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REVIEW OF PROJECT INSPECTION PROCEDURES AND DAM SAFETY

Prepared for

His Majesty's Government of Nepal
Ministry of Water Resources
Electricity Development Center

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Prepared by

Foster Pelton
Specialist-Power Operations/Safety

Acres International
140 John James Audubon Parkway
Amherst NY 14228 1180
Telephone 716 689 3737
Facsimile 716 689 3749
E mail amh@acres com

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Abbreviations and Acronyms

ACI	American Concrete Institute
AISC	American Institute of Steel Construction
ANSI	American National Standards Institute
ASTM	American Society for Testing and Materials
cumec	Cubic Meters per Second
EAP	Emergency Action Plan
EDC	Electricity Development Center
EPRI	Electric Power Research Institute
FERC	Federal Energy Regulatory Commission
GLOF	Glacial Lake Outburst Flood
HMG/N	His Majesty's Government of Nepal
IDF	Inflow Design Flood
m	Meter(s)
mm	Millimeter(s)
m/s	Meters per Second
NEA	Nepal Electricity Authority
O&M	Operation and Maintenance
PA	Project Agreement
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
PPA	Power Purchase Agreement
QC	Quality Control
QCIP	Quality Control Inspection Program
SEED	Safety Evaluation of Existing Dams
USACE	U S Army Corps of Engineers
USAID	U S Agency for International Development
USBR	U S Bureau of Reclamation
USEPA	U S Environmental Protection Agency
USFWS	U S Fish and Wildlife Service
USGS	U S Geological Service

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Terms and Definitions

Appurtenant Works
Structures or materials built and maintained in connection with dams These can be spillways, low-level outlet works and conduits

Cofferdam
A temporary structure enclosing all or part of the construction area so that construction can proceed in the dry

Conduit
An enclosed channel used to convey flows through or under a dam

Dam
Any artificial barrier and its appurtenant works constructed for the purpose of holding water or any other fluid

Detention/Retention Basin
Any structure that functions as a dam

Earth Dam
A dam made by compacting excavated earth obtained from a suitable borrow area

Energy Dissipator
A structure constructed in a waterway which reduces the energy of fast-flowing water

Flood Routing
The computation which is used to evaluate the interrelated effects of the inflow hydrograph, reservoir storage, and spillway discharge from the reservoir It is the process of determining progressively over time the amplitude of a flood wave as it moves past a dam and continues downstream to successive points along a river or stream

Freeboard
The vertical distance between the design high water level and the top of the dam, without camber

Gravity Dam
A dam constructed of concrete and/or masonry and/or laid-up stone that relies upon its weight for stability

Hazard
A situation which creates the potential for adverse consequences such as loss of life, property damage, or other adverse impacts Impacts in the area downstream of a dam defined by the flood waters released through spillways and outlet works of the dam or waters released by partial or complete failure of the dam There may also be impacts upstream of the dam due to backwater flooding or landslides around the reservoir perimeter

Height
The vertical dimension from the downstream toe of the dam at its lowest point to the top of the dam

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Hydrograph
A graphical representation of the streamflow stage or discharge as a function of time at a particular point on a watercourse

Independent Power Producers
Private sector power producers who have developed a thermal, hydroelectric, or other power plants to sell power The power is normally a grid sale to an existing power utility, but can also be sold directly to distributors or directly to large consumers depending on the provisions in the host country power regulations relating to wheeling and market entry

Inflow Design Flood
The floodflow above which the incremental increase in water surface elevation due to failure of a dam or other water impounding structure is no longer considered to present an unacceptable threat to downstream life or property The Inflow Design Flood of a dam or other water impounding structure is used in the design of a dam and its appurtenant works particularly for sizing the spillway and outlet works, and for determining maximum height of a dam, freeboard, and temporary storage requirements

Low-Level Outlet
An opening in a dam at a low level used to drain or lower the water

Maximum Impoundment Capacity
The volume of water held when the water surface is at the top of the dam

Maximum Wind
The most severe wind for generating waves that is reasonably possible at a particular reservoir The determination will generally include results of meteorologic studies which combine wind velocity, duration, direction, and seasonable distribution characteristics in a realistic manner

One Percent Chance Flood
A flood that has a one chance in 100 of being equalled or exceeded in a specified period, usually a year

Outlet Works
A dam appurtenance that provides release of water (generally controlled) from a reservoir

Private Power Developer
An individual, group, or local or international company that plans and develops power generation facilities on a private sector basis with the intention to own, operate, lease, and/or transfer the facility to another entity, normally a public utility, at a future point in time

Probable Maximum Flood
The flood that can be expected from the severest combination of critical meteorologic and hydrologic conditions possible for the particular region This is the upper limit for determining the Inflow Design Flood It is the flow resulting from the Probable Maximum Precipitation

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Probable Maximum Precipitation

The maximum amount of precipitation that can be expected over a drainage basin It is theoretically, the greatest depth of precipitation for a given duration that it is physically possible over a given size storm area at a particular geographical location during a certain time of the year

Production

The construction, operation, and maintenance of structures relating to the production of electricity

Project Agreements

Optional project-specific agreements that are normally in addition to the power purchase agreement Project Agreements consolidate in one document the government assurances and guarantees to private power producers required for successful project development and allocation of risk In high risk countries and/or the less detailed or less clearly defined the regulatory framework, the greater the need for a Project Agreement as an additional element in the security package the developer would take to the potential equity partners and debt lenders

Reservoir Regulation Procedure (Rule Curve)

The compilation of operating procedures that govern reservoir storage and releases

Spillway

A gated or ungated hydraulic structure used to discharge water from a reservoir Definitions of specific types of spillways are as follows

- **Service Spillway**
  A spillway that is designed to provide continuous or frequent regulated or unregulated releases from a reservoir without significant damage to either the dam or its appurtenant structures

- **Auxiliary Spillway**
  Any secondary spillway which is designed to be operated very infrequently, possibly, in anticipation of some degree of structural damage or erosion to the spillway would occur during operation

- **Emergency Spillway**
  A spillway that is designed to provide additional protection against overtopping of dams and is intended for use under extreme flood conditions or mis-operation or malfunction of the service spillway

Spillway Capacity

The maximum outflow flood which a dam can safely pass

Still Water Level

The elevation that a water surface would assume if all wave action were absent

Survey

The act of survey relating to the production, transmission, or distribution of electricity and will also denote the acts relating to feasibility study, detailed engineering design, and the works of investigation thereto

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Toe of Dam

The junction of the downstream face of a dam and the natural ground surface, also referred to as the downstream toe For an earth dam, the junction of the upstream face of the dam with the ground surface is called the upstream toe

Turnkey Contract

An arrangement where a contract is given by the project developer to a prime contractor who in turn will be fully responsible for the design and implementation of a project The Contractor will provide a completed, operational project on a stipulated date, often on a lump-sum basis

Wave Run Up

The vertical height above the still water level to which water from a specific wave will run up the face of a structure or embankment

Wind Setup

The vertical rise of the still water level at the face of a structure or embankment caused by wind stresses on the surface of the water

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Executive Summary

The Electricity Act 2049 and the implementing regulations contained in the document Electricity Regulation 2050 provide authority and responsibility to the Electricity Development Center (EDC) for reviewing applications and making recommendations to His Majesty's Government of Nepal (HMG/N) regarding the issuance of licenses for the construction and operation of hydroelectric generation facilities

The Specialist-Power Operations/Safety, in the first part of his assignment, reviewed the safety and operational regulations for the licensing, construction, and operation of hydroelectric generation facilities under the purview of EDC and prepared a report in September 1995 entitled "Review of Licensing/Safety Standards and Procedures " The recommendations in this report included items relating to the regulatory oversight of project construction and operation, and to dam safety

EDC is also responsible under the Electricity Act and the Electricity Regulation for monitoring both the construction and operation of licensed facilities The Terms of Reference for the second part of the assignment of the Specialist-Power Operations/Safety require the Specialist to focus on recommendations and guidelines for regulatory oversight during the construction phase of projects, for the further development of quality control inspection programs, for the further development of formal procedures relating to dam safety, and for the review of existing/proposed projects

In this second report, entitled "Review of Project Inspection Procedures and Dam Safety," the Specialist-Power Operations/Safety discusses regulatory oversight during construction in Section 2 It is recommended that regulations be made to require holders of production licenses to provide documentation to EDC of design criteria to be adopted in the detail design phase and that prior to construction they should submit to EDC construction drawings and specifications together with details of any flow diversion measures, cofferdams, or other means to be used for controlling water during construction Production licensees should also submit to EDC a quality control inspection program (QCIP) plan, a sediment and erosion control plan, and a temporary emergency action plan prior to commencement of construction Typical QCIP, sediment and erosion control, and temporary emergency action plan requirements are set out in Section 3 of the report

