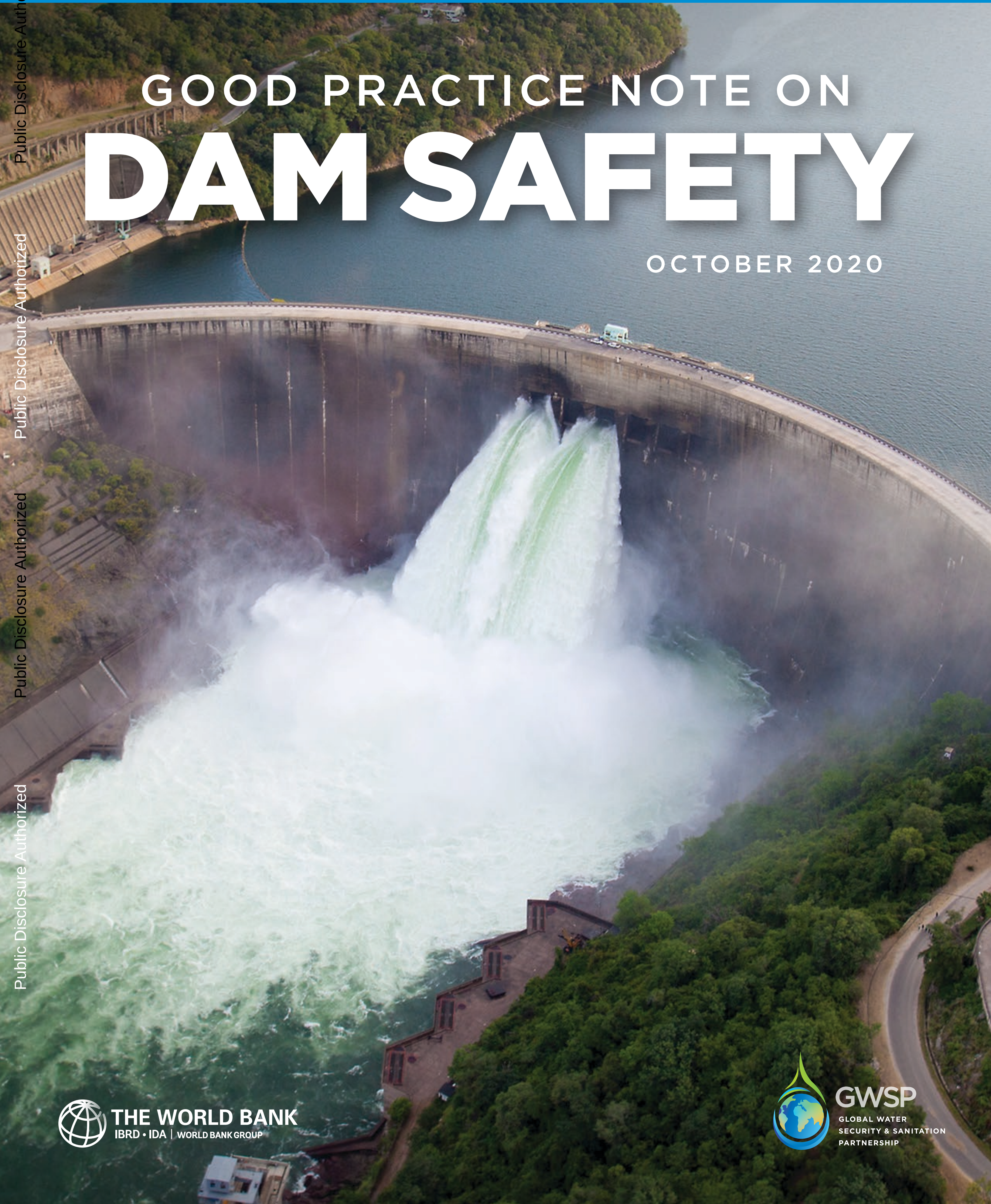
SAFETY OF DAMS AND DOWNSTREAM COMMUNITIES

GOOD PRACTICE NOTE ON DAM SAFETY

OCTOBER 2020



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Good Practice Note on Dam Safety

First Edition

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Good Practice Notes (GPNs) are produced to help World Bank staff in providing implementation support to Borrowers in meeting the requirements of the Environmental and Social Framework (ESF). They are written in a style and format that is intended for all staff and development partners to use. GPNs are advisory in nature and are not World Bank policy nor are they mandatory. They will be updated according to emerging good practice.

Cover photo: Kariba hydropower dam (Zambia and Zimbabwe) © Marcus Wishart/World Bank.

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Abbreviations

ANCOLD	Australian National Committee on Large Dams
BP	Bank Procedure
CSQAP	Construction Supervision and Quality Assurance Plan
DEM	digital elevation model
DSS	Dam Safety Specialist
DUC	dam under construction
EPP	Emergency Preparedness Plan
ESCP	Environmental and Social Commitment Plan
ESF	Environmental and Social Framework
ESIA	Environmental and Social Impact Assessment
ESMF	Environmental and Social Impact Framework
ESMP	Environmental and Social Management Plan
ESRS	Environmental and Social Review Summary
ESS	Environmental and Social Standard
E&SS	Environmental and Social Specialist
FCV	Fragility, Conflict, and Violence
FEMA	U.S. Federal Emergency Management Agency
FERC	U.S. Federal Energy Regulatory Commission
FMEA	failure modes and effects analysis
FMECA	failure modes, effects, and criticality analysis
GIIP	Good International Industry Practice
GNA	Guidance Note Annex
GPN	Good Practice Note
HEC-FIA	Hydrologic Engineering Center's Flood Impact Analysis
HEC-RAS	Hydrologic Engineering Center's River Analysis System
ICOLD	International Commission on Large Dams
IFC	International Finance Corporation
IP	Instrumentation Plan
IPF	Investment Project Financing
IRRM	interim risk reduction measures
LiDAR	light detection and ranging
LSM	Life Safety Model
MCE	maximum credible earthquake
MIGA	Multilateral Investment Guarantee Agency
OESRC	Operations Environmental and Social Review Committee
O&M	operation and maintenance
O&MP	Operation and Maintenance Plan
OMS	operational manual statement

OP	Operational Policy
OPCS	Operations Policy and Country Services
PAD	Project Appraisal Document
PAR	population at risk
PCN	Project Concept Note
PFMA	potential failure mode analysis
PLL	potential loss of life
PMF	probable maximum flood
POE	panel of experts
PPSD	Project Procurement Strategy for Development
QBS	quality-based selection
QCBS	quality cost-based selection
QER	Quality Enhancement Review
RSA	Regional Environmental and Social Standards Adviser
RFB	Request for Bids
RFP	Request for Proposal
RIDM	Risk-Informed Decision Making
SPD	Standard Procurement Document
TA	Technical Assistance
TN	Technical Note
TOR	terms of reference
TT	Task Team
USACE	U.S. Army Corps of Engineers
USBR	U.S. Bureau of Reclamation
VfM	value for money

Glossary

Cascade (or Cumulative) Failure The sequential failure of multiple dams within the same catchment basin triggered by the same event.

Catchment The area from which all the water drains naturally into one stream or other body of water.

Consequence Impacts downstream of a dam, or other areas, caused by a partial or complete failure of the dam or its appurtenances, or as a result of misoperation and an uncontrolled reservoir water release. In relation to risk analysis, represents the outcome or impact of a failure event.

Dam Failure The uncontrolled release of water, sediment, or other stored contents of a reservoir through partial or complete collapse of the impounding dam, or the inability of a dam to fulfil the intended design purposes.

Dam Safety Requirements Required minimum criteria and procedures that need to be followed regarding dam registration, licensing, construction permission, safety regulation, investigation, design, operation and maintenance, surveillance, inspection, and so on.

Dam Owner Any person, organization, or entity legally deemed to be the owner and/or responsible entity of the dam.

Dam Operator Any person, organization, or legal entity that is responsible for the control and operation and maintenance of the dam, and/or reservoir, and the appurtenant works.

Dam Portfolio All of the dams that fall under the responsibility of a single owner or single regulatory regime, or are located within a specific jurisdiction.

Deterministic Describing a process with an outcome that is always the same for a given set of inputs; hence, the outcome is determined by the input.

Emergency Any condition that develops unexpectedly; endangers the integrity of the dam or downstream life, property, or the environment; and requires immediate and coordinated action.

Failure Mode/ Failure Scenario A way that failure can occur, described by the means by which element or component failures must occur to cause loss of the subsystem or system function.

Hazard A source of potential harm or a situation with the potential to cause loss. Threat or condition may result from either an external cause (for example, earthquake, flood, or human agency) or an internal vulnerability with the potential to initiate a failure mode.

In dam safety, often seen as a measure of the consequences of dam failure. The terms *hazard* and *consequence* are, therefore, used in the same manner as the potential losses in the downstream area of the dam in the event of dam failure or misoperation, resulting in an uncontrolled release of flood waters.

High Risk — When the probability of a hazard or consequence materializing is categorized as high, or when the product of the probability of dam failure and the subsequent consequence or hazard is high.

Incident — An event that could deteriorate to a very serious situation or endanger the dam, or an event that would cause harm or damage to the downstream people, property, or the environment as a result of misoperation.

Inspection — A careful and critical observation and examination of all visible aspects of a dam, searching for abnormal visible phenomena on the surface and inside of the dam. There are generally several levels of inspection: routine inspection undertaken by onsite operators and specialized inspection undertaken by experienced dam engineers. Inspection leads to qualitative knowledge about the visible part of the dam.

Instrumentation — An arrangement of monitoring instruments or devices installed into dams or surrounding areas, possibly including the slopes of abutments and reservoir rims, that provide for measurements that can be used to evaluate the structural behavior, and load and performance parameters of the structure and surrounding areas.

Maintenance — The routine work required to maintain existing facilities and systems (civil engineering structures; hydraulic, mechanical, and electrical equipment) in a safe and reliable working condition to fulfil the intended designed purposes with routine or regular checking, testing, and repair works.

Misoperation — Incorrect operation of the dam resulting in an uncontrolled release of water as a result of not following proper operational procedures for hydraulic facilities, providing required notification or warning to downstream areas, and so on, possibly causing casualties and damages.

Monitoring — The observing of measuring instruments and devices that can provide quantitative data of physical parameters (for example, displacements, strains, water pressure, and leakage), which indicate the performance and behavioral trends of a dam and appurtenant structures, either on its surface or inside its body, and the recording and review of such data to detect any deficiencies in the dam behavior.

Operation and Maintenance — The operation, maintenance, repairs, replacements, testing, and exercising of any or all portions of the dam's structure and appurtenant facilities for the life of the system that are required to ensure facilities and systems are in a safe and reliable working condition to fulfil the intended purposes.

Population at Risk — Number of people directly exposed to floodwaters within the dam break-affected zone if they took no action to evacuate.

Potential Loss of Life — A subset of population at risk considering a fatality rate and the number of fatalities that would be highly likely because of a dam failure or misoperation, even if they took action to evacuate.

Portfolio Risk Assessment — A particular form of risk assessment or analysis that aims to make a comparative estimation of risks over all, or many, of the dams of a single owner or single regulatory or other jurisdiction.

Portfolio Risk Management	Managing all of, or many of, the dams of a single owner or single regulatory or other jurisdiction by prioritizing the dams that would warrant interventions and effective remedies in an optimal manner based on a particular form of risk assessment or analysis.
Potential Failure Mode	Any one of several mechanisms or set of circumstances that could result in a dam failure or an uncontrolled release of a large amount of water.
Potential Failure Mode Analysis	A process to systematically identify, describe, and evaluate ways a dam and its appurtenant structures could fail or cause an uncontrolled release of a large amount of water.
Probability	A measure of the likelihood that a specific event, outcome, or consequence will occur.
Public Safety	Protecting the welfare of the general public. Public safety considerations include potential dangers resulting from misoperations, such as sudden increases in turbine discharge or the opening of spillway gates without proper downstream notifications. There are also broader public safety considerations associated with dam operations and emerging issues of security that go beyond dam safety, which is primarily concerned with avoiding dam failure.
Qualitative Risk Analysis	An analysis using descriptive or numeric rating scales to describe the system failure likelihood and the magnitude of the subsequent consequences, considering all potential scenarios leading to dam failure or an uncontrolled release of water.
Quantitative Risk Analysis	An analysis based on numerical values of the probability of a series of system failure events and the magnitude of subsequent consequences, considering all potential scenarios leading to dam failure or an uncontrolled release of water.
Regulation	Written law passed by the executive arm of government under the authority of a statutory law or act that has been passed by the legislature (legislative arm of government).
Regulator	The authority that administers the relevant act that controls any aspect of dam safety.
Regulatory Framework	The structure behind regulations that describes the interaction between the regulatory instrument (for example, legislation, regulations, codes, industry standards, guidelines, or even self-regulatory documents) and the expected roles and responsibilities of the regulator and the person or entity being regulated.
Resilience	The capacity of dam safety systems to absorb, accommodate, and adapt to hazards and threats beyond the design criteria, thus preserving the critical core systems for maintaining the overall structural safety of the dam and its water storage and control functions.
Risk	Measure of the likelihood/probability and severity of an adverse consequence or impact to life, health, property, or the environment. In the general case, risk is estimated by the combined impact of all triplets of scenario, probability of occurrence, and the associated consequence. In the special case, average risk is estimated by the mathematical expectation of the consequences of an adverse event occurring (that is, the product of the probability of occurrence and the consequence, combined over all scenarios).

Risk Analysis Used to identify potential failure modes, structural performance, and adverse consequences of dams using qualitative or quantitative procedures and to estimate the risk—that is, the combination of likelihood of concurrence and magnitude of consequences.

Risk Assessment Used to examine the safety of dams, evaluating the results of risk analysis along with relevant social, environmental, economic, and other factors, and to make recommendations on risk reduction measures as needed, including additional investigations and enhanced monitoring.

Risk Index A basic qualitative risk analysis tool for preliminary risk screening of a portfolio of dams. The risk index is not a measure of risk but a relative indication of potential level of risk.

Risk-Informed Approach Uses the outcomes of a risk assessment as one of the important factors to support decision making, along with other factors, such as risk uncertainty, deterministic analyses, and other local and/or regional considerations.

Risk Management The systematic application of management policies, procedures, and practices to the tasks of identifying, analyzing, assessing, mitigating, controlling, and monitoring risk.

Risk-Based Approach Uses the outcomes of a risk assessment as the basis for decision making.

Safety Review A procedure for assessing the safety of a dam, composed of a detailed examination of structural, hydraulic, hydrological, and geotechnical design aspects and of all relevant design, construction, and surveillance records and reports to assess the integrity of a dam.

Standards-Based Approach The traditional approach to dams engineering in which risks are controlled by following established rules as to design events and loads, structural capacity, safety coefficients, and defensive design measures.

Supervising Engineer A suitably trained engineer recognized under dam safety laws to competently supervise all or specific aspects of a dam's design and construction or ongoing management.

Surveillance The continuing examination of the condition of a dam and its appurtenant structures aimed at managing risk and reducing the probability of occurrence by providing a means of early identification of any phenomena that can compromise the structural and operating integrity of the structure or its related operating equipment, including monitoring instrumentation, data interpretation, routine supervision, visual observation or inspection, tests of safety-related hydromechanical equipment, periodic audit, and dam safety review.

Threat An event that might cause damage or danger to the safety of a dam.

Vulnerability The level or degree of exposure of structures or areas to potential hazards to be adversely affected because of their locations, conditions, and other relevant factors.

Watershed An area or ridge of land that separates waters flowing to different rivers or basins.

Chapter 1
Introduction

The objective of this Good Practice Note (GPN) on Dam Safety is to provide additional guidance to World Bank staff on the application of relevant requirements under the Environmental and Social Framework (ESF). Such provisions are found in Environmental and Social Standard 4 (ESS4): Community Health and Safety and its Annex 1 on Safety of Dams. ESS4 stipulates, "Where the project involves a new or existing dam, the Borrower will provide sufficient resources to apply the requirements on safety of dams, as set out in Annex 1."[1] This GPN in particular provides guidance on using a risk management approach to the application of the dam safety requirements.

The GPN is one of a series accompanying the ESF to support its implementation, developed in partnership with specialists from inside and outside the World Bank and designed to be reviewed and updated periodically, when appropriate. The guidance contained in this note is designed to enhance the quality of practice without creating new requirements for the application of the ESF. It should be read with the ESF and regarded as complementary to, not a replacement of, the compliance requirements contained in the ESF, including the policy;[2] ESS1 to ESS10, in particular ESS4; and the accompanying Guidance Notes for Borrowers.

The GPN provides guidance on compliance requirements, a risk management approach to dam safety, risk analysis tools, quality of information and capacity, application to World Bank operations, and procedural aspects in Chapters 3 to 8.

The GPN pertains to: (a) construction of new dams or dams under construction (DUC) under Investment Project Financing (IPF); (b) rehabilitation of existing dams under IPF; and (c) existing dams or DUC that are not financed under IPF, on which the project relies or may rely.[3] This is elaborated on in Chapter 3. It should be noted that the GPN is relevant not only when dam construction and rehabilitation is financed by the World Bank but also in the case of co-financed projects when the dam is financed by the borrower or another co-financier but part of the project or associated with it.

In addition to this GPN, six Technical Notes (TNs) have been prepared to provide more detailed explanation and guidance on: hydrological risk (World Bank 2020g), geotechnical risk (World Bank 2020h), seismic risk (World Bank 2020i), small dam safety (World Bank 2020j), potential failure mode analysis (PFMA) (World Bank 2020k), and portfolio risk assessment using risk index (World Bank 2020l). Also, six appendixes are provided for sample frameworks of four dam safety plans (World Bank 2020a, 2020b, 2020c, 2020d) (see table 3.1), as well as sample terms of reference for panel of experts for new dam safety review (World Bank 2020e) and safety assessment for existing dams (World Bank 2020f).

1. ESS4, paragraph 8.
2. World Bank Environmental and Social Policy for Investment Project Financing (2016), paragraph 9.
3. ESF/ESS4 Annex 1, paragraphs 8–13 provide relevant provisions for existing dams and DUC on which World Bank-financed projects rely or may rely.

These are further expected to be complemented through a series of case studies and practice examples from the World Bank-financed projects.

It should be noted that tailings storage facilities are subject to the ESS4 Annex 1,[4] and the procedural aspect and high-level safety management concept of the GPN should be relevant for such facilities. The TN on tailings storage facilities (World Bank 2020m) provides detailed guidance on their distinct technical elements and challenges in safety management.[5]

It is important that Task Teams, Environment and Social Specialists, and Dam Safety Specialists coordinate from the early stage of project preparation to assess the potential risks and agree on the measures that should be captured in the ESF-related documents (see Chapter 8). The TNs and appendixes are intended to be used by technical specialists of the World Bank and borrowers related to dam safety who should be able to provide support for the project teams.[6]

4. The dams under ESF include tailings storage facilities and dams as under paragraph 2b—(a) retention of toxic materials and (b) are expected to become large dams during their operational life—as well as footnote 7, indicating "a tailings or a slimes dam or an ash impoundment dam" of ESS4 Annex 1.
5. While water storage dams are usually built by concrete or a combination of rockfill and soils to the full height before reservoir filling and operation, most tailings storage facilities are incrementally built with designs that partially depend on the tailings themselves for support and operated during the incremental building phase. Also, construction of a tailings storage facility may take many decades until it reaches final design height, with a single tailings storage facility often being used for the entire life of the mine. During the operational period of tailings storage facilities, many changes are likely to take place, including the operation and management personnel, creating additional challenges.
6. Wishart et al. (2020) also provides useful and relevant information on the development and assessment of appropriate regulatory frameworks for dam safety assurance.

Chapter 2
Background

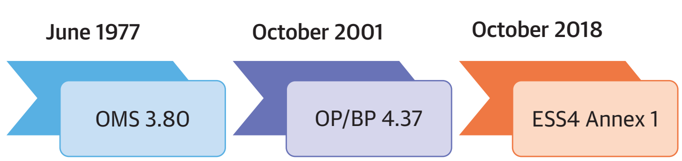
The Environmental and Social Framework (ESF) offers broad and systematic coverage of environmental and social risks. It requires attention be paid to such issues throughout the preparation and implementation of a project, with increased focus on stakeholder engagement and monitoring. It clarifies roles and responsibilities between the World Bank and its borrowers and sets out a risk management approach proportionate and tailored to the risks and impacts of projects.

Dam safety is intended to secure the water and services for which the dam was developed, as well as to protect and ensure the resilience of downstream communities, assets, and infrastructure, and the ESF reflects the steps in the evolution of the World Bank's approach (figure 2.1). The requirements of the ESF apply to all new projects from October 2018, replacing the provisions of Operational Policy (OP)/Bank Procedure (BP) 4.37: Safety of Dams.[1]

In the field of dam safety, *risk* is defined by the likelihood of an event and the associated consequences. The risks associated with the safety of dams are design- and situation-specific.[2] These will vary depending on the structural components, socioeconomic factors, and the environment within which the dam is being constructed and will operate. Application of the requirements in the ESF with respect to the safety of dams will need to reflect these considerations and be proportionate to the size, complexity, and potential risk of the dam.

