

**Developing Climate Resilient Flood and Flash Flood Management  
Practices to Protect Vulnerable Communities in Georgia**

**Task Report  
Best International Practices in Dam Safety Programs**

**December 12, 2013**

**Submitted to UNDP Georgia  
and the  
Ministry of Environmental Protection - Georgia  
Ministry of Regional Development and Infrastructure - Georgia**

**by**

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## Best International Practices in Dam Safety Programs

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## Acronyms

BuRec	United States Bureau of Reclamation
CCA	Climate Change Adaptation
CoE	U.S. Army Corps of Engineers
FEMA	U.S. Federal Emergency Management Agency
GoG	Government of Georgia
ICOLD	International Congress on Large Dams
UNECE	United Nations
UNDP	United Nations Development Program
WB	World Bank

## Report Limitations

This report has been prepared using information gathered from sixteen separate countries and three International Dam Organizations. The data that is presented in the report is the latest available from the referenced organizations. The country and international organizations have been selected based on the International Expert's knowledge of the status of dam safety in the respective countries. Other countries may have existing dam safety regulations equivalent to those reported herein, but the data are not readily available on the Internet or in recent publications.

## Acknowledgements

The contributions of the various authors who have summarized Dam Safety regulations and policy into the public domain is recognized and deeply appreciated. The References Section of this report notes the authors and their contributions are contained in the referenced document.

# Task Report

## Best International Practices in Dam Safety Programs

### December 12, 2013

#### 1. Executive Summary

In completion of the task of reviewing and identifying best international practices in dam safety and safety inspections, a total of 22 entities that have responsible roles in the design and implementation of dam safety were reviewed. These included 16 countries and 3 international congresses / organizations. Countries included those that are recognized as setting and implementing “best practices”;

countries with less than best practice programs or procedures (to enable a comparison with best practice); and countries in the immediate South Caucasus and former CIS region (to provide a view of what neighboring countries to Georgia are using in dam safety).

The review indicates that in the South Caucasus and former CIS regional countries, there is a strong and active movement to bring dam safety and inspection programs to international “best practice” status. Georgia’s neighbor, Turkey, has a dam safety and inspection program that is very close to international best practice standards.

Dam safety and inspection options, based on the review, have been provided in one of the last sections of this report of major components of a dam safety and inspection , with a recommendation made by the author for strong consideration of one of the options for adoption into a restructured and revitalized dam safety program for Georgia. Primary recommendations include:

1. The government reduces the number of entities involved in dam safety, to one or two Ministries, with departments within the ministry assigned specific responsibilities, not overlapping those of other departments. This would concentrate responsibility and reduce confusion on authority
2. A revised dam safety program be modeled after one or more of the recognized best practice dam safety programs, but significantly modified to meet the national interests or constraints of the country.
3. Using a tabulation of previous dam failure events at worldwide locations, identify failures that might occur at respective Georgian dams under consideration. Conduct modeling and analytic studies to establish the probability and severity of any potential failure event at the dam and/or reservoir. Establish a period within which dams have to undergo a dam inspection
4. Devise a full program that addresses the management, administrative, and technical factors that comprise a comprehensive dam safety program. This would include the management

authority / responsibility organization, the administrative structure to implement the dam safety program, and watershed to downstream population completeness.

## 2. Background

### 2.1 Objective of Task - Part of Overall Project

The task that is reported in this document is an integral part of a larger study, that being the project “**Developing Climate Resilient Flood and Flash Flood Management Practices to Protect Vulnerable Communities in Georgia**”. This project includes tasks related to Flood Prediction, Flood Plain Mapping, Hydraulic Modeling of selected portions of the Rioni Basin, and Meteorological Network Upgrades. The Dam Safety portion of the study addresses the following:

- Identification and status of laws, regulations, and guidelines pertaining to Dam Safety programs as currently existing in Georgia
- Identification and summarization of the Best International Practices in dam safety, based on review of dam safety programs in recognized leading countries and international organizations that develop and apply the elements of dam safety
- A review of the Rioni Basin dams in Georgia, their watersheds and reservoirs, and the structures and ancillary features of the dams
- Analysis of deficiencies in the Maintenance Programs that may exist at the Rioni Basin dams, which have apparently caused deterioration of components of these dams and affected operational efficiency
- Development of a Robust Dam Safety Program for use in the Rioni Basin and other watersheds of the country of Georgia

### 2.2 Focus on International Best Practices – Dam Safety Programs

The focus on International Best Practices in Dam Safety, reported in this report, is intended to provide the relevant best practices to the Government of Georgia for consideration. The report identifies from one to three best practices for each technical or organizational element of an overall dam safety program, and uses the one most likely to be practical for the Government of Georgia to apply and implement in the development of a Robust Dam Safety Program. Other selections could be used in the Robust Dam Safety Program, the current selection has been made by the International Expert based on his experience, knowledge of conditions in Georgia, and the materials reviewed as a part of this task study.

