of power generation. Himalayan Rivers contains quartz particles which is very harmful. Laboratory investigations have shown that the rate of erosion is directly proportional to sediment concentration, hardness, size, shape, wear resistance of material, and relative velocity (Fig. 9.3) Detail calculations are given in Annexure –IX/3.

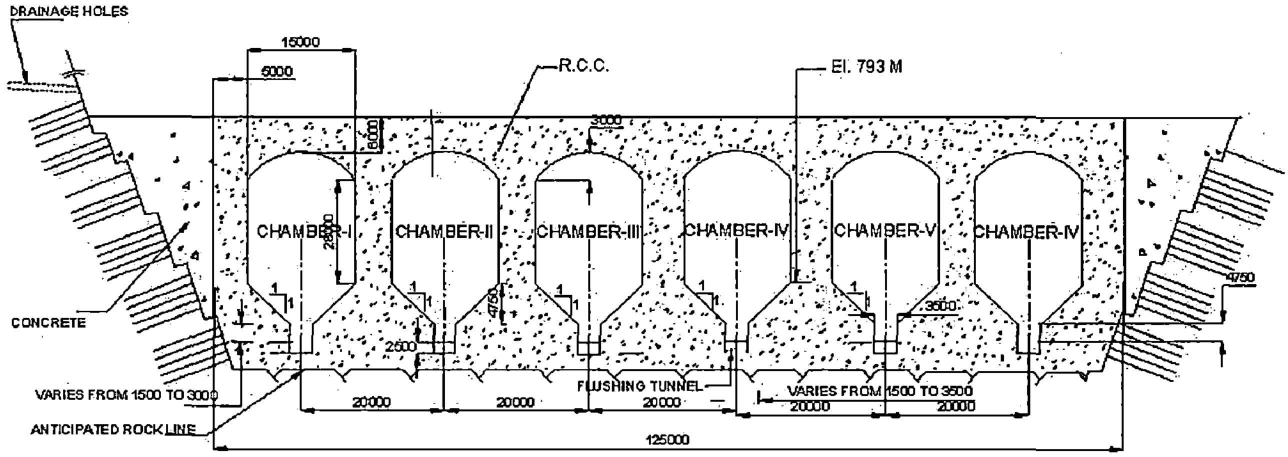


Fig. 9.3:

9.6.3. Head Race Tunnel

HRT is designed on velocity considerations. HRT is supposed to carry discharge of 615 cumes. Taking velocity of 5.0 m/sec. as limiting so required cross-sectional area of 123 sq metres, which gives the dia of 12.53 m. So let we adopt diameter of 12.5 m, so there will be velocity of 5.01 m/sec.

9.6.4. Penstocks

Design discharge = 615 cumecs

Net Head = 202-33 = 169 m (say).

Max. permissible velocity in penstocks (USBR formula)

$$V = 0.125 \sqrt{2gH}$$
$$= 0.125 \sqrt{2 \times 9.81 \times 169}$$
$$= 7.197 \text{ m/sec. say } 7 \text{ m/sec.}$$

Assuming 3 No. penstocks, discharge through each penstock = $\frac{615}{3}$ = 205 m^3 /sec

$Q = AV$

$A = \frac{205}{7.00}$

$= 29.29\ m^2$

Dia of penstock = 6.105 m
Say = 6.10 m

The dia of 6.10 m has been adopted.

Each penstock shall be bifurcated near the d/s end to feed two turbines.

For same head loss,

$D_n = D / n^{0.4}$

Where D_n = diameter of unit penstock

D = diameter of main penstock

n = 2 (bifurcation)

Hence D_n = 4.62m (say 4.65 M)

9.6.4.1. Thickness of penstock steel liner

Max. water level 907m (i/c water hammer pressure)
Min. water level = 634.0m

Head = 907-634 = 273 m

Max. pressure = 27.3 Kg/cm^2 using, ASTM, 517

Max. hoop stress $= \frac{Pd}{2\&}$ permissible stress = 2550 Kg/cm^2 (using F.O.S = 2)

$$2550 = \frac{27.3x6.55 \times 100}{2x\ t \times 0.90}$$

(efficiency of congitudinal joints varies between 0.85 +0.095 for welded joints)

$$t = \frac{27.3X6.55X100}{2550\ X\ 2\ X\ 0.90}$$

t = 3.89 cms
t = 38.9 mm
say 40mm.

9.6.4.2. Thickness of 4.65m dia. penstock liner

$$2550 = \frac{27.3X4.65\ X\ 100}{2\ X\ t\ X\ 0.9}$$

$$t = \frac{27.3 \times 4.65 \times 100}{2500 \times 2 \times 0.9}$$

$$= 2.821 \text{ cm}$$

$$= 28.21 \text{ mm} \quad \text{(Say 30 mm)}$$

9.6.5. POWER HOUSE

Power house contains hundreds of auxiliary equipments and controlling devices. In this study only primary dimensioning is done.

9.6.5.1. Selection of turbine

Selection of turbine requires more attention , when the overlapping of head is there, type of turbine for different head range is given in table 9.1. In our case study, maximum net head is 169 m, so as per IS 12837: 1989, Francis turbine is proposed.

Table. 9.1: Type of turbine for different range of head

Sl.No.	TYPE OF TURBINE	RANGE OF MAXIMUM NET HEAD
1.	Pelton	Above 300 m
2.	Francis	30 to 400 m (some times even up to 500 to 600 m)
3.	Kaplan	10 to 60 m
4.	Bulb	3 to 20 m
5.	Deriaz	50 to 150 m

Francis turbine is capable of working in between 125 to 65 % of rated head, load variation for 50 to 100 % of rated output, having specific speed from 60 to 400 .

9.6.5.2. Main parameters of turbine

Main parameter are calculated (Annexure IX/4) as per IS 12800 (Part 1):1993 .Detail of Francis turbine are given in table 9.2

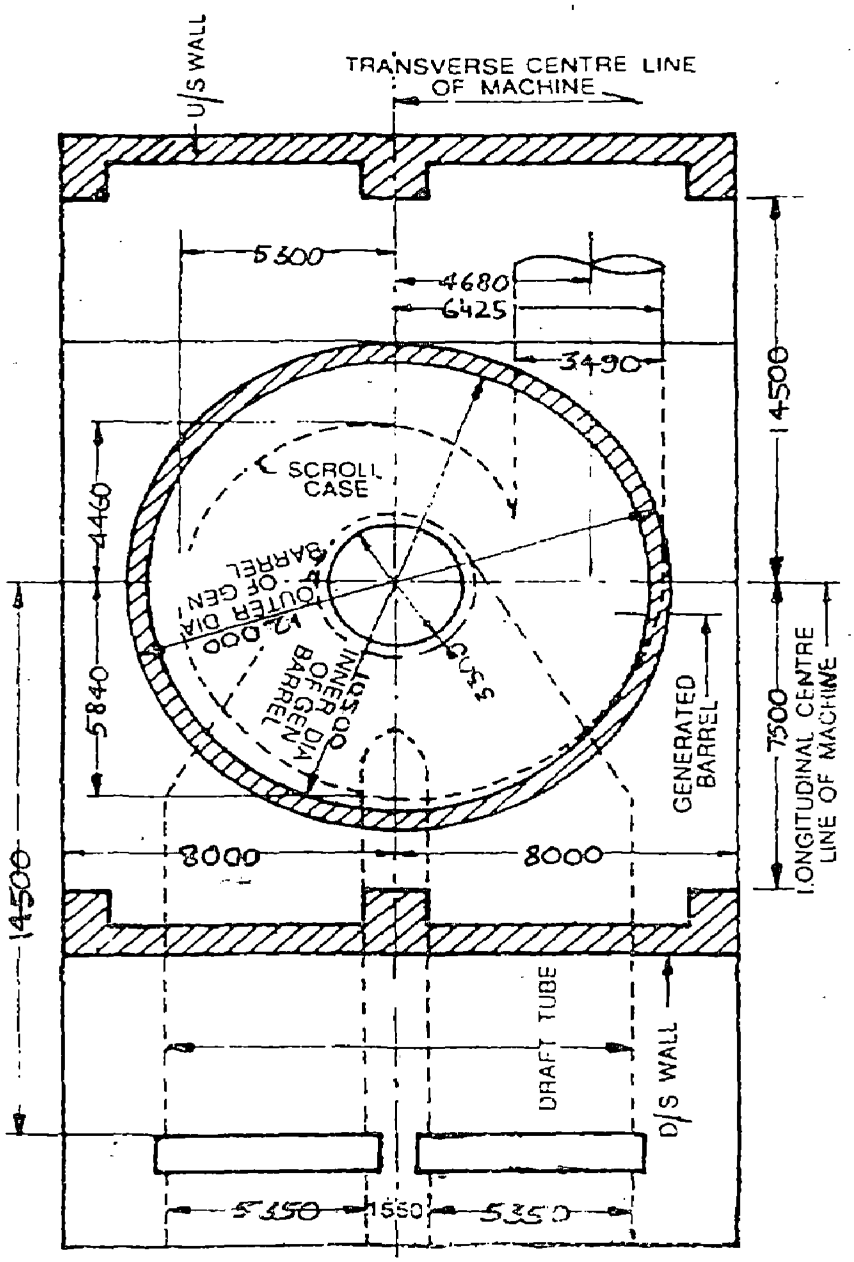


Fig.9.4 : Unit bay

Table.9.2 : Different parameters of turbine

Synchronous speed	200 r.p.m.
Specific speed	156.1823
Runner discharge diameter	3.23 m
Inner diameter of generator barrel	10.5
Weight of generator rotor	465 tonnes

9.6.5.3. Unit Width

The inner diameter of the generator barrel may be increased by 0.5 to 1.5 m depending upon the size of the machine. A clearance of 1.5 to 2.0 m should be added on either side of the extremities to determine the unit spacing. These clearances should be such that a concrete thickness on either side of scroll case should be at least 2.0 to 2.5 m in case of concrete scroll cases and 1.0 to 1.5 m in case of fully-embedded steel scroll cases, Figure 9.4.

Hence outer diameter of generator barrel =10.49+1.5=11.99 m (Say 12 m)

Extreme distance of scroll case = 6.425 m , add 1.5 m

Total = 7.945 m (say 8.0 m)

Hence unit width = 16 m

9.6.5.4. Overall dimension of power house

The overall dimensions of power house mainly depend upon the following:

a) Overall dimensions of the turbine, draft tube and scroll-case;

b) Overall dimensions of the generator;

c) Number of units in the power house; and

d) Size of the erection bay.

NOTE - Provision for inlet valve, erection of rotor etc should be made in such a way that the space required is minimum without impairing the operational and maintenance requirements.

9.6.5.5. Length of power house

The length of erection bay may be taken as 1.0 to 1.5 times the unit bay size as per erection requirement.

The total length L of the power houses can then be determined as follows:

L = Number of units X unit spacing + Length of Erection Bay + K

Where

K= Length required for the E.O.T. crane to handle the last unit. Depending upon the number and size of the E.O.T. crane, this length is usually 3.0 to5.0 meters. There are two E.O.T. cranes so we take K = 8 m .

9.6.5.6. Width of power house

For determining the width of the power house superstructure, the overall dimensions of the spiral casing and the hydrogenerator may be drawn with respect to the vertical axis of the machine. Superstructure columns should be clear of the downstream extremities by about 2.0 to 2.5 meters.

On the upstream side provision should be made for the following:

a) A clearance of about I.5 to 2.O m for concrete the upstream of scroll case;

b) A gallery of 1.5 to 2.0 m width for approaching the draft tube manhole;

c) In case the main inlet valve is also accommodated in the power house, a valve pit of appropriate size should have to be Provided.

d) A clearance of about I.5 to 2.0 meters for pressure relief valve in the scroll case, if required; and

e) The spaces as indicated against item (a) to (d) are supposed to be sufficient for accommodating the auxiliary equipment also but may have to be reviewed considering the layout of essential equipment and operational requirements.

Note: The inlet valve gallery, if provided, can be utilized for approaching the draft-tube man-hole also and hence no separate gallery is needed for this purpose. The above criteria gives the internal width of the Power House (excluding column width).

9.6.5.7. Height of power house

The height of power house from the bottom of the draft-tube to the centre line of the spiral casing H, (see Fig. 9.5), can be determined in accordance with IS 5496 : 1969. The thickness of the concrete below the lowest point of draft-tube may be taken from 1.0 to2.0 m depending upon the type of foundation strata, backfill conditions and size of the power house.

The height of power house from the centre line of the spiral-casing up to the top of the generator H2 can be determined, as follows:

$H_2 = L_t + h_f + K$

Where

L_t = Length of Stator frame

H_f=Height of load bearing bracket

K= 5.5 to 7.0 depending upon the size of the machine

The height of the machine hall above the top bracket of the generator depends upon the E.O.T. crane hook level and the corresponding E.O.T. crane rail level, and the clearance required between the ceiling and the top of the crane. Further the height should depend upon the height of the service bay floor from where the equipment is to be handled.

WATER RESOURCES DEVELOPMENT & MANAGEMENT
INDIAN INSTITUTE OF TECHNOLOGY – ROORKEE

No. WR/E-21/2006/ 714 Dated : July 12, 2006

Assistant Registrar (Acd)
P G S & R
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Subject : Results of M. Tech Dissertation

Please find enclosed herewith sealed envelopes containing the marks of the Dissertations alongwith the copy of the thesis of the following four M. Tech students for further necessary action at your end please.

SN	Name of the Student	Enrolment No.	Date of Exam	Title of the thesis
1.	Atul Kumar Maurya	048004	11.7.2006	Planning & Layout of a Run-of River Hydropower Scheme with Pondage- A Case Study
2.	Daniel Asseh Allan	048006	11.7.2006	Hydro Power Planning in the Basin of River PRA in Ghana
3.	Inam Uddin Rahmani	048009	10.7.2006	Development of Sick Tube Wells
4.	Sanjeev Gupta	048015	11.7.2006	Design of Pre-stressed Cable Anchors for Stabilization of Himalayan Slopes

Please acknowledge the receipt please.

Encl : As mentioned

(Nayan Sharma)
Professor & Chairman, DRC

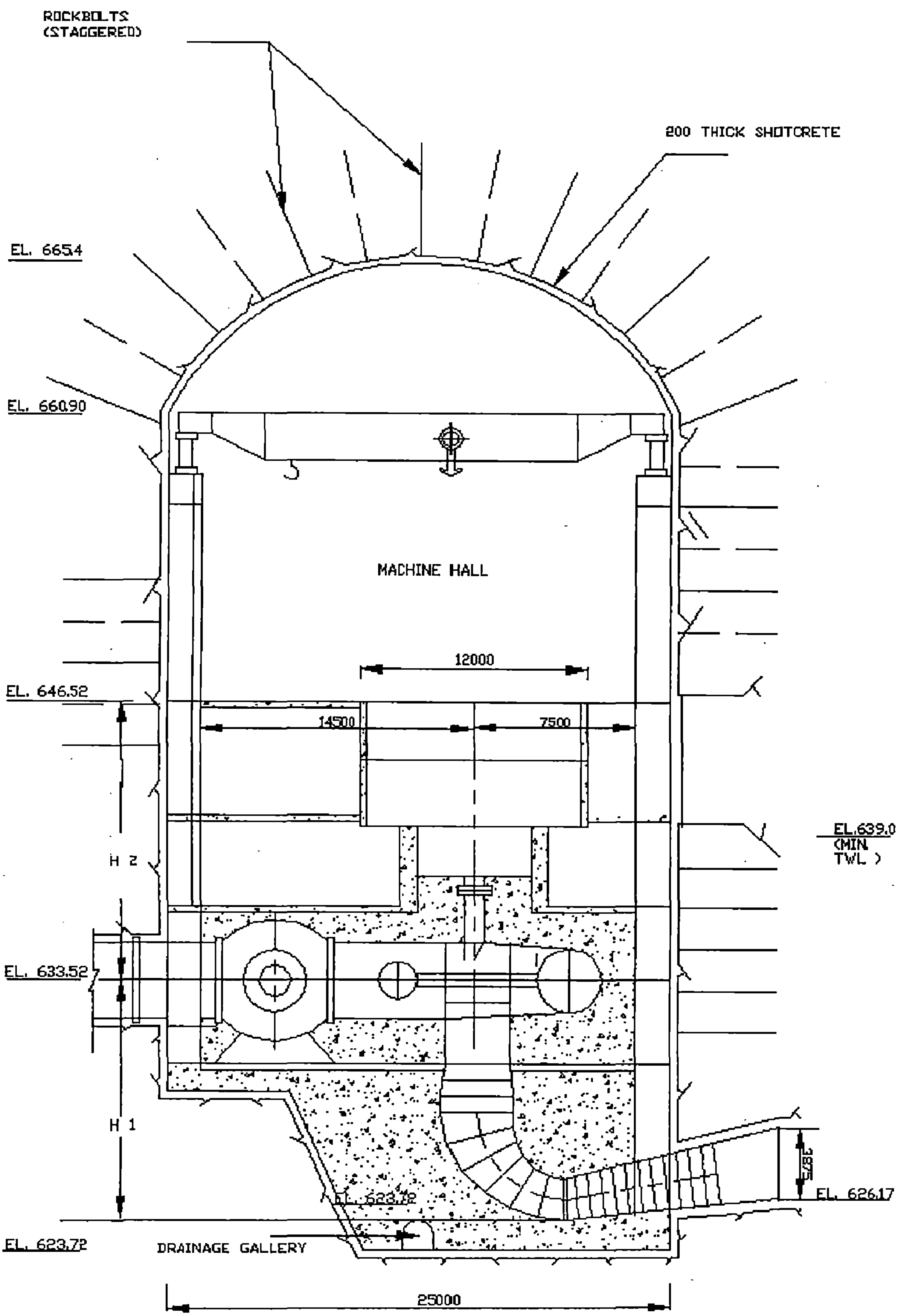

Fig. 9.5 : Sectional elevation of Power House

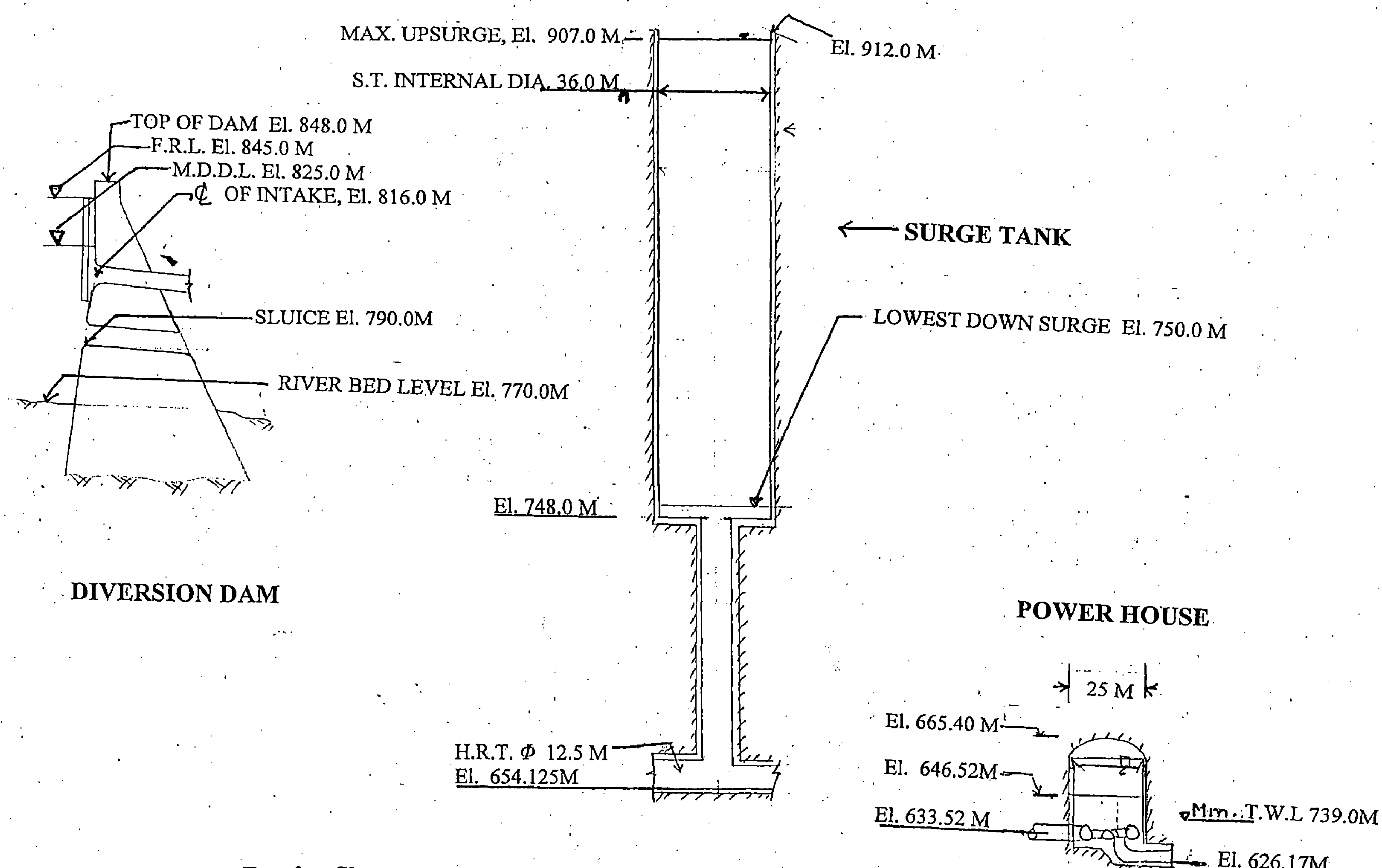

FIG. 9.6: SKETCH SHOWING ELEVATION OF DIFFERENT COMPONENTS

The E.O.T. crane hook level and the corresponding crane rail level are determined by providing adequate clearance for the following cases:

a) Hauling moving major items of equipment viz. turbine runner assembly, rotor assembly and even entire generator stator.

b) Hauling the main transformer with bushing into the erection bay under E.O.T. crane girder.

c) Clearance required for undertaking transformers.

d) Unloading of largest package from trailors. A height of 7 to 8.5 metres between the top erection bay floor and highest hook level may be sufficient.

The height of the power house ceiling above the highest level of the E.O.T. crane hook may generally vary from 4 to 6.5 m depending upon the width of the power house superstructure and capacity of E.O.T. crane. Keeping a clearance of O.5 metre between the highest part of the gantry crane and the ceiling of the Power house (Figure 9.4). Calculations of the overall dimensions of the power house are given in Annex –IX/4, which are

Length = 124 m

Width = 25 m

Height = 43 m

9.6.6. Tail Race Tunnel

TRT is designed same as HRT, on velocity considerations. So we adopt diameter of 12.5 m, so there will be velocity of 5.01 m/sec.

The relative elevations of main components of Luhri project are show in Figure 9.6

CONCLUSION

- In this study planning and design principles of a run-of-river scheme are discussed and illustrated by case study.
- Literature review has revealed different criterion for carrying out power planning study using flow duration curve. A comparative study has been made of different criterion and it is found that use of mean year FDC as recommended by Mosonyi shall be adopted.
- A design discharge of around Q_{34} as suggested by Mosonyi is reasonable. In the case studied a design discharge of Q_{29} has been found adequate to produce optimal energy by running the power house at full installed capacity at least for about 100 days in a year.
- The basic features worked out in the case study are

Design Head	162 m
Design Discharge	615 cumecs
Installed capacity	900 MW
Energy at 90 % dependability	3444 MU (91.3% of unrestricted energy)
Energy at 50% dependability	3747 MU (75.4% of unrestricted energy)
Energy for mean year	3832 MU (79.8% of unrestricted energy)

- Provision of small pondage in a run-of-river scheme is always advantageous because power house can be run to meet peaking. In the case study a small pondage of 6 MCM is required for a peaking of 3 hours in the minimum 10 daily flow.

- Preliminary dimensions of associated structures have been worked out to illustrate the design principles.

FURTHER SCOPE OF WORK

- Detailed topographical, geological and hydrological investigations should be carried out for this scheme
- Detailed economic analysis should be carried out to decide the installed capacity.
- Sediment data should be collected and studies should be carried out to determine optimal size to be removed on economic consideration.

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Annexure

TEN DAILY DISCHARGE DATA OF SATLUJ AT SUNI

Unit - Cumecs   Chatchment Area = 52915 KM2

MONTH	BLOCK	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
JAN	I	90	99	101	91	111	99	101	109	92	86	85	88	94	82	81	113	107
	II	83	88	98	81	106	86	853	109	85	36	83	94	89	76	76	109	108
	III	82	96	98	103	102	96	94	101	88	79	82	98	85	75	75	107	101
FEB	I	82	94	99	115	101	93	94	100	91	81	83	93	81	72	81	104	86
	II	82	95	93	119	102	94	94	97	89	78	85	92	84	71	81	105	74
	III	83	100	94	117	113	94	93	125	100	81	87	90	105	73	82	109	88
MAR	I	88	100	98	130	116	93	96	144	92	97	123	95	105	83	93	108	83
	II	91	105	108	146	115	100	108	149	89	94	118	109	119	88	113	112	102
	III	115	153	149	154	135	108	121	167	96	131	157	122	141	94	116	125	102
APR	I	116	194	160	205	141	135	120	233	118	128	225	147	153	93	125	145	110
	II	142	244	177	214	180	107	207	303	159	220	242	173	156	116	192	145	286
	III	150	684	230	304	351	118	216	379	234	261	299	227	238	152	262	200	339
MAY	I	135	1424	332	364	324	128	390	412	352	431	406	367	317	202	296	282	510
	II	315	604	299	629	423	145	582	412	401	459	385	593	463	443	505	285	591
	III	553	839	251	559	540	268	656	362	465	596	415	634	667	622	253	371	615
JUN	I	590	1139	430	785	956	473	839	368	733	477	647	820	1011	711	321	887	628
	II	737	2375	630	1495	761	339	740	821	853	448	1248	699	840	737	896	816	642
	III	898	1753	529	1497	558	723	1197	1706	1136	916	1024	956	763	763	1527	879	1096
JUL	I	1030	1400	639	854	709	1450	1523	1320	1107	846	1307	1090	857	788	1104	1237	1120
	II	924	1523	1168	1749	1400	1548	1254	1481	1312	1036	1301	715	573	828	1238	1048	1157
	III	1044	1161	1074	1256	1517	1200	1255	1185	1207	1277	1332	1288	854	784	1493	1210	1295
AUG	I	951	1002	1072	1540	938	1538	1557	1085	1317	1383	1231	1361	794	862	1282	963	1298
	II	880	991	1059	1685	812	1016	1391	1044	810	1185	1245	1153	878	948	1163	854	1071
	III	717	1005	725	1071	654	737	903	785	709	1017	795	1210	832	878	861	823	823
SEP	I	717	956	562	717	599	730	977	663	535	505	516	941	686	697	638	656	559
	II	526	683	408	552	415	587	738	387	407	352	561	710	400	476	360	463	418
	III	320	488	312	382	322	395	479	246	293	300	298	442	238	348	280	385	727
OCT	I	226	281	199	277	230	257	325	211	238	229	213	290	175	246	209	229	340
	II	200	218	185	236	191	207	255	188	188	171	182	232	152	330	195	176	219
	III	165	203	148	216	177	181	205	164	161	152	165	194	137	188	163	158	174
NOV	I	146	181	135	195	158	171	187	150	140	158	145	171	121	154	148	139	156
	II	132	156	121	180	144	156	173	132	125	130	134	147	105	134	136	129	144
	III	117	129	110	153	131	149	162	123	114	115	120	133	97	118	129	123	137
DEC	I	108	116	103	132	110	120	150	111	101	104	103	120	90	102	125	118	131
	II	107	108	100	125	101	124	136	98	93	94	99	110	88	205	123	113	125
	III	104	104	94	118	101	113	125	94	85	88	86	101	83	89	120	109	133

TEN DAILY DISCHARGE DATA OF SATLUJ AT SUNI

Unit - Cumecs Chatchment Area = 52915 KM2

MONTH	BLOCK	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
JAN	I	133	105	112	116	106	103	117	115	109	107	144	118	109	83	80	99.00	76.65
	II	126	101	104	114	106	105	112	110	105	103	139	116	100	80	82	91.63	79.52
	III	113	101	96	116	105	75	107	106	103	99	135	115	.97	78	73	89.63	76.42
FEB	I	112	104	96	127	105	99	105	103	103	97	133	113	86	77	76	87.92	79.72
	II	109	108	99	118	105	100	109	106	103	98	125	114	85	81	76	86.76	86.32
	III	107	107	99	126	107	103	115	122	101	102	128	127	87	78	81	86.83	94.31
MAR	I	111	108	116	112	107	101	112	112	102	117	126	113	87	98	100	86.25	95.50
	II	117	114	134	121	117	116	106	132	111	132	127	117	84	108	88	92.51	108.20
	III	131	201	162	145	139	126	131	140	109	126	127	122	98	119	128	105.49	131.66
APR	I	133	186	221	137	126	137	131	144	114	153	152	140	106	131	142	106.50	120.38
	II	142	194	198	155	149	128	142	227	135	165	201	158	116	166	206	114.88	141.72
	III	146	252	235	223	254	137	167	366	169	262	359	181	129	242	259	130.51	226.91
MAY	I	182	360	383	270	458	238	223	388	144	330	395	214	189	334	278	126.38	335.36
	II	312	966	511	429	299	280	672	365	168	349	463	480	321	886	618	235.60	343.61
	III	560	869	612	410	472	613	389	549	247	732	609	524	268	677	839	313.09	242.69
JUN	I	985	859	1029	481	527	789	739	607	330	687	310	456	393	818	1170	282.06	
	II	745	731	1361	782	755	676	1031	1136	485	621	660	526	556	1089	1087	456.80	
	III	663	1396	1181	1081	640	1317	587	1574	737	1147	839	618	544	912	915	466.55	
JUL	I	792	1261	1453	649	737	1365	894	888	689	1518	963	622	715	964	954	606.65	
	II	1145	1172	1261	980	1089	1200	1008	1060	877	1386	938	822	857	841	859	539.99	
	III	1308	961	1227	1254	715	1491	1032	1088	936	1054	1031	1139	812	755	929	538.14	
AUG	I	851	1058	1002	1059	758	1442	1035	1094	948	1029	1355	1037	743	808	1010	639.85	
	II	781	1048	705	973	631	1182	913	1259	817	1097	1011	678	922	969	782	635.90	
	III	881	857	796	858	557	1145	790	803	644	1141	848	593	664	810	686	473.42	
SEP	I	597	743	704	753	521	978	838	669	442	608	583	557	480	779	630	303.94	
	II	378	546	506	535	481	563	500	545	379	468	469	356	302	507	462	324.93	
	III	315	407	303	292	290	316	301	322	249	578	398	250	204	291	337	209.45	
OCT	I	226	265	231	239	215	258	236	257	195	351	254	198	166	213	205	173.72	
	II	189	225	195	194	176	208	202	205	153	373	198	185	151	190	180	152.23	
	III	177	190	173	165	150	175	170	170	133	287	180	172	137	171	154	146.90	
NOV	I	162	158	159	144	137	153	146	151	122	216	169	160	160	151	142	123.06	
	II	146	154	144	136	133	144	140	139	123	198	159	148	124	141	132	107.46	
	III	138	145	131	131	129	135	134	133	129	185	149	137	105	134	113	93.97	
DEC	I	114	138	125	122	123	129	128	128	122	167	138	128	95	126	106	81.89	
	II	120	133	123	110	112	125	120	121	122	154	130	122	88	127	104	79.49	
	III	121	120	121	106	105	122	118	114	115	148	121	111	86	96	100	76.06	

TEN DAILY DISCHARGE DATA OF SATLUJ RIVER AT RAMPUR

UNIT - Cumecs   Chatchment Area = 50880 KM^2

Month	BLOCK	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
Jan	I	84	92	85	103	100	92	92	103	90	83	82	86	92	77	78	111	106
	II	78	91	90	84	99	89	88	101	90	78	80	89	86	65	67	97	105
	III	77	91	91	76	95	90	88	100	90	87	78	88	84	72	73	105	100
Feb	I	77	88	92	107	94	86	88	97	94	78	79	88	81	69	77	103	84
	II	77	89	87	111	97	89	88	93	89	77	82	88	80	68	78	104	71
	III	79	93	88	109	105	88	87	94	94	63	65	88	82	70	80	105	73
MAR	I	83	93	90	123	109	87	89	99	96	83	85	90	93	79	90	106	76
	II	85	98	101	136	107	94	104	121	89	85	85	97	111	84	102	110	84
	III	110	142	138	143	126	102	112	133	102	108	101	103	115	89	104	120	91
Apr	I	107	180	148	190	131	126	115	188	120	105	170	134	146	89	116	138	98
	II	133	226	164	198	167	103	200	243	150	196	183	150	157	110	177	135	255
	III	142	630	213	281	321	113	206	345	234	250	244	199	239	144	235	190	319
May	I	174	1311	306	335	299	118	382	415	258	423	347	337	319	194	278	226	474
	II	280	557	276	569	390	138	552	407	387	437	317	577	450	223	476	209	553
	III	538	772	232	472	498	233	596	354	433	576	376	539	618	559	261	325	562
Jun	I	490	1024	344	685	849	379	791	377	716	465	633	776	929	549	301	785	580
	II	688	2215	536	1367	662	252	630	820	865	447	1237	651	767	611	801	685	582
	III	810	1616	438	1373	467	710	1137	1640	1106	930	1006	908	709	724	1349	768	995
Jul	I	910	1278	538	751	812	1314	1285	1231	1081	843	1333	1010	798	709	946	1081	975
	II	814	1395	1053	1613	1227	1403	1128	1451	1140	1017	1326	667	542	800	1104	977	1015
	III	924	1045	964	1138	1390	1083	1116	1173	1151	1243	1297	1193	773	833	1365	1133	1128
Aug	I	1116	894	962	1413	833	1433	1466	1067	1221	1293	1156	1270	726	713	1115	894	1054
	II	786	884	902	1551	697	853	1235	1021	756	1103	900	937	797	825	977	804	871
	III	605	987	628	960	558	642	786	776	685	784	712	1098	747	735	741	760	646
Sep	I	590	849	471	620	509	620	863	669	517	490	491	841	610	588	567	640	504
	II	417	567	319	460	329	457	614	373	393	345	415	616	386	397	346	436	386
	III	256	440	253	326	264	327	419	247	279	280	290	414	229	278	247	310	427
Oct	I	208	255	184	256	215	233	287	204	227	205	198	286	171	228	203	213	270
	II	183	202	170	218	178	189	227	173	185	167	179	227	149	258	178	169	205
	III	150	188	137	200	184	167	208	156	148	151	173	212	134	180	152	150	166
Nov	I	135	168	123	181	147	157	170	148	136	146	143	167	116	149	142	137	151
	II	120	145	113	167	134	144	165	133	120	118	130	142	99	129	134	127	141
	III	108	120	102	142	120	133	149	124	101	102	114	129	92	114	127	123	135
Dec	I	100	108	93	122	102	122	137	117	96	94	100	114	87	99	123	116	128
	II	100	100	93	107	94	114	124	111	100	88	96	101	84	90	121	112	124
	III	98	96	88	103	103	105	114	104	96	83	90	105	80	85	117	108	124