The specific provisions relating to the safety of dams are intended to address safety and security risks, impacts on project-affected communities, and the corresponding responsibility of borrowers to avoid or minimize such risks and impacts consistent with the mitigation hierarchy in Environmental and Social Standard 1 (ESS1), paragraph 27. The likelihood of an event undermining the safety of a dam can be reduced through careful design, construction, and operation and maintenance. The potential downstream consequences depend on several external factors beyond the dam owner, but these can at least be mitigated through appropriate measures intended to give particular attention to people who, because of their particular circumstances, may be vulnerable or disadvantaged.

FIGURE 2.1. Evolution of Dam Safety Policies



Note: BP = Bank Procedure; ESS = Environmental and Social Standard; OMS = operational manual statement; OP = Operational Policy.

1. Projects with a concept before October 1, 2018, and their Additional Financing are subject to OP/BP 4.37.
2. ESF/ESS4 Annex 1, paragraph 4.

Chapter 3
ESF Requirements on Dam Safety

The dam safety requirements of the Environmental and Social Framework (ESF)/Environmental and Social Standard 4 (ESS4) Annex 1 are applied to the following dams:

- Large new dams, which are defined as dams with either
  - A height of 15 meters or greater from the lowest foundation to crest; or
  - Between 5 and 15 meters, impounding more than 3 million cubic meters.
- All other new dams regardless of size or retention capacity (referred to as *small dams*) that
  - Could cause safety risks, such as
    - An unusually large flood-handling requirement;
    - Location in a zone of high seismicity;
    - Foundations that are complex and difficult to prepare;
    - Retention of toxic materials; or
    - Potential for significant downstream impacts.
  - Are expected to become large dams during their operating life.

If a dam does not fall into these two categories, dam safety measures designed by qualified engineers in accordance with Good International Industry Practice (GIIP) will be adopted and implemented (see also section on Small and Low-Risk Dams).

Existing dams or dams under construction (DUC), upon which an Investment Project Financing (IPF) project relies or may rely on, are also addressed in ESS4 Annex 1.[1] Further details are included in the next section on Safety Assessment of Existing Dams and DUC on Which World Bank-Funded Projects Rely.

It should be noted that three major modifications have been introduced under the provisions of ESS4 from Operational Policy (OP)/Bank Procedure (BP) 4.37. These include: (a) lowering the threshold for large dams with a reservoir capacity greater than 3 million cubic meters from 10 meters to 5 meters in height; (b) including all other dams, regardless of size or retention capacity (referred to as *small dams*) that could cause safety risks; and, (c) explicitly introducing a proportional risk management approach to the application of the dam safety requirements, considering a dam's size, complexity, and potential risk.

The specific application of the dam safety requirements per ESS4 Annex 1 is summarized in table 3.1 for the three types of recurrent operations involving dams: (a) construction of new dams or DUCs;[2] (b) rehabilitation of existing dams; and (c) projects that rely or may rely on existing dams' or

1. ESF/ESS4 Annex 1, paragraphs 8–13 provide relevant provisions for existing dams and DUC on which World Bank-financed projects rely or may rely. This includes upgrading and raising of existing dams.
2. This includes construction of a new dam and DUC financed by the borrower and/or other multilateral and bilateral financing agencies as an integral part of World Bank-funded projects under a co-financing or parallel financing agreement.

TABLE 3.1. Guidance on the Application of the ESF/ESS4 Annex 1 Requirements in Different Types of World Bank

World Bank-financed projects involving new dams or DUCs	World Bank-financed projects involving rehabilitation of existing dams	World Bank-financed project that relies or may rely on the performance of one or more existing dams and/or DUCs
Reviews by an independent POE of the investigation, design, and construction of the dam until completion of dam performance review after first reservoir filling.[a] (See Appendix 5 for sample TORs.)	Borrower assesses whether the dam has the potential of significant impacts downstream or it exhibits complex technical features (substantial or high risk). One or more dam specialists may be needed to carry out the assessment, including on needed rehabilitation/safety improvement measures. A PFMA[b] conducted by an individual consultant or a consulting firm may be necessary, depending on the above findings. A high-risk dam, which would involve complex and significant remedial works, would require reviews by POE.	Reviews borrower's assessment report by one or more independent dam specialists on conditions of the existing dams or DUC and dam safety management system.[c] One or more independent dam specialists may be needed to carry out the assessment of the dam's safety condition and O&M procedures, including any remedial and safety improvement measures to an acceptable standard of safety. (See the paragraph after this table and Appendix 6 for sample TORs.) The needs of POE would be reviewed case by case. A PFMA, conducted by an individual consultant or a consulting firm, may be necessary, depending on the above findings.
Preparation and implementation of the following detailed plans (dam safety plans): • CSQAP • IP • O&MP • EPP (See Appendixes 1–4 for sample frameworks for the four dam safety plans.)	For projects that include additional dam safety measures or require remedial works, detailed dam safety plans are updated or prepared if not in place. The scope and depth of such plans should be commensurate with the works and site condition. For a high- and substantial-risk dam or presence of complex technical features: same provisions as World Bank financing of new dams or DUCs (including independent POE). Implement needed measures identified in the PFMA. For a low- to moderate-risk dam and absence of complex technical features: • Qualified engineers are involved in design and supervision of rehabilitation works; and • Dam safety plans are updated or prepared if not in place.	Rehabilitation measures required: same provisions as World Bank financing of rehabilitation of existing dams. No rehabilitation measures required but borrower's dam safety management system not satisfactory to the World Bank: update or prepare and implement dam safety plans and provide related training to dam operators.
Prequalification of bidders during procurement and bid tendering.[d]	Prequalification of bidders may not be required unless the project involves substantial and complex remedial works.	If rehabilitation measures are required, suitable quality control mechanism is to be arranged.
Periodic safety inspections of the dam after completion[e] and implementation of measures required to address safety deficiencies. Periodic safety inspection procedures are defined in the O&MP.	Periodic safety inspection procedures are defined in the O&MP.	Periodic safety inspection procedures are defined in the O&MP.

Note: CSQAP = Construction Supervision and Quality Assurance Plan; DUC = dam under construction; EPP = Emergency Preparedness Plan; FERC = U.S. Federal Energy Regulatory Commission; IP = Instrumentation Plan; O&M = operation and maintenance; O&MP = Operation and Maintenance Plan; PFMA = potential failure mode analysis; POE = panel of experts; TOR = terms of reference.

a. In case of staged filling, the borrower may disband the POE when, based on their advice, a suitable water level has been reached. Some projects extend the project implementation period for about two years after completion of the dam and associated structures, which would allow them to undertake a comprehensive monitoring and inspection for about one year after the first reservoir filling completion, which constitutes a good practice.

b. PFMA, originally developed by the FERC, requires dam owners to perform a qualitative risk assessment to identify potential failure modes and to assess required remedial works, monitoring instrumentation, and so on. It has established a basis for dam safety performance assessment and provides an opportunity for comprehensive safety enhancements that might be overlooked by a traditional standards-based approach. A dedicated Technical Note for Potential Failure Mode Analysis (PFMA) has been prepared (World Bank 2020k).

c. The World Bank may accept previous assessments of dam safety or recommendations of improvements needed in the existing dam or DUC if the borrower provides evidence that: (a) an effective dam safety program is already in operation and (b) full-level inspections and dam safety assessments of the existing dam or DUC, which are satisfactory to the World Bank, have already been conducted and documented.

d. See the section on Prequalification or Initial Selection of Bidders in Chapter 8.

e. One of the borrower's specialized entities or consulting firms or a POE may carry out such inspections. Either party should be independent from the dam operator. The World Bank may require evidence of such inspections as part of the sector dialogue with the country.

DUCs' performance. The table provides guidance for key dam safety requirements: (a) panel of experts (POE), (b) dam safety plans,[3] (c) prequalification, and (d) dam safety inspection after closure. In addition, the section on Key Steps by World Bank Staff in Project Preparation and Implementation in Chapter 8 provides further detailed guidance on such dam safety requirements at various project stages (see table 8.1). The dam safety requirements differ between (a) World Bank-financed projects involving dams and (b) World Bank-financed projects that do not include dams but rely on them—these tables are formatted so that these distinctions can be easily understood.

Safety Assessment of Existing Dams and DUC on Which World Bank-Funded Projects Rely

In the case of a World Bank-funded project for water supply, irrigation, hydropower, and so on, which relies or may rely on the performance of an existing dam or DUC, because of the possibility that the safe and reliable operation of upstream dams and/or World Bank-funded invested facilities could be subject to extensive damage or failure, the borrower is required to hire one or more independent dam specialists and experts to: (a) inspect and examine the safety status of the dam and appurtenant structures and its performance history; (b) review and evaluate the owner's operation and maintenance procedures; and (c) provide a report on findings and recommendations for any remedial work or safety enhancement measures to upgrade the existing dam or DUC to an acceptable standard of safety.[4]

This requirement includes existing dams or those to be funded for rehabilitation, expansion (for example, dam height raising), or completion by the borrower and/or other multilateral and bilateral agencies located in the upstream of World Bank-funded projects.[5] For example, in case of an existing dam being raised for significantly increased storage capacity[6] with major rehabilitation or safety works, on which the World Bank-funded water supply project relies in the downstream area of the dam, the World Bank should discuss and agree on the dam safety requirements under the ESF/ESS4, including an independent dam safety review mechanism (for example, terms of reference [TORs] for POE) with the borrower and other financing institutions.

In the case of an existing dam located upstream of a World Bank-funded project, it is important to undertake an assessment of downstream consequences and impacts on the facilities to be funded by the World Bank in case of dam failure, including damage or failure of World Bank-invested facilities. The section on Consequence Assessment in Chapter 7 provides some benchmarks for potential areas with downstream impacts and should be subject to specific assessment case by case.

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3. Although ESS4 Annex 1, paragraph 14 refers to "dam safety reports," the report is composed of four dam safety plans, as shown in the same paragraph from (a) to (d). Also, *dam safety report* could be mixed up with *dam safety assessment* or *review report*. Hence, this note consistently uses *dam safety plan* with reference to paragraph 14.
4. ESS4 Annex 1, paragraph 8. Note also that ESS4 Annex 1, paragraph 10 states that the World Bank can rely on an existing dam safety assessment if: (a) an effective dam safety program is already in operation and (b) full-level inspections and dam safety assessments of the existing dam or DUC have already been conducted and documented, and are satisfactory to the Bank.
5. World Bank Environmental and Social Policy for Investment Project Financing (2016), paragraph 9 in relation to possible adoption of a "common approach."
6. Storage increase of 10 percent the existing gross reservoir capacity, or dam crest's rising above 4 meters, is considered significantly increased storage, as general guidelines.

Small and Low-Risk Dams

Dams that do not fall into the previous categories[7] (which would not cause safety risks or be expected to become large dams) must have dam safety measures that are designed and implemented by qualified engineers. Such measures should take into account the borrower's capacity and need to be carried out in accordance with GIIP.[8] The borrower may need provision of technical assistance or training to meet these requirements.

In such circumstances, the borrower will confirm, through the environmental and social assessment, that there will be no or negligible risk of significant adverse impacts as a result of potential failure of the dam structure to local communities and assets, including assets to be financed as part of the proposed project. The assessment should follow the definition given earlier, with adequate contextualization. Such dams could include farm ponds, local silt retention dams, and low embankment tanks.[9]

7. The categorized dams refer to ESS4 Annex 1, paragraph 2.
8. ESS4 Annex 1, paragraph 5. Please refer to the reference list of the Technical Note on Small Dam Safety (World Bank 2020j). Three are particularly useful for small dam safety management: (a) Cemagref Editions and Engref (France), with French Committee on Large Dams, *Small Dams: Guidelines for Design, Construction and Monitoring* (Cemagref and Engref, with French Committee on Large Dams, 2002); (b) ICOLD (International Commission on Large Dams), "Small Dams: Design, Surveillance and Rehabilitation" (Bulletin 157, ICOLD, Paris, 2016), https://www.icold-cigb.org/GB/publications/bulletins.asp; and (c) FAO (Food and Agriculture Organization), *Manual on Small Earth Dams: A Guide to Siting, Design and Construction* (Rome, FAO, 2012), www.fao.org/docrep/012/i1531e/i1531e.pdf. Per ESS1, footnote 23, *GIIP* is defined as the exercise of professional skill, diligence, prudence, and foresight that would reasonably be expected from skilled and experienced professionals engaged in the same type of undertaking under the same or similar circumstances globally or regionally. The outcome of such exercise should be that the project employs the most appropriate technologies in the project-specific circumstances.
9. ESS4 Annex 1, paragraph 5, footnote 9.

Chapter 4
A Risk-Management Approach to Dam Safety

The Environmental and Social Framework (ESF) places more emphasis on building capacity within the borrower to deal with social and environmental aspects by offering broader and more systematic coverage of risks. Environmental and Social Standard 4 (ESS4) Annex 1, addressing the safety of dams, introduces a comprehensive risk management approach in line with Good International Industry Practice (GIIP).[1] In the context of dam safety, *risk* is defined as a measure of both the likelihood and consequences of an adverse event on downstream communities, environment, assets, and infrastructure.[2]

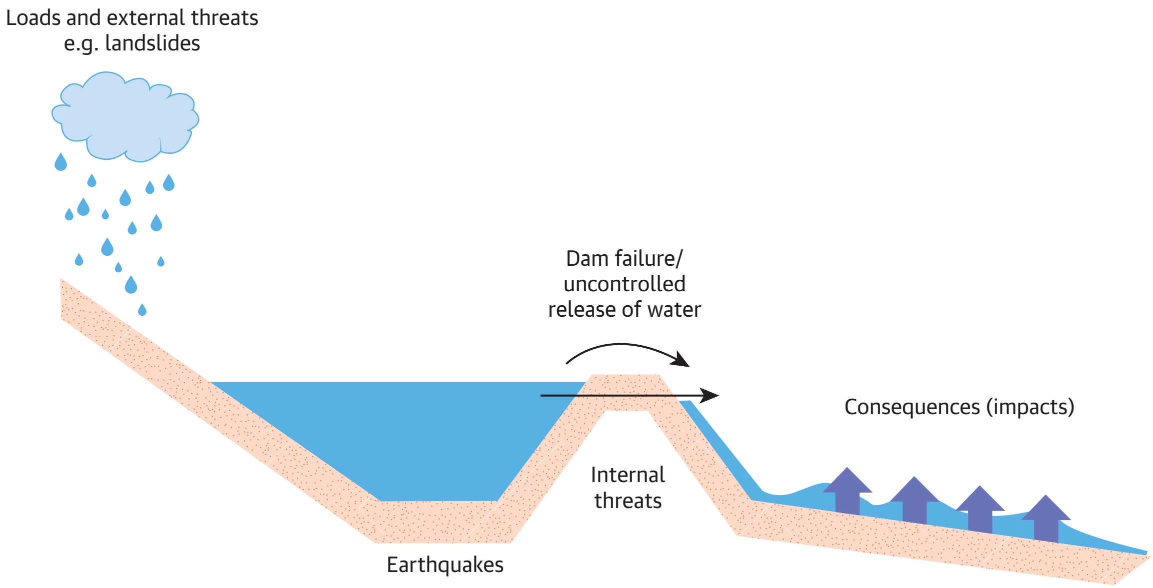
In a simple form, risk can be expressed as the expected value of risk calculated as the product of likelihood of dam failure and the consequences of subsequent flooding. The likelihood of dam failure can be further broken down to the probability of occurrence of (a) threats to, and loads upon, a dam (for example, storm, earthquake, and so on) and (b) the probability of the dam structure/reservoir performance or response leading to dam failure because of the threats and loads (see figure 4.1). Consequences represent negative effects resulting from an uncontrolled release of a large amount of water—not necessarily involving failure of the dam body but caused by failure or misoperation of spillway gates and so on—in terms of loss of life and other social, environmental, and economic impacts.[3]

In mathematical terms, risk can be characterized by the probability distribution of consequences. This is because the level of impacts or consequences of the dam failure/uncontrolled release of water depends on: (a) the size and scale of the threats to the dam (for example, intensity of the storm or earthquake); (b) the way the dam fails—that is, failure mode;[4] and (c) the time when the dam fails (day or night, weekend or weekday, winter or summer, and so on). The risk is thus estimated by combining the probability and consequence of each failure mode covering over all scenarios.[5]

Broad risk management approaches are increasingly being used to inform dam safety assurance, which is likely the result of increased stock of aging dams around the world and more frequent dam safety

1. Annex A provides a list of useful references. It should be noted that good international practice varies in space (country to country and within countries) and in time (continuous improvement and new approaches). As mentioned in note 8 of Chapter 3, GIIP is defined in ESS1, footnote 23.
2. The consequence assessment should also cover the impacts on the dam and associated facilities, as well as their lost operational functions for water supply, hydropower generation, and so on.
3. This note uses the word *consequence* in an interchangeable manner with *hazard*, following the practice in dams engineering. Although *hazard* in general refers to threat or condition that may result from either an external cause (for example, earthquake, flood, or human agency) or an internal threat or vulnerability (for example, internal erosion or piping) with the potential to initiate a failure mode, it is often referred to as a measure of consequences of dam failure (ICOLD 2005).
4. ICOLD Bulletin 130 (2005) defines *failure mode* as "a way that failure can occur, described by the means by which elements or component failures must occur to cause loss of sub-system or system function." The ISO International Standard "Risk Management - Risk Assessment Techniques" states that "a failure mode is what is observed to fail or to perform incorrectly." A failure mode is an event associated with unacceptable or deviant function or behavior, and it is a direct effect of failure mechanism. On the other hand, *failure mechanism* is a specific sequence of events that can lead to a dam failure, must be linked to a loading scenario, and has a logic sequence—an initiating event, one or more events of progressive failure, and ending with dam failure or uncontrolled release of a large amount of water. Failure mechanism is associated with deviant physical conditions or physical states and is a direct cause of a failure mode.
5. Source: Environment Agency, *Guide to Risk Assessment for Reservoir Safety Management - Volume 1* (Bristol, U.K.: Environment Agency, 2013). Figure 4.1 is also adapted from the Guide.

FIGURE 4.1. Conceptual Diagram of Threats/Loads, Dam Response/Performance, and Consequences



Source: Adapted from Environment Agency. 2013. *Guide to Risk Assessment for Reservoir Safety Management – Volume 1.* Bristol, U.K.: Environment Agency.

incidents because of nonstructural and contextual causes that are not well-captured by the traditional standard-based approach. There is also greater societal demand for full transparency, higher safety levels, better justification of the use of public and private funds, and the need to prioritize remedial action in reducing risks to acceptable[6] levels, as defined by dam safety practice.[7] Risk management approaches to dam safety assurance typically include the following process: (a) risk analysis,[8] (b) risk assessments,[9] (c) decision making for risk control and reduction measures, and (d) monitoring and evaluation. There is an important feedback loop in this approach—when the results of risk monitoring and evaluation are fed back into risk analysis and assessment, as well as any decisions needed on risk control and reduction measures. Robust operation and maintenance mechanism should be established and maintained to keep effective risk management system in place throughout the life cycle of the project. Given the breadth of this approach, dam safety practitioners increasingly refer to this as Risk-Informed Decision

6. Please refer to the risk mitigation hierarchy in ESS1, paragraph 27, which states "minimize or reduce risks and impacts to acceptable level." The acceptability of residual risks may need case-by-case discussions with the Environmental and Social Specialist and the Dam Safety Specialist. For information, the dam safety community generally uses the terminology of *tolerable risk*. Based on the U.K. Health and Safety Executive (2001) and ICOLD Bulletin 130 (2005), a tolerable risk criteria has been adopted for risk management of dams in various jurisdictions in Australia, Canada, the United States, and so on, and most risk management guidelines for dams also use it.
7. Chapter 6 of "Laying the Foundations: A Global Analysis of Regulatory Frameworks for the Safety of Dams and Downstream Communities" (Wishart et al. 2020) provides comprehensive overview of the risk tolerability.
8. Risk analysis is to identify potential failure modes, structural performance, and adverse consequences of dams using qualitative or quantitative procedures and to estimate the risk—that is, a combination of likelihood of concurrence and magnitude of consequences.
9. Risk assessment is to examine the safety of dams, evaluating the results of risk analysis along with relevant social, environmental, economic, and other factors, and to make recommendations on risk reduction measures as needed, including additional investigations and enhanced monitoring.

Making (RIDM) with its emphasis on a comprehensive decision-making process not based solely on numerical risk estimates but also deterministic analytical results and other relevant factors.

RIDM can be broadly defined as "a method of dam safety evaluation that uses the likelihood of loading, dam fragility, and consequences of failure to estimate risk. This risk estimate is used, along with standards-based analyses, to decide if dam safety investments are justified or warranted. This approach has many benefits including an improved understanding of the safety of the dam and identifying dam safety vulnerabilities that have not been identified using standards-based evaluation techniques."[10]

In conclusion, it is important to keep in mind that the risk is not static and will change depending on the condition of the dam and during the project cycle and so on.[11] The consequences of dam failure and subsequent flooding can also change for various reasons, such as growth in the population and assets in downstream areas of a dam.