### 2.3 General Scope of Study

The general scope of the study addresses information needed to provide the study elements noted in Section 2.1 of the report, and is focused on the Rioni Basin dams. It is recognized that the results of the study will probably apply to dams in the other hydrologic basins of Georgia. The study effort has been limited by contract to an overall forty day period, thus extensive detailed research and analysis has not been possible for the respective tasks in the dam safety component of the overall project.

## 3. Study Methodology

The methodology of the study was developed to provide the following:

- Review of dam safety programs used at national and regional (state / province) levels
- Review of dam safety program guidance of international lending / professional organizations
- Review of dam safety programs in high natural hazard areas
- Review of dam safety programs in a wide range of geographic areas
- Review of dam safety programs in countries where risk reduction is of high importance
- Review of dam safety programs in countries in transition
- Review of dam safety programs in the immediate Caucasus / Caspian region

An internet and literature search of the preceding types of countries / regions / organizations resulted in identification of information that would allow an identification of best international practices that are being used by the designers, constructors and operators of medium and large dams. Small dams, unless they pose high risk to populations, are generally not required to have a formal dam safety program in place.

### 3.1 Countries and Organizations Reviewed

The countries and international bodies selected for review are presented in Table 1. “Dam Safety Programs Reviewed”

**Table 1. Dam Safety Programs Reviewed**

Country / Organization	Level of Jurisdiction Or Guidance	Primary Entity Responsible for Guidelines and Subsidiary or Contribution Entities
<b>Countries</b>		
Australia	States	New South Wales – Dam Safety Act Queensland - Water Resources Act (2000) Australian Commission on Large Dams (2000)
Argentina	National	Organization Regulador de Seguridad de Presas
Armenia	National	Ministry of Agriculture Hydro Design Institute (state institute)
Austria	National	Federal Ministry of Agriculture and Forestry (FMAF) Federal Dam Supervisory Section
Brazil	National	Energy Regulatory Agency (2002) (use Canadian Dam Association Guidelines)

Canada	National	Individual Provinces Have Regulatory Bodies (all use slightly modified version of Canadian Dam Association Guidelines (2002))
Country / Organization	Level of Jurisdiction Or Guidance	Primary Entity Responsible for Guidelines and Subsidiary or Contribution Entities
<b>Countries</b>		
China	National	Detailed Rules on Hydropower Station Dam Safety (Multiple Jurisdictions, multiple regulations, need consolidation of jurisdictions and regulations)
France	National	Ministries of Public Works, Agriculture, Industrial and Scientific Development; Inspection and Surveillance of Dams Relevant to Public Safety (1983)
India	National	Central Water Commission (CWC) Dam Safety Organization of CWC Dam Safety Act of 2000
New Zealand	National	Regional Councils Responsible for Implementation Resource Management Act of 1991 New Zealand Society of Large Dams (guidelines)
Portugal	National	Ministry of Environment and Natural Resources Portuguese Code of Practice for Observation and Inspection of Dams (1990)
South Africa	National	Department of Water Affairs and Forestry National Water Act of 1998
Sweden	National	Svenska Kraftnat (Organization set up by power industry, dam safety guidelines are named GruvRIDAS)
Turkey	National	General Directorate of State Hydraulic Works – Dam Safety Branch
United Kingdom	National	Reservoirs Act of 1991 (regions administer regulations)