TEN DAILY DISCHARGE DATA OF SATLUJ RIVER AT RAMPUR

Chatchment Area = 50880 KM^2

Month	BLOCK	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Jan	I	122	101	91	112	105	102	115	112	108	93	141	115	96	81	65	86	*71.52*
	II	106	89	80	111	94	93	110	108	104	89	136	113	95	78	57	85	*74.05*
	III	108	99	87	113	103	99	116	105	102	85	132	113	93	75	59	65	*71.32*
Feb	I	106	103	90	114	100	97	104	102	102	83	130	110	84	75	69	66	*74.23*
	II	103	102	90	112	103	98	106	102	102	80	120	111	84	79	70	76	*80.05*
	III	102	101	93	108	104	100	109	105	100	81	121	110	86	76	72	78	*87.11*
MAR	I	108	102	98	111	104	99	107	107	101	87	121	110	85	91	81	79	*88.16*
	II	113	119	108	118	115	116	102	123	109	97	125	114	83	100	77	82	*99.37*
	III	123	147	146	133	125	134	100	131	106	102	125	120	95	112	104	92	*120.08*
Apr	I	124	137	200	134	118	145	120	138	112	122	148	137	101	122	113	97	*110.13*
	II	136	179	185	152	148	114	132	218	130	129	194	150	109	144	186	100	*128.96*
	III	140	240	232	226	262	140	160	345	165	241	313	166	118	195	233	116	*204.17*
May	I	161	413	360	247	439	237	215	361	221	321	339	198	168	291	264	112	*299.91*
	II	290	902	507	414	251	287	600	342	157	327	401	396	250	776	552	201	*307.19*
	III	512	759	571	377	480	584	360	564	239	713	504	414	214	570	728	279	*218.10*
Jun	I	879	736	1074	485	493	714	669	567	309	667	274	338	300	690	1026	*253*	
	II	675	729	1166	740	654	647	893	1029	446	586	533	451	419	869	904	*407*	
	III	634	1340	1112	907	578	1023	524	1483	637	1124	648	537	389	657	776	*416*	
Jul	I	720	1068	1318	602	699	1264	748	771	616	1487	754	465	527	797	798	*539*	
	II	1036	889	1182	876	876	1059	818	936	758	1332	735	636	612	712	656	*481*	
	III	1183	850	1079	1047	607	1308	851	1026	772	977	736	926	666	583	759	*479*	
Aug	I	740	937	833	863	659	1263	820	937	743	919	1037	918	608	624	775	*569*	
	II	694	828	642	780	552	937	925	912	789	980	731	588	712	785	632	*565*	
	III	757	722	681	692	522	904	657	645	589	672	634	535	548	659	553	*422*	
Sep	I	535	618	564	614	448	761	582	545	402	448	433	505	417	492	498	*272*	
	II	361	476	449	404	396	451	377	444	346	409	365	325	267	408	366	*291*	
	III	279	320	253	227	234	256	270	304	206	460	299	235	186	254	287	*189*	
Oct	I	220	241	221	214	198	229	220	244	133	294	220	167	148	186	172	*157*	
	II	185	207	183	180	165	198	191	192	93	270	185	154	137	162	147	*138*	
	III	170	174	163	152	146	164	160	163	73	245	170	144	128	151	141	*134*	
Nov	I	158	153	149	135	135	151	140	149	69	200	162	140	127	138	134	*112*	
	II	142	148	137	126	130	142	135	136	80	184	152	133	117	124	126	*99*	
	III	133	142	128	123	126	133	129	131	126	172	138	123	101	125	105	*87*	
Dec	I	125	134	122	119	120	115	123	126	115	159	120	116	90	121	96	*76*	
	II	116	130	120	107	108	123	117	118	109	151	126	102	85	113	90	*74*	
	III	115	112	119	104	102	119	127	111	100	140	117	100	82	96	87	*71*	

Note:- flow data from Jun 2004 to May 2005 is generated as per section 5.3

Establishment of relationship between discharge series of Sunni & Rampur

Useing linear relation $Y = B X + C$

Where

$$B = \frac{\Sigma XY - (\Sigma XY)^2 / n}{\Sigma X^2 - (\Sigma X)^2 / n}$$

$$C = \overline{Y} - B\overline{X}$$

And coefficient of correlation $r = \dfrac{\Sigma \Delta X \Sigma \Delta Y}{\sqrt{\Sigma \Delta X^2 \Sigma \Delta Y^2}}$

Y = Discharge of Rampur site
X = Discharge of Sunni site

and $\overline{Y} = \Sigma Y / n$

$\overline{X} = \Sigma X / n$

So we get B= 0.8828
A= 3.8384
R= 0.9915
Calculations are shown below.

year	month		Q_{sun} X	Q_{RAM} Y	X*X	X*Y	ΔX	ΔY	ΔXΔY	$ΔX^2$	$ΔY^2$	Rampur discharge generated	% error
1972	JAN	I	90	84	8100	7560	-308	-272	83792	95164	73779	83	0.8
		II	83	78	6889	6474	-315	-278	87586	99531	77075	77	1.1
		III	82	77	6724	6314	-316	-279	88180	100163	77631	76	1.0
	FEB	I	82	77	6724	6314	-316	-279	88180	100163	77631	76	1.0
		II	82	77	6724	6314	-316	-279	88180	100163	77631	76	1.0
		III	83	79	6889	6557	-315	-277	87271	99531	76520	77	2.4
	MAR	I	88	83	7744	7304	-310	-273	84646	96402	74323	82	1.8
		II	91	85	8281	7735	-307	-271	83213	94548	73237	84	1.0
		III	115	110	13225	12650	-283	-246	69631	80364	60331	105	4.2
	APR	I	116	107	13456	12412	-282	-249	70233	79798	61813	106	0.7
		II	142	133	20164	18886	-256	-223	57100	65785	49561	129	2.9
		III	150	142	22500	21300	-248	-214	53082	61745	45635	136	4.0
	MAY	I	185	174	34225	32190	-213	-182	38774	45576	32987	167	3.9
		II	315	280	99225	88200	-83	-76	6313	6970	5719	282	0.7
		III	553	538	305809	297514	155	182	28180	23875	33261	492	8.5
	JUN	I	590	490	348100	289100	192	134	25735	36678	18057	525	7.1
		II	737	688	543169	507056	339	332	112514	114592	110474	654	4.9
		III	898	810	806404	727380	500	454	226968	249514	206458	797	1.7
	JUL	I	1030	910	1060900	937300	632	554	350097	398810	307334	913	0.3
		II	924	814	853776	752136	526	458	240883	276165	210109	820	0.7
		III	1044	924	1089936	964656	646	568	366895	416688	323052	925	0.2
	AUG	I	951	1116	904401	1061316	553	760	420119	305272	578173	843	24.4
		II	880	786	774400	691680	482	430	207232	231856	185224	781	0.7
		III	717	605	514089	433785	319	249	79430	101451	62189	637	5.3
	SEP	I	717	590	514089	423030	319	234	74652	101451	54933	637	7.9
		II	526	417	276676	219342	128	61	7826	16260	3767	468	12.3
		III	320	256	102400	81920	-78	-100	7819	6160	9925	286	11.8
	OCT	I	226	208	51076	47008	-172	-148	25463	29751	21793	203	2.2
		II	200	183	40000	36600	-198	-173	34263	39397	29799	180	1.4
		III	165	150	27225	24750	-233	-206	48010	54516	42281	150	0.3
	NOV	I	146	135	21316	19710	-252	-221	55704	63749	48675	133	1.7

		II	132	120	17424	15840	-266	-236	62790	71015	55518	120	0.3
		III	117	108	13689	12636	-281	-248	69702	79234	61317	107	0.8
	DEC	I	108	100	11664	10800	-290	-256	74255	84382	65343	99	0.8
		II	107	100	11449	10700	-291	-256	74511	84964	65343	98	1.7
		III	104	98	10816	10192	-294	-258	75866	86722	66370	96	2.4
1973	JAN	I	99	92	9801	9108	-299	-264	78951	89692	69497	91	0.8
		II	88	91	7744	8008	-310	-265	82162	96402	70025	82	10.4
		III	96	91	9216	8736	-302	-265	80045	91498	70025	89	2.7
	FEB	I	94	88	8836	8272	-304	-268	81488	92712	71622	87	1.3
		II	95	89	9025	8455	-303	-267	80916	92104	71088	88	1.5
		III	100	93	10000	9300	-298	-263	78389	89094	68971	92	0.9
	MAR	I	100	93	10000	9300	-298	-263	78389	89094	68971	92	0.9
		II	105	98	11025	10290	-293	-258	75609	86134	66370	97	1.5
		III	153	142	23409	21726	-245	-214	52442	60263	45635	139	2.2
	APR	I	194	180	37636	34920	-204	-176	35912	41815	30843	175	2.7
		II	244	226	59536	55144	-154	-130	20025	23866	16802	219	3.0
		III	684	630	467856	430920	286	274	78338	81518	75283	608	3.5
	MAY	I	1424	1311	2027776	1866864	1026	955	979752	1051679	912745	1261	3.8
		II	604	557	364816	336428	206	201	41386	42236	40553	537	3.6
		III	839	772	703921	647708	441	416	183420	194052	173370	745	3.6
	JUN	I	1139	1024	1297321	1166336	741	668	494942	548361	446728	1009	1.4
		II	2375	2215	5640625	5260625	1977	1859	3675084	3906607	3457282	2100	5.2
		III	1753	1616	3073009	2832848	1355	1260	1707198	1834708	1588550	1551	4.0
	JUL	I	1400	1278	1960000	1789200	1002	922	923773	1003030	850779	1240	3.0
		II	1523	1395	2319529	2124585	1125	1039	1168794	1264531	1080304	1348	3.3
		III	1161	1045	1347921	1213245	763	689	525659	581427	475240	1029	1.6
	AUG	I	1002	894	1004004	895788	604	538	324918	364229	289850	888	0.6
		II	991	884	982081	876044	593	528	313071	351073	279182	879	0.6
		III	1005	987	1010025	991935	607	631	382939	367859	398637	891	9.7
	SEP	I	956	849	913936	811644	558	493	275064	310822	243421	848	0.1
		II	683	567	466489	387261	285	211	60140	80948	44680	607	7.0
		III	488	440	238144	214720	90	84	7553	8013	7119	435	1.2
	OCT	I	281	255	78961	71655	-117	-101	11822	13803	10125	252	1.2
		II	218	202	47524	44036	-180	-154	27727	32575	23600	196	2.8
		III	203	188	41209	38164	-195	-168	32768	38215	28098	183	2.6
	NOV	I	181	168	32761	30408	-217	-188	40805	47300	35202	164	2.6
		II	156	145	24336	22620	-242	-211	51073	58800	44362	142	2.4
		III	129	120	16641	15480	-269	-236	63497	72623	55518	118	1.9
	DEC	I	116	108	13456	12528	-282	-248	69950	79798	61317	106	1.6
		II	108	100	11664	10800	-290	-256	74255	84382	65343	99	0.8
		III	104	96	10816	9984	-294	-260	76455	86722	67404	96	0.4
1974	JAN	I	101	85	10201	8585	-297	-271	80507	88498	73237	93	9.4
		II	98	90	9604	8820	-300	-266	79816	90292	70556	90	0.4
		III	98	91	9604	8918	-300	-265	79516	90292	70025	90	0.7
	FEB	I	99	92	9801	9108	-299	-264	78951	89692	69497	91	0.8
		II	93	87	8649	8091	-305	-269	82061	93322	72158	86	1.2
		III	94	88	8836	8272	-304	-268	81488	92712	71622	87	1.3
	MAR	I	98	90	9604	8820	-300	-266	79816	90292	70556	90	0.4
		II	108	101	11664	10908	-290	-255	73964	84382	64833	99	1.8
		III	149	138	22201	20562	-249	-218	54294	62243	47360	135	1.9
	APR	I	160	148	25600	23680	-238	-208	49515	56876	43107	145	2.0
		II	177	164	31329	29028	-221	-192	42442	49056	36719	160	2.4
		III	230	213	52900	48990	-168	-143	24030	28388	20341	207	2.9
	MAY	I	332	306	110224	101592	-66	-50	3299	4420	2462	297	3.0
		II	299	276	89401	82524	-99	-80	7921	9897	6340	268	3.0
		III	251	232	63001	58232	-147	-124	18233	21752	15283	225	2.8
	JUN	I	430	344	184900	147920	32	-12	-366	993	135	383	11.5
		II	630	536	396900	337680	232	180	41760	53599	32536	560	4.5
		III	529	438	279841	231702	131	82	10751	17034	6786	471	7.5
	JUL	I	639	538	408321	343782	241	182	43864	57847	33261	568	5.6
		II	1168	1053	1364224	1229904	770	697	536641	592152	486335	1035	1.7
		III	1074	964	1153476	1035336	676	608	410967	456319	370122	952	1.2
	AUG	I	1072	962	1149184	1031264	674	606	408403	453621	367693	950	1.2

		II	1059	902	1121481	955218	661	546	360890	436279	298528	939	4.1
		III	725	628	525625	455300	327	272	88935	106611	74189	644	2.5
	SEP	I	562	471	315844	264702	164	115	18866	26737	13312	500	6.2
		II	408	319	166464	130152	10	-37	-348	91	1341	364	14.1
		III	312	253	97344	78936	-86	-103	8875	7480	10532	279	10.4
	OCT	I	199	184	39601	36616	-199	-172	34236	39795	29454	180	2.4
		II	185	170	34225	31450	-213	-186	39628	45576	34456	167	1.7
		III	148	137	21904	20276	-250	-219	54762	62743	47796	134	1.8
	NOV	I	135	123	18225	16605	-263	-233	61293	69425	54114	123	0.0
		II	121	113	14641	13673	-277	-243	67325	76999	58866	111	2.1
		III	110	102	12100	11220	-288	-254	73167	83224	64325	101	1.0
	DEC	I	103	93	10609	9579	-295	-263	77601	87312	68971	95	1.9
		II	100	93	10000	9300	-298	-263	78389	89094	68971	92	0.9
		III	94	88	8836	8272	-304	-268	81488	92712	71622	87	1.3
1975	JAN	I	91	103	8281	9373	-307	-253	77678	94548	63818	84	18.3
		II	81	84	6561	6804	-317	-272	86237	100797	73779	75	10.3
		III	103	76	10609	7828	-295	-280	82625	87312	78189	95	24.7
	FEB	I	115	107	13225	12305	-283	-249	70481	80364	61813	105	1.5
		II	119	111	14161	13209	-279	-245	68369	78112	59840	109	1.9
		III	117	109	13689	12753	-281	-247	69421	79234	60823	107	1.7
	MAR	I	130	123	16900	15990	-268	-233	62456	72085	54114	119	3.6
		II	146	136	21316	19856	-252	-220	55452	63749	48234	133	2.4
		III	154	143	23716	22022	-244	-213	51983	59773	45209	140	2.2
	APR	I	205	190	42025	38950	-193	-166	32046	37437	27431	185	2.7
		II	214	198	45796	42372	-184	-158	29079	34035	24845	193	2.6
		III	304	281	92416	85424	-94	-75	7051	8928	5569	272	3.1
	MAY	I	364	335	132496	121940	-34	-21	711	1189	425	325	2.9
		II	629	569	395641	357901	231	213	49186	53137	45530	559	1.7
		III	559	472	312481	263848	161	116	18680	25765	13544	497	5.4
	JUN	I	785	685	616225	537725	387	329	127309	149393	108489	697	1.7
		II	1495	1367	2235025	2043665	1097	1011	1108989	1202343	1022883	1324	3.2
		III	1497	1373	2241009	2055381	1099	1017	1117603	1206733	1035056	1325	3.5
	JUL	I	854	751	729316	641354	456	395	180100	207493	156323	758	0.9
		II	1749	1613	3059001	2821137	1351	1257	1698105	1823888	1580997	1548	4.0
		III	1256	1138	1577536	1429328	858	782	670899	735330	612114	1113	2.2
	AUG	I	1540	1413	2371600	2176020	1142	1057	1207010	1303054	1118046	1363	3.5
		II	1685	1551	2839225	2613435	1287	1195	1537869	1655118	1428926	1491	3.8
		III	1071	960	1147041	1028160	673	604	406452	452275	365271	949	1.1
	SEP	I	717	620	514089	444540	319	264	84208	101451	69895	637	2.7
		II	552	460	304704	253920	154	104	16023	23567	10895	491	6.8
		III	382	326	145924	124532	-16	-30	488	272	878	341	4.6
	OCT	I	277	256	76729	70912	-121	-100	12103	14759	9925	248	3.0
		II	236	218	55696	51448	-162	-138	22362	26402	18940	212	2.7
		III	216	200	46656	43200	-182	-156	28399	33301	24219	195	2.7
	NOV	I	195	181	38025	35295	-203	-175	35533	41407	30493	176	2.8
		II	180	167	32400	30060	-218	-189	41212	47736	35579	163	2.5
		III	153	142	23409	21726	-245	-214	52442	60263	45635	139	2.2
	DEC	I	132	122	17424	16104	-266	-234	62257	71015	54580	120	1.3
		II	125	107	15625	13375	-273	-249	67995	74795	61813	114	6.7
		III	118	103	13924	12154	-280	-253	70857	78672	63818	108	4.9
1976	JAN	I	111	100	12321	11100	-287	-256	73488	82648	65343	102	1.8
		II	106	99	11236	10494	-292	-257	75059	85548	65855	97	1.6
		III	102	95	10404	9690	-296	-261	77271	87904	67924	94	1.2
	FEB	I	101	94	10201	9494	-297	-262	77829	88498	68447	93	1.1
		II	102	97	10404	9894	-296	-259	76678	87904	66886	94	3.2
		III	113	105	12769	11865	-285	-251	71549	81502	62812	104	1.3
	MAR	I	116	109	13456	12644	-282	-247	69668	79798	60823	106	2.5
		II	115	107	13225	12305	-283	-249	70481	80364	61813	105	1.5
		III	135	126	18225	17010	-263	-230	60503	69425	52727	123	2.4
	APR	I	141	131	19881	18471	-257	-225	57837	66299	50456	128	2.1
		II	180	167	32400	30060	-218	-189	41212	47736	35579	163	2.5
		III	351	321	123201	112671	-47	-35	1644	2255	1199	314	2.3
	MAY	I	324	299	104976	96876	-74	-57	4218	5548	3206	290	3.1

		II	423	390	178929	164970	25	34	843	601	1182	377	3.3
		III	540	498	291600	268920	142	142	20148	20026	20271	481	3.5
	JUN	I	956	849	913936	811644	558	493	275064	310822	243421	848	0.1
		II	761	662	579121	503782	363	306	111066	131416	93867	676	2.1
		III	558	467	311364	260586	160	111	17766	25445	12405	496	6.3
	JUL	I	709	812	502681	575708	311	456	141711	96419	208280	630	22.4
		II	1400	1227	1960000	1717800	1002	871	872696	1003030	759298	1240	1.0
		III	1517	1390	2301289	2108630	1119	1034	1156965	1251073	1069936	1343	3.4
	AUG	I	938	833	879844	781354	540	477	257551	291075	227889	832	0.1
		II	812	697	659344	565964	414	341	141164	170994	116538	721	3.4
		III	654	558	427716	364932	256	202	51710	65287	40956	581	4.2
	SEP	I	599	509	358801	304891	201	153	30754	40206	23524	533	4.6
		II	415	329	172225	136535	17	-27	-440	273	709	370	12.5
		III	322	264	103684	85008	-76	-92	7008	5850	8395	288	9.1
	OCT	I	230	215	52900	49450	-168	-141	23693	28388	19775	207	3.8
		II	191	178	36481	33998	-207	-178	36854	43050	31550	172	3.1
		III	177	184	31329	32568	-221	-172	38012	49056	29454	160	13.0
	NOV	I	158	147	24964	23226	-240	-209	50171	57834	43524	143	2.5
		II	144	134	20736	19296	-254	-222	56400	64763	49117	131	2.3
		III	131	120	17161	15720	-267	-236	63026	71549	55518	119	0.4
	DEC	I	110	102	12100	11220	-288	-254	73167	83224	64325	101	1.0
		II	101	94	10201	9494	-297	-262	77829	88498	68447	93	1.1
		III	101	103	10201	10403	-297	-253	75152	88498	63818	93	9.7
1977	JAN	I	99	92	9801	9108	-299	-264	78951	89692	69497	91	0.8
		II	86	89	7396	7654	-312	-267	83316	97648	71088	80	10.4
		III	96	90	9216	8640	-302	-266	80347	91498	70556	89	1.6
	FEB	I	93	86	8649	7998	-305	-270	82366	93322	72697	86	0.1
		II	94	89	8836	8366	-304	-267	81183	92712	71088	87	2.4
		III	94	88	8836	8272	-304	-268	81488	92712	71622	87	1.3
	MAR	I	93	87	8649	8091	-305	-269	82061	93322	72158	86	1.2
		II	100	94	10000	9400	-298	-262	78091	89094	68447	92	2.0
		III	108	102	11664	11016	-290	-254	73674	84382	64325	99	2.8
	APR	I	135	126	18225	17010	-263	-230	60503	69425	52727	123	2.4
		II	107	103	11449	11021	-291	-253	73636	84964	63818	98	4.6
		III	118	113	13924	13334	-280	-243	68052	78672	58866	108	4.4
	MAY	I	128	118	16384	15104	-270	-238	64274	73163	56465	117	1.0
		II	145	138	21025	20010	-253	-218	55164	64255	47360	132	4.5
		III	268	233	71824	62444	-130	-123	16001	17027	15036	240	3.2
	JUN	I	473	379	223729	179267	75	23	1742	5552	546	421	11.2
		II	339	252	114921	85428	-59	-104	6164	3539	10738	303	20.3
		III	723	710	522729	513330	325	354	115000	105309	125583	642	9.6
	JUL	I	1450	1314	2102500	1905300	1052	958	1007747	1105681	918486	1284	2.3
		II	1548	1403	2396304	2171844	1150	1047	1203974	1321382	1096998	1370	2.3
		III	1200	1083	1440000	1299600	802	727	583003	642424	529077	1063	1.8
	AUG	I	1538	1433	2365444	2203954	1140	1077	1227666	1298492	1160741	1362	5.0
		II	1016	853	1032256	866648	618	497	307137	381323	247384	901	5.6
		III	737	642	543169	473154	339	286	96943	114592	82012	654	1.9
	SEP	I	730	620	532900	452600	332	264	87645	109901	69895	648	4.6
		II	587	457	344569	268259	189	101	19111	35537	10277	522	14.2
		III	395	327	156025	129165	-3	-29	100	12	819	353	7.8
	OCT	I	257	233	66049	59881	-141	-123	17349	20018	15036	231	1.0
		II	207	189	42849	39123	-191	-167	31906	36667	27763	187	1.3
		III	181	167	32761	30227	-217	-189	41023	47300	35579	164	2.0
	NOV	I	171	157	29241	26847	-227	-199	45184	51750	39451	155	1.4
		II	156	144	24336	22464	-242	-212	51316	58800	44784	142	1.7
		III	149	133	22201	19817	-249	-223	55541	62243	49561	135	1.8
	DEC	I	120	122	14400	14640	-278	-234	65061	77555	54580	110	10.0
		II	124	114	15376	14136	-274	-242	66322	75343	58382	113	0.6
		III	113	105	12769	11865	-285	-251	71549	81502	62812	104	1.3
1978	JAN	I	101	92	10201	9292	-297	-264	78424	88498	69497	93	1.1
		II	853	88	727609	75064	455	-268	-121638	206583	71622	757	760.1
		III	94	88	8836	8272	-304	-268	81488	92712	71622	87	1.3
	FEB	I	94	88	8836	8272	-304	-268	81488	92712	71622	87	1.3

		II	94	88	8836	8272	-304	-268	81488	92712	71622	87	1.3
		III	93	87	8649	8091	-305	-269	82061	93322	72158	86	1.2
	MAR	I	96	89	9216	8544	-302	-267	80650	91498	71088	89	0.5
		II	108	104	11664	11232	-290	-252	73093	84382	63314	99	4.6
		III	121	112	14641	13552	-277	-244	67602	76999	59352	111	1.2
	APR	I	120	115	14400	13800	-278	-241	67010	77555	57899	110	4.5
		II	207	200	42849	41400	-191	-156	29800	36667	24219	187	6.7
		III	216	206	46656	44496	-182	-150	27304	33301	22387	195	5.6
	MAY	I	390	382	152100	148960	-8	26	-224	72	696	348	8.9
		II	582	552	338724	321264	184	196	36038	33677	38564	518	6.2
		III	656	596	430336	390976	258	240	61900	66313	57781	583	2.2
	JUN	I	839	791	703921	663649	441	435	191790	194052	189553	745	5.9
		II	740	630	547600	466200	342	274	93704	116632	75283	657	4.3
		III	1197	1137	1432809	1360989	799	781	623940	637624	610550	1061	6.7
	JUL	I	1523	1285	2319529	1957055	1125	929	1045097	1264531	863741	1348	4.9
		II	1254	1128	1572516	1414512	856	772	660779	731904	596566	1111	1.5
		III	1255	1116	1575025	1400580	857	760	651273	733616	578173	1112	0.4
	AUG	I	1557	1466	2424249	2282562	1159	1110	1286387	1342154	1232937	1378	6.0
		II	1391	1235	1934881	1717885	993	879	872794	985084	773304	1232	0.3
		III	903	786	815409	709758	505	430	217131	254534	185224	801	1.9
	SEP	I	977	863	954529	843151	579	507	293525	334678	257431	866	0.4
		II	738	614	544644	453132	340	258	87723	115270	66759	655	6.7
		III	479	419	229441	200701	81	63	5103	6482	4017	427	1.8
	OCT	I	325	287	105625	93275	-73	-69	5043	5400	4709	291	1.3
		II	255	227	65025	57885	-143	-129	18456	20588	16544	229	0.9
		III	205	208	42025	42640	-193	-148	28563	37437	21793	185	11.1
	NOV	I	187	170	34969	31790	-211	-186	39257	44726	34456	169	0.6
		II	173	165	29929	28545	-225	-191	42983	50844	36337	157	5.1
		III	162	149	26244	24138	-236	-207	48863	55926	42693	147	1.4
	DEC	I	150	137	22500	20550	-248	-219	54325	61745	47796	136	0.5
		II	136	124	18496	16864	-262	-232	60798	68899	53649	124	0.1
		III	125	114	15625	14250	-273	-242	66081	74795	58382	114	0.2
1979	JAN	I	109	103	11796	11187	-290	-253	73230	84029	63818	100	3.2
		II	109	101	11882	11010	-289	-255	73708	83799	64833	100	0.9
		III	101	100	10299	10149	-297	-256	75920	88209	65343	93	6.6
	FEB	I	100	97	9937	9669	-299	-259	77277	89284	66886	92	5.3
		II	97	93	9450	9040	-301	-263	79122	90768	68971	90	3.6
		III	125	94	15598	11740	-274	-262	71579	74855	68447	114	21.4
	MAR	I	144	99	20728	14253	-255	-257	65314	64777	65855	131	32.3
		II	149	121	22260	18053	-249	-235	58489	62145	55048	136	12.0
		III	167	133	27729	22147	-232	-223	51641	53808	49561	151	13.4
	APR	I	233	188	54268	43796	-166	-168	27747	27400	28098	209	11.4
		II	303	243	91640	73561	-96	-113	10785	9171	12684	271	11.6
		III	379	345	143327	130612	-20	-11	211	396	113	338	2.0
	MAY	I	412	415	169645	171031	14	59	810	186	3526	368	11.4
		II	412	407	169873	167748	14	51	702	187	2640	368	9.7
		III	362	354	131106	128178	-36	-2	59	1325	3	323	8.6
	JUN	I	368	377	135151	138596	-31	21	-660	952	457	328	12.9
		II	821	820	674763	673580	423	464	196410	178890	215646	729	11.1
		III	1706	1640	2911554	2798377	1308	1284	1679761	1710449	1649624	1510	7.9
	JUL	I	1320	1231	1741884	1624679	921	875	806501	848828	766285	1169	5.0
		II	1481	1451	2194638	2149556	1083	1095	1186233	1172770	1199851	1312	9.6
		III	1185	1173	1405280	1390527	787	817	643242	619305	668105	1050	10.5
	AUG	I	1085	1067	1177954	1158053	687	711	488609	471762	506057	962	9.8
		II	1044	1021	1089033	1065483	645	665	429222	416130	442726	925	9.4
		III	785	776	616512	609302	387	420	162558	149534	176717	697	10.2
	SEP	I	663	669	439679	443603	265	313	82919	70012	98205	589	11.9
		II	387	373	149955	144441	-11	17	-195	126	302	346	7.3
		III	246	247	60607	60808	-152	-109	16543	23195	11799	221	10.5
	OCT	I	211	204	44355	42964	-188	-152	28487	35299	22990	190	7.0
		II	188	173	35247	32479	-211	-183	38487	44413	33351	170	2.0
		III	164	156	26994	25631	-234	-200	46749	54844	39849	149	4.6
	NOV	I	150	148	22416	22158	-249	-208	51650	61885	43107	136	8.1

		II	132	133	17316	17501	-267	-223	59417	71234	49561	120	9.8
		III	123	124	15096	15235	-276	-232	63840	75967	53649	112	9.4
	DEC	I	111	117	12400	13028	-287	-239	68516	82445	56941	102	12.7
		II	98	111	9555	10850	-301	-245	73567	90442	59840	90	18.8
		III	94	104	8763	9736	-305	-252	76714	92949	63314	86	16.8
1980	JAN	I	92	90	8392	8245	-307	-266	81514	94173	70556	85	5.9
		II	85	90	7146	7609	-314	-266	83390	98559	70556	78	12.8
		III	88	90	7713	7904	-311	-266	82519	96512	70556	81	9.6
	FEB	I	91	94	8202	8513	-308	-262	80560	94816	68447	84	10.9
		II	89	89	7988	7955	-309	-267	82416	95549	71088	83	7.0
		III	100	94	10092	9443	-298	-262	77971	88821	68447	93	1.6
	MAR	I	92	96	8552	8878	-306	-260	79447	93642	67404	85	11.0
		II	89	89	8009	7965	-309	-267	82384	95475	71088	83	6.9
		III	96	102	9287	9830	-302	-254	76624	91274	64325	89	12.8
	APR	I	118	120	14000	14198	-280	-236	66014	78493	55518	108	9.8
		II	159	150	25231	23827	-240	-206	49276	57428	42281	144	4.0
		III	234	234	54835	54795	-164	-122	19985	27000	14792	211	10.0
	MAY	I	352	258	123793	90775	-47	-98	4554	2176	9530	314	21.9
		II	401	387	160860	155216	3	31	81	7	985	358	7.5
		III	465	433	215982	201232	66	77	5126	4389	5987	414	4.4
	JUN	I	733	716	537490	524926	335	360	120600	111991	129872	651	9.1
		II	853	865	727093	737583	454	509	231365	206308	259465	757	12.5
		III	1136	1106	1289367	1255866	737	750	553040	543194	563065	1006	9.0
	JUL	I	1107	1081	1226131	1197000	709	725	514163	502428	526172	981	9.2
		II	1312	1140	1721531	1495761	914	784	716595	834638	615247	1162	1.9
		III	1207	1151	1456076	1388888	808	795	642819	653177	632624	1069	7.1
	AUG	I	1317	1221	1734390	1608011	918	865	794828	843599	748877	1166	4.5
		II	810	756	655471	612067	411	400	164605	169024	160302	719	5.0
		III	709	685	502766	485706	311	329	102296	96456	108489	630	8.1
	SEP	I	535	517	286348	276654	137	161	22049	18667	26043	476	7.9
		II	407	393	165432	159846	8	37	308	68	1397	363	7.7
		III	293	279	85690	81671	-106	-77	8103	11185	5871	262	6.0
	OCT	I	238	227	56625	54017	-161	-129	20647	25769	16544	214	5.8
		II	188	185	35516	34864	-210	-171	35836	44113	29112	170	8.0
		III	161	148	25803	23774	-238	-208	49384	56574	43107	146	1.6
	NOV	I	140	136	19662	19070	-258	-220	56721	66701	48234	128	6.2
		II	125	120	15596	14986	-274	-236	64467	74857	55518	114	4.9
		III	114	101	12976	11505	-285	-255	72459	80982	64833	104	3.4
	DEC	I	101	96	10132	9663	-298	-260	77322	88700	67404	93	3.4
		II	93	100	8662	9307	-305	-256	78072	93280	65343	86	14.0
		III	85	96	7159	8122	-314	-260	81490	98519	67404	79	18.2
1981	JAN	I	86	83	7400	7140	-312	-273	85184	97632	74323	80	3.9
		II	36	78	1307	2819	-362	-278	100594	131290	77075	36	54.2
		III	79	87	6287	6898	-319	-269	85743	101885	72158	74	15.1
	FEB	I	81	78	6623	6348	-317	-278	88036	100556	77075	76	3.0
		II	78	77	6060	5994	-321	-279	89338	102812	77631	73	5.8
		III	81	63	6628	5129	-317	-293	92783	100537	85628	76	20.2
	MAR	I	97	83	9321	8013	-302	-273	82316	91168	74323	89	7.3
		II	94	85	8831	7988	-305	-271	82408	92728	73237	87	2.1
		III	131	108	17086	14117	-268	-248	66306	71702	61317	119	10.4
	APR	I	128	105	16403	13448	-270	-251	67772	73123	62812	117	11.3
		II	220	196	48290	43071	-179	-160	28530	31946	25480	198	0.9
		III	261	250	68297	65334	-137	-106	14486	18810	11156	235	6.2
	MAY	I	431	423	185659	182263	32	67	2183	1049	4540	384	9.2
		II	459	437	210964	200718	61	81	4950	3699	6622	409	6.3
		III	596	576	355572	343468	198	220	43593	39130	48566	530	7.9
	JUN	I	477	465	227834	221953	79	109	8623	6215	11963	425	8.6
		II	448	447	200280	200044	49	91	4481	2405	8350	399	10.8
		III	916	930	838390	851542	517	574	297039	267444	329909	812	12.7
	JUL	I	846	843	715436	713038	447	487	218027	200121	237536	751	11.0
		II	1036	1017	1073969	1053942	638	661	421852	406838	437419	919	9.7
		III	1277	1243	1629580	1586752	878	887	779174	770996	787438	1131	9.0
	AUG	I	1383	1293	1912605	1788180	984	937	922832	969208	878675	1225	5.3