Typical aspects of dam safety programs, including hazard potential classification, overall design parameters, routine operation and inspection procedures, major inspections, emergency action plans, and public safety plans are addressed in Section 4 It is recommended that EDC include dam inspections as part of a regular annual project inspection and that major inspections for dams be performed every five years

Operational projects are discussed in Section 5 of the report, and overall conclusions and recommendations are given in Section 6 Typical data sheets, inspection checklists, and suggested contents of a five-year dam inspection report are included in the Appendices

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1 Introduction

1 1 Background

As part of the United States Agency for International Development (USAID) Private Electricity Project, a report was prepared in September 1995 by the Specialist-Power Operations/Safety entitled "Review of Licensing/Safety Standards and Procedures " This report discussed and made recommendations to the Electricity Development Center (EDC) of His Majesty's Government of Nepal (HMG/N) in relation to safety standards/guidelines and review procedures to be applied to the licensing, design, construction, and operation of hydroelectric generating plants

This present report is entitled "Review of Project Inspection Procedures and Dam Safety " and examines in more depth those items relating to construction oversight, quality control inspection programs, dam safety issues, and review of operating projects

Despite its vast water resources, financial constraints have prevented Nepal from developing its water and power sectors, and particularly those hydroelectric projects which could help expand the economy of the country

To overcome these constraints, HMG/N is attempting to accelerate hydropower development by opening the power sector to private investment, development, and operation and maintenance Promulgation of the Electricity Act and the Water Resources Act in 1992, together with the adoption of policies affording incentives to potential producers signalled a focused effort to develop private participation in such projects Under the Electricity Act, a separate agency evolved, the Electricity Development Center (EDC), which is charged with the responsibility of oversight of all private electricity generation projects larger than 1 MW, and with the oversight of transmission and distribution line facilities Regulations were adopted in 1933 regarding the application, licensing, and monitoring process as set forth in the various Acts and Policies

The Electricity Act 2049 and the implementing regulations contained in the document Electricity Regulation 2050 provide authority and responsibility to EDC for reviewing applications and making recommendations to HMG/N regarding the issuance of licenses for the construction and operation of generation facilities EDC must provide such recommendations based on facilities that are not only cost effective, in terms of capital cost, but constructed and operated according to sound industry standards for safety and maintenance EDC is also responsible for monitoring both the construction and operation of licensed facilities

The Electricity Act 2049, Section 40, paragraph (2), provides that HMG/N may frame rules on matters relating to the construction of hydroelectric generating facilities and to the appropriate design and construction quality standards necessary Additionally, Electricity Regulation 2050, which implements the provisions of the Electricity Act 2049, in Chapter 8, provides that HMG/N may, by publishing a notification in the Nepal Gazette, fix the measures to be taken for designing and constructing and constructing dams, powerhouses and other structures required for the production of electricity and for safety conditions affecting such structures and the reservoir

1 2 Specialist - Power Operations/Safety

The Terms of Reference for the Specialist-Power Operations/Safety require the Specialist to concentrate on the analysis of safety and operational regulations for the licensing, construction, and operation/monitoring of hydroelectric generation facilities under the purview of EDC The focus is on the development of guidelines for

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the "process" for assuring compliance with defined safety standards over the construction and operational life of such projects

Specific tasks are as follows

- Make recommendations regarding specific regulations for regulatory oversight during the construction phase of projects

- Prepare guidelines for the further development of quality control and inspection programs for use by EDC monitoring and safety staff including the areas of sediment and erosion control as well as development of emergency action plans

- Assist in the further development of formal procedures relating to dam safety, including hazard potential classification, routine operation and inspection procedures, safety inspection procedures and long term emergency action plans

- Review existing/proposed projects, developed/being developed and give recommendations to EDC regarding specific courses of action for such projects in the above areas

- Demonstrate the steps in the inspection process by jointly inspecting selected site or sites with staff of EDC Conduct field instruction on the procedures used in the inspection process and formulate the types of reports to be submitted

- Continue to assist EDC in the collection of documents available related to existing International Safety Standards (Civil, Electrical, Mechanical, and Environmental) of representative developed and developing countries related to design, construction, operation and maintenance of hydropower projects

- Continue with recommendations for concrete safety guidelines/standards for incorporation in corresponding regulations

With regard to the inspection of sites referred to above, the Specialist-Power Operations/Safety together with staff from the Inspection Division of EDC, during the period Saturday, February 17, 1996 through Tuesday, February 20, 1996 visited the Marsyangdi Hydroelectric Project and the First and Second Kulekhani Hydroelectric Projects

The principal references on which the Specialist-Power Operations/Safety has drawn from in performing this assignment and preparing this report are as follows

- *Engineering Guidelines for the Evaluation of Hydropower Projects*
  U S Federal Energy Regulatory Commission
  April 1991 and various later dates

- *Operating Manual for Inspection of Projects and Supervision of Licences for Water Power Projects*
  U S Federal Energy Regulatory Commission
  1989

- *Guidelines for Public Safety at Hydropower Projects*
  U S Federal Energy Regulatory Commission
  March, 1992

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- *Guidelines for Rehabilitation of Civil Works of Hydroelectric Plants*
  American Society of Civil Engineers

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2 Construction - Regulatory Oversight

2 1 Introduction

Specific recommendations of measures for institutional strengthening for incorporation in the regulations or in EDC procedures with regard to regulatory oversight of projects under construction were set out in the September 1995 report by the Specialist-Power Operations/Safety entitled "Review of Licensing/Safety Standards and Procedures "

The main recommendations relating to the construction phase referred to

- Inspection
- Quality Control
- Sediment and Erosion Control
- Emergency Action

This section deals with the extent and organization of inspection of works under construction by a regulatory body such as EDC Quality control, sediment and erosion control, and emergency action are discussed in Section 3, Quality Control Inspection Programs

The responsibility for direct detail supervision on a day-to-day basis of construction work and of the contractors and equipment suppliers performing this work lies with the project owners or developers and their engineer This responsibility derives from the various contracts which project owners or developers have with their various contractors and equipment suppliers

EDC, as the regulatory agency that licensed the project, should monitor construction activities sufficiently to ensure that the project owners or developers are constructing their projects in accordance with

- The terms and conditions of the production license, and in general conformance with contract plans and specifications
- Sound construction practices, satisfactory field supervision of geotechnical, structural, and engineering concerns, adequate quality control (QC), and satisfactory surveillance and monitoring of the work

Also, to ensure that records of significant details of construction are being maintained

2 2 Process

The organization of regulatory oversight for a hydroelectric project during the construction phase consists of the following steps

- Collection of all documentation relative to the project under construction
- Review of design criteria, construction drawings and specifications, and construction quality control inspection and other plans
- Determination of the frequency of inspection
- Site inspections
- Report Preparation

These steps are described in more detail below

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2 3 Project Documentation

Immediately following the award of the production license for a hydroelectric project, EDC should collect and maintain in a central location in their offices, the following documentation relevant to the project

- Survey License Application
- Survey License
- Project Agreement
- Production Licence Application
- Production Licence
- Power Purchase Agreement
- Survey Report
- Any other feasibility reports
- All geotechnical reports, including Borehole Logs (Percussion, Rotary, Etc), Trial Pit Records, Trial Trench Records, Exploratory Adit Records, etc
- Any other relevant documents

This documentation forms the basic data for the project As the construction and then the operation phases proceed, then other documentation, such as plans, specifications, quality control inspection and other plans, inspection reports and so on, will be added

EDC should maintain and continuously update data sheets for the project A sample data sheet is given in Appendix A

With the issue of the production license, detail design can begin In order to ensure that the quality of the design will be adequate and meet satisfactory international standards and in order to provide the design engineers with all the relevant standards and criteria for them to carry out the detailed design, the licensee should prepare and submit to EDC for approval a Design Criteria Document This is a most important document as it sets out the whole basis for the design of the project, including a detailed description of each of the structures to be designed, the standards and procedures to be followed in the design, and all other relevant data necessary for performing the detailed design work This will enable a quality assurance review to be performed on all the design methods and criteria before designs proceed

The Design Criteria Document should include as a minimum, the following items

- Introduction
- Overall Project Description
- Individual Structure Descriptions - Dams, Canals, Penstocks, Powerhouses, etc
- Hydrologic and Hydraulic Criteria
- Codes, Standards, and Regulations
- Material Properties
- Design Loads
- Structural Design Data
- Civil Structures - Methods of Stability Analyses, Factors of Safety, etc
- Mechanical Equipment
- Electrical Equipment

Following completion of the detailed design, the licensee should submit to EDC the plans and specifications for construction

It will be necessary for the licensee to provide a schedule for design and construction showing, among other things, the dates on which documents will be submitted to EDC and allowing sufficient time for EDC review

In addition, the licensee should have prepared and submitted to EDC for approval, the following items which should be in place prior to commencement of construction

- Quality Control Inspection Program
- Sediment and Erosion Control Plan
- Temporary Emergency Action Plan
- Any Other Required or Relevant Plans

