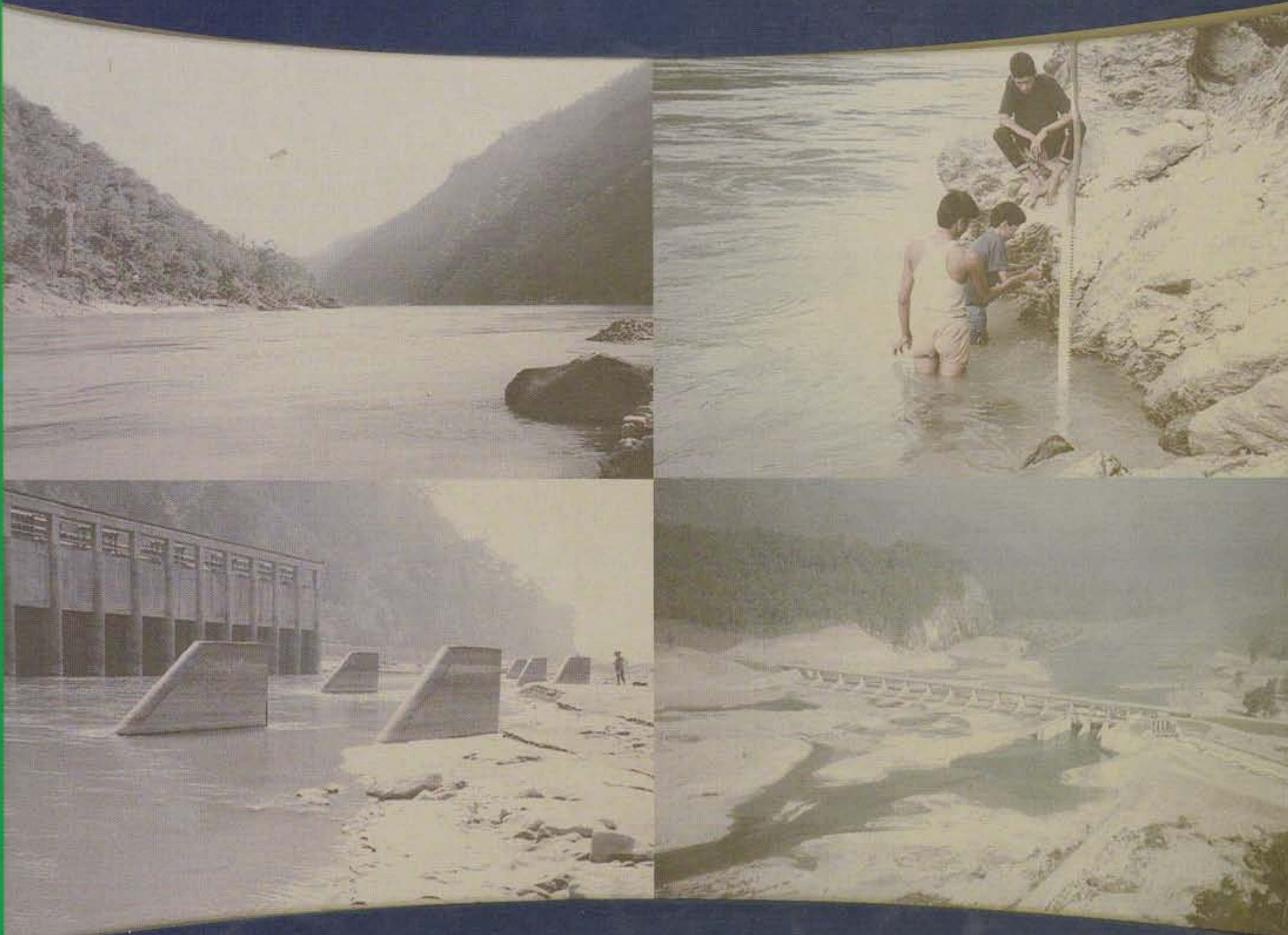
His Majesty's Government of Nepal

Ministry of Water Resources

Department of Electricity Development



GUIDELINES FOR STUDY OF HYDROPOWER PROJECTS

December 2003

Kathmandu

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BACKGROUND

Water resources are important natural resources for the economic development of Nepal. Availability of abundant water resources and geo-physical features provide ample opportunities for hydropower production in Nepal. Out of the total hydropower generation capacity of about 83,000 MW in the country, about 42,000 MW of power generation is financially and technically feasible. Less than 1% of total potential is developed so far. Hence His Majesty's Government of Nepal has given high priority to develop this sector.

In the course of licensing of hydropower projects, for survey or development for generation, transmission and distribution of electricity, the quality, volume and depth of study of the report submitted are not unique and differ from one developer to another. Further to this, the several types of study done for different hydropower projects under the same category of survey license also do not have same quality. For the same pre-feasibility or feasibility level of study different developers/ parties have set up their own approach and gone through different depth or coverage of study.

The uncertainties and differences in level and depth of studies carried out by different developers/agencies in several types of study reports have evoked Department of Electricity Development (DOED) for developing the guidelines for different phases of study for hydropower development, so that uniformity and quality of report can be achieved. Hence, DOED has prepared the guidelines for different phases of study for hydropower development based on their capacity and scheme of hydropower projects.

These guidelines shall be adopted as the National Guidelines for study of hydropower projects in Nepal.

OBJECTIVE

The overall objectives of these guidelines for study of hydropower projects are:

- To establish and maintain a criterion for different phases of study of hydropower projects based on different capacity and scheme of hydropower projects;
- To maintain and establish uniformity in similar type of studies carried out by different agencies/ developers;
- To ease out the problems and simplify the process associated in the course of license application and processing.

SCOPE OF GUIDELINES

The guidelines in general cover the scope of works in defined formats for different studies and specific details for each of those studies. The guidelines cover the following phases of study.

1. Reconnaissance or preliminary study
2. Pre-feasibility study
3. Feasibility study

The sets of guidelines so prepared for each phase of the study incorporate following sub classification of hydropower projects.

A. Capacity:

> 1 MW ≤ 10 MW
> 10 MW ≤ 100 MW
> 100 MW

B. Scheme Type:

Run-of-river Type
Storage Type

Besides these, distinction between the guidelines for underground and surface structures and different types of dams have also been described.

ADDITIONAL REQUIREMENTS FOR EXPORT ORIENTED PROJECTS AND CAPTIVE PLANTS

The basic study requirements and the extent of details required for different levels of the studies and different types of projects remain basically the same whether the projects are designed for domestic consumption or for export markets or for captive use. Only in terms of benefits, particularly in storage type projects, the flow regulation benefits could extend beyond the national boundary. Quantification of such benefits, wherever possible, needs to be incorporated in the study.

As far as captive plants are concerned their outputs could be better used if they are planned to operate in conjunction with the power utility serving the area. Even under isolated conditions (i.e., located far away from the grid), the surplus production available could be sold to the market areas surrounding the service area covered by the captive generation. If any such supply or power exchange with the grid (national or local) has been envisaged by the project, they need to be described in the report and associated benefits should be quantified as far as practicable.

NEED OF INCORPORATION OF OTHER ASSOCIATED BENEFITS

Flow regulation benefits at downstream of a storage project in terms of flood control, irrigation and/ or river navigation are obvious associated benefits. Even a run-of-river hydropower project could be developed with an aim to derive multiple benefits such as drinking water supply and irrigation water supply in addition to power. Any such associated benefits, automatically derivable downstream and/or derivable as a result of planned multipurpose function, must be described and quantified in the study report.

FORMATS FOR GUIDELINES FOR STUDY OF HYDROPOWER PROJECTS

Basic Formats "Guidelines for Hydropower Studies" applicable to run-of-river projects (A is for capacity range > 1 MW ≤ 10 MW, B for > 10 MW ≤ 100 MW and C for capacities above 100 MW) have been presented along with additional requirements for projects with underground type of works as Format-X and additional requirements for storage type projects as Format-Y.

FORMAT –A: GUIDELINES FOR STUDY OF HYDROPOWER PROJECTS
Run-of-River Type
Capacity Range >1 MW ≤ 10 MW

S. No.	Study Items	Details of Study Requirements		
		Reconnaissance Level	**Pre-feasibility Level**	**Feasibility Study**
1.	**TOPOGRAPHICAL SURVEYS AND MAPPING**			
1.1	Available Maps and Aerial Photographs	a. Collect and use available largest scale contour maps and aerial photographs of the project area. b. Enlarge by photogrametric method the available largest scale topo-map of the project area to 1:10,000 scale.	a. Collect and make use of available contour maps of the project area including those maps/sections/ profiles prepared during reconnaissance survey.	a. Topographical surveys and mapping that are expected to be carried out at pre-feasibility level correspond to the requirement of feasibility level. However, some augmentation of survey works for selected alternative may be needed, e.g., for setting up of additional geo-technical exploration locations and seismic refraction lines. These additional surveys and mapping should be compatible with the recommendations made for further survey and investigation by pre-feasibility level study. b. Make use of all available maps, aerial photographs, section / profiles and maps prepared during previous level of studies particularly of pre-feasibility level survey.
1.2	Topographical Survey	<u>If the project is dam type,</u> a. conduct cross-section survey of potential dam sites of the project area with fixing of bench marks. b. Conduct survey to prepare contour plan covering alternative dam, powerhouse and tailrace sites, spilway areas, river diversion area and pondage impoundment area <u>If the project is diversion type,</u> a. Conduct longitudinal profile survey of the river stretch to cover potential alternative weir and powerhouse sites of the project area (better to start from an un-destroiable point at the confluence) showing the confluence point of rivulets/ streams in between. b. Conduct river cross section surveys of potential weir and powerhouse sites showing highest flood marks and existing water levels. This survey should be coordinated in a manner to locate the cross sections on the longitudinal profile of the river. <u>Note</u>: The objective of longitudinal survey being to determine level difference between headworks sites and powerhouse sites, traverse survey through terrain could also be applied.	a. Establish the control points and new benchmarks. b. Conduct leveling and traverse survey for tying the control points/ benchmarks with triangulation points of the national grid established by the Survey Department of HMG. c. Carry out topographical survey of the project area as a whole with 5 m contour interval and of the lcoation of major structural components with contour interval of 1 m. At least two most promising alternatives should be covered by topographical survey. The topographical survey should include the borrow areas, if the project is dam type. d. Strip survey of water conveyance route (canal, aquaduct, syphon) with detailed cross sections of cross drainage lying across the canal route (s) and the penstock route with coverage of most promising alternatives to produce maps in 1:2000 scale with 2 m contour interval. e. Surveys for setting out the boreholes, seismic refraction lines, test pits, trenches need to be carried out. f. River cross section survey should be carried out both at intake and tailrace sites covering at least 500 m upstream and downstream at each site. The interval should be 50 m to 100 m depending upon river conditions. High flood marks and existing water levels must be shown in the cross sections. The detailed cross-section survey of cross drainage works are also need to be carried out. g. The Survey should include Impoundment or daily pondage basin area.	a. Conduct strip survey of access road alignment with 5 m contour interval to produce map in 1:5000 scale with fixing of bench marks in an interval of 500 m and at major crossing drainage. locations b. Conduct surveys to cover additional areas if prefeasibility study has recommended for need of such surveys. c. Conduct walkover survey of transmission routes using available 1:25,000 scale topo-sheets to compare with socio-environmental hazards including forested areas to be crossed for potential alternatives.

S. No.	Study Items	Details of Study Requirements		
		Reconnaissance Study	Prefeasibility Study	Feasibility Study
1.3	Mapping and Plotting	If the project is dam type. a. Prepare contour plan in 1:10,000 scale with 5 or 10 m contour of the project area including impoundment area.. b. Prepare cross sections of potential dam sites. If the project is derivation type. a. Plot the river profile, plot the cross sections of potential weir sites. b. Based on walkover survey, locate approximately the potential desanding sites and forebay sites, make route alignment for waterways (canal/tunnel, penstock) using the topo-map enlarged by photogrametric method to scale say 1:10,000, from the existing largest scale contour maps.	a. Prepare contour plan in 1:5,000 scale with 5 m contour of the whole project area. All the features such as rocky cliff, slide zones, cultivated land, etc., must be shown in the contour plan. b. Prepare map in 1:1000 scale with 1 m contour interval of dam/ weir sites, river diversion sites, desanding basin sites, forebay/ pondage basin sites, penstock alignment and powerhouse sites and of canal/tunnel alignment in 1:2000 scale with 2 to 5 m contour. c. The map in 1:1000 scale should also include the area of spillway location of dam type powerhouse, if the spillway location falls in the terrain outside the main dam. d. Prepare map of daily pondage basin in 1;2000 with 2 m contour. If impoundment by dam the map should be in 1:5000 scale with 5 m contour interval.	a. Additional mapping and plotting will be required only if pre-feasibility study has recommended for such works. b. Prepare access route map in scale 1:5000 with 5 m contour interval and cross-section along bridge/ culverts lying in the road alignment. The profile should be plotted in a scale of V 1:500 and H 1:5000.
2	**HYDROLOGICAL AND SEDIMENTATION STUDIES**			
2.1	Hydrology	a. Assess the mean monthly flows and determine the flow of 90% probability of exceedence. b. Carry out a discharge measurement at the headworks site during the driest period of the flow. c. Carry out a cross-section survey at the intake site covering the highest flood mark. d. Assess the peak flood discharge. e. Determine if there is any glacier lake in the catchment through map study.	a. Collect the long term historical rainfall data and climatological data pertinent to the study area. b. Collect the long term historical flow data and sediment data of the river under study, if available; if not, collect the data from other river with similar hydrological characteristics in the vicinity. c. Assess the mean monthly flows. d. Develop a flow duration curve. e. Establish a gauging station at the intake site and start collection of data. f. Carry out discharge measurements at the intake site. g. Estimate the design floods for the structures for the return periods of 50, 100 and 200 years. h. Conduct flood frequency analysis for the period October to May for ascertaining diversion flood. The frequency of diversion flood should be 1 in 20 years. i. Carry out three cross-section surveys at the headworks site and three at the tailrace site covering the highest flood marks. j. Compute the peak flood discharge corresponding to the flood marks at the intake site and tailrace site. k. Develop rating curves for the intake site and tailrace site. l. Assess the potentiality of GLOF in the catchment, if any.	a. Review the study made on pre-feasibility level and collect the additional data if any. b. Continue collection of data from the gauging station established during the pre-feasibility level study. c. Check the flow data with the rainfall data and generate long series of flow data if required. d. Update the flow data and assess accordingly the mean monthly flows and develop an upgraded flow duration curve. e. the frequency of diversion flood should be in 1 in 20 year. f. Carry out discharge measurements at the intake site at least 4 or 5 times in each season (rainy season, dry season and medium flow season) and update and upgrade the rating curve. g. Check these observed data with the data collected from secondary sources and modify the long term data accordingly, if needed. h. Carry out discharge measurements at the tailrace site and update and upgrade the rating curve for this site. i. Update and upgrade the design flow for power generation. j. Update and upgrade the design floods computed during the pre-feasibility level study. k. Update and upgrade the diversion floods computed during the pre-feasibility level study. l. Carry out three cross-section surveys at the headworks site and three at the tailrace site covering the highest flood marks, preferably at the same locations as of the pre-feasibility study so that any change in the cross-sections can be observed, if occurred and check the magnitude of flood peaks with the previous ones. m. Update and upgrade the rating curve for the tailrace site. n. Carry out the water quality analysis to determine the corrosive effectiveness. o. Collect the information on GLOF events in the past and assess the magnitude of the potential GLOF, if any.
2.2	Sediment	-	a. Estimate the sediment load in the river.	a. Collect sediment samples during the periods when the discharge measurements were carried out. b. Analyze the sediment samples to evaluate the volumes and characteristics of solid material transportation including particle size distribution, petrographic (hardness) analysis to determine the hardness of particles, particle size and the nature of material entering the power waterways.

S. No.	Study Items	Details of Study Requirements		
		Reconnaissance Study	**Prefeasibility Study**	**Feasibility Study**
3.	**GEOLOGICAL / GEO-TECHNICAL, CONSTRUCTION MATERIAL AND SEISMICITY**			
3.1	**Geological and Geo-technical**			
3.1.1	Regional Geological Study	a. Collect and review available literatures, topographical, geological maps, geological sections and aerial photographs. b. Prepare a report on regional geology and structure c. Prepare maps with plan and section in 1:50,000	a. Collect and review available literatures, topographical, geological maps, geological sections and aerial photographs. b. Review reconnaissance report to update and prepare a report on regional geology and structure. c. Prepare maps with plan and section in 1:25,000	a. Collect and review available literatures, topographical, geological maps, geological sections and aerial photographs. b. Review prefeasibility report to up date and prepare a report on regional geology and structure. c. Prepare maps with plan and section in 1:10,000
3.1.2	General Geology and Geomorphology of the Project Area	a. Prepare a report on general geology and geomorphology of the project area as findings from review	a. Prepare a report on general geology and geomorphology of the project area. b. Prepare maps with plan and section in 1:5,000	a. Prepare a report on general geology and geomorphology of the project area. b. Prepare maps with plan and section in 1:2,000
3.1.3	Detailed Geology and Geomorphology of Particular Sites	-	a. Conduct a detailed geological and geo-morphological survey of particular sites such as intake, desander, canal, surgetank, penstock, powerhouse and tailrace.	a. Review prefeasibility report to update the detailed geology and geomorphology of the particular sites and conduct additional survey of particular sites such as intake, desander, canal, surgetank, penstock, powerhouse and tailrace and prepare maps and sections in appropriate scale for design requirements or 1:2,000 scale.
3.1.4	Discontinuity Survey			a. Conduct a discontinuity survey such as bedding/ foliation planes, lithological contacts, major and minor joints, faults, thrusts and folds. b. Conduct discontinuity analysis to define measure orientation. Prepare analytical result in geological format. c. Prepare Rock Mass classification for each underground hydraulic structure.
3.1.5	Geo-technical Investigation			a. Excavate test pits and collect samples for laboratory analysis to know nature of soil at intake, desander and powerhouse sites. b. Perform SPT and permeability tests in each test pit to know the strength and permeable nature of soil at intake, desander and powerhouse sites. c. Perform seismic refraction or resistively survey for overburden thickness and nature of soil strata at intake, desander and powerhouse sites. d. Perform laboratory analysis such as sieve and sedimentation, Atterberg limits, natural moisture content and specific gravity of collected samples for physical properties.
3.2	**Construction Material Survey**			
			a. Identify and investigate borrow areas and quarry sites for the construction materials such as impervious soils, stones, sand and gravel etc. as required. b. Make an estimation of available quantity at each borrow area for the construction.	a. Identify and investigate borrow areas and quarry sites for the construction materials such as impervious soils, stones, sand and gravel etc. as required. b. Excavate test pits and log the nature of soil at borrow locations and collect samples for laboratory analysis. c. Perform laboratory analysis by seiving and sedimentation, Atterberg Limits, natural moisture content and specific gravity. d. Estimate available quantity at each borrow area to meet the requirement of the construction e. Collect rock block samples from each quarry site for laboratory tests f. Perform laboratory tests such as uniaxial compressive strength, point load, Los Angeles abrasion, aggregate crushing value, alkali reactivity and specific gravity etc tests on rock samples.
3.3	**Seismological Study**			
3.3.1	Tectonic Setting	a. Available Information on regional tectonics should be discussed with illustration in a map at suitable scale	a. Available information on regional tectonics should be used with map presentation at 1:1,000,000 or 1:2,000,000 scale	a. Regional tectonic setting of the project area and its surrounding regions should be addressed and depicted in a map of 1:1,000,000 or 1:2,000,000 scale with a view to indicate how and where the earthquake were generated and are likely to be generated.

S. No.	Study Items	Details of Study Requirements		
		Reconnaissance Study	Prefeasibility Study	Feasibility Study
3.3.2	Aerial Photo and Remote Sensing Interpretation	a. General review of aerial photos and landsat images should be carried out to assess tectonic features	a. General review information on aerial and landsat images study should be used	a. Interpretation of aerial photos and landsat images should be performed critically to review the tectonic features including the neo-tectonics.
3.3.3	Fault and Paleo seismicity		a. Information on different faults characteristics should be incorporated.	a. Different faults indicated and observed in the project area should be described in consideration of their length, distance and reoccurrence nature. Characteristics of rupture age of the deformation and intrinsic relationship of the epicentres with the fault should be mentioned. b. Identified faults should be categorized into active, inactive and capable faults. c. Available evidences of Pre-historic major earthquakes such as recent faults occurred during 11,000 years should be included.
3.3.4	Earthquake Catalogue, Historical and Instrumentally Recorded Earthquakes		a. Regional seismicity of the project area should be discussed and reflected in a map at suitable scale	a. Earthquake catalogue specially for those historical and instrumentally recorded earthquakes should be described giving emphasis on earthquakes of magnitude 4.0 M and more. For every significant earthquake, the location, distance, magnitude and intensity should be considered. Available information should be reflected in a map at suitable scale.
3.3.5	Seismic Zoning			a. The location of the project area with respect to the seismic zoning of the country should be mentioned.
3.3.6	Seismic Hazard Analysis			a. Empirical laws may be applied to deduce intensity or acceleration of the ground motion. The peak ground acceleration (PGA) for Maximum Design Earthquake (MDE) and Operating Basis Earthquake (OBE) should be given.
4.	**SELECTION OF PROJECT CONFIGURATION**			
		a. Most promising site should be selected for the immediate development. Various alternative scheme for the selected site should be worked out. b. Actual site conditions should be verified by reconnaissance field visit of the site. c. Locations and types of weir, desander, canal/ tunnel forebay, penstock and powerhouse should be confirmed after the analysis of the field investigation report, consisting of preliminary information about the topography, hydrology and geology of the site. On their basis the final scheme should be selected with its structural components.	a. Alternative access roads up to the project site should be studied and described. b. Alternative schemes for the selected site should be studied. c. Topographical and geological conditions of the alternative sites should be studied in the field in order to select the proper locations of the following structures: Weir, Desander, Canal, Forebay, penstock and Powerhouse. The locations and types of the structures should be selected after comparison of alternatives. d. General layout of the project should be prepared using the topomap plotted after field survey.	a. This stage of study should consist of the selection of the type of project, selection of location of structrues and their optimization. b. For the selection of location of the diversion weir, several alternative sites identified during reconnaissance study should be investigated in detail. Simultaneously the alternative sites for desilting basin, water conveyance, river crossings, forebay and powerhouse should also be investigated in detail. c. Topography, hydrology and geology will play the decisive role for the location of the structures. d. All comparison of alternative schemes of the project, based on the various locations of the structures, should be carried out in order to select the optimum alternative scheme. The criteria should be the maximum energy benefit at minimum cost.
5.	**OPTIMIZATION STUDIES**			
		a. Optimization studies are not needed at this stage of study.	a. Optimization study is premature at this stage of study. However, preliminary calculations with following approach should be adopted. b. Installed capacity should be determined assuming the capacity factor for the system. c. Number of units should be determined considering the reliability of operation of the plant and maximum utilization of dry season river flow. Apart from that transportation capabilities should also be considered.	1. General Approach a. Selection of parameters to be optimized, identify their range and establish a series of alternatives. b. Carry out the conceptual design, and estimate its cost for each alternative. c. Estimation of benefits for each alternative. d. Comparison of Cost and Benefits 2. Assumptions a. Price of firm energy b. Price of secondary energy c. Capacity benefit

S. No.	Study Items	Details of Study Requirements		
		Reconnaissance Study	Prefeasibility Study	Feasibility Study
				3. <u>Selected Alternatives</u> a. Determine number of alternatives within the range of installed capacities.
				4. <u>Energy Production</u> a. For ROR projects calculate energy production for all alternatives with following consideration: - 90% exceedence flow and average monthly flows to be used. - Firm and Secondary energy to be calculated. 5. <u>Project Layout</u> a. Optimize project structures individually for the given installed capacity. b. As the installed capacity increases, design of weir and undersluice to be kept constant. c. Size of desander to be adjusted. d. Tunnel diameter to be optimized considering the loss of energy due to increased head loss. e. Surge chamber dimension and penstock dimension to be optimized for a given installed capacity. f. Powerhouse and unit sizes to be obtained from empirical formula. 6) <u>Cost Estimate</u> a. Preliminary quantity and cost estimates should be developed for all the cases considered. b. Only the major items should be computed in detail, while minor items may be estimated based on curves and data of similar structures of other projects. c. Unit rates should be estimated based on the data of recent projects undertaken by NEA and private sector with some modifications. d. Electro-mechanical equipment costs should be calculated using empirical relations. e. The cost estimates should also consider the cost for access roads, project roads, infrastructure development and environmental impact mitigation. f. Technical contingencies should be taken into account for obtaining the implementation cost of the alternative. 7) <u>Economic Comparison</u> a. Economic comparison of the different alternatives should be carried out considering the implementation cost and operation cost with occurred benefits due to energy production for each case. b. The economic analysis should be carried out to determine the basic economic parameters like Net Present Valve (NPV), Internal Rate of Return (IRR), Benefit Cost Ratio (B/C), etc. c. The case with maximum B/C ratio and rate of return should be selected for optimum installed capacity. 8) <u>Number of Units</u> a. Minimum possible number of units should be adopted. b. Limitation of transport capabilities should be taken into consideration.
6.	**PROJECT DESCRIPTION AND DESIGN**			
6.1	General Layout and Civil Structures	a. Conceptual design of the project components should be carried out on the basis of preliminary assessment of topographical, geological and hydrological conditions of site. b. Brief description of major civil structures and turbine0generator equipments should be provided.	a. General layout of the selected alternative site of the project should be described. b. Preliminary design of the following civil structures should be carried out using the topographical maps, prepared at a larger scale: - Weir & Intake - Desanding basin	1. <u>General</u> Layout: The general layout of the selected scheme of the project comprising headworks, headrace tunnel, penstock, powerhouse and tailrace should be described.