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10. Source: U.S. Federal Energy Regulatory Commission. https://www.ferc.gov/industries-data/hydropower/dam-safety-and-inspections/risk-informed-decision-making-ridm.
11. Statistics clearly show that rate of failure is highest in the initial few years after the first reservoir filling. Failures in that period are generally the consequence of flaws in design or construction, as well as dysfunctional operation. They can also gradually evolve, if undetected, to an incident or failure at a later stage. If that is not the case, external hazards (floods, earthquakes, and so on), as well as nonstandard events (human error, lack of access, gate operation issue, and so on) could activate failure mechanisms. The failure likelihood can also increase as a result of structural degradation, increased floods by catchment degradation, and so on. The surveillance system should be able to detect the potential failure mechanism, analyze it, and implement remedial measures. P. Reagan, "Dams and Civil Structures: An Examination of Dam Failures vs. Age of Dams," *Hydro Review* 29, no. 4 (2010) https://www.hydroreview.com/2010/06/01/dams-civil-structures/#gref; P. Mèan and P. Droz, "Improving Dam Safety with a Surveillance Self-Assessment Toolkit," *Hydropower & Dams*, 26, 3, page 86-96 (2019).

Chapter 5
Risk Analysis Tools

Risk-Informed Decision Making (RIDM) consists of applying a combination of risk-based and standards-based analyses. Several tools have been developed and applied in international practice that can be broadly divided into two groups: standard-based and risk-based, and the latter is subdivided into two subgroups—that is, qualitative and quantitative methods (table 5.1). It should be noted that one form of analysis is not necessarily superior to another, provided it is appropriate for the decision context and carried out in terms of established principles of scientific analysis. World Bank operations typically rely on two qualitative risk analysis tools: risk indexes and potential failure mode analysis (PFMA).[1]

TABLE 5.1. Types of Risk Analyses

Type of tools	Risk content	Applicability to World Bank operations
Standard-based	Risk is not explicit in design. This is the traditional approach to dam engineering, whereby risks are controlled by following established rules with varying degrees of conservatism as to design events and loads, structural capacity, safety coefficients, and defensive design measures.	Traditionally done. At the base of design criteria (hydrological, seismic safety, and so on) and compliance requirements (for example, panel of experts, dam safety management plans, prequalification of bidders, and so on).
Risk-based	Increasingly used, particularly for assessing safety of existing dams to identify higher-risk dams and prioritizing the most critical and effective remedies.	Applies to all World Bank-financed projects involving dams in a proportionate manner to size, complexity, and potential risks.
- Qualitative methods	Risk is explicit, but no mathematical characterization (no probabilities of failure). Risk index[a] is the simplest method in this group and useful in risk assessment of a large portfolio of dams. It can inform decisions on monitoring and surveillance programs, prioritizing more detailed studies, and dam safety improvements.	Qualitative methods have been mostly used in World Bank operations, and it is expected that they will continue to be the main resource tool.
- Quantitative methods	Fully risk-based. Analysis is based on numerical values of the potential failure mode's likelihood and consequences, the intention being that such values are a valid representation of the actual magnitude of the consequences and the probability of the various failure modes/scenarios, which are examined.	Expected to be occasionally needed in World Bank operations when complicated or substantial remedial works are involved. Those cases would require specialized input in terms of both the data and expertise.

a. See Technical Note for Portfolio Risk Assessment Using Risk Index (World Bank 2020l), which also explains that risk index method can also be developed linking with failure modes.

1. Further detailed tools have been developed by various entities, such as the U.S. Army Corps of Engineers Risk Management Center, Ontario Power Generation, Hatch, the Ministry of Natural Resources and Forestry, Ontario Province, Canada, and so on. In addition to the PFMA, failure modes and effects analysis (FMEA) and failure modes, effects, and criticality analysis (FMECA) may also be used with inductive methods for potential failures analysis of a system. They consider each component of a system and analyze its failure modes and their causes and effects. The probability and severity of each failure mode is also assessed, which provides a characterization of its criticality in a qualitative manner using ranked scores. Some European countries have been using this type of approach for risk assessment. In particular, the United Kingdom has been using FMECA with a guideline: *Risk Management for UK Reservoirs* (London: Construction Industry Research and Information Association, 2000).

Detailed information on risk-informed approaches to the safety of dams is also provided in the global comparative assessment of legal and institutional frameworks for dam safety (Wishart et al. 2020).[2]

It should be noted that reviewing design criteria and standards (essentially factors of safety) pertains to the standard-based approach, as has always been done in projects involving large dams and still must be done. Engaging an experienced design team and an independent safety review (for example, panel of experts) are the two basic ingredients.

2. Chapter 6 of "Laying the Foundations: A Global Analysis of Regulatory Frameworks for the Safety of Dams and Downstream Communities" (Wishart et al. 2020) provides details of risk-informed approach adopted by various countries/jurisdiction based on the review of relevant ICOLD bulletins and guidelines by various institutions of the United States, United Kingdom, and other countries. The chapter reviewed typical steps for dam safety risk management, including identification of failure modes, risk estimation and analysis, risk assessment and evaluation, along with decision making for risk control and prioritization of risk reduction measures for a portfolio of dams in an optimized manner. The chapter also reviewed the risk tolerability criteria and practice by various countries and institutions. Although this note does not provide specific recommendations on quantitative risk assessment methods, risk tolerability criteria, and so on, some readers may refer to the report for more detailed information.

Chapter 6
Quality of Information and Institutional Capacity

Virtually all risk analyses and assessments are strongly influenced by the quality of information available to produce a qualified assessment. Information availability presents an overarching challenge that can obscure the assessment of both failure likelihood and consequences. Sometimes, information reliability is regarded as a third dimension of risk.

The scope of any analysis needs to be fit for purpose and informed by the context. The risks associated with the safety of dams vary depending on the structural components, socioeconomic factors, and the environment within which the dam is being constructed and will operate. Application of the Environmental and Social Framework (ESF) requirements with respect to the safety of dams will need to reflect these considerations and be proportionate to the size, complexity, and potential risks and impacts. To do that, the method of analysis selected should take into account and be compatible with the available level of knowledge about

- Infrastructure (for example, conditions of the works and structural components);
- Institution (for example, management structure and capacity of dam owner, operator, and regulator); and
- Information (for example, monitoring and surveillance data, downstream population, assets, and so on).[1]

It would be inappropriate and misleading to advance to a complex method of risk analysis and assessment when the state of knowledge on the infrastructure, institutions, and/or information is inadequate. Identification of the "weakest I" is the entry point to assess the support needed to improve the foundations for risk-informed dam safety management. Such needs assessments should be considered as a component of projects involving the construction of large dams, major dam rehabilitation programs, or projects with high risks with due consideration to long-term operation and maintenance capacity. It may also be appropriate for the World Bank to provide technical assistance for enhancing the quality of information and the capacity of the borrower. The client-appointed panel of experts can also add value by advising on specific subject-related matters and working closely with counterparts to build capacity.[2]

The concept of proportionality is central to the application of the requirements of the ESF. The level of effort and resources required for any risk assessment should be commensurate with the decision to be made. It is also important to consider the nature, importance, and precedence of the decision in determining the level of effort and degree of detail within the risk assessment. Any further improvement in the assessment of risk, if required, should be tailored to the specifics of the case in hand.[3]

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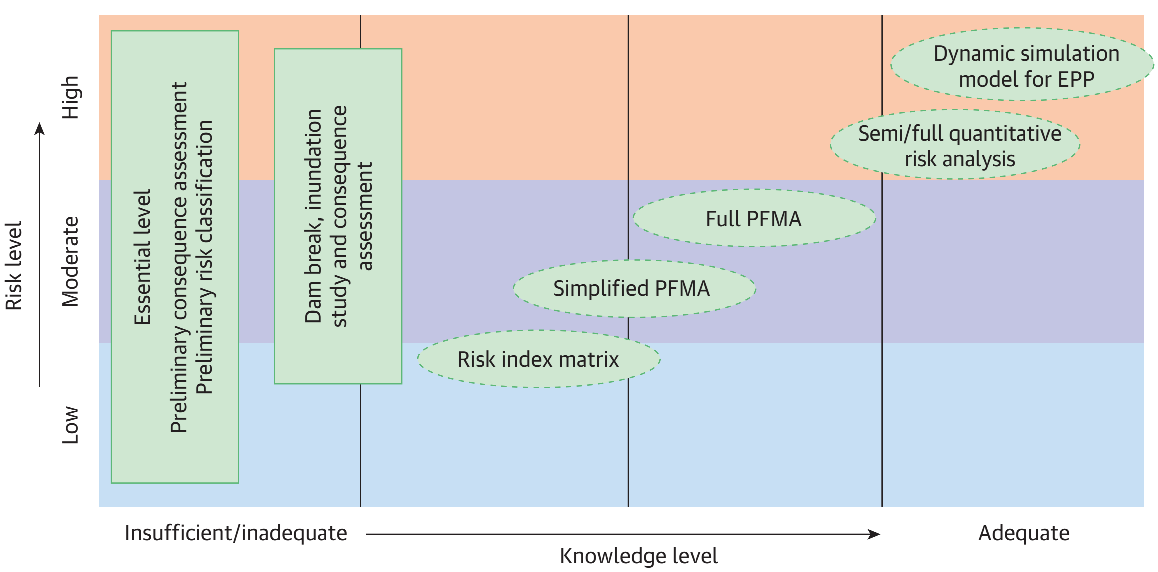
1. The list of information can be extensive. Separate Technical Notes provide guidance on the quality issue of data and information of geological, geotechnical, seismic, hydrological, climate, and other aspects.
2. The proportionality concept is also referred to the decision support tool for dam safety assurance framework under "Laying the Foundations: A Global Analysis of Regulatory Frameworks for the Safety of Dams and Downstream Communities" (Wishart et al. 2020).
3. A decision-support tool for developing and enhancing the dam safety assurance framework provided through a global assessment of relevant legal and institutional measures provides a useful accompaniment to this note (Wishart et al. 2020).

Preliminary risk assessment and classification by the borrower should be the first essential steps, which will allow a decision on whether the existing knowledge level is adequate to carry out an informed risk assessment. If not, the project should include a technical assistance component aimed at improving the level of knowledge to the extent required by the risk level of the specific case. That may also entail generating the minimum required database to arrive at acceptable levels of reliability. As stated earlier, the 3 I's approach can be used to make such capacity assessment.

Several tools are shown in figure 6.1, in which a progressive approach can be taken from the lower-left corner to the upper-right corner. To apply a more advanced and detailed tool in a meaningful manner, the level of knowledge—that is, quality of information and data—needs to be enhanced. Descriptions of the indicated tools (risk indexes, potential failure mode analysis [PFMA], dynamic simulation models, and so on) are provided in the following paragraphs. Detailed guidance for application of a risk index and PFMA is provided under separate Technical Notes (World Bank 2020l, 2020k). External experts may be needed to advise on detailed risk analysis for high-risk cases when the borrower's knowledge and capacity are limited. The principle of proportionality, embedded in the ESF, should feature prominently in the selection of the appropriate risk analysis tool. As shown in figure 6.1, proportionality should be based on two key elements: risk level and knowledge level. It must be stressed again that the preliminary risk level determines the appropriate risk analysis tool to be used, and that, in turn, requires an appropriate knowledge level. In substantial- to high-risk cases, it may be necessary to improve the level of knowledge and/or the capacity of the borrower or the borrower's implementing agency and enhance consultation with relevant stakeholders.

FIGURE 6.1. Conceptual Representation of Risk Analysis Tools



Note: EPP = Emergency Preparedness Plan; PFMA = potential failure mode analysis.

Chapter 7
Application to World Bank Operations

General Guidance and Essential Tools

The following framework provides guidance for the application of the qualitative and quantitative assessment tools to typical situations encountered in World Bank projects involving large dams (see also table 7.1). Application of the tools is presented in three tiers:

- First tier (all dams): It is expected that this level of preliminary assessment is essential for all projects involving dams.
- Second tier (moderate- to high-risk dams): Dam break analysis and inundation studies are mandatory for large dams and small dams that could cause safety risks and existing dams that include additional dam safety measures or require remedial work. This will also allow for refining risk assessment. Risk index schemes considering potential failure modes and/or simplified potential failure mode analysis (PFMA) may be necessary depending on results of the preliminary assessment along with additional knowledge and information.
- Third tier (high-risk dams involving complex works): This may be required for high-risk cases involving complex works. Adequate information needs to be provided for the advanced risk assessment.

When higher risks are identified by the initial assessment, the borrower needs to advance to the next tier for more detailed analyses and assessment. Although one could gradually go up from the first tier to the second and third as required, they could go directly to the second or third tier when the risk of the dam and project intervention clearly requires a higher level of analysis. The risk classification per se is explained in the next section, but the Task Team should consult with Dam Safety Specialists (DSS) regarding the appropriate level of risk assessment for each project.

Risk Classification by the Borrower

The borrower's risk classification for the dam project should be reviewed considering: (a) potential threats and loads, (b) key features and conditions of dams, and (c) consequences in case of dam failure. Note this risk classification by the borrower will be taken into account in the overall project risk classification done by the World Bank, under the Environmental and Social Policy and the Environmental and Social Directive for Investment Project Financing (IPF). When the capacity of borrowers is weak, the team should assist them in undertaking preliminary risk assessment with reference to the section on

Potential Failure Modes and Consequence Assessment. The designated dam safety risk classification, its basis, and required mitigation measures should be reviewed and provided for the Environmental and Social Review Summary (ESRS)[1] by the DSS in coordination with the Environmental and Social Specialist (E&SS), providing inputs for the overall rating of the Environmental and Social Risk Classification. Further details are provided in the following sections for new dams and existing dams.

TABLE 7.1. Guidance for Risk Assessment Level and Tools

Risk assessment level/tools	Guidance	Remarks
First tier (all dams)		
Preliminary consequence assessment	Assessment should cover: • PAR[a] • Economic impact • Environmental and social impact	It is always necessary to assess the consequences of dam failure or incident in a manner suitable to local contexts. The extent to which this determination is required depends on how risk analysis informs the decision process.
Preliminary risk classification	Refer to national dams classification system, if any	Many countries have developed dam classification systems,[b] which would be a starting point for discussing the required safety standard and requirements for dams under World Bank operations.
	Classification system for new dams[c]	This classification of dam risk is of very simple use for four proxy parameters to assess potential risk class of dams (see section on Risk Classification by the Borrower).
	Existing dams classification system	The risk classification is based on the *risk* concept, which is the product of two factors: likelihood of failure and consequence of failure (see section on Potential Failure Modes and Consequence Assessment).
Second tier (moderate- to high-risk dams)		
Dam break and inundation impact assessment	Mandatory for large dams and small dams that could cause safety risks and existing dams that include additional dam safety measures or require remedial work. Choose appropriate level of flooding simulation and consequence assessment considering potential risks.	• Collate input data (for example, hydrological or topographic). • Define breach scenarios (or potential dam failure modes for comprehensive assessment) and breach parameters. • Estimate/model dam break, downstream flood simulation/mapping (depth, velocity, and duration), and downstream impact/consequence assessment.
Risk index schemes	Risk index method can be applied to portfolio of existing dams for screening and ranking of riskier dams and approximate indication of project interventions comparing the risk index before and after (see TN for Portfolio Risk Assessment Using Risk Index). Good examples are the dams classification and risk categorization by Quebec Province, Canada, and Brazil.	It should be noted that risk indexing is a basic tool for risk screening across a portfolio of existing dams. It may need to be supplemented with more advanced methods depending on the risk of the dams. Because risk indexing approaches largely rely on visual inspection of the condition of dams, some critical failure modes could be missed or underestimated, and the TN provides a method for developing the risk index considering potential failure modes.

table continues on the next page

1. The required mitigation measures will be provided for the ESRS at appraisal stage. Preliminary risk classification is also be provided as an input for the ESRS at concept stage.

TABLE 7.1. continued

Risk assessment level/tools	Guidance	Remarks
Simplified PFMA	See TN for Potential Failure Mode Analysis (PFMA) for general guidance and generic ToRs, whereby two applications are presented: for the individual dam and for a portfolio of dams.	Individual dam: Failure modes are identified by an experienced professional in consultation with dam operators and designers. The expert elaborates probabilities of failure, which are revised and agreed in a meeting with dam operators and designers. Portfolio of dams: The assessment is carried out by a team of experts, in consultation with dam operators and designers. The process involves assigning scores for contributing factors to each potential failure mode based on the dam site inspection and evaluators' judgment.
Third tier (high-risk dams involving complex works)		
Detailed consequence assessment for elaborate emergency planning	For high-consequence cases in the event of dam failure, consequence assessment and EPP preparation should be undertaken in an elaborate manner to assess the PLL[d] considering the effectiveness of emergency warning and evacuation.	This kind of detailed simulation can be done by a dynamic simulation model for the EPP. Further details are provided in Chapter 8.
PFMA	Appropriate for high-hazard cases, with reasonable level of information or as a follow-up to simplified PFMA for higher hazard cases.	FERC: PFMA[e] reviews the chain of events leading to unsatisfactory performance and failure of the dam (see TN for Potential Failure Mode Analysis [PFMA]). Other similar methods could be used.[f]
Semi- and full quantitative	Not expected to be needed in most World Bank operations but could be used for high-hazard dams, which would involve comprehensive dam safety assessment and complex remedial works.	PFMA can evolve quantitatively by adding probability assessments.[g] Other quantitative risk assessment models using event tree analysis are also available.[h]

Note: EPP = Emergency Preparedness Plan; FERC = U.S. Federal Energy Regulatory Commission; ICOLD = International Commission on Large Dams; PAR = population at risk; PFMA = potential failure mode analysis; PLL = potential loss of life; TN = Technical Note; ToRs = terms of reference.

a. PAR refers to the number of people who would be directly exposed to flooding by dam break if they took no action to evacuate. The evaluation is usually based on the results of a dam break study, which evaluates the flooded area and the number of houses, infrastructures, and other impacted facilities.

b. "Laying the Foundations: A Global Analysis of Regulatory Frameworks for the Safety of Dams and Downstream Communities" (Wishart et al. 2020) provides a comprehensive review of dams classification system in Chapter 5.

c. ICOLD, "Selecting Seismic Parameters for Large Dams" (Bulletin 72, ICOLD, Paris, 1989).

d. PLL refers to the number of people who would lose their lives by dam break flooding even if they received warning and took action to evacuate. The evaluation is based on the number of people at risk in flooded areas with consideration of the lead time and effectiveness of warnings and other parameters related to evacuation activities. The evaluation typically depends on empirical approaches but could use more advanced dynamic simulation in case of extremely high consequence.

e. Source: FERC, "Chapter 14: Dam Safety Performance Monitoring Program" in *Engineering Guidelines for the Evaluation of Hydropower Projects* (FERC, Washington, DC, 2017), https://www.ferc.gov/sites/default/files/2020-04/chap14.pdf.

f. There are similar types of qualitative risk analysis techniques, such as failure mode effects analysis (FMEA) and failure mode effects and criticality analysis (FMECA), which could also be used for the same purpose. *Risk Management for UK Reservoirs* (London: Construction Industry Research and Information Association, 2000) provides detailed information on the application of these techniques.

g. See note 1 of Chapter 5 for other methods.

h. Quantitative risk assessment intends to provide a complete description of all risks and uncertainties by estimating the probability of dam failure and the resulting failure impacts. Both the probability of each failure scenario and the corresponding consequences need to be assessed. This kind of probabilistic evaluation of possible failure scenarios would assist in the identification of main dam failure scenarios driving the total risk. It also aids in the detailed assessment and determination of the urgency of required remedial works. It should be noted, however, that quantitative risk assessments tend to be complex, requiring detailed dam monitoring and surveillance data, along with supporting analyses of various associated uncertainties with estimated probabilistic values. These exercises are time-consuming and require substantial financial and human resources. Reliable statistical data or credible probabilistic models are often not available for assessing probability of some failure modes, such as piping and other forms of internal erosion. Also, in many borrowing countries, there is limited hydrometeorological, geological, and seismic data available, and the reliability of the data sets is often poor. In many cases, basic design reports and construction quality information, such as information about embankment materials and foundation treatments, are missing. Even when such data and resources are available, there could still be significant variation in results because of challenges in estimating probabilities for various possible events. With a lack of data, estimates of probability tend to be by collective expert judgment and, therefore, depend on the group involved. It is critical to ensure that the risk estimation procedure is logical, based on accepted scientific knowledge, and transparent along with a peer review process.

Risk Classification for New Dams

As the first step for a dam's risk classification, the Task Team should review with the borrower the national dams classification system under the laws, regulations, or guidelines relating to dam safety. Many countries have developed such a system for proportioning dam safety mandates so that more stringent regulatory requirements, such as design standards, inspection frequency, and so on, can be applied to higher-hazard dams.

Countries have developed different classification systems depending on their economic, environmental, and social conditions. The main criteria for dividing dams into classes are generally either geometrical parameters (typically dam height and reservoir capacity, sometimes including dam type), incremental consequences or hazard potential that would occur as a result of a dam failure, or a combination of these.

In some cases, the national standard may be inadequate compared with international practice. The Task Team should discuss with the DSS and, if applicable, the panel of experts (POE) the assessment of such potential gaps and advise the borrower to apply suitable higher safety standards and supplementary safety enhancement measures.