Typical formats and components of these programs and plans are given in Section 3 - Quality Control Inspection Programs

Finally, it should be noted that adequate inspection of projects under construction requires thorough familiarity with the project documentation, including the terms and conditions of the production license and the technical features of the construction plans and specifications

2 4 Frequency of Inspection

It is recommended that EDC inspect licensed projects during the construction phase as follows

- For major projects under construction, EDC should inspect the work in progress on a monthly basis
- Where unusual problems are encountered, more frequent inspections should be performed by EDC
- Fewer frequent inspections may suffice during periods of work interruption, winter slowdowns, or where the degree of complexity of work in progress indicates less intensive inspection would be appropriate
- Unannounced construction inspections may be made when necessary to investigate compliance matters or to ensure that construction activities are consistent with sound engineering

Typical sample construction inspection checklists are given in Appendix B

2 5 Construction Inspection Reports

The Construction Inspection Report is the means by which the EDC Inspector reports the construction progress and related activities observed during each construction inspection performed, with emphasis on any changes and problems that develop during construction The report should discuss the progress of current construction activities and the structural behaviour of completed or partially completed features upon which observations are being made, and also provide a continuous record of events and data for future reference The report should be comprehensive and, if possible, be adequately documented with referenced numbered photographs to show major construction activities and conditions

The construction report should not unduly depend on information supplied in the licensee's monthly progress report and should not be delayed due to untimely receipt of the licensee's report Any information normally obtained from the licensee's monthly progress report should be obtained during the construction inspection or, if not available at that time, can be obtained later and included in the next construction report The engineer making the inspection and report should be thoroughly familiar with the provisions of the license and the drawings and specifications, and the various Acts and Rules promulgated under the Acts insofar as they affect the inspector's responsibilities

A sample Construction Report Outline is included in Appendix C

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The construction report should be prepared in accordance with the instructions given in the following paragraphs

2 5 1 Summary

Submit general comments on progress and adequacy of the work during the report Highlight major items of interest, note any items of the license not being complied with, and note any matters requiring immediate attention When applicable, such items as flows should be included in the brief narrative summary to provide quick information on progress and problems of importance on the project

- Major structures started or completed, including unusual rates of concrete placement and earthwork
- Installation of major equipment started or completed
- Deviations or changes from the contract schedule which will affect time, money, or manpower
- Completion or probable completion within the next reporting period of major mileposts such as initial diversion, initial storage or closure, online dates, etc
- Any significant events or problems encountered or anticipated from labour, weather, lack of materials or drawings, or other reasons
- Failure of contractors' plant or equipment which would affect progress
- Unusual or innovative construction methods

2 5 2 Location Map

A suitable map or physical location chart should be developed to show the locations of work in progress and identify by separate contract if applicable

2 5 3 License Requirements

The initial inspection report should tabulate the terms and conditions of the license pertaining to or affected by the construction activities It should be noted what action has been taken in regard to each condition requiring specific action by licensee Subsequent reports should indicate only those remaining actions which have completed since the last report or remain to be accomplished Any violations concerning environmental matters, recreation, and public safety should be noted

2 5 4 General Construction Progress

Submit a concise description and status of construction activities and related events during the report period for each major project component Attention should be given to major items of work which affect overall progress, rather than be detailed statistical information

2 5 5 Foundations

Particular attention must be given to foundation conditions, foundation preparation, and the type of material and conditions of placement Scheduled or special inspections should be timed to permit observation of representative examples of all foundation treatments

Photograph and describe the foundation areas that have been uncovered Exposed foundation areas may reveal faults, cracks, crevices, and other conditions which may require special treatment In such cases, comment should be made on the corrective measures proposed or utilized by the licensee Copies of any special reports on the foundation or treatment thereof should be included with the Construction Report

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Where appropriate, foundations should be mapped for record purposes by the licensee during excavation, and a copy should be retained by the EDC Inspection Division

2 5 6 Quality Control

Carefully observe and describe the quality of materials used and work performed and report any deficiencies noted Project works should be constructed in conformity with contract plans, specifications, and good construction practice Capable managerial and supervisory forces should be available to exercise effective and efficient job control

(a) Licensee's Quality Control Inspection Program Identify the organization responsible for the quality control program Provide general observations and comments on the quality control organization, the competence of personnel, and the overall effectiveness of the program Subsequent reports need only make reference to the construction report containing this information However, any changes should be discussed in the current report

(b) Materials Testing and Results A summary of the results of all the material testing required by the quality control program which were performed since the previous inspection should be tabulated with particular attention given to the following items

(1) Note whether test facilities for controlling concrete materials, concrete mixing, and placing operations are adequate and include periodic summaries of tests on concrete specimens and results of all tests

(2) Furnish information on test methods and results of controlling and testing fill material being used in embankments Note whether moisture, density, and gradation variations are within specified limits, and provide summaries of test results Field control tests that fail to meet specifications and that cause an area to be reworked, should be reported Types of tests should be referenced to the appropriate standards were applicable All quality control data should be accessible for review at the time of inspection Such data should include field control tests, laboratory reports, construction progress drawings, and other pertinent construction records

(c) Construction Materials Sources of all major construction materials for which quality control is applicable should be reported The type of concrete materials, cement, aggregate and admixtures should be identified A plan should be included that shows the location of borrow areas and quarries

(d) Construction Practices Furnish information on construction practices and procedures as related to quality control Include general information relative to quality of concrete form work, placement, curing, and method of material placement and compaction in earth or rock fill structures

(e) Instrumentation A plan for instrumentation should be formulated and adopted by the licensee as soon as possible after the license is issued and all proposals for instrumentation should be reviewed for suitability, timeliness, and adequacy in accordance with this plan The basic instrumentation should be installed as soon as practical during construction However, the plan should be flexible enough to permit the placement of instruments at critical areas disclosed during construction and operation Instrumentation installed should be inspected and an appraisal included in the report

2 5 7 Other Items of Interest

Discuss here events not reported elsewhere in the inspection report Typical items are matters requiring continuing or follow-up action, public relations, job safety, important visitors, changes in job management, critical events and dates, and reservoir filling

Report any conditions which constitute a danger to life, health, and property, or adversely affect the scenic aspects of the project to the licensee and to the Deputy Director, Inspection, EDC This includes reporting on other pollutants to the environment, the degree of its impact on the environment and need for mitigative action to correct the problem These matters should be discussed in the construction report

Any variations noted between the work being and the approved specifications and drawings should be brought to the attention of the licensee's chief representative on the job for clarification and should be noted in the report

2 6 Final Construction Report

The final construction report should summarize

- The construction sequence, including photographs of major structures
- Overall results of quality control testing
- Surveillance monitoring of instrumentation
- Inspecting engineers' observations, with recommendations of specific features to be observed in future operation reports
- Observations made during the final construction inspection

The complexity of the project will dictate the type of report submitted

Representatives from EDC should witness the commissioning and acceptance tests for the turbines and generators, and receive a full report with results and evaluations from the licensee

3 Quality Control Inspection Programs

3 1 Quality Control Inspection Programs

Production licensees should be required to submit to EDC for approval and then subsequently implement, a quality control inspection program (QCIP) for the project construction The quality control inspection should not be carried out by the construction contractor, but should be performed by the licensee, the design engineer, or an independent firm directly accountable to the licensee The intent of this requirement is to make certain that the personnel responsible for quality control inspection are independent from the personnel who are responsible for construction

The inspection program, and the personnel involved, should be the subject of periodic review and evaluation to determine effectiveness and the need for any changes

An outline of a typical Quality Control Inspection Plan is given in Appendix D

3 2 Sediment and Erosion Control Plans

Production licensees should be required to submit to EDC for approval, a sediment and erosion control plan for the project construction This plan will require that the contractor implement and maintain appropriate erosion control and other measures to prevent environmental degradation of streams and watercourses during construction The sediment and erosion control plan should include provision for the preparation of a monthly report that addresses means for ensuring proper construction practices that will minimize erosion and other environmental problems during construction

Specifically, the sediment and erosion control plan provide for

- Inspection and monitoring of erosion control and other measure that would be required for the protection of the environmental integrity of streams and other areas affected by the construction
- Provision in the monthly construction inspection reports for discussion of erosion control and other measures and their effectiveness The monthly construction inspection reports should also include a discussion of any instances where sediments or other construction discharges entered the stream(s), the extent of discharges, an assessment of any damage to the stream(s), and corrective actions taken, including measures to prevent further problems

An outline of a typical Sediment and Erosion Control Plan is given in Appendix E

3 3 Temporary Emergency Action Plans

Production licensees should be required to submit to EDC for approval, a temporary emergency action plan for the project construction This plan would require the contractor to implement and maintain such a plan in effect where construction of a temporary or permanent cofferdam or large sediment control structure would create a temporary impoundment which might endanger construction workers or otherwise endanger public health or safety should the impounding structure fail