		II	1185	1103	1404557	1307210	787	747	587927	618825	558572	1050	4.8
		III	1017	784	1035142	797657	619	428	265137	383078	183507	902	15.1
	SEP	I	505	490	255499	247680	107	134	14376	11445	18057	450	8.1
		II	352	345	123803	121390	-47	-11	495	2174	113	314	8.9
		III	300	280	89905	83956	-99	-76	7460	9731	5719	269	4.1
	OCT	I	229	205	52261	46864	-170	-151	25568	28859	22687	206	0.3
		II	171	167	29360	28615	-227	-189	42843	51591	35579	155	7.1
		III	152	151	22973	22887	-247	-205	50525	60968	41871	138	8.8
	NOV	I	158	146	25024	23096	-240	-210	50372	57743	43942	143	1.7
		II	130	118	16785	15288	-269	-238	63904	72324	56465	118	0.2
		III	115	102	13132	11689	-284	-254	72002	80595	64325	105	2.9
	DEC	I	104	94	10920	9823	-294	-262	76914	86430	68447	96	2.2
		II	94	88	8913	8308	-304	-268	81378	92463	71622	87	0.9
		III	88	83	7806	7333	-310	-273	84549	96182	74323	82	1.4
1982	JAN	I	85	82	7299	7005	-313	-274	85659	98003	74870	79	3.3
		II	83	80	6822	6608	-316	-276	87067	99787	75968	77	4.1
		III	82	78	6800	6432	-316	-278	87736	99873	77075	77	1.8
	FEB	I	83	79	6905	6564	-315	-277	87245	99472	76520	77	2.3
		II	85	82	7208	6962	-314	-274	85804	98335	74870	79	3.9
		III	87	65	7517	5635	-312	-291	90612	97211	84462	80	23.7
	MAR	I	123	85	15145	10461	-275	-271	74535	75856	73237	112	32.3
		II	118	85	14019	10064	-280	-271	75797	78447	73237	108	27.5
		III	157	101	24733	15884	-241	-255	61420	58186	64833	143	41.3
	APR	I	225	170	50829	38327	-173	-186	32119	29941	34456	203	19.3
		II	242	183	58581	44292	-156	-173	27007	24477	29799	218	18.9
		III	299	244	89409	72959	-99	-112	11103	9895	12460	268	9.8
	MAY	I	406	347	164985	140946	8	-9	-66	59	74	362	4.4
		II	385	317	148274	122065	-13	-39	518	180	1492	344	8.4
		III	415	376	172343	156093	17	20	339	277	415	370	1.5
	JUN	I	647	633	418883	409685	249	277	68991	61864	76938	575	9.1
		II	1248	1237	1557842	1543944	850	881	748861	721904	776825	1106	10.6
		III	1024	1006	1048544	1030128	625	650	406809	391248	422990	908	9.8
	JUL	I	1307	1333	1708632	1742426	909	977	888104	825664	955266	1158	13.1
		II	1301	1326	1691651	1724642	902	970	875424	813872	941631	1152	13.1
		III	1332	1297	1774745	1727858	934	941	878972	871813	886190	1180	9.0
	AUG	I	1231	1156	1514727	1422738	832	800	666119	692651	640603	1090	5.7
		II	1245	900	1550226	1120573	847	544	460867	716722	296346	1103	22.6
		III	795	712	631464	565789	396	356	141183	156943	127004	705	0.9
	SEP	I	516	491	266641	253539	118	135	15959	13897	18327	460	6.4
		II	561	415	314515	232739	162	59	9639	26351	3526	499	20.2
		III	298	290	88890	86462	-100	-66	6585	10069	4306	267	7.9
	OCT	I	213	198	45268	42127	-186	-158	29274	34493	24845	192	3.2
		II	182	179	33228	32629	-216	-177-	38186	46742	31196	165	8.0
		III	165	173.	27070	28464	-234	-183	42726	54735	33351	149	13.8
	NOV	I	145	143	21134	20789	-253	-213	53817	64065	45209	132	7.6
		II	134	130	17895	17390	-265	-226	59726	70074	50906	122	6.2
		III	120	114	14343	13653	-279	-242	67346	77687	58382	110	3.9
	DEC	I	103	100	10532	10262	-296	-256	75629	87534	65343	94	5.6
		II	99	96	9723	9466	-300	-260	77857	89930	67404	91	5.3
		III	86	90	7359	7721	-313	-266	83061	97782	70556	80	11.6
1983	JAN	I	88	86	7824	7607	-310	-270	83591	96119	72697	82	4.7
		II	94	89	8806	8352	-305	-267	81226	92809	71088	87	2.6
		III	98	88	9524	8588	-301	-268	80527	90539	71622	90	2.3
	FEB	I	93	88	8643	8181	-306	-268	81764	93342	71622	86	2.4
		II	92	88	8435	8082	-307	-268	82064	94029	71622	85	3.5
		III	90	88	8049	7895	-309	-268	82634	95338	71622	83	5.6
	MAR	I	95	90	9036	8555	-303	-266	80598	92070	70556	88	2.5
		II	109	97	11947	10602	-289	-259	74790	83629	66886	100	3.4
		III	122	103	14851	12552	-277	-253	69881	76520	63818	111	8.2
	APR	I	147	134	21666	19724	-251	-222	55692	63147	49117	134	0.2
		II	173	150	29949	25959	-225	-206	46353	50818	42281	157	4.4
		III	227	199	51626	45216	-171	-157	26825	29334	24531	204	2.7
	MAY	I	367	337	134732	123699	-31	-19	585	988	347	328	2.7

		II	593	577	352047	342354	195	221	43135	37966	49008	528	8.6
		III	634	539	402170	341817	236	183	43219	55546	33627	564	4.6
	JUN	I	820	776	673125	636663	422	420	177381	178047	176717	728	6.2
		II	699	651	488573	455036	300	295	88759	90296	87248	621	4.6
		III	956	908	914118	868134	558	552	308010	310928	305120	848	6.6
	JUL	I	1090	1010	1187989	1100848	691	654	452477	478121	428209	966	4.4
		II	715	667	511831	477188	317	311	98687	100449	96956	635	4.7
		III	1288	1193	1658515	1536385	889	837	744719	790938	701200	1141	4.4
	AUG	I	1361	1270	1851959	1728301	962	914	879979	926177	836085	1205	5.1
		II	1153	937	1328673	1080062	754	581	438471	568809	337999	1021	9.0
		III	1210	1098	1464188	1328620	812	742	602476	658614	551123	1072	2.4
	SEP	I	941	841	885914	791574	543	485	263435	294571	235591	835	0.7
		II	710	616	503919	437281	311	260	81078	96961	67796	631	2.4
		III	442	414	195242	182931	43	58	2532	1881	3408	394	4.9
	OCT	I	290	286	84156	82968	-108	-70	7546	11748	4847	260	9.1
		II	232	227	53897	52700	-166	-129	21394	27666	16544	209	8.0
		III	194	212	37817	41227	-204	-144	29302	41624	20628	176	17.2
	NOV	I	171	167	29308	28590	-227	-189	42872	51661	35579	155	7.2
		II	147	142	21645	20892	-251	-214	53697	63183	45635	134	5.8
		III	133	129	17591	17109	-266	-227	60249	70680	51358	121	6.3
	DEC	I	120	114	14310	13637	-279	-242	67380	77765	58382	109	4.0
		II	110	101	12113	11116	-288	-255	73440	83190	64833	101	0.0
		III	101	105	10160	10584	-298	-251	74608	88619	62812	93	11.6
1984	JAN	I	94	92	8772	8617	-305	-264	80359	92918	69497	87	6.0
		II	89	86	7858	7623	-310	-270	83541	96003	72697	82	4.5
		III	85	84	7164	7110	-314	-272	85247	98498	73779	79	6.5
	FEB	I	81	81	6592	6577	-317	-275	87136	100675	75418	76	6.8
		II	84	80	7104	6743	-314	-276	86600	98721	75968	78	2.2
		III	105	82	11057	8623	-293	-274	80263	86044	74870	97	17.9
	MAR	I	105	93	11053	9777	-293	-263	77042	86057	68971	97	3.9
		II	119	111	14249	13250	-279	-245	68279	77907	59840	109	1.6
		III	141	115	19878	16214	-257	-241	61960	66305	57899	128	11.6
	APR	I	153	146	23388	22328	-246	-210	51474	60296	43942	139	4.9
		II	156	157	24427	24538	-242	-199	48106	58659	39451	142	9.7
		III	238	239	56860	56990	-160	-117	18664	25611	13601	214	10.3
	MAY	I	317	319	100472	101115	-82	-37	2985	6644	1341	284	11.1
		II	463	450	214409	208370	65	94	6093	4168	8907	413	8.3
		III	667	618	445168	412335	269	262	70507	72212	68842	593	4.1
	JUN	I	1011	929	1022076	939198	612	573	351188	375146	328761	896	3.5
		II	840	767	706338	644617	442	411	181809	195323	169231	746	2.8
		III	763	709	581941	540861	364	353	128758	132762	124875	677	4.5
	JUL	I	857	798	734438	683881	459	442	202833	210229	195697	760	4.7
		II	573	542	328223	310516	174	186	32508	30423	34736	510	6.0
		III	854	773	729368	660165	456	417	190134	207520	174203	758	2.0
	AUG	I	794	726	629821	576163	395	370	146346	156125	137179	704	3.0
		II	878	797	771172	699897	480	441	211719	230091	194814	779	2.2
		III	832	747	692747	621739	434	391	169790	188207	153176	739	1.1
	SEP	I	686	610	470898	418594	288	254	73193	82791	64708	610	0.1
		II	400	386	159719	154264	1	30	35	1	923	357	7.6
		III	238	229	56649	54504	-160	-127	20320	25752	16033	214	6.6
	OCT	I	175	171	30722	29972	-223	-185	41210	49823	34086	159	7.3
		II	152	149	23224	22707	-246	-207	50848	60561	42693	138	7.1
		III	137	134	18795	18371	-261	-222	57930	68325	49117	125	6.8
	NOV	I	121	116	14565	14000	-278	-240	66567	77173	57419	110	4.8
		II	105	99	11025	10395	-293	-257	75315	86133	65855	97	2.5
		III	97	92	9330	8886	-302	-264	79587	91141	69497	89	3.1
	DEC	I	90	87	8047	7804	-309	-269	82946	95347	72158	83	4.6
		II	88	84	7819	7428	-310	-272	84220	96138	73779	82	2.5
		III	83	80	6903	6647	-315	-276	86932	99479	75968	77	3.5
1985	JAN	I	82	77	6709	6307	-317	-279	88205	100221	77631	76	1.1
		II	76	65	5812	4955	-322	-291	93653	103845	84462	71	9.4
		III	75	72	5596	5386	-324	-284	91802	104767	80442	70	2.9
	FEB	I	72	69	5233	4992	-326	-287	93481	106371	82153	68	1.9

	II	71	68	5054	4834	-327	-288	94166	107186	82727	67	2.1
	III	73	70	5317	5104	-326	-286	92990	105995	81581	68	2.6
MAR	I	83	79	6899	6562	-315	-277	87253	99492	76520	77	2.3
	II	88	84	7742	7391	-310	-272	84338	96409	73779	82	3.0
	III	94	89	8813	8355	-305	-267	81215	92785	71088	87	2.6
APR	I	93	89	8575	8242	-306	-267	81556	93566	71088	86	3.8
	II	116	110	13488	12775	-282	-246	69351	79721	60331	106	3.3
	III	152	144	22972	21825	-247	-212	52254	60970	44784	138	4.4
MAY	I	202	194	40835	39203	-196	-162	31744	38577	26122	182	6.1
	II	443	223	196546	98864	45	-133	-5948	2011	17589	395	77.2
	III	622	559	387329	347898	224	203	45530	50118	41362	553	1.0
JUN	I	711	549	505065	390163	312	193	60371	97464	37395	631	15.0
	II	737	611	542823	450163	338	255	86389	114433	65217	654	7.1
	III	763	724	581941	552304	364	368	134223	132762	135702	677	6.5
JUL	I	788	709	620502	558493	389	353	137546	151503	124875	699	1.4
	II	828	800	685166	662198	429	444	190754	184266	197471	735	8.2
	III	784	833	614536	653008	385	477	183999	148562	227889	696	16.5
AUG	I	862	713	743607	614839	464	357	165766	215148	127718	765	7.3
	II	948	825	898386	781962	549	469	257850	301781	220315	841	1.9
	III	878	735	771233	645476	480	379	181992	230124	143927	779	6.0
SEP	I	697	588	485456	409687	298	232	69309	88960	53999	619	5.3
	II	476	397	226640	188999	78	41	3210	6019	1712	424	6.8
	III	348	278	121257	96805	-50	-78	3902	2527	6025	311	12.0
OCT	I	246	228	60357	56014	-153	-128	19502	23351	16288	221	3.2
	II	330	258	108771	85090	-69	-98	6705	4717	9530	295	14.3
	III	188	180	35301	33819	-211	-176	36986	44353	30843	170	5.7
NOV	I	154	149	23776	22975	-244	-207	50476	59679	42693	140	6.1
	II	134	129	18014	17314	-264	-227	59890	69838	51358	122	5.2
	III	118	114	13889	13435	-281	-242	67808	78755	58382	108	5.4
DEC	I	102	99	10352	10073	-297	-257	76151	88057	65855	94	5.4
	II	205	90	41997	18444	-194	-266	51413	37464	70556	185	105.3
	III	89	85	7836	7524	-310	-271	83884	96078	73237	82	3.5
1986 JAN	I	81	78	6503	6290	-318	-278	88241	101024	77075	75	3.8
	II	76	67	5775	5092	-322	-289	93078	104000	83303	71	5.9
	III	75	73	5677	5500	-323	-283	91327	104419	79876	70	3.6
FEB	I	81	77	6489	6203	-318	-279	88583	101080	77631	75	2.7
	II	81	78	6599	6336	-317	-278	88076	100648	77075	76	3.1
	III	82	80	6667	6532	-317	-276	87327	100384	75968	76	5.1
MAR	I	93	90	8639	8365	-306	-266	81159	93356	70556	86	4.6
	II	113	102	12786	11534	-285	-254	72387	81460	64325	104	1.6
	III	116	104	13377	12028	-283	-252	71166	79992	63314	106	1.9
APR	I	125	116	15570	14475	-274	-240	65586	74915	57419	114	1.7
	II	192	177	36797	33953	-207	-179	36914	42709	31906	173	2.2
	III	262	235	68875	61673	-136	-121	16410	18509	14550	236	0.2
MAY	I	296	278	87459	82214	-103	-78	7976	10558	6025	265	4.7
	II	505	476	255470	240590	107	120	12875	11439	14491	450	5.5
	III	253	261	63772	65911	-146	-95	13811	21303	8954	227	13.1
JUN	I	321	301	103303	96744	-77	-55	4210	5941	2984	288	4.5
	II	896	801	801936	717302	497	445	221362	247031	198361	794	0.8
	III	1527	1349	2330775	2059501	1128	993	1120729	1272838	986798	1352	0.2
JUL	I	1104	946	1218437	1044222	705	590	416418	497508	348545	978	3.4
	II	1238	1104	1533071	1366942	840	748	628402	705073	560068	1097	0.6
	III	1493	1365	2229798	2038287	1095	1009	1105030	1198510	1018842	1322	3.1
AUG	I	1282	1115	1643307	1429336	883	759	670856	780448	576653	1136	1.8
	II	1163	977	1351760	1135911	764	621	474835	583950	386109	1030	5.4
	III	861	741	740901	637820	462	385	178148	213694	148515	764	3.1
SEP	I	638	567	406866	361667	239	211	50598	57300	44680	567	0.0
	II	360	346	129418	124473	-39	-10	373	1501	93	321	7.1
	III	280	247	78381	69152	-119	-109	12874	14047	11799	251	1.6
OCT	I	209	203	43662	42418	-190	-153	28927	35922	23294	188	7.2
	II	195	178	37991	34695	-204	-178	36159	41442	31550	176	1.2
	III	163	152	26569	24776	-235	-204	47950	55454	41462	148	2.8
NOV	I	148	142	21875	21002	-251	-214	53530	62792	45635	134	5.3

		II	136	134	18450	18201	-263	-222	58210	68987	49117	124	7.6
		III	129	127	16638	16382	-269	-229	61613	72629	52269	118	7.3
	DEC	I	125	123	15609	15367	-274	-233	63634	74830	54114	114	7.2
		II	123	121	15135	14886	-275	-235	64630	75880	55048	112	7.1
		III	120	117	14395	14038	-279	-239	66458	77566	56941	110	6.2
1987	JAN	I	113	111	12783	12550	-285	-245	69821	81466	59840	104	6.6
		II	109	97	11902	10582	-289	-259	74843	83747	66886	100	3.2
		III	107	105	11412	11217	-292	-251	73096	85064	62812	98	6.5
	FEB	I	104	103	10786	10697	-295	-253	74431	86808	63818	96	7.3
		II	105	104	11052	10933	-293	-252	73815	86058	63314	97	7.1
		III	109	105	11902	11455	-289	-251	72528	83747	62812	100	4.6
	MAR	I	108	106	11601	11417	-291	-250	72585	84552	62312	99	6.7
		II	112	110	12605	12350	-286	-246	70301	81920	60331	103	6.4
		III	125	120	15616	14996	-274	-236	64448	74814	55518	114	4.9
	APR	I	145	138	21132	20061	-253	-218	55085	64069	47360	132	4.2
		II	145	135	21158	19637	-253	-221	55824	64023	48675	132	2.0
		III	200	190	39830	37919	-199	-166	32944	39566	27431	180	5.3
	MAY	I	282	226	79575	63753	-116	-130	15087	13548	16802	253	11.9
		II	285	209	81344	59609	-113	-147	16609	12832	21498	256	22.3
		III	371	325	137481	120505	-28	-31	848	767	938	331	1.9
	JUN	I	887	785	787225	696497	489	429	209867	238897	184365	787	0.3
		II	816	685	665239	558701	417	329	137395	174002	108489	724	5.7
		III	879	768	772247	674900	480	412	198060	230678	170055	780	1.5
	JUL	I	1237	1081	1530328	1337267	839	725	608285	703213	526172	1096	1.4
		II	1048	977	1098671	1024067	650	621	403702	422096	386109	929	4.9
		III	1210	1133	1463546	1370671	811	777	630674	658183	604315	1072	5.4
	AUG	I	963	894	927371	860923	565	538	303922	318677	289850	854	4.5
		II	854	804	729633	686765	456	448	204325	207662	201042	758	5.7
		III	823	760	677845	625718	425	404	171790	180478	163521	731	3.9
	SEP	I	656	640	430264	419805	257	284	73215	66285	80870	583	8.9
		II	463	436	214677	202013	65	80	5212	4205	6460	413	5.3
		III	385	310	148244	119357	-13	-46	614	181	2081	344	10.9
	OCT	I	229	213	52248	48687	-170	-143	24233	28869	20341	206	3.5
		II	176	169	30876	29696	-223	-187	41574	49627	34828	159	5.9
		III	158	150	24896	23668	-241	-206	49494	57938	42281	143	4.6
	NOV	I	139	137	19350	19057	-259	-219	56707	67279	47796	127	7.6
		II	129	127	16660	16392	-269	-229	61594	72583	52269	118	7.3
		III	123	123	15086	15107	-276	-233	64125	75989	54114	112	8.7
	DEC	I	118	116	13889	13671	-281	-240	67246	78755	57419	108	7.0
		II	113	112	12838	12690	-285	-244	69477	81329	59352	104	7.3
		III	109	108	11902	11782	-289	-248	71660	83747	61317	100	7.3
1988	JAN	I	107	106	11443	11339	-292	-250	72769	84981	62312	98	7.3
		II	108	105	11699	11357	-290	-251	72762	84289	62812	99	5.4
		III	101	100	10236	10117	-297	-256	76000	88394	65343	93	6.8
	FEB	I	86	84	7457	7254	-312	-272	84782	97425	73779	80	4.7
		II	74	71	5455	5244	-325	-285	92396	105382	81010	69	2.8
		III	88	73	7685	6400	-311	-283	87845	96609	79876	81	11.3
	MAR	I	83	76	6842	6286	-316	-280	88297	99712	78189	77	1.1
		II	102	84	10482	8600	-296	-272	80429	87679	73779	94	12.2
		III	102	91	10422	9290	-296	-265	78433	87851	70025	94	3.3
	APR	I	110	98	12169	10811	-288	-258	74240	83043	66370	101	3.3
		II	286	255	81570	72829	-113	-101	11358	12742	10125	256	0.4
		III	339	319	115059	108206	-59	-37	2171	3514	1341	303	4.9
	MAY	I	510	474	260305	241835	112	118	13224	12480	14013	454	4.2
		II	591	553	349569	326958	193	197	38046	37156	38958	526	4.9
		III	615	562	378187	345613	216	206	44677	46865	42591	547	2.7
	JUN	I	628	580	393971	364049	229	224	51424	52526	50345	558	3.8
		II	642	582	411816	373486	243	226	55064	59167	51246	570	2.0
		III	1096	995	1200388	1090144	697	639	445733	485998	408803	971	2.4
	JUL	I	1120	975	1254305	1091959	721	619	446863	520521	383628	993	1.8
		II	1157	1015	1339677	1174806	759	659	500439	576017	434778	1026	1.0
		III	1295	1128	1677812	1461103	897	772	692681	804282	596566	1147	1.7
	AUG	I	1298	1054	1684449	1367948	899	698	628104	808880	487730	1150	9.1

		II	1071	871	1146259	932523	672	515	346410	451784	265613	949	9.0
		III	823	646	677518	531732	425	290	123302	180310	84319	730	13.1
	SEP	I	559	504	312519	281753	161	148	23822	25776	22016	497	1.3
		II	418	386	174482	161236	19	30	584	370	923	373	3.5
		III	727	427	528124	310310	328	71	23428	107738	5095	645	51.1
	OCT	I	340	270	115386	91715	-59	-86	5035	3458	7331	304	12.5
		II	219	205	48066	44944	-179	-151	26999	32129	22687	197	3.7
		III	174	166	30343	28916	-224	-190	42531	50307	35957	158	5.1
	NOV	I	156	151	24484	23628	-242	-205	49521	58569	41871	142	6.0
		II	144	141	20660	20267	-255	-215	54675	64897	46063	131	7.3
		III	137	135	18870	18545	-261	-221	57609	68183	48675	125	7.3
	DEC	I	131	128	17250	16812	-267	-228	60809	71367	51812	120	6.4
		II	125	124	15737	15555	-273	-232	63242	74551	53649	115	7.6
		III	133	124	17597	16449	-266	-232	61573	70667	53649	121	2.5
1989	JAN	I	133	122	17602	16186	-266	-234	62100	70657	54580	121	0.9
		II	126	106	15758	13306	-273	-250	68136	74504	62312	115	8.2
		III	113	108	12661	12152	-286	-248	70811	81775	61317	103	4.5
	FEB	I	112	106	12611	11904	-286	-250	71439	81904	62312	103	2.9
		II	109	103	11840	11208	-290	-253	73178	83911	63818	100	3.0
		III	107	102	11360	10871	-292	-254	74034	85208	64325	98	4.0
	MAR	I	111	108	12389	12021	-287	-248	71112	82472	61317	102	5.5
		II	117	113	13723	13237	-281	-243	68260	79154	58866	107	5.1
		III	131	123	17227	16144	-267	-233	62165	71415	54114	120	2.7
	APR	I	133	124	17587	16444	-266	-232	61582	70687	53649	121	2.5
		II	142	136	20130	19296	-257	-220	56356	65846	48234	129	5.1
		III	146	140	21297	20431	-253	-216	54456	63783	46493	133	5.2
	MAY	I	182	161	32972	29235	-217	-195	42215	47048	37878	164	1.9
		II	312	290	97504	90554	-86	-66	5659	7436	4306	279	3.6
		III	560	512	314058	286929	162	156	25321	26219	24454	499	2.6
	JUN	I	985	879	969614	865542	586	523	306805	343635	273923	873	0.7
		II	745	675	555517	503098	347	319	110774	120301	102002	662	2.0
		III	663	634	439822	420463	265	278	73688	70069	77494	589	7.0
	JUL	I	792	720	627462	570330	394	364	143433	154952	132771	703	2.3
		II	1145	1036	1312164	1186735	747	680	508249	558026	462913	1015	2.0
		III	1308	1183	1711946	1547853	910	827	752853	827968	684553	1159	2.0
	AUG	I	851	740	724756	629981	453	384	174061	205064	147746	755	2.1
		II	781	694	610130	542089	383	338	129470	146399	114499	693	0.1
		III	881	757	776931	667248	483	401	193845	233241	161103	782	3.3
	SEP	I	597	535	355918	319175	198	179	35535	39244	32176	531	0.8
		II	378	361	142678	136360	-21	5	-112	431	29	337	6.6
		III	315	279	99147	87851	-84	-77	6406	6991	5871	282	1.0
	OCT	I	226	220	50992	49679	-173	-136	23418	29815	18394	203	7.6
		II	189	185	35857	35032	-209	-171	35682	43734	29112	171	7.6
		III	177	170	31270	30062	-222	-186	41144	49130	34456	160	5.9
	NOV	I	162	158	26396	25670	-236	-198	46643	55704	39055	147	6.8
		II	146	142	21210	20680	-253	-214	54015	63933	45635	132	6.8
		III	138	133	19067	18365	-260	-223	57971	67809	49561	126	5.5
	DEC	I	114	125	12938	14218	-285	-231	65668	81078	53187	104	16.6
		II	120	116	14354	13898	-279	-240	66778	77662	57419	110	5.5
		III	121	115	14728	13956	-277	-241	66683	76800	57899	111	3.5
1990	JAN	I	105	101	11130	10655	-293	-255	74602	85842	64833	97	4.0
		II	101	89	10285	9026	-297	-267	79206	88250	71088	93	4.9
		III	101	99	10265	10030	-297	-257	76261	88310	65855	93	5.8
	FEB	I	104	103	10883	10745	-294	-253	74313	86533	63818	96	6.9
		II	108	102	11760	11061	-290	-254	73561	84124	64325	100	2.4
		III	107	101	11352	10761	-292	-255	74335	85229	64833	98	3.1
	MAR	I	108	102	11717	11041	-290	-254	73612	84239	64325	99	2.6
		II	114	119	12938	13535	-285	-237	67377	81078	55990	104	12.4
		III	201	147	40581	29613	-197	-209	41107	38824	43524	182	23.6
	APR	I	186	137	34454	25430	-213	-219	46538	45312	47796	168	22.4
		II	194	179	37760	34783	-204	-177	36061	41684	31196	175	2.0
		III	252	240	63367	60415	-147	-116	16969	21538	13369	226	5.8
	MAY	I	360	413	129898	148851	-38	57	-2184	1450	3292	322	22.0

		II	966	902	932716	871127	567	546	309952	321813	298528	856	5.1
		III	869	759	755805	659852	471	403	189944	221732	162713	771	1.6
	JUN	I	859	736	737204	631934	460	380	175019	211710	144687	762	3.5
		II	731	729	535058	533246	333	373	124331	110882	139410	650	10.9
		III	1396	1340	1948378	1870430	997	984	981775	994721	968998	1236	7.8
	JUL	I	1261	1068	1590929	1347090	863	712	614663	744483	507481	1117	4.6
		II	1172	889	1372636	1041548	773	533	412359	597698	284491	1038	16.8
		III	961	850	923464	816825	562	494	278079	316388	244409	852	0.3
	AUG	I	1058	937	1118326	990886	659	581	383141	434311	337999	937	0.0
		II	1048	828	1099045	868037	650	472	306982	422328	223140	929	12.2
		III	857	722	734944	618963	459	366	168095	210500	134232	761	5.4
	SEP	I	743	618	551823	459080	344	262	90353	118585	68842	660	6.7
		II	546	476	297892	259798	147	120	17733	21700	14491	486	2.0
		III	407	320	165521	130190	8	-36	-298	70	1269	363	13.4
	OCT	I	265	241	70265	63883	-133	-115	15292	17799	13138	238	1.3
		II	225	207	50641	46582	-173	-149	25779	30085	22089	203	2.2
		III	190	174	36246	33127	-208	-182	37796	43307	32987	172	1.2
	NOV	I	158	153	24928	24157	-241	-203	48751	57888	41056	143	6.4
		II	154	148	23675	22772	-245	-208	50788	59838	43107	140	5.6
		III	145	142	21152	20652	-253	-214	54057	64033	45635	132	6.9
	DEC	I	138	134	19126	18532	-260	-222	57664	67698	49117	126	6.0
		II	133	130	17737	17314	-265	-226	59859	70386	50906	121	6.6
		III	120	112	14346	13415	-279	-244	67900	77679	59352	110	2.2
1991	JAN	I	112	91	12622	10224	-286	-265	75718	81874	70025	103	13.2
		II	104	80	10789	8310	-295	-276	81203	86798	75966	96	19.4
		III	96	87	9286	8384	-302	-269	81157	91277	72158	89	2.2
	FEB	I	96	90	9256	8659	-302	-266	80292	91372	70556	89	1.4
		II	99	90	9803	8911	-299	-266	79548	89687	70556	91	1.4
		III	99	93	9784	9199	-300	-263	78674	89742	68971	91	2.0
	MAR	I	116	98	13541	11404	-282	-258	72681	79593	66370	107	8.7
		II	134	108	18060	14514	-264	-248	65397	69749	61317	122	13.4
		III	162	146	26339	23695	-236	-210	49512	55788	43942	147	0.8
	APR	I	221	200	48865	44211	-177	-156	27613	31482	24219	199	0.5
		II	198	185	39188	36623	-201	-171	34214	40211	29112	179	3.5
		III	235	232	55396	54604	-163	-124	20166	26609	15283	212	8.8
	MAY	I	383	360	147046	138048	-15	4	-66	226	19	342	4.9
		II	511	507	261234	259133	113	151	17049	12684	22915	455	10.2
		III	612	571	375010	349669	214	215	46068	45751	46387	544	4.6
	JUN	I	1029	1074	1059733	1105611	631	718	453258	398094	516065	913	15.0
		II	1361	1166	1853155	1587283	963	810	780247	927023	656711	1206	3.4
		III	1181	1112	1395726	1313726	783	756	592184	612967	572106	1047	5.9
	JUL	I	1453	1318	2109902	1914461	1054	962	1014407	1111051	926169	1286	2.4
		II	1261	1182	1589929	1490412	862	826	712699	743799	682899	1117	5.5
		III	1227	1079	1505787	1324047	829	723	599404	686610	523274	1087	0.8
	AUG	I	1002	833	1003954	834645	603	477	288092	364199	227889	888	6.6
		II	705	642	496847	452529	306	286	87742	93873	82012	626	2.5
		III	796	681	634382	542404	398	325	129498	158400	105870	707	3.8
	SEP	I	704	564	495019	396817	305	208	63574	93080	43421	625	10.8
		II	506	449	255771	227076	107	93	10015	11503	8719	450	0.3
		III	303	253	91682	76606	-96	-103	9821	9158	10532	271	7.2
	OCT	I	231	221	53571	51151	-167	-135	22486	27900	18123	208	5.8
		II	195	183	38024	35685	-203	-173	35127	41407	29799	176	3.8
		III	173	163	30048	28255	-225	-193	43368	50689	37104	157	3.8
	NOV	I	159	149	25230	23667	-240	-207	49516	57430	42693	144	3.3
		II	144	137	20754	19737	-254	-219	55623	64731	47796	131	4.4
		III	131	128	17291	16832	-267	-228	60773	71284	51812	120	6.3
	DEC	I	125	122	15593	15234	-274	-234	63923	74865	54580	114	6.5
		II	123	120	15156	14773	-275	-236	64885	75833	55518	113	6.2
		III	121	119	14676	14416	-277	-237	65625	76918	55990	111	6.9
1992	JAN	I	116	112	13526	13026	-282	-244	68747	79629	59352	107	4.9
		II	114	111	12896	12605	-285	-245	69700	81183	59840	104	6.2
		III	116	113	13456	13108	-282	-243	68538	79798	58866	106	6.0
	FEB	I	127	114	16125	14476	-272	-242	65601	73713	58382	116	1.7