S. No.	Study Items	Details of Study Requirements		
		Reconnaissance Study	Prefeasibility Study	Feasibility Study
			- Headrace canal - Forebay - Penstock - Powerhouse - Tailrace - Switchyard (Civil) c. Preliminary selection of the electro-mechanical equipment should be carried out determining the basic parameters of: - Turbine and accessories. - Generator and accessories - Transformers and switch gears d. A single line electric diagram should be prepared representing the major electrical equipments of the powerhouse.	2) Civil Structures i) River Diversion a. An upstream coffer dam should be designed in order to protect the working area at weir site, to divert the river flow. A downstream cofferdam should also be provided to protect the weir construction site from entering the river flow after out flow from diversion channel (tunnel). The diversion channel (tunnel) should be designed to pass the flood of 1 in 20 years return period. ii) Headworks a. Design and description of the headworks comprising weir, undersluice spillway, intake, desander, etc. should be provided. b. The weir should be designed to divert the river flow to the power channel through desander according to topographical and geological conditions. It should be capable of passing the maximum flood of 1 in 100 years return period. Stability analysis of the weir should be done 1 in 200 year. c. A under sluice structure of headworks should be designed to pass a portion of the high flood discharge. However, during the low flow season, the design discharge should be allowed to flow through the intake by closing the sluice gates. d. Side Intake –Head Regulator: The hydraulic design of side intake should ensure the entry of the required design flow into the headrace canal. e. Desilting basin: Desilting basin should be designed for continuous supply of required design flow in the power canal and continuous flushing of permissible deposited suspended sediments of size greater than 0.2 mm in diameter. An emergency automatic spillway should be provided for the desilting basin. iii) Power Canal / Tunnel a. The power canal / tunnel including all hydraulic and cross-drainage structures from intake to forebay should be designed to convey the required design flow. iv) Forebay a. The forebay basin should be designed to create pressure flow in the penstock leading to turbines. The forebay levels should be determined is such a way that it will be possible to avoid entrance of air into the penstock during maximum drop of water level at sudden opening of turbine valves. v) Penstock a. Optimum diameter of penstock pipe should be determined. The thickness of the steel pipe should be able to with stand any variable load conditions to be encountered during operation of the plant. Anchor blocks for supporting penstock pipe should also be designed at appropriate places. The bifurcation of the penstock should also be designed. Surface type or cut and cover type should be decided on the basis of the topographic and environmental considerations. vi) Power Station Powerhouse a. A brief description of power station should be provided with the types and number of equipments, and power execution facilities b. The dimension of the powerhouse should be planned to accommodate all electro-mechanical equipments. c. The dimensions of spiral casing and the draft tube should also be determined.

S. No.	Study Items	Details of Study Requirements		
		Reconnaissance Study	Prefeasibility Study	Feasibility Study
6.2	Electro-Mechanical Equipment			i) Mechanical Equipment a. Selection of the type and determination of main parameters of the following essential and main mechanical equipment should be carried out: - Hydraulic Turbine; - Inlet valve; - Governor; - Lubricating system; - Pressure oil system; - Compressed air system; - Cooling system; - Control system. b. The description of the equipments mentioned above should be provided. ii) Electrical Equipment a. Following electrical equipments for the generation and evacuation of the power should be described with the determination of the main Paramters: - Generator; - Excitation system; - Switch gears; - Control panel; - Switchyard; - Transmission line b. A single line electrical diagram depicting the inter connection of all electrical equipment should be prepared. iii) Auxiliaries a. For the smooth operation of the power station, following auxiliaries should be provided: - Grease Lubricating system. - Fire fighting system - Station supply - Lifting arrangement.
7.	**ENERGY COMPUTATION AND BENEFIT ASSESSMENT**			
				1. Energy Computation a. Energy computation should be based on: - Reference hydrology (average flow) for average annual energy 90% reliable average monthly flow in the lowest flow month for firm energy. - Assumed design parameters (net head, turbine discharge, installed, consideration of compensation flow, installed capacity). b. Secondary energy is computed as average annual energy minus firm energy. Secondary energy available on monthly basis should also be presented. 2. Benefit Assessment a. There are two kinds of benefits accruable capacity and energy. Energy benefit could further be splited into firm energy and secondary energy benefits. Values for power and firm energy benefits should be based either on generation costs of other potential similar size hydropower projects in Nepal considering hydropower in the cheaper alternative than others (i.e., LRMC of hydro-generation in Nepal) or on perverting selling price to NEA under Power Purchase Agreement. For Secondary energy at the most thermal, fuel displacement value could be taken. In no case, the values for capacity benefit should exceed the value of dry season peaking capacity.

S. No.	Study Items	Details of Study Requirements		
		Reconnaissance Study	**Prefeasibility Study**	**Feasibility Study**
8.	**COST ESTIMATE**			
8.1	Criteria and Assumptions	a. All the criteria, assumptions adopted for Cost Estimation should be mentioned.	All the criteria and assumptions adopted for cost estimation should be mentioned including following: a. Consideration of the natural conditions prevailing at the site, construction scale, and levels of construction technology available in Nepal. b. To the extent possible, construction equipment available in Nepal should be used. c. A brief description of project with location should be mentioned. d. Year and month of the cost estimate should be mentioned. e. Exchange rate applied to calculation of NRs. and US$ adopted at the time of cost estimation should be mentioned. f. Identifiable Nepalese taxes, custom duties, royalties etc. for goods, materials and services, interest during construction etc whether included in cost estimation or not should be mentioned. **g.** Any source of references of rates or estimation should be mentioned with used escalation factors if any.	
8.2	Estimating Methodology	The following methodology should be applied for estimation of cost of each component of the project. a. **For Civil Works:** The cost estimate should base upon conceptual design and rates of major components. The rates of major civil works can be derived from rates of similar nature of ongoing project, form cost database with suitable modifications or generalized cost curves available if any. The cost estimation should focus on major items/only rather than preparing detailed estimate. The estimate should also include major indirect costs in percentage basis derived from similar projects. b. For Generating Equipment: **The cost estimate for generating** equipment **could be based on cost database with suitable** modification**, or from any cost curves or from other project of similar nature.** **C.** For Hydraulic Steel works: **The cost estimate for generating** equipment **could be based on cost database with** suitable **modification, or from any cost curves or from other project of similar nature.** d. Transformers, switchyard and Transmission Line **The cost of transformers and switchyard could be based on capacity. The rates for these items could be based on generalized cost curves or from other project of similar nature.** Tentative length of transmission line can be derived from available map. The unit cost can be adopted from current rates used by Nepal Electricity Authority for same type of transmission lines.	The following methodology should be applied for estimation of cost of each component of the project. a. For **Civil** Works: The cost estimates should be based on unit rates developed from prevailing labour rate, construction equipment rate and materials taking also into account the local situation and bill of quantities derived from design drawings. The cost estimate should be done by breaking down major structures into number of distinct construction activities or measurable pay items. Due consideration should be given to local labors. The rates for locally available labors can be obtained from 'District rates' of concerned districts and can be used after appropriate adjustments. The rates of skilled labors available around project area or within Nepal can be obtained from general inquiries and references of other projects. The rates for skilled expatriates can be obtained from reference of other projects or from publication like ' International Construction Contractors.' The rates of construction equipment can be taken from regularly updated cost data, quotation from the suppliers/ manufacturers.	The methodology for pre-feasibility level study should be applied, but should be based on feasibility level design with inclusion of items not included in pre-feasibility level study. a. For Civil Works: The cost estimates should be based on unit rates developed from prevailing labour rate, construction equipment rate and materials taking also into account the local situation and bill of quantities derived from design drawings. The cost estimate should be done by breaking down major structures into number of distinct construction activities or measurable pay items. Due consideration should be given to local labors. The rates for locally available labors can be obtained from 'District rates' of concerned districts and can be used after appropriate adjustments. The rates of skilled labors available around project area or within Nepal can be obtained from general inquiries and references of other projects. The rates for skilled expatriates can be obtained from reference of other projects or from publication like ' International Construction Contractors.' The rates of construction equipment can be taken from regularly updated cost data, quotation from the suppliers/ manufacturers.

S. No.	Study Items	Details of Study Requirements		
		Reconnaissance Study	Prefeasibility Study	Feasibility Study
		e. Land Acquisition and Access Road: **Costing of land acquisition can be derived from reconnaissance field visits. The length and type of access roads to be constructed or improved can be determined from field visit and available maps. Cost per km of different roads can be used to determine the cost of access road.** **f.** Resettlement/ Rehabilitation and Relocation: **Tentative area of resettlement, rehabilitation and relocation can be derived from reconnaissance field visit area. Costing can be derived from prevailing market rates.** Following costs are to be added to obtain total capital cost of the project: - Engineering, management and administration (8%) - Owner's Cost (2%) - Contingencies added to account for unforeseen cost increase due to uncertainties in site conditions and inadequacy of study levels for civil works by 25%, since cost of minor items would not be taken into account at this stage, while for generating equipments and transmission lines by 10%.	The construction material to be used for construction work should be divided into - Materials locally available - Materials to be imported from India - Materials to be imported from Overseas The rates of construction materials should be derived accordingly as their source of supply. While calculating the construction materials rate, sufficient attention should also be given to mode of transportation and their corresponding costs should also be included. When access roads for the project is not built (generally for small hydropower projects) the cost of air transportation for transporting heavy equipment from nearest town to the project area should also be included. From labor cost , material cost and equipment cost the direct cost per unit of construction activity can be calculated The estimate should be of contractor's type and, therefore, should also include all other indirect costs such as office overhead, contractor's financing cost, insurance, bonds, profit and risk margin. A suitable percentage for contractor's expenses should be allocated. The total percentage should be used as a bid factor on direct cost. Thus calculated direct cost can be used to derive unit bid costs which in turn, be used to determine the total civil works cost. b. For Generating Equipment: The cost estimate for generating equipment should either be based on quotations obtained from suppliers or in-house estimate using established current international prices/ relationships. The cost should include cost of control devices/ system, auxiliary etc. transportation and erection. c. Hydraulic Steel Works: The cost of hydraulic steel works should be based on quotation of suppliers or on market price if they are locally available. Transportation cost should also be added. d. Transformers, Switchyard and Transmission Line: The cost of transformer and switchyard could be based on capacity, while for estimate of cost of transmission line can be calculated from per km rates of transmission line. References of cost can be taken from current rates used by Nepal Electricity Authority for same type/ voltage of transmission lines taking into account different types of towers required, the conductors and types of terrains being crossed.	The construction material to be used for construction work should be divided into - Materials locally available - Materials to be imported from India - Materials to be imported from Overseas The rates of construction materials should be derived accordingly as their source of supply. While calculating the construction materials rate, sufficient attention should also be given to mode of transportation and their corresponding costs should also be included. When access roads for the project is not built (generally for small hydropower projects) the cost of air transportation for transporting heavy equipment from nearest town to the project area should also be included. From labor cost , material cost and equipment cost the direct cost per unit of construction activity can be calculated The estimate should be of contractor's type and, therefore, should also include all other indirect costs such as office overhead, contractor's financing cost, insurance, bonds, profit and risk margin. A suitable percentage for contractor's expenses should be allocated. The total percentage should be used as a bid factor on direct cost. Thus calculated direct cost can be used to derive unit bid costs which in turn, be used to determine the total civil works cost. b. For Generating Equipment: The cost estimate for generating equipment should either be based on quotations obtained from suppliers or in-house estimate using established current international prices/ relationships. The cost should include cost of control devices/ system, auxiliary etc. transportation and erection. c. Hydraulic Steel Works: The cost of hydraulic steel works should be based on quotation of suppliers or on market price if they are locally available. Transportation cost should also be added. d. Transformers, Switchyard and Transmission Line: The cost of transformer and switchyard could be based on capacity, while for estimate of cost of transmission line can be calculated from per km rates of transmission line. References of cost can be taken from current rates used by Nepal Electricity Authority for same type/ voltage of transmission lines taking into account different types of towers required, the conductors and types of terrains being crossed.

S. No.	Study Items	Details of Study Requirements		
		Reconnaissance Study	Prefeasibility Study	Feasibility Study
			e. Land Acquisition and Access Road: Due attention should be given to costing of land acquisition and construction of access road as well. The length and type of access roads to be constructed or to be improved can be determined from preliminary design. Cost per km of different types of roads can be used to determine the cost of access road. f. Camp and Other Facilities: The costs of construction camps and permanent buildings required for operation and also of construction power facilities required should be included in cost estimation. A lump sum amount for this can be allocated depending upon magnitude of project. g. Resettlement/ Rehabilitation, Relocation and Mitigation Costs of Socio-Economic and Environmental Impacts shall be as per existing Environmental Protection Act and Rules	e. Land Acquisition and Access Road: Due attention should be given to costing of land acquisition and construction of access road as well. The length and type of access roads to be constructed or to be improved can be determined from preliminary design. Cost per km of different types of roads can be used to determine the cost of access road. f. Camp and Other Facilities: The costs of construction camps and permanent buildings required for operation and also of construction power facilities required should be included in cost estimation. A lump sum amount for this can be allocated depending upon magnitude of project. g. Resettlement/ Rehabilitation and Relocation: Loss of assets or land need to be either compensated by cash or be substituted by implementing resettlement/ rehabilitation schemes. Similarly, some fixed asset would have to be relocated. Costing of these items should also be included in the project cost. Adherence of existing rules/ regulations and practices is a must while making cost estimate of these items. h. Mitigation cost of Socio-Economic and Environmental Impact: These costs should include all the costs of impact mitigation programs and are to be taken from IEE or EIA reports separately prepared for the project in compliance with the requirement of Environment Protection Act, 1997 and related regulations.
8.3	Base Cost and Total Project Cost		The total of all costs indicated above will constitute base cost of the project. To that the following costs are to be added for obtaining the total capital cost of the project: a. Engineering and Management (8% of base cost) b. Owner's Cost (2% of base cost) c. Contingencies added to account for unforeseen cost increases due to uncertainties in site conditions: ➢ for civil works (15% to 20% of civil work cost) ➢ for generating equipment and transmission line (8% to 10% of equipment / line cost)	At feasibility level, due to use of more detailed information collected and minor items included and designs concretized, level of uncertainties will decrease particularly in civil work component. Hence a maximum of 15% contingency for this item would be reasonable.
8.4	Local and Foreign Currency Breakdown		Local currency will be required for local labours, materials, government cost including land acquisition, resettlement, mitigation and management programs related to adverse socio-economic and environment impacts. Foreign currency will be required for materials, equipment expatriate service component. Hence, the cost estimation should include a breakdown of local foreign currency components.	Update based on more detailed information / data.

S. No.	Study Items	Details of Study Requirements		
		Reconnaissance Study	Prefeasibility Study	Feasibility Study
8.5	Presentation of Cost Estimate Data		In the main volume of the report summary cost estimate data broken down into above mentioned major sub-headings and into foreign and local currency should be presented, while the details of cost estimates including rate analysis and unit rate could be presented in Annex volume.	Presentation should be done as in the prefeasibility level, but with inclusion of more detailed items based on more detailed information.
8.6	Cash Disbursement Schedule		The costs will incur not at once, but will spread over the whole construction period. Interest during construction will depend on how cash will be disbursed during construction period. Hence cash disbursement schedule in accordance with the schedule of construction activities need to be prepared spreading over the project implementation period. Year-wise cash disbursement against each of the major activities is to be prepared and presented in the report	Cash disbursement schedule should be based on updated and more practical project implementation schedule.
9.	**CONSTRUCTION PLANNING AND SCHEDULE**			
		a. Project implementation schedule is not required at this stage of study.	a. A preliminary construction schedule should be prepared for the project, showing the major construction activities. The total construction period should be determined. b. Access to the site, availability of construction materials at site, waste disposal sites and sites for the construction of camps should be described. c. River Diversion sequences during construction should be analyzed.	1) <u>Transportation</u> a. Access road to the project site should be described with various alternatives. Most economical combination of transport should be selected. b. A description of the transportation through India covering the nearest sea port and railway or road transport should be analyzed for import of plant equipment and construction material. 2) <u>Construction Power</u> a. Various means of construction power supply should be studied consisting the electric power supply from NEA grid and individual diesel generating sets. Most reliable and feasible option should be selected. 3) <u>Construction Camps and Telecommunication</u> a. Sites for temporary conveys for the labours, fatching and crushing plants, workshops, fuel depots and permanent camps for operators' village and site office should be selected and described. b. Power line communicant facilities should be provided for communication with load dispatch centre (LDC) of NEA. Local telecommunication network should also be extended to project site. 4) <u>River Diversion During Construction</u> a. A plan for diversion of the rier during construction should prepared. It will consist the construction of cofferdams and diversion channel. The sequence of the construction of diversion structures should be inter related to the construction of headworks structures like weir, spillway, intake and desander. 5) <u>Project Implementation Schedule</u> a. Project implementation schedule should be prepared. It should consist all the major construction activities in sequence with interlinkage between them. Significant milestones should be indicated in the bar chart of schedule.

S. No.	Study Items	Details of Study Requirements		
		Reconnaissance Study	**Prefeasibility Study**	**Feasibility Study**
10	**ENVIRONMENTAL STUDY**			
10.1	Initial Environment Examination (IEE)	List environmental issues of greater significance, if any.	a. Collect baseline data of physical, biological and socio-cultural environment of project affected area to understand the socio-environmental situation. b. Assess impacts of major significance. c. Develop mitigation and management programs to minimize the impacts	a. Update and formalize the IEE study carried out during pre-feasibility level study to adhere the legal requirements (Environmental Protection Act 1997 and Environmental Protection Regulations 1997 with Amendment in 1998). b. The basic requirement are as follows: - IEE is required for projects with capacity <5 MW, while for capacity >5 MW EIA is required. - Terms of reference of IEE have to be approved from the related government agency, - Effected localities need to notified about the implementation of the project giving 15 days' notice for written opinions. - IEE report needs to be submitted to related agency for approval.
10.2	Environment Impact Assessment	List environmental issues of greater significance, if any.	a. Collect baseline data of physical, biological and socio-cultural environment of project affected area to understand the socio-environmental situation. b. Assess impacts of major significance. c. Develop mitigation and management programs to minimize the impacts. d. With a view to enhance the fulfillment of legal requirement, the format procedure of IEE or EIA as per Environmental Protection Act 1996, Environmental Protection Rules 1997 and its amendments could also be carried out at this level	a. Update and formalize the EIA study carried out during pre-feasibility level study to adhere the legal requirements (Environmental Protection Act 1997 and Environmental Protection Regulations 1997 with Amendment in 1998). b. The basic requirement are as follows: - EIA study need to be done in two stages (i) scoping, and 9ii) preparation of EIA report, - Effected localities are to be notified about the implementation of the project giving 15 days' notice for scoping document needs to be finalized taking into consideration the opinions received from affected local people agencies. - Approval on scoping documents as well as on the TOR for EIA should be received from the Ministry concerned. - After conduct of EIA and preparation of EIA report, public hearing at the project area is to be conducted. - EIA report, then, with the recommendation of concerned VDC or Municipality, need to be submitted to the concerned Ministry for approval.
11.	**PROJECT EVALUATION**			
11.1	Economic Analysis	a. Only the scheme alternatives with high promise selected after screening are considered. b. At the reconnaissance stage, the evaluation are based on tentative cost estimate and therefore, the cost of energy produced could be compared with the prevalent PPA (power purchase agreement) price. Or, benefit/ cost ratio could be taken as the evaluation parameter. c. Some obvious technical parameters would also be taken as measure for comparison.	a. The economic cost should comprise of the present day investment cost, O & M cost and replacement cost excluding duties and taxes which are transfer payment. Similarly, it should not include price contingency and interest during construction. b. Comparison should be done with cheapest similar size alternative and all assumptions made must be clearly stated. c. Economic analysis should be based on consumable energy. d. Both B/C ratio and Economic Rate of Return (EIRR) cold be used for economic evaluation.	a. The same analysis performed for pre-feasibility should be applied for feasibility as well, but cost and benefit parameters used should be those derived from feasibility level design and analysis.
11.2	Financial Analysis	-		a. In performing financial analysis, the financial internal rate of return (FIRR) and the loan reputability are examined based on financing conditions. the financial cost should include, besides economic cost, duties, taxes, price escalation and interest during construction. The benefits will comprise the revenue generation from the sales of energy. As a result of the financial analysis, the financial cash flow showing operating expenses, debt service (loan repayment), royalty and tax payments is required to be presented. All assumptions including finalizing conditions made for the analysis need to be clearly stated and FIRR determined.

S. No.	Study Items	Details of Study Requirements		
		Reconnaissance Study	Prefeasibility Study	Feasibility Study
11.3	Sensitivity Analysis	-	a. Sensitivity analysis are required to be performed in general, for the following cases: - Varied discounted rates (say 8% to 14%), - Capital cost decreased/ increased by 20% - Wet season available energy gets market. - Delay in commissioning (say 1 yr., 2 yr., commutative effect of cost and time overruns	a. Sensitivity analysis are required to be performed in general, for the following cases: - Varied discounted rates (say 8% to 14%), - Capital cost decreased/ increased by 20% - Wet season available energy gets market. - Delay in commissioning (say 1 yr., 2 yr., commutative effect of cost and time overruns
12.	**PRESENTATION OF DRAWINGS, MAPS AND CHARTS**			
12.1	General	a. Location Map	a. Location Map, b. Map showing physiographic regions	a. Location Map, b. Map showing physiographic regions
12.2	Topography	a. Weir/ Dam Site Cross-sections in scale 1:500	a. Control survey map showing Bench Marks,	a. Control survey map showing Bench Marks,
12.3	Hydrology	a. Catchment Map	a. Drainage Basin Map b. Rating Curves of Headworks Site and Tailrace Site c. Flow Duration Curve d. Reference Hydrograph e. Discharge-sediment relationship	a. Drainage Basin Map b. Rating Curves of Headworks Site and Tailrace Site c. Flow Duration Curve d. Reference Hydrograph e. Discharge-sediment relationship
12.4	Geology and Seismicity	a. Geological Map of Project Area 1:25,000	a. Regional Geological Maps (Plan and Section in scale 1:250,000) b. Geological Map of Project Area (plan & section in scale 1:5,000) c. Site specific geological maps (sections with drill hole logs) - Headworks in scale 1:1000 - Water Conveyance Route in scale 1:2000 - Powerhouse in scale 1:1000 d. Map showing Seismic Refraction Lines, Drill Holes, Adits in scale 1:5000 e. Map showing Borrow Areas and Test Pits and Trenches in scale 1:5000 f. Seismicity Map in scale 1:2,000,000 or 1:1,000,000	a. Regional Geological Maps (Plan and Section in scale 1:250,000) b. Geological Map of Project Area (plan & section in scale 1:5,000) c. Site specific geological maps (sections with drill hole logs) - Headworks in scale 1:1000 - Water Conveyance Route in scale 1:2000 - Powerhouse in scale 1:1000 d. Map showing Seismic Refraction Lines, Drill Holes, Adits in scale 1:5000 e. Map showing Borrow Areas and Test Pits and Trenches in scale 1:5000 f. Seismicity Map in scale 1:2,000,000 or 1:1,000,000
12.5	Optimization	a. General Layout Plans of the Alternative Considered in scale 1:25,000 or large	a. Reservoir/ Pondage Volume Curve. b. Optimization Study Charts	a. Reservoir/ Pondage Volume Curve. b. Optimization Study Charts
12.6	Design Drawings	a. Layout Plan of Selected Alternatives with High Promise in an enlarged map of 1:10,000 b. Conceptual Drawings of Major Project Components	a. Drawings of: - Alternatives Considered in scale 1:5000 - General Arrangement of Selected Project in scale 1:5000 - Headworks (General Arrangement, Elevations and Sections) in scale 1:1000 - Desanding Basin (Plan in scale 1:5000 and section in scale 1:500) - Headrace Water Conduit System (Plan in scale 1:2000 and Section in scale 1:200) - Forebay/ Surgetank to tailrace (Plan in scale 1:2000 and Section in scale 1:500) - Forebay/ Surgetank (Elevations and Sections in scale 1:500) - Powerhouse (General Arrangement in scale 1:1000, Plan and Sections in scale 1:500) - Powerhouse –Switchyard Layout in scale 1:1000	a. Drawings of: - Alternatives Considered in scale 1:5000 - General Arrangement of Selected Project in scale 1:5000 - Headworks (General Arrangement, Elevations and Sections) in scale 1:1000 - Desanding Basin (Plan in scale 1:5000 and section in scale 1:500) - Headrace Water Conduit System (Plan in scale 1:2000 and Section in scale 1:200) - Forebay/ Surgetank to tailrace (Plan in scale 1:2000 and Section in scale 1:500) - Forebay/ Surgetank (Elevations and Sections in scale 1:500) - Powerhouse (General Arrangement in scale 1:1000, Plan and Sections in scale 1:500) - Powerhouse –Switchyard Layout in scale 1:1000

S. No.	Study Items	Details of Study Requirements		
		Reconnaissance Study	**Prefeasibility Study**	**Feasibility Study**
12.7	Power Supply	a. Map Showing Transmission Line in scale 1:50,000	a. Map of Nepal Power System (Existing and Planned) b. Map Showing Transmission Line Requirements.	a. Map of Nepal Power System (Existing and Planned) b. Map Showing Transmission Line Requirements.
12.8	Access road and Others	a. Map Showing Access Road in scale 1:50,000	a. Access Road Map (Plan in scale 1:5000 and Profile in scale V1:500 & H 1:5000) b. Construction Schedule c. Charts related to Project Elevation.	a. Access Road Map (Plan in scale 1:5000 and Profile in scale V1:500 & H 1:5000) b. Construction Schedule c. Charts related to Project Elevation.

FORMAT – B: GUIDELINES FOR STUDY OF HYDROPOWER PROJECTS
Run-of-River Type
Capacity Range >10 MW ≤ 100 MW

S. No.	Study Items	Details of Study Requirements		
		Reconnaissance Study	**Prefeasibility Study**	**Feasibility Study**
1.	**TOPOGRAPHICAL SURVEYS AND MAPPING**			
1.1	Available Maps and Aerial Photographs	a. Collect and use available largest scale contour maps and aerial photographs of the project area. b. Enlarge by photogrametric method the available largest scale topo-map of the project area to 1:10,000 scale.	a. Collect and make use of available contour maps of the project area including those maps/sections/ profiles prepared during reconnaissance survey.	a. Topographical surveys and mapping that are expected to be carried out at pre-feasibility level correspond to the requirement of feasibility level. However, some augmentation of survey works for selected alternative may be needed, e.g., for setting up of additional geo-technical exploration locations and seismic refraction lines. These additional surveys and mapping should be compatible with the recommendations made for further survey and investigation by pre-feasibility level study. b. Make use of all available maps, aerial photographs, section / profiles and maps prepared during previous level of studies particularly of pre-feasibility level survey.
1.2	Topographical Survey	<u>If the project is dam type,</u> a. Conduct cross-section survey of potential dam sites of the project area with fixing of bench marks. b. Conduct survey to prepare contour plan covering alternative dam, powerhouse and tailrace sites, spilway areas, river diversion area and pondage impoundment area <u>If the project is diversion type,</u> a. Conduct longitudinal profile survey of the river stretch to cover potential alternative weir and powerhouse sites of the project area (better to start from an un-destroiable point at the confluence) showing the confluence point of rivulets/ streams in between. b. Conduct river cross section surveys of potential weir and powerhouse sites showing highest flood marks and existing water levels. This survey should be coordinated in a manner to locate the cross sections on the longitudinal profile of the river. <u>Note</u>: The objective of longitudinal survey being to determine level difference between headworks sites and powerhouse sites, traverse survey through terrain could also be applied.	a. Establish the control points and new benchmarks. b. Conduct leveling and traverse survey for tying the control points/ benchmarks with triangulation points of the national grid established by the Survey Department of HMG. c. Carry out topographical survey of the project area as a whole with 5 m contour interval and of the lcoation of major structural components with contour interval of 1 m. At least two most promising alternatives should be covered by topographical survey. The topographical survey should include the borrow areas, if the project is dam type. d. Strip survey of water conveyance route (canal, aquaduct, syphon) with detailed cross sections of cross drainage lying across the canal route (s) and the penstock route with coverage of most promising alternatives to produce maps in 1:2000 scale with 2 m contour interval. e. Surveys for setting out the boreholes, seismic refraction lines, test pits, trenches need to be carried out. f. River cross section survey should be carried out both at intake and tailrace sites covering at least 500 m upstream and downstream at each site. The interval should be 50 m to 100 m depending upon river conditions. High flood marks and existing water levels must be shown in the cross sections. The detailed cross-section survey of cross drainage works are also need to be carried out. g. The Survey should include Impoundment or daily pondage basin area.	a. Conduct strip survey of access road alignment with 5 m contour interval to produce map in 1:5000 scale with fixing of bench marks in an interval of 500 m and at major crossing drainage. locations b. Conduct surveys to cover additional areas if prefeasibility study has recommended for need of such surveys. c. Conduct walkover survey of transmission routes using available 1:25,000 scale topo-sheets to compare with socio-environmental hazards including forested areas to be crossed for potential alternatives.