A temporary emergency action plan for a hydroelectric construction site is required so that early warning can be received of flows that might overtop cofferdams, that workers can be quickly advised of an emergency, that means of egress from the site are provided, and that speedy notification can be provided to the emergency services

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An outline of a typical Temporary Emergency Action Plan is given in Appendix F

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4 Dam Safety

4 1 Introduction

Proper maintenance and operation of a dam and reservoir are critical to the continuing safety and integrity of the dam and reservoir and to the protection of life and property

A properly designed, constructed, and operated dam can be expected to improve the safety of downstream developments during floods However, the impoundment of water by a dam can create a potential hazard to downstream developments greater than would exist without the dam because of the potential for dam failure

The safety of dams is of the utmost importance in the interest of public safety Dam failures, or even abnormal releases of water downstream, can cause serious loss of life and also considerable damage and destruction to property, agriculture, and commerce

In general, the instances of dam failure are few But, when a failure occurs, the consequences can be catastrophic It is more economic overall to institute the necessary measures and procedures for the safe design and operation of dams, than to endure the social and economic consequences of even one failure event Also, such measures and procedures, in the case of hydroelectric facilities, will enable holders of production licenses to fulfill the requirements of the Electricity Act and provide safe and reliable means of electric generation

With regard to production facilities, it is understood that, at this time, EDC has no formal regulations covering design standards or procedures with regard to dam safety It is, therefore, recommended that suitable regulations covering dam safety should be put in place and that all holders of production licenses should be required to comply with these regulations

The appropriate regulations should cover both the design and the operation of such dams or other water retaining structures Design includes the standards and procedures necessary to ensure stable and safe structures Operation includes the methods of operation and maintenance of the structures, as well as the provision of public safety plans, emergency action plans, routine operation and inspection procedures, and independent consultant safety inspection requirements

This section discusses design and operation procedures for dams and the role of EDC as the regulatory agency involved, under the following headings

- Hazard Potential Classification
- Major Technical Factors
- Routine Operation and Inspection Procedures
- Five-Year Safety Inspection Requirements
- Emergency Action Plans
- Public Safety Plans

4 2 Hazard Potential Classification

Dams, whether concrete, earth, or rockfill, should be stable under a variety of loading conditions and should have adequate spillway capacity for the particular location and site However, this has to be achieved at an economical cost in relation to the degree of hazard that the dam poses in the event of a failure or extreme flood event Also, the extent of emergency action and public safety measures required depends on the impacts of the dam failure

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or flood event involved It is recommended therefore that dams regulated by EDC be classified in relation to the hazards posed

Effectively, the hazard classification of a project determines the level of engineering review and the design criteria that are applicable Therefore, it is critical to assess the appropriate hazard potential of a dam, because it sets the stage for the analyses that should be completed to properly evaluate the structural integrity of any dam

The hazard potential of dams describes the potential for loss of human life or property damage in the area downstream or upstream of the dam in the event of failure or incorrect operation of a dam Hazard classification does not indicate the structural integrity of the dam itself, but rather the effects if a failure should occur during both normal and flood flow conditions Generally, the three principal hazard classifications are low, significant, and high and these classifications are defined as follows

- *Low*
  Dams conforming to criteria for the low hazard potential category generally are located in rural or agricultural areas where failure may damage farm buildings, limited agricultural land, or township or country roads Low hazard potential dams have a small storage capacity, the release of which would be confined to the river channel in the event of a failure, and therefore would represent no danger to life

- *Significant*
  Significant hazard potential category structures are usually located in predominately rural or agricultural areas where failure may damage isolated homes or secondary highways, cause interruption of use or service of relatively important public utilities, or cause some incremental flooding of structures with possible danger to human life

- *High*
  Dams in the high hazard potential category are those located where failure may cause serious damage to homes, agriculture, industrial, and commercial facilities, important public utilities, or main highways, and there would be danger to human life

The hazard potential evaluation includes consideration of recreational development and use, and of socioeconomic matters Included in the high hazard potential category are dams where failure would cause serious damage to permanently established or organized recreational areas or activities Also, included in the high hazard potential category are dams where failure would result in loss of life of people gathered for an unorganized recreational activity (such as fishermen and kayakers) where concentrated use of a confined area below the dam is a common annual occurrence during certain times each year

In many cases, the hazard potential classification can be determined by field investigations and a review of available data, including topographic maps However, when the hazard potential classification is not apparent from a field reconnaissance, detailed studies, including dambreak analyses, are required for various floodflow conditions to evaluate the incremental effects of a failure of a dam in order to identify the flood level above which the consequences of a failure become acceptable This flood is defined as the Inflow Design Flood (IDF) and is the floodflow condition above which the additional incremental increase in elevation due to failure of a dam is no longer considered to present an unacceptable threat to downstream life and property

The selection of the appropriate IDF for a dam is related to the hazard classification for the dam The IDF for a dam having a low hazard potential is selected primarily to protect against loss of the dam and its benefits should

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a flood occur The IDF for high and significant hazard potential dams is the maximum flood above which there are no significant incremental impacts on downstream life and property

4 3 Major Technical Factors

As far as the design of a new dam is concerned, or the analysis of an existing dam, two factors are of prime importance in the field of dam safety

(a) **Spillway Flood Capacity**
The ability of the appropriate flood to be safely carried through the project

(b) **Structural Stability**
The ability of the dam to structurally withstand all the different applied load cases with adequate factors of safety

Spillways and flood outlets should be capable of safely conveying major floods to the watercourse downstream from the dam without the dam being overtopped They are selected for a specific dam and reservoir on the basis of release requirements, topography, geology, dam safety, and project economics

Spillways can be gated or ungated An ungated spillway releases water whenever the reservoir elevation exceeds the spillway crest level A gated spillway can regulate releases over a broad range of water levels

There are three specific classifications of spillways as follows

- *Service Spillways* should be designed for frequent use and should safely convey releases from a reservoir to the natural watercourse downstream from the dam

- *Auxiliary Spillways* are usually designed for infrequent use and it is acceptable to sustain limited damage during passage of the IDF

- *Emergency Spillways* may be used to obtain a high degree of hydrologic safety with minimal additional cost Because of their infrequent use it is acceptable for them to sustain significant damage when used and they may be designed with lower structural standards than those used for auxiliary spillways

Factors that affect the choice of spillway type include
- Discharge capacity
- Project objectives and flexibility - range of releases
- Operation and maintenance
- Reliability
- Data and control requirements
- Emergency evacuation of water from a reservoir
- Economics

In sizing spillways, floods due to glacial lake outbursts and reservoir bank landslides must be considered as appropriate as well as the normal floods due to rainfall, snow and ice melt, etc

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Structural stability requires that dams be analysed for different loading cases and then to achieve satisfactory factors of safety For example, gravity dams of moderate height are often analysed for the following loading combinations

- Case I - Usual Loading Combination - Normal Operating Condition
- Case II - Unusual Loading Combination - Flood Discharge
- Case IIA - Unusual Loading Combination - Ice
- Case III - Extreme Loading Combination - Normal Operating with Earthquake
- Case IIIA - Extreme Loading Combination (Unconstructed Dams Only) - Construction Condition with Earthquake

Also, freeboard should be considered as this provides a margin of safety against overtopping failure of dams

4 4 Routine Operation and Inspection Procedures

Dam safety involves three particular items regular inspections, monitoring, and frequency of inspection

(a) **Regular Inspections** Regular Inspections are the core of a good dam safety program Maintenance crews should be on site frequently Their duties include dam maintenance as well as reporting any unusual conditions observed Professional engineers on staff inspect the dams on a semi-annual basis Inspections are also made after the occurrence of unusual events such as earthquakes, high wind, sabotage, vandalism, and reports by citizens of unusual observances Photographic records of key indicators are also kept to allow time comparison of dam performance Following the identification of any observable defects in the dams, steps are taken to repair the defects The establishment of a good team of engineers and workers is very valuable in maintaining a regular, thorough inspection process

A written report is prepared that summarizes the inspection checklist (a typical sample checklist is given in Appendix G) and any maintenance items that require action by the maintenance crews All inspection reports are forwarded to the Plant Manager with copies to the appropriate operational personnel These are made a part of the project records so that changes in structures will be documented and available for reference

(b) **Monitoring** Monitoring includes the recording of reservoir levels daily Level sensors are used to measure lake levels Upstream flow is monitored with staff gages or gaging stations For earth dams, data are collected to monitor the phreatic surface within the dam and hydrostatic pressure beneath the concrete in the spillway Piezometers are read weekly and data are plotted to monitor fluctuations in the water level within each of the piezometers Isolated areas of seepage on downstream slopes of dams should be closely monitored Siltation studies can also be performed on reservoirs using surveying sonar equipment to develop topography of the reservoir bottom This provides a means to determine storage volume and absence or presence of any scouring action Strain gages can be placed on concrete dams in order to detect movement Surveys can be performed periodically on permanent monuments set in embankments to monitor for movement Additionally, the isolated seepage areas on the downstream slope should be surveyed regularly to note any changes