If there are no such dam classification systems, the Task Team should advise the borrower to consider international examples along with international guidelines, such as those issued by the International Commission on Large Dams (ICOLD). ICOLD Bulletin 72 provides a simple concept of risk classification using four parameters—that is, (a) dam height, (b) reservoir capacity, (c) number of people potentially affected, and (d) other potential consequence (table 7.2). Although dam height and reservoir capacity can be considered to represent the magnitude of flood wave's energy (water depth, velocity, and so on) and correlate with flooded area and duration in case of dam break, the number of people potentially

TABLE 7.2. ICOLD Dams Classification System

Dam's dimensional features	**Reservoir capacity (million m³)**	**<0.1**	**0.1–1**	**1–120**	**>120**
	Points	0	2	4	6
	Dam height (m)	**<15**	**15–30**	**30–45**	**>45**
	Points	0	2	4	6
Downstream consequence in case of dam failure	**Evacuation requirements (number of people)**	**None**	**1–100**	**100–1,000**	**>1,000**
	Points	0	4	8	12
	Potential damage downstream	**None**	**Low**	**Moderate**	**High**
	Points	0	4	8	12
Total risk points (summation of the four factors' points)		<6	7–18	19–30	31–36
Class		**I (low)**	**II (moderate)**	**III (substantial)**	**IV (high)**

Note: ICOLD = International Commission on Large Dams. *Source:* Adapted from ICOLD (1979).

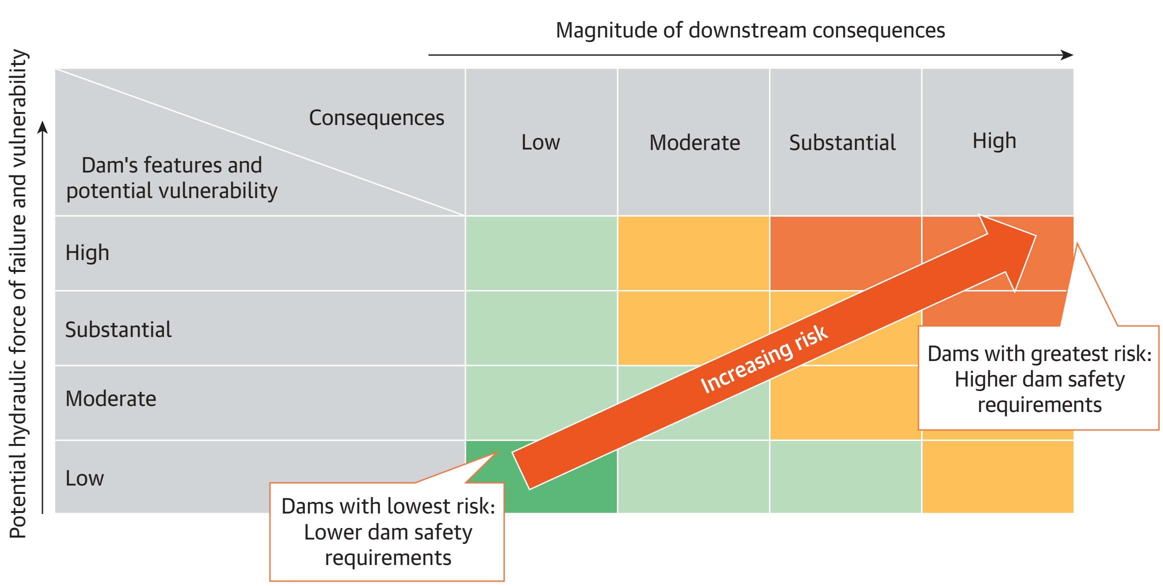
affected and other potential consequences can be considered to represent downstream hazard or consequence in case of dam failure.

It should be noted that the threshold values indicated by ICOLD should not be used as they are because they need to be considered and contextualized within the economic, social, and geographical conditions of the country. In particular, the downstream consequence should be put in the appropriate country and/or regional context in coordination with the DSS and E&SS.[2]

Risk matrices can be derived from this data with four categories—that is, red (high), orange (substantial), light green (moderate), and green (low), as in figure 7.1. These can conceptualize the risk classification using two elements: (a) structural dimensions, such as the dam height and reservoir capacity, and (b) downstream consequences (the number of people affected and other consequences) in case of dam failure. In addition, unusually high loads and threats, such as intensive floods, high seismicity, and structural vulnerabilities of dams as a result of a structure's type (such as embankment dam in comparison with concrete gravity dam), geological conditions, and so on should also be considered given their potential uncertainties.

Furthermore, a dam's risk classification table can be developed, which indicates the required dam safety standards (such as hydrological and seismic safety levels or their return periods) and safety requirements (depth of dam safety review, inspection frequency, sophistication level of emergency preparedness plan, and so on) as per dam class. Table 7.3 is an example showing the gradation of dam safety standards and requirements in accordance with dam class and should be tailored to each country's context.

FIGURE 7.1. Typical Risk Classification Diagram of New Dams



2. "Laying the Foundations: A Global Analysis of Regulatory Frameworks for the Safety of Dams and Downstream Communities" (Wishart et al. 2020) provides further details and examples of dams classification system.

TABLE 7.3. **Typical Risk Classification System for New Dams**

Risk	Hydrological Safety Level	Seismic Safety Level	Dam Safety Review Panel	Dam safety Plans	Supervision	Compliance Monitoring
Low	200 year	500 year	National or regional experts	Basic	Basic	Basic
Moderate	200–1,000 year	500–1,000 year	Regional or international experts	Full	Regular	Regular
Substantial	1,000–10,000 year	2,500 year	Experienced international experts	Elaborate	Intensive	Intensive
High	10,000 year – PMF	10,000 year or MCE	Highly experienced international experts	Highly Elaborate	Highly Intensive	Highly Intensive

Note: MCE = maximum credible earthquake; PMF = probably maximum flood; POE = panel of experts. The required safety standards are indicative only and should be consulted with Dam Safety Specialists and a POE. The scope of seismic hazard assessment, geotechnical investigation, POE, and so on should also be proportionate to potential risks.

Risk Classification for Existing Dams

As defined in Chapter 4, at least in the context of dam safety, *risk* is considered to be the combination of probability of occurrence of an event (for example, uncontrolled release of water from the spillway) and the associated consequences (for example, loss of life, economic losses as a result of flooding, and so on). Average risk is estimated by the mathematical expectation of the consequences of an adverse event occurring—that is, the product of the probability of occurrence and the consequences combined over all mutually exclusive scenarios. It should be noted that existing dams are not inherently less risky and may, in some cases, be riskier than new dams.

The required dam safety measures should be defined with due consideration to the dam safety risk—that is, product of likelihood of dam failure and potential hazard or consequence of dam failure. In figure 7.2, risk is classified into four categories—that is, red (high), orange (substantial), light green (moderate), and green (low). The level of likelihood of dam failure can be indicated based on the assessment of potential failure modes.

The required dam safety requirements can be indicated depending on risk classification (table 7.4). In particular, it is essential to prioritize high-risk dams and remedial measures in terms of risk or urgency for dam rehabilitation and safety operations. This should be done as early as possible during identification and preparation. It should be noted that the table should be tailored to the specific country and project contexts in consultation with the DSS and client-appointed POE, if applicable.

When the World Bank finances large-scale national or regional projects for the rehabilitation and safety improvement of existing dams, the Task Team needs to discuss and agree with the borrower on the required safety review and quality assurance mechanism. In particular, during preparation toward appraisal, the team should guide the borrower to undertake and share the results of a preliminary screening or portfolio risk assessment of an initial set of dams that would be rehabilitated during the first two to three years of project implementation and agree on the quality control mechanism corresponding to risk classification, including the terms of reference for detailed design and construction

FIGURE 7.2. **Typical Risk Classification Diagram of Existing Dams**

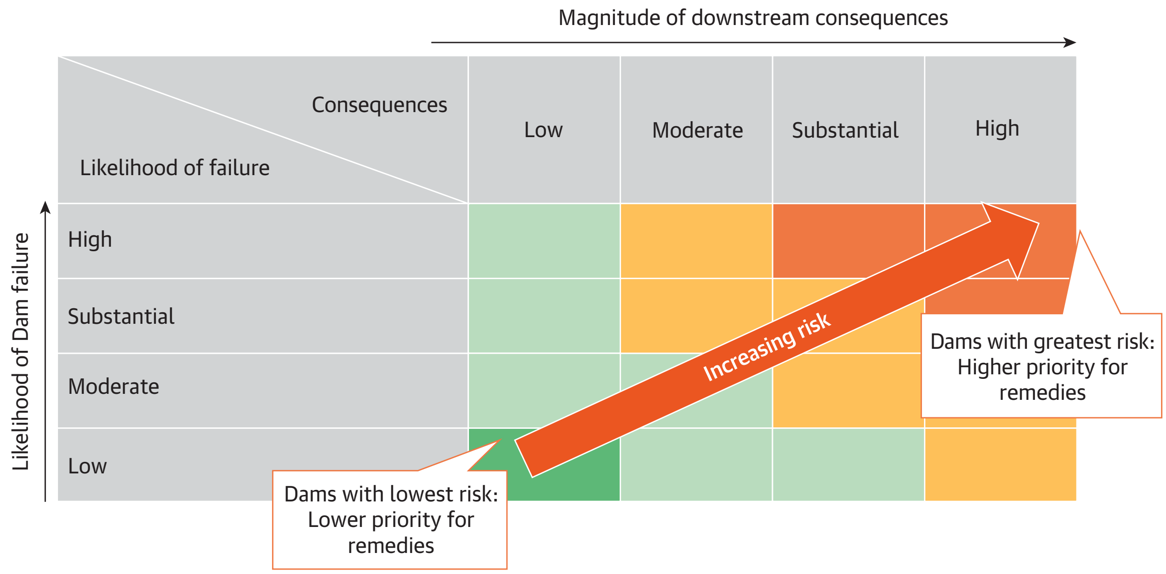


TABLE 7.4. **Typical Risk Classification System for Existing Dams**

Risk	Dam SafetyAssessment	Safety Measures & Remedies	Dam Safety Review Panel	Dam Safety Plans	Supervision	Compliance monitoring
Low	Basic	Regular O&M	Not necessary	Basic	Basic	Basic
Moderate	Detailed	Enhanced monitoring	One expert on specific technical issues	Full	Regular	Regular
Substantial	Qualitative/Semi-Quantnative	Urgent remedial works	More than one expert depending on specific technical issues	Elaborate	Intensive	Intensive
High	Advanced/Full Quantitative	Immediate remedial works	Full-fledged panel required	Elaborate	Intensive	Intensive

Note: O&M = operation and maintenance; POE = panel of experts. The dam safety requirements corresponding to risk classification are indicative only and should be consulted with dam safety experts and POE if established.

supervisory consultancies and POE. The risk analyses matrix should be finalized for assessing the risk of each existing dam before and after project interventions. Further detailed risk analyses including additional site investigations and detailed design works can be undertaken during the early phase of project implementation. The remainder of existing dams that would be picked up by the project for subsequent years can also be investigated and designed under the agreed prioritization and quality control framework including detailed risk analyses and assessment. Technical Notes (TNs) for Potential Failure Mode Analysis (PFMA) and Portfolio Assessment Using Risk Index (World Bank 2020k, 2020l) provide relevant information for these types of framework projects. It is, however, recommended that a preliminary risk screening of all dams should be undertaken to have an overall estimate of the required scope and budget for remedial and safety improvement works.

Potential Failure Modes and Consequence Assessment

As risk is defined as a measure of both failure likelihood and consequence, it is important to undertake preliminary assessments in both aspects in a phased manner as detailed in the section on General Guidance and Essential Tools and with due consideration to the quality of information and capacity, as shown in Chapter 6.

Potential Failure Modes Assessment

As it is not a simple matter to estimate the likelihood or probability of dam failure without semiqualitative or quantitative risk assessment, it is recommended that the borrower undertake its preliminary assessment with reference to: (a) the national dams classification system or adapted one from ICOLD for new dams and (b) the preliminary dam safety inspection and assessment reports for existing dams, as shown in table 7.1. The former does not indicate failure likelihood but can provide proxies for estimating potential magnitude of dam failure and impacts.

Although PFMA is recommended from the second-tier assessment, the consideration of credible failure modes is quite useful in reviewing the design of a new dam or assessing the condition of an existing dam and required remedial and safety enhancement measures. Typical failure modes are described for embankment and concreted dams based on historical records in the following paragraphs.[3] The TN for Potential Failure Mode Analysis (PFMA) (World Bank 2020k) provides more details on failure modes for various types of dams. TNs on Hydrological Risk and Geotechnical Risk (World Bank 2020g, 2020h) also provide detailed guidance on required assessment on detailed elements, such as climate change, glacial, and geological risks, including the dam site and surrounding areas.

For an embankment dam made of earthfill, clay core/rockfill, and so on, the common failure modes are: (a) overtopping of dam crest eroding slope of dam (as a result of insufficient spillway capacity); (b) internal erosion or foundation piping; (c) slope instability or cracking of the dam face; (d) operational issues that can lead to failure (for example, poor maintenance or low capability of dam operators); and (e) geological hazards (earthquake shaking and landslide instability).

For a concrete dam, the common failure modes are: (a) flood overtopping eroding toe of dam; (b) sliding on a plane of weakness in the foundation or at the dam/foundation interface; (c) structural failure of the dam body; (d) operational issues that can lead to failure (for example, poor maintenance or low capability of dam operators); and (e) geological hazards (abutment slope failure, earthquake shaking, and landslide instability).

Differentiation should be made between embankment and concrete dams, mainly because of the higher vulnerability of the former to overtopping. In each project, dam type is selected according to the site characteristics and to the available construction materials; therefore, several other types of dams exist. Teams should direct attention and resources to investigating and assessing failure modes for high- and substantial-risk dams in coordination with the DSS in a given context.

3. ICOLD 2019.

Consequence Assessment

An assessment of dam failure consequences should estimate the number of population at risk (PAR) and other social, environmental, and economic impacts. This should be used for the overall risk assessment/classification and evacuation planning in case of a dam failure. The physical parameters that are required for flooding simulation are speed and depth of the flooding. These depend on the extent of the dam breach and the speed at which water is released from the reservoir. Determining these parameters requires a dam breach model. It is often necessary and generally recommended to start the assessment with simplified criteria for a preliminary estimate of PAR.

A conservative assumption is to assume instantaneous failure of full dam height. Two main approaches apply for estimating the potential inundation area: (a) using existing inundation maps (as available) and (b) undertaking a visual inspection and applying simple rules and technical judgment.

The minimum level of assessment for all dam projects (tier one) can assume an initial (dam break) water depth at the dam of half the dam height and follow the map contours and valley slope to identify the potential inundation area. Technical judgment is needed to determine how far the volume of water released from the reservoir might spread. To estimate a distance downstream, consider how the stored volume of water might disperse by looking at the downstream valley width and, say, a 0.5-meter depth of standing water (after the flood wave passes). A length may then be estimated that broadly matches the released volume (that is, volume = length × valley width × 0.5 meters depth). Limits can also be estimated by looking for locations downstream where the river course enters in a much larger river valley, and hence the flood volume would rapidly disperse. For medium- and high-hazard dams (tier two) assessments, more detailed analysis is required. Simplified dam breach analysis and routing of the dam breach flood wave down a valley can be carried out using one of the following two methods:

- Simplified methodology (such as by Environment Agency, UK, 2013)[4]
- Two-dimensional computational hydraulic model (such as with Hydrologic Engineering Center's River Analysis System [HEC-RAS] 5.0)

Topographic mapping should cover the entire downstream areas affected by dam failure, including a more detailed survey of any singularity or major infrastructure reducing the hydraulic capacity of the river, such as bridges, river crossing, and so on. Table 7.5 provides general guidance from ANCOLD (2012)[5] on the recommended flood routing distance corresponding to the storage capacity of the reservoir, which should be considered as a minimum. The land use of flooding areas, including location of residential and commercial properties, critical infrastructure, agricultural land, and designated envi-

4. *Guide to Risk Assessment for Reservoir Safety Management: Volumes 1 and 2* (Bristol, U.K.: Environment Agency, 2013). The simplified methodology involves: (a) defining the downstream valley into a number of zones on 1:10,000 or 1:25,000 scale topographic maps; (b) defining a typical trapezoidal cross-section shape, bed slope, and Manning's n value to each zone; (c) applying a simplified relationship to attenuate the dam breach flood wave through each zone; and (d) estimating an approximate flood depth and flood width for each zone and using this information to develop a simplified flooding map. This method should be considered only as a first approximation to indicate flood depth, width, and discharges as the flood wave attenuates down the valley.
5. ANCOLD 2012.

TABLE 7.5. Total Distance to Route Dam Break Flood Flow

Reservoir storage	Total distance downstream to route dam break flood
>2 million m^3	60 km or greater
0.2–2 million m^3	20 km or greater
<0.2 million m^3	5 km or greater

ronmental/cultural heritage sites, should also be checked to assess the PAR and potential loss of life (PLL); damages to property; and infrastructure, agricultural, and environmental, cultural, and social damages. Further details are provided in the second and third paragraphs from the section on the Emergency Preparedness Plan (EPP) in Chapter 8.

If there are multiple flow paths by breaches at different sections of the dam, which would result in significantly different flooding areas, such as breach of saddle dams, failure of each section of the dam should be analyzed separately. If there are multiple dams in cascade along a river, it is necessary to consider cascade failure of downstream dams triggered by the failure of the upstream subject dam.[6]

In case of small dams located in the upstream of World Bank-funded projects, Annex C provides useful and practical information to conduct preliminary assessment of their potential impacts.[7]

For high-risk dams involving complex works (tier three) and very high consequences, more detailed consequence assessment should be undertaken, preferably using dynamic simulation model for estimating PLL with advanced simulation models, such as LIFESim by Utah University, Hydrological Engineering Center's Flood Impact Analysis (HEC-FIA) by the U.S. Army Corps of Engineers (USACE), and Life Safety Model (LSM) by BC Hydro[8] in connection with the preparation of the EPP (see Chapter 8).

The assessment should also consider the social aspects, such as poverty and vulnerability, of those people who might be affected by dam break floods. Poor and marginalized people are more severely affected by natural hazards and climate extremes for several reasons. First, they often face greater exposure to

6. IFC (International Finance Corporation), *Good Practice Handbook - Cumulative Impact Assessment and Management: Guidance for the Private Sector in Emerging Markets* (Washington, DC, IFC, 2013). This *Good Practice Handbook* provides useful information on the cumulative impact assessment of hydropower projects under ESS1.
7. In some borrowers' countries, it can be challenging to collect sufficient information on the number of dams, size, location, and so on. Developing an inventory is an important step to assess the potential cumulative impacts of those small dams. Satellite imagery could be a powerful tool to facilitate the process of collecting this information to establish inventories (see Annex 5 of Technical Note on Small Dam Safety [World Bank 2020j]).
8. Two advanced models are available. First, the LIFESim model has been developed by Utah State University with support from the USBR, USACE, and Australian National Committee on Large Dams (ANCOLD) (Aboelata and Bowles 2005) and is a spatially distributed, dynamic simulation model for estimating PLL and economic damage by simulating a set of event-exposure scenarios, including various dam failure modes, flood severities and timing (day or night, weekend or weekday), and so on. USACE has also been using HEC-FIA, which contains a simplified version of the LIFESim model. Second, the LSM has been developed by BC Hydro (Lumbroso et al. 2011) with HR Wallingford (U.K.) and is a physics-based, dynamic numerical model to simulate a set of probable scenarios, including variables such as the effectiveness of warning, road capacity, and time-varying population density. The model uses results of flood water depth and velocity from 2-D hydraulic models over the course of event. The model is particularly useful in assessing dam failure and evacuation scenarios in densely populated urbanized areas. The model can be used to simulate evacuation patterns and traffic congestion, simulating the movement of flood water and its interaction with people who may be located within structures, in motor vehicles or on foot. Fatalities are estimated based on criteria including flood depths, velocity, and exposure periods. USBR has also started using the LSM on a limited basis.

hazards by living in marginal or unsafe areas (for example, on floodplains and along riverbanks). Their vulnerability is greater as they are more likely to live in substandard housing and possess uncertain landownership rights that provide no incentives for investments in risk reduction. Second, poor and marginalized households are less able to absorb and recover from the impact of destructive events when they hit. With little savings and limited or no access to credit, the poor rely on a range of suboptimal coping mechanisms following a disaster. Finally, after being hit with a disaster, poor and marginalized communities can suffer the consequences of uneven relief and recovery efforts. The poor also face obstacles to accessing entitlements, such as government relief or recovery assistance. Special efforts are needed to ensure that the EPP is developed within the context of the downstream communities.

In addition to the effects on human and economic assets, environmental consequences should also be assessed as part of risk assessment and classification.[9] Such consequences are typically measured based on the potential environmental damages on the ecosystem, such as the loss of fish, wildlife, and their habitat, as well as the possibility to regenerate these ecosystem and habitats. In case of tailing facilities, potential contamination- and pollution-caused hazardous waste discharge can also be a critical issue. Moreover, the potential loss of cultural and historical heritage sites may also be relevant for a particular location.[10]

Assessing the Capacity of the Borrower

In addition to the structural dimension, failure likelihood, and potential consequence, the assessment should also consider the borrower's capacity to manage dam safety, including specifying the risk class and required safety standards and requirements. The following guidance descriptions are offered to assess borrower's capacity (table 7.6).

The Task Team is expected to provide additional support and mitigation measures (more than those required by risk designation alone) in coordination with the DSS when the borrower's capacity is limited. Such measures may include an enhanced scope of works or budget (including on-the-job training) for owner's engineer consultancy, periodic dam safety inspection, and more intensive World Bank supervision, compliance monitoring, and so on. The client's capacity is included in the ESF dashboard (see Chapter 8) and should be treated as one of the important indicators for assessing required measures for both borrower and the World Bank.