S. No.	Study Items	Details of Study Requirements		
		Reconnaissance Study	**Prefeasibility Study**	**Feasibility Study**
1.3	Mapping and Plotting	If the project is dam type. a. Prepare contour plan in 1:10,000 scale with 5 or 10 m contour of the project area including impoundment area.. b. Prepare cross sections of potential dam sites. If the project is derivation type. a. Plot the river profile, plot the cross sections of potential weir sites. b. Based on walkover survey, locate approximately the potential desanding sites and forebay sites, make route alignment for waterways (canal/tunnel, penstock) using the topo-map enlarged by photogrametric method to scale say 1:10,000, from the existing largest scale contour maps.	a. Prepare contour plan in 1:5,000 scale with 5 m contour of the whole project area. All the features such as rocky cliff, slide zones, cultivated land, etc., must be shown in the contour plan. b. Prepare map in 1:1000 scale with 1 m contour interval of dam/ weir sites, river diversion sites, desanding basin sites, forebay/ pondage basin sites, penstock alignment and powerhouse sites and of canal/tunnel alignment in 1:2000 scale with 2 to 5 m contour. c. The map in 1:1000 scale should also include the area of spillway location of dam type powerhouse, if the spillway location falls in the terrain outside the main dam. d. Prepare map of daily pondage basin in 1;2000 with 2 m contour. If impoundment by dam the map should be in 1:5000 scale with 5 m contour interval.	a. Additional mapping and plotting will be required only if pre-feasibility study has recommended for such works. b. Prepare access route map in scale 1:5000 with 5 m contour interval and cross-section along bridge/ culverts lying in the road alignment. The profile should be plotted in a scale of V 1:500 and H 1:5000.
2	**HYDROLOGICAL AND SEDIMENTATION STUDIES**			
2.1	Hydrology	a. Assess the mean monthly flows and determine the flow of 90% probability of exceedence. b. Carry out a discharge measurement at the headworks site during the driest period of the flow. c. Carry out a cross-section survey at the intake site covering the highest flood mark. d. Assess the peak flood discharge. e. Determine if there is any glacier lake in the catchment through map study.	a. Collect the long term historical rainfall data and climatological data pertinent to the study area. b. Collect the long term historical flow data and sediment data of the river under study, if available; if not, collect the data from other river with similar hydrological characteristics in the vicinity. c. Assess the mean monthly flows. d. Develop a flow duration curve. e. Establish a gauging station at the intake site and start collection of data. f. Carry out discharge measurements at the intake site. g. Estimate the design floods for the structures for the return periods of 50, 100, 200, 500 and 1000 years. h. Conduct flood frequency analysis for the period October to May for ascertaining diversion flood. The frequency of diversion flood should be 1 in 20 years. i. Carry out three cross-section surveys at the headworks site and three at the tailrace site covering the highest flood marks. j. Compute the peak flood discharge corresponding to the flood marks at the intake site and tailrace site. k. Develop rating curves for the intake site and tailrace site. l. Assess the potentiality of GLOF in the catchment, if any.	a. Review the study made on pre-feasibility level and collect the additional data if any. b. Check the consistency of data. c. Continue collection of data from the gauging station established during the pre-feasibility level study. d. Check the flow data with the rainfall data and generate long series of flow data if required. e. Install a cable way at the intake site wherever necessary for discharge measurement. f. Carry out regional analysis. g. Update the flow data and assess accordingly the mean monthly flows and develop an upgraded flow duration curve. h. Carry out discharge measurements intensively during the rainy season (June to September) to cover the peak floods at the intake site and a reasonable numbers during other months (October to May) i. Check these measured data with the previous rating curve and upgrade it, if necessary. j. Carry out discharge measurements at the tailrace site and update and upgrade the rating curve for this site. k. Update and upgrade the design flow for power generation. l. Update and upgrade the design floods computed during the pre-feasibility level study and determine the flood for 10,000 years return period. m. Update and upgrade the diversion floods computed during the pre-feasibility level study. n. Carry out three cross-section surveys at the headworks site and three at the tailrace site covering the highest flood marks, preferably at the same locations as of the pre-feasibility study so that any change in the cross-sections can be observed if occurred, and check the magnitude of flood peaks with the previous ones. o. Update and upgrade the rating curve for the tailrace site. p. Carry out the water quality analysis to determine the corrosive effectiveness (hardness). q. Collect the information on GLOF events in the past and assess the magnitude of the potential GLOF, if any.

S. No.	Study Items	Details of Study Requirements		
		Reconnaissance Study	Prefeasibility Study	Feasibility Study
2.2	Sediment	a. Identify in which zone of sedimentation the catchment lies, high, medium or low.	a. Estimate the sediment load in the river.	a. Collect sediment samples daily during the rainy season (June to September) and a reasonable numbers during other months (October to May) so that a rating curve for the sediment concentration against the discharge could be drawn. b. Analyze the sediment samples to evaluate the volumes and characteristics of solid material transportation including particle size distribution, petrographic analysis (hardness) to determine the hardness of particles, particle size and the nature of material entering the power waterways. c. Compute the daily sediment load and assess the annual load in the river. d. Check this figure with the data collected from the secondary sources.
3.	**GEOLOGICAL / GEO-TECHNICAL, CONSTRUCTION MATERIAL AND SEISMICITY**			
3.1	Geological and Geo-technical			
3.1.1	Regional Geological Study	a. Collect and review available literatures, topographical, geological maps, geological sections and aerial photographs. b. Prepare a report on regional geology and structure. c. Prepare maps with plan and section in 1:50,000 scale	a. Collect and review available literatures, topographical, geological maps, geological sections and aerial photographs. b. Review reconnaissance report to up date and prepare a report on regional geology and structure . c. Prepare maps with plan and section based on field observation in 1:25,000 scale	a. Collect and review available literatures, topographical, geological maps, geological sections and aerial photographs. b. Review prefeasibility report to up date and prepare a report on regional geology and structure. c. Prepare maps with plan and section in 1:25,000 scale. d. Conduct field survey for verification
3.1.2	General Geology and Geomorphology of the Project Area	a. Prepare a report on general geology and geomorphology of the project area.	a. Prepare a report on general geology and geomorphology of the project area. b. Prepare maps with plan and section in 10,000 scale.	a. Prepare a report on general geology and geomorphology of the project area. b. Prepare maps with plan and section in 1:5000 scale.
3.1.3	Detailed Geology and Geomorphology of Particular Sites	a. Prepare a report on geology and geomorphology of each site based on field observations.	a. Conduct a detailed geological and geo-morphological survey of particular site such as intake, desander, canal, surgetank, penstock, powerhouse and tailrace. Map should prepared in 1:2000 scale.	a. Review pre-feasibility report to update the detailed geology and geomorphology of the particular sites and conduct additional survey of particular sites such as intake, desander, canal, surgetank, penstock, powerhouse and tailrace access and transmission line and prepare maps and sections in 1:2000 scale for design requirements.
3.1.4	Discontinuity Survey			a. Conduct a discontinuity survey such as bedding/ foliation planes, lithological contacts, major and minor joints, faults, thrusts and folds. b. Conduct a discontinuity analysis by computer or other method to define major orientations. Prepare analytical results in graphical format. c. Prepare rock mass classification for each underground structure.

S. No.	Study Items	Details of Study Requirements		
		Reconnaissance Study	**Prefeasibility Study**	**Feasibility Study**
3.1.5	Geo-technical Investigation		a. Excavate test pits and collect samples for laboratory analysis to access nature of soil at intake, desander and powerhouse sites. b. Perform SPT and permeability tests in each test pit to know the strength and permeable nature of soil at intake, desander and powerhouse sites. c. Perform seismic refraction or resistively survey for overburden thickness and nature of soil strata at intake, desander, surgetank, powerhouse and tairace sites. d. Perform drilling and logging at weir and powerhouse sites. e. Perform laboratory analysis such as sieve and sedimentation, Atterberg limits, natural moisture content and specific gravity of collected samples for physical properties.	a. Perform drilling and logging at weir diversion, intake, surgetank and powerhouse sites. b. Perform permeability and grout intake tests in each drill hole to know permeable nature of rock at weir, diversion, intake and desander sites. c. Perform additional seismic refraction or resistively survey to know depth to bedrock, overburden thickness and nature of soil strata at intake, desander, surgetank, powerhouse and tairace sites. d. Perform laboratory analysis for soil and rock laboratory test such as (I) sieve and sedimentation, (ii) Atterberg limits, (iii) Natural moisture content and (iv) specific gravity of collected samples for physical properties of soil. e. Laboratory test (i) triaxial compressive strength test (ii) uniaxial ultimate compressive stength test, (iii) point load tensile strength test, (iv) Los Angeles abrasion test (v) crushing value test (vi) Impact test (vii) specific gravity test (viii) swelling pressure test and (ix) Alkali aggregate reaction test for rock.
3.2	Construction Material Survey			
			a. Identify and investigate borrow areas and quarry sites for the construction materials such as impervious soils, stones, sand and gravel etc. as required. b. Excavate test pits and log the pit to understand the nature of soils at borrow areas and collect samples for laboratory analysis. c. Collect rock samples from bedrock exposures for laboratory analysis. d. Perform laboratory analysis for soils and rocks. e. Make an estimation of available quantity at each borrow area for the construction.	a. Identify and investigate borrow areas and quarry sites for the construction materials such as impervious soils, stones, sand and gravel etc. as required. b. Review construction material study reports and update for the feasibility. c. Excavate additional test pits if required and log the pit to understand the nature of soils at borrow areas and collect samples for laboratory analysis. d. Perform laboratory analysis by seiving and sedimentation, Atterberg Limits, natural moisture content and specific gravity etc for soil samples. e. Collect rock block samples from each quarry site for laboratory tests f. Perform laboratory tests such as uniaxial compressive strength, point load, Los Angeles abrasion, aggregate crushing value, alkali reactivity and specific gravity etc tests on rock samples. g. Make an estimation of available quantity after defining the quality of the materials at each borrow area for the construction.
3.3	Seismological Study			
3.1.1	Tectonic Setting	a. Background information on regional tectonics of the project area and surrounding region are required to be addressed and illustrated in a map.	a. Information on tectonic features of the project area and adjoining regions representing 200 km radius should be used and shown in a map.	a. Tectonic characteristics of the project area and surrounding regions covering 200 km radius should be stated and depicted in a map. b. Information should be specific in respect of identification of the sources of earthquake generation and assessment of the project site in terms of seismic safety.
3.1.2	Aerial Photos and Remote Sensing Interpretation	a. General studies of aerial photos and landsat images should be performed to review tectonics features.	a. Information gathered from studies of aerial Photos and landsat images should be indicated.	a. Interpretation of aerial photos and landsat images should be critically carried out to verify and review the tectonic features of the surrounding regions including the neo-tectonics.

S. No.	Study Items	Details of Study Requirements		
		Reconnaissance Study	Prefeasibility Study	Feasibility Study
3.3.3	Fault and paleo Seismicity		a. Information on different fault characteristics should be presented	a. Faults existent around the project area should be stated in terms of their activity nature such as active, capable or inactive. b. Respective length, distance, return period and reoccurrence nature should be addressed. Characteristic of rupture age of the most recent deformation and consistency of the epicenters with associate fault should be suggested. c. Existing information on paleo-seismicity evidences representing pre-historic major earthquakes occurred during the past years should be presented.
3.3.4	Earthquake Catalogue and Historical and Instrumentally Recorded Earthquakes		a. Information on regional seismicity should be presented and depicted in a map at suitable scale.	a. The earthquake catalogue on historical and instrumentally recorded seismicity data representing magnitude 4 M and above should be delivered and shown in map. b. For each significant events, the location, distance, recurrence, magnitude and intensity should be reflected.
3.3.5	Seismic Zoning			a. Representation of the project area in reference of the seismic zoning of the country should be discussed. b. Characterization of various earthquake sources inherent in this zone need to be determined.
3.3.6	Seismic Hazard Analysis			a. Attenuation law based on the controlling earthquake which caused the greatest ground motion should be established. Its likely affect at the site should be expressed in terms of intensity or acceleration. The greatest earthquake which may effect an installation during lifetime or the maximum earthquake likely to occur during the project life should be addressed. b. The probability of exceedence for different level of intensity or acceleration of the ground motion at the site during a particular period of time should be expressed. c. The peak ground acceleration (PGA) for Maximum Design earthquake (MDE) and Operating Basis Earthquake (OBE) should be recommended. Empirical laws may be applied as necessary. d. Risk assessment in consideration of ground movement, dislocation and rock shattering of fault, ground creep, landslide and rock fall due to earthquake should be taken into account.

S. No.	Study Items	Details of Study Requirements		
		Reconnaissance Study	**Prefeasibility Study**	**Feasibility Study**
4.	**SELECTION OF PROJECT CONFIGURATION**			
		Desk Study: a. Most promising site should be selected for the study. b. Several alternative schemes of the selected site should be identified. Field Study: a. Preliminary field investigation should be carried out to assess the topographical, geological and hydrological conditions of the site. Selection of project configuration: a. Locations and types of the structures should be decided on the basis of actual site conditions after field study. A preliminary comparison of the alternative scheme should be carried out to select the technically best scheme.	Access Road a. Alternative routes of access road from the nearest road head to the project site should be compared and the best option should be selected. Study of Alternatives i) Alternative Schemes a. Alternative schemes for the selected site should be compared for selecting the best scheme. ii) Weir and Intake a. Alternative locations and types of weir and intake should be studied at suitable topographical sites. The best location should be selected on the basis of better geological conditions. In this stage surface geological data should be used. Iii) Desander a. Alternative desander locations should be studied comparing topographic and surface geological conditions. iv) Water Conveyance (Canal/ Tunnel) a. Alternative canal/ tunnel alignments on both river banks should be compared. v) Forebay / Surgetank a. Alternative forebay/ surgetank sites should be studied. The site with favourable topography and good surface geology should be selected. vi) Penstock (Surface / Underground) a. Several penstock alignments should be compared. The alternative with good surface geology and short length of penstock should be selected. If surface penstock is not possible, then underground penstock should be studied. vii) Powerhouse a. Alternative locations of powerhouse should be studied. Topographic and geological conditions should decide the best location. Based on the alternatives studied here above, the project configuration is selected for the final feasibility study level layout and design	1. Access Roads: Following access roads should be used a. Access Road to Project b. Access Road to Headworks c. Access Road to Powerhouse d. Access Road to Surge Tank e. Alternative routes of access roads should be studied and the best option should be selected. 2. Study of Alternatives (i) Diversion and Intake a. Alternate locations of diversion weir and intake should be explored together with the location for desander. b. The option with less excavation and slope stabilization measures with good geological conditions should be selected. (ii) Desander a. Selection of type of desander should be done analyzing various systems used for flushing desanding basins. The role of the power plant in the system and actual site conditions for flushing should be taken into consideration for selecting the proper type of flushing the desander. (iii) Surge Tank / Forebay a. Alternative locations of surge tank/ forebay should be studied. b. Sufficient rock cover for surge tank should be provided. c. Surge tank with opening at the top may be used due to topography and geology of the site. d. Forebay will require favourable topography and good geology. (iv) Powerhouse a. Alternate locations of powerhouse (underground and surface) should be studied. b. Generally underground location of powerhouse will be acceptable if the rock quality is good inside. Underground powerhouse should be preferred if there is a potential danger from GLOFs or river blocking by land slides at upstream reaches of the rivers. (v) Pressure Tunnel Versus Surface Penstock a. Both alternatives should be studied. b. Surface penstock should be acceptable if gradient of penstock alignment is $\leq 45^o$ and the geological conditions are favourable. c. Pressure tunnel will be necessary if penstock gradient is more than 45^o and surface geology is not good. d. Cost comparison of both alternatives should be done. 3. Selected Alternatives a. Determine number of alternatives within the range of installed capacities.

S. No.	Study Items	Details of Study Requirements		
		Reconnaissance Study	Prefeasibility Study	Feasibility Study
5.	**OPTIMIZATION STUDIES**			
		Optimization studies at this stage of study are not required.	Speaking of optimization at this stage is premoture. But the basic parameters of the project should be determined as follows: i) Installed Capacity a. A preliminary assessment of the installed capacity should be carried out on the basis of capacity factor of the system. ii) Daily Pondage for Peaking a. If the hydropower station is planned to operate as a peaking plant the reservoir storage volume to generate peaking energy for minimum of 4 hours depending upon topographic conditions should be determined. b. The weir/dam height should be determined to accommodate the live storage and dead storage. iii) Optimum Number of Units a. Optimum number of generating units should be determined considering the transportation limitations to the remote hilly areas for heavy machinery. b. Number of units should be taken as minimum as possible from the point of view of reliability of operation of the plant and maximum utilization of the hydraulic energy of the river in dry season.	1. Objective & General Approach The main objective of the optimization study should be: a. To determine the optimum installed capacity of the project. b. To determine the optimum levels of the pondage for generating required peak power. c. To determine the optimum number of generating units for the selected installed capacity. The general optimization procedure should be as follows: a. Determination of economic size according to established empirical formula. b. Selection of a range of sizes to define the trend of the results of the optimization analysis. c. Conceptual design of each alternative. d. Estimation of cost and benefits for each alternative. e. Selection of optimum size. 2. Range of Options for Optimization a. Nearly 6 or 7 alternatives with installed capacities with a wide range covering the plant discharge of 90% exceedence of probability to 40% exceedence of probability at an equal increment of capacity (say 5 MW or 10 MW) should be considered for optimization studies. 3. Determination of Storage a. Reservoir storage required to produce peaking energy for six hours in a day should be determined for each installed capacity. b. The storage volume required for each alternative should be determined. 4. Conceptual Layout and Sizing a. A preliminary layout of the project for the base case should be prepared. b. Preliminary layout of the headworks should include a weir, an intake, a desander and tunnel intake. Preliminary layout of water conveyance system (canal/tunnel), powerhouse complex and tailrace channel should be prepared. c. For all the other alternatives, sizing of the various elements should be determined by pro-rating from the base case. d. Main project parameters like canal size (tunnel diameter), forebay size (surge tank dimensions), penstock pipe (steel line tunnel diameters) should be optimized for all alternatives using the procedures described above. e. Certain project parameters, which are independent of the project size like transmission line and access road should be taken as constant for each alternative.

S. No.	Study Items	Details of Study Requirements		
		Reconnaissance Study	**Prefeasibility Study**	**Feasibility Study**
6.	**PROJECT DESCRIPTION AND DESIGN**			
		a. Conceptual design of the structures should be carried out. b. Volume of civil works should be estimated tentatively. c. Preliminary selection of turbines and generators should be carried out. d. Brief description of the structures and electro-mechanical equipments should be provided	i) General Layout a. The general layout plan of the selected scheme with optimum installed capacity should be described. ii) Civil Structures Design and description of the following structures for the selected option of installed capacity should be provided: a. Diversion structures (cofferdams, diversion channel/ tunnel), b. Weir /dam, c. Emergency spillway, d. Under sluice, e. Side intake, f. Desilting basin, g. Power canal / tunnel, h. Forebay /surge tank, i. Penstock, j. Powerhouse, - Tailrace Switchyard (civil) iii) Electro-mechanical Equipment a. Mechanical equipments: - Preliminary selection of type and dimension of turbines should be carried out. A brief description of turbine auxiliaries should be provided. b. Electrical Equipments: - Parameters of the generators should be determined. A brief description of exicitation and electrical auxiliaries should be provided. c. Single line diagram: - An electrical single line diagram showing the major electrical equipments of powerhouse should be prepared	1) Project Layout a. A description of the general arrangement of the main structure determined from the optimization of individual structures and the optimization studies should be provided. 2) General Arrangement of Headworks a. A description of general arrangement of headworks comprising weir, intake and desander should be given. Geology and Foundation Conditions a. A geological map of the headworks area and a geological section along the weir axis with desander should be provided. b. Geology and foundation conditions at headworks area should be described in detail. Analysis of the results of seismic refraction survey and drillings should be done. Diversion During Construction a. A general plan to divert the river in dry season in order to carryout the construction works at weir site and intake site should be prepared, which may require several dry seasons. Diversion Channel A diversion channel (tunnel) should be designed to pass a 1 in 20 years dry season flow. Cofferdams a. An upstream cofferdam should be designed blocking the river to divert the river flow to the diversion channel thus protecting the construction area of weir and intake. b. A downstream cofferdam should also be designed at a proper location to block the river flow discharged from diversion channel from entering the construction area at the downstream site of weir/ spillway/ stilling basin. Pondage Requirements Pondage volume should be fixed based on the following constraints:: a. The Minimum Operating Level (MOL) should be fixed based on the flushing requirements of the desanding structure which will set the minimum elevation of the intake from the river. b. The volume required to maintain a minimum of 4 hours (if terrain permits) of operation of the plant at full capacity during peak load. Gated Overflow Weir with Stilling Basin Design Criteria and Description of Structure a. Provision of gates (radial) in the spillway should be made for the regulation of required pondage volume. b. The elevation of the spillway crest should be determined. c. The flushing gates on the spillway crest should be sized to pass a 1 in 100 year flood. Stalsility analysis should be carried out for 1 in 200 years flood. d. A stilling basin should be designed for energy dissipation before releasing spillway flows back into the river. e. Design of fish ladder should be provided for the movement of the fish over the structures at the left/ right abutment of the gated weir.

S. No.	Study Items	Details of Study Requirements		
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				<u>Desander Intake</u> a. The intake should pass the design flow. b. The desander intake should be designed consisting of at least two gates, trashracks and stoplogs. c. The elevation of the intake and the sizing of the gates should be determined. <u>Desanding Basin and Flushing Structure</u> <u>Design criteria</u> The following criteria should be adopted in the design of desander with the determination of basic parameters: a. Design flow. b. Number of units available during monsoon. c. Number of bays in desander d. Particle size to be settled e. Flow through velocity, V f. Fall velocity, w g. Design depth of flow in desander, h. Net desander length. i. Width of each bay j. Maximum operating level. k. Minimum operating level. l. Desanding basin and flushing conduit gradient <u>Description of Structure</u> <u>Desanding basin</u> a. A description of the structure of desanding basin should be given, consisting of inlet channel, number of bays, dimensions and longitudinal slope, elevations at the upstream and downstream ends etc. <u>Flushing structure</u> a. Types of flushing should be described and consequently the structure needed for it. b. Description of flushing conduits with the flushing gates should be provided. c. The flushing process should be described. <u>Emergency Overflow Weir</u> a. An emergency overflow weir should be designed at the end of desanding basin. It should be capable to discharge the turbine flow at the end of the spillway stilling basin. <u>Power Intake</u> a. Design of intake should be carried out setting in the invert elevation to maintain a minimum submergence. <u>3) Hydro-mechanical Equipment</u> <u>Desander Intake Gate</u> a. Vertical lift gates should be provided determining their sizes to control inflows to the desander. b. A set of stoplogs should be provided for the maintenance of gate guides.

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				<u>Flushing Gates</u> a. Roller gates should be provided at the end of flushing conduits. Size of the gates should be given. <u>Desander Outlet Stoplogs</u> a. One set of stoplogs should be provided before the power tunnel intake. b. One set of stoplogs should be provided before the flushing gates. 4) <u>Power Tunnel</u> i) <u>General</u> a. A general description of the power tunnel should be provided specifying the design discharge. b. Configuration of the power tunnel should be given, comprising headrace tunnel and pressure tunnel with lining types, finished diameter and length. ii) <u>Headrace Tunnel</u> a. Optimization of the tunnel diameters should be carried out. b. Head losses through the tunnel system at the design flow should be determined. c. Lining and rock support types along the tunnel alignment should be described. <u>Rocktrap</u> a. A rock trap should be provided at the end of the headrace tunnel, upstream of the surge tank to trap loose rocks and displaced shotcrete. iv) <u>Surge Tank</u> a. Description of the surge tank with its dimensions should be provided. b. The invert level of the surge tank and the height of the surge tank should be indicated. v) <u>Dropshaft (if surface penstock is not possible)</u> a. Concrete lined vertical dropshaft should be designed in the downstream of surge tank. Dimensions of the dropshaft and thickness of the concrete lining should be determined. vi) <u>Penstock Tunnel (if surface penstock is not possible)</u> a. Designing of penstock tunnel should be carried out. The penstock tunnel should comprise of two sections concrete lined tunnel and steel lined tunnel. Dimensions of these tunnel sections should be determined. <u>Construction Adits</u> a. Provision of construction adits should be made at various locations of tunnel alignment in order to meet the construction schedule.

S. No.	Study Items	Details of Study Requirements		
		Reconnaissance Study	Prefeasibility Study	Feasibility Study
				5) Power House i) General Arrangement a. Description of the general arrangement of the powerhouse complex should be provided. Location of the powerhouse, access to the site, slopes, location of the switchyard etc. should be described. ii) Description of Powerhouse a. Description of the powerhouse building should be provided giving details of equipments layout at generator floor level, turbine floor level and drainage floor level. Dimension of powerhouse should be determined. b. Provisions of the layout of the following equipments inside the powerhouse should be made: turbines, generators, powerhouse crane unit, control panels and excitation system, control room, battery room, main inlet valve, provision for runner removal for maintenance, station service transformer, etc. iii) Geology and Foundation Condition a. The geology and topography of the powerhouse area should be described in detail. iv) Tailrace a. The design of tailrace should be carried out to pass the discharge from turbines to the river. Dimension of tailrace should be determined. 6) Mechanical Equipment a. Description of the following items should be provided: - Unit Selection - Mode of Operation - Design Criteria b. Rating conditions should be determined. Following turbine characteristics should be provided. - Rated net head - Rated flow - Rated Turbine Efficiency - Turbine rated output - Rated speed (synchronous) c. The physical dimensions of the unit should be determined as follows: - Runner outlet diameter - Runner crown diameter - Spiral case inlet diameter - Draft tube outlet cross-section - Submergence below minimum TWL. Description of Turbine a. Description of the turbine should be provided with its parts and accessories.