(c) **Frequency of Inspection** Normally, all high and significant hazard dams will be inspected once a year, however, when unusual conditions are encountered, inspections may be made at more frequent intervals Normally, a special inspection of a project will be made following an unusual occurrence, such as an earthquake, slide, or a significant change in a seepage condition The operation inspection frequency for a low hazard potential dam will be at least biennially for dams that are 25 feet or higher or have a storage

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capacity of 50 acre-feet or more Smaller dams that do not meet the above criteria will be inspected at least triennially

However, Rule 79 in Electricity Regulation 2050 requires the licensee to arrange for an examination of his operating plant every year and, therefore, whatever the hazard classification, the project dams should also be inspected on an annual basis Annual project inspection is also referred to in Section 5 3 under the heading of frequency of inspection of operating plants

4 5 Five-Year Safety Inspection

In the case of significant and high hazard dams, a major inspection of the project works, excluding transmission lines and generating equipment, is recommended every five years This is to determine whether there are any current or potential deficiencies in the condition of project structures, quality and adequacy of maintenance, or methods of operation, which might endanger public safety

This inspection should be performed under the direction of a suitably qualified engineer duly approved by EDC If in the course of the inspection, the engineer discovers any condition for which emergency corrective measures are advisable, the independent consultant must immediately notify EDC and the holder of the production license of that condition

The suggested main headings for a Five-Year Safety Inspection Report are as follows

- Summary - Significant Findings
- Description of Project Features
- Summary of Construction History and Operation
- Geologic and Seismic Considerations
- Instrumentation
- Field Inspection
- Structural Stability
- Spillway Adequacy
- Adequacy of Maintenance and Methods of Operation
- Conclusions
- Recommendations
- Certification

A more detailed outline of the contents of the report are given in Appendix H

It is recommended that the first five year safety inspection be performed within one year of the completion of project construction for new projects and as soon as agreement can be reached in the case of existing projects

For the first five-year safety inspection report, calculations approved by the inspecting engineer relating to structural stability and spillway adequacy should be attached to the report as an appendix, with summaries include in the body of the report

The first report will require the preparation of a lot of information In subsequent inspections, it will only be necessary to document changes

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4 6 Emergency Action Plans

The primary purpose of an emergency action plan (EAP) is to provide operating and mobilization procedures to be followed in case of an emergency An emergency is defined as an impending or actual sudden release of water at the project caused by natural disaster, accident, or failure of the project works

The EAP should be designed to, among other things, provide an early warning to upstream and downstream inhabitants, property owners, recreation users, and other persons in the vicinity of the project or dam potentially endangered in case of an emergency Notification procedures for such parties should be established and coordinated with appropriate agencies responsible for disasters or emergencies, community officials, and recreation facility operators

The EAP should be simple and concise in that it is a communication on "who" does "what " The main headings of a typical EAP are as follows

- Notification Flowcharts
- General Responsibilities
- Notification Procedures
- Preventive Actions
- Appendices
  - project description
  - engineering analysis
  - inundation maps
  - training, testing, and annual review

A more detailed list of contents of a typical EAP is given in Appendix I

4 7 Public Safety Plans

The public frequently has access to intakes, dams and related water retaining structures For example, in many cases, these structures provide the only means of crossing the river for the local population In addition, the safety of the plant operators who often must perform difficult and dangerous tasks at intakes and dams is a major concern A public safety plan describes the measures and devices to be provided to facilitate the safety of the public

Safety measures and devices can be divided into two groups

- Those which limit access or deter people and animals from getting into an intake or a forebay
- Those which are escape devices in the event a person enters a forebay either deliberately or by accident

Fencing, guardrails, warning signs, and pipe safety barriers are safety devices which limit or deter people and animals from entering the forebay area Of these, fencing is probably the most effective deterrent, however, warning signs are heeded by some people and guardrails are used to keep people and vehicles from accidentally falling or driving into intakes and forebays Pipe safety barriers present enough of an obsatacle to reduce the temptation to use pipe crossings over a forebay as a walkway

Safety nets, safety cables, safety racks, and safety ladders are devices which aid people to escape from a canal

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Hazardous features at projects include

- Spillways
- Powerhouse Intakes
- Powerhouse Tailrace Areas
- Spillway Tailraces
- Canals and Forebays
- Intake Areas
- Dam Crests
- Boat or Raft Ramps
- Switchyards and Transmission Lines
- Bridges
- Project Structures in general
- Natural and Other Hazards
- Recreation Areas
- Winter Conditions

Safety devices and measures include the following

- Education and Information
- Warning Devices (these include danger warning signs, audible warning signs, lights and illumination, beacons and strobe lights, buoys, and verbal warnings)
- Restraining Devices (these include boat restraining barriers, fences, guardrails, natural barriers, trashracks, and debris deflector booms)
- Escape Devices (these include such items as life preservers safety ropes escape nets escape ladders and suspended cables)

The project mode of operation may also be a factor especially where rapid changes in water flows or levels can occur

Each project should be reviewed for public safety needs on a case-specific basis It is extremely important to assess the number and type of public safety measures at any project based on the public use patterns at a project For example, projects that do not have significant and documented use may require only nominal public safety measures, such as proper signing

The Public Use Plan will document the project description and mode of operation, details of the project structures and an indication of the hazard posed, the extent of public access, and the details and design requirements for the public safety devices and measures required

A sample outline for a Public Use Plan is included in Appendix J

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5 Projects In Operation

5 1 Introduction

Projects in operation are inspected to see that they are being properly maintained to assure the continued operation of the project and the safety of the structures, that no unauthorized modifications have been made to the projects, and that the project is being operated efficiently and safely and in compliance with the terms and conditions of the relevant production license

5 2 Project Documentation

Prior to inspection, the project documentation held by EDC should be reviewed for project familiarization and to ascertain if there are any outstanding action items from previous inspections or from six monthly reports or from other notifications

Project documentation at the operational stage will include but not be limited to the following

- Pertinent Data Sheet
- Survey License Application
- Survey License
- Project Agreement
- Production License Application
- Production License
- Power Purchase Agreement
- Survey Report
- Other Feasibility Reports
- Geotechnical Reports
- Design Criteria Document
- Construction Drawings
- Equipment Drawings
- Specifications
- Construction Reports and Records
- Commissioning and Acceptance Test Reports
- Six-Monthly Reports by Licensee
- Annual Inspection Reports
- Five-Year Dam Inspection Reports
- Any Other Relevant Documentation

5 3 Frequency of Inspection

Rule 79 in Electricity Regulation 2050 requires the licensee to arrange for an examination of his operating plant every year and to obtain a certificate verifying this

EDC should inspect all operating plants at least once every year

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5 4 Inspection Report

A typical Operation Inspection Checklist is included as Appendix K and a sample Outline of an Operation Inspection Report is included as Appendix L

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6 Conclusions And Recommendations

6 1 General Conclusions

Following the issue of production licenses by HMG/N for a hydroelectric power project, EDC is the responsible agency tasked with monitoring both the construction and operation of licensed facilities This monitoring is to ensure that licensees are taking adequate steps to build sound projects in accordance with the Electricity Act 2049, the implementing regulations contained in the document Electricity Regulation 2050, together with the terms and conditions of the respective production licenses

EDC is also tasked with making recommendations to HMG/N regarding measures to be taken while designing and constructing dams, powerhouses and other structures and in connection with safety standards At this time, for example, it is understood HMG/N has no formal dam safety requirements that production licensees should provide for

At the same time, it is important for the production licensees that they are aware of their commitments under their licenses particularly as far as items such as dam and project safety are concerned

As with the licensing process up to award of license, so with the subsequent phases of construction and operation, three questions are relevant

- Why are regulatory oversight and monitoring needed?
- How much oversight is necessary?
- Why are safety requirements and other procedures necessary?