United States	National	National Dam Safety Program (States and Agencies must meet or exceed standards of the Dam Safety Program)
Country / Organization	Level of Jurisdiction Or Guidance	Primary Entity Responsible for Guidelines and Subsidiary or Contribution Entities
<b>Entity</b>		
California	State	Department of Water Resources Division of Dam Safety
<b>U.S. National Agencies</b>		National Agencies either have responsibility for portions of the National Dam Safety Program; or for dams under their jurisdiction
FEMA	National	Federal Emergency Management Agency
Corps of Engineers	C of E Facilities	United States Corps of Engineers (Army)
Bureau of Reclamation	Bu of Rec Facilities	United States Bureau of Reclamation
<b>International</b>		International Organizations or Conferences generate requirements for dam safety with respect to funding projects, or provide international norms
ICOLD	International	International Congress on Large Dams
World Bank	International	World Bank Guidelines for Dam Safety Evaluation
UNECE	CIS Region	Regional Compact Working Group (in - progress)

### 3.2 Treat as an Integrated System

Most Dam Safety programs reviewed treat the safety, security, staff qualifications, permitting, and the technical and environmental factors associated with the siting, design, construction, operations and maintenance as in integrated system. Experience has shown over the past several hundred years (and even earlier) that all components should be addressed during the life cycle of a dam and

reservoir. Section 6.0 of this report provides discussion of the relevance of the respective components to the safety of dams.

## 4. Review Process

### **Advanced Countries**

The review process for dam safety programs in advanced countries (regions) / international organizations noted for their excellence in dam safety included a detailed review of each of the components of Section 5.0 of this report, with a summarization developed for the regions

### **Emerging Countries**

The emerging countries that were selected for review included several that were in areas of high natural hazard and where recent and historic dam failures have caused large losses of life and property damage. The review included identification of whether the components of Section 5.0 were addressed in the dam safety programs of the region, or whether was absent

The summaries of the advanced and emerging country regions are presented in Appendix B to this report.

### **Caucasus Region**

The dam safety programs of the neighboring countries to Georgia are of interest, as several of the trans-boundary watersheds which feed into or out of Georgian territory contain dams and reservoirs within the neighboring country. Large flows originating in Georgia could impact the integrity of the neighboring countries dams, if their dam safety programs were inadequate; conversely failure of a neighboring country dam in a country with an inadequate dam safety program could cause severe damage to Georgian dams or reservoirs. An initiative to develop dam safety programs in the Caucasus region, and in the Central Asian countries, has been initiated under funding and guidance of the UNECE. The countries currently participating in the program include Tajikistan, Kazakhstan, and Uzbekistan. Other Central Asian countries may join the project.

In general, as reviewed, the dam safety programs of the Caucasus region are comparable with those of the emerging country programs noted in Appendix B.

## 5. Dam Safety Components Covered

This section identifies components of an integrated dam safety program

### ***Watersheds***

The physical and environmental characteristics of a dam's watershed area is significant to the amount, timing and duration of weather event flows into the dams reservoir and over / through the dam structure and spillway. Additionally the change in reservoir characteristics, principally the amount of forestation / vegetative cover that changes over time, can have significant impact of weather event flows, as well as normal diurnal flows during the year.

Physical characteristics would include

- Watershed steepness and presence / absence of constrictions that could impede flood flow
- Watershed areal size and shape – the collection area for rainfall and natural long term flow
- Presence, percentage, type and density of vegetative and / or forested cover
- Geology as it may affect infiltration of rainfall or soil adsorption of water
- Meteorological instrumentation and monitoring stations, communication networks

### *Siting*

The siting process that was implemented prior to permitting and construction of the dam is of importance in assessing the risks to the dam and its ancillary structures and features. Siting considerations should be well documented in the records of the dam and would include:

- Whether the siting process looked at the watershed and reservoir areas and considered the potential for extreme flood flows from the watershed
- Whether the siting process considered the reservoir configuration and slope stability
- Whether the siting process considered the rate and extent of siltation into the reservoir
- Whether the siting process considered the geologic and soils conditions of the selected site
- Whether the siting process considered the immediate downstream zone erodability

### *Feasibility Requirements*

A feasibility study for a dam is designed to evaluate the technical feasibility of the planned structure to be constructed and perform in a safe manner; to evaluate the economic feasibility of construction and operation; and to provide the socioeconomic benefits to the populace that lies in the affected area. Feasibility analyses would include:

- Feasible topographic and geologic conditions for the dam and its ancillary features
- Competency of the proposed abutment areas against erosion and high stress
- Feasible economics during construction and operations
- Ability to perform its functions in water storage and release, flood control
- Sustainability of natural resources and biodiversity, to the extent possible
- Positive socioeconomic impact on the local and regional populations