S. No.	Study Items	Details of Study Requirements		
		Reconnaissance Study	Prefeasibility Study	Feasibility Study
				<u>Turbine maintenance</u> a. Yearly maintenance of the turbine should be described. Runner removing for maintenance without removing generator stator should be explained. <u>Governor</u> a. Type and capacity of the governor should be determined. Hydraulic pressure system of the governor and its interconnection with other equipments should be described. <u>Main Inlet Valve</u> a. Type and dimension of the main inlet valve should be determined. Location of the valve should be identified. <u>Main Powerhouse Crane</u> a. An overhead travelling crane should be provided in the machine hall, which should be capable of lifting the heaviest parts of the equipments, like generator rotor and twine runner. <u>Gates</u> a. Draft tube gates, and tailrace gates should be described with hoisting facilities. Following pertinent data related to the gates should be provided: - Maximum Water Level - Sill Elevation - Top of Gate - Span - Height - Maximum head on Sill - Number of Gates. <u>Drainage and De-watering System</u> a. The station drainage system and unit de-watering system should be provided. Description of both system should be provided with necessary equipment for de-watering. <u>Upstream Water conveyance De-watering System</u> a. For maintenance and inspection of the water conveyance system upstream of inlet valve including headrace tunnel, surge tank, dropshaft, penstock, a de-watering system should be provided. The description of this system with the procedure of de-watering should be given. <u>Cooling Water System</u> a. Cooling water needs inside the powerhouse should be provided. The sources of cooling water with tapping and filters should be described. <u>Compressed Air System</u> a. The High pressure Air System and Low Pressure Air System should be described with the necessary compressors and other accessories. Location of the equipments should be identified. <u>Oil Handling System</u> a. The following system of oil should be provided: - Lubricating oil for bearing - Oil for hydraulic system of governor a. Both the system with oil purification and storage facilities should be described. Treatment of transformer oil should also be described.

S. No.	Study Items	Details of Study Requirements		
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				<u>Ventilation System</u> a. Ventilation requirements of all the floor levels inside the powerhouse should be determined. Necessary equipments for it should be selected and their location should be identified. <u>Fire Protection System</u> a. Various options of fire water supply should be studied and both the high and low pressure fire water should be provided. b. Water deluge system for transformer and oil storage room should be described. c. Inside the powerhouse a low pressure firewater system should be provided. d. Fire protection of generators should be provided. e. Fire fighting equipment to protect the control room should be described. 7) Electrical Equipment <u>Generator, Excitation and Ancillaries</u> Description of the generators, excitation system with ancillaries should be provided. Dimension of the generator should be determined. Following parameter of generator should be determined: a. Number of Units b. Rating c. Power Factor d. Normal Capability e. Cooling f. Synchronous Speed g. Number of Poles h. Frequency i. Rated Voltage j. Neutral Grounding <u>Generator Associated Equipment</u> a. The transition cubicle of generator 11 kV switch gear, bus bas, potential transformers, neutral cubicles and associated equipment should be described. <u>Main Unit Power Transformers</u> a. Three single phase transformers or one three phase transformer should be selected after thorough comparison. b. Following basic parameters of the transformer should be determined: - Rating - Cooling - Primary Voltage - Secondary voltage - Vector group - Frequency - Taps - Impedance <u>Powerhouse Unit AC Auxiliaries</u> a. AC auxiliary for essential services of powerhouse should be described with the selection of equipments. The essential auxiliaries should consist of governor oil pumps, turbine and lubrication oil system, the transformer cooling water pumps, and the excitation system.

S. No.	Study Items	Details of Study Requirements		
		Reconnaissance Study	Prefeasibility Study	Feasibility Study
				<u>AC Auxiliaries for Common Services</u> The common auxiliary services regarded as non-essential common services should serve the following equipments: a. PLC-power line carrier equipment b. Lighting c. De-watering pumps d. Governor air compressors and battery charges e. Station crane f. Majority of air conditioners g. Compressed air h. Oil filtering equipment <u>DC Powerhouse Auxiliaries</u> a. The DC supply system should be provided by the battery sets, one set being main and the other redundant. b. For control, protection and emergency lighting 110 V DC should be used and for communication system 24 V or 48 V DC should be used. <u>Emergency Diesel Generator</u> a. One emergency diesel generator with sufficient capacity should be provided in case of failure of the system or power failure. Location of the generator should be identified in powerhouse. <u>Distribution to Outlying Works</u> a. Power supply should be provided to the: Lighting at powerhouse area, switchyard and headworks. Power for the headworks and tailrace. <u>Distribution to Housing Complex</u> a. Electric supply to the housing complex near the powerhouse area should be provided. A separate LT line (400/230 V) should be planned. <u>Control and Protection</u> a. A control room should be located inside the powerhouse, from where it should be possible to control the units and the auxiliary systems. <u>Grounding</u> a. Adequate grounding should be provided inside the powerhouse and switchyard to provide low resistance grounding and to assure the proper oepation of the protective relay system. <u>Construction Power</u> a. Construction power needed for the project should be estimated. b. Alternative for the supply of construction power to the project should be studied. The reliable alternative should be selected. <u>Single Line Diagram</u> a. Load flow analysis should be carried out. b. An electrical single line diagram should be prepared.

S. No.	Study Items	Details of Study Requirements		
		Reconnaissance Study	Prefeasibility Study	Feasibility Study
7.	ENERGY COMPUTATION AND BENEFIT ASSESSMENT			
				1. Energy Computation Energy computation should be based on: a. Reference hydrology (average flow) for average annual energy 90% reliable average monthly flow in the lowest flow month for firm energy. b. Assumed design parameters (net head, turbine discharge, installed, consideration of compensation flow, installed capacity). Secondary energy is computed as average annual energy minus firm energy. Secondary energy available on monthly basis should also be presented. 2. Benefit Assessment There are two kinds of benefits accruable capacity and energy. Energy benefit could further be splited into firm energy and secondary energy benefits. Values for power and firm energy benefits should be based either on generation costs of other potential similar size hydropower projects in Nepal considering hydropower in the cheaper alternative than others (i.e., LRMC of hydro-generation in Nepal) or on perverting selling price to NEA under Power Purchase Agreement. For Secondary energy at the most thermal, fuel displacement value could be taken. In no case, the values for capacity benefit should exceed the value of dry season peaking capacity.
8.	COST ESTIMATE			
8.1	Criteria and Assumptions	All the criteria, assumptions adopted for Cost Estimation should be mentioned.	All the criteria and assumptions adopted for cost estimation should be mentioned including following: a. Consideration of the natural conditions prevailing at the site, construction scale, and levels of construction technology available in Nepal. b. To the extent possible, construction equipment available in Nepal should be used. c. A brief description of project with location should be mentioned. d. Year and month of the cost estimate should be mentioned. e. Exchange rate applied to calculation of NRs. and US$ adopted at the time of cost estimation should be mentioned. f. Identifiable Nepalese taxes, custom duties, royalties etc. for goods, materials and services, interest during construction etc whether included in cost estimation or not should be mentioned. g. Any source of references of rates or estimation should be mentioned with used escalation factors if any.	

S. No.	Study Items	Details of Study Requirements		
		Reconnaissance Study	Prefeasibility Study	Feasibility Study
8.2	Estimating Methodology	1. The following methodology should be applied for estimation of cost of each component of the project. a. For Civil Works: The cost estimate should base upon conceptual design and rates of major components. The rates of major civil works can be derived from rates of similar nature of ongoing project, form cost database with suitable modifications or generalized cost curves available if any. The cost estimation should focus on major items/only rather than preparing detailed estimate. The estimate should also include major indirect costs in percentage basis derived from similar projects. b. For Generating Equipment: The cost estimate for generating equipment could be based on cost database with suitable modification, or from any cost curves or from other project of similar nature. c. For Hydraulic Steel works: The cost estimate for generating equipment could be based on cost database with suitable modification, or from any cost curves or from other project of similar nature. d. Transformers, switchyard and Transmission Line The cost of transformers and switchyard could be based on capacity. The rates for these items could be based on generalized cost curves or from other project of similar nature. Tentative length of transmission line can be derived from available map. The unit cost can be adopted from current rates used by Nepal Electricity Authority for same type of transmission lines. e. Land Acquisition and Access Road: Costing of land acquisition can be derived from reconnaissance field visits. The length and type of access roads to be constructed or improved can be determined from field visit and available maps. Cost per km of different roads can be used to determine the cost of access road. f. Resettlement/ Rehabilitation and Relocation: Tentative area of resettlement, rehabilitation and relocation can be derived from reconnaissance field visit area. Costing can be derived from prevailing market rates. 2. Following costs are to be added to obtain total capital cost of the project: a. Engineering, management and administration (8%) b. Owner's Cost (2%) c. Contingencies added to account for unforeseen cost increase due to uncertainties in site conditions and inadequacy of study levels for civil works by 25%, since cost of minor items would not be taken into account at this stage, while for generating equipments and transmission lines by 10%.	The following methodology should be applied for estimation of cost of each component of the project. a. For Civil Works: The cost estimates should be based on unit rates developed from prevailing labour rate, construction equipment rate and materials taking also into account the local situation and bill of quantities derived from design drawings. The cost estimate should be done by breaking down major structures into number of distinct construction activities or measurable pay items. Due consideration should be given to local labors. The rates for locally available labors can be obtained from 'District rates' of concerned districts and can be used after appropriate adjustments. The rates of skilled labors available around project area or within Nepal can be obtained from general inquiries and references of other projects. The rates for skilled expatriates can be obtained from reference of other projects or from publication like ' International Construction Contractors.' The rates of construction equipment can be taken from regularly updated cost data, quotation from the suppliers/ manufacturers. The construction material to be used for construction work should be divided into - Materials locally available - Materials to be imported from India - Materials to be imported from Overseas The rates of construction materials should be derived accordingly as their source of supply. While calculating the construction materials rate, sufficient attention should also be given to mode of transportation and their corresponding costs should also be included. When access roads for the project is not built (generally for small hydropower projects) the cost of air transportation for transporting heavy equipment from nearest town to the project area should also be included.	The methodology for pre-feasibility level study should be applied, but should be based on feasibility level design with inclusion of items not included in pre-feasibility level study. a. For Civil Works: The cost estimates should be based on unit rates developed from prevailing labour rate, construction equipment rate and materials taking also into account the local situation and bill of quantities derived from design drawings. The cost estimate should be done by breaking down major structures into number of distinct construction activities or measurable pay items. Due consideration should be given to local labors. The rates for locally available labors can be obtained from 'District rates' of concerned districts and can be used after appropriate adjustments. The rates of skilled labors available around project area or within Nepal can be obtained from general inquiries and references of other projects. The rates for skilled expatriates can be obtained from reference of other projects or from publication like ' International Construction Contractors.' The rates of construction equipment can be taken from regularly updated cost data, quotation from the suppliers/ manufacturers. The construction material to be used for construction work should be divided into - Materials locally available - Materials to be imported from India - Materials to be imported from Overseas The rates of construction materials should be derived accordingly as their source of supply. While calculating the construction materials rate, sufficient attention should also be given to mode of transportation and their corresponding costs should also be included. When access roads for the project is not built (generally for small hydropower projects) the cost of air transportation for transporting heavy equipment from nearest town to the project area should also be included.

S. No.	Study Items	Details of Study Requirements		
		Reconnaissance Study	Prefeasibility Study	Feasibility Study
			From labor cost , material cost and equipment cost the direct cost per unit of construction activity can be calculated The estimate should be of contractor's type and, therefore, should also include all other indirect costs such as office overhead, contractor's financing cost, insurance, bonds, profit and risk margin. A suitable percentage for contractor's expenses should be allocated. The total percentage should be used as a bid factor on direct cost. Thus calculated direct cost can be used to derive unit bid costs which in turn, be used to determine the total civil works cost. b. For Generating Equipment: The cost estimate for generating equipment should either be based on quotations obtained from suppliers or in-house estimate using established current international prices/ relationships. The cost should include cost of control devices/ system, auxiliary etc. transportation and erection. c. Hydraulic Steel Works: The cost of hydraulic steel works should be based on quotation of suppliers or on market price if they are locally available. Transportation cost should also be added. d. Transformers, Switchyard and Transmission Line: The cost of transformer and switchyard could be based on capacity, while for estimate of cost of transmission line can be calculated from per km rates of transmission line. References of cost can be taken from current rates used by Nepal Electricity Authority for same type/ voltage of transmission lines taking into account different types of towers required, the conductors and types of terrains being crossed. e. Land Acquisition and Access Road: Due attention should be given to costing of land acquisition and construction of access road as well. The length and type of access roads to be constructed or to be improved can be determined from preliminary design. Cost per km of different types of roads can be used to determine the cost of access road. f. Camp and Other Facilities: The costs of construction camps and permanent buildings required for operation and also of construction power facilities required should be included in cost estimation. A lump sum amount for this can be allocated depending upon magnitude of project.	From labor cost , material cost and equipment cost the direct cost per unit of construction activity can be calculated The estimate should be of contractor's type and, therefore, should also include all other indirect costs such as office overhead, contractor's financing cost, insurance, bonds, profit and risk margin. A suitable percentage for contractor's expenses should be allocated. The total percentage should be used as a bid factor on direct cost. Thus calculated direct cost can be used to derive unit bid costs which in turn, be used to determine the total civil works cost. b. For Generating Equipment: The cost estimate for generating equipment should either be based on quotations obtained from suppliers or in-house estimate using established current international prices/ relationships. The cost should include cost of control devices/ system, auxiliary etc. transportation and erection. c. Hydraulic Steel Works: The cost of hydraulic steel works should be based on quotation of suppliers or on market price if they are locally available. Transportation cost should also be added. d. Transformers, Switchyard and Transmission Line: The cost of transformer and switchyard could be based on capacity, while for estimate of cost of transmission line can be calculated from per km rates of transmission line. References of cost can be taken from current rates used by Nepal Electricity Authority for same type/ voltage of transmission lines taking into account different types of towers required, the conductors and types of terrains being crossed. e. Land Acquisition and Access Road: Due attention should be given to costing of land acquisition and construction of access road as well. The length and type of access roads to be constructed or to be improved can be determined from preliminary design. Cost per km of different types of roads can be used to determine the cost of access road. f. Camp and Other Facilities: The costs of construction camps and permanent buildings required for operation and also of construction power facilities required should be included in cost estimation. A lump sum amount for this can be allocated depending upon magnitude of project.

S. No.	Study Items	Details of Study Requirements		
		Reconnaissance Study	Prefeasibility Study	Feasibility Study
			g. Resettlement/ Rehabilitation, Relocation and Mitigation Costs of Socio-Economic and Environmental Impacts shall be as per existing Environmental Protection Act, 1997 and Environmental Protection Regulations, 1997 with First amendment, 1999.	g. Resettlement/ Rehabilitation and Relocation: Loss of assets or land need to be either compensated by cash or be substituted by implementing resettlement/ rehabilitation schemes. Similarly, some fixed asset would have to be relocated. Costing of these items should also be included in the project cost. Adherence of existing rules/ regulations and practices is a must while making cost estimate of these items. h. Mitigation cost of Socio-Economic and Environmental Impact: These costs should include all the costs of impact mitigation programs and are to be taken from IEE or EIA reports separately prepared for the project in compliance with the requirement of Environmental Protection Act, 1997 and Environmental Protection Regulations, 1997 with First amendment, 1999.
8.3	Base Cost and Total Project Cost		The total of all costs indicated above will constitute base cost of the project. To that the following costs are to be added for obtaining the total capital cost of the project: a. Engineering and Management (8% of base cost) b. Owner's Cost (2% of base cost) c. Contingencies added to account for unforeseen cost increases due to uncertainties in site conditions and indecency of study levels:: - for civil works (15% to 20% of civil work cost) - for generating equipment and transmission line (8% to 10% of equipment / line cost)	At feasibility level, due to use of more detailed information collected and minor items included and designs concretized, level of uncertainties will decrease particularly in civil work component. Hence a maximum of 15% contingency for this item would be reasonable.
8.4	Local and Foreign Currency Breakdown		a. Local currency will be required for local labours, materials, government cost including land acquisition, resettlement, mitigation and management programs related to adverse socio-economic and environment impacts. Foreign currency will be required for materials, equipment expatriate service component. Hence, the cost estimation should include a breakdown of local foreign currency components.	a. Update based on more detailed information / data.
8.5	Presentation of Cost Estimate Data		a. In the main volume of the report summary cost estimate data broken down into above mentioned major sub-headings and into foreign and local currency should be presented, while the details of cost estimates including rate analysis and unit rate could be presented in Annex volume.	a. Presentation should be done as in the prefeasibility level, but with inclusion of more detailed items based on more detailed information.
8.6	Cash Disbursement Schedule		a. The costs will incur not at once, but will spread over the whole construction period. Interest during construction will depend on how cash will be disbursed during construction period. Hence cash disbursement schedule in accordance with the schedule of construction activities need to be prepared spreading over the project implementation period. Year-wise cash disbursement against each of the major activities is to be prepared and presented in the report	a. Cash disbursement schedule should be based on updated and more practical project implementation schedule.

S. No.	Study Items	Details of Study Requirements		
		Reconnaissance Study	**Prefeasibility Study**	**Feasibility Study**
9.	**CONSTRUCTION PLANNING AND SCHEDULE**			
		a. Project implementation schedule is not required to be prepared at this stage of study. Construction period should be estimated tentatively. b. A brief description of accessibility to the site should be provided.	i) Access to the Site a. A brief description of the access to the site from the nearest road head should be provided. ii) Preparatory works: a. Possibilities for consideration camps, construction power and telecommunication should be briefly described. iii) Implementation Schedule: a. A preliminary construction schedule should be prepared in bar chart form showing the major construction activities. The total construction period of the project should be determined.	i) Access and Infrastructure a. The access up to the project site inside Nepal should be described. b. The access through a port city of India for importing machineries should be studied. ii) Construction Schedule a. A construction schecule of the project should be prepared using timeline gant chart presenting all the major activities. b. Major construction activities should consist the following: - River diversion during construction. - Desander - Weir and under sluice - Intake portal and headrace tunnel - Surge tank / forebay - Construction Adits (haul roads) - Dropshaft and penstock tunnels / surface penstock - Powerhouse complex. - Tailrace channel / tunnel - Turbine and generator installation. - Transmission facilities. - Critical construction sequences. iii) Construction Camps and Offices a. Construction camps and offices should be constructed near the powerhouse area and headworks area. Permanent camps should also be planned for operators of the plant. iv) Construction Material a. The major construction materials required for the project like cement, explosives, aggregates, steel, etc. should be estimated. Location of local materials should be identified. v) Disposal of Excavated Materials a. An environmentally safe plan should be prepared for the disposal of the excavated materials. vi) Contract Packages Contract packages should be divided into: a. Construction b. Access road c. Civil works d. Electro-mechanical equipment e. Hydro-mechanical equipment f. Transmission lines vii) Key Construction Dates a. Key construction dates from the commencement up to the commissioning of the unit should be determined.

S. No.	Study Items	Details of Study Requirements		
		Reconnaissance Study	**Prefeasibility Study**	**Feasibility Study**
10	**ENVIRONMENTAL STUDY**			
10.1	Environment Impact Assessment	a. List environmental issues of greater significance, if any.	a. Collect baseline data of physical, biological and socio-cultural environment of project affected area to understand the socio-environmental situation. b. Assess impacts of major significance. c. Develop mitigation and management programs to minimize the impacts d. With a view to enhance the fulfillment of legal requirement, the format procedure of or EIA as per Environmental Protection Act, 1997 and Environmental Protection Regulations, 1997 with First amendment, 1999 could also be carried out at this level	a. Update and formalize the EIA study carried out during pre-feasibility level study to adhere the legal requirements (Environmental Protection Act, 1997 and Environmental Protection Regulations, 1997 with First amendment, 1999). b. The basic requirement are as follows: - EIA study need to be done in two stages (i) scoping, and 9ii) preparation of EIA report, - Effected localities are to be notified about the implementation of the project giving 15 days' notice for scoping document needs to be finalized taking into consideration the opinions received from affected local people agencies. - Approval on scoping documents as well as on the TOR for EIA should be received from the Ministry concerned. - After conduct of EIA and preparation of EIA report, public hearing at the project area is to be conducted. - EIA report, then, with the recommendation of concerned VDC or Municipality, need to be submitted to the concerned Ministry for approval.
11.	**PROJECT EVALUATION**			
11.1	Economic Analysis	a. Only the scheme alternatives with high promise selected after screening are considered. b. At the reconnaissance stage, the evaluation are based on tentative cost estimate and therefore, the cost of energy produced could be compared with the prevalent PPA (power purchase agreement) price. Or, benefit/ cost ratio could be taken as the evaluation parameter. c. Some obvious technical parameters would also be taken as measure for comparison.	a. The economic cost should comprise of the present day investment cost, O & M cost and replacement cost excluding duties and taxes which are transfer payment. Similarly, it should not include price contingency and interest during construction. b. Comparison should be done with cheapest similar size alternative and all assumptions made must be clearly stated. c. Economic analysis should be based on consumable energy. d. Both B/C ratio and Economic Rate of Return (EIRR) cold be used for economic evaluation.	a. The same analysis performed for pre-feasibility should be applied for feasibility as well, but cost and benefit parameters used should be those derived from feasibility level design and analysis.
11.2	Financial Analysis			a. In performing financial analysis, the financial internal rate of return (FIRR) and the loan reputability are examined based on financing conditions. the financial cost should include, besides economic cost, duties, taxes, price escalation and interest during construction. The benefits will comprise the revenue generation from the sales of energy. As a result of the financial analysis, the financial cash flow showing operating expenses, debt service (loan repayment), royalty and tax payments is required to be presented. All assumptions including finalizing conditions made for the analysis need to be clearly stated and FIRR determined.
11.3	Sensitivity Analysis		Sensitivity analysis are required to be performed in general, for the following cases: a. Varied discounted rates (say 8% to 14%), b. Capital cost decreased/ increased by 20% c. Wet season available energy gets market. d. Delay in commissioning (say 1 yr, 2 yr.). e. Cumulative effect of cost and time over-run.	Sensitivity analysis are required to be performed in general, for the following cases: a. Varied discounted rates (say 8% to 14%), b. Capital cost decreased/ increased by 20% c. Wet season available energy gets market. d. Delay in commissioning (say 1 yr, 2 yr.). e. Cumulative effect of cost and time over-run.

S. No.	Study Items	Details of Study Requirements: Reconnaissance Study	Prefeasibility Study	Feasibility Study
12.	**PRESENTATION OF DRAWINGS, MAPS AND CHARTS**			
12.1	General	Location Map	a. Location Map, b. Map showing physiographic regions	a. Location Map, b. Map showing physiographic regions
12.2	Topography	a. Weir/ Dam Site Cross-sections in scale 1:500	a. Control survey map showing Bench Marks,	a. Control survey map showing Bench Marks,
12.3	Hydrology	b. Catchment Map	a. Drainage Basin Map b. Rating Curves of Headworks Site and Tailrace Site c. Flow Duration Curve d. Reference Hydrograph e. Discharge-sediment relationship	a. Drainage Basin Map b. Rating Curves of Headworks Site and Tailrace Site c. Flow Duration Curve d. Reference Hydrograph e. Discharge-sediment relationship
12.4	Geology and Seismicity	a. Geological Map of Project Area 1:25,000	a. Regional Geological Maps (Plan and Section in scale 1:250,000) b. Geological Map of Project Area (plan & section in scale 1:5,000) c. Site specific geological maps (sections with drill hole logs) - Headworks in scale 1:1000 - Water Conveyance Route in scale 1:2000 - Powerhouse in scale 1:1000 d. Map showing Seismic Refraction Lines, Drill Holes, Adits in scale 1:5000 e. Map showing Borrow Areas and Test Pits and Trenches in scale 1:5000 f. Seismicity Map in scale 1:2,000,000 or 1:1,000,000	a. Regional Geological Maps (Plan and Section in scale 1:250,000) b. Geological Map of Project Area (plan & section in scale 1:5,000) c. Site specific geological maps (sections with drill hole logs) - Headworks in scale 1:1000 - Water Conveyance Route in scale 1:2000 - Powerhouse in scale 1:1000 d. Map showing Seismic Refraction Lines, Drill Holes, Adits in scale 1:5000 e. Map showing Borrow Areas and Test Pits and Trenches in scale 1:5000 f. Seismicity Map in scale 1:2,000,000 or 1:1,000,000
12.5	Optimization	a. General Layout Plans of the Alternative Considered in scale 1:25,000 or large	a. Reservoir/ Pondage Volume Curve. b. Optimization Study Charts	a. Reservoir/ Pondage Volume Curve. b. Optimization Study Charts
12.6	Design Drawings	a. Layout Plan of Selected Alternatives with High Promise in an enlarged map of 1:10,000 b. Conceptual Drawings of Major Project Components	Drawings of: a. Alternatives Considered in scale 1:5000 b. General Arrangement of Selected Project in scale 1:5000 c. Headworks (General Arrangement, Elevations and Sections) in scale 1:1000 d. Desanding Basin (Plan in scale 1:5000 and section in scale 1:500) e. Headrace Water Conduit System (Plan in scale 1:2000 and Section in scale 1:200) f. Forebay/ Surgetank to tailrace (Plan in scale 1:2000 and Section in scale 1:500) g. Forebay/ Surgetank (Elevations and Sections in scale 1:500) h. Powerhouse (General Arrangement in scale 1:1000, Plan and Sections in scale 1:500) i. Powerhouse –Switchyard Layout in scale 1:1000	Drawings of: a. Alternatives Considered in scale 1:5000 b. General Arrangement of Selected Project in scale 1:5000 c. Headworks (General Arrangement, Elevations and Sections) in scale 1:1000 d. Desanding Basin (Plan in scale 1:5000 and section in scale 1:500) e. Headrace Water Conduit System (Plan in scale 1:2000 and Section in scale 1:200) f. Forebay/ Surgetank to tailrace (Plan in scale 1:2000 and Section in scale 1:500) g. Forebay/ Surgetank (Elevations and Sections in scale 1:500) h. Powerhouse (General Arrangement in scale 1:1000, Plan and Sections in scale 1:500) i. Powerhouse –Switchyard Layout in scale 1:1000
12.7	Power Supply	Map Showing Transmission Line in scale 1:50,000	a. Map of Nepal Power System (Existing and Planned) b. Map Showing Transmission Line Requirements.	a. Map of Nepal Power System (Existing and Planned) b. Map Showing Transmission Line Requirements.
12.8	Access road and Others	Map Showing Access Road in scale 1:50,000	a. Access Road Map (Plan in scale 1:5000 and Profile in scale V1:500 & H 1:5000) b. Construction Schedule c. Charts related to Project Elevation.	a. Access Road Map (Plan in scale 1:5000 and Profile in scale V1:500 & H 1:5000) b. Construction Schedule c. Charts related to Project Elevation.