Three of the main reasons for regulatory oversight and monitoring are as follows

- To ensure public safety
- Such oversight and monitoring are required under the Electricity Act 2049 and the resulting Electricity Regulation 2050
- To ensure that, without relieving the production licensees of their responsibilities, hydroelectric projects are designed and built in such a way as to be safe and reliable sources of power

Sufficient oversight is necessary to ensure that projects are safe and reliable Production licensees should have a clear idea of the construction and operation requirements they have to fulfill, particularly with regard to safety Then, just sufficient review and oversight are required to check that projects are being properly constructed and operated and that all safety procedures are in place and being followed

Safety requirements and procedures are important because they provide the framework for production licensees to fulfill the requirements of the Electricity Act and the Electricity Regulations and to provide safe and reliable generation

As far as dam safety is concerned, two items that are of prime importance and for which guidelines specific to Nepal are required are the determination of the project flood to be used for design purposes and the determination of design criteria and factors of safety to be used for dam stability analysis

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6 2 Overall Recommendations

The overall recommendations of the Specialist - Power Operations/Safety are that

- EDC, as the regulatory institution, and production licensees need to have clear and comprehensive guidelines for their respective roles in the construction and operation of hydroelectric power generation facilities
- The overall licensing framework set out in the rules contained in the document, Electricity Regulation 2050, is satisfactory However, further amplification and addition of requirements, especially with regard to safety and reliability are needed
- EDC needs guidelines regarding the degree of inspection of both projects under construction and projects in operation necessary to fulfill their role of a regulatory agency
- Production licenses should contain conditions that will permit EDC to satisfactorily discharge their responsibilities for regulatory oversight of both the construction and operation phases of licensed hydroelectric power projects
- The regulations and licenses should contain clauses that adequately address the questions of project and public safety
- EDC staff should be qualified to properly discharge their oversight responsibilities, and training should be provided to reach and maintain the level of expertise necessary
- EDC should initiate a study to establish guidelines specific to Nepal for determining flood flows for project design and for the selection of spillway and other flood outlet structure hydraulic capacities The study should look at projects already designed and in operation, as well as guidelines from other countries The study should investigate hydrological methods, the effects of glacial lake outburst floods and reservoir bank landslides, and also the necessary freeboard
- EDC should initiate a study to establish guidelines specific to Nepal for the determination of design criteria and suitable factors of safety for the analysis of the stability of concrete, earthfill, rockfill, and other types of dams

6 3 Construction - Regulatory Oversight

Specific recommendations for incorporation in the regulations or in EDC procedures as appropriate are as follows

- Rules should be drawn up requiring the production licensee to provide to EDC the following documentation prior to commencement of construction
  - Schedule for submission of documentation to EDC for review - schedule to include adequate time for EDC to review the documentation
  - Design Criteria Document
  - Construction Specifications and Drawings
  - Construction Schedule

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- The Design Criteria Document should include as a minimum, the following items
  - Introduction
  - Overall Project Description
  - Individual Structure Descriptions - Dams, Canals, Penstocks, Powerhouses, etc
  - Hydrologic and Hydraulic Criteria
  - Codes, Standards, and Regulations
  - Material Properties
  - Design Loads
  - Structural Design Data
  - Civil Structures - Methods of Stability Analysis, Factors of Safety, etc
  - Mechanical Equipment
  - Electrical Equipment

- EDC should set up procedures to inspect construction work in progress at hydroelectric projects with production licenses The following documents are attached to this report for guidance
  - Appendix A Typical Data Sheet
  - Appendix B Typical Construction Inspection Checklist
  - Appendix C Sample Construction Report Outline

  This inspection should include monitoring of the Quality Control Inspection Program, the Sediment and Erosion Control Plan, the Temporary Emergency Action Plan, and any other relevant plan or program in place at the construction site under consideration

6 4 Quality Control and Inspection

Specific recommendations for incorporation in the regulations are as follows

- The production licensee should be required to submit to EDC for approval prior to the commencement of construction, the following program and plans
  - Quality Control Inspection Program
  - Sediment and Erosion Control Plan
  - Temporary Emergency Action Plan
  - Any other relevant plans specific to the project

  The following documents are attached to this report for guidance
  - Appendix D Sample Outline of Quality Control Inspection Program
  - Appendix E Sample Outline of Sediment and Erosion Control Plan
  - Appendix F Sample Outline of Temporary Emergency Action Plan

- Following approval by EDC, the production licensee should be required to implement the above-mentioned plans throughout the period of construction of the hydroelectric power project

6 5 Dam Safety

Specific recommendations for incorporation in the regulations or in EDC procedures as appropriate are as follows

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- EDC should inspect all dams, water retaining structures, spillways, and flood outlets at least once a year

- Every five years, the production licensee should be required to perform a major dam inspection for all the water retaining structures, spillways, and flood outlets on the licensed project This will cover all aspects including hazard classification, spillway flood capacity, dam stability, physical condition of structures, etc It is recommended that the first five-year inspection be performed within one year of the completion of project construction for new projects and as soon as agreement can be reached in the case of existing projects

  The following documents are attached to this report for guidance
  - Appendix G Typical Dam Inspection Checklist
  - Appendix H Sample Outline of Five-Year Dam Safety Inspection Report

- Production Licensees should submit to EDC for approval prior to commencement of the operation phase the following plans
  - Long Term Emergency Action Plan
  - Public Safety Plan

  The following documents are attached to this report for guidance
  - Appendix I Sample Outline of Emergency Action Plan
  - Appendix J Sample Outline of Public Use Plan

  Following approval by EDC, the production licensee should be required to implement the above-mentioned plans throughout the operation phase of the project

6 6 Projects in Operation

Specific recommendations for incorporation into the regulations or in EDC procedures as appropriate are as follows

- EDC should inspect all operating plants with production licences at least once every year

  The following documents are attached to this report for guidance
  - Appendix K Typical Operation Inspection Checklist
  - Appendix L Sample Outline of Operation Inspection Report

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Appendices

Appendix A

Typical Data Sheet

Name of Project

Type of Project (e g , Run-of-river, run-of-river with daily pondage, storage, etc)

Location On river at

Access km

Installed Capacity MW

Average Annual Energy GWh

Dates of Project Construction to

Hydrology
- Catchment Area km^2
- 90% Dependable Flow cumec
- Probable Maximum Flood cumec
- Inflow Design Flood cumec

Reservoir
- Normal pool area km^2
- Gross storage at normal pool bill m^2
- Net storage at normal pool bill m^2

Dam
- Type (e g Concrete gravity, gravel with central core, etc)
- Elevation (above mean sea level)
- Crest m
- Base m
- Normal Pool m
- Flood Pool m
- Crest Length m

Spillway
- Type
- Discharge Capacity cumec
- Crest Length m
- Crest Elevation m
- Number of Gates
- Size of Gates m x m

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Intake
- Type
- Number of Gates
- Size of Gates — m x m

Desander

Tunnels
- Type
- Number
- Diameter — m
- Length — m

Powerhouse
- Width — m
- Length — m
- Height — m
- Number of water passages
- Intake invert elevation — m
- Draft tube outlet invert elevation — m
- Normal headwater elevation — m
- Normal tailwater elevation — m
- Minimum tailwater elevation — m
- Rated net head — m
- Minimum net head — m

Turbine/Generator Data
- Number of turbines
- Type
- Turbine rated head — m
- Turbine rated discharge per unit — cumec
- Total hydraulic discharge — cumec
- Turbine rated output per unit
- Speed — rpm
- Number of generators
- Type
- Generator rated output per unit — kW

Transformers
- Type
- Size
- Number

Switchyard

Transmission Line
- Voltage — kV
- Length — km

Appendix B

Typical Construction Inspection Checklist

B1 Construction Progress

Inspect each part of the project under construction List structures and make estimate of progress for different types of work for different structures, using schedules obtained from licensee or contractor

- **Types of Work**
  - General Excavation
  - Foundation Excavation
  - Blinding Concrete
  - Mass Concrete
  - Structural Concrete
  - Fill Materials
  - Etc

- **Types of Structure**
  - Dams
  - Spillways
  - Powerhouses
  - Tunnels
  - Etc

B2 Foundations

- Conditions
- Preparation
- Type of Material
- Conditions of Placement

B3 Quality Control

- Observe quality of materials being used
- Observe operation of licensee's quality control and inspection program
- Review on site the materials testing and the results being obtained
- Check borrow areas and other sources of materials
- Construction Practices
- Instrumentation

B4 Sediment and Erosion Control Plan

- Performance

B5 Temporary Emergency Action Plan

- In operation

B6 Power Generation Equipment

Check delivery dates of

- Major Equipment (Turbines, Generators, etc)
- Powerhouse Electrical Equipment
- Powerhouse Mechanical Equipment
- Switchyard Equipment
- Gates, Guides, and Hoists
- Valves
- Stoplogs and Hoisting Equipment
- Trashracks and Trashrakes

Appendix C

Sample Construction Inspection Report Outline

C1 Summary

1 Location Map

2 License Requirements

3 General Construction Progress

4 Foundations

5 Quality Control
- Quality Control Inspection Program
- Materials Testing and Results
- Construction Materials
- Construction Practices
- Instrumentation

6 Other Items of Interest

Appendix D

Quality Control Inspection Program Sample Outline

It should be noted that items under the outline headings are suggested topics Additional topics may be included if appropriate to fully describe the Quality Control Inspection Program for the project under consideration A statement of 'not applicable is required for outline headings not needed in a particular Quality Control Inspection Program

D1 Introduction

- Purpose
- Background
- Description of structures and types of construction
- Specialized construction techniques and equipment