Risk Control and Resilience Enhancement Options

This section provides an overview of risk control and resilience enhancement options for dam safety. Although the former is to implement and enforce actions to control risk and to periodically reevaluate the effectiveness of these actions, the latter is to absorb, accommodate, and adapt to hazards and threats

9. Quite a number of countries, such as Canada and Australia, have included the environmental consequences for dams classification system (Wishart et al. 2020).

10. Specific requirements on cultural heritage are found in ESS8.

TABLE 7.6. **Borrower's Capacity Level**

Risk level	Description
Low	Borrower has a positive track record with implementation and management of dams more challenging than or similar to the project under preparation. A regulatory framework for dam safety is in place, or there is strong commitment to enhance or develop one.
Moderate	Borrower has a reasonable track record with implementation and management of dams similar to the project under preparation. Basic dam safety practice (surveillance, monitoring, inspection, record keeping, independent reviews) is satisfactory, or capacity-building programs are welcome. Borrower is committed to develop and/or enhance a framework for dam safety.
Substantial	Borrower has shown mixed performance in implementation and management of dams or limited experience only in much smaller dams than the project under preparation. Inadequate regulatory framework for dam safety in the country. Borrower intends to improve management framework/capacity.
High	Borrower has poor track record in implementation and management of dams or no experience of similar type/size of the project under preparation. No regulatory framework for dam safety in the country. Borrower has limited capacity to manage dam safety throughout the project cycle.

beyond the design criteria, thus preserving the critical core systems for maintaining the overall structural safety of the dam and its water storage and control functions.

Risk Control Options

The most effective risk control measure is proper design and construction—that is, risk prevention and reduction measures. These measures are related to dam siting (dam location, footprint, height, reservoir capacity, and so on) and design criteria (hydrological, geotechnical, seismic, environmental, social, and so on). It is by the optimized combination of such parameters that a good and safe dam project should be prepared and executed.

The upstream engagement of the World Bank for the borrower's project preparation and design could help compare properties of various potential sites and sizes of dams, discuss favorable and unfavorable factors in various aspects, and guide how to arrive at an optimized combination of location and design through a multivariant analysis.

In addition to such risk prevention, minimization, and reduction measures in the upstream of project preparation, there is a range of risk control options (table 7.7).[11] Each of these has its own institutional perspective of the developer or owner, either public or private, who needs to make the choice of options, and the options should not be considered mutually exclusive or appropriate in all circumstances.

These risk reduction and mitigation measures should be adequately covered by the required dam safety plans explained in Chapter 8.

11. Adapted from ICOLD 2005.

TABLE 7.7. **Risk Control Options**

Risk control option	Institutional perspective
Reduce likelihood of failure mode progression leading to dam failures or uncontrolled release of water: typically, through structural measures in the design, quality control, and/or dam safety management activities, such as monitoring, surveillance, and periodic inspections.	Design requirements, quality control, and dam safety operation and maintenance procedures. Adequate project implementation period, including initial operational periods. Water infrastructure rehabilitation and modernization, including capacity-building programs.
Reduce/mitigate consequences: nonstructural measures, early warning systems, emergency preparedness plans, emergency response capacity building.	Dam safety operations, possibly in combination with broader natural hazard management projects.
Retain/tolerate/accept residual risk: after implementation of adequate risk mitigation measures.[a]	Following comprehensive risk assessment, suitable mitigation and resilience measures are incorporated in the project/business plan to manage residual risks.
Transfer the risk: by contractual arrangements with other entities for dam construction, operational responsibility, ownership transfer, insurance, and so on.	Parallel financing, with another partner financing the dam component. This still requires the World Bank to apply the ESF requirements and perform due diligence in terms of dam safety.
Avoid/eliminate: a choice that can be made before a dam is built, or through decommissioning of an existing dam.	Drop the project or component. Entails forgoing expected project's development objectives and results.

Note: ESF = Environmental and Social Framework.

a. This note does not deal with risk tolerability and proportionality of mitigation and safety improvement measures given that it is not easy to define them in borrowing countries' contexts with due consideration to their economic, social, cultural, and other elements. Please refer to Chapter 6 of "Laying the Foundations: A Global Analysis of Regulatory Frameworks for the Safety of Dams and Downstream Communities" (Wishart et al. 2020) for a comprehensive review and examples of risk tolerability and proportionality.

Although table 7.7 is prepared for considering risk control options related to dam safety, the Task Team should consider the overall project design and risk management approach with reference to a mitigation hierarchy approach under the ESF/Environmental and Social Standard 1 (ESS1).

Resilience Enhancement Measures

There is a range of structural and nonstructural measures that should be considered for enhancing the resilience of dam and associated facilities throughout the project cycle (table 7.8).

It is important to review these resilience enhancement options, including the structural and nonstructural measures in a comprehensive manner, and their effectiveness should be assessed case by case. Although structural resilience enhancement measures may be required for some cases, nonstructural measures may also be effective for others. Because some of the measures, including catchment/watershed conservation,[12] typically involve other ministries and agencies, Task Teams are encouraged to explore various options in coordination with other global practices beyond the particular World Bank-funded projects involving dams.

12. Catchment/watershed conservation measures, such as slope correction using terraces, planting cover crops, revising grazing practices, and so on, should be considered in steep and rugged terrains for preventing sudden increase of peak flood volume and geomorphological and geological hazards, such as landslides and debris flows, as well as reducing soil erosion and sediment deposits for sustaining the life of dam reservoirs. Effective tools and methodologies have been developed to help prioritize effective watershed management interventions. See, for example, World Bank 2019.

TABLE 7.8. Resilience Enhancement Measures

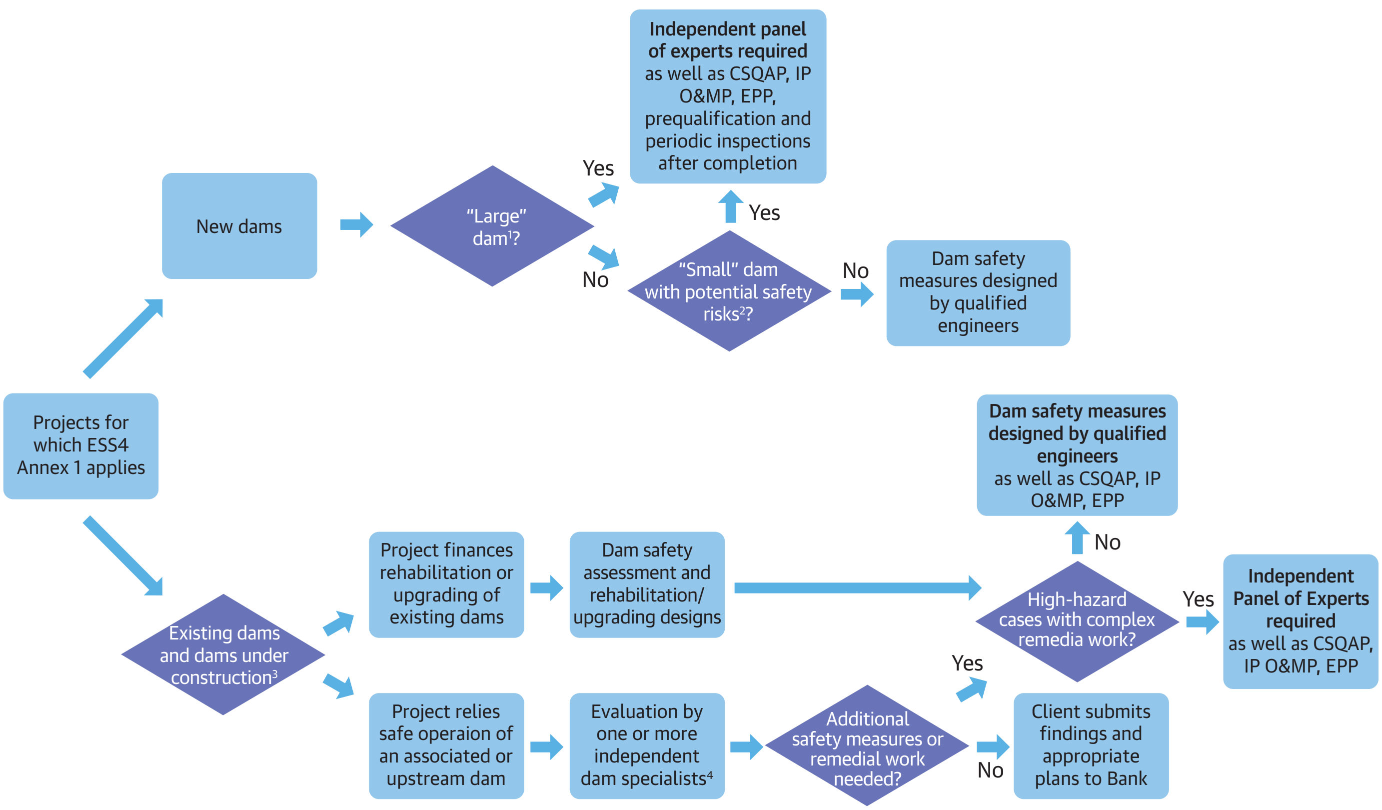
Project stage	Structural measures
Planning	Selection of dam types: easy to raise, resistant to overtopping
	Emergency off-stream diversion or storage
	Feeder canals from adjacent watersheds (water security)
Design	Structural design to allow future dam raising, if and when necessary
	Structural design to allow for easy and cost-effective addition of discharge capacity in the future, if and when hydrological loads increase
	Emergency spillway, including fuse plugs, fuse gates, and so on under extreme high floods
	Multilevel intakes for selective withdrawals (water security)
	Low-level outlets to permit in-stream releases during construction, reservoir filling, and operation of the project (ecological flows)
Construction	Build and maintain river diversion structures to allow future use in sediment flushing
Operation and maintenance	Test gates' operation regularly to ensure their reliability in emergency conditions
	Consider adding controllable gates to free spillways
	Increase reservoir freeboard during flood seasons
	Change number or type of turbines to increase installed capacity
Re-engineering	Retrofit dams to provide more resistance to overtopping, in particular for small earthfill dams
	Increase spillway capacity
	Nonstructural measures
Planning	Catchment/watershed conservation and management to prevent peak flood increase, landslides or debris flow, and sediment yields (and maintain water discharge during dry season)
	Sediment assessment and management plan using most suitable techniques (for sustainable storage management)[10]
	Enhanced hydromet monitoring/gauging involving communities, as appropriate
	Price adjustment of water and energy for water saving and optimal water allocation
	Initiate and maintain risk register, covering all technical and nontechnical risks throughout all phases of a dam's life cycle
Design	Risk analysis and assessment, including PFMA to assess potential risks, mitigation measures, and design adaption for all phases of dam life cycle
Construction	Quality control, EPP, and first reservoir filling plan, including warning procedures
Operation and maintenance	Hydromet monitoring of rainfall, snow pack, temperature, river flow, and so on[11]
	Update reservoir operation rules
	Emergency preparedness—identification, classification, notification/warning, and response
	Training dam operators and downstream communities for EPP
	Enhanced reservoir operation and decision support system linked with flood forecasting system
Re-engineering	Establishment of adaptation fund—annual replenishment and periodic reevaluation

Note: EPP = Emergency Preparedness Plan; PFMA = potential failure mode analysis.
a. Useful references, including G. W. Annandale, G. L. Morris, and P. Karki, *Extending the Life of Reservoirs Sustainable Sediment Management for Dams and Run-of-River Hydropower* (Washington, DC: World Bank, 2016).
b. Technical Note on Hydrological Risk (World Bank 2020g) provided more details on hydromet monitoring and assessment, including the glacial lake outburst flood.

Chapter 8
Procedural Aspects: Stages, Plans, and Technical Support in Project Preparation and Implementation

The following section describes stages, plans, technical support, and some other important aspects of project preparation and implementation when dam safety is involved (figure 8.1). It also addresses two critical areas of dam safety risk management (under recurrent consideration): prequalification of bidders and independent review.

FIGURE 8.1. Decision Tree for Determining the Relevant Dam Safety Requirements under the ESF/ESS4



Note: CSQAP = Construction Supervision and Quality Assurance Plan; EPP = Emergency Preparedness Plan; ESF = Environmental and Social Framework; ESS4 = Environmental and Social Standard 4; IP = Instrumentation Plan; O&MP = Operation and Maintenance Plan.

a. *Large dams* are defined in Chapter 3.

b. *Small dams* with potential safety risks or that are expected to become large dams as defined in Chapter 3.

c. Includes dams for which rehabilitation works are being directly financed through World Bank projects, as well as dams for which their safety and performance are critical to World Bank-financed projects.

d. Previously prepared assessment or recommendations may be acceptable in some cases as laid out in ESS4 Annex 1, paragraph 10.

Key Steps by World Bank Staff in Project Preparation and Implementation

Table 8.1 describes the key steps and actions by World Bank staff, pertaining to dam safety, throughout the project life cycle.

TABLE 8.1. Key Steps and Essential Elements

Step	World Bank-financed projects involving dams	World Bank-financed projects relying on dams
	Essential elements for new dams, DUC, or rehabilitation of existing dams under World Bank-financed projects	**Essential elements for dam safety assurance of existing dams or DUC on which World Bank-financed projects rely or may rely**
By PCN review meeting	• Reviews key features of the dams funded under World Bank-financed projects, potential risks, and borrower's dam safety management system and capacity • Guides borrower on the dam safety requirements that apply to the proposed project • Reviews reports on the new dam's design and/or safety assessment reports of existing dams (prepared by the borrower or its designer) and required additional studies or measures, if any, including their TORs • Reviews the ToRs and proposed experts' qualification for the independent POE for dam safety review (see Appendix 5 for sample TORs) • Provides dam safety-related technical inputs for risk classification and necessary due diligence details to be reflected in the ESRS	• Confirms that the borrower has identified the relevant existing dams or DUC whose safe and reliable performance could affect World Bank-funded projects downstream, and assess borrower's system and capacity for safety management • Agrees with borrower on the dam safety requirements that apply to the proposed project • Reviews the existing dams' safety inspection and assessment reports (prepared by the owner or independent experts); if such reports are not available, agrees with borrower on the required safety assessment of those existing dams, including the TORs (see Appendix 6 for sample TORs) • Provides dam safety-related technical inputs for risk classification and required actions for the ESRS
By QER	• As necessary, agrees on a strategy or program to enhance borrower's capacity on risk-informed dam safety management • Reviews the borrower's progress in complying with the requirements and agreed actions, including upgrading of design study, POE establishment, and dam safety plans preparation, along with their reflection in the ESCP	• Reviews any additional or newly prepared safety assessment reports of the existing dams by the borrower and agrees on required safety assurance measures and reflection in the ESCP, if needed
By decision meeting (authorization to appraise) and appraisal	• Reviews required documents submitted by borrower (additional investigation, upgraded dam design or safety assessment reports, and so on)[a] • Ensures that POE has visited the dam site and reviewed the dam design report and that the borrower has agreed on and incorporated required measures and steps • Reviews borrower's dam safety plans, which are due at appraisal, and agrees on the preparation schedule of full-fledged ones: – CSQAP including TORs, RFP, and budget estimate for construction supervisory consultancy – Preliminary O&MP – Broad framework of the EPP with an estimate of the funds for preparing the full-fledged plan • Provides dam safety-related technical inputs for risk classification and due diligence to be included in the ESRS and material measures and actions to be included in the ESCP	• Reviews any additionally submitted documents by the borrower related to existing dams' safety • Reviews borrower-submitted dam safety plans, if applicable, and agrees on the preparation schedule of full-fledged ones • Provides dam safety-related technical inputs for risk classification and agreed actions in the ESRS and ESCP

table continues on the next page

TABLE 8.1. continued

Step	World Bank-financed projects involving dams Essential elements for new dams, DUC, or rehabilitation of existing dams under World Bank-financed projects	World Bank-financed projects relying on dams Essential elements for dam safety assurance of existing dams or DUC on which World Bank-financed projects rely or may rely
Implementation	• Reviews borrower's bidding packages to confirm that the packages include key technical elements of design and procurement process, including prequalification and initial selection[b] • Confirms that the borrower has selected a construction supervisory consulting firm and contractors for performing adequate quality control • Confirms that POE has visited project site and reviewed construction progress and quality, as per agreed-upon schedule and dam safety plans as required • Review and confirm if borrower has duly reflected POE recommendations in the construction design and procedures in coordination with the contractors and construction supervisor • Monitors borrower's implementation of any capacity-development program for dam safety enhancement as agreed with the World Bank • Reviews borrower's dam safety plans: – O&MP not less than six months before starting the first reservoir filling or agreed-upon schedule for existing dams – EPP, along with dam break analysis and flooding maps, and the first reservoir filling plan not less than one year before starting the reservoir filling or agreed-upon schedule for existing dams	• Monitors borrower's implementation of the agreed-upon safety assurance measures of existing dams, including the preparation of dam safety plans, if any
Operation	• Confirms the POE has reviewed dam's behavior and performance during the first filling and provided advice on the revision of O&MP and EPP, if needed, as well as recommendations on the level of independent review appropriate for the dam • Monitors whether the borrower has carried out periodic safety inspections of the dam after completion and implementation of required dam safety measures in line with O&MP and EPP • Monitors whether the borrower has maintained adequate dam safety management capacity and resources as per the agreed-upon program and as specified in the ESCP	• Provides implementation support to the borrower in implementing the existing dam's O&MP and EPP

Note: CSQAP = Construction Supervision and Quality Assurance Plan; DUC = dam under construction; EPP = Emergency Preparedness Plan; ESCP = Environmental and Social Commitment Plan; ESRS = Environmental and Social Review Summary; O&M = operation and maintenance; O&MP = Operation and Maintenance Plan; PCN = Project Concept Note; POE = panel of experts; PPSD = Project Procurement Strategy for Development; QER = Quality Enhancement Review; RFP = Request for Proposal; TORs = terms of reference.

a. Also reviews the borrower's procurement strategy (as part of the PPSD) and procurement plan.

b. Monitor to ensure that the borrower or construction supervisory consulting firm manages performance of the contracts closely including against a contract management plan.

For a framework-type project in which all subprojects and investment schemes are not identified by appraisal, the dam safety requirements, procedures, and estimated budget and timeline should be discussed and agreed upon with borrowers during project preparation. These requirements and procedures should be reflected in the Environmental and Social Review Summary (ESRS) and Environmental and Social Commitment Plan (ESCP) by appraisal in coordination with the Environmental and Social

Specialist (E&SS) and Dam Safety Specialist (DSS). The environmental and social management framework (ESMF) should also cover such elements in connection with Environmental and Social Standard 1 (ESS1).

The climate and disaster risk screening is one of the corporate requirements in project preparation to ensure climate change and disaster risks are addressed upfront. This GPN and the TN on Hydrological Risk (World Bank 2020g) provide detailed technical guidance on sourcing, assessing, and using the data on climate change, climate risks, and other disaster risks and on their management throughout the project life cycle. The World Bank Climate and Disaster Risk Screening Tools toolbox (available at https://climatescreeningtools.worldbank.org/) provides detailed information for the screening at an early stage of planning processes or project design.[1]

E&SS in the Task Team should coordinate with and seek advice from the DSS for reviewing risk and required remedial and safety improvement measures, as well as other dam safety-related matters, as per the Environmental and Social Standard 4 (ESS4) Annex 1. The DSS will coordinate with the World Bank's Lead Dam Specialist for ensuring consistent interpretation and application of the dam safety requirements under the Environmental and Social Framework (ESF)/ESS4 when providing advice to Task Teams. External dam safety expert consultants may be appointed in coordination with the DSS and Lead Dam Specialist. In this case, the Task Team should consult the DSS to ensure the requirement of ESS4 on dam safety is properly addressed. The Lead Dam Specialist will coordinate with Operations Policy and Country Services (OPCS)—in particular, with the Chief Environmental and Social Standards Officer—and ESF Implementation Support Unit.

Dam Safety Provisions under the Environmental and Social Review Summary and the Environmental and Social Commitment Plan

The ESRS requires the ESS, in coordination with the DSS, to indicate whether dam safety measures are relevant under the ESF/ESS4 and the designated risk classification.

The ESCP sets out material measures and actions, along with any specific documents or plans that are required over a specified time frame. It is important to ensure the dam safety requirements, such as the establishment of an independent panel of experts (POE) and the preparation of dam safety plans, along with any other requirements, are stipulated in the ESCP.

The World Bank's database of dam-related projects has been developed as one of the measures for supporting implementation of the ESF. This facilitates the introduction of a risk-informed management system for Investment Project Financing (IPF), including dams, and provides a strong basis for the realization of a comprehensive contingency management system (see more details in Annexes F and H).

1. The purpose of the Climate and Disaster Risk Screening Tools is described as follows: "Climate and Disaster Risk Screening represents a proactive approach to considering short- and long-term climate and disaster risks in project and national or sector planning processes. Screening is an initial, but essential, step to ensure these risks are assessed and managed to support mainstreaming of climate and disaster resilience into key development policies, programs, and projects." Source: World Bank Climate and Disaster Risk Screening Tools, World Bank, Washington, DC (2017) https://climatescreeningtools.worldbank.org/.

For projects involving the safety of dams, the dashboard derived from this database provides a list of safety-related elements and indicates the required level of dam safety measures commensurate to risks. In other words, the dashboard will provide a risk management tool to improve portfolio monitoring of investment projects during project preparation and implementation, allowing the user to focus on high-risk projects involving dams and adequate resource allocation. This tool will be upgraded to incorporate the full range of World Bank-supported activities relating to the safety of dams.