		II	118	112	13871	13191	-281	-244	68388	78798	59352	108	3.7
		III	126	108	15910	13622	-272	-248	67441	74176	61317	115	6.7
	MAR	I	112	111	12479	12400	-287	-245	70152	82240	59840	102	7.7
		II	121	118	14523	14221	-278	-238	66053	77269	56465	110	6.6
		III	145	133	20982	19265	-254	-223	56465	64330	49561	132	1.0
	APR	I	137	134	18783	18365	-261	-222	57940	68349	49117	125	6.8
		II	155	152	23964	23530	-244	-204	49620	59381	41462	140	7.6
		III	223	226	49670	50368	-176	-130	22764	30842	16802	201	11.2
	MAY	I	270	247	73033	66751	-128	-109	13930	16445	11799	242	1.9
		II	429	414	184445	177801	31	58	1809	960	3408	383	7.5
		III	410	377	168210	154621	12	21	249	136	457	366	2.9
	JUN	I	481	485	231094	233150	82	129	10639	6763	16738	428	11.7
		II	782	740	611698	578762	384	384	147457	147168	147746	694	6.2
		III	1081	907	1168329	980370	682	551	376263	465679	304016	958	5.6
	JUL	I	649	602	421256	390723	251	246	61731	62778	60702	577	4.2
		II	980	876	960039	858319	581	520	302511	337944	270792	869	0.8
		III	1254	1047	1572611	1312978	856	691	591509	731969	478002	1111	6.1
	AUG	I	1059	863	1120490	913513	660	507	334892	435661	257431	938	8.7
		II	973	780	945953	758629	574	424	243641	329608	180096	862	10.6
		III	858	692	735435	593442	459	336	154427	210763	113149	761	10.0
	SEP	I	753	614	567219	462428	355	258	91634	125779	66759	669	8.9
		II	535	404	286572	216271	137	48	6620	18725	2340	476	17.9
		III	292	227	85178	66251	-107	-129	13715	11371	16544	261	15.2
	OCT	I	239	214	57246	51202	-159	-142	22550	25353	20057	215	0.5
		II	194	180	37743	34970	-204	-176	35864	41702	30843	175	2.6
		III	165	152	27177	25058	-234	-204	47573	54584	41462	149	1.7
	NOV	I	144	135	20713	19429	-255	-221	56163	64803	48675	131	3.0
		II	136	126	18531	17152	-262	-230	60243	68831	52727	124	1.6
		III	131	123	17243	16151	-267	-233	62151	71382	54114	120	2.6
	DEC	I	122	119	14819	14486	-277	-237	65487	76593	55990	111	6.5
		II	110	107	12179	11808	-288	-249	71636	83018	61813	101	5.4
		III	106	104	11245	11029	-292	-252	73585	85523	63314	97	6.3
1993	JAN	I	106	105	11281	11152	-292	-251	73250	85423	62812	98	7.0
		II	106	94	11281	9984	-292	-262	76465	85423	68447	98	3.8
		III	105	103	11014	10810	-294	-253	74154	86164	63818	96	6.3
	FEB	I	105	100	10942	10460	-294	-256	75123	86366	65343	96	3.8
		II	105	103	10975	10790	-294	-253	74202	86275	63818	96	6.5
		III	107	104	11403	11105	-292	-252	73399	85091	63314	98	5.7
	MAR	I	107	104	11453	11130	-291	-252	73340	84953	63314	98	5.5
		II	117	115	13773	13496	-281	-241	67646	79032	57899	107	6.6
		III	139	125	19201	17321	-260	-231	59943	67557	53187	126	0.9
	APR	I	126	118	15860	14861	-273	-238	64764	74283	56465	115	2.5
		II	149	148	22063	21983	-250	-208	51896	62476	43107	135	8.8
		III	254	262	64578	66580	-144	-94	13516	20841	8765	228	12.9
	MAY	I	458	439	209769	201064	60	83	4963	3543	6952	408	7.0
		II	299	251	89304	75008	-100	-105	10425	9930	10946	268	6.6
		III	472	480	223094	226717	74	124	9184	5453	15470	421	12.3
	JUN	I	527	493	277400	259657	128	137	17612	16436	18872	469	4.9
		II	755	654	570725	494073	357	298	106514	127433	89029	671	2.6
		III	640	578	409335	369800	241	222	53661	58229	49451	569	1.6
	JUL	I	737	699	543753	515440	339	343	116374	114860	117908	655	6.3
		II	1089	876	1186309	954120	691	520	359420	477056	270792	965	10.2
		III	715	607	511450	434101	317	251	79604	100281	63190	635	4.6
	AUG	I	758	659	574709	499585	360	303	109097	129319	92038	673	2.1
		II	631	552	398748	348569	233	196	45752	54279	38564	561	1.7
		III	557	522	310677	290955	159	166	26437	25249	27681	496	5.0
	SEP	I	521	448	271108	233265	122	92	11288	14931	8533	463	3.5
		II	481	396	231710	190620	83	40	3346	6869	1630	429	8.3
		III	290	234	84263	67926	-108	-122	13160	11708	14792	260	11.2
	OCT	I	215	198	46434	42666	-183	-158	28845	33489	24845	194	2.0
		II	176	165	31080	29089	-222	-191	42354	49368	36337	159	3.3
		III	150	146	22634	21965	-248	-210	51995	61525	43942	137	6.4
	NOV	I	137	135	18639	18530	-261	-221	57633	68241	48675	125	7.4

		II	133	130	17626	17259	-266	-226	59953	70609	50906	121	6.9
		III	129	126	16616	16242	-270	-230	61902	72675	52727	118	6.6
	DEC	I	123	120	15173	14782	-275	-236	64869	75794	55518	113	6.2
		II	112	108	12503	12076	-287	-248	70986	82180	61317	103	5.0
		III	105	102	11033	10714	-293	-254	74425	86111	64325	97	5.3
1994	JAN	I	103	102	10698	10550	-295	-254	74833	87059	64325	95	6.7
		II	105	93	10937	9726	-294	-263	77186	86380	68971	96	3.4
		III	75	99	5693	7470	-323	-257	82898	104351	65855	70	28.8
	FEB	I	99	97	9836	9620	-299	-259	77408	89585	66886	91	5.8
		II	100	98	9952	9776	-299	-258	76959	89238	66370	92	6.2
		III	103	100	10559	10276	-296	-256	75596	87456	65343	95	5.4
	MAR	I	101	99	10199	9998	-297	-257	76344	88503	65855	93	6.1
		II	116	116	13465	13460	-282	-240	67681	79777	57419	106	8.4
		III	126	134	15979	16939	-272	-222	60299	74027	49117	115	13.9
	APR	I	137	145	18903	19936	-261	-211	54972	68119	44362	125	13.6
		II	128	114	16485	14637	-270	-242	65261	72950	58382	117	2.8
		III	137	140	18772	19181	-261	-216	56380	68370	46493	125	10.9
	MAY	I	238	237	56583	56376	-161	-119	19053	25797	14071	214	9.8
		II	280	287	78325	80322	-119	-69	8140	14071	4709	251	12.6
		III	613	584	375758	357987	215	228	48988	46012	52156	545	6.7
	JUN	I	789	714	622422	563301	390	358	139929	152452	128434	700	1.9
		II	676	647	456343	437069	277	291	80725	76754	84900	600	7.2
		III	1317	1023	1734942	1347467	919	667	613110	843984	445392	1167	14.0
	JUL	I	1365	1264	1861999	1724792	966	908	877551	933281	825149	1208	4.4
		II	1200	1059	1439048	1270380	801	703	563487	641789	494739	1063	0.4
		III	1491	1308	2224070	1950662	1093	952	1040801	1194311	907022	1320	0.9
	AUG	I	1442	1263	2080534	1821759	1044	907	947229	1089768	823333	1277	1.1
		II	1182	937	1396020	1107096	783	581	455245	613162	337999	1047	11.7
		III	1145	904	1311441	1035244	747	548	409470	557554	300717	1015	12.3
	SEP	I	978	761	956294	744184	579	405	234882	335724	164330	867	13.9
		II	563	451	316692	253802	164	95	15667	26984	9097	501	11.0
		III	316	256	100051	80975	-82	-100	8187	6753	9925	283	10.6
	OCT	I	258	229	66377	58999	-141	-127	17835	19839	16033	231	1.0
		II	208	198	43072	41092	-191	-158	30098	36461	24845	187	5.5
		III	175	164	30591	28684	-224	-192	42844	49990	36719	158	3.5
	NOV	I	153	151	23380	23089	-246	-205	50252	60310	41871	139	8.1
		II	144	142	20705	20433	-255	-214	54387	64817	45635	131	7.8
		III	135	133	18258	17971	-263	-223	58631	69360	49561	123	7.4
	DEC	I	129	115	16642	14835	-269	-241	64844	72621	57899	118	2.4
		II	125	123	15705	15414	-273	-233	63545	74620	54114	114	6.9
		III	122	119	14852	14502	-277	-237	65454	76518	55990	111	6.4
1995	JAN	I	117	115	13648	13435	-282	-241	67774	79332	57899	107	7.0
		II	112	110	12497	12297	-287	-246	70420	82196	60331	103	6.8
		III	107	116	11495	12437	-291	-240	69795	84839	57419	98	15.1
	FEB	I	105	104	10945	10880	-294	-252	73944	86358	63314	96	7.5
		II	109	106	11853	11540	-290	-250	72295	83878	62312	100	5.7
		III	115	109	13176	12512	-284	-247	69967	80487	60823	105	3.5
	MAR	I	112	107	12568	11995	-286	-249	71201	82014	61813	103	3.9
		II	106	102	11232	10810	-293	-254	74187	85560	64325	97	4.5
		III	131	100	17046	13056	-268	-256	68488	71785	65343	119	19.1
	APR	I	131	120	17145	15713	-268	-236	63040	71581	55518	119	0.5
		II	142	132	20159	18741	-257	-224	57361	65795	50007	129	2.1
		III	167	160	27861	26707	-232	-196	45300	53624	38268	151	5.5
	MAY	I	223	215	49904	48029	-175	-141	24622	30658	19775	201	6.5
		II	672	600	451276	403063	273	244	66785	74685	59720	597	0.5
		III	389	360	151119	139946	-10	4	-43	95	19	347	3.6
	JUN	I	739	669	546359	494499	341	313	106760	116060	98205	656	1.9
		II	1031	893	1062383	920433	632	537	339748	399719	288774	914	2.3
		III	587	524	344189	307418	188	168	31687	35415	28351	522	0.4
	JUL	I	894	748	799811	668952	496	392	194554	245853	153960	793	6.1
		II	1008	818	1016309	824643	610	462	281881	371655	213792	894	9.3
		III	1032	851	1065646	878488	634	495	313977	401722	245398	915	7.5
	AUG	I	1035	820	1071474	848799	637	464	295638	405303	215646	918	11.9

		II	913	925	833338	844408	514	569	292880	264594	324190	810	12.5
		III	790	657	624576	519228	392	301	118084	153519	90828	702	6.8
	SEP	I	838	582	702979	487971	440	226	99595	193558	51246	744	27.8
		II	500	377	249711	188391	101	21	2164	10246	457	445	18.0
		III	301	270	90391	81176	-98	-86	8377	9572	7331	269	0.3
	OCT	I	236	220	55663	51905	-163	-136	22046	26424	18394	212	3.6
		II	202	191	40757	38560	-197	-165	32365	38652	27101	182	4.7
		III	170	160	28977	27236	-228	-196	44653	52103	38268	154	3.7
	NOV	I	146	140	21439	20499	-252	-216	54351	63537	46493	133	4.9
		II	140	135	19461	18833	-259	-221	57138	67073	48675	127	5.9
		III	134	129	17874	17246	-265	-227	60008	70116	51358	122	5.5
	DEC	I	128	123	16277	15693	-271	-233	63018	73389	54114	116	5.3
		II	120	117	14291	13987	-279	-239	66561	77807	56941	109	6.5
		III	118	127	13856	14949	-281	-229	64192	78835	52269	108	15.2
1996	JAN	I	115	112	13116	12827	-284	-244	69179	80634	59352	105	6.3
		II	110	108	12138	11899	-288	-248	71393	83125	61317	101	6.4
		III	106	105	11271	11147	-292	-251	73263	85452	62812	98	7.1
	FEB	I	103	102	10585	10494	-296	-254	74971	87380	64325	95	7.2
		II	106	102	11224	10806	-293	-254	74195	85580	64325	97	4.5
		III	122	105	14937	12833	-276	-251	69240	76325	62812	112	6.4
	MAR	I	112	107	12541	11983	-286	-249	71230	82082	61813	103	4.0
		II	132	123	17324	16189	-267	-233	62079	71217	54114	120	2.4
		III	140	131	19577	18329	-259	-225	58080	66857	50456	127	2.8
	APR	I	144	138	20865	19934	-254	-218	55285	64536	47360	131	4.8
		II	227	218	51621	49530	-171	-138	23572	29338	18940	204	6.2
		III	366	345	133715	126156	-33	-11	349	1077	113	327	5.3
	MAY	I	388	361	150159	139889	-11	5	-59	121	29	346	4.2
		II	365	342	133539	124977	-33	-14	450	1093	186	326	4.5
		III	549	564	301805	309843	151	208	31440	22765	43421	489	13.3
	JUN	I	607	567	367857	343892	208	211	43972	43275	44680	539	4.9
		II	1136	1029	1289470	1168479	737	673	496321	543261	453436	1006	2.2
		III	1574	1483	2475963	2333529	1175	1127	1324705	1380703	1270979	1393	6.1
	JUL	I	888	771	788402	684586	489	415	203300	239546	172538	788	2.2
		II	1060	936	1124609	992606	662	580	384204	438231	336837	940	0.4
		III	1088	1026	1184828	1116799	690	670	462568	476116	449405	965	6.0
	AUG	I	1094	937	1196039	1024737	695	581	404144	483233	337999	969	3.4
		II	1259	912	1585880	1148497	861	556	478946	741030	309555	1116	22.3
		III	803	645	644381	517763	404	289	116980	163416	83739	712	10.5
	SEP	I	669	545	448179	364857	271	189	51316	73428	35864	595	9.1
		II	545	444	297017	241977	147	88	12948	21464	7810	485	9.2
		III	322	304	103440	97773	-77	-52	3968	5908	2665	288	5.3
	OCT	I	257	244	65896	62635	-142	-112	15826	20103	12460	230	5.6
		II	205	192	41875	39290	-194	-164	31719	37579	26773	184	3.9
		III	170	163	28741	27633	-229	-193	44102	52421	37104	154	5.8
	NOV	I	151	149	22757	22478	-248	-207	51166	61321	42693	137	8.0
		II	139	136	19388	18937	-259	-220	56936	67208	48234	127	6.8
		III	133	131	17685	17421	-266	-225	59638	70491	50456	121	7.5
	DEC	I	128	126	16322	16097	-271	-230	62166	73295	52727	117	7.4
		II	121	118	14719	14316	-277	-238	65860	76819	56465	111	6.0
		III	114	111	12909	12612	-285	-245	69685	81149	59840	104	6.2
1997	JAN	I	109	108	11960	11811	-289	-248	71594	83593	61317	100	7.1
		II	105	104	11009	10912	-294	-252	73867	86178	63314	96	7.2
		III	103	102	10580	10491	-296	-254	74978	87397	64325	95	7.2
	FEB	I	103	102	10592	10498	-296	-254	74963	87360	64325	95	7.2
		II	103	102	10522	10463	-296	-254	75049	87561	64325	94	7.5
		III	101	100	10285	10142	-297	-256	75938	88250	65343	93	6.6
	MAR	I	102	101	10349	10275	-297	-255	75561	88065	64833	94	7.3
		II	111	109	12327	12102	-287	-247	70894	82632	60823	102	6.6
		III	109	106	11863	11545	-290	-250	72283	83851	62312	100	5.7
	APR	I	114	112	13034	12787	-284	-244	69266	80837	59352	105	6.6
		II	135	130	18105	17492	-264	-226	59549	69659	50906	123	5.7
		III	169	165	28629	27918	-229	-191	43707	52572	36337	153	7.1
	MAY	I	144	221	20660	31765	-255	-135	34295	64898	18123	131	40.8

		II	168	157	28164	26348	-231	-199	45815	53206	39451	152	3.2
		III	247	239	60975	59016	-152	-117	17675	22969	13601	222	7.2
	JUN	I	330	309	108887	101964	-69	-47	3194	4693	2174	295	4.5
		II	485	446	235325	216356	87	90	7828	7503	8168	432	3.1
		III	737	637	543502	469613	339	281	95314	114745	79173	655	2.8
	JUL	I	689	616	475365	424712	291	260	75765	84670	67796	613	0.6
		II	877	758	769227	664808	479	402	192565	229029	161907	778	2.7
		III	936	772	875947	722531	537	416	223775	288836	173370	830	7.5
	AUG	I	948	743	898203	704168	549	387	212767	301675	150061	841	13.1
		II	817	789	667867	644796	419	433	181475	175348	187816	725	8.1
		III	644	589	414509	379212	245	233	57256	60191	54465	572	2.9
	SEP	I	442	402	195698	177836	44	46	2036	1926	2151	394	1.9
		II	379	346	143858	131233	-19	-10	185	369	93	339	2.1
		III	249	206	62146	51354	-149	-150	22323	22259	22387	224	8.7
	OCT	I	195	133	37842	25873	-204	-223	45405	41598	49561	176	32.0
		II	153	93	23410	14229	-245	-263	64469	60262	68971	139	49.4
		III	133	73	17570	9676	-266	-283	75159	70721	79876	121	65.6
	NOV	I	122	69	14940	8434	-276	-287	79181	76317	82153	112	61.9
		II	123	80	15163	9851	-275	-276	75893	75817	75968	113	40.7
		III	129	126	16521	16195	-270	-230	61987	72874	52727	117	6.9
	DEC	I	122	115	14854	14016	-277	-241	66559	76513	57899	111	3.1
		II	122	109	14951	13328	-276	-247	68121	76294	60823	112	2.6
		III	115	100	13123	11456	-284	-256	72579	80616	65343	105	5.0
1998	JAN	I	107	93	11461	9956	-291	-263	76536	84932	68971	98	5.8
		II	103	89	10627	9175	-295	-267	78760	87260	71088	95	6.6
		III	99	85	9836	8430	-299	-271	81000	89585	73237	91	7.5
	FEB	I	97	83	9386	8041	-302	-273	82224	90964	74323	89	7.7
		II	98	80	9624	7848	-300	-276	82793	90231	75968	90	13.1
		III	102	81	10472	8289	-296	-275	81331	87708	75418	94	16.3
	MAR	I	117	87	13670	10172	-282	-269	75636	79281	72158	107	23.0
		II	132	97	17448	12813	-266	-259	68896	70966	66886	120	24.2
		III	126	102	15959	12886	-272	-254	69025	74069	64325	115	13.1
	APR	I	153	122	23513	18708	-245	-234	57272	60096	54580	139	14.1
		II	165	129	27126	21246	-234	-227	52982	54657	51358	149	15.7
		III	262	241	68763	63197	-136	-115	15618	18566	13138	235	2.4
	MAY	I	330	321	108878	105919	-69	-35	2372	4695	1199	295	8.1
		II	349	327	121916	114177	-49	-29	1412	2433	819	312	4.6
		III	732	713	535533	521774	333	357	119119	111099	127718	650	8.9
	JUN	I	687	667	472217	458349	289	311	89893	83344	96956	610	8.5
		II	621	586	385275	363733	222	230	51194	49381	53074	552	5.8
		III	1147	1124	1315633	1289240	749	768	575149	560289	590403	1016	9.6
	JUL	I	1518	1487	2302843	2256540	1119	1131	1266040	1252219	1280014	1344	9.7
		II	1386	1332	1920294	1845815	987	976	963938	974683	953312	1227	7.9
		III	1054	977	1111941	1030233	656	621	407623	430336	386109	935	4.3
	AUG	I	1029	919	1059861	946106	631	563	355496	398173	317394	913	0.7
		II	1097	980	1203146	1074943	698	624	436061	487754	389846	972	0.8
		III	1141	672	1302429	766913	743	316	234990	551683	100094	1011	50.5
	SEP	I	608	448	369474	272314	209	92	19340	43831	8533	540	20.6
		II	468	409	219323	191543	70	53	3727	4877	2849	417	2.0
		III	578	460	334509	266049	180	104	18775	32357	10895	514	11.8
	OCT	I	351	294	123126	103162	-48	-62	2933	2265	3797	314	6.7
		II	373	270	139470	100833	-25	-86	2143	626	7331	334	23.5
		III	287	245	82368	70315	-111	-111	12333	12429	12237	257	5.0
	NOV	I	216	200	46832	43281	-182	-156	28336	33153	24219	195	2.6
		II	198	184	39300	36477	-200	-172	34366	40097	29454	179	2.8
		III	185	172	34292	31851	-213	-184	39168	45500	33717	167	2.7
	DEC	I	167	159	27790	26506	-232	-197	45574	53723	38661	151	5.0
		II	154	151	23745	23268	-244	-205	50008	59727	41871	140	7.4
		III	148	140	22002	20766	-250	-216	53940	62578	46493	135	3.7
1999	JAN	I	144	141	20632	20253	-255	-215	54696	64947	46063	131	7.3
		II	139	136	19421	18953	-259	-220	56910	67147	48234	127	6.7
		III	135	132	18284	17849	-263	-224	58873	69310	50007	123	6.7
	FEB	I	133	130	17609	17251	-266	-226	59967	70642	50906	121	6.9

		II	125	120	15545	14962	-274	-236	64515	74969	55518	114	5.1
		III	128	121	16269	15434	-271	-235	63568	73406	55048	116	3.8
	MAR	I	126	121	15822	15220	-273	-235	63982	74365	55048	115	5.1
		II	127	125	16159	15890	-271	-231	62584	73641	53187	116	7.2
		III	127	125	16234	15926	-271	-231	62516	73481	53187	116	6.9
	APR	I	152	148	23146	22517	-246	-208	51147	60687	43107	138	6.7
		II	201	194	40250	38921	-198	-162	31979	39150	26122	181	6.7
		III	359	313	128645	112264	-40	-43	1697	1585	1817	320	2.4
	MAY	I	395	339	155867	133837	-4	-17	61	14	276	352	3.9
		II	463	401	214554	185743	65	45	2936	4188	2059	413	2.9
		III	609	504	370719	306869	210	148	31216	44260	22016	541	7.4
	JUN	I	310	274	96023	84906	-89	-82	7233	7852	6662	277	1.2
		II	660	533	435533	351753	261	177	46377	68363	31463	586	10.0
		III	839	648	703773	543615	440	292	128770	193975	85484	744	14.9
	JUL	I	963	754	927016	725964	564	398	224816	318469	158704	854	13.2
		II	938	735	879524	689305	539	379	204614	290891	143927	832	13.2
		III	1031	736	1063519	759015	633	380	240697	400416	144687	914	24.2
	AUG	I	1355	1037	1836029	1405136	957	681	651747	914922	464274	1200	15.7
		II	1011	731	1021978	738989	612	375	229897	375087	140908	896	22.6
		III	848	634	719575	537808	450	278	125212	202313	77494	753	18.7
	SEP	I	583	433	339338	252234	184	77	14241	33871	5987	518	19.7
		II	469	365	219854	171144	70	9	660	4956	88	418	14.5
		III	398	299	158124	118897	-1	-57	47	1	3206	355	18.7
	OCT	I	254	220	64427	55842	-145	-136	19619	20927	18394	228	3.6
		II	198	185	39390	36717	-200	-171	34127	40007	29112	179	3.2
		III	180	170	32563	30677	-218	-186	40472	47539	34456	163	4.0
	NOV	I	169	162	28590	27392	-229	-194	44417	52625	37490	153	5.5
		II	159	152	25334	24193	-239	-204	48731	57274	41462	144	5.0
		III	149	138	22343	20628	-249	-218	54190	62006	47360	136	1.6
	DEC	I	138	120	19099	16584	-260	-236	61330	67750	55518	126	4.9
		II	130	126	16976	16417	-268	-230	61584	71928	52727	119	5.7
		III	121	117	14528	14102	-278	-239	66326	77258	56941	110	5.8
2000	JAN	I	118	115	13889	13553	-281	-241	67527	78755	57899	108	6.2
		II	116	113	13498	13128	-282	-243	68494	79697	58866	106	5.8
		III	115	113	13188	12977	-284	-243	68819	80455	58866	105	6.9
	FEB	I	113	110	12847	12468	-285	-246	70037	81305	60331	104	5.5
		II	114	111	13106	12707	-284	-245	69474	80659	59840	105	5.5
		III	127	110	16251	14023	-271	-246	66566	73445	60331	116	5.8
	MAR	I	113	110	12860	12474	-285	-246	70023	81272	60331	104	5.5
		II	117	114	13703	13345	-281	-242	67999	79201	58382	107	6.0
		III	122	120	14910	14653	-276	-236	65122	76386	55518	112	7.0
	APR	I	140	137	19714	19236	-258	-219	56422	66604	47796	128	6.7
		II	158	150	25073	23752	-240	-206	49379	57668	42281	144	4.2
		III	181	166	32705	30020	-218	-190	41270	47368	35957	163	1.5
	MAY	I	214	198	45941	42439	-184	-158	29026	33910	24845	193	2.5
		II	480	396	230123	189966	81	40	3280	6597	1630	427	7.9
		III	524	414	274653	216966	126	58	7331	15772	3408	466	12.7
	JUN	I	456	338	207692	154038	57	-18	-1009	3277	311	406	20.2
		II	526	451	276886	237316	128	95	12181	16311	9097	468	3.9
		III	618	537	381328	331607	219	181	39727	47975	32898	549	2.2
	JUL	I	622	465	386814	289204	223	109	24441	49933	11963	553	18.9
		II	822	636	675196	522603	423	280	118660	179113	78611	729	14.7
		III	1139	926	1298387	1055147	741	570	422639	549054	325330	1010	9.0
	AUG	I	1037	918	1074656	951650	638	562	358892	407261	316268	919	0.1
		II	678	588	459410	398545	279	232	64906	78015	53999	602	2.4
		III	593	535	351522	317198	194	179	34872	37794	32176	527	1.4
	SEP	I	557	505	310106	281220	158	149	23659	25086	22313	495	1.9
		II	356	325	126620	115647	-43	-31	1306	1819	938	318	2.2
		III	250	235	62564	58780	-148	-121	17895	22010	14550	225	4.4
	OCT	I	198	167	39222	33073	-200	-189	37808	40177	35579	179	7.0
		II	185	154	34386	28557	-213	-202	42956	45391	40652	168	8.8
		III	172	144	29576	24765	-227	-212	47934	51306	44784	156	8.1
	NOV	I	160	140	25524	22367	-239	-216	51474	56989	46493	145	3.5

		II	148	133	21921	19692	-250	-223	55751	62714	49561	135	1.2
		III	137	123	18694	16817	-262	-233	60892	68519	54114	125	1.3
	DEC	I	128	116	16311	14815	-271	-240	64883	73318	57419	117	0.5
		II	122	102	14764	12394	-277	-254	70248	76717	64325	111	8.9
		III	111	100	12259	11072	-288	-256	73560	82810	65343	102	1.6
2001	JAN	I	109	96	11933	10487	-289	-260	75096	83665	67404	100	4.5
		II	100	95	10006	9503	-298	-261	77785	89077	67924	92	3.0
		III	97	93	9472	9051	-301	-263	79092	90699	68971	90	3.5
	FEB	I	86	84	7411	7231	-312	-272	84855	97593	73779	80	5.0
		II	85	84	7222	7138	-314	-272	85155	98285	73779	79	6.1
		III	87	86	7599	7497	-311	-270	83938	96917	72697	81	6.1
	MAR	I	87	85	7489	7356	-312	-271	84420	97310	73237	80	5.6
		II	84	83	7135	7011	-314	-273	85608	98605	74323	78	5.5
		III	98	95	9593	9304	-301	-261	78329	90327	67924	90	4.9
	APR	I	106	101	11178	10678	-293	-255	74544	85710	64833	97	3.8
		II	116	109	13504	12667	-282	-247	69616	79681	60823	106	2.4
		III	129	118	16726	15261	-269	-238	63958	72446	56465	118	0.0
	MAY	I	189	168	35680	31734	-210	-188	39325	43930	35202	171	1.5
		II	321	250	103340	80366	-77	-106	8135	5932	11156	288	15.1
		III	268	214	71845	57360	-130	-142	18474	17016	20057	240	12.4
	JUN	I	393	300	154661	117981	-5	-56	290	27	3094	351	17.0
		II	556	419	309459	233086	158	63	10001	24902	4017	495	18.1
		III	544	389	296070	211664	146	33	4861	21210	1114	484	24.5
	JUL	I	715	527	510822	376656	316	171	54195	100003	29370	635	20.5
		II	857	612	735055	524700	459	256	117643	210559	65729	761	24.3
		III	812	666	659544	540874	414	310	128383	171095	96334	721	8.2
	AUG	I	743	608	552383	451881	345	252	87004	118845	63694	660	8.5
		II	922	712	849594	656275	523	356	186474	273789	127004	818	14.8
		III	664	548	440393	363664	265	192	51006	70296	37009	590	7.6
	SEP	I	480	417	230803	200335	82	61	5029	6713	3767	428	2.6
		II	302	267	91227	80644	-96	-89	8548	9302	7854	270	1.3
		III	204	186	41431	37859	-195	-170	33067	38002	28772	184	1.3
	OCT	I	166	148	27480	24534	-233	-208	48317	54156	43107	150	1.5
		II	151	137	22683	20633	-248	-219	54192	61443	47796	137	0.1
		III	137	128	18761	17532	-262	-228	59527	68391	51812	125	2.5
	NOV	I	160	127	25642	20337	-238	-229	54494	56813	52269	145	14.3
		II	124	117	15482	14558	-274	-239	65397	75109	56941	114	2.8
		III	105	101	10921	10555	-294	-255	74854	86425	64833	96	4.9
	DEC	I	95	90	8936	8508	-304	-266	80737	92389	70556	87	3.0
		II	88	85	7811	7512	-310	-271	83921	96165	73237	82	3.7
		III	86	82	7416	7062	-312	-274	85471	97574	74870	80	2.6
2002	JAN	I	83	81	6885	6721	-316	-275	86646	99545	75418	77	4.8
		II	80	78	6406	6243	-318	-278	88409	101410	77075	74	4.5
		III	78	75	6068	5842	-321	-281	89965	102779	78749	73	3.2
	FEB	I	77	75	5958	5789	-321	-281	90164	103234	78749	72	4.0
		II	81	79	6516	6377	-318	-277	87901	100974	76520	75	4.9
		III	78	76	6100	5936	-320	-280	89587	102645	78189	73	4.2
	MAR	I	98	91	9591	8912	-301	-265	79534	90333	70025	90	0.8
		II	108	100	11568	10755	-291	-256	74369	84641	65343	99	1.2
		III	119	112	14076	13288	-280	-244	68176	78312	59352	109	3.1
	APR	I	131	122	17031	15922	-268	-234	62607	71814	54580	119	2.4
		II	166	144	27594	23921	-232	-212	49175	53996	44784	150	4.5
		III	242	195	58379	47116	-157	-161	25197	24608	25800	217	11.4
	MAY	I	334	291	111847	97320	-64	-65	4139	4103	4176	299	2.8
		II	886	776	784572	687350	487	420	204839	237437	176717	786	1.3
		III	677	570	458438	385936	279	214	59724	77615	45957	602	5.5
	JUN	I	818	690	669118	564418	420	334	140275	175989	111808	726	5.2
		II	1089	869	1186667	946639	691	513	354670	477283	263556	966	11.1
		III	912	657	832639	599506	514	301	154909	264201	90828	809	23.2
	JUL	I	964	797	928632	768033	565	441	249453	319416	194814	855	7.2
		II	841	712	706733	598560	442	356	157586	195530	127004	746	4.8
		III	755	583	570482	440342	357	227	81132	127318	51700	671	15.0
	AUG	I	808	624	653527	504448	410	268	110014	168038	72026	718	15.0