FORMAT –C : GUIDELINES FOR STUDY OF HYDROPOWER PROJECTS
Run-of-River Type
Capacity Range >100 MW

S. No.	Study Items	Details of Study Requirements		
		Reconnaissance Study	**Prefeasibility Study**	**Feasibility Study**
1.	**TOPOGRAPHICAL SURVEYS AND MAPPING**			
1.1	Available Maps and Aerial Photographs	a. Collect and use available largest scale contour maps and aerial photographs of the project area. b. Enlarge by photogrametric method the available largest scale topo-map of the project area to 1:10,000 scale.	a. Collect and make use of available contour maps of the project area including those maps/sections/ profiles prepared during reconnaissance survey.	a. Topographical surveys and mapping that are expected to be carried out at pre-feasibility level correspond to the requirement of feasibility level. However, some augmentation of survey works for selected alternative may be needed, e.g., for setting up of additional geo-technical exploration locations and seismic refraction lines. These additional surveys and mapping should be compatible with the recommendations made for further survey and investigation by pre-feasibility level study. b. Make use of all available maps, aerial photographs, section / profiles and maps prepared during previous level of studies particularly of pre-feasibility level survey.
1.2	Topographical Survey	<u>If the project is dam type,</u> a. conduct cross-section survey of potential dam sites of the project area with fixing of bench marks. b. Conduct survey to prepare contour plan covering alternative dam, powerhouse and tailrace sites, spillway areas, river diversion area and pondage impoundment area <u>If the project is diversion type,</u> a. Conduct longitudinal profile survey of the river stretch to cover potential alternative weir and powerhouse sites of the project area (better to start from an un-destroiable point at the confluence) showing the confluence point of rivulets/ streams in between. b. Conduct river cross section surveys of potential weir and powerhouse sites showing highest flood marks and existing water levels. This survey should be coordinated in a manner to locate the cross sections on the longitudinal profile of the river. <u>Note</u>: The objective of longitudinal survey being to determine level difference between headworks sites and powerhouse sites, traverse survey through terrain could also be applied.	a. Establish the control points and new benchmarks. b. Conduct leveling and traverse survey for tying the control points/ benchmarks with triangulation points of the national grid established by the Survey Department of HMG. c. Carry out topographical survey of the project area as a whole with 5 m contour interval and of the lcoation of major structural components with contour interval of 1 m. At least two most promising alternatives should be covered by topographical survey. The topographical survey should include the borrow areas, if the project is dam type. d. Strip survey of water conveyance route (canal, aquaduct, syphon) with detailed cross sections of cross drainage lying across the canal route (s) and the penstock route with coverage of most promising alternatives to produce maps in 1:2000 scale with 2 m contour interval. e. Surveys for setting out the boreholes, seismic refraction lines, test pits, trenches need to be carried out. f. River cross section survey should be carried out both at intake and tailrace sites covering at least 500 m upstream and downstream at each site. The interval should be 50 m to 100 m depending upon river conditions. High flood marks and existing water levels must be shown in the cross sections. The detailed cross-section survey of cross drainage works are also need to be carried out. g. The Survey should include Impoundment or daily pondage basin area.	a. Conduct strip survey of access road alignment with 5 m contour interval to produce map in 1:5000 scale with fixing of bench marks in an interval of 500 m and at major crossing drainage. locations b. Conduct surveys to cover additional areas if prefeasibility study has recommended for need of such surveys. c. Conduct walkover survey of transmission routes using available 1:25,000 scale topo-sheets to compare with socio-environmental hazards including forested areas to be crossed for potential alternatives.

S. No.	Study Items	Details of Study Requirements		
		Reconnaissance Study	Prefeasibility Study	Feasibility Study
1.3	Mapping and Plotting	If the project is dam type. a. Prepare contour plan in 1:10,000 scale with 5 or 10 m contour of the project area including impoundment area.. b. Prepare cross sections of potential dam sites. If the project is derivation type. a. Plot the river profile, plot the cross sections of potential weir sites. b. Based on walkover survey, locate approximately the potential desanding sites and forebay sites, make route alignment for waterways (canal/tunnel, penstock) using the topo-map enlarged by photogrametric method to scale say 1:10,000, from the existing largest scale contour maps.	a. Prepare contour plan in 1:5,000 scale with 5 m contour of the whole project area. All the features such as rocky cliff, slide zones, cultivated land, etc., must be shown in the contour plan. b. Prepare map in 1:1000 scale with 1 m contour interval of dam/ weir sites, river diversion sites, desanding basin sites, forebay/ pondage basin sites, penstock alignment and powerhouse sites and of canal/tunnel alignment in 1:2000 scale with 2 to 5 m contour. c. The map in 1:1000 scale should also include the area of spillway location of dam type powerhouse, if the spillway location falls in the terrain outside the main dam. d. Prepare map of daily pondage basin in 1;2000 with 2 m contour. If impoundment by dam the map should be in 1:5000 scale with 5 m contour interval.	a. Additional mapping and plotting will be required only if pre-feasibility study has recommended for such works. b. Prepare access route map in scale 1:5000 with 5 m contour interval and cross-section along bridge/ culverts lying in the road alignment. The profile should be plotted in a scale of V 1:500 and H 1:5000.
2	**HYDROLOGICAL AND SEDIMENTATION STUDIES**			
2.1	Hydrology	a. Assess the mean monthly flows and determine the flow of 90% probability of exceedence. b. Carry out discharge measurements at the headworks site during the driest period of the flow. c. Carry out a cross-section survey at the intake site and one at the tailrace site covering the highest flood mark. d. Assess the peak flood discharges. e. Determine if there is any glacier lake in the catchment through map study.	a. Collect the long term historical rainfall data and climatological data pertinent to the study area. b. Collect the long term historical flow data and sediment data of the river under study, if available; if not, collect the data from other river with similar hydrological characteristics in the vicinity. c. Assess the mean monthly flows. d. Develop a flow duration curve. e. Establish a gauging station at the intake site and start collection of data. f. Carry out discharge measurements at the intake site. g. Estimate the design floods for the structures for the return periods of 50, 100, 200, 500 and 1000 years. h. Conduct flood frequency analysis for the period October to May for ascertaining diversion flood. The frequency of diversion flood should be 1 in 20 years. i. Carry out three cross-section surveys at the headworks site and three at the tailrace site covering the highest flood marks. j. Compute the peak flood discharge corresponding to the flood marks at the intake site and tailrace site. k. Develop rating curves for the intake site and tailrace site. l. Assess the potentiality of GLOF in the catchment, if any.	a. Review the study made on pre-feasibility level and collect the additional data if any and check the consistency of data. b. Continue collection of data from the gauging station established during the pre-feasibility level study. c. Check the flow data with the rainfall data and generate long series of flow data if required, carry out regional analysis. d. Update the flow data and assess accordingly the mean monthly flows and develop an upgraded flow duration curve. e. Install a cable way at the intake site wherever necessary for discharge measurement. f. Carry out discharge measurements intensively during the rainy season (June to September) to cover the peak floods at the intake site and a reasonable numbers during other months (October to May) g. Check these measured data with the previous rating curve and upgrade it, if necessary. h. Carry out discharge measurements at the tailrace site and update and upgrade the rating curve for this site. i. Update and upgrade the design flow for power generation. j. Update and upgrade the design floods computed during the pre-feasibility level study and determine the flood for 10,000 years return period. k. Calculate the PMP and determine accordingly the PMF. l. Update and upgrade the diversion floods computed during the pre-feasibility level study. m. Carry out three cross-section surveys at the headworks site and three at the tailrace site covering the highest flood marks, preferably at the same locations as of the pre-feasibility study so that any change in the cross-sections can be observed if occurred, and check the magnitude of flood peaks with the previous ones. n. Update and upgrade the rating curve for the tailrace site. o. Carry out the water quality analysis to determine the corrosive effectiveness. p. Collect the information on GLOF events in the past and assess the magnitude of the potential GLOF, if any.

S. No.	Study Items	Details of Study Requirements		
		Reconnaissance Study	**Prefeasibility Study**	**Feasibility Study**
2.2	Sediment	a. Identify in which zone of sedimentation the catchment lies, high, medium or low.	a. Estimate the sediment load in the river.	a. Collect sediment samples daily during the rainy season (June to September) and a reasonable numbers during other months (October to May) so that a rating curve for the sediment concentration against the discharge could be drawn. b. Analyze the sediment samples to evaluate the volumes and characteristics of solid material transportation including particle size distribution, petrographic analysis (hardness) to determine the hardness of particles, particle size and the nature of material entering the power waterways. c. Compute the daily sediment load and assess the annual load in the river. d. Check this figure with the data collected from the secondary sources.
3.	**GEOLOGICAL/ GEO-TECHNICAL, CONSTRUCTION AND SEISMICITY**			
3.1	Geological / Geo-Technical			
3.1.1	Regional Geological Study	a. Collect and review available literatures, topographical, geological maps, geological sections, aerial photographs and Landsat imagery. b. Prepare a report on regional geology and structure. c. Prepare maps with plan and section in 1:50,000	a. Collect and review available literatures, topographical, geological maps, geological sections, aerial photographs and Landsat imagery. b. Review reconnaissance report to up date and prepare a report on regional geology and structure. c. Prepare maps with plan and section in 1:25,000 based on field observation	a. Collect and review available literatures, topographical, geological maps, geological sections, aerial photographs and Landsat imagery. b. Review prefeasibility report to up date and prepare a report on regional geology and structure. c. Prepare maps with plan and section in 1:10,000 d. Conduct field survey for verification
3.1.2	General Geology and Geomorphology of the Project Area	a. Prepare a report on general geology and geomorphology of the project area.	a. Review the reconnaissance report and prepare a report on general geology and geomorphology of the project area. b. Prepare maps with plan and section in 1:10,000	a. Review pre-feasibility report and prepare a report on general geology and geomorphology of the project area. b. Prepare maps with plan and section in 1:5,000
3.1.3	Detailed Geology and Geomorphology of Particular Sites	a. Prepare a report on geology and geomorphology of each site based on field observations.	a. Conduct a detailed geological and geomorphological survey of particular site such as intake, desander, canal, surgetank, penstock, powerhouse and tailrace on recently prepared topographical maps.	a. Review prefesibility report to update the detailed geology and geomorphology of the particular sites and conduct additional survey of particular sites such as intake, desander, canal, surgetank, penstock, powerhouse and tailrace, access road and transmission line and prepare maps and sections in appropriate scale for design requirements in 1:2000 scale.
3.1.4	Discontinuity Survey	a. Conduct a discontinuity survey such as bedding/ foliation planes, lithological contacts, major and minor joints, faults, thrusts and folds. b. Tabulate all measured discontinuity along with location of their occurrences. c. Conduct a discontinuity analysis by computer or other method to define major orientations. Prepare analytical results in graphical format.	a. Review and update the reconnaissance survey. b. Conduct a discontinuity survey such as bedding/ foliation planes, lithological contacts, major and minor joints, faults, thrusts and folds. c. Conduct a discontinuity analysis by computer or other method to define major orientations. Prepare analytical results in graphical format. d. Prepare rock mass classification for each underground hydraulic structures.	a. Review and update the reconnaissance survey. b. Conduct a discontinuity survey such as bedding/ foliation planes, lithological contacts, major and minor joints, faults, thrusts and folds. c. Conduct a discontinuity analysis by computer or other method to define major orientations. Prepare analytical results in graphical format. d. Prepare risk mass classification for each underground hydraulic structures.

S. No.	Study Items	Details of Study Requirements		
		Reconnaissance Study	**Prefeasibility Study**	**Feasibility Study**
3.1.5	Geo-technical Investigation		a. Excavate test pits and collect samples for laboratory analysis to access nature of soil at dam spillway, river diversion, stilling basin cofferdam, intake portal, surgetank powerhouse and tailrace sites. b. Perform SPT and permeability tests in each test pit to know the strength and permeable nature of soil at dam spillway, river diversion, stilling basin, cofferdam, intake portal, surgetank powerhouse and tailrace sites. c. Perform seismic refraction or resistively survey to assess depth to bedrock, nature of overburden soils and the thickness at dam spillway, river diversion, stilling basin cofferdam, intake portal, headrace tunnel, surgetank powerhouse and tailrace sites. d. Perform drilling and logging dam spillway, river diversion, stilling basin cofferdam, intake portal, surgetank powerhouse and tailrace sites. e. Perform laboratory analysis for soil and rock f. Laboratory test such as (I) sieve and sedimentation, (ii) Atterberg limits, (iii) Natural moisture content and (iv) specific gravity (v) Proctor compaction tests on collected samples for physical properties of soil.	a. Perform drilling and logging at dam spillway, river diversion, stilling basin cofferdam, intake portal, surgetank powerhouse and tailrace sites. b. Perform permeability and grout intake tests in each drill hole to know permeable nature of rock and grout take at dam, diversion, spillway, intake portal and stilling basin sites. c. Perform additional seismic refraction or resistively survey to know depth to bedrock, overburden thickness and nature of soil strata at dam spillway, river diversion, stilling basin cofferdam, intake portal, headrace tunnel, surgetank powerhouse and tailrace sites. d. Perform laboratory analysis for soil and rock e. Laboratory test such as (I) sieve and sedimentation, (ii) Atterberg limits, (iii) Natural moisture content and (iv) specific gravity (v) Proctor compaction tests on collected samples for physical properties of soil. f. Laboratory test such as (i) triaxial compressive strength (ii) uniaxial ultimate compressive stength, (iii) point load tensile strength, (iv) Los Angeles abrasion, (v) crushing value, (vi) Impact value, (vii) specific gravity, (viii) swelling pressure, and (ix) Alkali aggregate reaction tests on rock samples.
3.2	Construction Material Survey			
		a. Identify borrow areas and quarry sites for the construction materials such as impervious soils, stones, sand and gravel etc. as required.	a. Identify and investigate borrow areas and quarry sites for the quantification of construction materials such as impervious soils, stones, sand and gravel etc. as required. b. Excavate test pits and log the pit to understand the nature of soils at borrow areas and collect samples for laboratory analysis. c. Collect rock samples from bedrock exposures for laboratory analysis. d. Perform laboratory analysis for soils and rocks. e. Make an estimation of available quantity at each borrow area for the construction.	a. Review pre-feasibility studies and identify and investigate additional borrow areas and quarry sites if required for the assessment of construction materials such as impervious soils, stones, sand and gravel etc. as required. b. Review construction material study reports and update for the feasibility. c. Excavate additional test pits if required and log the pit to understand the nature of soils at borrow areas and collect samples for laboratory analysis. d. Perform laboratory analysis by seiving and sedimentation, Atterberg Limits, natural moisture content and specific gravity etc for soil samples. e. Collect rock block samples from each quarry site for laboratory tests f. Perform laboratory tests such as uniaxial compressive strength, point load, Los Angeles abrasion, aggregate crushing value, alkali reactivity and specific gravity etc tests on rock samples. g. Make an estimation of available quantity after defining the quality of the materials at each borrow area for the construction.
3.3	Seismological Study			
3.3.1	Tectonic Setting	a. General information on the regional tectonic situation of the project area should be addressed and shown in a map of 1:1,000,000 or 1:2,000,000 scale	a. Information on tectonic characteristics of the study area covering 200 km radius should be incorporated describe and illustrate in map at scale 1:1,000,000 or 1:2,000,000.	a. Information on tectonic setting of the study area as well as that of the surrounding regions lying within a radius of 200 km is to be given with presentation of the map at 1:1,000,000 or 1:2,000,000 scale in order to provide a basis how and where the earthquakes were generated and are likely to be generated.

S. No.	Study Items	Details of Study Requirements		
		Reconnaissance Study	Prefeasibility Study	Feasibility Study
3.3.2	Aerial Photos and Remote Sensing Interpretation	a. General review of aerial photos and landsat images should be established to assess tectonics features	a. Aerial Photos and landsat images studies information should be used to review the neo-tectonics of the project area.	a. Interpretation of aerial photos and remote sensing studies should be critically reviewed to define the tectonic features of the project area including the neo-tectonics..
3.3.3	Fault and Paleio Seismicity		a. Characteristics of faults encountered in the project area should be discussed	a. Active, capable and extinct faults occurred in the project area and surrounding regions need to be addressed in terms of length, distance, return period and reoccurrence nature. Rupture rate of the most recent faulting, present state of stress and degree of reliability in associating epicenters to the fault area are also required to be suggested. b. Information on paleo-seismicity for earthquakes that occurred within past 11,000 years useful to support the instrumental and historical major seismic data should be established. c. Field indications of the pre-historic major earthquakes should be given.
3.3.4	Earthquake Catalogue and Historical and Instrumentally Recorded Earthquake		a. Regional seismicity should be considered with depiction in the appropriate map	a. The earthquake catalogue of historical and instrumentally recorded seismicity data of the region specifically for those above 4 M should be mentioned for assessment of seismicity of the region. For each significant events, the location, distance reoccurrence period magnitude and intensity should be given and depicted in map.
3.3.5	Seismic Zoning			a. Representation of the project area in reference to the seismic zoning of the country should be reflected. Characterization of various earthquake sources inherent in this zone should be established.
3.3.6	Seismic Hazard Analysis			a. The greatest earthquake likely to affect the construction during the life time or the maximum earthquake anticipated to occur in a particular period should be addressed. Attenuation law for the greatest ground motion at the site in terms of intensity or acceleration should be established in consideration of the known controlling earthquake. b. The probability of exceeding different level of intensity or acceleration of the ground in the site during a particular period of time should be expressed. Empirical laws may be applied as necessary to determine the peak ground acceleration (PGA) for Maximum Design Earthquake (MDE) and Operating Basis Earthquake (OBE). c. Risk evaluation with respect to ground motion, dislocation and rock shattering of fault, ground creep, landslide and rock fall due to earthquake should be considered.

S. No.	Study Items	Details of Study Requirements		
		Reconnaissance Study	**Prefeasibility Study**	**Feasibility Study**
4.	**SELECTION OF PROJECT CONFIGURATION**			
		a. Most promising site should be selected and conceptual layout of the project should be prepared. b. Alternative schemes for the selected project site should be prepared. c. A preliminary study of topographic, geological and hydrological conditions of the project site should be carried out. Based on these field data appropriate locations and type of the following structures should be selected analyzing several alternative locations: - Dam - Desander - Canal / Tunnel - Forebay/ Surge tank - Penstock - Powerhouse	1. Selection of Scheme a. Alternative schemes of the most promising site should be prepared. Comparison of these schemes should be carried out in order to select the best scheme. 2. Study of Alternatives a. Alternative locations of the following structures should be studied considering the topography, geology and hydrology of the site: - Dam/ Intake / undersluice - Desilting basin - Water conveyance (Canal/ tunnel) - Forebay / surgetank - Penstock (Surface / underground) - Powerhouse (surface / underground) b. The types and locations of these structures should be finalized on the basis of economy and safety of the structures. Topography and geology should play decisive roles. 3. Access Road a. Access road options from the nearest road head to the project site should be studied. -	1. Selection of Scheme a. Additional alternative schemes of the selected site should be studied. The best scheme should be selected after thorough comparison on the basis of actual topographical, geological and hydrological conditions of the site. 2. Dam a. Alternative locations of dam should be studied. The best location should be chosen on the basis of b. More reservoir volume at same dam height. - Minimum length of headrace canal (tunnel) - Adequacy of foundation conditions. - Provision of required storage volume for daily flow regulation 3. Desilting Basin a. The location of desilting basin should be selected at suitable topographical conditions with mild slopes and flat area which should possess good geology. b. If topographical conditions are not favourable, then underground option should be studied. c. Type of desander should be determined on the basis of the role of the power plant in the system. Proper type of flushing should be adopted depending upon actual site conditions. 4. Water Conveyance (Canal/ Tunnel) a. Alternative Alignments of water conveyance (Canal/ Tunnel) should be studied for left and right banks. The alignment with following criteria should be selected: - Minimum length of canal/ tunnel - Better geology (Canal/ Tunnel) - Less number of river-crossing structures (Canal) - Less environmental hazards (Canal). 5. Forebay / Surgetank a. Location of forebay should be selected at a proper place, comparing different options. The site should be selected with the following criteria: - Less excavation (forebay) - Good geology(forebay / surgetank) - Less environmental problems (forebay) 6. Powerhouse a. Several locations of powerhouse should be studied. b. Selection of the best location of powerhouse should be based on: - Good geological conditions of penstock alignment and powerhouse foundation. - It should have a lower net comparative cost. - The maximum head utilization. 7. Access Road Alternatives i. Access Road to Project Site. ii. Access road to Dam Site. iii. Access Road to Powerhouse. iv. Access road between dam site and powerhouse site. a. Several alternatives for all these access roads should be studied in detail. b. Selection of the road alignment should be carried out on the basis of least cost and environmental considerations.

S. No.	Study Items	Details of Study Requirements		
		Reconnaissance Study	Prefeasibility Study	Feasibility Study
5.	**OPTIMIZATION STUDIES**			
		a. Optimization study is not required at this stage. b. A preliminary calculation of the following project parameters should be done: - Installed Capacity - Number of Units - Dam height	a. The optimization studies will not be necessary at this stage. However, following approach should be adopted for determination of following parameters of the project 1. Installed Capacity a. At this stage selection of specific values of installed capacity will be somewhat obituary. A simple approach for determining installed capacity should be adopted. Run-of-river plant should be developed either with or without daily pondage, with capacity based on given flow and selected capacity factor. b. The installed capacity should be calculated using the design turbine flow with a 50% CF, assuming overall plant efficiency of 89%. 2. Number of Units a. For the selection of number of units, the size of the unit should be determined considering the limitations of transportation capabilities. b. Generation unit capacity should not exceed 10% of the system capacity. c. Reliability and flexibility of operation of the plant and maximum utilization of dry season flow should also be considered	1. Objective Optimization of the following project components should be carried out: a. The full supply level of dam (FSL). b. The water conveyance system comprising the low pressure headrace tunnel, the high pressure tunnel section and the tailrace tunnel. c. The installed capacity of the plant and number of units. d. Spillway arrangement for the dam. 2. General Approach a. An economic analysis should be carried out for the optimization of water conveyance, the plant capacity and the spillway arrangement. b. Conceptual layouts should be developed for each alternative from which cost estimates should be prepared. c. A comparison between the cost and power benefits for each alternative should be done. On that basis the optimum size of the plant should be determined, which would maximize the benefits. 3. Weir/ Gated Spillway a. For the selected location of spillway, an optimization exercise should be carried out to find the most economic arrangement for the gated spillway. b. For this purpose, number of spillway gates should be varied while maintaining the capacity to pass the design flood at FSL and finding the corresponding freeboard required between FSL and the top of core to pas the PMF. c. Cost comparison between various options should be carried out. 4. Water Conveyance (Canal/ Tunnel) a. The size/ optimal diameter of the various canal/tunnel sections comprising the power waterways should be determined for the range of flows corresponding to the installed capacities used in the capacity optimization. b. Analysis of the following types of tunnels should be carried out: - Nominally unlined or shot crete lined tunnel. - Concrete lined tunnel. - Steel lined tunnel. c. The optimization should be based on the following economic and cost parameters: - Project value of energy. - Discount rate - Capacity benefit - Unit cost of tunnel excavation. - Unit cost of concrete lining - Unit cost of steel lining. 5. Full Supply Level and Installed Capacity i) General The optimization of the FSL and installed capacity should be based on the following assumptions: a. Firm flows are defined as those with 90% probability of exceedence on a monthly basis. b. Secondary energy is defined as the difference between the monthly average energy and the monthly firm energy. c. 100% of the firm power produced by the plant is utilized. d. The turbines and generators will require major overhaul after 25 years. e. The plant will be used to supply the domestic market only. f. A compensation flow (10% of Q min) should be released downstream, which should be deducted from the available dry season flows for the computation of the energy estimates.

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		Reconnaissance Study	Prefeasibility Study	Feasibility Study
				ii) Range of Options a. The optimization of FSL and plant capacity should be carried out simultaneously. b. A capacity range with equal intervals should be adopted. c. The Low Supply Level (LSL) in the reservoir should be fixed at a certain levels, as to provide sufficient volume to trap sediments and maintain the live storage for 50 years. d. Following assumptions with regard to efficiencies and head loss in the power waterway should be made for derivation of flows from the installed capacities and heads: - Head loss (5% of gross head) - Turbine Efficiency (93%) - Generator Efficiency (97%). Transformer Efficiency (98%). iii) Determination of Storage a. The storage capacity of the daily pondage basin for each installed capacity should be determined, b. The storage should be sufficient to produce the daily 6 hours peak energy for each case. iv) Cost Estimates a. A base case layout should be adopted with a storage volume close to the optimized storage found from the prefeasibility study. b. The layout should be adjusted for different dam heights to accommodate the diversion tunnel and spillway arrangement. c. Quantities should be calculated for each capacity option. d. The cost of electro-mechanical equipments should be derived from in house experience data and curves or from manufacturers. e. For the power tunnel rock mass classification method should be used to estimate rock support requirements. f. Calculate quantities of excavation, shotcrete, rockbolts, concrete lining and steel ribs. g. Cost of transmission line should be based on supply to domestic market only. h. Environmental costs should be taken on a lump sum basis on the basis of general practice from past experience. i. Following contingencies may be applied for civil and mechanical portions: - Civil work 20% - Mechanical works 15% j. Summaries and detail cost estimates should be provided. v) Estimate of Capacity and Energy Potential a. The energy outputs should be calculated using computer programs, preferably the HEC3 reservoir simulation program. b. Monthly, average and firm energy for each capacity and reservoir option should be calculated. c. Mean operating level for the reservoir should be computed for each capacity option. d. The energy output of the plants should be calculated assuming an outage rate of 5%. e. 100% of the firm power produced by the plant should be utilized. For this, an approximate simulation of reservoir operation assuming average in flows should be carried out. vi) Plant Capacity Optimization Economic Parameters Following economic parameters should be adopted for optimization: a. A discount rate of 10% (variable to actual situations) b. Cost and benefits should be expressed at current prices and discounted to first year of construction. c. An economic project life of 50 years should be assumed for the evaluation of benefits.