### *Dam Design*

Key to a dam safety program is the design of the dam and its ancillary features, recording of the design and reviews by independent experts, and the specific design elements that have been considered and included in the final design. Design elements that are important and should be included in the documentation include:

- Selection of type of dam (concrete gravity or thin arch; earthfill; rockfill; rolled earth/cement)
- Selection of type of spillway (side channel; integral to dam; glory hole)
- Selection of type of emergency spillway (conventional; fuse plug)
- Evaluation / inclusion of seismic design (level and duration of acceleration; type of analysis)
- Evaluation of foundation materials (erosion or solution potential; grouting requirements)
- Need for drainage and / or inspection galleries within the dam structure

- Dam monitoring instrumentation systems

### *Dam Construction*

Dam construction records should be collected throughout the construction process, and any subsequent modifications or emergency repairs to the dam and its ancillary structures. The dam construction records would most desirably include as built drawings, photographs of all stages of construction, modification and repair, and writer reports regarding construction events.

Key construction documents that should be available to the dam safety program would include:

- As built drawings of the dam and ancillary structures
- Foundation excavation surveys and geologic mapping; photographs of excavations
- Records of soils, rock and cement testing and characteristics
- Records of grouting programs, including locations, takes and pressures
- Records of groundwater elevations and inflows into excavations
- Names and qualifications of all contractors and subcontractors during the construction

### *Emergency Programs*

It is critically important to have an emergency program in place as an integral part of a dam safety program. The emergency program should consider all emergency scenarios, as well as combinations of cascading emergency situations.

The emergency program for a dam should consider and document the following:

- Each emergency type, probability of occurrence, and the consequence of occurrence
  - (fire or flood of control room, security threat, partial or full failure of dam, abnormal inflows)
- Response actions for each type of emergency
- Location and availability of personnel and equipment for emergency response
- Location and emergency services (fire, medical, police) and communication links
- Required notifications to local, regional and national authorities
- Flood warnings for downstream populace (in case of dam partial or full failure)

### *Immediate Downstream Areas*

A dam safety program should include consideration of the areas immediately downstream of the dam, as the development of adverse conditions in these areas may have severe impact on the stability of the dam, its abutments and the downstream channel.

Consideration of the immediate downstream areas should include:

- Potential for back erosion of the downstream channel, undermining the dam structure
- Potential for excessive erosion of the spillway stilling pool, affecting the integrity and performance of the spillway
- Potential for gravel mining of the downstream channel, altering the characteristics of downstream flow
- Potential for excessive vegetation growth in the downstream area, forcing the downstream flow against either abutment area, potentially affecting abutment integrity

### *Qualifications of Personnel*

The qualifications and training of the personnel operating the dam and its ancillary structures is important to dam safety, as well trained and supervised personnel will be able to identify, react

to, and mitigate issues that may influence the safety of the dam. Personnel who understand the hydraulics of the dam and its underflow, the signs of incipient failure, and have the ability to take positive action are essential to maintaining a dam in a safe condition.

Considerations to be examined in a dam safety program, with respect to qualifications of personnel include:

- Key personnel understanding of the dam operational instrumentation and controls
- Key personnel understanding of the signs of incipient failure of the dam embankment, foundation, spillway and reservoir integrity
- Key personnel understanding of their ability to act in case of emergency , without seeking superiors approval
- Key personnel training in emergency medical procedures
- Key personnel experience in risk identification and quantification

### *Maintenance*

Once a dam is constructed, it starts to age and must be maintained to ensure the proper level of performance. Maintenance is a key part of a dam safety program, and is frequently not given adequate attention. This may be due to shortage of operational revenue, lack of management attention, lack of training of operational staff regarding maintenance importance, or poor work ethic on the part of the dam’s operational staff.

Key items for consideration with respect to a maintenance program include:

- Is there a formal maintenance program with checklists available
- Have the operational staff been adequately trained in maintenance procedures
- Has there been adequate provision for the funding of maintenance
- Do the operational staff and management understand the consequences of inadequate maintenance
- Does the maintenance program extend to the reservoir area, downstream area and ancillary structures such as the spillways, access roads, etc
- Is a log kept of the maintenance issues, how corrected and next interval for inspection

### *Periodic Inspection*

Dam safety inspections by an entity independent of the dam owner and / or operator are an essential element of a dam safety program. By being independent and removed from day-to-day operations, the dam inspection team is able to “take a fresh look” at the dam, its ancillary structures, the reservoir area, operational procedures, and many other aspects of the dam. Independent inspections should be conducted at periodic intervals, on the order of between 1 and 5 years. In the interim years it is also beneficial for the dam operator to conduct internal inspections to ensure the integrity of the dam and its ancillary structures, the operations, and the maintenance.