		II	969	785	939587	760918	571	429	245104	325854	184365	860	9.5
		III	810	659	655779	533659	411	303	124784	169181	92038	719	9.1
	SEP	I	779	492	606426	383137	380	136	51857	144588	18599	691	40.5
		II	507	408	256680	206708	108	52	5665	11696	2743	451	10.6
		III	291	254	84764	73950	-107	-102	10909	11523	10327	261	2.7
	OCT	I	213	186	45196	39542	-186	-170	31532	34556	28772	192	3.0
		II	190	162	35970	30724	-209	-194	40434	43610	37490	171	5.7
		III	171	151	29329	25860	-227	-205	46496	51633	41871	155	2.7
	NOV	I	151	138	22949	20905	-247	-218	53753	61008	47360	138	0.3
		II	141	124	19770	17435	-258	-232	59731	66502	53649	128	3.2
		III	134	125	18048	16793	-264	-231	60917	69771	53187	122	2.0
	DEC	I	126	121	15815	15217	-273	-235	63988	74381	55048	115	5.1
		II	127	113	16224	14393	-271	-243	65778	73502	58866	116	2.9
		III	96	96	9124	9170	-303	-260	78657	91788	67404	88	8.2
2003	JAN	I	80	65	6431	5250	-318	-290	92356	101311	84193	75	14.0
		II	82	57	6688	4702	-317	-298	94418	100303	88878	76	32.2
		III	73	59	5379	4317	-325	-297	96489	105720	88064	69	16.5
	FEB	I	76	69	5797	5284	-322	-286	92262	103907	81923	71	2.4
		II	76	70	5750	5340	-323	-285	92022	104108	81340	71	0.5
		III	81	72	6613	5876	-317	-283	89872	100595	80293	76	4.7
	MAR	I	100	81	9983	8044	-299	-275	82141	89145	75687	92	14.3
		II	88	77	7821	6792	-310	-279	86449	96129	77744	82	6.7
		III	128	104	16410	13287	-270	-252	68111	73107	63456	117	12.7
	APR	I	142	113	20114	15956	-257	-243	62399	65875	59107	129	14.7
		II	206	186	42243	38150	-193	-170	32803	37232	28902	185	0.2
		III	259	233	67282	60529	-139	-122	17007	19348	14950	233	0.2
	MAY	I	278	264	77104	73236	-121	-92	11099	14595	8441	249	5.6
		II	618	552	381650	340852	219	196	43007	48089	38461	549	0.5
		III	839	728	704058	610512	441	372	163890	194124	138364	745	2.3
	JUN	I	1170	1026	1368217	1200193	771	670	517057	594783	449488	1036	1.0
		II	1087	904	1180705	982660	688	549	377582	473504	301092	963	6.5
		III	915	776	837031	709894	516	420	217050	266677	176659	812	4.6
	JUL	I	954	798	910529	761528	556	442	245879	308836	195756	846	6.0
		II	859	656	737739	563225	460	300	138182	211997	90069	762	16.2
		III	929	759	862804	704565	530	403	213689	281310	162323	824	8.6
	AUG	I	1010	775	1020346	782688	612	419	256411	374098	175747	896	15.6
		II	782	632	610754	494096	383	277	105948	146705	76514	694	9.7
		III	686	553	470906	379254	288	197	56697	82794	38826	610	10.3
	SEP	I	630	498	396354	313422	231	142	32863	53398	20225	560	12.4
		II	462	366	213746	169405	64	11	689	4076	117	412	12.4
		III	337	287	113593	96648	-61	-69	4232	3776	4742	301	5.1
	OCT	I	205	172	42148	35373	-193	-183	35416	37321	33608	185	7.4
		II	180	147	32255	26450	-219	-208	45605	47912	43409	162	10.3
		III	154	141	23868	21751	-244	-215	52417	59532	46153	140	0.4
	NOV	I	142	134	20255	19073	-256	-222	56769	65621	49111	129	3.4
		II	132	126	17427	16606	-266	-230	61243	71009	52821	120	4.3
		III	113	105	12675	11865	-286	-250	71542	81741	62616	103	2.1
	DEC	I	106	96	11178	10202	-293	-259	75863	85710	67148	97	0.7
		II	104	90	10750	9379	-295	-265	78172	86908	70313	95	5.4
		III	100	87	10031	8755	-298	-268	80015	89000	71937	92	5.5
2004	JAN	I	99	86	9800	8514	-299	-270	80747	89694	72692	91	6.1
		II	92	85	8396	7827	-307	-270	82915	94159	73014	85	0.8
		III	90	65	8034	5806	-309	-291	89828	95391	84590	83	28.1
	FEB	I	88	66	7730	5803	-311	-290	89947	96452	83881	81	23.4
		II	87	76	7527	6616	-312	-279	87085	97173	78044	80	5.5
		III	87	78	7540	6775	-312	-278	86514	97128	77060	80	3.2
	MAR	I	86	79	7439	6783	-312	-277	86484	97491	76720	80	1.7
		II	93	82	8558	7566	-306	-274	83788	93622	74987	86	4.5
		III	105	92	11128	9691	-293	-264	77279	85847	69566	97	5.5
	APR	I	107	97	11342	10304	-292	-259	75588	85256	67016	98	1.1
		II	115	100	13197	11489	-284	-256	72494	80432	65340	105	5.2
		III	131	116	17033	15179	-268	-239	64132	71811	57275	119	2.4
	MAY	I	126	112	15971	14164	-272	-244	66271	74044	59314	115	3.0

	II	236	201	55507	47417	-163	-154	25143	26532	23828	212	5.2
	III	313	279	98025	87241	-85	-77	6574	7292	5925	280	0.6
		466627	416435	364761104	323809387	1594	1422	157299108	178181453	141254904	411944	
Average		398	356								Average Error =	0.71

B = 0.8828
A= 3.8384   r= 0.9915

GENERATION OF RAMPUR DISCHARGE DATA (FROM JUN-2004 TO MAY-2005

		Q_{SUNNI} (cumec)	Q_{RAMPUR} (Generated) (cumec)
JUN	I	282.06	253
	II	456.8	407
	III	466.55	416
JUL	I	606.65	539
	II	539.99	481
	III	538.14	479
AUG	I	639.85	569
	II	635.9	565
	III	473.42	422
SEP	I	303.94	272
	II	324.93	291
	III	209.45	189
OCT	I	173.72	157
	II	152.23	138
	III	146.9	134
NOV	I	123.06	112
	II	107.46	99
	III	93.97	87
DEC	I	81.89	76
	II	79.49	74
	III	76.06	71
JAN	I	76.65	72
	II	79.52	74
	III	76.42	71
FEB	I	79.716	74
	II	86.319	80
	III	94.311	87
MAR	I	95.501	88
	II	108.2	99
	III	131.66	120
APR	I	120.38	110
	II	141.72	129
	III	226.91	204
MAY	I	335.36	300
	II	343.61	307
	III	242.69	218

TEN DAILY DISCHARGE DATA OF SATLUJ RIVER AT LURHI DAM SITE

UNIT - Cumecs   Chatchment Area = 52403 KM^2

Month	BLOCK	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
Jan	I	88	97	97	94	108	97	99	107	91	85	85	88	93	81	80	113	107
	II	82	89	96	82	104	87	661	107	86	47	82	93	88	73	74	106	107
	III	81	95	96	96	100	94	92	101	88	81	81	95	84	74	75	106	101
Feb	I	81	92	97	113	99	91	92	99	91	81	82	92	81	72	80	104	86
	II	81	93	91	117	101	93	92	96	89	78	84	91	83	70	80	105	73
	III	82	98	92	115	111	92	91	117	99	77	81	89	99	72	81	108	84
MAR	I	87	98	96	128	114	91	94	133	93	93	113	94	102	82	92	107	81
	II	89	103	106	143	113	98	107	142	89	92	110	106	117	87	110	112	98
	III	114	150	146	151	133	106	119	158	98	125	143	117	134	93	113	124	99
Apr	I	114	190	157	201	138	133	119	222	119	122	212	144	151	92	123	144	107
	II	140	239	174	210	177	106	205	288	157	214	227	167	156	115	188	143	278
	III	148	670	226	298	343	117	213	370	234	258	285	220	239	150	256	197	334
May	I	182	1396	325	357	318	125	388	413	328	429	391	359	317	200	291	268	501
	II	306	592	293	614	415	143	574	411	398	454	368	589	460	388	498	266	582
	III	549	822	246	537	529	259	641	360	457	591	405	610	655	606	255	359	602
Jun	I	565	1110	408	760	929	449	827	370	729	474	644	809	990	670	316	862	616
	II	725	2335	606	1463	736	317	712	821	856	447	1245	687	822	705	872	783	627
	III	876	1719	506	1466	535	720	1182	1690	1128	919	1019	944	749	753	1482	851	1070
Jul	I	1000	1369	614	828	735	1416	1463	1297	1101	845	1314	1070	842	768	1064	1198	1083
	II	896	1491	1139	1715	1356	1512	1222	1474	1269	1031	1307	703	565	821	1204	1030	1122
	III	1014	1132	1046	1226	1485	1171	1220	1182	1193	1268	1323	1264	834	796	1461	1190	1253
Aug	I	993	975	1044	1508	912	1512	1534	1081	1293	1360	1212	1338	777	825	1240	946	1237
	II	856	964	1019	1651	783	975	1352	1038	796	1164	1158	1098	858	917	1116	842	1020
	III	689	1000	701	1043	630	713	874	783	703	959	774	1182	811	842	831	807	779
Sep	I	685	929	539	693	576	702	948	665	531	502	510	916	667	669	620	652	545
	II	499	654	386	529	393	554	707	384	403	350	524	686	396	456	356	456	410
	III	304	476	297	368	307	378	464	246	289	295	296	435	236	331	272	366	651
Oct	I	221	274	195	272	226	251	315	209	235	223	209	289	174	241	207	225	322
	II	196	214	181	231	188	202	248	184	188	170	181	231	152	312	191	174	216
	III	161	199	145	212	179	177	206	162	157	151	167	199	136	186	160	156	172
Nov	I	143	178	132	191	155	167	183	149	139	155	145	170	120	153	146	139	155
	II	129	153	119	177	141	153	171	132	124	127	133	146	103	133	135	129	143
	III	115	127	108	150	128	145	159	123	111	111	118	132	95	117	128	123	137
Dec	I	106	114	100	129	108	121	147	113	99	102	102	118	89	101	124	117	130
	II	105	106	98	120	99	121	133	101	95	93	98	108	87	176	123	113	125
	III	102	102	92	114	102	111	122	96	87	87	87	102	82	88	119	109	130

Note:- flow data is generated as per section 7.2.1.2

TEN DAILY DISCHARGE DATA OF SATLUJ RIVER AT LURHI DAM SITE

Chatchment Area = 52403 KM^2

Month	BLOCK	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Jan	I	130	104	107	115	106	103	116	114	109	104	143	117	106	82	76	96	*75*
	II	121	98	98	113	103	102	111	110	105	100	139	115	99	80	76	90	*78*
	III	111	101	94	115	104	81	109	106	103	96	134	114	96	77	70	83	*75*
Feb	I	111	104	95	124	103	99	104	103	103	93	132	113	86	77	74	82	*78*
	II	107	107	97	116	104	99	108	105	102	94	124	114	85	80	74	84	*85*
	III	105	105	97	122	106	102	113	118	101	97	126	123	87	78	79	85	*92*
MAR	I	110	107	112	112	106	100	111	111	102	109	125	113	86	96	95	84	*94*
	II	116	115	128	120	117	116	105	129	111	123	127	116	84	106	86	90	*106*
	III	129	188	158	142	135	128	123	138	108	120	127	122	97	117	122	102	*129*
Apr	I	130	173	216	136	124	139	128	143	114	145	151	140	105	128	134	104	*118*
	II	140	190	195	154	148	125	139	225	133	156	199	156	114	161	201	111	*139*
	III	144	249	235	224	256	138	165	360	168	257	347	177	126	230	253	127	*221*
May	I	176	374	378	264	453	238	221	381	163	328	381	210	184	324	274	123	*326*
	II	307	950	510	426	287	282	654	360	165	344	448	459	303	858	601	227	*334*
	III	548	842	602	402	474	606	382	553	245	727	582	496	254	650	811	304	*237*
Jun	I	958	828	1041	482	518	770	722	597	325	682	301	426	370	786	1134	*275*	
	II	728	731	1312	772	730	668	996	1109	475	612	628	507	522	1034	1041	*444*	
	III	656	1382	1164	1037	624	1243	571	1551	712	1141	791	597	505	848	880	*454*	
Jul	I	774	1213	1419	637	728	1339	858	859	671	1510	910	582	667	922	915	*590*	
	II	1118	1100	1241	954	1036	1164	960	1029	847	1372	887	775	796	808	808	*525*	
	III	1277	933	1190	1202	688	1445	987	1073	895	1035	957	1086	775	712	886	*523*	
Aug	I	823	1027	959	1009	733	1397	981	1054	896	1002	1275	1007	709	762	951	*622*	
	II	759	993	689	924	611	1120	916	1172	810	1067	940	655	869	923	744	*618*	
	III	850	823	767	816	548	1085	757	763	630	1023	794	578	635	772	653	*460*	
Sep	I	581	711	668	718	502	923	774	638	432	568	545	544	464	707	596	*296*	
	II	374	528	491	502	460	535	469	520	371	453	443	348	293	482	438	*316*	
	III	306	385	290	276	276	301	293	317	238	549	373	246	199	282	324	*204*	
Oct	I	224	259	229	233	211	250	232	254	179	337	245	190	161	206	197	*170*	
	II	188	220	192	191	173	205	199	201	138	347	195	178	147	183	171	*149*	
	III	175	186	171	162	149	172	168	168	118	276	178	165	135	166	151	*144*	
Nov	I	161	157	156	142	137	152	145	150	109	212	167	155	152	148	140	*120*	
	II	145	152	142	134	132	143	138	138	112	195	157	144	123	136	130	*105*	
	III	137	145	131	129	128	135	133	132	128	182	147	133	104	132	111	*92*	
Dec	I	117	137	124	121	122	125	126	127	120	165	134	125	93	125	103	*80*	
	II	119	132	122	110	111	125	119	120	119	153	129	117	88	124	100	*78*	
	III	120	118	121	106	104	121	120	113	111	146	120	108	85	96	97	*75*	

Note:- flow data is generated as per section 7.2.1.2

CALCULATION OF MEAN TEN DAILY FLOW

montł	block	1972-73	1973-74	1974-75	1975-76	1976-77	1977-78	1978-79	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89
Jun	I	565	1110	408	760	929	449	827	370	729	474	644	809	990	670	316	862	616
	II	725	1720	606	1463	736	317	712	821	856	447	1245	687	822	705	872	783	627
	III	876	1719	506	1466	535	720	1182	1690	1128	919	1020	944	749	753	1482	851	1070
Jul	I	1000	1369	614	828	735	1416	1463	1298	1101	845	1314	1070	842	768	1064	1198	1084
	II	896	1491	1139	1715	1357	1512	1222	1474	1269	1032	1307	703	565	821	1204	1030	1122
	III	1014	1132	1046	1226	1485	1171	1220	1182	1193	1268	1323	1264	834	796	1461	1191	1253
Aug	I	993	975	1044	1508	912	1512	1534	1081	1293	1360	1212	1338	777	825	1240	946	1237
	II	856	964	1020	1651	783	975	1352	1038	796	1165	1158	1098	858	917	1116	842	1020
	III	689	1001	701	1043	630	713	874	783	703	959	774	1182	811	842	831	807	779
Sep	I	685	929	539	693	576	702	948	665	531	502	510	916	667	669	620	652	545
	II	499	654	386	529	393	554	707	384	403	350	524	686	396	456	356	457	410
	III	304	476	297	368	307	378	464	246	289	295	296	435	236	331	272	366	651
Oct	I	222	275	195	272	226	251	315	209	235	223	209	289	174	241	208	225	322
	II	196	214	181	232	188	203	248	184	188	170	182	231	152	312	191	174	216
	III	161	199	145	212	179	178	206	162	158	151	167	199	136	186	160	156	172
Nov	I	143	178	132	192	155	168	183	149	139	155	145	170	120	153	146	139	155
	II	129	153	119	177	142	153	171	132	124	127	133	146	104	133	135	129	143
	III	115	127	108	150	128	145	159	123	111	111	118	132	95	117	129	123	137
Dec	I	106	114	101	130	108	121	147	113	100	102	102	118	89	101	124	117	131
	II	105	106	98	121	99	122	133	101	95	93	98	108	87	176	123	113	125
	III	103	102	93	114	102	111	122	96	88	87	87	102	82	88	119	109	131
Jan	I	97	97	94	108	97	99	107	91	85	85	88	93	81	80	113	107	130
	II	89	96	82	104	87	661	107	86	70	82	93	88	73	74	106	107	121
	III	95	96	96	100	95	93	101	88	81	81	95	85	74	75	106	101	111
Feb	I	93	97	113	99	91	93	99	91	81	82	92	81	72	80	104	86	111
	II	94	92	117	101	93	93	96	89	78	84	91	83	70	80	105	73	107
	III	98	93	115	111	93	92	117	99	77	81	89	99	72	81	108	84	105
MAR	I	98	96	128	114	92	94	133	93	93	114	94	102	82	92	107	81	111
	II	103	106	144	113	99	107	142	89	92	110	106	117	87	110	112	98	116
	III	150	146	151	133	107	119	158	98	125	143	117	134	93	113	124	99	129
Apr	I	191	157	201	139	133	119	222	119	122	212	144	151	92	123	144	107	130
	II	240	174	210	177	106	205	288	157	214	227	167	157	115	188	143	278	140
	III	670	226	298	344	117	214	370	234	259	285	220	239	150	256	197	334	144
May	I	1396	326	357	318	126	388	413	328	429	391	360	318	200	291	268	501	176
	II	592	293	614	415	143	575	411	398	454	368	589	460	388	498	266	582	307
	III	822	246	537	529	259	641	360	457	591	405	610	655	606	255	359	602	548
Avr. Discharge		422	482	354	493	346	429	481	412	399	377	431	430	329	346	404	403	401
Run Off in Hydrological year		13324	15168	11153	15541	10922	13545	15129	12973	12614	11942	13615	13618	10401	10901	12743	12733	12657

CALCULATION OF MEAN TEN DAILY FLOW

montł	block	1989-90	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000	2000-01	2001-02	2002-03	2003-04	2004-05	mean discharge cumec
Jun	I	958	828	1041	482	518	770	722	597	325	682	301	426	370	786	1134	275	**659**
	II	728	731	1312	772	730	668	996	1109	475	612	628	507	522	1034	1041	444	**802**
	III	656	1382	1164	1037	624	1243	571	1551	712	1141	791	597	505	848	880	454	**963**
Jul	I	774	1213	1419	637	728	1339	858	859	671	1510	910	583	668	922	915	590	**988**
	II	1118	1101	1241	954	1036	1164	960	1029	847	1372	887	775	796	808	808	525	**1069**
	III	1277	933	1190	1202	688	1445	987	1073	895	1035	957	1086	775	712	886	523	**1082**
Aug	I	823	1027	960	1009	733	1397	981	1054	896	1002	1275	1007	709	762	951	622	**1060**
	II	759	993	689	924	612	1120	916	1172	810	1068	941	655	869	923	744	618	**952**
	III	850	823	767	816	549	1085	757	763	630	1023	794	578	635	772	653	460	**790**
Sep	I	581	711	669	718	502	923	774	638	432	568	545	544	465	707	596	296	**637**
	II	374	528	492	502	460	535	469	520	371	453	443	348	293	482	438	316	**460**
	III	306	385	290	276	276	301	293	317	238	549	373	246	199	282	324	204	**329**
Oct	I	224	259	229	233	211	250	232	254	179	337	245	190	161	206	197	170	**232**
	II	188	221	192	191	174	205	199	202	138	347	195	178	147	183	172	149	**198**
	III	175	186	171	162	149	172	168	168	118	276	178	165	135	166	151	144	**170**
Nov	I	161	157	156	142	137	152	145	150	109	212	167	155	152	148	140	120	**152**
	II	145	152	142	134	132	143	138	138	112	195	157	144	123	136	130	105	**139**
	III	137	145	131	129	128	135	133	133	128	182	147	133	104	132	111	92	**128**
Dec	I	117	137	124	121	122	126	126	127	120	165	134	125	93	125	103	81	**117**
	II	119	132	122	110	111	125	119	121	119	153	129	117	88	124	100	78	**114**
	III	120	118	121	106	104	121	120	113	111	146	120	108	85	96	97	75	**106**
Jan	I	104	107	115	106	103	116	114	109	104	143	117	106	83	77	96	75	**101**
	II	98	98	113	103	102	111	110	105	100	139	115	99	80	76	90	78	**113**
	III	101	94	115	105	81	109	106	103	96	134	114	96	77	70	83	75	**95**
Feb	I	104	95	124	103	99	105	103	103	93	132	113	86	77	74	82	78	**95**
	II	107	97	116	104	99	108	105	102	94	124	114	85	80	75	84	85	**95**
	III	105	97	122	106	102	113	118	101	97	126	123	87	78	79	85	93	**98**
MAR	I	107	112	112	106	101	111	111	102	109	125	113	86	96	95	84	94	**103**
	II	115	128	120	117	116	105	130	111	123	127	116	84	106	86	90	106	**110**
	III	188	158	142	135	128	123	138	108	120	127	122	97	117	122	102	129	**127**
Apr	I	173	216	136	124	139	128	143	114	146	151	140	105	128	134	104	118	**142**
	II	191	195	154	148	125	140	225	133	156	199	156	114	161	201	111	139	**174**
	III	249	235	224	256	138	165	361	168	257	347	177	127	230	253	127	221	**245**
May	I	374	378	264	453	238	221	381	163	328	381	210	184	324	274	123	326	**340**
	II	950	510	426	287	282	654	360	165	344	448	459	304	858	601	227	334	**441**
	III	842	602	402	474	606	382	553	245	727	583	496	254	650	811	304	237	**505**
Avr. Dischar		400	424	425	372	311	448	381	389	315	453	361	294	307	372	343	237	**387**
Run Off in Hydrological year(cumecs)		12663	13379	13380	11739	9781	14129	12004	12254	9945	14282	11377	9279	9688	11735	10813	7438	

CALCULATION OF DISCHARGE FOR 90% AND 50% DEPENDABLE YEAR

Unrestricted Annual Energy (Million Units) For Years
Net Rated Head = 162 Efficie= 0.92
Envir.Rele.(cume.) 14

		1972-73			1973-74			1974-75			1975-76			1976-77			1977-78			1978-79		
	BLOCK	Q	P	E	Q	P	E	Q	P	E	Q	P	E	Q	P	E	Q	P	E	Q	P	E
Jun	I	551	805	193	1096	1603	385	394	577	138	746	1090	262	915	1338	321	435	637	153	813	1189	285
	II	711	1039	249	2321	3393	814	592	866	208	1449	2118	508	722	1056	253	303	443	106	698	1021	245
	III	862	1260	302	1705	2492	598	492	719	173	1452	2123	509	521	762	183	706	1032	248	1168	1708	410
Jul	I	986	1441	346	1355	1982	476	600	877	210	814	1190	286	721	1054	253	1402	2050	492	1449	2119	508
	II	882	1290	310	1477	2159	518	1125	1645	395	1701	2487	597	1342	1963	471	1498	2189	525	1208	1767	424
	III	1000	1462	386	1118	1634	431	1032	1509	398	1212	1772	468	1471	2151	568	1157	1691	446	1206	1763	466
Aug	I	979	1431	343	961	1405	337	1030	1506	362	1494	2184	524	898	1312	315	1498	2190	526	1520	2223	533
	II	842	1232	296	950	1389	333	1005	1470	353	1637	2394	575	769	1124	270	961	1405	337	1338	1956	469
	III	675	987	260	986	1442	381	687	1004	265	1029	1505	397	616	900	238	699	1022	270	860	1257	332
Sep	I	671	981	235	915	1338	321	525	768	184	679	992	238	562	822	197	688	1006	242	934	1366	328
	II	485	708	170	640	935	225	372	543	130	515	753	181	379	555	133	540	790	190	693	1013	243
	III	290	424	102	462	675	162	283	414	99	354	517	124	293	429	103	364	532	128	450	658	158
Oct	I	207	303	73	260	381	91	181	265	64	258	377	90	212	310	74	237	346	83	301	441	106
	II	182	266	64	200	292	70	167	244	59	217	318	76	174	254	61	188	276	66	234	342	82
	III	147	215	57	185	271	71	131	192	51	198	289	76	165	241	64	163	239	63	192	280	74
Nov	I	129	189	45	164	239	57	118	172	41	177	259	62	141	206	50	153	224	54	169	247	59
	II	115	168	40	139	204	49	105	153	37	163	238	57	127	186	45	139	203	49	157	230	55
	III	101	147	35	113	165	40	94	137	33	136	199	48	114	167	40	131	191	46	145	212	51
Dec	I	92	134	32	100	146	35	86	126	30	115	169	41	94	137	33	107	156	37	133	194	47
	II	91	133	32	92	134	32	84	123	30	106	156	37	85	125	30	107	157	38	119	174	42
	III	88	129	34	88	129	34	78	115	30	100	147	39	88	128	34	97	142	37	108	158	42
Jan	I	83	122	29	83	121	29	80	117	28	94	138	33	83	122	29	85	124	30	93	136	33
	II	75	109	26	82	120	29	68	99	24	90	132	32	73	106	26	647	945	227	93	136	33
	III	81	118	31	82	120	32	82	120	32	86	126	33	80	118	31	78	115	30	87	127	34
Feb	I	78	115	28	83	122	29	99	145	35	85	125	30	77	113	27	78	115	28	85	124	30
	II	79	116	28	77	113	27	103	151	36	87	127	30	79	115	28	78	115	28	82	120	29
	III	84	123	24	78	115	22	101	148	28	97	142	27	78	115	22	77	113	22	103	151	29
MAR	I	84	123	30	82	120	29	114	167	40	100	147	35	77	113	27	80	117	28	119	173	42
	II	89	130	31	92	135	32	129	189	45	99	145	35	84	124	30	93	136	33	128	187	45
	III	136	199	53	132	193	51	137	201	53	119	174	46	92	135	36	105	153	40	144	211	56
Apr	I	176	258	62	143	209	50	187	274	66	124	182	44	119	174	42	105	153	37	208	304	73
	II	225	330	79	160	234	56	196	287	69	163	238	57	92	135	32	191	280	67	274	400	96
	III	656	960	230	212	310	74	284	416	100	329	482	116	103	150	36	199	292	70	356	521	125
May	I	1382	2020	485	311	455	109	343	501	120	304	444	107	111	163	39	374	547	131	399	583	140
	II	578	845	203	279	408	98	600	877	211	401	586	141	129	189	45	560	819	197	397	580	139
	III	808	1182	312	232	340	90	523	765	202	515	754	199	245	358	95	627	917	242	346	506	134
		Total		5256	Total		6219	Total		4378	Total		6160	Total		4279	Total		5344	Total		5994

CALCULATION OF DISCHARGE FOR 90% AND 50% DEPENDABLE YEAR

Unrestricted Annual Energy (Million Units) For Years
Net Rated Head = 162
Envir.Release(cumecs) = 14

		1979-80			1980-81			1981-82			1982-83			1983-84			1984-85			1985-86		
	BLOCK	Q	P	E	Q	P	E	Q	P	E	Q	P	E	Q	P	E	Q	P	E	Q	P	E
Jun	I	356	520	125	715	1045	251	460	673	161	630	921	221	795	1163	279	976	1428	343	656	959	230
	II	807	1180	283	842	1231	295	433	634	152	1231	1800	432	673	984	236	808	1181	284	691	1010	243
	III	1676	2450	588	1114	1629	391	905	1324	318	1005	1470	353	930	1360	326	735	1075	258	739	1081	259
Jul	I	1283	1877	450	1087	1589	381	831	1215	292	1300	1900	456	1056	1544	370	828	1211	291	754	1102	265
	II	1460	2134	512	1255	1835	440	1017	1488	357	1293	1890	454	689	1008	242	551	806	193	807	1180	283
	III	1168	1708	451	1179	1723	455	1254	1834	484	1309	1914	505	1250	1828	482	820	1198	316	782	1144	302
Aug	I	1067	1560	374	1279	1870	449	1346	1968	472	1198	1751	420	1324	1936	465	763	1115	268	811	1185	284
	II	1024	1497	359	782	1144	274	1150	1682	404	1144	1673	402	1084	1586	381	844	1234	296	903	1320	317
	III	769	1124	297	689	1007	266	945	1381	365	760	1111	293	1168	1707	451	797	1165	308	828	1211	320
Sep	I	651	951	228	517	755	181	488	713	171	496	725	174	902	1319	317	653	955	229	655	958	230
	II	370	540	130	389	569	137	336	491	118	510	746	179	672	983	236	382	559	134	442	646	155
	III	232	340	82	275	402	97	281	411	99	282	412	99	421	615	148	222	324	78	317	463	111
Oct	I	195	285	68	221	323	78	209	305	73	195	285	68	275	402	97	160	234	56	227	332	80
	II	170	249	60	174	254	61	156	228	55	167	245	59	217	317	76	138	201	48	298	435	104
	III	148	217	57	143	210	55	137	201	53	153	223	59	185	270	71	122	179	47	172	251	66
Nov	I	135	198	47	125	183	44	141	206	50	131	191	46	156	228	55	106	154	37	139	203	49
	II	118	172	41	110	160	38	113	165	40	119	174	42	132	193	46	89	131	31	119	174	42
	III	109	160	38	97	141	34	97	142	34	104	153	37	118	172	41	81	119	29	103	150	36
Dec	I	99	144	35	85	125	30	88	128	31	88	129	31	104	152	37	75	110	26	87	127	31
	II	87	127	31	81	118	28	79	115	28	84	123	29	94	137	33	73	107	26	162	237	57
	III	82	120	32	73	107	28	73	107	28	73	107	28	88	128	34	68	100	26	74	108	28
Jan	I	77	113	27	71	104	25	71	103	25	74	108	26	79	116	28	67	97	23	66	96	23
	II	72	105	25	33	48	11	68	99	24	79	115	28	74	108	26	59	87	21	60	87	21
	III	74	109	29	67	98	26	67	98	26	81	119	31	70	103	27	60	88	23	61	89	23
Feb	I	77	113	27	67	97	23	68	100	24	78	114	27	67	98	24	58	84	20	66	96	23
	II	75	110	26	64	93	22	70	103	25	77	112	27	69	101	24	56	82	20	66	97	23
	III	85	124	24	63	92	18	67	98	19	75	110	21	85	125	24	58	85	16	67	98	19
MAR	I	79	116	28	79	116	28	99	145	35	80	117	28	88	129	31	68	99	24	78	114	27
	II	75	110	26	78	114	27	96	140	34	92	135	32	103	151	36	73	107	26	96	141	34
	III	84	123	32	111	162	43	129	189	50	103	151	40	120	176	46	79	115	30	99	144	38
Apr	I	105	153	37	108	158	38	198	289	69	130	190	46	137	201	48	78	114	27	109	159	38
	II	143	209	50	200	292	70	213	312	75	153	224	54	142	208	50	101	147	35	174	255	61
	III	220	322	77	244	357	86	271	396	95	206	301	72	225	328	79	136	198	48	242	353	85
May	I	314	459	110	415	607	146	377	552	132	345	505	121	303	444	106	186	272	65	277	405	97
	II	384	561	135	440	643	154	354	517	124	575	841	202	446	652	156	374	547	131	484	708	170
	III	443	647	171	577	844	223	391	572	151	596	872	230	641	937	247	592	866	229	241	352	93
		Total		5114	Total		4954	Total		4691	Total		5372	Total		5376	Total		4063	Total		4268

CALCULATION OF DISCHARGE FOR 90% AND 50% DEPENDABLE YEAR

Unrestricted Annual Energy (Million Units) For Years
Net Rated Head = 162
Envir.Release(cumecs) = 14

		1986-87			1987-88			1988-89			1989-90			1990-91			1991-92			1992-93		
	BLOCK	Q	P	E	Q	P	E	Q	P	E	Q	P	E	Q	P	E	Q	P	E	Q	P	E
Jun	I	302	442	106	848	1239	297	602	880	211	944	1380	331	814	1190	286	1027	1501	360	468	684	164
	II	858	1254	301	769	1124	270	613	896	215	714	1043	250	717	1048	252	1298	1898	456	758	1108	266
	III	1468	2146	515	837	1224	294	1056	1544	371	642	938	225	1368	2000	480	1150	1681	404	1023	1496	359
Jul	I	1050	1535	368	1184	1731	415	1069	1564	375	760	1111	267	1199	1753	421	1405	2054	493	623	911	219
	II	1190	1740	418	1016	1486	357	1108	1619	389	1104	1614	387	1086	1589	381	1227	1794	431	940	1374	330
	III	1447	2116	559	1176	1720	454	1239	1812	478	1263	1846	487	919	1344	355	1176	1719	454	1188	1737	459
Aug	I	1226	1792	430	932	1362	327	1223	1787	429	809	1183	284	1013	1481	356	945	1382	332	995	1455	349
	II	1102	1611	387	828	1210	290	1006	1471	353	745	1090	261	979	1431	344	675	987	237	910	1331	319
	III	817	1194	315	793	1160	306	765	1118	295	836	1222	323	809	1183	312	753	1102	291	802	1172	310
Sep	I	606	886	213	638	933	224	531	777	186	567	829	199	697	1020	245	654	957	230	704	1029	247
	II	342	500	120	442	647	155	396	579	139	360	526	126	514	752	180	477	698	168	488	714	171
	III	258	377	90	352	515	124	637	932	224	292	427	102	371	542	130	276	404	97	262	382	92
Oct	I	193	283	68	211	308	74	308	451	108	210	308	74	245	358	86	215	314	75	219	320	77
	II	177	258	62	160	234	56	202	295	71	174	255	61	206	302	72	178	260	62	177	258	62
	III	146	214	56	142	207	55	158	231	61	161	236	62	172	252	66	157	229	61	148	216	57
Nov	I	132	194	46	125	182	44	141	206	50	147	215	52	143	209	50	142	208	50	128	187	45
	II	121	177	43	115	167	40	129	189	45	131	191	46	138	202	49	128	188	45	120	175	42
	III	114	167	40	109	159	38	123	180	43	123	180	43	131	191	46	117	171	41	115	168	40
Dec	I	110	161	39	103	151	36	116	170	41	103	150	36	123	180	43	110	161	39	107	157	38
	II	109	159	38	99	145	35	111	162	39	105	153	37	118	173	42	108	158	38	96	140	34
	III	105	154	41	95	139	37	116	170	45	106	155	41	104	152	40	107	156	41	92	134	35
Jan	I	99	144	35	93	136	33	116	170	41	90	132	32	93	136	33	101	148	36	92	134	32
	II	92	135	32	93	137	33	107	156	37	84	123	30	84	123	29	99	145	35	89	130	31
	III	92	135	36	87	127	34	97	142	38	87	127	33	80	117	31	101	148	39	90	132	35
Feb	I	90	131	31	72	105	25	97	141	34	90	132	32	81	118	28	110	160	39	89	131	31
	II	91	133	32	59	86	21	93	136	33	93	136	33	83	121	29	102	150	36	90	132	32
	III	94	138	26	70	102	20	91	134	26	91	133	26	83	122	23	108	157	30	92	135	26
MAR	I	93	136	33	67	98	24	96	141	34	93	135	33	98	143	34	98	143	34	92	135	32
	II	98	143	34	84	122	29	102	149	36	101	148	35	114	166	40	106	155	37	103	150	36
	III	110	160	42	85	125	33	115	168	44	174	254	67	144	211	56	128	187	49	121	177	47
Apr	I	130	189	45	93	136	33	116	170	41	159	233	56	202	295	71	122	179	43	110	161	39
	II	129	188	45	264	386	93	126	185	44	176	258	62	181	264	63	140	205	49	134	197	47
	III	183	268	64	320	468	112	130	191	46	235	343	82	221	322	77	210	307	74	242	354	85
May	I	254	371	89	487	712	171	162	237	57	360	526	126	364	532	128	250	366	88	439	642	154
	II	252	368	88	568	830	199	293	428	103	936	1368	328	496	725	174	412	602	144	273	399	96
	III	345	505	133	588	859	227	534	781	206	828	1210	319	588	860	227	388	567	150	460	673	178
		Total		5023	Total		5012	Total		4987	Total		4989	Total		5278	Total		5285	Total		4614