S. No.	Study Items	Details of Study Requirements		
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				d. Economic cost should not include duties and taxes. e. Energy and capacity benefits should be evaluated using the following values: - Firm energy US$ 0.07 / Kwh - Secondary Energy US$ 0.023/ Kwh - Capacity US$ 129.4/ Kwh/year The latest revised rates of these items at the present time should be verified from NEA sources and that should be used. Plant Maintenance a. For the optimization purposes it may be assumed that for storage projects with reservoirs acting as a sediment trap, major maintenance will be required on the guide vanes and runners at some stage in the life of the plant. Consequently a conservatively high outage rate of 8% may be adopted in the optimization. Benefit Cost Analysis Procedure a. The net present value (NPV) method should be used to assess the economic viability of each of the capacity and FSL options. b. Evaluations should be carried out for two cases: - With firm energy generation only. - With firm and secondary energy generation. Number of Units a. The number of units should be chosen as minimum as possible. b. The size of units should not exceed 10% of the total Nepal Power System at the time of commissioning. c. Transportation imitations should be considered for the project site. d. A cost comparison between various number of units should be carried out.
6.	**PROJECT DESCRIPTION AND DESIGN**			
		a. Conceptual design of the following structures based on the preliminary field data should be carried out: - Dam/ Spillway and Intake - Desander - Headrace canal/ Tunnel - Forebay/ surge tank - Powerhouse - Tailrace. b. Preliminary selection of turbines and generators should be carried out.	1) River Diversion a. The river diversion works, consisting of the cofferdams and a bypass channel (tunnel) should be designed for the 1:20 yr return period dry season flood in order to meet the requirement of de-watering of the headworks site. b. Optimum size of the structures should be determined using the combined cost of the diversion channel (tunnel) and the upstream cofferdam. For the main diversion works, a single concrete lined channel (tunnel) should be assumed, with the head required to drive the flow through the channel (tunnel) being provided by an upstream cofferdam. 2) Daily Pondage Basin a. The pondage volume curve should be prepared. b. The volume of the regulating pondage should be sufficient to ensure daily peak generation for 6 hours. c. The dead storage volume should be calculated based on the annual volume of bed load material and suspended load. d. Following main operating levels and corresponding storage volumes should be determined: - Full supply level. - Minimum operating level - Live storage - Dead storage	1. General Arrangement of Structures a. The general arrangement of the main structures, determined from the optimization of the individual structures and the optimization studies should be described here in brief. b. Salient features (data) of the project should be provided. 2. Reservoir Following details of reservoir should be provided: a. Reservoir mapping. b. Area/ Elevation/ Volume (A/E/V) relationships. c. Area of reservoir (km2). d. Backwater extension (km) e. LSL/ Dead storage volume (Mm3). f. Sediment Studies. g. Computer simulation of the reservoir sedimentation pattern. FSL/ Live Storage (Mm^3) 3. Dam i) Site Conditions a. The site condition should be described. b. The suitability of the site conditions should be justified. ii) Geology and Foundation Conditions a. Significant geological and engineering aspects of the site should be discussed and their input on layout optimization and dam type should be evaluated.

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			3) Headworks i) Spillway a. The spillway should consist of gated overflow sections with radial gates of appropriate size and number, which should be capable all together passing the maximum design flood. Following reference levels of spillway should be determined. - River bed level - Spillway crest - Minimum operating level - FSL - Flood surcharge - Deck level - Live storage ii) Desilting Basin a. Appropriate type of desander should be selected. b. The desander should be designed to remove the particles of size >0.2 mm. c. Continuous flushing should be provided. d. Following basic desander dimensions should be determined: - Net chamber length - Average cross-section area. - Maximum depth of flow channel - Number of chambers. - FSL - Turbine flow - Flushing flow e. Geo-technical aspects should be studied in order to select the appropriate location of desander. f. Stability and structural aspects should be addressed. - The structure should have a factor of safety against flotation of greater than unity when fully de-watered and with the pondage at FSL. - The structure should also be checked for sliding under maximum earthquake loading. 4) Headrace Tunnel a. The size of the tunnel should be determined through optimization. b. The optimum size of tunnel should correspond to the minimum total of annual construction cost, plus the value of the headloss. c. The lining of the tunnel should be worked out appropriate to the geological conditions. 5) Forebay a. The dimension of the forebay should be fixed according to the existing topography, and location of outlet portal. b. The depth of the forebay should be determined considering the: - Headloss in the tunnel. - Draw down resulting from full load rejection at MOL. - Water cover over the top of the penstock at the entry to prevent vertex formation. c. The maximum and minimum water level of forebay should be determined.	Geology a. A detail description of the geology of dam site should be provided. Foundation Conditions a. The foundation conditions should be described in detail. Soil and rock conditions should be analyzed. b. Suitability of the foundation conditions for high dam construction and necessary measures to be taken for dam construction should be described. iii) Construction Material a. Availability of adequate construction materials at site should be described. Seismicity a. Seismic risk potential at the project site should be described. d) Dam Design i) Dam Embankment a. Site conditions, foundation conditions and indigenous construction materials should be the basis for the selection type of dam. b. Dimensions of the dam should be given with FSL and freeboard above FSL ii) Zoning Arrangement a. Draw down of the reservoir from FSL to MOL should be considered while designing the dam particularly upstream zone, central core zone etc. iii) Foundation Treatment The foundation treatment procedures should be described for: a. Overburden b. Bedrock 4) Diversion Facilities i) Cofferdams a. The methodology for the diversion of monsoon flows during construction should be described in detail. b. The tunnel should be designed to pass the 1 in 10 year flood. c. The upstream and downstream cofferdams should be designed with the determination of their elevations providing freeboard of 2 m above 1:20 year flood level. ii) Tunnel Design a. Geology of the tunnel alignment should be described. b. Rock support types should be determined. c. Structures should be provided to reduce hydraulic losses. 5) Main Spillway i) Geology and Foundation Conditions a. The geology and foundation conditions should be described. ii) Hydraulic Design a. The spillway should be designed to pass the 1 in 10000 years flood at FSL. b. The results of flood routing for the various major flood should be provided. c. The shape of the crest structure should be designed in accordance with the standard low ogee crest profile used by the US Army Corps of Engineers. iii) Structural Design a. A stability analysis should be carried out for several different loading conditions. iv) Hydro-Mechanical Equipments a. Provisions of the gates (radial) should be made on the spillway. Their dimension should be determined. b. A set of stop logs should be provided in order to carry out maintenance of the gates.

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			6) <u>Penstock</u> a. The size of penstock should be determined through optimization. b. Required steel thickness should be determined shell thickness should be calculated at various ports. Anchor block supports for penstock should also be designed. 7) <u>Powerhouse</u> a. The dimension of the powerhouse should be determined to accommodate all the electro-mechanical equipments and auxiliary services including control room and repair bay. b. Substructure design should be based on sound geology of the foundation conditions. c. The vehicular access to the repair bay of powerhouse should be possible. 8) <u>Tailrace</u> a. Tailrace should be designed to pass the outflow of turbines to the river. 9) <u>Mechanical Equipments</u> i) <u>Turbines</u> a. Type of turbine should be selected on the basis of available net head and design discharge. b. Following basic parameters of turbine should be determined: - Rated Capacity - Runner diameter - Rated net head - Design discharge. - Specific speed. - rpm - Efficiency c. Appropriate type of governor should be selected. ii) <u>Gates and Trashracks</u> a. Provision of following gates (including hoist and controls) should be made: - Bulkhead gates to close the diversion tunnel - Spillway radial gates. - Desander flushing gates. - Bulkhead maintenance gates at headrace tunnel. - Draft tube gates b. Trashrack should be provided at the side intake. iii) <u>Cranes</u> <u>Powerhouse Crane</u> a. An overhead travelling crane should be provided in the powerhouse. It should be crapable of lifting the heaviest machinery parts. <u>Gantry Cranes</u> a. Gantry crane should be provided at the following places: - Spillway bay - Desandingbasin intake and outlet - Tunnel intake - For draft tube gates - Bulkhead gates and trashracks. - Penstock intake	6) <u>Auxiliary Spillway</u> i) <u>Geology and foundation conditions</u> a. The geology and foundation conditions of the auxiliary spillway should be described. ii) <u>Hydraulic Design</u> The auxiliary spillway is required to ensure that there is additional spill capacity available at the site, in the event of failure of gates in the main spillway or at the time of GLOF. The spillway should be designed to pass that flood. iii) <u>Structural Design</u> a. The elevation of crest structure should be determined. b. The thickness of the concrete lining in the Chute should be determined, which should be anchored to bed rock. c. In all other respects the structural design of the spillway should be identical. 7) <u>Power Intake</u> i) <u>General</u> a. A general description of intake should be provided with its location and site conditions. b. The sill elevation of intake should be fixed. ii) <u>Geology and foundation conditions</u> a. The geology and foundation conditions should be described. iii) <u>Hydraulic Design</u> a. The opening size should be determined to maintain an entrance velocity of 0.5 m/s at the trashrack when the reservoir is drawn down to LSL. iv) <u>Structural Design</u> a. The structural requirements for the intake should be full filled. v) <u>Hydro-mechanical Equipment</u> a) <u>Trashracks and Stop logs</u> a. Trashracks will be required over the full length of each of the openings. b. The stoplogs size should be determined depending on the rate at which siltation occurs. b) <u>Intake Gate</u> a. The main control gate should be described with its operating details. Size of the gate should be determined. c) <u>Bulkhead Gate</u> a. A bulkhead gate should be provided in the upstream side of the intake gate. It should be used to dewater the guides of intake gate for repair and maintenance. d) <u>Intake Gate Hoist</u> a. The technical details of intake gate hoist should be given covering the braking systems. b. The place and type of mounting the gate hoist should be described. e) <u>Power Supply and Instrumentation</u> a. The details of power supply system for operating the intake gates hoist should be provided. b. Provisions for pressure measurements should be made. 8) <u>Power Tunnels</u> i) <u>General</u> a. A description of the power tunnel configuration should be provided consisting of lining types, diameter and length of headrace tunnel, dropshaft, penstock tunnel and tailrace tunnel. ii) <u>Headrace Tunnel</u> a. The headrace tunnel should be described with its lining details in the total length. b. A rock trap at the end of the headrace should be provided and its dimensions should be determined.

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			iv) Mechanical Services Following mechanical services should be provided: a. Cooling water system b. Compressed air system. c. Oil handling system.Dewatering and drainage system. d. Fire fighting system. e. Ventilation system. Electrical Equipment Single Line Diagram a. A single line electrical diagram should be prepared representing the main electrical equipments of the powerhouse. Connection scheme of the generating equipment and power excavation should be described. Generators a. Type and capacity of the generators should be selected matching to the turbines. Following basic parameters of the generators should be determined. - Rated capacity - Generation voltage - Power factor - Frequency - Synchronous speed. b. Excitation system of generator should be selected to meet the fast response requirements of maintenance of system stability. Unit Step-u Transformers Following parameters of the step-up transformers should be determined.: a. Type of transformer b. Capacity c. Voltage rating d. Frequency e. Winding connection group A.C. Auxiliary Services Power Supply System for Station Service Intake and Spillway a. Provision of station service transformers should be made for the supply of AC auxiliary power. The ratings of station service transformers should be sufficient to meet the total station service load. b. For the supply of power to intake and spillway, an 11 kV line should be provided. c. An emergency diesel generator should be provided for the black start-up of the generators. DC Auxiliary Services Power Supply System a. A DC supply system of DC batteries should be provided for the DC supply to protection, metering and signaling circuits. Control, Protection and Communications a. The control and protection system of the powerhouse equipments should be in accordance with modern practice. Facilities for remote control should be provided in the control room. b. Provision of power line carrier communication should be made.	iii) Surge Tank a. A description of surge tank with its dimensions and lining details should be given. Its inter linkage with the other structures should also be described. iv) Dropshaft a. Dimensions and thickness of lining for dropshaft should be determined. b. Consolidation grouting should be provided around the dropshaft to prevent the potential leakage from the shaft. v) Steel lined Penstock and Manifold a. Connection of steel lined penstock with upstream structures and downstream structure should be described. The dimenstions should be given. b. Consolidation grouting should be provided vi) Optimization of Tunnel Diameter a. Optimization of tunnel diameter should be carried out. b. The head looses through the tunnel system at the design flow should be determined. vii) Geology and Geo-technical Design of Tunnel a. The geological conditions along the tunnel alignment should be described. Rock types along the tunnel alignment should be determined. b. Geology of the tunnel inlet protal should be described. c. Different support types for the rock mass along the tunnel alignment should be designed. viii) Construction Adits a. Locations of construction adits should be determined. b. Dimensions shape, length, thickness of concrete slab etc. should be determined for the adits. 9. Power Complex (U/G) i) General a. A brief description of the location area surroundings of powerhouse should be provided. b. The overall layout of the powerhouse complex including access tunnel and construction adits should be presented. The general arrangement of powerhouse and transformer gallery with typical cross sections through these caverns should be designed. ii) Geology and Geo-technical Design of Cavern a. The geology of powerhouse area should be described. Rock type should be identified. b. Support design for the cavern should be carried out using empirical methods and number analysis. iii) Access Facilities a. Main access tunnel to the powerhouse and transformer gallery should be designed, the invert level of its portal should be above the maximum water level estimated for 1:10000 year flood. Length and gradient of the tunnel should be determined. b. A separate construction adit should be provided to facilitate the excavation of the powerhouse and transformer gallery. iv) Powerhouse and Transformer Gallery Layout a. The powerhouse should contain turbine/ generator units, associated electrical and mechanical equipments, a service by and a control room. Bus duct, tunnels and draft tubes should also be included in the layout within powerhouse. b. Dimension of powerhouse should be governed by the layout of equipments. c. Main elevations of generator floor, turbine floor, drainage gallery floor and distributor floor should be determined. Generator Floor a. This flood should provide area for electrical equipment and lay down space during unit erection and maintenance. Service Bay a. The service bay should accommodate turbine and generator components during erection period and maintenance period.

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				Turbine Floor a. Mechanical and electrical auxiliary equipments are provided at this floor along with air compressors. Drainage Gallery Floor a. The drainage gallery floor should accommodate main inlet valves, dewatering sumps, oil/water separator sumps and the drainage sump. Service Area a. Service Area for an oil room, a compressor room, a storage room and mechanical workshop should be provided. Control Room a. A control room should be provided, containing all the necessary equipment to control the operation of powerhouse. Bus Duct Tunnels a. Bus duct tunnels should be provided connecting the powerhouse to the transformer gallery. Transformer Gallery a. The transformer gallery should have sufficient space for accommodation of all the transformers and switch gears. It must have vehicular access. b. A spare transformer bay should be provided to facilitate transformer replacement/ repair. Tailrace Tunnel a. A tailrace tunnel should be provided for dischargeing the flow to the irver. b. A structure should be provided at the outlet of the tailrace tunnel to allow closure of the tunnel by stoplogs for maintenance purposes. 10. Power Facilities: Mechanical Equipment i) Unit Selection a. For the available head and discharge, an appropriate type of turbine should be selected. ii) Mode of Operation a. Mode of operation of the plant as a storage scheme should be described covering the peaking role of the plant, draw dawn periods from FSL to MOL. iii) Design Criteria Design and selection of turbine and governors should be based on the following criteria: a. The turbine should minimize cavitation and encourage natural turbine venting. b. The governors should be electro-hydraulic type with electronic controls. c. Governors timing should be selected to optimize pressure and speed rises and avoid draft tube column separation. iv) Rating Conditions a. Rating conditions of the turbines should be analyzed. b. Following turbine characteristics should be determined: - Rated capacity - Rated net head - Maximum net head. - Minimum net head. - Normal tailwater level - Minimum tailwater level (1 unit operating) - Rated flow/ unit. - Speed (r.p.m.) - Specific speed. - Physical dimension of the unit should also be determined. v) Description a. Description of the turbine unit should be provided which should include the turbine parts, governor, spiral, casing, draft tute, coupling with generator, access hatches for maintenance etc.

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				vi) <u>Turbine Maintenance</u> a. Maintenance requirement of the turbine for reservoir conditions should be analyzed. b. Easy and less time consuming removal of the turbine runner without removing the generators should be foreseen. vii) <u>Governors</u> a. An appropriate type of governor should be selected. b. Pressure system of the governor should be described. c. Required capacity of the governor should be determined. Following data should be derived. - Servomotor capacity (m. kg) - Servomotor volume (liters) d. Location of the equipment should be identified with elevation and floor level in the powerhouse. viii) <u>Main Inlet Valves</u> a. Type of valve with its dimensions should be determined appropriate to the available head. b. Location of the valve and interconnection with upstream and downstream structure should be described. c. An expansion joint should be provided if necessary. ix) <u>Main Powerhouse Crane</u> a. An overhead travelling crane should be provided, which should be capable of lifting the heaviest piece of equipment. Details of the crane should be described b. Crane span should be sufficient to move the major equipments down the powerhouse. - Lifting capacity of the crane should be provided. x) <u>Draft Tube Gates</u> a. The function and operation of the draft tube in various conditions should be described. - The type and dimension of the gate should be determined. Following pertinent data related to the gates should be provided: - Maximum water level - Sill elevation. - Top of gate - Spam - Height - Maximum head on sill - Number of gates. b. Lifting arrangement of the gates should be described. xi) <u>Tailrace Tunnel Stoplogs</u> a. Requirement of stoplogs and their operating conditions should be described. b. Following data related to stoplogs should be provided: - Maximum water level - Sill elevation - Top of stoplogs. - Span. - Height - Maximum head on sill c. Hoisting system of stoplogs should be described. xii) <u>Drainage and Dewatering System</u> <u>Station Drainage</u> a. Drainage of the powerhouse and transformer gallery should be described covering the floor drains, trench drains and equipment drains, drainage sump, drainage gallery, sump, type of pumps and oil interceptions etc.

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				Unit Dewatering System a. Requirement of unit dewatering system for safe and effective isolating to turbine should be described. Total volume of water to be pumped should be determined. b. Pumping arrangement should be described. Capacity of the pump, dewatering time and floor space for their installation should be determined. Upstream Water conveyance Dewatering System a. Dewatering system for dewatering the structures upstream of the inlet valves including penstock, dropshaft, surge tank and the headrace tunnel should be described. xiii) Station water system General a. A general description of the station water system including the cooling water system and the service and domestic water supply should be provided. Cooling Water a. Various alternatives should be considered for cooling water system b. One of these system appropriate to the requirements of high water quality in the cooling system should be selected. xiv) Compressed Air System High Pressure Air System a. A description of high pressure air system should be provided, which is needed for governor air oil accumulation and generator tracking/ jacking systems. b. Number and capacity of air compressors should be determined. c. Location of compressed air system inside the powerhouse should be identified. Low Pressure Air System a. The low pressure air system supplying dried and filtered compressed air for the maintenance of tools and instrumentation should be described. xv) Oil Handling Systems a. Two separate oil handling system should be planned, one to service the bearing lubricating oil and the other to service the governor oil. b. Transformer oil treatment should be provided. xvi) Ventilation System General a. The ventilation system of an underground powerhouse must full fill the following basic requirements: - Provide adequate ventilation for personnel. - Remove heat generated by mechanical and electrical equipment. - Provide smoke exhaust ventilation in the case of fire. - Provide CO_2 evacuation from the generator enclosure in case of fire. b. The powerhouse and transformer gallery should be provided with separate ventilation systems. Powerhouse Ventilation a. Ventilation system of powerhouse should be designed to provide ventilation of the generator floor, turbine floor and inlet valve/ drainage gallery level. Transformer and GIS Gallery Ventilation a. The transformer and GIS gallery should have two levels and the distribution of air should be proportional to the needs of the various areas. b. The major components of this ventilation system should be described.

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				xvii) Fire Protection System General Following distinct methods of fire fighting should be provided in the powerhouse: a. A high pressure water deluge sprinkle system. b. A low pressure water hose station. c. A carbon dioxide deluge system. d. Portable fire fighting equipment. Firewater Supply a. The systems commonly used for firewater supply should be analyzed for selecting the best suitable system. Water Deluge System a. Appropriate water deluge system should be provided to protect the transformers and oil storage room. Standpipe water protection systems a. In addition to high pressure deluge and sprinkles system, low pressure firewater system should be provided in the powerhouse, transformer gallery and vehicular access tunnels. Carbon Dioxide Deluge system a. A carbon dioxide, CO_2, deluge system should be provided for the protection of generators. The system should be described in detail. 11. Power Facilities Electrical Equipment i) Generator, Excitation and Ancillaries a. Unit rating of the turbine generator should be selected based on the criteria that the capacity of each unit does not exceed 10% of the total NEA's forecasted load of the system at the time of commissioning of the units. b. The preliminary main parameters of the generators will be determined as follows: - Number of units. - Rating - Power factor - Normal capability - Cooling - Synchronous speed. - Number of poles - Frequency - Rated voltage - Neutral grounding. c. Appropriate excitation system should be selected for the fast response necessary to assist with the stability of the HV (230) kV system during disturbances. d. Insulation class for rotor and stator windings should be determined. e. A description of generator fire protection, generator brakes and jacks should be provided. ii) Isolated Phase Bus, PT and Neutral Cubicles and Associated Equipments a. An acceptable solution should be found for the connection between the generator terminals and main step up transformers. Connection with Isolated Phase Bus (IPB), Potential Transformers (PT), and other auxiliary equipments should be described. Connection of neutral grounding should be explained. b. Bus duct tunnel should be provided between generators floor and transformer gallery. Connection of Unit Auxiliary Service Transofrmer and main unit switchgear should be described. c. Appropriate ratings of the generator circuit beakers on 11 kV should be determined. A comparison with HV (230 kV) circuit brakers should be done on cost effectiveness.

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				iii) Main Unit Power Transformers a. All the power transformers should be located in the transformer gallery and their type and connection with generators, HV Gas Insulated Switchgear (GIS) and neutral grounding should be described. b. Due to transportation limitations in size and weight, possibility of using three single phase transformers instead of one three phase transformer should be analyzed in detail. c. Following parameters of the transformer should be determined; - Rating - Cooling - Primary voltage - Secondary voltage - Vector group - Frequency - Taps - Impedance. d. An adequate fire protection system of the transformer should be provided. iv) HV (230 kV) Cables a. HV (230 kV) cables should be provided to connect the underground GIS out going terminals to the above ground cable potheads. Rating of the cable should be determined. b. A cable tunnel should be designed for laying these 230 kV cables near the transformer gallery and GIS room floor. Details of cable layout should be provided. v) Powerhouse Electrical Auxiliaries 1) Ac powerhouse Auxiliaries Unit AC Auxiliaries a. An unit auxiliary transformer should be provided to supply power from the main IPB to the Essential unit auxiliaries. Common Service AC Auxiliaries a. The common services auxiliaries should be divided in three sub groups: - Non-essential common service auxiliaries. - Operational common service auxiliaries - Maintenance common service auxiliaries. b. The selected scheme of the auxiliary services should be shown in the Auxiliary service single line diagram. Several alternative sources of supply should be provided. 2) DC Powerhouse Auxiliaries a. A DC supply system consisting of redundant battery sets should be provided to supply the control, protection, alarm and telemetering equipment for the utmost reliability. Emergency lighting should also be supplied by DC batteries. b. The batteries for the control, protection and emergency lighting should be 110 V DC and those for communication system should be at 24 V or 48 V DC. 3) Emergency Diesel Generator a. A diesel generator should be provided for emergency cases when there is system and power failure. b. The capacity of diesel generator should be determined with sufficient power to black start one of the units and feed the necessary services for it. 4) Distribution to Outlying works a. The following outlying works should be supplied by power: - Lighting around the powerhouse complex, the switchyard and headworks. - Power for the headworks and tailrace.

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				5) Distribution Housing Complex a. A distribution transformer (11 kV: 400/30 V) should be provided for supplying power to the housing complex. Connection should be shown on single line diagram. vi) Control and Protection a. A control room should be provided in the powerhouse. It should be possible to control the units and the auxiliary systems from this control room. Powerhouse group and Unit control a. Full automatic control of the units should be possible from the control room. b. The station control console should be located in the powerhouse control room. HV switchgear and Transmission line Protection a. The protective relay system of high voltage equipments should be capable to minimize damage to system equipment, to minimize the effects of system disturbances. The protective relays must be capable of reliable operation to sense and isolate all faults rapidly. For maximum reliability, all circuits of the system should be protected by two protective schemes. b. Full local back up protection should be provided. c. Breaker failure protection should be provided. Control and Indication at he Headworks. a. Only equipment failure alarms should be transmitted to the control room in the powerhouse. Communication System a. A communication system between powerhouse, the Load Dispatch Centre (LDC), and substations should be established. viii) Grounding a. A proper grounding system should be provided in the powerhouse area. Interconnection of powerhouse grounding system to switchyard ground system and to tailrace pond should be explored. ix) A single line electrical diagram should be prepared showing all the electrical equipment for generation and power evacuation. x) Load flow analysis should be carried out for the INPS including the given powerhouse.
7.	**ENERGY COMPUTATION AND BENEFIT ASSESSMENT**			
				1. Energy Computation Energy computation should be based on: a. Reference hydrology (average flow) for average annual energy 90% reliable average monthly flow in the lowest flow month for firm energy. b. Assumed design parameters (net head, turbine discharge, installed, consideration of compensation flow, installed capacity). Secondary energy is computed as average annual energy minus firm energy. Secondary energy available on monthly basis should also be presented. 2. Benefit Assessment There are two kinds of benefits accruable capacity and energy. Energy benefit could further be splited into firm energy and secondary energy benefits. Values for power and firm energy benefits should be based either on generation costs of other potential similar size hydropower projects in Nepal considering hydropower in the cheaper alternative than others (i.e., LRMC of hydro-generation in Nepal) or on perverting selling price to NEA under Power Purchase Agreement. For Secondary energy at the most thermal, fuel displacement value could be taken. In no case, the values for capacity benefit should exceed the value of dry season peaking capacity.