## 6. Guiding Principles of International Best Practice Dam Safety Programs

International Best Practice Dam Safety Programs usually follow a similar pattern, with elements of the program structured so that clarity of purpose of the element, and its contents are straightforward, consistent with logical thinking, and easy to understand and implement. Where

these characteristics are lacking, a less than best practice program may result, with higher probability of issues being overlooked, authority and responsibility overlap and confusion, and less than optimum performance of the dam and the dam operational staff.

### *Clear Lines of Authority, Responsibility and Communication*

The program for dam safety should have clear lines of authority and responsibility. Where multiple agencies or departments are given responsibility for certain elements of dam safety (for example: dam structure integrity, reservoir and watershed characteristics), the responsibility of the entity should be clearly defined, without overlap with other entities on the particular aspect. Lines of communication should be established between each entity and the requirement for communication between entities mandated. At the highest levels of authority and responsibility, authority and responsibility for action may be delegated downward. With the recognition that the highest level will in the end be answerable to the Government or Dam Owner / Operator. Clear lines of communication are essential, together with the requirements for periodic reports. Depending on the element being considered, the periodicity of reporting may vary, but at an outer limit should be no more than five years (conditions can change materially within a five year period).

### *Integration of Technical and Management Systems*

Best practices generally recognize that there is need for integration of technical and management aspects of dam safety, as dam safety depends just as much on investment conditions, management understanding of the operational aspects of the dam and like management matters, as on the technical systems and conditions existing at the dam. This integration extends to basin wide dam safety, where the demands of irrigation, public water supply and industrial use may conflict with the goals of an individual dam operator. Many countries have mandated that basin – wide authorities have the overall general management and authority to manage the dams and reservoirs within the basin, to provide alignment with basin, regional and national goals.

### *Consideration of All Physical Elements that Contribute to Dam Safety*

A best international practice dam safety program should consider all the physical elements that contribute to the safety of a dam and the downstream populations. These elements would include the following:

- The watershed that captures and feeds water into the dams reservoir
- Any upstream dams and reservoirs that could be subject to failure
- The reservoir that stores normal and flood flows from the upstream watershed (s)
- The dam and its ancillary structures
- The downstream channel that takes flood flows to downstream populations

Within the above noted categories, the technical elements that should be included in overall evaluations of dam safety:

- Climate change
- Topography

- Ground cover
- Environment
- Geology
- Seismicity
- Soils and Rock Stability
- Sedimentation and Erosion
- Structural Stability

### ***Program has the Ability to be Implemented***

Any dam safety program that is developed for a particular country, state or dam owner's organization must be capable of being implemented by the respective responsible party. If the capacity and capability for administering, providing the technical resources for, and reporting on the dam safety program do not exist, or are severely limited, then either a revised dam safety program that meets the capacity and capability of the responsible party needs to be generated, or the responsibility for dam safety assumed by an organization that does have the requisite capacity and capability. In either case, the dam safety program should provide inspections and reporting that is acceptable to either a best international practice standard, or a standard that is acceptable to the regulating entity within the country.

### ***Adequate and Documented Siting / Feasibility Evaluation / Permitting***

Another of the guiding principles of Best International Practices in dam safety is that the process of siting, evaluation of the feasibility of a dam, and the permitting be in alignment with international standards and guidelines. This allows a rational and defensible basis for construction of the dam, ensures that all factors affecting the safety of the dam are addressed adequately, and that the public has opportunity to weigh in on the acceptance of the dam. Typically, best practice dam safety programs seek completeness and transparency of the process of design, construction and operation of a dam, so that all risks to the dam are understood and evaluated.