CALCULATION OF DISCHARGE FOR 90% AND 50% DEPENDABLE YEAR

Unrestricted Annual Energy (Million Units) For Years
Net Rated Head = 161.5
Envir.Release(cumecs) = 14

		1993-94			1994-95			1995-96			1996-97			1997-98			1998-99			1999-2000		
	BLOCK	Q	P	E	Q	P	E	Q	P	E	Q	P	E	Q	P	E	Q	P	E	Q	P	E
Jun	I	504	737	177	756	1105	265	708	1034	248	583	852	204	311	454	109	668	977	234	287	419	101
	II	716	1047	251	654	957	230	982	1436	345	1095	1601	384	461	674	162	598	874	210	614	898	215
	III	610	892	214	1229	1797	431	557	814	195	1537	2247	539	698	1021	245	1127	1648	396	777	1136	273
Jul	I	714	1044	250	1325	1938	465	844	1233	296	845	1235	296	657	961	231	1496	2187	525	896	1310	315
	II	1022	1494	358	1150	1682	404	946	1384	332	1015	1484	356	833	1218	292	1358	1986	477	873	1276	306
	III	674	985	260	1431	2093	552	973	1422	375	1059	1548	409	881	1288	340	1021	1493	394	943	1379	364
Aug	I	719	1051	252	1383	2022	485	967	1414	339	1040	1521	365	882	1290	310	988	1444	347	1261	1844	442
	II	597	874	210	1106	1617	388	902	1319	316	1158	1693	406	796	1164	279	1053	1540	370	926	1355	325
	III	534	781	206	1071	1565	413	743	1086	287	749	1095	289	616	901	238	1009	1476	390	780	1141	301
Sep	I	488	714	171	909	1330	319	760	1111	267	624	913	219	418	611	147	554	809	194	531	776	186
	II	446	652	156	521	761	183	455	665	160	506	739	177	357	522	125	439	642	154	429	627	150
	III	262	383	92	287	420	101	279	408	98	303	443	106	224	328	79	535	782	188	359	525	126
Oct	I	197	288	69	236	346	83	218	319	76	240	350	84	165	241	58	323	472	113	231	338	81
	II	159	233	56	191	279	67	185	271	65	187	274	66	124	181	43	333	487	117	181	265	64
	III	135	198	52	158	231	61	154	225	59	154	225	59	104	151	40	262	384	101	164	240	63
Nov	I	123	179	43	138	202	49	131	191	46	136	199	48	95	139	33	198	290	70	153	224	54
	II	118	173	41	129	189	45	124	182	44	124	182	44	98	144	34	181	264	63	143	210	50
	III	114	167	40	121	176	42	119	173	42	118	173	42	114	167	40	168	245	59	133	194	47
Dec	I	108	158	38	111	163	39	112	164	39	113	166	40	106	155	37	151	220	53	120	175	42
	II	97	142	34	111	162	39	105	153	37	106	156	37	105	153	37	139	204	49	115	168	40
	III	90	132	35	107	157	41	106	155	41	99	145	38	97	142	37	132	193	51	106	154	41
Jan	I	89	130	31	102	150	36	100	146	35	95	139	33	90	131	31	129	189	45	103	151	36
	II	88	128	31	97	142	34	96	140	34	91	133	32	86	125	30	125	182	44	101	148	36
	III	67	99	26	95	140	37	92	134	35	89	130	34	82	119	32	120	176	46	100	147	39
Feb	I	85	124	30	90	132	32	89	130	31	89	130	31	79	116	28	118	173	41	99	144	35
	II	85	125	30	94	138	33	91	133	32	88	129	31	80	116	28	110	160	38	100	146	35
	III	88	129	25	99	145	28	104	152	29	87	127	24	83	121	23	112	164	31	109	159	31
MAR	I	86	126	30	97	142	34	97	141	34	88	128	31	95	139	33	111	162	39	99	144	35
	II	102	149	36	91	133	32	115	169	41	97	141	34	109	160	38	113	165	40	102	150	36
	III	114	167	44	109	159	42	124	181	48	94	138	36	106	155	41	113	165	44	108	157	42
Apr	I	125	183	44	114	167	40	129	188	45	100	146	35	131	192	46	137	200	48	126	184	44
	II	111	162	39	125	183	44	211	308	74	119	175	42	142	207	50	185	270	65	142	208	50
	III	124	181	43	151	221	53	346	507	122	154	225	54	243	355	85	333	487	117	163	238	57
May	I	224	327	78	207	303	73	367	536	129	149	218	52	314	459	110	367	536	129	196	287	69
	II	268	391	94	640	935	224	346	505	121	151	221	53	330	482	116	434	634	152	445	650	156
	III	592	865	228	368	537	142	539	788	208	231	338	89	713	1043	275	568	831	219	482	705	186
		Total		3818	Total		5587	Total		4725	Total		4822	Total		3883	Total		5652	Total		4472

CALCULATION OF DISCHARGE FOR 90% AND 50% DEPENDABLE YEAR

Unrestricted Annual Energy (Million Units) For Years
Net Rated Head = 162
Envir.Release(cumecs) = 14

		2000-01			2001-02			2002-03			2003-04			2004-05		
	BLOCK	Q	P	E	Q	P	E	Q	P	E	Q	P	E	Q	P	E
Jun	I	412	603	145	356	520	125	772	1128	271	1120	1637	393	261	381	91
	II	493	721	173	508	742	178	1020	1491	358	1027	1501	360	430	629	151
	III	583	853	205	491	718	172	834	1220	293	866	1266	304	440	643	154
Jul	I	568	831	199	653	955	229	908	1327	319	901	1317	316	576	842	202
	II	761	1113	267	782	1143	274	794	1161	279	794	1161	279	511	747	179
	III	1072	1567	414	761	1113	294	698	1020	269	872	1275	337	509	745	197
Aug	I	993	1452	348	695	1016	244	748	1094	262	937	1370	329	608	889	213
	II	641	937	225	855	1250	300	909	1329	319	730	1067	256	604	883	212
	III	564	825	218	621	907	240	758	1108	293	639	934	247	446	653	172
Sep	I	530	775	186	450	659	158	693	1013	243	582	852	204	282	412	99
	II	334	488	117	279	408	98	468	684	164	424	620	149	302	442	106
	III	232	340	82	185	271	65	268	392	94	310	454	109	190	278	67
Oct	I	176	258	62	147	215	52	192	281	67	183	268	64	156	227	55
	II	164	239	57	133	195	47	169	247	59	157	230	55	135	197	47
	III	151	221	58	121	176	47	152	222	59	137	200	53	130	189	50
Nov	I	141	206	49	138	201	48	134	196	47	126	185	44	106	156	37
	II	130	190	46	109	159	38	122	179	43	116	170	41	91	133	32
	III	119	174	42	90	131	31	118	173	41	97	141	34	78	114	27
Dec	I	111	162	39	79	116	28	111	162	39	89	131	31	66	97	23
	II	103	150	36	74	108	26	110	160	39	86	126	30	64	94	22
	III	94	137	36	71	104	27	82	119	32	83	121	32	61	89	23
Jan	I	92	134	32	68	100	24	62	91	22	82	119	29	61	90	22
	II	85	124	30	66	96	23	62	90	22	76	111	27	64	94	23
	III	82	120	32	63	92	24	56	81	21	69	101	27	61	89	24
Feb	I	72	105	25	63	92	22	60	88	21	68	100	24	64	94	23
	II	71	103	25	66	97	23	60	88	21	70	103	25	71	103	25
	III	73	107	20	64	93	18	65	95	18	71	103	20	78	115	22
MAR	I	72	105	25	82	120	29	81	118	28	70	103	25	80	116	28
	II	70	102	25	92	134	32	72	105	25	76	111	27	92	134	32
	III	83	122	32	103	151	40	108	158	42	88	129	34	115	168	44
Apr	I	91	132	32	114	167	40	120	176	42	90	132	32	104	152	36
	II	100	147	35	147	214	51	187	273	65	97	142	34	125	182	44
	III	112	164	39	216	316	76	239	349	84	113	165	40	207	303	73
May	I	170	248	60	310	453	109	260	380	91	109	159	38	312	457	110
	II	289	423	102	844	1234	296	587	858	206	213	311	75	320	469	112
	III	240	352	93	636	930	246	797	1165	308	290	425	112	223	325	86
		Total		3611	Total		3774	Total		4606	Total		4233	Total		2864

Duration	Unrestricted Energy(MU)
1972-73	5256
1973-74	6219
1974-75	4378
1975-76	6160
1976-77	4279
1977-78	5344
1978-79	5994
1979-80	5114
1980-81	4954
1981-82	4691
1982-83	5372
1983-84	5376
1984-85	4063
1985-86	4268
1986-87	5023
1987-88	5012
1988-89	4987
1989-90	4989
1990-91	5278
1991-92	5285
1992-93	4614
1993-94	3818
1994-95	5587
1995-96	4725
1996-97	4822
1997-98	3883
1998-99	5652
1999-2000	4472
2000-01	3611
2001-02	3774
2002-03	4606
2003-04	4233
2004-05	2864

CALCULATION OF DISCHARGE FOR 90% AND 50% DEPENDABLE YEAR

Calculations to Find Out 90% & 50% Dependable years.

Sl. No.	Duration	Unrestricted Energy(MU)*	Energy in Descen. Order	
1	1972-73	**5240**	6200	
2	1973-74	**6200**	6141	
3	1974-75	**4365**	5976	
4	1975-76	**6141**	5635	
5	1976-77	**4266**	5570	
6	1977-78	**5328**	5359	
7	1978-79	**5976**	5356	
8	1979-80	**5098**	5328	
9	**1980-81**	**4939**	5268	50% dependable year
10	1981-82	**4676**	5262	
11	1982-83	**5356**	5240	
12	1983-84	**5359**	5098	
13	1984-85	**4050**	5007	
14	1985-86	**4255**	4997	
15	1986-87	**5007**	4974	
16	1987-88	**4997**	4971	
17	1988-89	**4971**	4939	
18	1989-90	**4974**	4807	
19	1990-91	**5262**	4710	
20	1991-92	**5268**	4676	
21	1992-93	**4600**	4600	
22	1993-94	**3806**	4592	
23	1994-95	**5570**	4458	
24	1995-96	**4710**	4365	
25	1996-97	**4807**	4266	
26	1997-98	**3872**	4255	
27	1998-99	**5635**	4220	
28	1999-2000	**4458**	4050	
29	2000-01	**3599**	3872	
30	2001-02	**3763**	3806	90% dependable year
31	2002-03	**4592**	3763	
32	2003-04	**4220**	3599	
33	2004-05	**2856**	2856	

a) 90% dependable year = [(N+1)*0.9] year =34*0.9=30.6 say 31st year
b) 50% dependable year = [(N+1)*0.5] year =34*0.5=17 say 17st year
* Energy values are taken from Table Annxure D

Month	BLOCK	DISCHARGE FOR dependable year 90%	DISCHARGE FOR dependable year 50%
Jun	I	370	729
	II	522	856
	III	505	1128
Jul	I	668	1101
	II	796	1269
	III	775	1193
Aug	I	709	1293
	II	869	796
	III	635	703
Sep	I	465	531
	II	293	403
	III	199	289
Oct	I	161	235
	II	147	188
	III	135	158
Nov	I	152	139
	II	123	124
	III	104	111
Dec	I	93	100
	II	88	95
	III	85	88
Jan	I	83	85
	II	80	70
	III	77	81
Feb	I	77	81
	II	80	78
	III	78	77
MAR	I	96	93
	II	106	92
	III	117	125
Apr	I	128	122
	II	161	214
	III	230	259
May	I	324	429
	II	858	454
	III	650	591

CALCULATION OF TEN DAILY FLOW FOR90% 50% SYNTHETIC YEAR FLOW

Ten Daily Discharge Data (cumec) arranged in Descending order for lurhi dam site

Sl. No.	ceedence Orobabili	JUN I	JUN II	JUN III	JUL I	JUL II	JUL III	AUG I	AUG II	AUG III	SEP I	SEP II	SEP III
1	2.9	565	725	876	1000	896	1014	993	856	689	685	499	304
2	5.9	1110	1720	1719	1369	1491	1132	975	964	1001	929	654	476
3	8.8	408	606	506	614	1139	1046	1044	1020	701	539	386	297
4	11.8	760	1463	1466	828	1715	1226	1508	1651	1043	693	529	368
5	14.7	929	736	535	735	1357	1485	912	783	630	576	393	307
6	17.6	449	317	720	1416	1512	1171	1512	975	713	702	554	378
7	20.6	827	712	1182	1463	1222	1220	1534	1352	874	948	707	464
8	23.5	370	821	1690	1298	1474	1182	1081	1038	783	665	384	246
9	26.5	729	856	1128	1101	1269	1193	1293	796	703	531	403	289
10	29.4	474	447	919	845	1032	1268	1360	1165	959	502	350	295
11	32.4	644	1245	1020	1314	1307	1323	1212	1158	774	510	524	296
12	35.3	809	687	944	1070	703	1264	1338	1098	1182	916	686	435
13	38.2	990	822	749	842	565	834	777	858	811	667	396	236
14	41.2	670	705	753	768	821	796	825	917	842	669	456	331
15	44.1	316	872	1482	1064	1204	1461	1240	1116	831	620	356	272
16	47.1	862	783	851	1198	1030	1191	946	842	807	652	457	366
17	50.0	616	627	1070	1084	1122	1253	1237	1020	779	545	410	651
18	52.9	958	728	656	774	1118	1277	823	759	850	581	374	306
19	55.9	828	731	1382	1213	1101	933	1027	993	823	711	528	385
20	58.8	1041	1312	1164	1419	1241	1190	960	689	767	669	492	290
21	61.8	482	772	1037	637	954	1202	1009	924	816	718	502	276
22	64.7	518	730	624	728	1036	688	733	612	549	502	460	276
23	67.6	770	668	1243	1339	1164	1445	1397	1120	1085	923	535	301
24	70.6	722	996	571	858	960	987	981	916	757	774	469	293
25	73.5	597	1109	1551	859	1029	1073	1054	1172	763	638	520	317
26	76.5	325	475	712	671	847	895	896	810	630	432	371	238
27	79.4	682	612	1141	1510	1372	1035	1002	1068	1023	568	453	549
28	82.4	301	628	791	910	887	957	1275	941	794	545	443	373
29	85.3	426	507	597	583	775	1086	1007	655	578	544	348	246
30	88.2	370	522	505	668	796	775	709	869	635	465	293	199
31	91.2	786	1034	848	922	808	712	762	923	772	707	482	282
32	94.1	1134	1041	880	915	808	886	951	744	653	596	438	324
33	97.1	275	444	454	590	525	523	622	618	460	296	316	204
Synthetic year with 90 % dependable discharge		786	1034	848	922	808	712	762	923	772	707	482	282
Synthetic year with 50 % dependable discharge		616	627	1070	1084	1122	1253	1237	1020	779	545	410	651

CALCULATION OF TEN DAILY FLOW FOR90% 50% SYNTHETIC YEAR FLOW

Ten Daily Discharge Data (cumec) arranged in Descending order at lurhi dam site

OCT			NOV			DEC			JAN			FEB		
I	II	III	I	II	III	I	II	III	I	II	III	I	II	III
222	196	161	143	129	115	106	105	103	97	89	95	93	94	98
275	214	199	178	153	127	114	106	102	97	96	96	97	92	93
195	181	145	132	119	108	101	98	93	94	82	96	113	117	115
272	232	212	192	177	150	130	121	114	108	104	100	99	101	111
226	188	179	155	142	128	108	99	102	97	87	95	91	93	93
251	203	178	168	153	145	121	122	111	99	661	93	93	93	92
315	248	206	183	171	159	147	133	122	107	107	101	99	96	117
209	184	162	149	132	123	113	101	96	91	86	88	91	89	99
235	188	158	139	124	111	100	95	88	85	70	81	81	78	77
223	170	151	155	127	111	102	93	87	85	82	81	82	84	81
209	182	167	145	133	118	102	98	87	88	93	95	92	91	89
289	231	199	170	146	132	118	108	102	93	88	85	81	83	99
174	152	136	120	104	95	89	87	82	81	73	74	72	70	72
241	312	186	153	133	117	101	176	88	80	74	75	80	80	81
208	191	160	146	135	129	124	123	119	113	106	106	104	105	108
225	174	156	139	129	123	117	113	109	107	107	101	86	73	84
322	216	172	155	143	137	131	125	131	130	121	111	111	107	105
224	188	175	161	145	137	117	119	120	104	98	101	104	107	105
259	221	186	157	152	145	137	132	118	107	98	94	95	97	97
229	192	171	156	142	131	124	122	121	115	113	115	124	116	122
233	191	162	142	134	129	121	110	106	106	103	105	103	104	106
211	174	149	137	132	128	122	111	104	103	102	81	99	99	102
250	205	172	152	143	135	126	125	121	116	111	109	105	108	113
232	199	168	145	138	133	126	119	120	114	110	106	103	105	118
254	202	168	150	138	133	127	121	113	109	105	103	103	102	101
179	138	118	109	112	128	120	119	111	104	100	96	93	94	97
337	347	276	212	195	182	165	153	146	143	139	134	132	124	126
245	195	178	167	157	147	134	129	120	117	115	114	113	114	123
190	178	165	155	144	133	125	117	108	106	99	96	86	85	87
161	147	135	152	123	104	93	88	85	83	80	77	77	80	78
206	183	166	148	136	132	125	124	96	77	76	70	74	75	79
197	172	151	140	130	111	103	100	97	96	90	83	82	84	85
170	149	144	120	105	92	81	78	75	75	78	75	78	85	93
206	183	166	148	136	132	125	124	96	77	76	70	74	75	79
322	216	172	155	143	137	131	125	131	130	121	111	111	107	105

CALCULATION OF TEN DAILY FLOW FOR90% 50% SYNTHETIC YEAR FLOW

Ten Daily Discharge Data (cumec) arranged in Descending order at lurhi dam site

MAR			APR			MAY		
I	II	III	I	II	III	I	II	III
98	103	150	191	240	670	1396	592	822
96	106	146	157	174	226	326	293	246
128	144	151	201	210	298	357	614	537
114	113	133	139	177	344	318	415	529
92	99	107	133	106	117	126	143	259
94	107	119	119	205	214	388	575	641
133	142	158	222	288	370	413	411	360
93	89	98	119	157	234	328	398	457
93	92	125	122	214	259	429	454	591
114	110	143	212	227	285	391	368	405
94	106	117	144	167	220	360	589	610
102	117	134	151	157	239	318	460	655
82	87	93	92	115	150	200	388	606
92	110	113	123	188	256	291	498	255
107	112	124	144	143	197	268	266	359
81	98	99	107	278	334	501	582	602
111	116	129	130	140	144	176	307	548
107	115	188	173	191	249	374	950	842
112	128	158	216	195	235	378	510	602
112	120	142	136	154	224	264	426	402
106	117	135	124	148	256	453	287	474
101	116	128	139	125	138	238	282	606
111	105	123	128	140	165	221	654	382
111	130	138	143	225	361	381	360	553
102	111	108	114	133	168	163	165	245
109	123	120	146	156	257	328	344	727
125	127	127	151	199	347	381	448	583
113	116	122	140	156	177	210	459	496
86	84	97	105	114	127	184	304	254
96	106	117	128	161	230	324	858	650
95	86	122	134	201	253	274	601	811
84	90	102	104	111	127	123	227	304
94	106	129	118	139	221	326	334	237

95	86	122	134	201	253	274	601	811

111	116	129	130	140	144	176	307	548

CALCULATION OF TEN DAILY FLOW FOR90% 50% SYNTHETIC YEAR FLOW

Month	Block	Ten Daily Flow of 90 % Synthetic. year	Ten Daily Flow of 50 % Synthetic. year
Jun	I	786	616
	II	1034	627
	III	848	1070
Jul	I	922	1084
	II	808	1122
	III	712	1253
Aug	I	762	1237
	II	923	1020
	III	772	779
Sep	I	707	545
	II	482	410
	III	282	651
Oct	I	206	322
	II	183	216
	III	166	172
Nov	I	148	155
	II	136	143
	III	132	137
Dec	I	125	131
	II	124	125
	III	96	131
Jan	I	77	130
	II	76	121
	III	70	111
Feb	I	74	111
	II	75	107
	III	79	105
MAR	I	95	111
	II	86	116
	III	122	129
Apr	I	134	130
	II	201	140
	III	253	144
May	I	274	176
	II	601	307
	III	811	548

Maximum flood at Luhri site by Gumbel's Method (using Sunni Data)

$x_T = x_{mean} + K\sigma_{n-1}$

where σ_{n-1}= standard deviation of the sample of size N

K = frequency factor expressed as

$K = (y_T - y_n) / S_n$

in which y_T = reduce variate , a function of T and is given by[17]

$y_t = -[0.834 + 2.303 \log \log(T/T-1)]$

and y_n = reduce mean, a function of sample size N and is given in table 7.3 (reference 24)

= 0.532

S_n = reduced standard deviation, a function of a sample size N and is given in table 7.4 (ref. 24)

= 1.0961

Table to calculate reduce variate y_T and maximum flood.

T in years	T/(T-1)	log(T/T-1)	loglog(T/T-1)	y_T	K	Maximum flood (x_{mean}+K σ_{n-1}) (at Sunni site)
10000	1.0001	4.3432E-05	-4.362194	9.212133	7.91911	8294
1000	1.001	0.00043451	-3.3619985	6.908682	5.81761	6598
500	1.002	0.00086946	-3.060751	6.214910	5.18466	6087
400	1.00251	0.0010871	-2.9637322	5.991475	4.98082	5923
200	1.00503	0.00217692	-2.6621577	5.296949	4.34718	5411
100	1.0101	0.00436481	-2.3600351	4.601161	3.7124	4899
50	1.02041	0.00877392	-2.0568061	3.902824	3.07529	4385
20	1.05263	0.02227639	-1.6521551	2.970913	2.22508	3699
10	1.11111	0.04575749	-1.3395378	2.250956	1.56825	3169
5	1.25	0.09691001	-1.0136313	1.500393	0.88349	2616
2	2	0.30103	-0.5213902	0.366762	-0.1508	1781

S.No.	Year	Flood Peak (Cumecs) x	$(x-x_{mean})$	$(x-x_{mean})^2$
1	1979	2135	231.9	53791.4
2	1980	1781	-122.1	14901.2
3	1981	1674	-229.1	52473.2

4	1982	1681	-222.1	49315.2
5	1983	1719	-184.1	33881.9
6	1984	1131	-772.1	596092.6
7	1985	1368	-535.1	286300.3
8	1986	2057	153.9	23694.3
9	1987	1419	-484.1	234324.1
10	1988	2114	210.9	44491.3
11	1989	2242	338.9	114873.3
12	1990	2794	890.9	793755.6
13	1991	1689	-214.1	45826.1
14	1992	1562	-341.1	116329.0
15	1993	1831	-72.1	5194.1
16	1994	2029	125.9	15858.3
17	1995	1859	-44.1	1942.2
18	1996	1732	-171.1	29265.1
19	1997	2600	696.9	485710.9
20	1998	1788	-115.1	13241.2
21	1999	2001	97.9	9590.2
22	2000	5253	3350.1	11223434.4
23	2001	1587	-316.1	99900.5
24	2002	1412	-491.1	241150.1
25	2003	1239	-663.7	440473.1
26	2004	782	-1120.8	1256281.9

Annexure-VII/8
(contd.)

N = 26 sum 16282092

average : 1903.07035

and $\sigma_{n-1} = [\Sigma(x - x_{mean})^2 / (N-1)]^{0.5}$

= 807.021478

Calculation of maximum flood for Lurhi site (by area)

Catchment area of Luhri = 52403 sq km

Catchment area of Sunni)= 52915 sq km

Q_{Luhri} = Qsunni *(CA of Lurhi/ CA of Sunni)$^{3/4}$

T(in years)	Q_{Sunni}	Q_{Luhri}
10000	8294	8233.738
1000	6598	6550.06069
100	4899	4863.40517

Maximum flood at Luhri site by Log-pearson Type III (by using Sunni Data)

In this method[4], $Z = \log Q$

For this Z series, for any recurrence interval T, $Z_t = Z_{mean} + K_z\sigma_z$

where K_z = a frequency factor which is a function of recurrence interval T and the coefficient of skew C_s

σ_z = standard deviation of the Z variate sample

$= [\Sigma (Z - Z_{mean})^2 /(N-1)]^{0.5}$

0.14834

C_s = coefficient of skew of variate Z

$= N\Sigma(Z-Z_{mean})^3 / (N-1)(N-2)(\sigma_z)^3$

= 0.71505

K_z = function of C_s & T and given in table 7.6 (reference 24)

and $Z_T = Z_{mean} + K_z\, \sigma_z$

and max. discharge = antilog (Z_T)

As we are using the data of Sunni site for above method, so we get maximum flood for Sunni site, so by area corelation we can calculate the maximum flood at Luhri site.

Catchment area of Luhri (in SqKM)= 52403

Catchment area of Sunni (in SqKM)= 52915

Q_{Luhri} = Qsunni *(CA of Lurhi/ CA of Sunni $)^{3/4}$

T in years	K_z	Z_T	maximum flood at Sunni site	Q_{Luhri}
1000	5.14183	4.015319219	10359	10283.767
200	3.8594	3.825077604	6685	6636.0648
100	3.30308	3.742551728	5528	5487.629
50	2.73592	3.658416388	4554	4521.155
25	2.18867	3.577233573	3778	3750.305
10	1.35445	3.453482231	2841	2820.4295
2	-0.2304	3.218376608	1653	1641.3818

S.No.	Year	Flood Peak (Cumecs) Q	Z = log Q	$(Z-Z_{mean})$	$(Z-Z_{mean})^2$	$(Z-Z_{mean})^3$
1	1979	2135	3.3293979	0.0768414	0.0059046	0.00045372
2	1980	1781	3.2506639	-0.0018926	3.582E-06	-6.779E-09
3	1981	1674	3.2237555	-0.028801	0.0008295	-2.389E-05
4	1982	1681	3.2255677	-0.0269888	0.0007284	-1.966E-05
5	1983	1719	3.2352759	-0.0172806	0.0002986	-5.16E-06
6	1984	1131	3.0534626	-0.1990939	0.0396384	-0.0078918
7	1985	1368	3.1360861	-0.1164704	0.0135653	-0.00158
8	1986	2057	3.3132343	0.0606778	0.0036818	0.0002234
9	1987	1419	3.1519824	-0.1005741	0.0101151	-0.0010173
10	1988	2114	3.325105	0.0725485	0.0052633	0.00038184
11	1989	2242	3.3506356	0.0980791	0.0096195	0.00094347
12	1990	2794	3.4462264	0.1936699	0.037508	0.00726418
13	1991	1689	3.2276296	-0.0249268	0.0006213	-1.549E-05
14	1992	1562	3.193681	-0.0588754	0.0034663	-0.0002041
15	1993	1831	3.2626883	0.0101319	0.0001027	1.0401E-06
16	1994	2029	3.307282	0.0547256	0.0029949	0.0001639
17	1995	1859	3.2692794	0.0167229	0.0002797	4.6767E-06
18	1996	1732	3.2385479	-0.0140086	0.0001962	-2.749E-06
19	1997	2600	3.4149733	0.1624169	0.0263792	0.00428443
20	1998	1788	3.2523675	-0.000189	3.57E-08	-6.747E-12
21	1999	2001	3.3012471	0.0486906	0.0023708	0.00011543
22	2000	5253	3.7204247	0.4678683	0.2189007	0.1024167
23	2001	1587	3.2005769	-0.0519795	0.0027019	-0.0001404
24	2002	1412	3.1498347	-0.1027218	0.0105518	-0.0010839
25	2003	1239	3.0932076	-0.1593489	0.0253921	-0.0040462
26	2004	782	2.8933348	-0.3592217	0.1290402	-0.0463541
N = 26				5.329E-15	0.550154	0.05386814

Z_{mean} = 3.2525565

Maximum flood at Luhri site by Gumbel's Method (using Rampur Data)

$x_T = x_{mean} + K\sigma_{n-1}$

where σ_{n-1}= standard deviation of the sample of size N

K = frequency factor expressed as

$K = (y_T - y_n) / S_n$

in which y_T = reduce variate , a function of T and is given by

$y_t = -[0.834 + 2.303 \log \log(T/T-1)]$

and y_n = reduce mean, a function of sample size N and is given in table 7.3 (reference24)

= 0.5448

S_n = reduced standard deviation, a function of a sample size N and is given in table 7.4 (ref. 24)

= 1.1458

Table to calculate reduce variate y_T and maximum flood.

T in years	T/(T-1)	log(T/T-1)	loglog(T/T-1)	y_T	K	Maximum flood (x_{mean}+K σ_{n-1}) (at Rampur site)
10000	1.0001	4.3432E-05	-4.362194	9.212133	7.56444	7276
1000	1.001	0.00043451	-3.3619985	6.908682	5.5541	5807
500	1.002	0.00086946	-3.060751	6.214910	4.9486	5364
400	1.00251	0.0010871	-2.9637322	5.991475	4.7536	5222
200	1.00503	0.00217692	-2.6621577	5.296949	4.14745	4779
100	1.0101	0.00436481	-2.3600351	4.601161	3.5402	4335
50	1.02041	0.00877392	-2.0568061	3.902824	2.93072	3890
20	1.05263	0.02227639	-1.6521551	2.970913	2.1174	3295
10	1.11111	0.04575749	-1.3395378	2.250956	1.48905	2836
5	1.25	0.09691001	-1.0136313	1.500393	0.834	2358
2	2	0.30103	-0.5213902	0.366762	-0.1554	1635

Annexure-VII/9
(contd.)

S.No.	Year	Flood Peak (Cumecs) x	$(x-x_{mean})$	$(x-x_{mean})^2$
1	1963	1092.5	-655.7	429958.0
2	1964	1393.8	-354.4	125607.8
3	1965	1083.3	-664.9	442107.8
4	1966	2256.3	508.1	258153.6
5	1967	1850.4	102.2	10442.4
6	1968	2384	635.8	404226.6
7	1969	1999	250.8	62894.7
8	1970	1261	-487.2	237375.4
9	1971	1677	-71.2	5071.1
10	1972	1287	-461.2	212716.4
11	1973	3053	1304.8	1702472.1
12	1974	1871	122.8	15076.9
13	1975	2427	678.8	460753.4
14	1976	1999	250.8	62894.7
15	1977	2356	607.8	369406.4
16	1978	2118	369.8	136743.3
17	1979	2740	991.8	983643.8
18	1980	1967	218.8	47868.3
19	1981	1698	-50.2	2521.2
20	1982	1531	-217.2	47181.0
21	1983	1621	-127.2	16182.9
22	1984	1059	-689.2	475013.0
23	1985	1230	-518.2	268543.5
24	1986	1812	63.8	4068.9
25	1987	1390	-358.2	128315.7
26	1988	1507	-241.2	58183.2
27	1989	1659	-89.2	7958.8
28	1990	1299	-449.2	201791.3
29	1991	1563	-185.2	34303.4
30	1992	1138	-610.2	372358.5
31	1993	944	-804.2	646756.7
32	1994	1830	81.8	6689.3
33	1995	1082	-666.2	443838.2
34	1996	1609	-139.2	19379.9
35	1997	2577	828.8	686889.8

36	1998	1586	-162.2	26312.7
37	1999	1388	-360.2	129752.6
38	2000	5101	3352.7	11240845.9
39	2001	1105	-643.0	413457.0
40	2002	1119	-628.8	395435.9
41	2003	1261	-487.1	237309.2
42	2004	1500	-248.2	61609.1

N = 42 sum 21892110.2

average : 1748.21184

and $\sigma_{n-1} = [\Sigma(x - x_{mean})^2 / (N-1)]^{0.5}$

$= 730.721497$

Calculation of maximum flood for Lurhi site (by area)

Catchment area of Luhri = 52403 sq km

Catchment area of Rampur = 50880 sq km

$Q_{Luhri} = Q_{Rampur} * (\text{CA of Lurhi/ CA of Rampur})^{3/4}$

T(in years)	Q_{Rampur}	Q_{Luhri}
10000	7276	7438.74166
1000	5807	5936.88466
100	4335	4431.96057

Maximum flood at Luhri site by Log-pearson Type III (by using RampurData)

In this method, $Z = \log Q$

For this Z series, for any recurrence interval T, $Z_t = Z_{mean} + K_z\sigma_z$

where K_z = a frequency factor which is function of recurrence interval T and the coefficient of skew C_s

σ_z = standard deviation of the Z variate sample

$= [\Sigma (Z - Z_{mean})^2 /(N-1)]^{0.5}$

0.15308

C_s = coefficient of skew of variate Z

$= N\Sigma(Z-Z_{mean})^3 / (N-1)(N-2)(\sigma_z)^3$

= 0.0951

K_z = function of C_s & T and given in table 7.6 (reference24)

and $Z_T = Z_{mean} + K_z \sigma_z$

and max. discharge = antilog (Z_T)

As we are using the data of Sunni site for above method, so we get maximum flood for Sunni site, so by area corelation we can calculate the maximum flood at Luhri site.

Catchment area of Luhri (in SqKM)= 52403

Catchment area of Rampur (in SqKM)= 50880

$Q_{Luhri} = Q_{Rampur}$ *(CA of Lurhi/ CA of Rampur $)^{3/4}$

T in year	K_z	Z_T	maximum flood at Sunni site	Q_{Luhri}
1000	3.22789	3.731397365	5388	5427
200	2.66539	3.647953422	4446	4478
100	2.11773	3.56671123	3687	3714
50	2.1044	3.564733455	3671	3697
25	1.78333	3.517104604	3289	3313
10	1.29151	3.444145158	2781	2801
2	-0.0162	3.250158222	1779	1792

Annexure-VII/9 (contd.)