D2 Organization and Staffing Responsibilities

- Responsibilities of various organizations
- Number of staff and availability required
- Titles, duties and responsibilities of staff
- Specialty inspectors
- Lines of communication and authority
- Approval and rejection of work
- Authority to stop work
- Statement of independence
- Resumes

D3 Inspection Plan and Field Procedures

- Inspection criteria
- Knowledge of contract plans and specifications
- Inspection equipment and resources
- Contractor operations
- Coordination with contractor's schedule
- Quality Control Inspection Program operations
- Frequency of inspections
- Documentation and follow-up action
- Training

D4 Documentation

- Daily inspection reports
- Nonconformance reports
- Other periodic reports
- Maintenance of records
- Photographs

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D5 Training

- Study materials
- Classroom instruction
- On-the-job-training and supervision
- Proficiency testing and certification
- Resume update

D6 Material Testing

- Testing schedule
- Testing standards
- Testing organization
- Adequacy of on-site laboratory
- Adequacy of off-site laboratory
- Evaluation of testing data and actions required
- Documentation

D7 Sediment and Erosion Control Compliance

- Sediment and erosion control plan
- Frequency of inspections
- Documentation and corrective actions

D8 Schedule

- Start and finish dates
- Anticipated construction sequence
- Staged and phased construction

D9 Appendices

- Organizational chart
- Descriptions of duties and responsibilities of QCIP staff
- QCIP personnel resumes
- Project layout
- List of contract documents
- Materials testing schedule and referenced documents
- Example of reports to be used, e g nonconformance report
- Flow chart for tracking construction deficiency
- Contractor's schedule
- Record keeping procedures

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Appendix E

Sediment And Erosion Control Plan
Sample Outline

E1 Introduction

1 1 General
1 2 Agency Consultation

E2 General Description Of The Locale

2 1 Topography
2 2 Geology
2 3 Soils
2 4 Vegetation
2 5 Rare, Sensitive, Threatened, Endangered Plant Species

E3 Proposed Construction Activities

3 1 Drawings
3 2 Land Disturbing Activities
- (a) Dam sites
- (b) Spillways
- (c) Tunnel access
- (d) Surge tank access
- (e) Powerhouse
- (f) Tailrace area
- (g) Switchyard
- (h) Spoil areas
- (i) Access roads

E4 Sediment And Erosion Control Plan

4 1 General (All Sites)
- (a) Riprap
- (b) Vegetative cover and mulching
- (c) Land grading
- (d) Dust control
- (e) Sediment barriers
- (f) Silt curtain
- (g) Outlet protection
- (h) Topsoiling
- (i) Grassed waterway
- (j) Trees, shrubs, and ground covers

(k) Detention basin(s)
(l) Construction entrance
(m) Site-specific measures

4 2 Dam Sites
4 3 Spillways
4 4 Tunnel Access
4 5 Surge Tank Access
4 6 Powerhouse
4 7 Tailrace Area
4 8 Switchyard
4 9 Spoil Areas
4 10 Access Roads
4 11 Staging/Laydown Areas

E5 Monitoring And Reporting

5 1 General
5 2 Unscheduled Monitoring
5 3 Inspection Schedule
5 4 Periodic Review

E6 Schedule

E7 References

E8 Attachments

Attachment A Project Drawings
Attachment B Sediment and Erosion Control Specifications

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Appendix F

Temporary Emergency Action Plan
Sample Outline

F1 Notification Procedures

- Identification of emergency conditions
- Safety incident report
- Initiation of emergency action plan
- Termination of plan

F2 Preventive Actions

- Flood warning systems
- Site emergency warning devices - sirens, etc
- Means of egress from site - ladders, roads, etc
- Emergency supplies and resources - fill materials, rip-rap, etc
- Response during periods of darkness
- Response during periods of adverse weather
- Availability and use of alternate systems of communication

F3 Description of Project

F4 Flood Frequency and Flood Water Level Study

F5 Plan for Testing and Review

F6 Document Distribution

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Appendix G

Typical Dam Inspection Checklist

ITEM **COMMENTS**

G1 Head Works

- Piers and Deck Concrete
  - Erosion
  - Cracking
  - Deterioration
- Spillway Concrete
  - Erosion.
  - Cracking
  - Deterioration
  - Epoxy Repairs at Sill
  - Drainage Gallery
  - Manometer Readings
- Stilling Basin
  - Erosion
  - Cracking
  - Deterioration
- Radial Gates - __ No [number of gates]
  - Condition of Steelwork
  - Hoist Mechanisms
  - Seals/Leakage from Gates
  - Condition of Paint
  - Standby Generator
  - Crane for Stoplogs - Availability
- Sluice
  - Concrete Condition
  - Condition of Diamond Plate Repair
  - Sluice Gate Condition
  - Gate Seals

G2 Dam

- Settlement
- Movement
- Upstream Slope Rip-Rap
- Downstream Slope Rip-Rap
- Seepage
- Piezometer Readings

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G3 Reservoir Rim

- Slope Stability

G4 Intake Canal

- Canal
  - Side Slope Rip-Rap
- Footbridge
  - Deck
  - Piers
- Sill No ___ - El ___
  - Condition
    (Discussion with operators)
- Sill No ___ - El ___
  - Condition
    (Discussion with operators)

G5 Settling Basin

- Performance
  - Settling Performance - Sand
- Sill No ___ - El ___
  - Condition
- Boom
  - Condition

G6 Flushing Structure

- Piers and Deck Concrete
  - Erosion
  - Cracking
  - Deterioration
- Spillway Concrete
  - Erosion
  - Cracking
  - Deterioration
  - Sill Erosion
  - Downstream Concrete Slabs
- Radial Gates - ___ No
  - Condition of Steelwork
  - Hoist Mechanisms
  - Seals/Leakage from Gates
  - Condition of Paintwork
  - Standby Generator
  - Stoplog Gantry

G7 Power Intake Structure

- Condition of Concrete
- Condition of Rip-Rap
- Trashracks

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G8 Compensating Pond

- Performance
  - Settling Performance - Silt
- Sand Dredge
  - Performance
- Side Slopes
  - Condition

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Appendix H

Sample Outline of Five-Year Dam Safety Inspection Report

The contents of the Five-Year Dam Safety Inspection Report should include, but not be limited to, the following, as appropriate

H1 Summary (Significant Findings)

A Field Inspection
B Stability Evaluation
C Spillway Adequacy
D Operation and Maintenance
E Monitoring Data

H2 Description Of Project Features

A Dam(s)
B Spillway(s)
C Powerhouse(s)
D Intake and Outlet Works (i e , Canals, Desanders, Tunnels, Penstock, Surge Tanks)
E Map of Vicinity
F Plan and Sectional Drawings
G Standard Operational Procedures (i e , Reservoir Levels, Gate Operations)

H3 Summary Of Construction History And Operation Obtained From Various Information Sources

A Design Reports
B Laboratory Reports
C Construction Reports
D Geology Reports
E Seismicity Reports
F Plans and Specification Reports
G Operation and Maintenance Reports

H4 Geologic And Seismic Considerations

A Regional Geology
B Local Geology
C Foundation Condition
D Faulting
E Seismicity
F Sinkhole Potential

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H5 Instrumentation

A Location and Type (include Plan and Sectional Drawings)
B Time vs Reading Graphs of Data
C Evaluation

H6 Field Inspection

A Settlement
B Movement
C Erosion
D Seepage
E Leakage
F Cracking
G Deterioration
H Geologic Conditions
I Foundation Deterioration
J Condition of Spillway and Outlets
K Observation of Operation of Representative Number of Spillway Gates and Standby Power
L Reservoir Rim Stability
M Uplift Pressures in Structures, Foundations, and Abutments
N Functioning of Foundation Drains and Relief Wells
O Other Significant Conditions

H7 Structural Stability

A Visual Observations
B Method of Analysis
C Properties of Materials Based on Site-Specific Data
D Uplift Assumptions (Concrete Structures)
E Phreatic Surface Assumptions (Embankments)
F Factors of Safety
G Stress Analysis and Evaluation (e g , Arch and Buttress Dams)
H Loading Diagrams and Summary of Results
I Liquefaction Potential (Earthfill Structures and Foundations)

H8 Spillway Adequacy

A Flood of Record
B Inflow Design Flood
  1 Determination of Probable Maximum Flood (Assumptions, Analyses, Results)
    a Probable Maximum Precipitation Distribution
    b Watershed Model for Converting Rainfall to Runoff
    c Runoff and Flood Routing Procedures
  2 Freeboard Adequacy
  3 Dam Break Analysis (Inadequate Spillway Capacity)
C Spillway Rating Curve

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H9 Adequacy Of Maintenance And Methods Of Operations

A Procedures
B Maintenance of Dam
C Maintenance of Facilities
D Surveillance
E Evaluation