### ***Safe Design***

Depending on the type, size and criticality of the proposed dam, the design may be led by an international firm with local subcontractor support, or by a qualified and experienced national or regional engineering firm. Guidelines used by Best International Practice dam safety entities include:

- For any dam designed by an engineering firm, the designers should have previous experience on at least several dams of equivalent size and type
- For high risk dams, the dam designer should convene an independent panel of experts, in all relevant disciplines, to review the design
- Subcontractors may be used in their specialty areas, with adequate quality control and coordination with the primary dam design team
- Where the prime contractors staff is augmented with subcontracted staff, the work of the subcontracted staff should be reviewed and approved by a qualified member of the prime contractor
- At each step of the design, redundancy should be examined, the consequences of failure of the design element understood and accommodated, and all design documented

- Modeling, either physical or computer based should be used to examine clearances, flow patterns, stresses, and other key forces on the dam and its components
- Where new technologies are considered for dam construction, consideration should be given to partial or full scale field trials of the technology

### ***Safe Operation***

The safety of a dam can be compromised by unsafe operation. This may be caused by inadequate training of personnel, by trained personnel taking “shortcuts”, by mislabeled controls systems or by failure of one or more control systems by mechanical or electrical / electronic faults.

Safe operation considerations include:

- Maintaining adequate training of personnel
- Developing and maintaining (updating) operations and maintenance manuals
- Adequate inspection of key elements of the structure / controls / emergency provisions
- Providing adequate staffing and optimal working hours (from a physical and mental capacity standpoint)

### ***Prioritization of Flood Mitigation / Hydroelectric Power / Water Storage***

Dams typically serve several purposes, including generation of hydroelectric power, flood control, and water storage. These purposes at times can generate conflicting demand and lead to unsafe conditions in the reservoir and in the dam operation. For example, flood control might dictate that the reservoir pool be kept at a low level, which could reduce the ability to generate maximum power output. The functions of a multi-purpose dam should be clearly defined and prioritized, and the authority to manage the several purposes maintained at a fairly high management level within the dam organization. A multi-purpose dam and its functions should include prioritization, through modeling and risk evaluations, of the purposes of the dam, and the operations made consistent with the prioritizations. For example, in most international best practice operations, the integrity of the dam and risk to downstream populations is of the highest priority, followed by flood control, and lastly by power generation being maintained.

### ***Basic Safety and Integrity of Components of the System***

Security of critical structures has become a major issue in the last several decades, as external influences have recognized that damaging a critical structure can cause cascading regional or national consequences. The basic safety and integrity of the components of a dam are important to a dam safety program and require adequate attention.

Elements of Safety, Security and Integrity of dams and there component systems should include:

- Adequate control on access to the key facilities of the dam / reservoir (fences, gates, etc)
- Positive control on personnel access to the facilities
- Monitoring systems for off hours operation (sensors, lights, etc.)
- Adequate reinforcement of buildings and other features (transformers) against attack
- Secure communications systems for contact with local authorities

### ***Environmental Protection / Biodiversity / Climate Change***

The successful operation of a dam and reservoir is dependent on the maintaining and understanding the characteristics of its watershed and the impacts of climate change. Changes



in watershed characteristics can be caused by human or natural actions. Human actions would include deforestation, overgrazing, introduction of alien species and arson caused forest fires. Natural actions could include loss of biodiversity and subsequent alteration of forest and vegetation conditions, climate change induced reduction or increase in rainfall, climate change induced glacial melting, and desertification.

Many advanced dam operators now retain naturalists / environmentalists, or external firms to periodically monitor the “health” of their watersheds, and to recommend mitigation actions against adverse human caused or natural action events that may materially change the watershed characteristics.

## 7. Results of Survey of International Best Practices

### 7.1 Overall Structure of Dam Safety Organizations in Classes of Countries

The survey of best international practices has included examples of best practices that are used in:

- Countries that are recognized in the dams and dam safety professions as setting high standards for design and construction of dams, for dam safety programs that safeguard the dam and its ancillary features, and that provide early warning and protection for the downstream populations.
- Countries that have numerous dams and large downstream populations, yet are just recently upgrading their dam design and construction standards and their dam safety program requirements. These were surveyed in order to gain a good understanding of what “less than best international practices” are
- Countries in the Southern Caucasus region and the immediate CIS countries, for the information of the Government of Georgia and UNDP. These countries and their current or developing standards of design and construction, and dam safety programs, provide a picture of what is currently used in these surrounding regional countries

#### Country / Regional Practice Summaries

The dam safety practices of the various countries and regions surveyed were reviewed and are presented in Appendix B. These summary regional practice summaries are subdivided into three basic categories:

Dam Safety Practices in Advanced Countries / Regions

Dam Safety Practices In Emerging Countries / Regions

Dam Safety Practices in the South Caucasus and Regional Central Asian Countries

## 8. Summary of Best International Practices

Three Best In Category (on judgment basis, mutual acceptance by countries)

From the review of the countries and organizations, the design and implementation of their dam safety and inspection programs, it is possible to develop three generic categories of design, implementation, and responsibility for the dam safety programs. These are presented in the following section, with a recommendation for consideration of one of the options by the Government of Georgia, as being the most suitable for the government and the local Georgian conditions

Recommended Best Practices for Consideration (in Georgia context)

The following are the best international dam safety practices that might be considered by the Government of Georgia, and the respective dam owners and operators, for adoption in the Rioni Basin and in Georgia in general. Several options are presented for consideration, and a recommendation is made regarding the most feasible and best practice option for the Government of Georgia to consider implementing.

### **Overall Authority and Responsibility for Dam Design / Construction / Dam Safety**

The three most common options of the best practice country's authority and responsibility for dams and dam safety are:

1. The government assigns the authority and responsibility to one or two Ministries. The responsibility to implementation of regulations and guidelines is then assigned to a Department or Bureau within the parent organizations.
2. The government sets up an organization for the management of dam design, construction and dam safety, with post construction ownership of dams transferred to a national energy organization (government owned). Private firms may be allowed to operate the dams under a privatization scheme
3. The government assigns the authority and responsibility to one or two Ministries, for preparation, dissemination and oversight review and final approval of design, construction and implementation of dam safety programs. Private entities complete design, construction and operation, and conduct periodic dam safety inspections

***It is felt that Option 3 is the best practice for Georgia to adopt. It closely resembles the current situation, although with a reduction in the number of governmental ministries involved.***

### **Design and Implementation of Dam Safety Regulations, Procedures and Guidelines**

The most common three options for designing the dam safety program for a country are:

1. The dam safety program is modeled after one or more of the premier and internationally recognized dam safety programs, such as the programs of the United States Bureau of Reclamation, the United States Corps of Engineers, the dam safety programs of Australia and New Zealand, or the dam safety program of the Russian Federation
2. The dam safety program is modeled after one or more of the recognized best practice dam safety programs, but is significantly modified to meet the national interests or constraints of the country. These may be economic, political, or existence of a lesser standard of valuation of human life

3. The dam safety program is developed by a national team of engineers, scientists, economists, and public officials. General public and dam operators input is generally allowed. This results in dam safety programs of variable quality, and allows self-interest to surface in the generation of the dam safety programs.

***It is felt that Option 2 is the best practice for Georgia to adopt. It provides a program modeled after the best international practices, but recognizes the constraints (economic, capacity, capability) of Georgia at the present and into the near future. Further upgrading could be implemented in the mid-future.***

#### **Dam Safety Scenarios of Failure Events and Dam Inspection Requirements**

The most common three options for conduct of dam safety scenario identification and evaluation, and establishment of dam inspection safety intervals, are through the following:

1. Review of previous dam failure events at worldwide locations, and the conditions under which they occurred, review of the characteristics of the dam / reservoir / watershed conditions of the dam under consideration, and development of an empirical failure event for the dam. Depending on this review and the conditions of the dam, establishment of a period within which the dam has to undergo a dam inspection
2. Review of previous dam failure events within the geographic region or nearby watersheds, and the conditions under which they occurred, review of the characteristics of the dam / reservoir / watershed conditions of the dam under consideration, and development of an empirical failure event for the dam. Depending on this review and the conditions of the dam, establishment of a period within which the dam has to undergo a dam inspection
3. Using the tabulation of previous dam failure events at worldwide locations, identify those that might occur at the dam under consideration. Conduct modeling and analytic studies to establish the probability and severity of any potential failure event at the dam and/or reservoir. Depending on this review and the conditions of the dam, establishment of a period within which the dam has to undergo a dam inspection

***It is felt that Option 3 is the best practice for Georgia to adopt. The natural hazard conditions in Georgia are many and can have severe consequences on dam safety. In addition degradation of watersheds, siltation of reservoirs, and potential climate change impacts are already severe to moderate and predicted to increase in severity.***

#### **Technical and Administrative Content of Dam Safety Inspections**

The most common three options for development of dam safety program content and establishment of dam inspection safety intervals, considering technical and administrative content, are through the following:

1. A full program that addresses the management, administrative, and technical factors that comprise a comprehensive dam safety program. This would include the management authority and responsibility organization, the administrative structure that has been put in place to implement the dam safety program, and the completeness of the technical factors considered in the program (watershed to downstream population)

2. A partial program that focused principally on the dam and reservoir, with limited attention paid to watersheds and climate change, or to the downstream conditions and the need for early warning systems in the case of extreme floods or potential structural failure of the dam. This approach is common in advanced, but “non-best practice” countries
3. A limited program that focuses only on dam safety when failure of a dam and reservoir is imminent; when funds are very limited and only key dams can be inspected; or when political or military conditions prevent comprehensive or partial programs to be put into place.

***It is felt that Option 1 is the best practice for Georgia to adopt. This option could allow an initial study of the dams in Georgia to establish baseline conditions for all technical and administrative factors, and periodic (say 10 year) updates of the baseline conditions. In interim periods between the 10 year comprehensive reviews, more focused dam inspections of those key factors identified by the baseline study could be completed.***

#### 9. Barriers to Implementation / Resolution of Barriers

During the survey of best practice and “less than best practice” dam safety programs, it is apparent that there are numerous cases where best international practice programs exist in the laws, regulations, and guidelines of the country, but are not fully implemented or are subject to low quality inspections. These latter cases can be due to barriers to implementation, some of which are:

- a. Lack of recognition of the importance of dam safety and the consequences of failure  
This barrier is common in countries where there have been few dam failure events in the past, and the importance of dam safety has not been stressed by the regulatory bodies. This barrier can be addressed by:
  - Regulatory dictat
  - Running failure scenarios and consequence analyses
  - Providing training to dam staff on dam safety
- b. Lack of funding for staffing and implementing dam safety programs / inspections.  
This is a difficult barrier to address, particularly in countries where national budgets are tight. Measures that can be taken to overcome the barrier include:
  - Analysis and publication of the cost of a dam safety program vs. the annualized cost of a failure, in human life, loss of property, and cost to the government in relief
  - Increasing the fees for water and energy (or on telephone charges), by a small amount, to accumulate sufficient funding for dam safety programs
  - Lobbying the national legislatures to recognize the importance of dam safety, and to gain support for shifting some program funding into the dam safety area
- c. Dam operators view the dam safety program as the “responsibility of others”  
In some cases, both with private and governmental dam operators, there is a feeling that the dam safety program is outside the responsibility of the dam operator or owner,

and should be the responsibility of others. All of the international bodies dealing with dam safety are in agreement that the primary responsibility for dam safety programs rests with the owner and operator of the dam. If the owner and operator are separate entities, then the responsibility has to be defined clearly. Methods of overcoming this type of barrier include:

- Reinforcement by the governmental bodies of high authority, of the fact that the responsibility for dam safety program implementation and reporting lies with the dam owner / operator
- Increasing the insurance requirements and rates to the owner, for liability insurance against damages caused by dam failure
- Training programs for the dam operators, education programs for the local authorities that are in jurisdictions that would be affected by dam failure

d. Lack of recognition of changing conditions in watersheds, reservoirs, climate, and downstream populations.

It is a common human trait to look only at that which is immediately around ones-self, and in the current time frame. Long term changes, especially those which are not in one's immediate perception, tend to have low recognition priority.

The barriers to recognition of changing conditions may be overcome by:

- Provision of analyses of the probable changing conditions to dam owners and operators, their potential consequences on dam safety, and the importance of recognizing and monitoring change.
- Requiring periodic surveys of watershed changes, tracking of annual and decade flows, tracking of climate change within the watersheds through instrumentation, tracking of reservoir sedimentation and capacity loss, and other similar measures
- Training and educational programs for dam owners and operations, dam staff, and the local authorities

## 10. Conclusions

From review of the limited information on the dam safety programs of the Government of Georgia, and contrasting the dam safety program of the GoG against the International Best Practices determined in the course of this research, it is apparent that the dam safety practices of Georgia would benefit from upgrading to standards close to those of the International Best Practices.

This will be addressed in a later task, the development of a Robust Dam Safety Program for the consideration of the Government of Georgia.

## 11. Appendices

Appendix A. References

Appendix B. Summary Table of Country / Regional Dam Safety Practices

### Appendix A. References

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