Note: *This Section, revised December 2006, replaces the respective chapter of the EIA published in August 2006. In this context Appendix R has been added December* 2006.

VIII.5. Dam Safety and Emergency Response

VIII.5.1. Overview on Parties Involved in Dam Safety for the Project

Dam safety is an integrated part of the planning and implementation process for the Yusufeli Dam and Hydroelectric Power Plant Project and it's operation, which is in line with DSI's policy for this issue. This policy is applied for DSI dams throughout Turkey.

The Yusufeli Dam was designed to meet applicable standards with respect to dam safety. The necessary safety considerations are dealt with in the planning by competent consulting engineering companies. The design documents were prepared by the planning consortium of Japan Electric Power Development Company (EPDC), Su-Is Project Engineering Company (Turkey), and Terzibasoglu Consultancy and Engineering Company (Turkey) in 1990.

The project will be constructed by an EPC contractor, namely a consortium comprised of Dogus Insaat ve Ticaret A.S. (Turkey), Alstom Ltd. (Switzerland), Alstom Power (France), Alstom Power Hydraulique (France), Alstom Brasil Ltda (Brasil), and a consortium for engineering and consultancy services.

The consortium for Engineering and Consultancy Services comprised of Coyne & Bellier Bureau d'Ingenieurs Conseils (France) and Dolsar Muhendislik Ltd. Sti. (Turkey), shall act as Owner's Engineer for DSI with the role of supervision of the execution drawings and the construction in an advisory capacity to the Owner.

During the operation of the plant, the dam will be monitored by EUAS with state of the art equipment and monitoring results are reported to DSI, who is the owner of the Dam. EUAS and DSI will act in coordination during the operation since EUAS is responsible for operation of the power plant for energy production in accordance with the need of the whole country.

VIII.5.2. DSI Approach to Dam Safety

DSI Policy on Dam Safety

In 1998, DSI introduced an internal policy guide named "Dam Safety Working Program" (DSI, 1998. *Dam Safety Working Program*. DSI Technology Department, Ankara, Turkey), which provides an overview on the issues to be considered and the works that have to be conducted during the project planning, construction, and operation phases in a structured manner. This also includes an outline of emergency preparedness activities. The guideline applies for DSI dam projects with a height

above 7.5 m and storage capacity larger than 65,000 m^3. This policy is also applicable for the Yusufeli Project.

The table of content of this guide is provided here for information:

1. Introduction (Dam safety in the world and studies of dam safety in Turkey)
2. Objectives and scope (Dam safety program and management structure)
3. Works to be conducted in project planning and design phase
4. Works to be conducted in construction phase
5. Works to be conducted in operation phase
6. Measures for emergency preparedness
7. Legal framework
8. Conclusion and recommendations

This document was prepared based on the increasing importance of dam safety in the world due to some occasions of dam failures in various countries that caused significant damages, although no such occasion have been encountered in Turkey to date. For preparation of this document international practice and reference documents have been used, such as the standards and guides of the U.S. Bureau of Reclamation and publications of International Commission on Large Dams (ICOLD).

The main elements and principles of DSI's Dam Safety policy comprises, proper;

- Planning,
- Engineering Design,
- Construction,
- Operation, and
- Emergency Preparedness.

The works to be conducted in project planning and engineering design phase consist of the studies related to hydrology, geology, hydrogeology, engineering geology, construction materials, earthquake and flood risks, engineering design, design/selection of measurement and monitoring systems for dam safety, impact assessment, and all related field studies, surveys, tests and laboratory analyses.

For dam construction, the document addresses: planning and implementation of construction supervision and quality control, planning and installation of instrumentation systems, construction management and monitoring of dam stability, environment and health and safety issues.

For operation and maintenance the following issues are covered: description of all units, equipment, facilities and their characteristics; operation and maintenance practices for these units, equipment and facilities; management and monitoring structure, staff and training needs as well as reporting requirements.

Emergency preparedness includes;

(1) actions to be taken for preparing to an emergency (installation of; gauging stations, measurement and monitoring instruments, warning systems, communication systems, and carrying out impact studies, preparation of maps outlining inundation zones for various conditions, monitoring equipment selection, training of staff for vigilance, procedures for warning, communication, mobilization of emergency forces and equipment, responsibilities, evacuation of threatened areas.);
(2) actions to be taken during emergency conditions (basically implementation of the emergency preparedness plan EPP), and
(3) actions to be taken after the emergency conditions (assessment of damage and identification of further remedial action to be taken).

DSI Institutional Capacity for Dam Safety

DSI has established a "Dam Safety Section" in December 2005 within it's head office under the *Dams and Hydroelectric Power Plants Department*.