Dam Safety Plans

World Bank-financed projects involving the construction of new dams, dams under construction (DUC), or existing dams require the preparation and implementation of the four dam safety plans as described in ESS4 Annex 1, paragraph 14:

- Construction Supervision and Quality Assurance Plan (CSQAP)
- Instrumentation Plan (IP)
- Operation and Maintenance Plan (O&MP)
- Emergency Preparedness Plan (EPP)

Each of these plans is required to be submitted by the borrower at different times throughout the project life cycle (table 8.2). This timing corresponds to the various steps in the transition—from design to construction and operation of the dam—and is aimed at ensuring the necessary provisions, resources, and capacity are in place to achieve safe, sustainable outcomes in line with the development objectives.

TABLE 8.2. Submission Timing of Dam Safety Plans

Dam safety plan	Timing: New dams or DUC	Timing: Existing dams	Review
CSQAP	Due at appraisal[a]	Due at appraisal if substantial remedial works are required[b]	The World Bank TT/DSS, POE in high-hazard cases involving significant and complex remedial works
IP	Before bid tendering	Before remedial works tendering if substantial remedial works are required	The World Bank TT/DSS and POE (if applicable)
O&MP	Outline at appraisal; final plan not less than six months before starting reservoir filling	Updated or new plan developed during project implementation; PAD specifies timing	The World Bank TT/DSS and POE (if applicable)
EPP[c]	Framework EPP at appraisal; final EPP not less than one year before starting reservoir filling	Updated or new plan developed during project implementation; PAD specifies timing	The World Bank TT/DSS and POE (if applicable)

Note: CSQAP = Construction Supervision and Quality Assurance Plan; DSS = Dam Safety Specialist; DUC = dam under construction; EPP = Emergency Preparedness Plan; ESF = Environmental and Social Framework; ESS4 = Environmental and Social Standard 4; IP = Instrumentation Plan; O&MP = Operation and Maintenance Plan; PAD = project appraisal document; POE=Panel of Experts, TT = Task Team.

a. In case of a framework-type project in which subprojects and investment schemes have not been identified by appraisal, the terms of reference for CSQAP are required at appraisal.

b. When the design of remedial works need further detailed assessment or investigation during project implementation, the terms of reference for CSQAP are required at appraisal.

c. In addition, the borrower is required to prepare an emergency response plan mainly for the environmental and social risks of a dam's construction works as per ESF/ESS4, paragraphs 20–21.

The Task Teams should ensure that the timing of these instruments is reflected in the legal agreements and ESCP, stipulating the measures and actions to be taken by the borrower. It is good practice to include these requirements as conditions or dated covenants. Although it is often difficult for Task Teams to translate these into specific dates, an initial estimate should be made at the time of negotiations and the implementation of the design and construction should continue to be monitored so that the milestones can be amended in consultation with the country lawyer. The required level of detail, scope, and depth for the four dam safety plans should reflect the risk classification of particular dams under or associated with the World Bank-financed project.

Construction Supervision and Quality Assurance Plan

The objective of the CSQAP is to set out details of the organization, staffing levels, procedures, equipment, and qualifications for supervision of the construction of a new dam or of remedial work on an existing dam.

The first step is to develop terms of reference (ToRs) during project preparation for the entity that will supervise construction activities. That entity can be a consulting firm acting as supervision engineer, owner's engineer, or employer's representative (depending on construction contract type). In special cases when experienced and competent in-house engineers are available, it could be the owner itself through one of its specialized departments. The CSQAP should be adapted to the dam's type, size, construction site condition, and so on. A sample framework is provided in Appendix 1 (World Bank 2020a).

The scope of work, along with the qualification of the key experts and the level of construction supervision, will vary depending on the complexity of the project. In the case of minor repairs of existing small dams, the required scope and level of construction supervision could be minimal and included with a broader scope of work for supervising associated downstream works, such as irrigation, water supply works, and so on.

The Request for Proposal (RFP), including the TORs, key staff qualifications, required staff time, and so on, should be reviewed and cleared by the Task Team and DSS before appraisal. Procurement for the selection of a suitably qualified consulting firm is usually through quality cost-based selection (QCBS) or quality-based selection (QBS). In the case of new dam construction, although the weight of technical and financial aspects for bid evaluation depends on the complexity of the project, the technical weight, when applying QCBS, is generally recommended as 90 percent versus the financial weight of 10 percent.[2] Consistent with the Project Procurement Strategy for Development (PPSD) or its subsequent updates, QBS may also be applied to ensure total focus on technical (quality) features and avoid that cost aspects might negatively affect safety aspects. In such cases, it is essential to ensure that all required expertise and level of effort (for example, staff time) are sufficiently stated in the RFP.

The CSQAP and ToRs for the owner's engineer or construction supervisor and the technical specification of the main bidding document for the civil works related to dams should be reviewed by the Task Team,

2. World Bank Procurement Regulations for IPF Borrowers (2018), Annex X, paragraph 40 and table 5.1. See also Annex G for IPF procurement involving dam safety.

DSS, and client-appointed POE for dam safety, if applicable. In particular, the contractor's quality assurance, including the scope and frequency of various in situ and laboratory tests, should be reviewed in connection with the construction supervisor's quality assurance.

During the construction period, the quality assurance program and its effectiveness should be reviewed by the POE at least twice per year, and any issues and recommended measures should be reviewed, discussed, and agreed between the borrower and Task Team, including the DSS, during supervision missions.

Instrumentation Plan

The objective of the IP is to provide a detailed description of the instruments to monitor and record the behavior and performance of the dam and associated structures, as well as to evaluate the safe performance during the construction and first reservoir filling and throughout the operation period of the dam.

The plan will typically be prepared by the design engineer and included as part of the technical specifications in the tender documents.[3] The requirements of the IP should be reflected in dedicated items of the bill of quantities for the tenderer. The plan is reviewed by the Task Team and DSS and, if applicable, by the client-appointed POE. A sample framework is provided in Appendix 2 (World Bank 2020b).

The scope and detail of the plan should be commensurate with the dam's type, size, potential risk, and so on. The plan should cover a list of monitoring equipment, including their number, type, location, technical specification, and so on. The plan should also consider data acquisition, analysis, reporting, and storage systems, covering the required data transmission, storage equipment, and software. The procedure and responsibility for equipment installation, calibration, and testing should be carefully reviewed. The plan should also specify the procedure and frequency of monitoring data collection, processing, analysis, reporting, and maintenance works, which can also be referred to or complemented by the O&MP.

Toward the end of the construction and first reservoir filling, it is important to ensure that a set of monitoring instruments are properly installed, calibrated, and functioning for monitoring the dam's condition and performance during the first filling. The Task Team, including the DSS, should discuss and agree with the borrower on any areas for remedies or improvement. For existing dams, in particular, the dam owner and/or operator's instrumentation monitoring procedure, practice, status of monitoring equipment, staff capacity, and training needs should be considered for preparing the upgraded IP. The plan should also consider the results of dam safety assessment so that the new and/or upgraded instruments in the early stages can monitor potentially weak spots and detect any anomalies. In this regard, conducting workshops about potential failure mode analysis is very useful. To the extent possible, the plan should indicate critical thresholds, above which appropriate cautions and internal warnings would be triggered.

3. Depending on the types of contracts, less details are specified in tender documents, specifications, or employer's requirements.

Operation and Maintenance Plan

The objective of the O&MP is to set out details of the organizational structure, staffing, technical expertise, and training required; equipment and facilities needed to operate and maintain the dam; operation and maintenance (O&M) procedures; and estimated budget/arrangements for funding O&M, including long-term maintenance and safety inspections. A sample framework is provided in Appendix 3 (World Bank 2020c).[4]

A preliminary O&MP for new dams is required at appraisal, and the final plan is required not less than six months before starting the initial reservoir filling. In the case of existing dams, a preliminary plan should be submitted at appraisal, and the final plan should be prepared during the early stage of project implementation as the project implementation schedule allows. The plan is reviewed by the Task Team and DSS, and, if applicable, by the client-appointed POE for dam safety-related aspects.

The scope and detail of the plan varies depending on the dam's risk classification, but the plan is typically composed of: (a) the O&M structure, including staffing, required expertise and qualifications, and training needs; (b) the O&M procedure and manual for various electrical-mechanical facilities and equipment; (c) the surveillance, instrumentation monitoring, and reporting procedure and periodic inspection and dam safety review; (d) reservoir operation procedure during normal, flood, and dry seasons, including rapid drawdown for peaking power, structural dam safety assurance, and so on, as well as downstream notification and warning procedure; and (e) the O&M budget, sources, and long-term maintenance program. The plan should give careful consideration to management of potential risks related to structural and operational aspects of hydromechanical equipment in addition to civil works.

The dam safety assessment undertaken during project preparation should cover the dam owner's and/or operator's O&M practice and capacity in addition to the review of the condition status of various facilities and equipment. The required budget and staffing for O&M should be carefully assessed and agreed with the borrower. Depending on the capacity of owner and/or operator of the dam, the staff training program should be discussed and agreed upon. In addition, external technical assistance may be needed for establishing and maintaining a proper O&M procedure.

For high- or substantial-risk dams, it is important for the owner to establish a dedicated dam safety team or retain an external professional service to ensure a dam safety assurance function independent from the business or operational line being cognizant that the dam safety function is typically commingled with the general O&M function for hydropower or other utility dams.[5]

4. World Bank, *O&M Strategies for Hydropower - Handbook for Practitioners and Decision Makers* (Washington, DC: World Bank, 2020), https://openknowledge.worldbank.org/handle/10986/33313. This report also provides relevant information on O&MP, in particular for hydropower dams.
5. World Bank, *O&M Strategies for Hydropower - Handbook for Practitioners and Decision Makers* (Washington, DC: World Bank, 2020), https://openknowledge.worldbank.org/handle/10986/33313. This report also provides relevant information on O&MP, in particular for hydropower dams.

As a standard industry practice, the first reservoir filling or impoundment plan should also be prepared by the borrower in coordination with the contractor and construction supervisory consultant. The plan should define the reservoir filling schedule, including some holding points or elevations, surveillance and monitoring procedures, frequency of instrumentation readings, thresholds for triggering alarms, notification and warning procedures, and so on. The plan should be closely linked with the IP, O&MP, and EPP—not necessarily duplicated but cross-referenced. The plan can be incorporated into the O&MP or EPP but preferably is a separate document. The plan should be reviewed by the POE and Task Team, including the DSS.

Emergency Preparedness Plan

The objective of the EPP[6] is to specify the roles of responsible parties when emergency situations are evident. Emergencies include flow release that can threaten downstream life, property, or economic activities that depend on river flow levels, intentional or accidental water release, or, in the worst case, dam failure. The EPP includes emergency communications, specifying the mechanisms through which at-risk downstream communities will be informed in the event of an emergency.

An effective EPP should provide clear and concise guidance on emergency actions: (a) how to identify an emergency as early as possible, (b) how to classify the emergency, and (c) how to respond to the emergency. Further details are provided in a sample framework EPP (see Appendix 4 [World Bank 2020d]), including the emergency response level matrix.

It is important that the EPP be coordinated with other key entities, such as the national and regional emergency or disaster management agencies and downstream districts and communities. Although dam owners and/or operators are responsible for assessing dam safety conditions and notifying relevant entities of potential risks, the emergency management authorities[7] are responsible for evacuation planning and execution. Warning the population immediately downstream in the case of imminent danger remains the responsibility of a dam's operators, according to an established protocol, and Appendix 4 (World Bank 2020d) provides further detailed descriptions using the sample EPP.

For that purpose, the EPP should include a protocol for communicating the changing situations of an emergency to the entities in charge of responses in the field. Response management should be based on maps, outlining inundation levels for emergency conditions; flood warning system characteristics; and procedures for evacuating people in threatened areas and mobilizing emergency forces and equipment.

A framework EPP is required at appraisal, and it should contain an estimate of funds needed to prepare and implement the plan in detail. The final EPP is required not less than one year before commencement of the initial filling of the reservoir.

6. In addition, borrower is required to prepare an emergency response plan, mainly for the environmental and social risks of dam's construction works as per ESF/ESS4, paragraphs 20-21.
7. The specific institutional arrangements for emergency preparedness and management should be checked for a specific country and region in which the project is located.

Should river diversion entail significant storage,[8] the framework EPP should include provision for that phase, requiring the contractor to complete the framework with a method statement for river diversion covering suitable measures, such as enhanced resilience of the cofferdams, adequate monitoring and water system, and so on.

In the case of existing dams, a framework plan should be submitted by appraisal, and a final plan is to be submitted during the early implementation stage as the project implementation schedule permits. The timing should be specified in the ESCP or legal agreement. The plan is reviewed by the Task Team, DSS, and, if applicable, client-appointed POE.

A sample framework EPP provided in Appendix 4 (World Bank 2020d) should be tailored to the actual circumstances of the project, including the dam type, size, downstream consequence in case of dam failure, and so on. The framework EPP is intended to provide general guidance for preparing the final EPP based on topographic survey, dam break analysis, and downstream flooding simulation/mapping.

The level of details of the final EPP should be commensurate with the downstream hazard or potential consequence in case of dam failure. Again, the preliminary consequence assessment and dam risk classification should indicate the required scope and detail of the EPP.

The required level of topographic survey (topographic maps, digital elevation model [DEM],[9] or light detection and ranging [LiDAR] to delineate flooding area); dam break analysis (breaching models and parameters, dam breach outflow hydrograph, and so on); flooding simulation (simplified routing method, 1-D or 2-D hydraulic model, and so on); and flood mapping (arrival time, flood depth, velocity, and so on) should be specified in the framework plan, considering the potential risk or consequence of dam failure in each case. Detailed flooding maps indicating the water depth and velocity that is determined by topography are critical for undertaking a detailed consequence assessment, including potential loss of life (PLL), affected houses, commercial buildings, and main infrastructure and indicating the required emergency measures in coordination with relevant stakeholders.

The dam break analysis should include various potential failure modes and simulation scenarios, including large floods and "sunny day" events. It is important to note that downstream emergencies could be caused by a sudden uncontrolled release of water or controlled but rapid increase of water discharge, such as peaking power discharge through hydropower turbines. The downstream area could suffer major impacts, even by 50- to 100-year return period floods. Even during normal operation periods, an intentional or accidental release of water could cause incidents and human casualties, including

8. The significance of the diversion-stage storage should be assessed based on consequence levels downstream, considering the expected duration of the diversion phase, before reservoir filling, and the type of cofferdam.

9. Some global DEMs are available for free. ASTER Global DEM released in 2009 has a 30-meter resolution created by stereoscopy (http://asterweb.jpl.nasa.gov/gdem.asp). The latest ASTER data (version 3) was released recently with the same resolution but an improved vertical and horizontal accuracy (https://asterweb.jpl.nasa.gov/gdem.asp). Another example is SRTM, originally at 90-meter resolution but now available globally at 30 meters (data available for download at https://www.usgs.gov/centers/eros). Some additional references are provided in Annex A.

recreational users.[10] It is important to establish a proper downstream flood or discharge warning system and procedure, along with suitable hydromet monitoring and a flood forecasting system. This may be covered in the O&MP.

It is important for dam owners, operators, and other relevant agencies to undertake drills, testing, and training to ensure smooth coordination in case of emergencies. Periodic review and upgrading of the EPP is also important to reflect changes in staffing of dam owner and relevant agencies and downstream conditions. Adequate stakeholder analysis and engagement, including disadvantaged or vulnerable groups, should also be undertaken to tailor the means of communication, such as posters, brochures, social media, outreach to local associations, and others, as well as to engage the local communities so that they would be part and informed of the emergency action plan.

Prequalification or Initial Selection of Bidders

Prequalification or initial selection is aimed at ensuring that only entities with proven experience in dam engineering and associated works are invited to bid. The World Bank should verify that the submitted bids include adequate dam safety provisions. Those may include bidder-proposed technical specifications, or reservations thereof, including Geotechnical Baseline Reports[11] and other contract management elements that have significant relevance to dam safety. Gaps in these areas should be appropriately addressed before award of contract in accordance with the bidding documents.

Prequalification or initial selection of bidders is a compliance requirement in the case of large dams.[12] At the same time, proportionality requires examination of how to apply the provision to various types of World Bank operations, including dam safety aspects. Table 8.3 lists typical situations and provides related guidance. For nontypical situations, the Task Team should seek guidance from the DSS.

The World Bank has introduced a new procurement framework, in which all IPF with Project Concept Note (PCN) approval after July 1, 2016, is subject to the Procurement Regulations, which have a significantly modernized procurement process.[13] The borrower is required to stipulate project-funded procurement activities and selection methods in the PPDS, ensuring that procurement processes are fit for purpose; allow choice; and are appropriate to the size, value, and risk of the project. The new procurement framework also stresses the concept of value for money with a shift in focus to the best overall

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10. More information on public safety of dams is provided by "Laying the Foundations: A Global Analysis of Regulatory Frameworks for the Safety of Dams and Downstream Communities" (Wishart et al. 2020), including some useful references, such as *Guidelines for Public Safety Around Dams* (CDA 2011) and TVA downstream warning and communication systems (https://www.tva.com/Environment/Lake-Levels/Hazardous-Waters).
11. A Geotechnical Baseline Report is a document describing the contractual understanding of the site conditions, referred to as the geotechnical or geological baseline: (a) contractor bears risk at or below baseline and employer accepts risk above baseline; and (b) baseline setting determines risk allocation and has a great influence on risk acceptance, bid prices, quantity of change orders, and the final cost of the project. A recommended reference is ASCE (American Society of Civil Engineers), *Geotechnical Baseline Report for Construction – Suggested Guidelines* (Reston, Virginia: ASCE, 2007).
12. This will be revised and defined as part of the borrower's Project Procurement Strategy for Development and Procurement Plan.
13. Sources: World Bank Procurement Regulations for IPF Borrowers (July 31, 2018), Procurement Guidance – Standard Procurement Documents – An Overview of Practitioners (November 2016), and Procurement Guidance – A Beginner's Guide for Borrowers – Procurement under World Bank IPF (April 2018).

TABLE 8.3. Typical Prequalification-Related Situations and Recommendations

Situation	Rationale	Recommended course of action
Repairs and/or rehabilitation works at small dams	In line with the provisions of ESS4, prequalification of bidders is not required.	Task Team should assess capacity of the entities who will be invited to tender and that of the designer or supervisor of rehabilitation works. Assess whether the latter entity may require technical support by other national institutions. Community involvement in basic surveillance during operation of the dams should be considered.
Rehabilitation works involving mainly nonstructural measures	In several cases, rehabilitation measures involve mainly upgrading of the monitoring and instrumentation system, updating dam safety plans, adding flood warning systems, training, and so on. Structural measures are of very limited extent in such cases.	Prequalification of bidders should be limited to suppliers of specialized equipment. For consulting firms, QBS or QCBS[a]-procurement should be adopted with clear terms of reference.
Site investigations and testing for feasibility studies of new dams	The World Bank often includes preparation of a new dam/hydro as a project component, with no commitment to finance that infrastructure. Major site investigation activities (access tracks, trench and pit excavation, boreholes, exploratory adits, and so on) may be involved to inform feasibility study.	Site investigation companies should have proven technical capacity. For consulting firms, QBS or QCBS25 procurement should be adopted with clear terms of reference.

Note: ESS4 = Environmental and Social Standard 4; QBS = quality-based selection; QCBS = quality cost-based selection.
a. See section on Dam Safety Provisions under the ESRS and the ESCP and Annex G for procurement aspects related to dam safety.

value for money, taking into account quality, cost, and other factors as needed and introducing some new procurement methods and features. Although new RFP documents for procuring goods, works, and nonconsulting services beyond consulting services include initial selection, updated requests for bids include prequalification with some new features. Annex G provides relevant information for projects involving dam safety.

The Task Team and DSS should discuss suitable selection methods of contractors and consulting firms for ensuring the quality and safety of dam design and construction in coordination with procurement specialists, who should be able to provide a complete set of procurement-related documents, information, and guidance.

Independent Review

Independent review of dam safety is required for new dam construction, existing dam rehabilitation, and safety improvements, along with dam safety assessments of associated dams. The objective of the independent review is to examine the safety and quality of a dam's design and safety plans in an objective manner and detect potential safety issues that might have been overlooked by the client and designer who have been involved in project development. Independent review of new dams and DUC involves the client appointing a POE. The Guidance Note for Borrowers ESS4: Community Health and

Safety provides guidance on the independent POE for dam safety in Guidance Note Annex (GNA) 1.6.1, 1.6.2, and 1.7.1.

The level of independent review required varies in form and degree, depending on potential risk. Appendixes 5 and 6 (World Bank 2020e, 2020f) provide sample TORs, respectively, for POE for safety review of new dams and safety assessment of existing dams on which World Bank-funded project relies or may rely. The latter is typically carried out by an individual DSS or expert. The appropriate level of review should be tailored to the specific technical issues, potential risk involved, country context, and so on.

The Task Team should seek guidance for required independent dam safety review from the DSS in coordination with the E&SS. The DSS can also assist in recommending suitable experts if requested by clients. Although construction of new dams with potential high- or substantial-risk classification may require internationally reputable experts in their respective fields, safety review of moderate- or-low risk classification of existing dams may be sufficiently covered by regional or national experts. Task Teams should seek no objection from the DSS regarding the TORs for safety review and recommended experts.