H10 Conclusions

A Assessment of Dams and Other Water Retaining Structures
  1 Field Inspection
  2 Stability Analysis (Adequacy of Factors of Safety)
  3 Stress Evaluation
  4 Spillway Adequacy
B Adequacy of Instrumentation and Monitoring of Instrumentation
C Adequacy of Maintenance and Surveillance
D Adequacy of Project Operation
E Adequacy of Operation of Spillway Gates and Standby Power

H11 Recommendations

A Corrective Measures Required for the Structures
B Corrective Measures Required for the Maintenance or Surveillance Procedures
C Corrective Measures Required for the Methods of Operation of the Project Works
D Schedules to Carry Out Each Corrective Measure
E Any New or Additional Monitoring Instruments, Periodic Observations, or Other Methods of Monitoring Project Works or Conditions that may be required

H12 Certification

A Statement of Independence
B List of Participants
C Signature of Inspector

H13 Appendices

A EDC Letter Approving Inspector
B Scope of Work of Inspector
C Inspector's Resume (Qualifications)

Appendix I

Emergency Action Plan
Sample Outline

I1 Notification Flowchart

- Failure is imminent or has occurred
- Potentially hazardous situation is developing

I2 General Responsibilities Under The Emergency Action Plan

- Purpose and scope
- Description of the dam
- Hazard classification
- Responsibility and authority

I3 Notification Procedures

- Identification of emergency conditions
- Dam safety incident report
- Initiation of the emergency action plan
- Termination of the emergency

I4 Preventive Actions

- General provisions for surveillance
- Surveillance at remotely controlled or unattended dams
- Response during periods of darkness
- Response during periods of adverse weather
- Availability and use of alternate systems of communication
- Emergency supplies and resources
- Other concerns and actions

I5 Appendices

A Description of the Project
B Summary of Studies and Analyses to Determine Extent of Inundation
C Inundation Maps
D Plans for Training, Testing, and Annual Review
E Documentation Distribution

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Appendix J

Public Safety Plan
Sample Outline

J1 General Project Data

J2 Description of Structures And Facilities

- Locations open to public
- Locations open to project staff only

J3 Project Mode of Operation

- Water level changes

J4 Public Safety Measures

- Fences
- Gates
- Lighting
- Boat Safety Devices, including booms
- Log boom/ Trashboom
- Camera System
- Signs

J5 Emergency Escape Devices

- Ladders
- Safety cables
- Safety nets
- Life preservers

J6 Warning Devices

- Audible warning devices
- Buoys
- Lighting

J7 Administration

- Plan periodic review
- Training
- Document Distribution

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Appendix K

Typical Operation Inspection Checklist

ITEM **COMMENTS**

K1 Head Works

- Piers and Deck Concrete
  - Erosion
  - Cracking
  - Deterioration
- Spillway Concrete
  - Erosion.
  - Cracking
  - Deterioration
  - Epoxy Repairs at Sill
  - Drainage Gallery
  - Manometer Readings
- Stilling Basin
  - Erosion
  - Cracking
  - Deterioration
- Radial Gates - ___ No
  - Condition of Steelwork
  - Hoist Mechanisms
  - Seals/Leakage from Gates
  - Condition of Paint
  - Standby Generator
  - Crane for Stoplogs - Availability
  - Main Electrical Supply
- Sluice
  - Concrete Condition
  - Condition of Diamond Plate Repair
  - Sluice Gate Condition
  - Gate Seals

K2 Dam

- Settlement
- Movement
- Upstream Slope Rip-Rap
- Downstream Slope Rip-Rap
- Seepage
- Piezometer Readings

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K3 Reservoir Rim

- Slope Stability

K4 Intake Canal

- Canal
  - Side Slope Rip-Rap
- Footbridge
  - Deck
  - Piers
- Sill No ___ - El ___
  - Condition
    (Discussion with operators)
- Sill No ___ - El ___
  - Condition
    (Discussion with operators)

K5 Settling Basin

- Performance
  - Settling Performance - Sand
- Sill No ___ - El ___
  - Condition
- Boom
  - Condition

K6 Flushing Structure

- Piers and Deck Concrete
  - Erosion
  - Cracking
  - Deterioration
- Spillway Concrete
  - Erosion
  - Cracking
  - Deterioration
  - Sill Erosion
  - Downstream Concrete Slabs
- Radial Gates - ___ No
  - Condition of Steelwork
  - Hoist Mechanisms
  - Seals/Leakage from Gates
  - Condition of Paintwork
  - Standby Generator
  - Stoplog Gantry

K7 Compensating Pond

- Performance
  - Settling Performance - Silt

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- Sand Dredge
  - Performance
- Side Slopes
  - Condition.

K8 Power Intake Structure

- Condition of Concrete
- Condition of Rip-Rap
- Trashracks
- Trashrake
- Erosion

K9 Headrace Tunnel

- Any Problems

K10 Surge Tank

- Any Problems
- Condition of Concrete
- Slope Protection at Surge Chamber

K11 Pressure Shaft

- Any Problems

K12 Manifold

- Any Problems

K13 Powerhouse - Civil Structures

- Check condition of concrete floor, walls, columns, and ceilings at the following locations
  - Ground Floor
  - Shafts
  - Control Building
  - Superstructure
- Check Slope Protection, including tests on anchors, behind powerhouse
- Tailrace Tunnels - Any Problems
- Check Retaining Wall along river in front of powerhouse

K14 Powerhouse Mechanical and Electrical Equipment

- The powerhouse mechanical and electrical equipment should be visually inspected as far as possible The operation and maintenance records since the last inspection should be examined for any outages or downtime attributable to equipment malfunction Discussions should be held with station operators regarding equipment performance
- Records should be examined to check that all electrical relay settings and protection devices are kept up-to-date All meter calibrations should be checked at least on an annual basis
- A generic list of **typical** mechanical and electrical plant follows

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K15 Major Equipment

- Turbines
  - Cavitation
  - Erosion due to sediment
  - Erosion of nozzles and deflectors (Impulse Turbines)
  - Shaft Seals
- Generators
  - Last Rewind, if any
  - Thrust Bearing
  - Cooling System
- Speed Increasers or Step-Up Gears, if any
- Governors
- Inlet Valves, including Butterfly Valves
- Draft Tube Gates, Hoists, and Stoplogs
- Powerhouse Crane

K16 Powerhouse Mechanical Equipment

- Dewatering Pumps
- Drainage Pumps
- Compressed Air
  - Portable Compressor
  - Fixed Compressor
- Unit Heaters
- Fire Protection System
  - Halon
  - CO^2
  - Water
- Drinking Water System
- Sanitary Water System
- Bearing Oil Cooling Water Supply
- Embedded and Exposed Pipework
- Heating, Ventilating, and Air Conditioning

K17 Powerhouse Electrical Equipment

- Switchgear, including Generator Breakers
- Control, Metering, and Relay Panels
- Excitation Transformer
- Static Exciter and Voltage Regulator
- Generator Neutral Resistor Cubicle
- Station Service Transformer, Distribution Panel, and Motor Starters
- Station Batteries and D C Panels
- Embedded and Exposed Conduit
- Supervisory Control and Data Acquisition
- Grounding
- Telephone
- Emergency or Standby Generation (Diesel)
  - Fuel Store

K18 Switchyard Electrical Equipment

- Step Up Transformer
- Lightning Arrestor
- Circuit Breaker
- Disconnect Switch

K19 Switchyard Civil

- Access
- Means for Retaining Spilled Oil (if transformer is oil filled)
  - Transformer and oil filled circuit breaker bases should have catchments and holding basins to collect and contain any oil spells
  - Crushed stone surround
- Equipment Reinforced Concrete Bases
- Perimeter Fence

K20 Stores and Workshops

- Large Items
  - Turbine Runners
  - Bearings
- Mechanical Stores
- Electrical Stores
- Mechanical Workshop
- Electrical Workshop
- Accounting
  - Adequate supply of spares on site
  - Method of tagging and recording
  - Method of issuing stores
  - Method of ordering
  - Work orders

K21 Equipment to be Exercised Annually

- Spillway and Sluice Gates and Stoplogs
- Power Tunnel Intake Gates and Stoplogs
- Butterfly Valves
- Draft Tube Gates and Stoplogs

K22 Access Roads

- Main Access to Projects
- Access Around Project

Appendix L

Operation Inspection Report
Sample Outline

L1 Summary

L2 Data Sheet

L3 Operation Inspection Report

- Safety of the Project
  - Dams and Appurtenant Structures
  - Instrumentation
  - Downstream Hazard Potential Update
  - Items Arising from Five-Year Dam Safety Inspection Reports
  - Licensee's Inspection Program
- Operation and Maintenance
  - Dams and Appurtenant Structures
  - Spillway Gates and Standby Power
  - Power Plant Equipment
  - Reservoir
  - Project Operation and Maintenance Records
  - Emergency Action Plans
- Public Safety Plan
- Findings and Follow-Up Action Required

L4 Production License Compliance Report

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