S.No.	Year	Flood Peak (Cumecs) Q	Z = log Q	(Z-Z_{mean})	(Z-Z_{mean})^2	(Z-Z_{mean})^3
1	1963	1093	3.0384	-0.2141	0.0459	-0.0098
2	1964	1394	3.1442	-0.1084	0.0117	-0.0013
3	1965	1083	3.0347	-0.2178	0.0474	-0.0103
4	1966	2256	3.3534	0.1008	0.0102	0.0010
5	1967	1850	3.2673	0.0147	0.0002	0.0000
6	1968	2384	3.3773	0.1247	0.0156	0.0019
7	1969	1999	3.3008	0.0483	0.0023	0.0001
8	1970	1261	3.1007	-0.1518	0.0231	-0.0035
9	1971	1677	3.2245	-0.0280	0.0008	0.0000
10	1972	1287	3.1096	-0.1430	0.0204	-0.0029
11	1973	3053	3.4847	0.2322	0.0539	0.0125
12	1974	1871	3.2721	0.0195	0.0004	0.0000
13	1975	2427	3.3851	0.1325	0.0176	0.0023
14	1976	1999	3.3008	0.0483	0.0023	0.0001
15	1977	2356	3.3722	0.1196	0.0143	0.0017
16	1978	2118	3.3259	0.0734	0.0054	0.0004
17	1979	2740	3.4378	0.1852	0.0343	0.0064
18	1980	1967	3.2938	0.0412	0.0017	0.0001
19	1981	1698	3.2299	-0.0226	0.0005	0.0000
20	1982	1531	3.1850	-0.0676	0.0046	-0.0003
21	1983	1621	3.2098	-0.0428	0.0018	-0.0001
22	1984	1059	3.0249	-0.2277	0.0518	-0.0118
23	1985	1230	3.0899	-0.1627	0.0265	-0.0043
24	1986	1812	3.2582	0.0056	0.0000	0.0000
25	1987	1390	3.1430	-0.1095	0.0120	-0.0013
26	1988	1507	3.1781	-0.0744	0.0055	-0.0004
27	1989	1659	3.2198	-0.0327	0.0011	0.0000
28	1990	1299	3.1136	-0.1389	0.0193	-0.0027
29	1991	1563	3.1940	-0.0586	0.0034	-0.0002
30	1992	1138	3.0561	-0.1964	0.0386	-0.0076
31	1993	944	2.9750	-0.2776	0.0771	-0.0214
32	1994	1830	3.2625	0.0099	0.0001	0.0000
33	1995	1082	3.0342	-0.2183	0.0477	-0.0104
34	1996	1609	3.2066	-0.0460	0.0021	-0.0001
35	1997	2577	3.4111	0.1586	0.0251	0.0040
36	1998	1586	3.2003	-0.0523	0.0027	-0.0001
37	1999	1388	3.1424	-0.1102	0.0121	-0.0013
38	2000	5101	3.7077	0.4551	0.2071	0.0943
39	2001	1105	3.0434	-0.2091	0.0437	-0.0091
40	2002	1119	3.0490	-0.2036	0.0414	-0.0084
41	2003	1261	3.1007	-0.1518	0.0230	-0.0035
42	2004	1500	3.1761	-0.0765	0.0058	-0.0004
N = **42**				-1.572801	0.960735	0.013320

Z_{mean} = 3.215109

CALCULATION OF LOSSES

Taking installed capacity= 900 MW

FIXING OF HEAD

As per LHEP some important levels are taken for this study ae given below.

FRL	=	845m
MDDL	=	825m
Normal TWL	=	643m
Gross head	=	202m
Combined efficiency	=	92%

Gross Head	=	202.00 m
Assume Losses	=	33.00 m
So Net Head	=	169.00 m
And Net rated net head	=	162.33 m
Installed Capacity	=	**900.00** MW
Required Discharge	=	614.30 Cumecs
		615.00
HRT Diameter		
restricting flow velocity to		5.00 m/sec
Required Diameter	=	12.51 meters
Say		**12.50** meters
Now flow velocity in HRT	=	**5.01** m/sec

A.5 HEAD LOSS CALCULATIONS UPTO SURGE SHAFT :

i) Head Losses in HRT :

Velocity through tunnel = v = 5.01 M/Sec

Length of HRT = 29 KM

Length of HRT	=	29000 m
flow in HRT	=	615 cumecs
Diameter of HRT	=	12.5
Velocity of flow	=	5.01 m/sec

Head loss by Mannings formula

$$h_f = V^2 n^2 L / R^{1.3333}$$

where

R = Hydraulic mean depth .=R/P

= 3.125 m

for concrete lined tunnels n may varies from 0.010 to0.018

taking n = 0.014

So $h_f =$ 31.22 m

ii) Trash rack losses

$$h_t = K_t V^2 / 2 g$$

where

K_t = $1.45+0.45(a_n/a_t)-(a_n/a_t)^2$

a_n .= net area through trash rack bars

a_t .= Gross area of opening

V 1.309828 (as per Justin & Greager we can take v up to 1.5 m/sec)

a_n/a_t = 0.7 assume

so h_t = 0.111 m

iii) Entrance losses : Opening size of Bell mouth= 10.15m X 9.4 m (h)

$$V = Q/A = \frac{769/6}{10.15x9.4} = 1.31 m/sec$$

$$: he = \frac{Ke.v^2}{2g} = \frac{0.16x(1.31)^2}{2x9.81}$$ Ke= 0.16 for square bell mouth

Entrances

$$= 0.014 \text{ m}$$

iv) Bend Losses :

v = 5.01m/Sec.

$$h = Kb. \frac{V2}{2g}$$

$$= \frac{0.0375x(5.02)^2}{2x9.81} = 0.0375x\ 1.2388 = 0.048m$$

v) Gate loss

Gate opening size = 7.2mX6.0m (h)

Area = 43.2 m^2

$$V = \frac{768.9}{43.2} X \frac{1}{6} = 2.96 \text{ m/sec}$$

$$\text{Loss} = \frac{0.10 \times (2.96)^2}{2 X 9.81}$$

$$= 0.045 \text{ m}$$

Head loss in penstock

Length of Penstock = 175 m
flow in each penstock = 225.5 cumecs
Diameter of penstock= 6.55
Velocity of flow = 6.69 m/sec

Head loss by Mannings formula

$$h_f = V^2 n^2 L / R^{1.3333}$$

where

R = Hydraulic mean depth .=R/P
= 1.638 m

for concrete lined tunnels n may varies from 0.012 to0.018

taking n = 0.011

So $h_f =$ 0.491 m

Total Losses = 31.22 + 0.111 + 0.014+0.048*3+0.045+0.49
= 32.024 m

<u>But assumed head loss =33.0 m</u>

<u>Hence take net rated head</u> = 162 m

Required Discharge = 615 cumec

Diameter of HRT = 12.50 m

Installed capacity = 900 MW

ENERGY GENERATION FOR DIFFERENT INSTALLED CAPACITIES (for mean flow)

Annexure-VIII/2

CAPACITY UTILIZATION STUDIES (Instaled Capacity Vs Incremental Energy)
for Mean ten daily flow — Envir.Release= 14 cumecs
head(m) 162 — effincey: 0.92

Month	Block	discha-rge cumecs	unrestricted power (MW)	IC(MW) 300 Power (MW)	IC(MW) 300 Energy (GwH)	IC(MW) 350 Power (MW)	IC(MW) 350 Energy (GwH)	IC(MW) 400 Power (MW)	IC(MW) 400 Energy (GwH)	IC(MW) 450 Power (MW)	IC(MW) 450 Energy (GwH)	IC(MW) 500 Power (MW)	IC(MW) 500 Energy (GwH)	IC(MW) 550 Power (MW)	IC(MW) 550 Energy (GwH)	IC(MW) 600 Power (MW)	IC(MW) 600 Energy (GwH)	IC(MW) 650 Power (MW)	IC(MW) 650 Energy (GwH)
Jun	I	645	943	300	72	350	84	400	96	450	108	500	120	550	132	600	144	650	156
	II	788	1152	300	72	350	84	400	96	450	108	500	120	550	132	600	144	650	156
	III	949	1388	300	72	350	84	400	96	450	108	500	120	550	132	600	144	650	156
Jul	I	974	1424	300	72	350	84	400	96	450	108	500	120	550	132	600	144	650	156
	II	1055	1542	300	72	350	84	400	96	450	108	500	120	550	132	600	144	650	156
	III	1068	1562	300	79	350	92	400	106	450	119	500	132	550	145	600	158	650	172
Aug	I	1046	1529	300	72	350	84	400	96	450	108	500	120	550	132	600	144	650	156
	II	938	1371	300	72	350	84	400	96	450	108	500	120	550	132	600	144	650	156
	III	776	1135	300	79	350	92	400	106	450	119	500	132	550	145	600	158	650	172
Sep	I	623	911	300	72	350	84	400	96	450	108	500	120	550	132	600	144	650	156
	II	446	652	300	72	350	84	400	96	450	108	500	120	550	132	600	144	650	156
	III	315	461	300	72	350	84	400	96	450	108	461	111	461	111	461	111	461	111
Oct	I	218	319	300	72	319	76	319	76	319	76	319	76	319	76	319	76	319	76
	II	184	269	269	65	269	65	269	65	269	65	269	65	269	65	269	65	269	65
	III	156	228	228	60	228	60	228	60	228	60	228	60	228	60	228	60	228	60
Nov	I	138	202	202	48	202	48	202	48	202	48	202	48	202	48	202	48	202	48
	II	125	183	183	44	183	44	183	44	183	44	183	44	183	44	183	44	183	44
	III	114	167	167	40	167	40	167	40	167	40	167	40	167	40	167	40	167	40
Dec	I	103	151	151	36	151	36	151	36	151	36	151	36	151	36	151	36	151	36
	II	100	146	146	35	146	35	146	35	146	35	146	35	146	35	146	35	146	35
	III	92	135	135	36	135	36	135	36	135	36	135	36	135	36	135	36	135	36
Jan	I	87	127	127	31	127	31	127	31	127	31	127	31	127	31	127	31	127	31
	II	99	145	145	35	145	35	145	35	145	35	145	35	145	35	145	35	145	35
	III	81	118	118	31	118	31	118	31	118	31	118	31	118	31	118	31	118	31
Feb	I	81	118	118	28	118	28	118	28	118	28	118	28	118	28	118	28	118	28
	II	81	118	118	28	118	28	118	28	118	28	118	28	118	28	118	28	118	28
	III	84	123	123	24	123	24	123	24	123	24	123	24	123	24	123	24	123	24
MAR	I	89	130	130	31	130	31	130	31	130	31	130	31	130	31	130	31	130	31
	II	96	140	140	34	140	34	140	34	140	34	140	34	140	34	140	34	140	34
	III	113	165	165	44	165	44	165	44	165	44	165	44	165	44	165	44	165	44
Apr	I	128	187	187	45	187	45	187	45	187	45	187	45	187	45	187	45	187	45
	II	160	234	234	56	234	56	234	56	234	56	234	56	234	56	234	56	234	56
	III	231	338	300	72	338	81	338	81	338	81	338	81	338	81	338	81	338	81
May	I	326	477	300	72	350	84	400	96	450	108	477	114	477	114	477	114	477	114
	II	427	624	300	72	350	84	400	96	450	108	500	120	550	132	600	144	624	150
	III	491	718	300	79	350	92	400	106	450	119	500	132	550	145	600	158	650	172
Total Energy					1996		2193.1		2376.7		2560.3		2728.8		2888.4		3048		3201.5

ENERGY GENERATION FOR DIFFERENT INSTALLED CAPACITIES (for mean flow)

CAPACITY UTILIZATION STUDIES (Instaled Capacity Vs Incremental Energy)
for Mean ten daily flow Envir.Release= 14 cumecs (continued)
head(m) 161.5 effincey: 0.92

Month	Period	IC(MW)	700	IC(MW)	750	IC(MW)	800	IC(MW)	850	IC(MW)	900	IC(MW)	950	IC(MW)	1000	IC(MW)	1050	IC(MW)	1100
		Power (MW)	Energy (GwH)	Power (MW)	Energy (GwH)	Power (MW)	Energy (GwH)	Power (MW)	Energy (GwH)	Power (MW)	Energy (GwH)	Power (MW)	Energy (GwH)	Power (MW)	Energy (GwH)	Power (MW)	Energy (GwH)	Power (MW)	Energy (GwH)
Jun	I	700	168	750	180	800	192	850	204	900	216	943	226	943	226	943	226	943	226
	II	700	168	750	180	800	192	850	204	900	216	950	228	1000	240	1050	252	1100	264
	III	700	168	750	180	800	192	850	204	900	216	950	228	1000	240	1050	252	1100	264
Jul	I	700	168	750	180	800	192	850	204	900	216	950	228	1000	240	1050	252	1100	264
	II	700	168	750	180	800	192	850	204	900	216	950	228	1000	240	1050	252	1100	264
	III	700	185	750	198	800	211	850	224	900	238	950	251	1000	264	1050	277	1100	290
Aug	I	700	168	750	180	800	192	850	204	900	216	950	228	1000	240	1050	252	1100	264
	II	700	168	750	180	800	192	850	204	900	216	950	228	1000	240	1050	252	1100	264
	III	700	185	750	198	800	211	850	224	900	238	950	251	1000	264	1050	277	1100	290
Sep	I	700	168	750	180	800	192	850	204	900	216	911	219	911	219	911	219	911	219
	II	652	157	652	157	652	157	652	157	652	157	652	157	652	157	652	157	652	157
	III	461	111	461	111	461	111	461	111	461	111	461	111	461	111	461	111	461	111
Oct	I	319	76	319	76	319	76	319	76	319	76	319	76	319	76	319	76	319	76
	II	269	65	269	65	269	65	269	65	269	65	269	65	269	65	269	65	269	65
	III	228	60	228	60	228	60	228	60	228	60	228	60	228	60	228	60	228	60
Nov	I	202	48	202	48	202	48	202	48	202	48	202	48	202	48	202	48	202	48
	II	183	44	183	44	183	44	183	44	183	44	183	44	183	44	183	44	183	44
	III	167	40	167	40	167	40	167	40	167	40	167	40	167	40	167	40	167	40
Dec	I	151	36	151	36	151	36	151	36	151	36	151	36	151	36	151	36	151	36
	II	146	35	146	35	146	35	146	35	146	35	146	35	146	35	146	35	146	35
	III	135	36	135	36	135	36	135	36	135	36	135	36	135	36	135	36	135	36
Jan	I	127	31	127	31	127	31	127	31	127	31	127	31	127	31	127	31	127	31
	II	145	35	145	35	145	35	145	35	145	35	145	35	145	35	145	35	145	35
	III	118	31	118	31	118	31	118	31	118	31	118	31	118	31	118	31	118	31
Feb	I	118	28	118	28	118	28	118	28	118	28	118	28	118	28	118	28	118	28
	II	118	28	118	28	118	28	118	28	118	28	118	28	118	28	118	28	118	28
	III	123	24	123	24	123	24	123	24	123	24	123	24	123	24	123	24	123	24
MAR	I	130	31	130	31	130	31	130	31	130	31	130	31	130	31	130	31	130	31
	II	140	34	140	34	140	34	140	34	140	34	140	34	140	34	140	34	140	34
	III	165	44	165	44	165	44	165	44	165	44	165	44	165	44	165	44	165	44
Apr	I	187	45	187	45	187	45	187	45	187	45	187	45	187	45	187	45	187	45
	II	234	56	234	56	234	56	234	56	234	56	234	56	234	56	234	56	234	56
	III	338	81	338	81	338	81	338	81	338	81	338	81	338	81	338	81	338	81
May	I	477	114	477	114	477	114	477	114	477	114	477	114	477	114	477	114	477	114
	II	624	150	624	150	624	150	624	150	624	150	624	150	624	150	624	150	624	150
	III	700	185	718	190	718	190	718	190	718	190	718	190	718	190	718	190	718	190
Total Energy			3337.6		3464.7		3587.1		3709.5		3831.9		3943.2		4041.6		4140		4238.4

Annexure-VIII/2

ENERGY GENERATION FOR DIFFERENT INSTALLED CAPACITIES (for mean flow)

CAPACITY UTILIZATION STUDIES (Instaled Capacity Vs Incremental Energy)
for Mean ten daily flow — Envir.Release= 14 cumecs
head(m) 161.5 — effincey: 0.92

Month	Block	IC(MW) 1150 Power (MW)	IC(MW) 1150 Energy (GwH)	IC(MW) 1200 Power (MW)	IC(MW) 1200 Energy (GwH)	IC(MW) 1250 Power (MW)	IC(MW) 1250 Energy (GwH)	IC(MW) 1300 Power (MW)	IC(MW) 1300 Energy (GwH)	IC(MW) 1350 Power (MW)	IC(MW) 1350 Energy (GwH)
Jun	I	943	226	943	226	943	226	943	226	943	226
	II	1150	276	1152	277	1152	277	1152	277	1152	277
	III	1150	276	1200	288	1250	300	1300	312	1350	324
Jul	I	1150	276	1200	288	1250	300	1300	312	1350	324
	II	1150	276	1200	288	1250	300	1300	312	1350	324
	III	1150	304	1200	317	1250	330	1300	343	1350	356
Aug	I	1150	276	1200	288	1250	300	1300	312	1350	324
	II	1150	276	1200	288	1250	300	1300	312	1350	324
	III	1135	300	1135	300	1135	300	1135	300	1135	300
Sep	I	911	219	911	219	911	219	911	219	911	219
	II	652	157	652	157	652	157	652	157	652	157
	III	461	111	461	111	461	111	461	111	461	111
Oct	I	319	76	319	76	319	76	319	76	319	76
	II	269	65	269	65	269	65	269	65	269	65
	III	228	60	228	60	228	60	228	60	228	60
Nov	I	202	48	202	48	202	48	202	48	202	48
	II	183	44	183	44	183	44	183	44	183	44
	III	167	40	167	40	167	40	167	40	167	40
Dec	I	151	36	151	36	151	36	151	36	151	36
	II	146	35	146	35	146	35	146	35	146	35
	III	135	36	135	36	135	36	135	36	135	36
Jan	I	127	31	127	31	127	31	127	31	127	31
	II	145	35	145	35	145	35	145	35	145	35
	III	118	31	118	31	118	31	118	31	118	31
Feb	I	118	28	118	28	118	28	118	28	118	28
	II	118	28	118	28	118	28	118	28	118	28
	III	123	24	123	24	123	24	123	24	123	24
MAR	I	130	31	130	31	130	31	130	31	130	31
	II	140	34	140	34	140	34	140	34	140	34
	III	165	44	165	44	165	44	165	44	165	44
Apr	I	187	45	187	45	187	45	187	45	187	45
	II	234	56	234	56	234	56	234	56	234	56
	III	338	81	338	81	338	81	338	81	338	81
May	I	477	114	477	114	477	114	477	114	477	114
	II	624	150	624	150	624	150	624	150	624	150
	III	718	190	718	190	718	190	718	190	718	190
Total Energy			4332.8		4406.5		4479.7		4552.9		4626.1

Installed capacity (MW)	Energy (GwH)	Incremental Increase in Energy(GwH)	Incremental Increase in Energy per MW
300	1996.0	0.0	0.0
350	2193.1	197.2	3.9
400	2376.7	183.6	3.7
450	2560.3	183.6	3.7
500	2728.8	168.5	3.4
550	2888.4	159.6	3.2
600	3048.0	159.6	3.2
650	3201.5	153.4	3.1
700	3337.6	136.1	2.7
750	3464.7	127.1	2.5
800	3587.1	122.4	2.4
850	3709.5	122.4	2.4
900	3831.9	122.4	2.4
950	3943.2	111.3	2.2
1000	4041.6	98.4	2.0
1050	4140.0	98.4	2.0
1100	4238.4	98.4	2.0
1150	4332.8	94.3	1.9
1200	4406.5	73.7	1.5
1250	4479.7	73.2	1.5
1300	4552.9	73.2	1.5
	4626.1		

ENERGY CALCULATION FOR DIFFERENT INSTALLED CAPACITIES (FOR 90 Percente DEPENDABLITY)

CAPACITY UTILIZATION STUDIES (Instaled Capacity Vs Incremental Energy)

for 90 % dependabl flow — Envir.Release= 14 cumecs

head(m) 162 — effincey= 0.92

Month	Block	discha.-rge cumecs	unrestricted power (MW)	IC(MW) 300 Power (MW)	Energy (GwH)	IC(MW) 350 Power (MW)	Energy (GwH)	IC(MW) 400 Power (MW)	Energy (GwH)	IC(MW) 450 Power (MW)	Energy (GwH)	IC(MW) 500 Power (MW)	Energy (GwH)	IC(MW) 550 Power (MW)	Energy (GwH)	IC(MW) 600 Power (MW)	Energy (GwH)	IC(MW) 650 Power (MW)	Energy (GwH)
Jun	I	356	520	300	72	350	84	400	96	450	108	500	120	520	125	520	125	520	125
	II	508	742	300	72	350	84	400	96	450	108	500	120	550	132	600	144	650	156
	III	491	718	300	72	350	84	400	96	450	108	500	120	550	132	600	144	650	156
Jul	I	654	955	300	72	350	84	400	96	450	108	500	120	550	132	600	144	650	156
	II	782	1143	300	72	350	84	400	96	450	108	500	120	550	132	600	144	650	156
	III	761	1113	300	79	350	92	400	106	450	119	500	132	550	145	600	158	650	172
Aug	I	695	1016	300	72	350	84	400	96	450	108	500	120	550	132	600	144	650	156
	II	855	1250	300	72	350	84	400	96	450	108	500	120	550	132	600	144	650	156
	III	621	907	300	79	350	92	400	106	450	119	500	132	550	145	600	158	650	172
Sep	I	451	659	300	72	350	84	400	96	450	108	500	120	550	132	600	144	650	156
	II	279	408	300	72	350	84	400	96	408	98	408	98	408	98	408	98	408	98
	III	185	271	271	65	271	65	271	65	271	65	271	65	271	65	271	65	271	65
Oct	I	147	215	215	52	215	52	215	52	215	52	215	52	215	52	215	52	215	52
	II	133	195	195	47	195	47	195	47	195	47	195	47	195	47	195	47	195	47
	III	121	176	176	47	176	47	176	47	176	47	176	47	176	47	176	47	176	47
Nov	I	138	201	201	48	201	48	201	48	201	48	201	48	201	48	201	48	201	48
	II	109	159	159	38	159	38	159	38	159	38	159	38	159	38	159	38	159	38
	III	90	131	131	31	131	31	131	31	131	31	131	31	131	31	131	31	131	31
Dec	I	79	116	116	28	116	28	116	28	116	28	116	28	116	28	116	28	116	28
	II	74	107	107	26	107	26	107	26	107	26	107	26	107	26	107	26	107	26
	III	71	104	104	27	104	27	104	27	104	27	104	27	104	27	104	27	104	27
Jan	I	69	100	100	24	100	24	100	24	100	24	100	24	100	24	100	24	100	24
	II	66	96	96	23	96	23	96	23	96	23	96	23	96	23	96	23	96	23
	III	63	92	92	24	92	24	92	24	92	24	92	24	92	24	92	24	92	24
Feb	I	63	92	92	22	92	22	92	22	92	22	92	22	92	22	92	22	92	22
	II	66	97	97	23	97	23	97	23	97	23	97	23	97	23	97	23	97	23
	III	64	93	93	18	93	18	93	18	93	18	93	18	93	18	93	18	93	18
MAR	I	82	120	120	29	120	29	120	29	120	29	120	29	120	29	120	29	120	29
	II	92	134	134	32	134	32	134	32	134	32	134	32	134	32	134	32	134	32
	III	103	151	151	40	151	40	151	40	151	40	151	40	151	40	151	40	151	40
Apr	I	114	167	167	40	167	40	167	40	167	40	167	40	167	40	167	40	167	40
	II	147	214	214	51	214	51	214	51	214	51	214	51	214	51	214	51	214	51
	III	216	316	300	72	316	76	316	76	316	76	316	76	316	76	316	76	316	76
May	I	310	453	300	72	350	84	400	96	450	108	453	109	453	109	453	109	453	109
	II	844	1234	300	72	350	84	400	96	450	108	500	120	550	132	600	144	650	156
	III	636	930	300	79	350	92	400	106	450	119	500	132	550	145	600	158	650	172
				Total=	1837		2013		2184		2346		2494		2635		2770		2906

ENERGY CALCULATION FOR DIFFERENT INSTALLED CAPACITIES (FOR 90 Percente DEPENDABLITY)

Annexure-VIII/3

CAPACITY UTILIZATION STUDIES (Instaled Capacity Vs Incremental Energy)
for 90 % dependabl flow   Envir.Release= 14 cumecs   (continued)
head(m) 161.5   effincey= 0.92

Month	Period	IC(MW) Power (MW)	700 Energy (GwH)	IC(MW) Power (MW)	750 Energy (GwH)	IC(MW) Power (MW)	800 Energy (GwH)	IC(MW) Power (MW)	850 Energy (GwH)	IC(MW) Power (MW)	900 Energy (GwH)	IC(MW) Power (MW)	950 Energy (GwH)	IC(MW) Power (MW)	1000 Energy (GwH)	IC(MW) Power (MW)	1050 Energy (GwH)	IC(MW) Power (MW)	1100 Energy (GwH)
Jun	I	520	125	520	125	520	125	520	125	520	*125*	520	125	520	125	520	125	520	125
	II	700	168	742	178	742	178	742	178	742	*178*	742	178	742	178	742	178	742	178
	III	700	168	718	172	718	172	718	172	718	*172*	718	172	718	172	718	172	718	172
Jul	I	700	168	750	180	800	192	850	204	900	*216*	950	228	955	229	955	229	955	229
	II	700	168	750	180	800	192	850	204	900	*216*	950	228	1000	240	1050	252	1100	264
	III	700	185	750	198	800	211	850	224	900	*238*	950	251	1000	264	1050	277	1100	290
Aug	I	700	168	750	180	800	192	850	204	900	*216*	950	228	1000	240	1016	244	1016	244
	II	700	168	750	180	800	192	850	204	900	*216*	950	228	1000	240	1050	252	1100	264
	III	700	185	750	198	800	211	850	224	900	*238*	907	240	907	240	907	240	907	240
Sep	I	659	158	659	158	659	158	659	158	659	*158*	659	158	659	158	659	158	659	158
	II	408	98	408	98	408	98	408	98	408	*98*	408	98	408	98	408	98	408	98
	III	271	65	271	65	271	65	271	65	271	*65*	271	65	271	65	271	65	271	65
Oct	I	215	52	215	52	215	52	215	52	215	*52*	215	52	215	52	215	52	215	52
	II	195	47	195	47	195	47	195	47	195	*47*	195	47	195	47	195	47	195	47
	III	176	47	176	47	176	47	176	47	176	*47*	176	47	176	47	176	47	176	47
Nov	I	201	48	201	48	201	48	201	48	201	*48*	201	48	201	48	201	48	201	48
	II	159	38	159	38	159	38	159	38	159	*38*	159	38	159	38	159	38	159	38
	III	131	31	131	31	131	31	131	31	131	*31*	131	31	131	31	131	31	131	31
Dec	I	116	28	116	28	116	28	116	28	116	*28*	116	28	116	28	116	28	116	28
	II	107	26	107	26	107	26	107	26	107	*26*	107	26	107	26	107	26	107	26
	III	104	27	104	27	104	27	104	27	104	*27*	104	27	104	27	104	27	104	27
Jan	I	100	24	100	24	100	24	100	24	100	*24*	100	24	100	24	100	24	100	24
	II	96	23	96	23	96	23	96	23	96	*23*	96	23	96	23	96	23	96	23
	III	92	24	92	24	92	24	92	24	92	*24*	92	24	92	24	92	24	92	24
Feb	I	92	22	92	22	92	22	92	22	92	*22*	92	22	92	22	92	22	92	22
	II	97	23	97	23	97	23	97	23	97	*23*	97	23	97	23	97	23	97	23
	III	93	18	93	18	93	18	93	18	93	*18*	93	18	93	18	93	18	93	18
MAR	I	120	29	120	29	120	29	120	29	120	*29*	120	29	120	29	120	29	120	29
	II	134	32	134	32	134	32	134	32	134	*32*	134	32	134	32	134	32	134	32
	III	151	40	151	40	151	40	151	40	151	*40*	151	40	151	40	151	40	151	40
Apr	I	167	40	167	40	167	40	167	40	167	*40*	167	40	167	40	167	40	167	40
	II	214	51	214	51	214	51	214	51	214	*51*	214	51	214	51	214	51	214	51
	III	316	76	316	76	316	76	316	76	316	*76*	316	76	316	76	316	76	316	76
May	I	453	109	453	109	453	109	453	109	453	*109*	453	109	453	109	453	109	453	109
	II	700	168	750	180	800	192	850	204	900	*216*	950	228	1000	240	1050	252	1100	264
	III	700	185	750	198	800	211	850	224	900	*238*	930	246	930	246	930	246	930	246
			3031		3146		3245		3345		3444		3527		3590		3643		3692

ENERGY CALCULATION FOR
DIFFERENT INSTALLED CAPACITIES (FOR 90 Percente DEPENDABLITY)

Annexure-VIII/3
(continued)

CAPACITY UTILIZATION STUDIES (Instaled Capacity Vs Incremental Energy)
for 90 % dependabl flow Envir.Release= 14 cumecs
head(m) 161.5 effincey= 0.92

Month	Block	IC(MW) Power (MW)	1150 Energy (GwH)	IC(MW) Power (MW)	1200 Energy (GwH)	IC(MW) Power (MW)	1250 Energy (GwH)	IC(MW) Power (MW)	1300 Energy (GwH)	IC(MW) Power (MW)	1350 Energy (GwH)
Jun	I	520	125	520	125	520	125	520	125	520	125
	II	742	178	742	178	742	178	742	178	742	178
	III	718	172	718	172	718	172	718	172	718	172
Jul	I	955	229	955	229	955	229	955	229	955	229
	II	1143	274	1143	274	1143	274	1143	274	1143	274
	III	1113	294	1113	294	1113	294	1113	294	1113	294
Aug	I	1016	244	1016	244	1016	244	1016	244	1016	244
	II	1150	276	1200	288	1250	300	1250	300	1250	300
	III	907	240	907	240	907	240	907	240	907	240
Sep	I	659	158	659	158	659	158	659	158	659	158
	II	408	98	408	98	408	98	408	98	408	98
	III	271	65	271	65	271	65	271	65	271	65
Oct	I	215	52	215	52	215	52	215	52	215	52
	II	195	47	195	47	195	47	195	47	195	47
	III	176	47	176	47	176	47	176	47	176	47
Nov	I	201	48	201	48	201	48	201	48	201	48
	II	159	38	159	38	159	38	159	38	159	38
	III	131	31	131	31	131	31	131	31	131	31
Dec	I	116	28	116	28	116	28	116	28	116	28
	II	107	26	107	26	107	26	107	26	107	26
	III	104	27	104	27	104	27	104	27	104	27
Jan	I	100	24	100	24	100	24	100	24	100	24
	II	96	23	96	23	96	23	96	23	96	23
	III	92	24	92	24	92	24	92	24	92	24
Feb	I	92	22	92	22	92	22	92	22	92	22
	II	97	23	97	23	97	23	97	23	97	23
	III	93	18	93	18	93	18	93	18	93	18
MAR	I	120	29	120	29	120	29	120	29	120	29
	II	134	32	134	32	134	32	134	32	134	32
	III	151	40	151	40	151	40	151	40	151	40
Apr	I	167	40	167	40	167	40	167	40	167	40
	II	214	51	214	51	214	51	214	51	214	51
	III	316	76	316	76	316	76	316	76	316	76
May	I	453	109	453	109	453	109	453	109	453	109
	II	1150	276	1200	288	1234	296	1234	296	1234	296
	III	930	246	930	246	930	246	930	246	930	246
			3730		3754		3774		3774		3774

Installed capacity (MW)	Energy (GwH)	Incremental Increase in Energy(GwH)	Incremental Increase in Energy per MW
300	1837.4	0.0	0.0
350	2012.8	175.4	3.5
400	2184.4	171.6	3.4
450	2346.0	161.6	3.2
500	2494.2	148.2	3.0
550	2634.6	140.5	2.8
600	2770.2	135.6	2.7
650	2905.8	135.6	2.7
700	3031.5	125.7	2.5
750	3145.6	114.1	2.3
800	3245.2	99.6	2.0
850	3344.8	99.6	2.0
900	3444.4	99.6	2.0
950	3527.4	83.0	1.7
1000	3589.9	62.5	1.3
1050	3643.1	53.1	1.1
1100	3692.3	49.2	1.0
1150	3730.0	37.8	0.8
1200	3754.0	24.0	0.5
1250	3774.2	20.2	0.4
1300	3774.2	0.0	0.0

INSTALLED CAPACITIES AND CORRESPONDING ENERGY, INCREMENTAL ENERGY FOR DIFFERENT FLOWS

for Mean year daily flow			
Installed capacity (MW)	Energy (GwH)	Increm. Increase in Energy (GWH)	Increme. Increase in Energy per MW GWH/MW
300	1996	0.0	0.0
350	2193	197.2	3.9
400	2377	183.6	3.7
450	2560	183.6	3.7
500	2729	168.5	3.4
550	2888	159.6	3.2
600	3048	159.6	3.2
650	3201	153.4	3.1
700	3338	136.1	2.7
750	3465	127.1	2.5
800	3587	122.4	2.4
850	3710	122.4	2.4
900	3832	122.4	2.4
950	3943	111.3	2.2
1000	4042	98.4	2.0
1050	4140	98.4	2.0
1100	4238	98.4	2.0
1150	4333	94.3	1.9
1200	4406	73.7	1.5
1250	4480	73.2	1.5
1300	4553	73.2	1.5