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8.	**COST ESTIMATE**			
8.1	Criteria and Assumptions	All the criteria, assumptions adopted for Cost Estimation should be mentioned.	All the criteria and assumptions adopted for cost estimation should be mentioned including following: a. Consideration of the natural conditions prevailing at the site, construction scale, and levels of construction technology available in Nepal. b. To the extent possible, construction equipment available in Nepal should be used. c. A brief description of project with location should be mentioned. d. Year and month of the cost estimate should be mentioned. e. Exchange rate applied to calculation of NRs. and US$ adopted at the time of cost estimation should be mentioned. f. Identifiable Nepalese taxes, custom duties, royalties etc. for goods, materials and services, interest during construction etc whether included in cost estimation or not should be mentioned. g. Any source of references of rates or estimation should be mentioned with used escalation factors if any.	All the criteria and assumptions adopted for cost estimation should be mentioned including following: a. Consideration of the natural conditions prevailing at the site, construction scale, and levels of construction technology available in Nepal. b. To the extent possible, construction equipment available in Nepal should be used. c. A brief description of project with location should be mentioned. d. Year and month of the cost estimate should be mentioned. e. Exchange rate applied to calculation of NRs. and US$ adopted at the time of cost estimation should be mentioned. f. Identifiable Nepalese taxes, custom duties, royalties etc. for goods, materials and services, interest during construction etc whether included in cost estimation or not should be mentioned. g. Any source of references of rates or estimation should be mentioned with used escalation factors if any.
8.2	Estimating Methodology	The following methodology should be applied for estimation of cost of each component of the project. a. For Civil Works: The cost estimate should base upon conceptual design and rates of major components. The rates of major civil works can be derived from rates of similar nature of ongoing project, form cost database with suitable modifications or generalized cost curves available if any. The cost estimation should focus on major items/only rather than preparing detailed estimate. The estimate should also include major indirect costs in percentage basis derived from similar projects. b. For Generating Equipment: The cost estimate for generating equipment could be based on cost database with suitable modification, or from any cost curves or from other project of similar nature. c. For Hydraulic Steel works: The cost estimate for generating equipment could be based on cost database with suitable modification, or from any cost curves or from other project of similar nature. **d. Transformers, switchyard and Transmission Line** The cost of transformers and switchyard could be based on capacity. The rates for these items could be based on generalized cost curves or from other project of similar nature. Tentative length of transmission line can be derived from available map. The unit cost can be adopted from current rates used by Nepal Electricity Authority for same type of transmission lines.	The following methodology should be applied for estimation of cost of each component of the project. a. For Civil Works: The cost estimates should be based on unit rates developed from prevailing labour rate, construction equipment rate and materials taking also into account the local situation and bill of quantities derived from design drawings. The cost estimate should be done by breaking down major structures into number of distinct construction activities or measurable pay items. Due consideration should be given to local labors. The rates for locally available labors can be obtained from 'District rates' of concerned districts and can be used after appropriate adjustments. The rates of skilled labors available around project area or within Nepal can be obtained from general inquiries and references of other projects. The rates for skilled expatriates can be obtained from reference of other projects or from publication like ' International Construction Contractors.' The rates of construction equipment can be taken from regularly updated cost data, quotation from the suppliers/ manufacturers.	The methodology for pre-feasibility level study should be applied, but should be based on feasibility level design with inclusion of items not included in pre-feasibility level study. a. For Civil Works: The cost estimates should be based on unit rates developed from prevailing labour rate, construction equipment rate and materials taking also into account the local situation and bill of quantities derived from design drawings. The cost estimate should be done by breaking down major structures into number of distinct construction activities or measurable pay items. Due consideration should be given to local labors. The rates for locally available labors can be obtained from 'District rates' of concerned districts and can be used after appropriate adjustments. The rates of skilled labors available around project area or within Nepal can be obtained from general inquiries and references of other projects. The rates for skilled expatriates can be obtained from reference of other projects or from publication like ' International Construction Contractors.' The rates of construction equipment can be taken from regularly updated cost data, quotation from the suppliers/ manufacturers.

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		e. **<u>Land Acquisition and Access Road:</u>** Costing of land acquisition can be derived from reconnaissance field visits. The length and type of access roads to be constructed or improved can be determined from field visit and available maps. Cost per km of different roads can be used to determine the cost of access road. f. **<u>Resettlement/ Rehabilitation and Relocation:</u>** Tentative area of resettlement, rehabilitation and relocation can be derived from reconnaissance field visit area. Costing can be derived from prevailing market rates. Following costs are to be added to obtain total capital cost of the project: a. Engineering, management and administration (8%) b. Owner's Cost (2%) c. Contingencies added to account for unforeseen cost increase due to uncertainties in site conditions and inadequacy of study levels for civil works by 25%, since cost of minor items would not be taken into account at this stage, while for generating equipments and transmission lines by 10%.	The construction material to be used for construction work should be divided into - Materials locally available - Materials to be imported from India - Materials to be imported from Overseas The rates of construction materials should be derived accordingly as their source of supply. While calculating the construction materials rate, sufficient attention should also be given to mode of transportation and their corresponding costs should also be included. When access roads for the project is not built (generally for small hydropower projects) the cost of air transportation for transporting heavy equipment from nearest town to the project area should also be included. From labor cost , material cost and equipment cost the direct cost per unit of construction activity can be calculated The estimate should be of contractor's type and, therefore, should also include all other indirect costs such as office overhead, contractor's financing cost, insurance, bonds, profit and risk margin. A suitable percentage for contractor's expenses should be allocated. The total percentage should be used as a bid factor on direct cost. Thus calculated direct cost can be used to derive unit bid costs which in turn, be used to determine the total civil works cost. b. <u>For Generating Equipment</u>: The cost estimate for generating equipment should either be based on quotations obtained from suppliers or in-house estimate using established current international prices/ relationships. The cost should include cost of control devices/ system, auxiliary etc. transportation and erection. c. <u>Hydraulic Steel Works</u>: The cost of hydraulic steel works should be based on quotation of suppliers or on market price if they are locally available. Transportation cost should also be added. d. <u>Transformers, Switchyard and Transmission Line</u>: The cost of transformer and switchyard could be based on capacity, while for estimate of cost of transmission line can be calculated from per km rates of transmission line. References of cost can be taken from current rates used by Nepal Electricity Authority for same type/ voltage of transmission lines taking into account different types of towers required, the conductors and types of terrains being crossed.	The construction material to be used for construction work should be divided into - Materials locally available - Materials to be imported from India - Materials to be imported from Overseas The rates of construction materials should be derived accordingly as their source of supply. While calculating the construction materials rate, sufficient attention should also be given to mode of transportation and their corresponding costs should also be included. When access roads for the project is not built (generally for small hydropower projects) the cost of air transportation for transporting heavy equipment from nearest town to the project area should also be included. From labor cost , material cost and equipment cost the direct cost per unit of construction activity can be calculated The estimate should be of contractor's type and, therefore, should also include all other indirect costs such as office overhead, contractor's financing cost, insurance, bonds, profit and risk margin. A suitable percentage for contractor's expenses should be allocated. The total percentage should be used as a bid factor on direct cost. Thus calculated direct cost can be used to derive unit bid costs which in turn, be used to determine the total civil works cost. b. <u>For Generating Equipment</u>: The cost estimate for generating equipment should either be based on quotations obtained from suppliers or in-house estimate using established current international prices/ relationships. The cost should include cost of control devices/ system, auxiliary etc. transportation and erection. c. <u>Hydraulic Steel Works</u>: The cost of hydraulic steel works should be based on quotation of suppliers or on market price if they are locally available. Transportation cost should also be added. d. <u>Transformers, Switchyard and Transmission Line</u>: The cost of transformer and switchyard could be based on capacity, while for estimate of cost of transmission line can be calculated from per km rates of transmission line. References of cost can be taken from current rates used by Nepal Electricity Authority for same type/ voltage of transmission lines taking into account different types of towers required, the conductors and types of terrains being crossed.

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			e. Land Acquisition and Access Road: Due attention should be given to costing of land acquisition and construction of access road as well. The length and type of access roads to be constructed or to be improved can be determined from preliminary design. Cost per km of different types of roads can be used to determine the cost of access road. f. Camp and Other Facilities: The costs of construction camps and permanent buildings required for operation and also of construction power facilities required should be included in cost estimation. A lump sum amount for this can be allocated depending upon magnitude of project. g. Resettlement/ Rehabilitation, Relocation and Mitigation Costs of Socio-Economic and Environmental Impacts shall be as per existing Environmental Protection Act, 1997 and Environmental Protection Regulations, 1997 with first Amendment, 1999.	e. Land Acquisition and Access Road: Due attention should be given to costing of land acquisition and construction of access road as well. The length and type of access roads to be constructed or to be improved can be determined from preliminary design. Cost per km of different types of roads can be used to determine the cost of access road. f. Camp and Other Facilities: The costs of construction camps and permanent buildings required for operation and also of construction power facilities required should be included in cost estimation. A lump sum amount for this can be allocated depending upon magnitude of project. g. Resettlement/ Rehabilitation and Relocation: Loss of assets or land need to be either compensated by cash or be substituted by implementing resettlement/ rehabilitation schemes. Similarly, some fixed asset would have to be relocated. Costing of these items should also be included in the project cost. Adherence of existing rules/ regulations and practices is a must while making cost estimate of these items. h. Mitigation cost of Socio-Economic and Environmental Impact: These costs should include all the costs of impact mitigation programs and are to be taken from IEE or EIA reports separately prepared for the project in compliance with the requirement of Environmental Protection Act, 1997 and Environmental Protection Regulations, 1997 with First Amendment, 1999.
8.3	Base Cost and Total Project Cost		The total of all costs indicated above will constitute base cost of the project. To that the following costs are to be added for obtaining the total capital cost of the project: a. Engineering and Management (8% of base cost) b. Owner's Cost (2% of base cost) c. Contingencies added to account for unforeseen cost increases due to uncertainties in site conditions and indecency of study levels:: ➢ for civil works (15% to 20% of civil work cost) ➢ for generating equipment and transmission line (8% to 10% of equipment / line cost)	At feasibility level, due to use of more detailed information collected and minor items included and designs concretized, level of uncertainties will decrease particularly in civil work component. Hence a maximum of 15% contingency for this item would be reasonable.
8.4	Local and Foreign Currency Breakdown		a. Local currency will be required for local labours, materials, government cost including land acquisition, resettlement, mitigation and management programs related to adverse socio-economic and environment impacts. Foreign currency will be required for materials, equipment expatriate service component. Hence, the cost estimation should include a breakdown of local foreign currency components.	a. Update based on more detailed information / data.
8.5	Presentation of Cost Estimate Data		a. In the main volume of the report summary cost estimate data broken down into above mentioned major sub-headings and into foreign and local currency should be presented, while the details of cost estimates including rate analysis and unit rate could be presented in Annex volume.	a. Presentation should be done as in the prefeasibility level, but with inclusion of more detailed items based on more detailed information.

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8.6	Cash Disbursement Schedule		a. The costs will incur not at once, but will spread over the whole construction period. Interest during construction will depend on how cash will be disbursed during construction period. Hence cash disbursement schedule in accordance with the schedule of construction activities need to be prepared spreading over the project implementation period. Year-wise cash disbursement against each of the major activities is to be prepared and presented in the report	a. Cash disbursement schedule should be based on updated and more practical project implementation schedule.
9.	**CONSTRUCTION PLANNING AND SCHEDULE**			
		a. Construction schedule is not necessary to prepare at this stage.	a. A project construction schedule should be prepared. b. A description of construction sequence, overall scheduling of the activities, and proposed camps and support facilities should be provided. c. The construction sequence should include the following activities: - Pre-mobilization - Prediversion may need several dry seasons and wet seasons. - Diversion tunnel and cofferdams - Spillway - Desanding basin - Headrace canal/ Tunnel - Penstocks - Powerhous. - Tailrace - Turbines/ generators. d. The work volume (excavation, concrete , lining etc.) and rate of advance of each construction activity should be determined. The schedule of construction of each structure should be calculated. e. The critical path for implementation of the project should be determined. The total time required for the completion of the project should be evaluated. f. Material requirement of the project including the concrete volume for each structures should be assessed. Provision of batching plants should be made. Locally available materials like boulders, gravel, sand, etc., should be assessed g. Construction camps should be provided at the project site, which should consist of labour camps, main camps, permanent village for operators etc. Location map of these camps should be provided.	i) Access and Infrastructure Access in India a. A preliminary assessment of the transportation facilities within India should be made. The most feasible rail route and road routes from Calcutta to the nearest Nepal border towns should be described. Access in Nepal a. The nearest road head to the project site should be studied in detail describing its interconnection with the national highways. ii) Construction Schedule a. A detail construction schedule of the project should be prepared. The critical path of activities should be determined. Basically there will be two centres for the operation of construction activities, from headworks area and from powerhouse area. The construction activities to be operated from these centres should be described. The construction activities of the following structure should be described. a) River Diversion During Construction b) Diversion Tunnel c) Cofferdams d) Main Spillway e) Main Dam v) Auxiliary Spillway vi) The Intake Portal and Headrace Tunnel vii) Surge Shaft viii) Construction Adits and Access Tunnel ix) penstock tunnel and Drop Shaft x) Powerhouse Complex xi) Tailrace Channel and Tailrace Tunnel xii) Turbine and Generator Installation xiii) Critical Construction Sequences 3) Construction Camps and Offices. a. Peak labour force should be estimated at headworks and powerhouse sites. Suitable locations for construction camps and office should be identified. It should be near to the construction site. The camps should be sufficient to accommodate all work force. 4) Construction Materials a. Borrow areas for local construction materials should be identified. 5) Disposal of Excavated Material a. A plan should be prepared for the disposal of waste materials from the headworks, tunnel and powerhouse site.

S. No.	Study Items	Details of Study Requirements		
		Reconnaissance Study	Prefeasibility Study	Feasibility Study
				6) <u>Contract Packages</u> a. Various contract packages should be considered such as follows: - Civil works contracts. - Electro-mechanical contract. - Hydro-mechanical contract. - Transmission line contract. - Construction power. - Access road. b. Details should be provided. 7) <u>Key Construction Dates</u> Following key construction dates should be determined: a. Award site investigation contract. b. Commence detail design engineering. c. Award contract for construction power. d. Award contact for access road to headworks. e. Award main civil contract. f. Award contract for access road to powerhouse site. g. Award electro-mechanical contract. h. Award hydro-mechanical contract. i. Award transmission line contract. j. Fist unit of line.
10	**ENVIRONMENTAL STUDY**			
10.1	Environment Impact Assessment	a. List environmental issues of greater significance, if any.	a. Collect baseline data of physical, biological and socio-cultural environment of project affected area to understand the socio-environmental situation. b. Assess impacts of major significance. c. Develop mitigation and management programs to minimize the impacts d. With a view to enhance the fulfillment of legal requirement, the format procedure of IEE or EIA as per Environmental Protection Act, 1997 and Environmental Protection Regulations, 1997 with first Amendment, 1999 could also be carried out at this level	a. Update and formalize the EIA study carried out during pre-feasibility level study to adhere the legal requirements (Environmental Protection Act, 1997 and Environmental Protection Regulations, 1997 with first Amendment, 1999). b. The basic requirement are as follows: - EIA study need to be done in two stages (i) scoping, and 9ii) preparation of EIA report, - Effected localities are to be notified about the implementation of the project giving 15 days' notice for scoping document needs to be finalized taking into consideration the opinions received from affected local people agencies. - Approval on scoping documents as well as on the TOR for EIA should be received from the Ministry concerned. - After conduct of EIA and preparation of EIA report, public hearing at the project area is to be conducted. - EIA report, then, with the recommendation of concerned VDC or Municipality, need to be submitted to the concerned Ministry for approval.

S. No.	Study Items	Details of Study Requirements		
		Reconnaissance Study	Prefeasibility Study	Feasibility Study
11.	**PROJECT EVALUATION**			
11.1	Economic Analysis	a. Only the scheme alternatives with high promise selected after screening are considered. b. At the reconnaissance stage, the evaluation are based on tentative cost estimate and therefore, the cost of energy produced could be compared with the prevalent PPA (power purchase agreement) price. Or, benefit/ cost ratio could be taken as the evaluation parameter. c. Some obvious technical parameters would also be taken as measure for comparison.	a. The economic cost should comprise of the present day investment cost, O & M cost and replacement cost excluding duties and taxes which are transfer payment. Similarly, it should not include price contingency and interest during construction. b. Comparison should be done with cheapest similar size alternative and all assumptions made must be clearly stated. c. Economic analysis should be based on consumable energy. d. Both B/C ratio and Economic Rate of Return (EIRR) cold be used for economic evaluation.	a. The same analysis performed for pre-feasibility should be applied for feasibility as well, but cost and benefit parameters used should be those derived from feasibility level design and analysis.
11.2	Financial Analysis	-		a. In performing financial analysis, the financial internal rate of return (FIRR) and the loan reputability are examined based on financing conditions. the financial cost should include, besides economic cost, duties, taxes, price escalation and interest during construction. The benefits will comprise the revenue generation from the sales of energy. As a result of the financial analysis, the financial cash flow showing operating expenses, debt service (loan repayment), royalty and tax payments is required to be presented. All assumptions including finalizing conditions made for the analysis need to be clearly stated and FIRR determined.
11.3	Sensitivity Analysis	-	Sensitivity analysis are required to be performed in general, for the following cases: a. Varied discounted rates (say 8% to 14%), b. Capital cost decreased/ increased by 20% c. Wet season available energy gets market. d. Delay in commissioning (say 1 yr, 2 yr.). e. Cumulate effect of cost and time over-run.	Sensitivity analysis are required to be performed in general, for the following cases: a. Varied discounted rates (say 8% to 14%), b. Capital cost decreased/ increased by 20% c. Wet season available energy gets market. d. Delay in commissioning (say 1 yr, 2 yr.). e. Cumulate effect of cost and time over-run.
12.	**PRESENTATION OF DRAWINGS, MAPS AND CHARTS**			
12.1	General	Location Map	a. Location Map, b. Map showing physiographic regions	a. Location Map, b. Map showing physiographic regions
12.2	Topography	a. Weir/ Dam Site Cross-sections in scale 1:500	a. Control survey map showing Bench Marks,	a. Control survey map showing Bench Marks,
13.3	Hydrology	a. Catchment Map	a. Drainage Basin Map b. Rating Curves of Headworks Site and Tailrace Site c. Flow Duration Curve d. Reference Hydrograph e. Discharge-sediment relationship	a. Drainage Basin Map b. Rating Curves of Headworks Site and Tailrace Site c. Flow Duration Curve d. Reference Hydrograph e. Discharge-sediment relationship

S. No.	Study Items	Details of Study Requirements		
		Reconnaissance Study	Prefeasibility Study	Feasibility Study
12.4	Geology and Seismicity	a. Geological Map of Project Area 1:25,000	a. Regional Geological Maps (Plan and Section in scale 1:250,000) b. Geological Map of Project Area (plan & section in scale 1:5,000) c. Site specific geological maps (sections with drill hole logs) - Headworks in scale 1:1000 - Water Conveyance Route in scale 1:2000 - Powerhouse in scale 1:1000 d. Map showing Seismic Refraction Lines, Drill Holes, Adits in scale 1:5000 e. Map showing Borrow Areas and Test Pits and Trenches in scale 1:5000 f. Seismicity Map in scale 1:2,000,000 or 1:1,000,000	a. Regional Geological Maps (Plan and Section in scale 1:250,000) b. Geological Map of Project Area (plan & section in scale 1:5,000) c. Site specific geological maps (sections with drill hole logs) - Headworks in scale 1:1000 - Water Conveyance Route in scale 1:2000 - Powerhouse in scale 1:1000 d. Map showing Seismic Refraction Lines, Drill Holes, Adits in scale 1:5000 e. Map showing Borrow Areas and Test Pits and Trenches in scale 1:5000 f. Seismicity Map in scale 1:2,000,000 or 1:1,000,000
12.5	Optimization	a. General Layout Plans of the Alternative Considered in scale 1:25,000 or large	a. Reservoir/ Pondage Volume Curve. b. Optimization Study Charts	a. Reservoir/ Pondage Volume Curve. b. Optimization Study Charts
12.6	Design Drawings	a. Layout Plan of Selected Alternatives with High Promise in an enlarged map of 1:10,000 b. Conceptual Drawings of Major Project Components	Drawings of: a. Alternatives Considered in scale 1:5000 b. General Arrangement of Selected Project in scale 1:5000 c. Headworks (General Arrangement, Elevations and Sections) in scale 1:1000 d. Desanding Basin (Plan in scale 1:5000 and section in scale 1:500) e. Headrace Water Conduit System (Plan in scale 1:2000 and Section in scale 1:200) f. Forebay/ Surgetank to tailrace (Plan in scale 1:2000 and Section in scale 1:500) g. Forebay/ Surgetank (Elevations and Sections in scale 1:500) h. Powerhouse (General Arrangement in scale 1:1000, Plan and Sections in scale 1:500) i. Powerhouse –Switchyard Layout in scale 1:1000	Drawings of: a. Alternatives Considered in scale 1:5000 b. General Arrangement of Selected Project in scale 1:5000 c. Headworks (General Arrangement, Elevations and Sections) in scale 1:1000 d. Desanding Basin (Plan in scale 1:5000 and section in scale 1:500) e. Headrace Water Conduit System (Plan in scale 1:2000 and Section in scale 1:200) f. Forebay/ Surgetank to tailrace (Plan in scale 1:2000 and Section in scale 1:500) g. Forebay/ Surgetank (Elevations and Sections in scale 1:500) h. Powerhouse (General Arrangement in scale 1:1000, Plan and Sections in scale 1:500) i. Powerhouse –Switchyard Layout in scale 1:1000
12.7	Power Supply	Map Showing Transmission Line in scale 1:50,000	a. Map of Nepal Power System (Existing and Planned) b. Map Showing Transmission Line Requirements.	a. Map of Nepal Power System (Existing and Planned) b. Map Showing Transmission Line Requirements.
12.8	Access road and Others	Map Showing Access Road in scale 1:50,000	a. Access Road Map (Plan in scale 1:5000 and Profile in scale V1:500 & H 1:5000) b. Construction Schedule c. Charts related to Project Elevation.	a. Access Road Map (Plan in scale 1:5000 and Profile in scale V1:500 & H 1:5000) b. Construction Schedule c. Charts related to Project Elevation.

FORMAT – X : ADDITIONAL REQUIREMENTS FOR THE HYDROPOWER PROJECT STUDIES WITH UNDERGROUND STRUCTURAL COMPONENTS

(All categories of projects)
(In addition to Basic Formats: A, B and C)

S. No.	Study Items	Details of Study Requirements		
		Reconnaissance Level	**Pre-feasibility Level**	**Feasibility Study**
1.	**ADDITIONAL GEOLOGICAL AND GEO-TECHNICAL INVESTIGATION WITH RESPECT OF DIFFERENT UNDERGROUND STRUCTURAL COMPONENTS**			
1.1	Discontinuity Survey			• Conduct a discontinuity survey such as bedding/ foliation planes, lithological contacts, major and minor joints, faults, thrusts and folds at each component locations such as diversion tunnel, underground stilling basin, intake tunnel, headrace tunnel, tailrace tunnel and underground powerhouse. • Conduct a discontinuity analysis by computer or other methods to define major orientations and prepare analytical results in graphical format.
1.2	Rock Mass Classification			• Conduct rock mass classification in accordance with CSIR or NGI Classification or any other approved method for diversion tunnel, underground stilling basin, intake tunnel, headrace tunnel, tailrace tunnel and underground powerhouse locations. • Prepare analytical report.
1.3	Test Adit			• Excavate test adit as required to find out in advance the nature of underground condition of soil and rock and type of support requirement during construction at diversion tunnel, underground stilling basin, intake tunnel, headrace tunnel, tailrace tunnel and underground powerhouse locations. • Conduct geological mapping of adit and record all types of rocks and weathering grades and discontinuity etc in plan (1:100 scale). • Conduct a discontinuity survey such as bedding/ foliation planes, lithological contacts, major and minor joints, faults, thrusts and folds with their characteristic properties at each component locations such as diversion tunnel, underground stilling basin, intake tunnel, headrace tunnel, tailrace tunnel and underground powerhouse. • Conduct a discontinuity analysis by computer or other methods to define major orientations and prepare analytical results in graphical format. • Prepare analytical report.
1.4	Rock Mechanic Tests			• Conduct in situ tests such as subsurface deformation, pressure and stresses and residual rock stresses in adit as required to assess the rock mass behavior and support requirement in advance for the construction for diversion tunnel, underground stilling basin, intake tunnel, headrace tunnel, tailrace tunnel and underground powerhouse locations. • Prepare analytical report.
				• Assessment of (i) slope condition and overburdens at the tunnel portals and (ii) active faults or high stress zones inherent within the proposed underground structure should be done in respect to seismic effect on underground structure. • Past earthquakes with seismic intensity at the proposed structure construction site greater than vii should be specifically mentioned.

S. No.	Study Items	Details of Study Requirements		
		Reconnaissance Level	Pre-feasibility Level	Feasibility Study
2.	**HYDRAULIC TRANSIENT ANALYSIS***			
			The analysis is carried out for preliminary dimensioning of surge tank.	• In order to ensure that the plant can operate stable, a study on the transient behavior of the water conveyance system should be carried out by computer simulation. This study is essential for medium and large projects. • The transient state parameters, basically, the closure and opening time for the turbine wicket gates should be determined. • Calculations should be carried out to estimate the over pressure and excess speed for different closure times during a plant shut down from full load. • The analysis should be carried out for both load rejection and load acceptance. Maximum upsurge and maximum down surge for both cases should be determined.
3.	**POWERHOUSE COMPLEX**			
				1) <u>Access facilities</u> • Main access tunnel to the powerhouse and transformer gallery should be designed, the invert level of portal should be above the maximum water level estimated for 1:10000 year flood, length and gradient of the tunnel should be determined. • Branch off the main access tunnel should be provided to facilitate the connection of the steel lined penstock and the steel tunnel manifold. The bud and curves of these access tunnel should be sufficient to transport the steel liner cans. • A separate construction adit should be provided to facilitate the excavation of the powerhouse and transformer gallery. 2) <u>Design of Powerhouse Davern</u> • Support design of the cavern should be carried out on the basis of detail geological and geo-technical information. 3) <u>Bus Duct Tunnels</u> • Bus duct tunnels should be provided connecting the powerhouse to the transformer gallery. 4) <u>Transformer gallery</u> • The transformer gallery should have sufficient space for accommodation of all the transformers and swichgears. It must have vehicular access. • A spare transformer bay should be provided to facilitate transformer replacement/ repair.

* This study is not required for the dam type (powerhouse integrated with dam or located very close to main dam) hydropower projects not involving longer water conveyance system, and also for the derivation type (involving longer conveyance system) of project with an open forebay of adequate storage volume and depth in between headrace tunnel and penstock.