The POE should be established by the client as early as possible during project preparation and maintained at least until the completion of the first reservoir filling and initial commissioning period.[14] The POE's overall confirmation of the adequacy of the dam design and other safety-related aspects should be obtained in advance of appraisal. To fulfill its quality assurance and due diligence function, the World Bank may hire external expert consultants for safety review in consultation with the DSS.

As aforementioned, Appendix 5 (World Bank 2020e) provides a sample TOR for POE for new dams and DUC. This applies to such dams irrespective of funding sources, whether government funds or other international and bilateral agencies. The arrangements may need to be carefully discussed and adjusted depending on the potential risk involved and country or client contexts.

The most effective POEs are small (three to four members), and members are carefully selected to cover the major disciplines involved in the project. POE members are free to review any aspect that they deem relevant to safety and sustainable operation of the dam. In some cases, feasibility study and detailed design have already been subject to independent review before the POE's involvement. In those cases, the borrower may limit the POE's review to some specific points that are relevant to the project's safe and efficient implementation. In other cases, the Task Team may find that the quality of documents, such as RFPs, TORs, technical specification of bidding documents, and so on is insufficient. In such cases, considering the borrower's capacity, the team may request the borrower use the POE to enhance the quality of those documents.

POE members should have an established technical record with wide practical experience. An effective POE is made up of individuals who are not afraid to state their opinions yet are able to work collectively

14. The actual timing of the POE release may be reviewed depending on duration of the first reservoir filling completion.

in a group setting. In forming the POE, the borrower should ask each potential member not only whether they would be willing to serve on the project POE but also whether they would be willing to serve together with other potential members.

It is generally not advisable for the client to hire a consulting firm to undertake the independent review but rather to base selection on the individual's record and expertise, unlinked to commercial interests, such as major consulting, contracting, or equipment companies. Any individual selected for the POE should document any conflicts of interest and acknowledge that any organization for which he or she works will be excluded from any major decision-making role in the project.

It is desirable that the POE includes a combination of national and international experts of proven and practical experience. At least one or more international experts are generally required to introduce relevant good international practices and ensure the full independence of the POE.

Proportionate to risk, for the safety review of existing dams associated with World Bank projects featuring less demanding technical aspects, one single expert may be adequate. However, rehabilitation of high-risk dams involving significant and complex remedial works may require a POE composed of internationally recognized experts in relevant fields that cover the key issues identified.

The borrower's liaison with the members of the POE should prepare a project status report ahead of each POE visit, including subjects on which the borrower seeks advice and other subjects that the POE deems necessary to review. Such reports should be shared with the World Bank and the Task Team should be invited to participate in the visit of the POE, as appropriate.

The World Bank has been increasing lending projects for the rehabilitation of existing dams and safety improvement involving hundreds of dams on a national or regional basis. In such cases, the Task Team needs to discuss with and obtain from the borrower the required safety review and quality assurance mechanism, including POE and other entities, such as design and construction supervision firms and so on. The Task Team should discuss and agree with the borrower on the scope and size of POE based on the preliminary portfolio risk assessment of those dams, seeking advice from the DSS during project preparation before appraisal (see section on Risk Classification for Existing Dams in Chapter 7 and TN for Portfolio Risk Assessment Using Risk Index [World Bank 2020l]). Based on the risk profile of the portfolio of dams, the POE's work/site visit programs should be developed to optimize efficiency and use of time.

The World Bank is increasingly involved in supporting, in one form or another, projects in which the main developer is a private entity or a public-private partnership. In those cases, the World Bank often enters the operation when project preparation is fairly advanced yet has to conduct appropriate due diligence. That type of operation often involves IFC and/or Multilateral Investment Guarantee Agency (MIGA) for provision of guarantees to safeguard the developer's investment.

In such cases, OP4.03 - Performance Standards for Private Sector Activities and IFC (World Bank Group) Performance Standard 4 (PS4) - Community Health, Safety, and Security (2012) applies, and paragraph 6 of PS4 on Infrastructure and Equipment Design and Safety noted that "when structural elements or components, such as dams, tailing dams, or ash ponds are situated in high-risk locations, and their failure or malfunction may threaten the safety of communities, the client will engage one or more external experts with relevant and recognized experience in similar projects, separate from those responsible for the design and construction, to conduct a review as early as possible in project development and throughout the stages of project design, construction, operation, and decommissioning."

Although PS4 does not specifically use the term *POE*, it requires independent review of dam safety aspects. Depending on the extent of the World Bank's involvement in each case, it would be advisable to secure independent review of dam safety aspects by individual experts in coordination with IFC and/or MIGA.[15] Because it is usual to find that such projects have been satisfactorily prepared by the developer team, in most cases, independent review may effectively be provided by one senior expert.

Technical Assistance Related to Dam Safety

In addressing the environmental and social risks and impacts related to dam safety associated with recipient-executed technical assistance (TA) that is supported through IPF[16] in accordance with the ESF, Operations Environmental and Social Review Committee (OESRC) Advisory Note: "Technical Assistance and the Environmental and Social Framework" (2019) should be referred to.[17]

Out of four types of TA activities, dam safety may be relevant in type 1: "Preparing future investments in infrastructure or other sectors, including the preparation of feasibility studies, detailed technical designs, safeguard instruments, bid documents," type 2: "Drafting of policies, programs, plans, strategies, laws and/or regulations," and type 3: "Capacity building activities."

The IPF-financed TA activities subject to the ESF need to be assessed, for risk classification purposes, in accordance with the ESF and the Bank Directive - Environmental and Social Directive for Investment Financing (2018). The note states, "Task teams and E&S specialists need to bear in mind that the relevant risk that need to be assessed are not simply the impacts resulting from the TA activities themselves but also the potential downstream environmental and social implications that may arise when and if the TA leads to future investments. ... If the future construction of a dam in a sensitive ecological setting is considered high risk, the TA supporting its design should also be considered high risk."

The note also states: "The Bank's responsibility will usually not extend to ensuring that other activities of the Borrower - whether subsequent or parallel to the provision of the TA - are consistent with the ESF. For example, a TA recipient later may decide to obtain financing from sources other than the Bank, and

15. IFC and MIGA have had practices of hiring a firm as lender's engineer for large projects involving dams for reviewing project-related technical aspects, including dam safety and facilitation of technical discussions between financiers, client, developer, and so on. This is not necessarily considered an independent review as per IFC "(determined on a case by case basis, depending, inter alia, on the TORs of the Lenders' Engineer)."

16. The principles and concepts described here may be of use to a team designing and implementing TA with instruments such as Reimbursable Advisory Services and Bank-Executed Trust Fund or in the form of Advisory Services and Analytics in a proportionate manner to potential risks as described in this GPN, in line with the OESRC Advisory Note (May 21, 2019).

17. For the TA under IPF operations subject to safeguard policies, refer to the World Bank "Interim Guidelines on the Application of Safeguard Policies to TA Activities in Bank-Financed Projects and Trust Funds Administered by the Bank" (OPCS/LEGEN, Washington, DC, 2014).

to apply national standards and/or other donors' policies to the projects that were prepared under the Bank-financed TA or that arise from the program/plan prepared under the TA. In such cases, the activities in question will not be subject to the ESF.... Hence, it is extremely important that project documentation define precisely and as narrowly as possible what the project is financing."

Table 8.4 provides an indicative risk classification for TA involving dam safety, but each case should be discussed with the E&SS, DSS, and Regional Environmental and Social Standards Adviser (RSA). For preparing the TORs for design studies, programs, and capacity building under all three types, the DSS should be consulted to provide a review and technical advice. For preparing the feasibility studies and detailed designs of substantial- and high-risk dams (according to the aforementioned new dams and existing dams rehabilitation and upgrading), an independent review by a POE or individual expert is recommended, and in each case, the DSS should be consulted.

Furthermore, in coordination with legal counsel, the E&SS, and the DSS, the Task Team may also want to include the following standard language used in some TA studies: "Although the studies that resulted in the present reports were funded and reviewed by the World Bank, the World Bank does not take responsibility for the use made of them. At present, the Bank has not determined or considered a future engagement with respect to the Project."

For analytical work, the Task Team may want to include the following caveats as part of the acknowledgments or executive summary: "This assessment is not intended to represent nor replace appraisal of the project, and the presentation of the findings, their interpretations, and the conclusions expressed herein do not necessarily reflect the views of the World Bank, its Board of Executive Directors, the governments they represent, or any other organization or individual acknowledged here. It is one of a number of supporting activities intended to complement preparations being carried out by the [client] for the [project]."

At the closure of World Bank-financed projects, the World Bank may not be satisfied with the quality of the feasibility studies or other project preparatory documents produced under a TA with inadequate

TABLE 8.4. Risk Classification for TA Involving Dam Safety

<table>
<tr><th>TA types</th><th>Indicative risk classification</th><th>Remarks</th></tr>
<tr><td>Type 1: Preparing feasibility studies, detailed designs, or other activities directly in support of the preparation of a future investment project (whether or not funded by the World Bank).</td><td>Substantial to high</td><td>Classification depends on the risk profile of the future project, and risk-informed dam safety should be applied. The POE's review is recommended for high-risk projects. The World Bank's future financing possibility of the studied dams should also be considered.</td></tr>
<tr><td>Type 2: Assisting in formulation of policies, programs, plans, strategies, laws, or regulations, and so on</td><td>Low to moderate</td><td rowspan="2">TA should not include structural works, such as access roads, site investigations, and so on. In the case of monitoring equipment provision for particular dams, overall dam safety condition should be assessed with required safety measures.</td></tr>
<tr><td>Type 3: Strengthening client capacity</td><td>Low to moderate</td></tr>
</table>

Note: POE = panel of experts; TA = technical assistance.

reflection of previous comments by the World Bank and/or independent reviewers or dam safety panel and provide its final comments to the client, expecting them to be addressed at the next stage of project preparation. It should be clearly agreed with the client with documentation that whichever project entity picks up the project preparation at the next stage, they should have access to and reflect the comments from the World Bank, independent reviewers, or POE.

Institutional, Legislative, and Regulatory Framework for Dam Safety[18]

ESS4 Annex 1, paragraph 13 indicates, "Where appropriate, the Borrower may discuss with the Bank any measures necessary to strengthen the institutional, legislative and regulatory frameworks for dam safety programs in the country." Furthermore, Guidance Note for Borrowers ESS4: Community Health and Safety indicates in GNA 1.13 notes: "With respect to certification and approval of structural elements of the project, where governmental 'approving authority' capacity is limited or inadequate, the roles and responsibilities of alternative approving authorities, such as third-party professionals, should be agreed to and formulated before project implementation."

The team is encouraged to refer to "Laying the Foundations: A Global Analysis of Regulatory Frameworks for the Safety of Dams and Downstream Communities" (Wishart et al. 2020) including the decision support tool detailed in its Appendix E to facilitate the assessment of the country's dam safety framework and a gap analysis of capacity among regulators and owners. The Task Team is expected to seek advice from the DSS on any required technical support and capacity enhancement measures related to projects during project preparation.

Requirements under Other Parts of the ESF and Legal Operational Policies

This chapter provides the relations of this Good Practice Note to other parts of the ESF and legal operational policies.

ESS1 – Assessment and Management of Environmental and Social Risks and Impacts

In accordance with ESS1, the Environmental and Social Assessment will include an environmental and social impact assessment (ESIA), an environmental and social management plan (ESMP), and other instruments in ESS1 Annex 1 as necessary, including a cumulative impact assessment considering all relevant environmental and social risks and impacts of the project. In case of a framework-type project in which all subprojects and investment schemes are not identified by appraisal, an ESMF may also be prepared. For co-financed projects, use of a common approach may also be discussed. While the ESIA/ESMP covers all risks and impacts including dam safety, dam safety-related documents, such as safety assessment and inspection reports of existing dams, as well as design reports for new dams construction and rehabilitation of existing dams, dam safety plans (see section on Dam Safety Plans in Chapter 8) and so on will be required under ESS4 Annex 1. Dam safety experts will provide inputs for the environmental

18. As per FY17 large dams legislation of the U.S. government, one of the conditions for the U.S. executive director to support a project involving large dams is that the country has in place sound dam management practices or, where necessary, commit to appropriate and timely capacity building. Outstanding operational problems with existing dams in the country in the same river basin are being addressed before investments in new dams, among many.

risk rating in the ESRS and for the ESRS and ESCP (see section on Dam Safety Provisions under the ESRS and the ESCP in Chapter 8) from a dam safety perspective, in particular when dams are located in areas where hydrological, seismic, geological, and other potential risks are substantial or high.

ESS10 – Stakeholder Engagement and Information Disclosure

ESS10 establishes a systematic, timely, and transparent engagement between the borrower and project stakeholders disclosing information on potential impacts of World Bank-funded projects and mitigation measures. Effective stakeholder engagement improves the environmental and social suitability of projects, enhances acceptance of the project, and makes a significant contribution to successful project design and implementation. Following stakeholder identification and analysis, a stakeholder engagement plan is prepared to ensure that the project will include appropriate mechanisms for taking stakeholder views into account and that information disclosure and consultations are planned and managed to ensure effective participation.

Although the World Bank has been following an international practice of classifying dam safety-related documents as confidential because of their safety and security contents,[19] it is important to ensure that the borrower will prepare the EPP in consultation with relevant government offices and other stakeholders and disseminate information and raise awareness on required emergency preparedness and action for local communities, such as community-level warning systems and procedures, evacuation procedures and routes, and so on. This information should be in appropriate formats that are tailored to the diverse stakeholders within potential flooding areas (leaflets, brochures, signposts, radio, social media, outreach to associations, and so on) in coordination with the national and local emergency management offices (see section on Emergency Preparedness Plan).

For small dams with low risks, the Task Team should consider the participation of local community organizations or water user groups in dam safety assurance, such as basic surveillance, monitoring, reporting, repairs, emergency preparedness, and so on. As appropriate, this participation should be in coordination with the dam safety regulators and/or owners. Adequate technical support, training, and periodic oversight should be provided. Further detailed guidance is provided under the TN on Small Dam Safety (World Bank 2020j), and specific guidance from social development specialists and DSS should be sought.

Legal Operational Policy – OP/BP 7.50 Projects on International Waterways

If dams involved in World Bank-funded projects or technical assistance are using or risk polluting water from transboundary rivers, including their tributaries, the project will likely trigger the World Bank's Operational Policy (OP)/Bank Procedure (BP) 7.50 concerning Projects on International Waterways, and the policy requirements according to OP/BP 7.50 need to be addressed. Depending on the nature and scope of financed activities, notification to other riparian countries or approval of an exception to the notification requirement may be required. Dam safety experts will provide technical inputs regarding the design of dams, reservoir operational patterns and procedures, emergency preparedness, and so on.

19. See section on security in Chapter 7 of "Laying the Foundations: A Global Analysis of Regulatory Frameworks for the Safety of Dams and Downstream Communities" (Wishart et al. 2020).

In case of such projects triggering OP 7.50, the EPP should consider transboundary impacts and include the coordination or communication mechanism with the affected neighboring countries. These projects should be discussed on a case-by-case basis with LEGEN (Environment and International Law Unit, Legal Vice-Presidency) the E&SS, and the DSS.

For the purposes of OP 7.50, it should be noted that the requirement for a borrower's safety inspection and evaluation of an existing dam or a DUC on which a World Bank-funded project relies or may rely on is specified as dams in the borrower's territory.[20]

Dam Safety Requirements in Fragility, Conflict, and Violence Situations

Where a borrower is deemed by the World Bank to (a) be in urgent need of assistance because of a natural or manmade disaster or conflict or (b) experience capacity constraints because of fragility or specific vulnerabilities (including for small states), the applicable provisions of OP 10.00 will apply as per the policy.[21]

Specific dam safety requirements and possible adjustments should be discussed on a case-by-case basis with relevant staff, including OPCS and ESF Implementation Unit, ensuring that critical dam safety requirements would be identified and covered in a commensurate manner to the potential risk of the dams.

For data collection, monitoring, and evaluation for the project's design and supervision in fragility, conflict, and violence (FCV) situations, many technologies are available, including satellite imagery, remote sensing, mobile applications, and so on. The application of such technologies should be selected considering the local contexts.[22]

20. ESS4 Annex 1, paragraph 8.
21. World Bank Environmental and Social Policy for Investment Project Financing (2016), paragraph 14.
22. K. Garber and S. Carrette, "Using Technology in Fragile, Conflict, and Violence Situations: Five Key Questions to Be Answered" (FCV Health Knowledge Note, World Bank, Washington, DC 2018).

Annex A
Essential References: Risk Analysis in Dam Safety Management

The following references are those directly used in the preparation this Good Practice Note. For a more complete list of references on the subject, the reader should refer to Chapter 6 of "Laying the Foundations: A Global Analysis of Regulatory Frameworks for the Safety of Dams and Downstream Communities" (Wishart et al. 2020).

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Annex B
Brief Summary of Most Relevant ICOLD Bulletins to Risk-Informed Dam Safety Management

For the purposes of World Bank operations, a recommended reference that broadly covers all the concepts, and provides pertinent examples, is ICOLD Bulletin 130 on "Risk Assessment in Dam Safety Management" (2005). Several of the definitions used in the following come from there. Annex A contains a list of references on the subject.

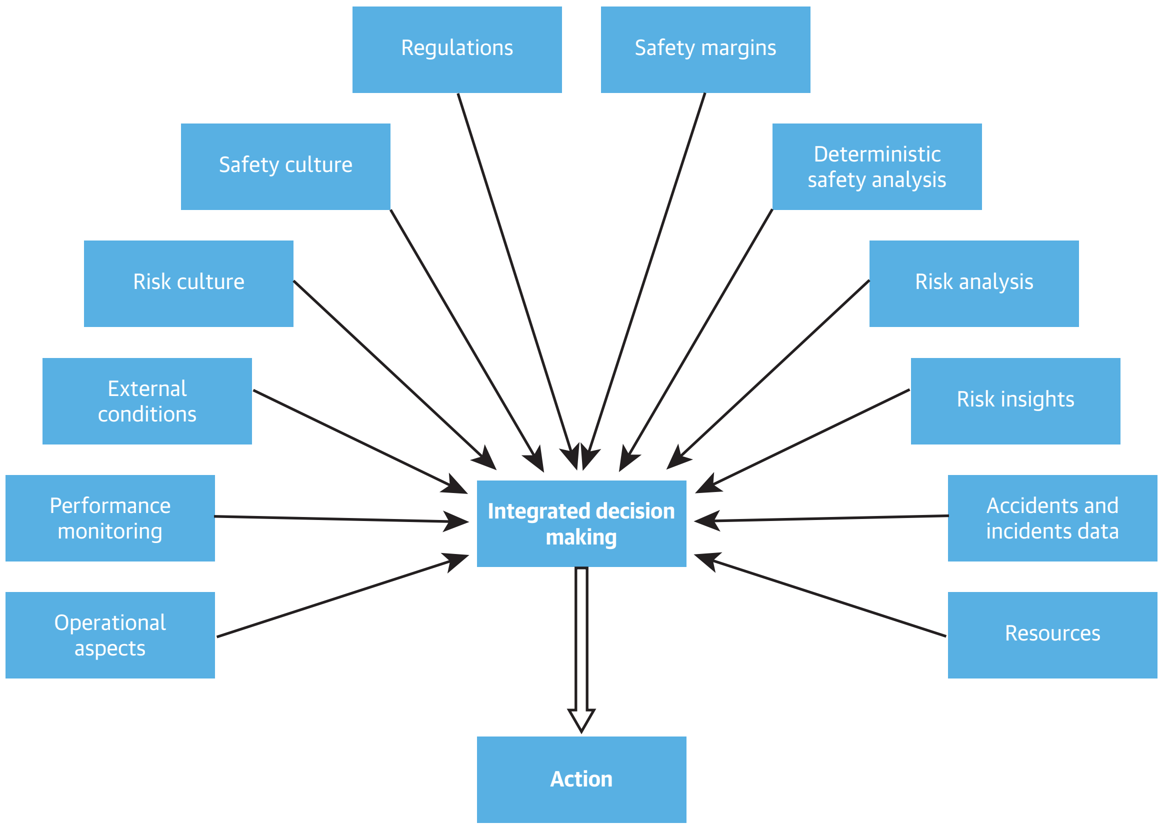
ICOLD Bulletin 154 on "Dam Safety Management: Operational Phase of the Dam Life Cycle" (2017) provides a broader and more comprehensive description of the risk-informed approach in making decisions about safety of existing dams and states:

> *In defining the decision-making model for the Dam Safety Management System (DSMS), all insights from the safety analysis should be taken into account. The general integrated decision-making model is conceptually illustrated in Figure below. The approach presented on Figure below combines the insights from deterministic and probabilistic safety analyzes with other requirements (such as legal, regulatory, business). The degrees to which individual components of the decision-making process are included may vary from organization to organization. However, it is important that the DSMS clearly establish the structure and parameters of the decision-making model.*

Appendix B: Decision Making in Dam Safety of ICOLD Bulletin 154 (2017) also provides the guidance on inclusion of explicit or implicit risk information in decision making in dam safety.

ICOLD Bulletin 175 on "Dam Safety Management: Preoperational Phases of the Dam Life Cycle" (preprint) points out that risks involved in planning, design, and construction present a different level of complexity, which are caused by both technical and nontechnical factors, and "uncertainty accompanies the whole development process from the preliminary studies to the construction phase. It concerns not only the technical aspects, but also the economic and financial ones. … uncertainties in dam design might lead to adopt too high safety levels (conservatism) and to increase costs unnecessarily. It is therefore of utmost interest for the Owner and the Designer to estimate the amount of uncertainty by applying reliability type of analyses to the design data and to try to obtain better or more consistent data by increasing the amount of investigation."