For 90% dependable year flow			
Installed capacity (MW)	Energy (GwH)	Increm. Increase in Energy (GWH)	Increme. Increase in Energy per MW GWH/MW
300	1837	0.0	0.0
350	2013	175.4	3.5
400	2184	171.6	3.4
450	2346	161.6	3.2
500	2494	148.2	3.0
550	2635	140.5	2.8
600	2770	135.6	2.7
650	2906	135.6	2.7
700	3031	125.7	2.5
750	3146	114.1	2.3
800	3245	99.6	2.0
850	3345	99.6	2.0
900	3444	99.6	2.0
950	3527	83.0	1.7
1000	3590	62.5	1.3
1050	3643	53.1	1.1
1100	3692	49.2	1.0
1150	3730	37.8	0.8
1200	3754	24.0	0.5
1250	3774	20.2	0.4
1300	3774	0.0	0.0

For 50% dependable year flow			
Installed capacity (MW)	Energy (GwH)	Increm. Increase in Energy (GWH)	Increme. Increase in Energy per MW GWH/MW
300	1905	0.0	0.0
350	2106	201.2	4.0
400	2291	185.4	3.7
450	2463	172.2	3.4
500	2635	171.6	3.4
550	2807	171.6	3.4
600	2971	164.2	3.3
650	3118	147.5	2.9
700	3254	135.6	2.7
750	3390	135.6	2.7
800	3514	124.9	2.5
850	3636	122.0	2.4
900	3747	110.4	2.2
950	3857	110.4	2.2
1000	3968	110.4	2.2
1050	4066	98.0	2.0
1100	4151	85.2	1.7
1150	4234	83.6	1.7
1200	4308	73.2	1.5
1250	4376	68.6	1.4
1300	4437	61.2	1.2

for 90% synthetic year flow			
Installed capacity (MW)	Energy (GwH)	Increm. Increase in Energy (GWH)	Increme. Increase in Energy per MW GWH/MW
300	1928	0.0	0.0
350	2123	195.4	3.9
400	2300	176.9	3.5
450	2460	159.6	3.2
500	2619	159.6	3.2
550	2779	159.6	3.2
600	2938	159.6	3.2
650	3098	159.6	3.2
700	3254	155.8	3.1
750	3401	147.6	3.0
800	3549	147.6	3.0
850	3697	147.6	3.0
900	3834	137.6	2.8
950	3970	135.6	2.7
1000	4105	135.6	2.7
1050	4224	118.9	2.4
1100	4333	108.9	2.2
1150	4415	82.2	1.6
1200	4470	54.8	1.1
1250	4511	40.7	0.8
1300	4547	36.0	0.7

for 50% synthetic year flow			
Installed capacity (MW)	Energy (GwH)	Increm. Increase in Energy (GWH)	Increme. Increase in Energy per MW GWH/MW
300	2006	0.0	0.0
350	2190	183.6	3.7
400	2373	183.6	3.7
450	2552	178.3	3.6
500	2712	159.7	3.2
550	2871	159.6	3.2
600	3026	154.5	3.1
650	3173	147.6	3.0
700	3321	147.6	3.0
750	3468	147.6	3.0
800	3605	137.0	2.7
850	3728	122.4	2.4
900	3844	116.5	2.3
950	3938	94.0	1.9
1000	4025	86.4	1.7
1050	4111	86.4	1.7
1100	4198	86.4	1.7
1150	4275	77.9	1.6
1200	4349	73.2	1.5
1250	4422	73.2	1.5
1300	4495	73.2	1.5

FOR DIFFERENT INSTALLED CAPACITY REQUIRED DISCHARGE AND ENERGY GENERATED

Type	Installed Capacity=600MW Discharge = 410 cumec			Installed Capacity= 700MW Discharge = 478 cumec			Installed Capacity= 800MW Discharge = 547 cumec			Installed Capacity= 900MW Discharge = 615 cumec		
	Energy (MU)	Exceedence Probabilty	No of days in one year	Energy (MU)	Exceedence Probabilty	No of days in one year	Energy (MU)	Exceedence Probabilty	No of days in one year	Energy (MU)	Exceedence Probabilty	No of days in one year
A) mean year flow	3048 MU	36.0%	131 days	3338	31.0%	113days	3587 MU	29.0%	106 days	**3832 MU**	27.5%	100 days
B) 90 % dependable flow	2770 MU	31.5%	115 days	3031 MU	29.0%	106 days	3245 MU	24.0%	88 days	**3444 MU**	22.5%	82 days
B) 50 % dependable flow	2971 MU	37.5%	137 days	3254 MU	31.5%	115 days	3514 MU	29.0%	106 days	**3747 MU**	26.5%	97 days
C) 90 % synthetic year flow	2938 MU	36.0%	131 days	3254 MU	35.0%	128 days	3549 MU	34.0%	124 days	**3834 MU**	32.0%	117 days
d) 50 % synthetic year flow	3026 MU	35.0%	128 days	3321 MU	34.0%	124 days	3605 MU	30.0%	110 days	**3844 MU**	27.0%	99 days

COMPARASION OF ANNUAL ENERGY GENERATED FOR DIFFERENT TEN DAILY FLOW (for 900 MW)

Envir.Release= 14 cumecs

head(m) 162 effinciency= 0.92

Month	Block	DISCHARGE (cumecs) mean year	DISCHARGE dependable year 90%	DISCHARGE dependable year 50%	DISCHARGE synthetic year 90%	DISCHARGE synthetic year 50%	Unrestricted power in MW mean year	Unrestricted power dependable year 90%	Unrestricted power dependable year 50%	Unrestricted power synthetic year 90%	Unrestricted power synthetic year 50%	Unrestricted Energy in MU mean year	Unrestricted Energy dependable year 90%	Unrestricted Energy dependable year 50%	Unrestricted Energy synthetic year 90%	Unrestricted Energy synthetic year 50%		Restricted Energy in MU mean year	Restricted Energy dependable year 90%	Restricted Energy dependable year 50%	Restricted Energy synthetic year 90%	Restricted Energy synthetic year 50%
Jun	I	645	356	715	772	602	943	520	1045	1128	880	226	125	251	271	211		216	125	216	216	211
	II	788	508	842	1020	613	1152	742	1231	1491	896	276	178	295	358	215		216	178	216	216	215
	III	949	491	1114	834	1056	1387	718	1629	1220	1544	333	172	391	293	371		216	172	216	216	216
Jul	I	974	654	1087	908	1070	1424	955	1589	1327	1564	342	229	381	319	375		216	216	216	216	216
	II	1055	782	1255	794	1108	1543	1143	1835	1161	1619	370	274	440	279	389		216	216	216	216	216
	III	1068	761	1179	698	1239	1562	1113	1723	1021	1812	412	294	455	269	478		238	238	238	238	238
Aug	I	1046	695	1279	748	1223	1530	1016	1870	1094	1787	367	244	449	262	429		216	216	216	216	216
	II	938	855	782	909	1006	1372	1250	1143	1329	1471	329	300	274	319	353		216	216	216	216	216
	III	776	621	689	758	765	1135	907	1007	1108	1118	300	240	266	293	295		238	238	238	238	238
Sep	I	623	451	517	693	531	911	659	755	1013	777	219	158	181	243	186		216	158	181	216	186
	II	446	279	389	468	396	652	408	569	684	579	156	98	137	164	139		156	98	137	164	139
	III	315	185	275	268	637	461	271	403	392	932	111	65	97	94	224		111	65	97	94	216
Oct	I	218	147	221	192	308	319	215	323	281	451	77	52	78	67	108		77	52	78	67	108
	II	184	133	174	169	202	269	195	254	247	295	65	47	61	59	71		65	47	61	59	71
	III	156	121	144	152	158	228	176	210	223	231	60	47	55	59	61		60	47	55	59	61
Nov	I	138	138	125	134	141	202	201	183	196	206	49	48	44	47	50		49	48	44	47	50
	II	125	109	110	122	129	182	159	160	179	189	44	38	38	43	45		44	38	38	43	45
	III	114	90	97	118	123	167	131	141	173	180	40	31	34	41	43		40	31	34	41	43
Dec	I	103	79	86	111	117	151	116	125	162	170	36	28	30	39	41		36	28	30	39	41
	II	100	74	81	110	111	146	107	118	161	162	35	26	28	39	39		35	26	28	39	39
	III	92	71	74	82	117	134	104	107	119	170	35	27	28	31	45		35	27	28	31	45
Jan	I	87	69	71	63	116	127	100	104	91	170	30	24	25	22	41		30	24	25	22	41
	II	99	66	56	62	107	145	96	81	90	156	35	23	19	22	37		35	23	19	22	37
	III	81	63	67	56	97	118	92	98	81	142	31	24	26	21	38		31	24	26	21	38
Feb	I	81	63	67	60	97	118	92	97	88	141	28	22	23	21	34		28	22	23	21	34
	II	81	66	64	61	93	118	97	93	88	137	28	23	22	21	33		28	23	22	21	33
	III	84	64	63	65	91	123	93	92	95	134	24	18	18	18	26		24	18	18	18	26
MAR	I	89	82	79	81	97	130	120	116	118	141	31	29	28	28	34		31	29	28	28	34
	II	96	92	78	72	102	140	134	114	105	149	34	32	27	25	36		34	32	27	25	36
	III	113	103	111	108	115	165	151	162	158	168	44	40	43	42	44		44	40	43	42	44
Apr	I	128	114	108	120	116	188	167	158	176	170	45	40	38	42	41		45	40	38	42	41
	II	160	147	200	187	126	233	214	292	273	185	56	51	70	65	44		56	51	70	65	44
	III	231	216	245	239	130	338	316	357	349	191	81	76	86	84	46		81	76	86	84	46
May	I	326	310	415	260	162	476	453	607	380	237	114	109	146	91	57		114	109	146	91	57
	II	427	844	440	587	293	624	1234	643	859	428	150	296	154	206	103		150	216	154	206	103
	III	491	636	577	797	534	717	930	844	1165	781	189	246	223	308	206		189	238	223	238	206
												4803	3774	4963	4606	4987	TAL	3832	3444	3747	3834	3844

COMPARASION OF ANNUAL ENERGY GENERATED FOR DIFFERENT TEN DAILY FLOW for 95% OF PLANT AVAILIBILITY (for 900MW)

216 237.8

head(m) 162 Envir.Release= 14 cumecs effinciency= 0.874 Plant availiblity Factor = 0.95 M/c Effiency = 0.92

Month	Block	DISCHARGE (cumecs) mean year	dependable year 90%	dependable year 50%	synthetic year 90%	synthetic year 50%	Unrestricted power in MW mean year	dependable year 90%	dependable year 50%	synthetic year 90%	synthetic year 50%	Unrestricted Energy in MU mean year	dependable year 90%	dependable year 50%	synthetic year 90%	synthetic year 50%		Restricted Energy in MU mean year	dependable year 90%	dependable year 50%	synthetic year 90%	synthetic year 50%
Jun	I	645	356	715	772	602	896	494	993	1072	836	215	119	238	257	201		215	119	216	216	201
	II	788	508	842	1020	613	1094	705	1169	1417	851	263	169	281	340	204		216	169	216	216	204
	III	949	491	1114	834	1056	1318	682	1547	1159	1467	316	164	371	278	352		216	164	216	216	216
Jul	I	974	654	1087	908	1070	1353	908	1509	1261	1486	325	218	362	303	357		216	216	216	216	216
	II	1055	782	1255	794	1108	1465	1086	1743	1103	1538	352	261	418	265	369		216	216	216	216	216
	III	1068	761	1179	698	1239	1484	1058	1637	970	1721	392	279	432	256	454		238	238	238	238	238
Aug	I	1046	695	1279	748	1223	1453	966	1776	1039	1698	349	232	426	249	408		216	216	216	216	216
	II	938	855	782	909	1006	1303	1188	1086	1262	1398	313	285	261	303	335		216	216	216	216	216
	III	776	621	689	758	765	1078	862	957	1053	1062	285	228	253	278	280		238	228	238	238	238
Sep	I	623	451	517	693	531	865	626	718	962	738	208	150	172	231	177		208	150	172	216	177
	II	446	279	389	468	396	619	388	541	650	550	149	93	130	156	132		149	93	130	156	132
	III	315	185	275	268	637	438	257	382	372	885	105	62	92	89	212		105	62	92	89	212
Oct	I	218	147	221	192	308	303	205	307	267	428	73	49	74	64	103		73	49	74	64	103
	II	184	133	174	169	202	256	185	241	234	280	61	44	58	56	67		61	44	58	56	67
	III	156	121	144	152	158	217	168	199	211	220	57	44	53	56	58		57	44	53	56	58
Nov	I	138	138	125	134	141	192	191	174	186	196	46	46	42	45	47		46	46	42	45	47
	II	125	109	110	122	129	173	151	152	170	179	42	36	37	41	43		42	36	37	41	43
	III	114	90	97	118	123	158	124	134	164	171	38	30	32	39	41		38	30	32	39	41
Dec	I	103	79	86	111	117	143	110	119	154	162	34	26	29	37	39		34	26	29	37	39
	II	100	74	81	110	111	139	102	112	153	154	33	25	27	37	37		33	25	27	37	37
	III	92	71	74	82	117	128	99	102	113	162	34	26	27	30	43		34	26	27	30	43
Jan	I	87	69	71	63	116	121	95	99	87	161	29	23	24	21	39		29	23	24	21	39
	II	99	66	56	62	107	138	91	77	86	148	33	22	19	21	36		33	22	19	21	36
	III	81	63	67	56	97	112	88	93	77	135	30	23	25	20	36		30	23	25	20	36
Feb	I	81	63	67	60	97	112	87	92	84	134	27	21	22	20	32		27	21	22	20	32
	II	81	66	64	61	93	112	92	88	84	130	27	22	21	20	31		27	22	21	20	31
	III	84	64	63	65	91	117	88	87	90	127	22	17	17	17	24		22	17	17	17	24
MAR	I	89	82	79	81	97	123	114	110	113	134	30	27	26	27	32		30	27	26	27	32
	II	96	92	78	72	102	133	127	108	99	142	32	31	26	24	34		32	31	26	24	34
	III	113	103	111	108	115	157	143	154	150	160	41	38	41	40	42		41	38	41	40	42
Apr	I	128	114	108	120	116	178	159	150	167	162	43	38	36	40	39		43	38	36	40	39
	II	160	147	200	187	126	222	204	278	259	176	53	49	67	62	42		53	49	67	62	42
	III	231	216	245	239	130	321	300	340	332	181	77	72	82	80	43		77	72	82	80	43
May	I	326	310	415	260	162	452	430	576	361	226	109	103	138	87	54		109	103	138	87	54
	II	427	844	440	587	293	593	1172	611	816	407	142	281	147	196	98		142	216	147	196	98
	III	491	636	577	797	534	681	884	802	1107	742	180	233	212	292	196		180	233	212	238	196
												4563	3586	4714	4376	4738	'AL	**3741**	**3347**	**3659**	**3765**	**3737**

DESIGN / DIMENSIONS OF SURGE SHAFT :

According to Thoma, for stability conditions of surge system, the limit cross-sectional area of surge tanks with small amplitude is given as

F (Thoma) = n.l.f / 2g BHo (Ref P- 177, high head plant Vol.I, EMIL MOSONYI)

Where n= F.O.S = 1.5

l= length of tunnel= 29000 m.

f= Area of x-section of tunnel

$= (\frac{pi}{4} \times 12.5^2) = 122.79 m^2$

B = Constant = Y/V^2

Where

Y= Head losses upto surge tank= 33m say.

$V = Q/A = \frac{615}{122.79} = 5.01$ m/sec

B =$33/(5.01)^2$ = 1.314

Ho = Net Head = 202-33 = 169 m.

f= x d^2 (m^2)	H (m)	Y (m)	Ho	V= q/f M/sec.	B= Y/V^2	F (m^2)	Diameter of surge tank (m)
122.79	202	33	169	5.01	1.314	1225.94	40.43

For great amplitudes, Thoma formula modified by Charles Jalger gives the critical area as defined below(Ref P- 178, high head plant Vol.I, EMIL MOSONYI, 1960)

$$Fcm = \frac{n^* l . f}{2g\ B\ Ho}$$

Where $n^* = 1 + \frac{0.482\ Ymax}{Ho}$

Ymax = Vo (lf/gF) ½

The other terms are already defined above.

Trial value of dia of surge tank	Fcm	Vo=Q	Y_{max}	n^*	Fcm computed(m^2)	Diameter computed
40	1225.94	5.01	63.35	1.181	964.04808	35.028
38	1134.57	5.01	63.35	1.180	964.04800	35.028
35	962.50	5.01	68.78	1.196	976.69000	35.257
35.5	990.20	5.01	67.81	1.193	974.43770	35.216
35.25	976.30	5.01	68.30	1.195	975.55770	35.237

Surge tank of 36m dia(1018.28 sq m) has been proposed. The actual size shall however be finalized after conducting the model studies.

9.3.1 Max. upsurge

$$= Ymax \quad = Vo\sqrt{lf/gF}$$

$$= 5.01\sqrt{\frac{29000 \times 122.79}{9.81 \times \frac{Pi}{4}(36)^2}}$$

$$= 94.59\ m$$

Ymax. is measured from initial steady state.

FRL = 845m

Water level at surge tank at steady state = 845-33 = 812m.

Max. upsurge level = 812 + 94.59 = 906.59 say 907 m .
Add 5 m for freeboard so EL of top = 912 m

9.3.2 Lowest down surge:

It is assumed that the full load shall be accepted when the reservoir is at FRL. For preliminary calculations the amplitude for max. down surge is assumed the same as for max. up surge.

The amplitude for max. down surge is measured from initial static level i.e. FRL.

Lowest down surge level =845- 94.59= 750.41 say 750m.

9.3.3 Height of surge tank

Max. up surge level = 907m.

Free board = 5m

El. of top of surge shaft = 907+ 5

= 912m

lowest down surge = 750m.

Margin below bottom of shaft = 2m

EL. Of Bottom of surge shaft = 750-2.0 = 748m

Invert level of HRT at junction = 654.625m

Overt level of HRT at junction = 654.625+ 12.5 = 667.125

= say 667m

Height of connecting shaft

Above crown of tunnel = 748-667 =81 m

Height of surge shaft = 912-748

= 164 metres

9.3.4 Size of Orifice : (Ref IS 7396 Part- 1 – 1985 clause 5.5.3)

$$hor = \frac{Qd^2}{Cd^2\ Ao^2\ 2g}$$

Where hor = head loss in orifice

Qd = Max. discharge through turbines
= 615 cumecs.
Ao = Area of orifice.
Cd = Coeff of discharge = 0.75 Say.(0.6 to 0.9 depends on no.,shape & size of orifice)

$$h_{or} = \frac{(615)^2}{0.75^2 \times Ao^2 \times 9.81 \times 2} = \frac{34271.15}{Ao^2}$$

$$\frac{Z^*}{\sqrt{2}} + \frac{1}{4} hf < h_{or} < \frac{Z^*}{\sqrt{2}} + \frac{3}{4} hf.$$

WHERE Z^* = Surge height corresponding to change In discharge neglecting friction & orifice loss.

$$= V_o \sqrt{(L/g)} \times (At/AS)$$

$$= 5.01 \sqrt{(29000/9.81)} \times 122.79/1018.29 = 94.6$$

Where At= area of HRT= 122.79, As= Area of surge shaft=1018.29.

$$\left[\frac{94.6}{\sqrt{2}} + \frac{1}{4}(33)\right], < \frac{34271.15}{Ao^2} < \left[\frac{94.6}{\sqrt{2}} + \frac{3}{4}(33)\right]$$

$$\text{or } 75.15 < \frac{34271.15}{Ao^2} < 91.35$$

By trial orifice dia. as 5.0 m satisfies the above eq.

$$Ao = \frac{Pi\,(5.0)^2}{4} = 19.64\ m^2$$

$$Ao^2 = 385.84\ m^2$$

$$75.15 <, \frac{34271.15}{385.84} < 91.35$$

$$75.15 < 88.82 < 91.35$$

Hence O.K.

Dia of orifice be kept as 5.0 m..

Design steps for Intake design (as per IS 9761:1995)

Each intake is suposed to discharge of 769/6 = 128 cumecs
FRL = 845 m

Assumed centre line of tunnel of intake = 816 m

Assume height of tunnel at gate opening= 6 m (say D)

Head = 32 m

maximum permissible velocity at gate opening = 0.12 X (2gH)0.5

.= 3.01 m/sec

discharge to pass by each intake = 128 cumecs

width of gate opening be = Q/v D

7.095 m

So velocity v = 3.007 m/ sec

Assuming that intake tunnel having slope of 1:50, Θ = 1.457
0.02544 radians

$$h_1 = [\ (1.21 \tan^2\Theta + 0.0847)^{0.5} + \frac{1}{2\cos\theta} - 1.10 \tan\Theta\ ]\ D$$

$$h_2 = [\ \frac{0.791}{\cos\theta} + 0.077 \tan\Theta]\ D$$

So h1 = 4.58729
Hence h2 = 4.759 m

Now he = h1+ h2 9.347 m

To avoid vortex formation (to check the air entrance in tunnel)

(i) Fr = v/ (gD)0.5 ≤ 1/3

so Fr = 0.314 OK

(ii) As per USBR , water seal = 0.3 he = 2.80397 m

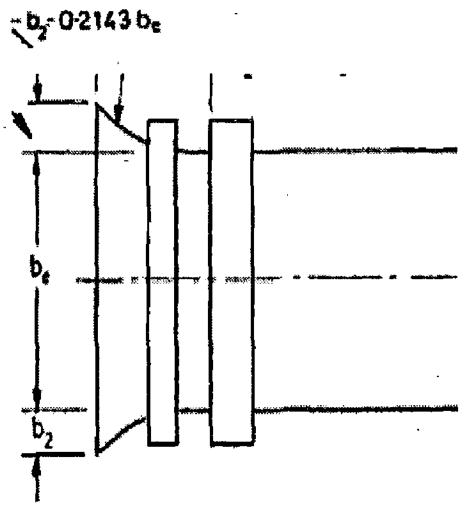
hence MDDL = 823.56 m (OK ,we are taking at 825 m)

Profile of roof is given by

$$\frac{X^2}{(1.1D)^2} + \frac{Y^2}{(0.291\ D)^2} = 1$$

Profile of side wall is given by

$$\frac{X^2}{(0.55\,b_e)^2} + \frac{Y^2}{(0.2143\ b_e)^2} = 1$$



So width of intake at face = width at gate opening + 2 b2

where b2 = 0.2143 be

so intake width = 10.14 m say 10.15 m

Hence invert level of intake = 811.241 m
say 811.25 m

Design of Desilting Arrangement

Design to arrest the particles size grater then 0.2 mm
Design discharge = 615 cumecs
total discharge required including flushing = 615 / 0.8 = 768.75 cumecs

so flushing discharge = 153.75 (20% of total inflow)
Average discharge= 691.88
No of chambers = 6
Average discharge through each chamber = 692 / 6 = 115.31 cumec
Let us take depth of flow = 28 m
Assume width of chamber 15 m
So Flow through velocity U = 0.2746 m/sec
Hence cross sectional area of each chamber= 420.00 sq m

hence U = 0.275 m/sec

Settling velocity ω= 0.028 m/sec
(using Sudry's curve, Masony,Page 36, vol-II,1960)
Now $\omega_e = \omega - \omega'$
where, $\omega' = \alpha U$ and ω_e is effective fall velocity
And $\alpha = 0.132/\sqrt{h}$ where h is depth of flow in m

ω' = 0.0068
so ω_e= 0.021 m/sec

L = length of chamber = Uh/ω_e =
L= 363.46 m

As per Velikanov approach
The settling length = $\lambda^2 v^2 (\sqrt{h}-0.2)^2 / 7.51 X \omega^2$
so λ= 1.0465
For this value of λ, the Velikanov's curve gives an efficiency of 92.5 %
again In order to achieve efficiency of 94 % λ= 1.09
The settling length = 511.8 m

As per Camp's approach
for efficiency, the two parameters to be used are worked out as below
$(\omega D^{1/6}) / (n U\sqrt{g})$ = 4.0529
$(\omega L) / (UD)$ = 1.3238
for above values curve gives efficiency of 100 %

Hence 6 chambers of 510 m length, 15 m width and 28 m deep should be provided

DIMENSIONING OF POWER HOUSE

total capacity =	900 MW	
No of units=	6	
unit capicity=	150 MW	150000 KW
Max Head =	168 M	
Rated Head=	162 M	
Minim Head=	148 M	

Trail specific Speed n's= 165 from fig 1 of Is 12008 part 1

Trail Synchoronus speed = n's*H1.25/(1.358*P)0.5
where P is power in KW

Trial Synchoronus speed in rpm (n') = 211 rpm

the rotational/synchronous/rated speed of the turbine in revolution per minute is is determined from the formula as Rated speed in r. p. m., n = 60*f /p

where f =frequency incycles per second = 50

p= number of pairs of poles

The selection of rated speed by the above formula is subject to the following considerations:

a) An even numer of pairs of poles should be preferred for the generator, through standdard generators with odd number of pairs of poles are also available; and
b) If the head is expected to vary less than 10% from the design head,the next greator speed should be chosen. A head varying in excess of 10% from the design head suggests the next lower speed.

on account of heavy silt abrasion is apprehended then a lower value may be adopted.

Let us take no of pair of poles= 13

Synchoronus speed for 13 pairs of poles= 231 r p m
Synchoronus speed for 14 pairs of poles= 200 r p m
let us take no of pair of poles= 15

As this is for run of the river devlopment so silt will more so adopt less speed as 200

Synchoronus speed for 15 pairs of poles= 200

so corrected specific speed= 156

SETTING OF TURBINE

In reaction turbine , the setting of turbine with respect of minimum tail water level should be fixed from the consideration of cavitation. The suction height of distributor centre line above the minimum tail water level can be determined from the following formula.

$$Hs = Hb - \sigma H - Hv$$

Hs = suction head in metres;
Hb= Barometric pressure in metres of water column;
Hv= Vapour pressure
σ = Thoma's cavitation coefficent , which can be obtained from Fig. 3 of IS 12800 part1

Here Hb= 10 M
Hv= 0.4 M
σ = 0.09 from fig. 3 corresponding to specific speed of 156.22 (IS 12800_1) 156.1823
So Hs= -4.98

With a further margin of 0.5 m , the center line of distributer should be set 4.98 + 0.5 = 5.48 metres below minimum tailrace level.

So EL of centre line of distributer = 639 - 5.48 = 632.52m (say 632.5 m)

SIZE OF RUNNER

The runner discharge diameter determined by the peripheral velocity coefficient K,

Discharge diameter , D3=60(2gH)0.5Ku/πn
Ku = Peripheral velocity coefficient whichh is defined as Ku = πDns/60(2gH)0.5
H= 162
n= 200
Ku = 0.6 from fig. 6 corresponding to specific speed of 181.04 (is 12800_1) 156.182274
So D3= 3.229 m

SPIRAL CASE

Metallic spiral casing should be used for gross head generally above 30 meters.

DIMENSIONS OF SPIRAL CASE

As the gross head above the turbine is more than 30 meters , metallic spiral casing should be used, The main dimension of the spiral casing as determined in accordance with Fig. 8, 9 and 10 (of IS 12800 part I) work out to be as shown below

A =	1 X	3.23	.=	3.49	meters
B =	1 X	3.23	.=	4.68	meters
C =	2 X	3.23	.=	5.30	meters
D =	2 X	3.23	.=	5.84	meters
E =	1 X	3.23	.=	4.46	meters
F =	2 X	3.23	.=	5.75	meters
G =	2 X	3.23	.=	4.84	meters
H =	1 X	3.23	.=	4.20	meters
I =	0.21 X	3.23	.=	0.68	meters
L =	0.95 X	3.23	.=	3.07	meters
M =	0.6 X	3.23	.=	1.94	meters

SIZE OF DRAFT TUBE

SIZE OF DRAFT TUBE

The various dimensions of draft tube shown in Fig. As determined in accordance with IS 5496: 1969 should be as below:

Height of draft tube at exit end h= 0.94*D3 to 1.32*D3

As the specific speed of turbine is lower side,'h' will be on higher side.

Taking h=1.2*D3 Hence h = 3.875 m

Depth of draft tube H1 for Francis turbine = 2.5 to3.0 D3

Taking H1= 2.75D3 Hence H1= 8.88

Length of draft tube L = 4 to 5 D3

Taking L =4.5 D3 Hence L= 14.5

Clear width 'B' of the draft tube at exit end = 2.6 to 3.3 D3

Taking B = 3 D3, Hence B = 9.69

since the clear width of the draft tube is excessive, a pier of 1.5 meters width should be introdused in the centre of the draft tube.

The total width thus . 11.1867 m (say 11.2 m)

Since power in KW = 9.8*Q*H*η

where Q = discharge

H = rated head

η = efficency of machine

Assuming efficency of machine to be 92% ie 0.92

Q= 102.6 cumecs

so velocity at exit end of draft tube,

Ve= 2.733 m/sec

In accordance with 2.5 of IS 5496 : 1969, minimum submergence at the outlet end of draft tube should be greater than 0.3 metre, or

V2e/2g ie 0.381 m
say 0.4 m.

Keeping bed slope 1 vertical to 10 horizontal at the bottom of the draft tube, the exit end of draft 1.45 meters above the bottom of draft tube.

1.453 .+ 3.874682

Hence top of exit end of draft tube will be 1.45 .+ 3.875 .= 5.328 meters above the bottom of the draft tube.

Since height of draft - tube below centre line of guide apparatus is 8.879 meters and the centre line of guide apparatus it self is 5.48 metres below the minimum tail water level, the top of the exit end of draft tube will be 5.48 .+ 8.879 .- 5.327688 is = 9.032 meters below minimum tail water level, which is in order.

GENERATOR PARAMETERS

Air Gap Diameter 'Dg'

Total number of pair of | 15

Rated KVA of generator = 166666.67

166667

From Fig.15, Vr (peripheral rotor velocity)= 71 m/sec

Dg = 60*Vr / (π*n) = 6.78 m

Outer core diameter Do

= Dg (1+π/2p)

where p is number of pair of poles

7.49 meters

Stator frame diameter Df

Do + 1.2 metres

8.69 metres

Inner diameter of generator barrel Db

Df+ 1.6 to 2.0 m

8.4863: 1.8

10.49 meters

Outer diameter of generator barrel =12.0 m

Core length of stator 'Lc'=W/(KoDg2n)

W= 166667 KVA

Ko= 6.8 from Fig. 16 (IS 12800_1)

hence Lc= 2.666 metres

say 2.66594 m

Length of stator frame 'Lf' = Lc + 1.5 to 1.6 m

hence L_f = 4.16594 m

Axial hydraulic thrust P_h = KD3Hmax

where

K Axial hydraulics thrust coefficient

0.15

D3= 3.2289 (discharge diameter in m)

Hence P_h= 262.7 tonnes

Weight of generator rotor Wr =

As Dg = 6.78 m

Wr/Lc = 175 (Fig. 18 of IS 12800 Part 1)

hence Wr= 466.54 tonnes

Weight of turbine runner = 22 tonnes (from Fig. 19 of IS 12800 part 1)

Height of load bering bracket 'hf' = Total weight of rotating part + axial thrust

357+18+238.7

751.27 tonnes

let us provide 6 arms in bearing bracket

Load on each 125.212 tonnes

height of load bearing bracket hj = KDf0.5 (for suspended type of construction)

(KDg)0.5 (for umbrella type construction)

K = 0.85 (Sec. 5.7.1 of IS 12800 part 1)

so hj= 2.50574 m for suspended type

2.40063 m for umbrella type

OVERALL DIMENSIONS OF POWER HOUSE

the extremities of scroll case 6.42552
the extremities of draft tube 5.59
the extremities of generator 6 as per section 7.2.2

the extremities of scroll case/draft tube/generator in longitudinal direction are at 6.425515 on spiral inlet side and 6.0 m on opposite side of the transverse centre line of the machine. Adding l.5 to 2 metres to these dimensions, the size of the unit bay in longit. direction or unit spacing work out to be 16 metres.

Length of erection bay = 0.7 to l.5 times the unit bay size = 1.25 x 16 = 20 m

Space required for the EOT. crane to handle the last unit will depend upon the number and size of the crane. For preliminary purpose assuming it to be 3 to 5 metres (8 metres in the present case , as its proposed to provide two nos of EOT crane having 250 Tonne capacity each)

Total length of power house cavity = 124 m

From Fig. , the distance of the inner face of downstream columns from the longitudinal centre line of machine works out to be 6.0 + (1.5 or 2.0 m, say 1.5 m)=7.5 m

Distance of the inner face of upstream columns from the longitudinal centre line of machine = 6.5 (extremity of draft-tube/scroll-case/ generator barrel) + 4..0 (For accommodating control valve) + 2 m(for draft tube manhole) + 2 m (for Pressure relief valve)= 14.5 m

Hence Inner width of power house = 14.5 +7.5 = 22 m

width of machine hall .= 25 m including columns.

Height of Machine Hall:-

Total height of machine = H_1+H_2

From the size of draft-tube as already calculated above,.H_1= 8.87948 m

And H_2=L_f+h_f+K

As already calculated, Lf = 4.1659401

hj = 2.506 (For suspended type machine).

K = 5.5 to 7.0, Say 6.0 m. (As per IS 12800 Part 1)

H_2= 4.166+2.5+6 = 12.7

Hence Total height of machine = 8.88 + 12.7 = 21.55 m

Total height of machine hall will depend upon type of foundation, height of E.O.T. crane, size of assemblies, type of roof and can be determined accordingly.

The maxamium possible length of generator unit = $2h_j+L_f+$ *some length for coupling*

.=2X2.505+4.166+3= 12.177

let assume

(a) height of hook = 2 m

(b) Head room/ Depth of E.O.T. crane= 2.5 m

(c) cleare distance between roof and E.O.T. crane= 0.5 m

(d) crown height as roof will be arch = 4 m

hence Height of Machine Hall = 42.729

say 43 metres

EL of foundation of power house =632.5-8.8 = 624.7 m