FORMAT - Y: ADDITIONAL REQUIREMENTS FOR THE STORAGE TYPE HYDROPOWER PROJECT STUDIES

(In addition to Basic Formats: A, B and C)

S. No.	Study Items	Details of Study Requirements		
		Reconnaissance Level	**Pre-feasibility Level**	**Feasibility Study**
1.	**SELECTION OF DAM TYPE, SAFETY AND COST CONSIDERATION**			
		• Location, type of dam and dam volumes for different full supply levels in consideration with terrain and geological conditions should be considered at this stage.	• Dams for storage hydropower projects, generally, fall in large category both in terms of height (>15 m) and volume as classified by International Commission on Dams due to the reason that (i) sufficient volume is required not only for sediment accumulation but also for regulation of flood flows (ii) head of water is to be created for power generation. The basic principle underlying the location and design of the dam is economy and safety. For safety, a dam must be relatively impervious, in both foundations and dam itself and stable under all conditions. Cost are dependent on topography affecting on dam volume, foundation condition, availability of construction materials close by the project area, accessibility, and on quantity of water handling requirements. Depending on site conditions, different dam types e.g. Masonry Dams (solid or hollow masonry, arched masonry) or Embankment Dams (earth-fill, rock fill) with central impervious section. All the possible alternatives appropriate for the given site conditions need to be analyzed in order to arrive at a particular type. Stability (geologic and tectonic consideration) and cost effectiveness should be the criteria for choice. Flood handling facilities (spillway, diversion and outlet facilities) need also to be taken into account for choice of alternative dam type. The recommendation of dam type and height need to be supported by related analysis.	• More detailed analysis of recommended type of dam, particularly in terms of stability should be carried out. Such analysis should be carried out for other possible types of dam as well , if from safety and cost points of view, the difference found at pre-feasibility study level for different types of dams is marginal. • Dam height optimization in consideration with spillway is to be carried out. • Flood routing for selected alternative is to be presented
2.	**RESERVOIR SEDIMENTATION STUDY**			
		• Since the rate of sedimentation in the reservoir is the key parameter for the reservoir sedimentation study, the sediment sampling at the intake site should start right from its reconnaissance level of study. Particular emphasis should be given to the rainy season when the concentration is high. During each sampling a discharge measurement should also be carried out.	• Continue the sediment samplings and discharge measurements at the intake site. • Collect the sediment data pertinent to the study river from the secondary sources. • Collect the data/ information on reservoir sedimentation of the projects within the country and in the neighboring countries. • Estimate the sediment yield including bed load. • Based on empirical area reduction method, predict the distribution of deposited sediment and their effect on reservoir area-capacity relationship to find out the dead storage volume and live storage volume of the reservoir at appropriate intervals of years till the reservoir is full.	• Review the studies carried out during the pre-feasibility level study. • Continue the sediment samplings and discharge measurements at the intake site. • Update the database including all new collected data. • Upgrade the prediction of the distribution of deposited sediment and their effect on reservoir area-capacity relationship and accordingly the dead storage volume and live storage volume of the reservoir at appropriate intervals of years till the reservoir is full.
3.	**RESERVOIR EVAPORATION**			
		i) Collect the evaporation data from the secondary sources for the catchment and assess the average monthly evaporation from the catchment.	i) The creation of reservoir produces net losses from the open water surface, which will be high in comparison to the natural evapotranspiration of the area prior to the creation of the reservoir. So due attention is to be given in the reservoir evaporation losses. ii) Analyse the existing network of the evaporation stations. Determine and establish at least the minimum requirement of the pan evaporation station in the reservoir area to record daily evaporation. iii) Start collection of data. iv) Update the average monthly evaporation.	i) Review the study conducted in the pre-feasibility level study. ii) Collect additional data from the stations established during the pre-feasibility level study and other stations. iii) Update the database and upgrade the average monthly evaporation data.

S. No.	Study Items	Details of Study Requirements		
		Reconnaissance Level	**Pre-feasibility Level**	**Feasibility Study**
4.	**RESERVOIR OPERATION STUDY**			
		• At reconnaissance level, the study could base on constant head and average annual flow taking into account the available live storage volume.	• Reservoir operation simulation studies should be carried out for assessing the energy availability at different FSL and MOL for optimization study and finding out effective reservoir operation pattern for a selected alternative. In a storage project, particularly, the dam type storage hydropower project where a large variation in available heads occurs, estimate of energy output using flow-duration curve would not be appropriate. Therefore, the sequential stream flow routing method should be used to obtain more accurate energy output conclusions. This method is based on the continuity equation, i.e., change in reservoir storage at any time interval is dictated by reservoir inflow, reservoir outflow and losses (evaporation, diversion, leakage, etc.). Accuracy depends on the chosen time interval. • The constant energy mode of operation for the proposed power station should be preferred for simulation.	• Reservoir operation simulation studies should be carried out for assessing the energy availability at different FSL and MOL for optimization study and finding out effective reservoir operation pattern for a selected alternative. In a storage project, particularly, the dam type storage hydropower project where a large variation in available heads occurs, estimate of energy output using flow-duration curve would not be appropriate. Therefore, the sequential stream flow routing method should be used to obtain more accurate energy output conclusions. This method is based on the continuity equation, i.e., change in reservoir storage at any time interval is dictated by reservoir inflow, reservoir outflow and losses (evaporation, diversion, leakage, etc.). Accuracy depends on the chosen time interval. The time interval used for any study should not exceed one month. Feasibility estimate of firm energy during critical periods of the year should be based even on daily time interval. • The yearly-use method, where it is intended practically to empty the reservoir at the end of each water (hydrologic) year, is to be applied for simplicity of operation study. During reservoir operation study, operation mode and energy outputs of the existing storage plant(s) of the system needs to be taken into account.
5.	**RE-REGULATION STUDY**			
		-	• Storage hydropower projects are designed for also peak operation in addition to flow regulation purpose. The storage projects functioning as peak power supply plants particularly in dry season, changes the daily water flow regime at downstream in an unacceptable manner ranging from a minimum of compensation flow requirement to a maximum corresponding to all installed turbines operated in full capacity. Smoothening of such daily variation in flows is to be carried out to maintain natural revering environment and not to a adversely impact the downstream uses by construction of a re-regulating reservoir, in which even a base load power plant could be accommodated depending upon site condition. Study of such re-regulating facilities needs to be considered as a part of the storage project except in the case where the storage project is designed as a baseload plant. The volume of re-regulating facilities to be created depends on the extent of daily peaking role of the project.	• Re-regulating dam needs to be designed incorporating hydropower plant(s), if possible. If the dam is located on the main river course, it should take into account also the flood discharge that will be spilled from the spillway of main dam.
6.	**CONSIDERATION OF FLOW REGULATION BENEFITS OTHER THAN HYDROPOWER**			
		• Magnitude of flood reduction potential in wet season and flow augmentation potential in dry season should be indicated in monthly average term.	• Preliminary assessment of flow regulation benefits in terms of flood control and augmented water supply in dry season is to be carried out. The study could be based on map study and preliminary field visit.	• Assessment of downstream benefits both from flood control and dry season augmented water supply should be done based on necessary mapping and field survey.

S. No.	Study Items	Details of Study Requirements		
		Reconnaissance Level	Pre-feasibility Level	Feasibility Study
7.	**ADDITIONAL GEOLOGICAL STUDIES**			
7.1	Reservoir Geological Survey			• Collect and review available literatures, topographical, geological maps, geological sections, aerial photographs and Landsat imagery to assess any possibility of leakage from the reservoir. • Review prefeasibility report to up date and prepare a report on rservoir geology and structure. • Conduct geological mapping of reservoir area and record all types of rocks, weathering condition and discontinuity etc in plan (1:10,000 scale). • Conduct a discontinuity survey within the reservoir area such as bedding/ foliation planes, lithological contacts, major and minor joints, faults, thrusts and folds. • Conduct a discontinuity analysis by computer or other methods to define major orientations and prepare analytical results in graphical format. •
7.2	Test Adit			• Excavate test adit as required to find out in advance the nature of underground condition of soil and rock of abutment of a storage dam location. • Conduct geological mapping of adit and record all types of rocks and weathering grades discontinuity etc in plan (1:100 scale). • Conduct a discontinuity survey such as bedding/ foliation planes, lithological contacts, major and minor joints, faults, thrusts and folds with their characteristic properties at storage dam location. • Conduct a discontinuity analysis by computer or other methods to define major orientations and prepare analytical results in graphical format. • Prepare analytical report.
7.3	Rock Mechanic Tests			• Conduct in situ tests using Flat Jack, Dilatometer, Over Coring test equipments etc to derive in abutment adit as required to assess the rock mass behavior. • Prepare analytical report.
7.4	Grout Pattern Test			• Perform drilling and logging at four corner of 2m by 2m area of a storage dam site location to develop a curtain grout pattern to reduce water seepage and estimate construction cost. • Perform permeability and grout intake tests in each drill hole to know permeable nature of rock at storage dam site location. • Perform drilling and logging at the center of 2m by 2m area of a storage dam site location to check the effectiveness of the grout test. • Perform permeability and grout intake tests in the central drill hole to know permeable nature of rock at storage dam site location. • Test drill depth shall be at least 2/3 of storage dam height.

S. No.	Study Items	Details of Study Requirements		
		Reconnaissance Level	Pre-feasibility Level	Feasibility Study
7.5	Seismicity			• Available strong motion accelogram data should be used to select appropriate response spectra. • Information on water induced seismicity should be established. • Installation of micro-seismic network will be necessary for the large category high storage dam type project. • Seismic risk should be specified in term of value and kinematic of co-seismic displacement and the return period in case of earthquake due to cross cutting of the active fault in the structural components of dam.
8.	**RESERVOIR WATER QUALITY**			
			• It is anticipated that after the creation of the reservoir, the temperature of water in the reservoir will change than in the natural condition. The water column will be turbid and well mixed in the upper and central layers following rapid filling each year from June to September. A thermal stratification will be developed in the reservoir. The reservoir water will be deficit in oxygen in the subsurface layers due to continued oxygen depletion by decomposition of in-flowing dissolved and particulate organic matter. The combination of all these will have a great impact in the changes of the physical and chemical qualities of reservoir water and ultimately in the aquatic ecosystems. Hence, the water quality analyses of the rivers in-flowing into the reservoir should be focused to cover these aspects. • Collect samplings for water quality analysis from each of the main steam of the rivers.	• In order to fulfil the condition explain in item i) of pre-feasibility level, conduct samplings for water quality analyses from each of the main steam of the rivers in-flowing into the reservoir in the following periods: a) winter, b) summer, c) rainy season, d) before plantation of the main crop, e) during flowering season, and f) after harvesting of the crop. • Carry out studies for assessing the possible consequences in reservoir water quality.
9.	**STUDY OF RESOURCE LOSS BY SUBMERGENCE**			
		• Assess the resources losses due to creation of reservoir in terms of land, assets and others through map study.	• Conduct field survey at least at the VDC level for gathering the data/ information on assets and infrastructures lying in the reservoir submergence area. • Verify the loss of land estimated during the reconnaissance level study and categorized it in different land uses. • Estimate the cost of lost resources at current price level.	• Review the data/ information on resources losses collected during the pre-feasibility level study. • Conduct sampling survey at the village level for verifying the data/ information collected during the pre-feasibility study and collect additional data/ information on assets and infrastructures lying in the reservoir submergence area. • Confirm the loss of land and its categorization in different uses estimated at the pre-feasibility study. • Update the cost of the lost resources.
10.	**RESETTLEMENT STUDY**			
10.1		• Based on the present CBS data, assess the number of population and household to be evacuated from the reservoir submergence area.	• Conduct field survey at least at VDC level for gathering the data/ information on the population, household lying in the reservoir submergence area and their socio-economic status. Collect the information on cattles also lying in the reservoir submergence area. • ii) Identify the potential land area for resettlement of the displaced people from the reservoir submergence area through map study.	• Conduct sampling survey at the village level for verifying the data/ information collected during the pre-feasibility study and collect additional data/ information on population, household and their socio-economic status and cattles, lying in the reservoir submergence area. • Verify through site visit the potential land area for resettlement identified during pre-feasibility study and identify the new sites, if any. • iii) Collect the cost of lands proposed for resettlement.

FORMATS FOR REPORTS

The results of each stage of the hydropower study must be summarized in a coherent formal report so that they can be presented to the decision making body in a readily understandable form. A good approach, particularly for prefeasibility and feasibility stage of work, is to divide the report into three parts (a) executive summary, (b) the main report, and (c) appendix. Since the Environmental Act and Rules require a separate IEE or EIA report, to comply with the requirement a separate report would have to be prepared. However, a chapter that summarizes the IEE or EIA report, should be included in the main report. As far as it relates to preliminary or reconnaissance level study a single report without division into parts will be sufficient.

The content should include at least the sections/ sub-sections as outlined in following sections:

FORMAT FOR RECONNAISSANCE STUDY REPORT

1. INTRODUCTION
   - 1.1 Intent of Study
   - 1.2 The Project Area
   - 1.3 Available Data and Maps
2. FIELD RECONNAISSANCE
   - 2.1 Survey to Find Out Potential Sites
   - 2.2 Surface Geological Observation
   - 2.3 Locating of Sites with High Promise
   - 2.4 Cross-sectional Survey of Selected Weir / Dam Sites
   - 2.5 Traverse Survey between Weir / Dam Sites and Powerhouse Sites
3. ANALYSIS OF ALTERNATIVE SITES
   - 3.1 Determination of Power Potentials
     - 3.1.1 Available Heads
     - 3.1.2 Estimate of Average Flow and 90% Dependable Flow
     - 3.1.3 Power and Energy Potential
   - 3.2 General Layout of Selected Alternatives
   - 3.3 Conceptual Dimensioning of Project Components
   - 3.4 Type and Capacity of Generating Equipment
   - 3.5 Indicative Cost Estimates of Alternatives
   - 3.6 Comparison between Alternative Sites
4. DESCRIPTION AND PROJECT FEATURES OF SELECTED SITE(S)
5. INTENDED SUPPLY AREA AND MARKET CONDITIONS
6. DESCRIPTION OF ACCESS AND TRANSMISSION REQUIREMENTS
7. ENVIRONMENTAL CONCERNS OF MAJOR SIGNIFICANCE
8. CONCLUSIONS AND RECOMMENDATIONS

MAP AND DRAWINGS TO BE ATTACHED

1. Location Map
2. Catchment Map
3. Geological Map of Project Area

4. General Layout Plan of the Project
5. Layout Plan of Selected Alternatives with High Promise.
6. Weir/ Dam Site Cross-sections and Conceptual Drawings of Major Project Components
7. Map Showing Access and Transmission Line.

FORMAT FOR PRE-FEASIBILITY STUDY REPORT

PART – I : EXECUTIVE SUMMARY

CONTENTS

Salient Features of the Project

1. Project Background
2. Project Area
3. Field Investigations
4. Basic Studies
5. Project Layout
6. Optimization
7. Physical Description of Project
8. Environmental Impacts and Mitigation
9. Construction Planning, Schedule and Cost
10. Project Outputs and Benefits
11. Project Evaluation
12. Conclusion and Recommendations.

ATTACHMENTS

i. Location Map
ii. Project Area map
iii. Drawing Showing General Arrangement of Project

The Contents of the salient features should be as follows:

Location	:
Purpose	:
Hydrology	
Catchment Area	:
Average Flow	:
Design Flow	:
Reservoir	
Normal Water Level (NWL)	:
Minimum Operating Level	:
Surface Area at NWL	:
Live Storage Volume	:
Dead Storage Volume	:

Dam / Weir

Type	:	
Slope	:	
Crest Elevation	:	
Crest Length	:	
Maximum Height	:	
Volume	:	

Diversion Facilities

Length	:	
Diameter / Cross-section	:	
Diversion Flow	:	
Coffer Dams	:	

Spillway

Type	:	
Crest Elevation	:	
Maximum Flood Level	:	
Width	:	
Discharge	:	

Water Conveyance System

Length	:	
Dimensions	:	
Discharge	:	

Forebay / Surge Tank Dimensions :

Penstock

Length

Diameter / thickness

Power Facilities

Powerhouse Type and Dimension	:	
Installed Capacity	:	
Firm Capacity	:	
Average Energy Output	:	
Firm Energy Output	:	

RE-regulating Facilities (if any)	:	
Transmission Facilities	:	
Costs	:	
Benefits	:	
Economic and Financial Indicators	:	

PART –II: MAIN REPORT

5. SEDIMENTATION STUDIES
    5.1 Sources of Sediment
    5.2 Analysis of Sampled Data
    5.3 Estimate of Sediment Yield
6. GEOLOGICAL STUDIES
    6.1 Regional Geology
    6.2 Geology of Project Area
    6.3 Seismicity
7. ALTERNATIVE LAYOUTS AND RECOMMENDED PROJECT LAYOUT
    7.1 Study of Possible Alternative Layouts for the Project
    7.2 Presentation of Recommended Layout
8. PROJECT OPTIMIZATION
    8.1 Range of Options (Dam heights Full Supply Level and Power Discharges)
    8.2 Conceptual Layout and Dimensioning
    8.3 Estimate of Energy Production
    8.4 Cost Estimates
    8.5 Economic Analysis
    8.6 Recommendation of Full Supply Level and Installed Capacity
9. PROJECT DESCRIPTION AND DESIGN
    9.1 Design Basis
    9.2 General Arrangement of Project Components
    9.3 Description of Project Components
        9.3.1 Headworks
        9.3.2 Water Conveyance
        9.3.3 Powerhouse Complex
    9.4 Generating Equipment
        9.4.1 Mechanical Equipment
        9.4.2 Electrical Equipment
    9.5 Transformers, Switchyard and Transmission Line
10. COMPUTATION OF PROJECT OUTPUTS AND RELATED BENEFITS
    10.1 Basis for Computation
    10.2 Energy Computation
    10.3 Estimate of Marketable Energy
    10.4 Estimate of Peaking Role
    10.5 Assessment of Power and Energy Benefits
11. CONSTRUCTION PLANNING
    11.1 Access Road
    11.2 Transportation Method
    11.3 Camping Facilities
    11.4 Construction Power
    11.5 Contract Package

11.6 Implementation Schedule

12. ENVIRONMENT IMPACT ASSESSMENT
    12.1 Baseline Conditions
    12.2 Impacts
    12.3 Impact Mitigation and Management
13. COST ESTIMATE
    13.1 Criteria and Assumptions
    13.2 Estimating Methodology
    13.3 Capital Cost
        13.3.1 Land Acquisition, Access Road, Camp and Construction Power Facilities
        13.3.2 Civil Works
        13.3.3 Electrical and Mechanical Equipment
        13.3.4 Transformers, Switchyard and Transmission Lines
        13.3.5 Physical Contingencies
        13.3.6 Resettlement Cost and Environment Impact Mitigation and Management Cost
        13.3.7 Engineering, Management and Administration Cost
14. DISBURSEMENT SCHEDULE
15. PROJECT EVALUATION**
    15.1 Criteria and Assumptions
    15.2 Economic Analysis
    15.3 Financial Analysis
    15.4 Sensitivity Analysis
16. CONCLUSION AND RECOMMENDATIONS
    16.1 Conclusions
    16.2 Recommendations

Note: For Storage Type of Project:

(i) reservoir sedimentation study, and
(ii) reservoir operational studies have to be included .

PART –III: APPENDIX:

The Appendix should contain supporting materials in report of the following:

- Topographic Survey and Mapping
- Hydrology and Sedimentation Studies
- Geological and Geo-technical Studies
- Optimization Studies
- Hydraulic Design
- Cost Estimate
- Economical and Financial Analysis

FORMAT FOR FEASIBILITY STUDY REPORT

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Crest Length	:
Maximum Height	:
Volume	:

Diversion Facilities

Length :

Diameter / Cross-section :

Diversion Flow :

Coffer Dams :

Spillway

Type :

Crest Elevation :

Maximum Flood Level :

Width :

Discharge :

Water Conveyance System

Length :

Dimensions :

Discharge :

Forebay / Surge Tank Dimensions :

Penstock

Length

Diameter / thickness

Power Facilities

Powerhouse Type and Dimension :

Installed Capacity :

Firm Capacity :

Average Energy Output :

Firm Energy Output :

RE-regulating Facilities (if any) :

Transmission Facilities :

Costs :

Benefits :

Economic and Financial Indicators :

PART –II: MAIN REPORT

1. INTRODUCTION
    - 1.1 Study Background
    - 1.2 Previous Studies
    - 1.3 Objective and Scope of Work

2. DESCRIPTION OF PROJECT AREA
    - 2.1 Location
    - 2.2 Physical Features
    - 2.3 Accessibility

3. FIELD INVESTIGATION AND DATA COLLECTION
  - 3.1 Topographical Survey and Mapping
    - 3.1.1 Available Maps
    - 3.1.2 Surveying
    - 3.1.3 Mapping
  - 3.2 Hydrological Investigations
    - 3.2.1 Collection of Available Meteorological and Hydrological Data
    - 3.2.2 Establishment of Gauging Station
    - 3.2.3 Water Level Recording and Flow Measurement
  - 3.3 Sediment Investigations
    - 3.3.1 Collection of Available Sediment Data
    - 3.3.2 Sediment Sampling
  - 3.4 Geological and Geo-technical Investigations
    - 3.4.1 Collection of Available Data and Maps
    - 3.4.2 Seismic Refraction Survey
    - 3.4.3 Drilling and Permeability Testing
    - 3.4.4 Aditing and In-Situ Testing
  - 3.5 Construction Material Surveys and Testing
    - 3.5.1 Coarse Aggregate
    - 3.5.2 Sand
    - 3.5.3 Impervious Materials
  - 3.6 Strip Survey of Access Road Corridor and Walkover Survey of Transmission Line

4. HYDROLOGICAL STUDIES
  - 4.1 Catchments Characteristics
  - 4.2 Basin Rainfall
  - 4.3 Reference Hydrology and Stream Flow Data
  - 4.4 Flow Duration Curve
  - 4.5 Flood Hydrology
    - 4.5.1 Design Floods
    - 4.5.2 Construction Floods
  - 4.6 Development of Rating Curves
  - 4.7 Compensation Flow

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  - 5.1 Sources of Sediment
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  - 5.3 Estimate of Sediment Yield

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   - 11.3 Camping Facilities
   - 11.4 Construction Power
   - 11.5 Contract Package
   - 11.6 Implementation Schedule
12. ENVIRONMENT IMPACT ASSESSMENT[1]
   - 12.1 Baseline Conditions
   - 12.2 Impacts
   - 12.3 Impact Mitigation and Management

[1] Must be based on IEE or EIA study report separately prepared to fulfill the requirements dictated by EPR' 97 and related regulations (with its first amendment in 1998).

13. COST ESTIMATE
    - 13.1 Criteria and Assumptions
    - 13.2 Estimating Methodology
    - 13.3 Capital Cost
        - 13.3.1 Land Acquisition, Access Road, Camp and Construction Power Facilities
        - 13.3.2 Civil Works
        - 13.3.3 Electrical and Mechanical Equipment
        - 13.3.4 Transformers, Switchyard and Transmission Lines
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LITERATURES REFERRED DURING PREPARATION OF GUIDELINES

- Tamur River Water Power Development (two projects), Energo Invest, Sarajevo-Yugoslavia, 1966.
- Chameliya Hydroelectric Project, (three Projects), NEA,
- Reconnaissance Study of 26 Medium Scale Hydropower Projects, NEA &CIWEC, 1997.

- Hydroelectric Power Schemes on the Babai and Rapti Rivers (three projects), Nippon Koei, Co., 1972;
- Kankai Dam and Power Project (four separate projects, of which three at reconnaissance level), Investigation Division, Electricity Department, 1972;
- Karnali Bend Site KRIA (The Upper Karnali Hydroelectric Project), Himalayan Power Consultants, 1989;
- Bagmati Multipurpose Project, (Phase-I Feasibility), SMEC and others, 1981.
- Kali-Gandaki-2 Storage Hydropower Project, NEA, 1985;
- Burhi Gandaki Storage Hydroelectric Project, MoWR, 1984;
- Lower Arun Hydroelectric Project, NEA, 1989;
- Bheri-Babai Hydroelectric Project (Phase-I Feasibility), Nippon Koei and CKC, 1999
- West Rapti Multipurpose Project (two projects).
- Marsyangdi Hydroelectric Project, Lahmeyer and SMEC, 1979.
- Mulghat Hydropower Project, Electrowatt Engineering Services, 1982;
- Naugarh Gad HEP, Nepalconsult, 1994
- Upper Arun Hydroelectric Project, Morrission-Knudsen Engineers, Lahmeyer International, Tokyo Electricity Power Services and NEPECON, 1991;
- Sapta Gandaki Hydropower Development Project, JICA, 1983;
- Ilam Small Hydropower Development Project, Chuo Kaihatsu Corporation, 1994;
- Kulekhani -I Storage Project, JICA, 1974
- Khimti Khola Hydroelectric Project, Butwal Power Company with Norpower, 1992.
- The Chisapani High dam Project, Nippon Koei Co. Ltd., 1966;
- Middle Marsyangdi Hydroelectric Project, Nepal Electricity Authority, 1994.
- Medium Hydropower Projects,
  - Kabeli –"A", Nepalconsult in Association with Hydro-Engineering Services (P) Ltd, 1998
  - Rahughat, WRC, 1998
  - Likhu –4, Shah Consult International, 1998
  - Buriganga, Metecon, 1998.
- Arun –3 Hydroelectric Project, JICA Study Team, 1987
- Langtang Khola Small Hydroelectric Project, East Consult (P) Ltd., 1993;
- Tadi Small Hydropower project, ITECO, 1995.
- Koshi High Dam Project, GOI, 1981.
- Tamur-Mewa hydropower Projects (two projects), NEA and CIWEC, 1998
- Indrawati Hydroelectric Project, Shah Consult International, 1997.
- Upper Modi Hydroelectric Project, NEA, 1994.
- Maliung Hydropower Project, Silt Consult, 2000.
- Gandi Gad Small HEP, Water Resources Consult, 1998.
- Daraundi Khola Small Hydropower Project, HES & Nepalconsult, 1998.
- Pancheswor Multipurpose Project (Draft) (main project + re-regulating plant), PACO & Pancheswor office, 1995.

- Karnali Multipurpose Project (main project + re-regulating plant), HPC, 1989
- Inventory of Glaciers and Glacial Lakes of Nepal, ICIMOD and UNEP, 2001 (at a final stage of publication).

The other four documents as given below were also referred as a reference materials for setting the guidelines for different level of studies falling within the suggested classification of hydropower projects.

- Manual of Standards and Criteria for Planning Water Resources Projects. Water Resources Series No. 26 – A United Nations Publication
- Civil Engineering Guidelines for Planning and Designing Hydroelectric Development (in five volumes), American Society of Civil Engineers (ASCE), 1989.
- Engineering and Design – Hydropower, Department of the Army Crops of Engineers, USA, 1985.
- Dams and Development –The Report of the World Commission on Dams, 2000.

Following Policies, Acts, Regulations/ Rules were also referred in order to make the guidelines in consonance with them.

- Hydropower Development Policy, 1992
- Electricity Act, 1992
- Electricity Rules, 1993
- Environmental Protection Act, 1997
- Environmental Protection Regulations, 1997
- Water Resources Act, 1992