FIGURE B.1. Integrated (Risk-Informed) Decision Making



Source: ICOLD 2017.

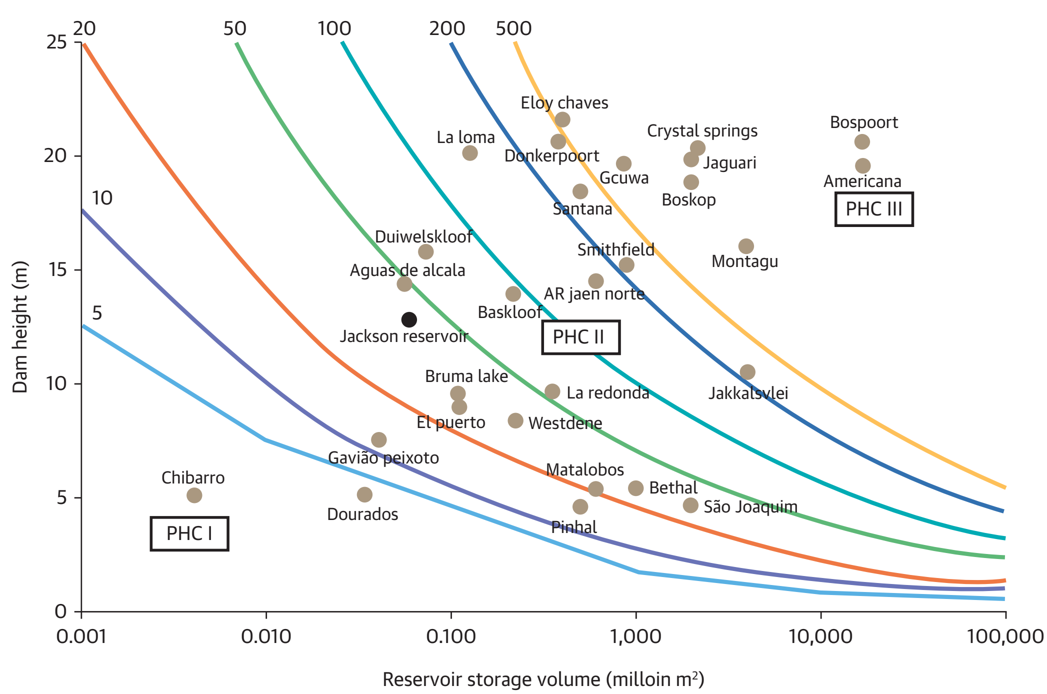
Annex C
ICOLD Small Dams Hazard Classification

The reader may refer to ICOLD Bulletin 157 on "Small Dams Design, Surveillance and Rehabilitation" (2016) to assess the potential safety risk of small dams as in table C.1 and figure C.1. The bulletin defines *small dams* with the criteria of 2.5 meters < H < 15 meters and $H^2\sqrt{V}$ <200 (where H = dam height in meters and V = storage volume in million cubic meters).[1]

TABLE C.1. Potential Hazard Classification of Small Dams

Component	Potential Hazard Classification (PHC)		
	Low - (1)	**Medium - (II)**	**High - (III)**
$H^2 \cdot \sqrt{V}$ parameter	$H^2 \cdot \sqrt{V} < 20$	$20 < H^2 \cdot \sqrt{V} < 200$	$H^2 \cdot \sqrt{V} \geq 200$
Life Safety Risk (number of lives)	~ 0	< 10	≥ 10
Economic Risk	low	moderate	high or extreme
Environment Risk	low or moderate	high	extreme
Social Disruption	low (rural area)	regional	national

FIGURE C.1. Relationship $H^2\sqrt{V}$ with the Indication of the PHC



Source: ICOLD 2016.
Note: PHC = potential hazard classification. Examples of small dams in Brazil, Spain, and South Africa shown.

1. The hazard class terms have different meanings, depending on which classification context is used. The low, medium, and high hazard rating of ICOLD Bulletin 157 (2016) may be translated into moderate, substantial, and high risk under the Environmental and Social Review Summary, which would require more specific review.

ICOLD Bulletin 157 (2016) also provides practical guidelines on dams less than 15 meters in height for assessing the distance from the dam where the dam break flood level is lower than 0.5 meters.

Dam height (m)	Distance from dam section (km)
5	4.7
10	7.0
15	7.0

Further detailed guidance on small dams compliance requirements is contained in the Technical Note on Small Dam Safety (World Bank 2020j).

Annex D
U.S. Joint Federal Risk Categories

The joint federal risk categories can be a useful reference for risk classification of existing dams and portfolio risk assessment and management as shown in table D.1. They are derived from the Federal Guidelines for Dam Safety Risk Management (U.S. Federal Emergency Management Agency 2015) with support from the U.S. Interagency Committee on Dam Safety (including Departments of Defense, Interior, Agriculture, and Energy; U.S. Federal Energy Regulatory Commission; and U.S. Federal Emergency Management Agency).

TABLE D.1. U.S. Joint Federal Risk Categories

Urgency of action	Characteristics and considerations	Potential actions
1 - VERY HIGH URGENCY	CRITICALLY NEAR FAILURE: There is direct evidence that failure is in progress, and the dam is almost certain to fail during normal operations if action is not taken quickly. OR EXTREMELY HIGH RISK: Combination of life or economic consequences and likelihood of failure is very high with high confidence.	• Take immediate action to avoid failure. Communicate findings to potentially affected parties. • Implement IRRMs. • Ensure that the emergency action plan is current and functionally tested. • Conduct heightened monitoring and evaluation. Expedite investigations and actions to support long-term risk reduction. • Initiate intensive management and situation reports.
II - HIGH URGENCY	RISK IS HIGH WITH HIGH CONFIDENCE, OR IT IS VERY HIGH WITH LOW TO MODERATE CONFIDENCE: The likelihood of failure from one of these occurrences, prior to taking some action, is too high to delay action.	• Implement IRRMs. • Ensure that the emergency action plan is current and functionally tested. • Give high priority to heightened monitoring and evaluation. Expedite investigations and actions to support long-term risk reduction. • Expedite confirmation of classification.
III - MODERATE URGENCY	MODERATE TO HIGH RISK: Confidence in the risk estimates is generally at least moderate, but can include facilities with low confidence if there is a reasonable chance that risk estimates will be confirmed or | potentially increase with further study.	• Implement IRRMs. • Ensure that the emergency action plan is current and functionally tested. • Conduct heightened monitoring and evaluation. Prioritize investigations and actions to support long-term risk reduction. • Prioritize confirmation of classification as appropriate.
IV - LOW TO MODERATE URGENCY	LOW TO MODERATE RISK: The risks are low to moderate with at least moderate confidence, or the risks are low with low confidence, and there is a potential for the risks to increase with further study.	• Ensure that routine risk management measures are in place. • Determine whether action can wait until after the next periodic review. • Before the next periodic review, take appropriate interim measures and schedule other actions as appropriate. • Give normal priority to investigations to validate classification, but do not plan for risk reduction measures at this time.
V - NO URGENCY	LOW RISK: The risks are low and are unlikely to change with additional investigations or studies.	• Continue routine dam safety risk management activities and normal operations and maintenance.

Source: U.S. Federal Emergency Management Agency 2015.
Note: IRRM = interim risk reduction measures.

Annex E
Risk Management Strategies from Past World Bank Operations

Table E.1 is a summary of some general strategies that have been adopted by clients of World Bank-funded dam safety projects, which have used some risk management strategies as one of their decision bases (Bowles 2006).

TABLE E.1. Risk Control Strategy

Type	Risk control strategy
A	Rapidly address very high probability risks using both short-term and long-term measures. The urgency is sometimes related to the degree of departure from traditional design standards and criteria.
B	Give the highest priority to risk reduction measures that are most cost-effective for reducing life-safety risks, at least to a point of diminishing returns.
C	Group fixes and investigations into phases, with the earlier phases including those measures with the highest levels of justification.
D	Stage measures at individual dams, as separable rehabilitation upgrade projects, to increase the rate of risk reduction for a portfolio of dams.
E	Benchmark to calibrate the rate, extent, and basis for the risk reduction pathway through obtaining information on risk reduction decisions by comparable dam owners.

Several World Bank operations have used some of these strategies. Table E.2 provides relevant examples.

TABLE E.2. Examples of Risk Control Strategy Application

Project	Strategies used	Tools used
Albania Hydropower Dam Safety Improvement Project	B, D	Risk indexes + quantified approach
Armenia Dam Safety Project	A, B	Risk indexes
Dominican Republic, Emergency Recovery and Disaster Management Project	A, B, C	PFMA
India Dam Rehabilitation Project	C, D	Dam safety database
Indonesia Dam Operational Improvement and Safety Project	C, D, E	Risk indexes
Romania, Hazard Risk Mitigation and Emergency Preparedness Project	C, D	Risk indexes
Sri Lanka Water Resources and Dam Safety Project	C, D, E	Risk indexes + quantified approach
Tajikistan, Nurek Dam Rehabilitation Project	A, B	PFMA
Vietnam Dam Safety and Rehabilitation Project	C, D	Risk indexes
Zambia/Zimbabwe, Kariba Dam Rehabilitation Project	A, B	PFMA

Note: PFMA = potential failure mode analysis.

Annex F
Dam Safety Dashboard: Environmental and Social Review Summary

In connection with the Environmental and Social Review Summary, the dashboard is being developed to provide a user-friendly tool that can: (a) support teams and clients in managing dam safety-related risks; (b) help with filing and compliance monitoring; and (c) portfolio monitoring of World Bank-financed dam-related activities.

This dashboard framework as shown in figure F.1 provides the three steps process based on: (a) capture criteria, (b) risk assessment, and (c) compliance requirements. The cells will need to include provisions for: (a) yes/no, (b) reviewed by Dam Safety Specialist, and (c) dated covenants.

The development of the dashboard is being coordinated with Operations Policy and Country Services and will be updated.

FIGURE F.1. Basic Concept of the ESF Dashboard on Dam Safety

ESF Dashboard on Dam Safety: Classification and Capture Criteria

Type		Characteristic		Institutional		Assessments	
New		Type		Owner		Feasibility study	
Existing		Height		Operator		Detailed design	
Assiociated		Volume		Regulator		Dam safety assessment	
Protfolio	Y/N	Length		Client		Downstream population	
# large =		Location		Consultant		Downstream assets	
# Small =		Age		Contractor		Checked by dam safety specialist	

ESF Dashboard on Dam Safety: Compliance Criteria

Plans		Panels of experts		Assessments			
O&M		Dam safety		Institutional			
Instrumentation		Hydrology		Regulatory			
EPP		Geology		Dam safety			
Supervision and QA		Electro-mechanical		Capacity			
		Other #		Consequences			

Dashboard on Dam Safety: Risk classification (Prior and Post/Residual)

Likelihood \ Consequences	Low	Moderate	Substantial	High
High				
Substantial				
Moderate				
Low				

Note: ESF = Environmental and Social Framework.

Annex G
Procurement Aspects Related to Dam Safety

Procurement Regulations (Post-July 2016) vs. Guidelines (Pre-July 2016)[1]

Procurement under the Investment Project Financing (IPF) is governed by either the Procurement Regulations (post-July 2016) or the Guidelines (for pre-July 2016). The World Bank's vision under the Procurement Regulations is "Procurement in IPF supports Borrowers to achieve value for money (VfM) with integrity in delivering sustainable development." The VfM concept is set as a core principle in all procurements financed by the World Bank. This means a shift in focus from the lowest evaluated compliant bid to bids that provide the best overall value for money, taking into account quality; cost, including life-cycle costs; and other factors as appropriate.

For projects whose Project Concept Note (PCN) were approved after July 1, 2016, standard procurement documents (SPDs) are used for international competitive procurements, although the borrower may use its own procurement documents that are acceptable to the World Bank.

The IPF projects for pre-July 2016 are usually governed by the World Bank's Procurement Guidelines (for goods, words, and nonconsulting services) and Consultant Guidelines (for the selection and employment of consultants) along with the standard bidding documents (SBD) and the standard Request for Proposal (RFP) for consulting services, respectively.

The IPF projects for post-July 1, 2016, are principally governed by the Procurement Regulations using the SPDs composed of Request for Bids (RFB) documents and new RFP documents. The RFP approach enables bidders to offer solutions or proposals that optimize value for money and fit for purpose, in response to business needs or functional requirements. RFBs have also incorporated some new and enhanced features.

Key Features of the New RFP and RFB under the Procurement Regulations (Post-July 2016)

The distinguishing features of the RFP include: (a) functional- and performance-based specifications that describe the desired outcomes, where the specifications do not prescribe design or methods of delivery; (b) initial selection (similar to a shortlisting exercise) is normally used; (c) multistage or single stage; (d) evaluated on a mix of qualifying criteria and rated criteria (which are scored against technical, quality, price, and other pertinent factors); and (e) the most advantageous proposal is the proposal meets the qualification criteria and has been determined to be substantially responsive to the RFP and the highest ranked proposal.

1. Although the IPFs subject to the Environmental and Social Framework (ESF) are on and after October 1, 2018, for concept review, the Guidelines for pre-July 2016 is introduced to highlight some key differences and evolution of procurement aspects related to dam safety.

The distinguishing features of the RFB include: (a) conformance-based specifications that prescribe in details the technical requirements of the design, construction, and so on; (b) prequalification may be used, subject to the procurement category, risk complexity, and size; (c) evaluated using qualifying criteria (pass or fail) only; (d) normally single stage; and (e) the most advantageous bid is the bid that meets the qualification criteria and has been determined to be substantially responsive to the RFB and the lowest evaluated cost.

There are also other features, such as best and final offer, negotiations, and value engineering that could be applied to optimize value for money, as appropriate. The abnormally low bid/proposal feature enables the borrowers to address those that appear so low that they raise material concerns as to the capability to perform the contract for the offered price. Sustainable procurement features identified in the Project Procurement Strategy for Development (PPSD) could also be applied.

Key Features of Initial Selection in RFPs and Prequalification in RFBs

Although initial selection in RFPs may seem similar to prequalification in RFBs, there are some essential differences. Under RFB prequalification, applicants are assessed against qualifying criteria only. All substantially qualified applicants are invited to the RFB stage. There is no method to identify the applicants that best meet the criteria.

Under RFP initial selection, applicants are assessed against qualifying criteria. All substantially responsive applicants are scored against rated criteria and then ranked on the basis of scores from highest to lowest. Based on the scores and a pre-disclosed methodology, only the highest ranked applicants are invited to the RFP stage.

Project Procurement Strategy for Development for Defining Procurement Approaches and Methods

The World Bank requires the borrower to develop a PPSD for each project financed under IPF. The PPSD should address how procurement activities will support the development objectives of the project and deliver the best VfM under a risk-based approach, ensuring that procurement processes are fit for purpose, allow choice, and are appropriate to the size, value, and risk of the project. It should provide adequate justification for the selection methods in the Procurement Plan. The borrower prepares the PPSD and Procurement Plan (at least for the first 18 months) during project preparation, and the World Bank reviews the PPSD and agrees to the plan before loan negotiations.

Quality Cost-Based Selection—Quality vs. Cost Scores Weighting

When using quality cost-based selection (QCBS), the scores of the quality and the cost scores are weighted appropriately and added to determine the most advantageous proposal. The weighting of quality and cost scores depends on the nature and complexity of the consulting assignment. The range is normally as shown in table G.1, except for justifiable reasons with the World Bank's priory review.

TABLE G.1. Combined Quality-Cost Ratio for QCBS (Consulting Services)

Description	Quality-cost score weighting (%)
High complex, downstream consequences, specialized assignments (or may use QBS method)	90/10
Moderate complexity	70–80/30–20
Assignments of a standard or routine nature (or may use least cost-based selection)	60–50/40–50

Note: QBS = quality-based selection; QCBS = quality cost-based selection.

World Bank Guidance: Procurement Hands-on Expanded Implementation Support (March 2019)

The guidance allows the following activities for and with borrowers:[2]

- Drafting procurement documents
- Attending pre-bid meetings and attending bid openings
- Identifying strengths and weaknesses in bids
- Advising on areas to clarify or negotiate
- Attending negotiations as observers
- Observing debriefings
- Supporting the borrower in addressing procurement-related complaints
- Drafting the final award letter or contract
- Supporting the borrower in defining arrangements for monitoring

It should be noted, however, that when it comes to design and implementation of projects involving large dams with a higher level of uncertainty, such as geotechnical risk, the merits and risks of using hands-on expanded implementation support should be carefully assessed—in particular, regarding detailed technical and engineering tasks, such as preparation of technical requirements (not to mention detailed design report), evaluation of bidders' methods statements, FIDIC (International Federation of Consulting Engineers) conditions of contract, and so on by the World Bank beyond technical support for more standard procurement-related tasks.

2. For more information, see https://ispan.worldbank.org/sites/ppf3/PPFDocuments/5902fe769a6c471fb5d8eefead8cf23a.pdf.

Annex H
Standard Project Preparation Data Table for Projects with Dams

Section 1. General project description			
Project name			
Project ID			
Dam Safety Specialist at preparation			
Does this project support multiple dams?		Y/N	If yes, proceed to section 3.
Does this project support applicable structures other than dams?		Y/N	If yes, proceed to section 4.
Section 2. Dam characteristics			
Direct financing or reliance on safety of existing dam		*If direct financing, nature of support*[a]	
Height from lowest foundation (m)		*Crest length (m)*	
Reservoir volume (million m³)		*Reservoir area (km²)*	
Size classification	Large/small	*Type of dam*	
Spillway type	Gated/ungated	*Spillway capacity (m³/s)*	
Powerhouse: installed capacity (MW)		*Power generation (GWh/y)*	
Longitude[b]		*Latitude*	
Year of commissioning		*Name of owner*	
Name of operator		*Name of regulator*	
Section 3. Portfolio of dams (multiple dams only)			
No. of large dams		*No. of small dams*	
Attach list with names, nature of support, size classification, and primary purpose of dams.			
Section 4. Applicable structures other than dams			
No. of structures		*Type of structure:*[c]	
Do any structures meet the requirements for treatment as a large dam?	Y/N	If yes, attach list with names (if applicable) and nature of support.	
Section 5. ESF compliance			
POE required	Y/N	*Dam safety assessment(s) completed*	Y/N
O&MP(s) completed	Y/N	*Instrumentation plan(s) completed*	Y/N
EPP(s) completed	Y/N	*Supervision and quality assurance plan(s) completed*	Y/N

Note: EPP = Emergency Preparedness Plan; GWh/y = gigawatt hours per year, which is a unit of energy representing 1 billion (1,000,000,000) watt hours per year and is equivalent to 1 million kilowatt hours per year; MW = megawatt, which is a unit of electric capacity and equivalent to 1,000 kilowatts (kW); O&MP = Operation and Maintenance Plan; POE = panel of experts.

a New dam (greenfield), dam under construction (completion), rehabilitation (including upgrading), or technical assistance.

b The exact location of a dam (longitude and latitude) may not be immediately available but can be checked during a site visit.

c Levees, tanks, bunds, check dams, settling ponds, storage ponds, dykes, and so on.

Annex I
Small Dam Safety: Risk Mitigation and Management

Given the local essence of small dams, local surveillance and management seem to be the logical answer to provide safe and reliable operation of the assets. Regrettably, experience in that regard is at least mixed. However, that should not be a pretext to give up the possibility of involving local communities.

To that end, it is not appropriate to aim at sophisticated or ideal procedures and organizations but rather realistic to start with desirable elements of basic governance of small dams safety (as shown in table I.1).

The second key question should be: What can local communities realistically do? Table I.2. summarizes community contributions to dam safety that are possible with some training.

Contextualization of these points to the specifics of the project should guide the design of appropriate safety measures of projects involving small dams. The Technical Note on Small Dam Safety (World Bank 2020j) provides detailed background information and recommendation on possible community contribution to small dam safety assurance.

TABLE I.1. Governance of Small Dam Safety: Desirable Elements

Awareness creation among stakeholders, especially people living within the catchment area: • The intended activity • The reason for the intervention • Scope of works and duration • Likely impacts and how they could be addressed • The role of various stakeholders in maintaining the facility
Identify and empower the entity responsible for surveillance, maintenance, and operation.
Such entity should be at the lowest appropriate level, ideally at the local level (for example, water user associations).
Establish a regional or national entity responsible for gathering surveillance information and assist the local entity as needed.
Provide access to and disseminate appropriate handbooks or manuals for planning and construction of small dams.
Train responsible staff to enhance their understanding of safety-related tasks and to serve as "trainers of trainees" for the community-level trainings that they may deliver.
Training should cover at least the following essential elements: • The causes of dam failure and their possible effects • The emergency response procedures and the chain of command • The notification flowchart and the roles and responsibilities of relevant stakeholders
Prepare a concise and clear description of duties, including checklists.
Periodic training of surveillance staff.
Allocate budget to remunerate surveillance staff.

TABLE I.2. Local Communities' Potential Contributions to Small Dam Safety

What can communities do?	With basic training	With some more training
Surveillance	✓	
Routine observations	✓	
Seepage measurements (especially for long embankments)		✓
Basic maintenance tasks		✓
Respond to simple and clear emergency protocols		✓

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