The duties of the Section consist of the following:

- To prepare dam failure analysis, against the possibility of a dam failure, with regard to assessment of the possible damages on the existing inhabited areas, agricultural and industrial installations downstream, in case of any emergency.
- To prepare a Construction Completion Report which will be kept at the dam site, compiling the problems that are encountered and the solutions that are applied during implementation of the project; the studies conducted and, tests and investigations performed, and periodic archiving of all the related data/results and experimental studies in visual and written form.
- To prepare Dam Safety Files containing all kinds of documents, technical reports, etc. for the dam and appurtenant structures and relevant application drawings and final (as-built) drawings and summary information sheets about the technical characteristics.
- To evaluate the general safety conditions of the dam and prepare a Dam Safety Report, in consideration with the results of field observations, supervisions, determinations, studies conducted on topographic survey and geological maps, satellite photographs, geotechnical and engineering test results and instrumentation readings to be performed periodically by a group of consultants during the operation phase, in coordination with pertinent engineering disciplines.
- To make classification of dams under operation according to their risk groups, and to set up early warning systems for them according to the calamity scenarios, counter measure strategies and methods, and to prepare emergency preparedness plans (EPP) to be used in organization with the relevant units in case of any safety-related risks.

- During operation and maintenance, in case needed, to check integrity of the dam and appurtenant structures against stability and hydraulic sizing and to verify on the function of dam and HEPP components by using special application software or through acquiring additional new software that would better fit the prevailing situation in parallel to the existing ones, which will be undertaken through joint collaboration and coordination with specialist technical personnel to be requested from the other service units of DSI.

VIII.5.3. Dam Safety Measures for Yusufeli Project

In the pre-construction phase studies for the engineering works were conducted during feasibility and design stage.

With respect to dam safety, estimations of maximum ground accelerations of the probable earthquakes and probable maximum flood as well as probable landslides into reservoir were studied based on the baseline characteristics of the area and the results were taken into consideration in technical decisions regarding the design of the dam and associated structures.

Construction phase includes the implementation of the measures/plans developed for the construction activities. Grouting for the dam foundation safety against seepage will be performed in line with the final design for the project (based on the site conditions).

- Prequalification and tendering requirements will be set to select only quality proven subcontractors for procurement and construction.
- Construction supervision will be done by the Owners Engineer on behalf of DSI.
- Quality assurance plan and an instrumentation plan will be developed by the Consortium, which are already in the scope of the Contract.
- A maintenance plan will be prepared and implemented by DSI. It should be noted that companies that form the Consortium are applying integrated management systems for quality, environmental and occupational health and safety management systems, which reflect ISO 9001:2000, ISO 14001 and OHSAS 18001. The members of the Consortium all possess relevant certifications.

In the Conditions of Contract for Yusufeli Dam and HEPP Project, the Consortium for Engineering and Consultancy Services, comprised of Coyne & Bellier Bureau d'Ingenieurs Conseils of France and DOLSAR Muhendislik Ltd. Sti. of Turkey, has been designated as the engineers and consultants to carry out, on behalf of Owner (DSI), the necessary dam safety related reviews and supervision procedures through out the design, procurement and construction phases of the project.

The tasks of the Owner's Engineer with respect to dam safety issues can be summarized as follows:

- To review the final design and technical specifications, and prepare revised final design drawings if necessary on behalf of and as directed by DSI.
- To define, supervise, and interpret additional investigations and tests (assessing necessity, elaboration of terms of reference, supervising of works and evaluation of results).
- To check the coordination between the civil works and electromechanical and hydromechanical design and activities.
- To supervise the construction, erection activities, tests and acceptance of the works.
- To participate in the planning, monitoring and control of construction progress.
- To review the preparations and to monitor the implementation of the quality assurance system.
- To prepare instrumentation and monitoring plans and procedures that will continue to be used (for monitoring purposes) during the operation of the project by EUAS.

In this context the responsibilities of the involved parties can be summarized as:

- Relevant field investigations, drillings, exploratory adits, etc. will be planned for DSI by the Owner's Engineer and will be implemented by the Consortium.
- All measuring and surveying work including control measurements of the construction is included in the existing conditions of contract. DSI, Owner's Engineer and Consortium will perform the quality control tests.
- Continuous supervision of construction (Civil Works, Electromechanical Works) will be done by DSI and Owner's Engineer.
- Tests will be carried out by DSI and Consortium together, and Alstom (member of the Consortium) will carry out the tests for the electromechanical equipment.

In conclusion, the proper design, meeting all engineering standards, will ensure the safety of the Yusufeli Dam together with necessary device installations, controls/monitoring and supervision. The complex of granitic rocks forming the foundation of the Yusufeli Dam site is found to provide more than adequate support as bedrock for the dam (EPDC, 1990). With this regard, the earlier feasibility and design reports (JICA 1986; EPDC, 1990) have been reviewed by the Consortium as part of the contract obligations, because the Contract aims at the construction of a sound and safe structure, with respect to public and environment, which will serve its purposes throughout its economic service life.

During **the operation phase** structural dam integrity monitoring will be ensured by installing relevant devices (*i.e.* strong motion accelerographs) and continuous monitoring during construction and operation. The final design contains detailed plans for the installation of instruments to monitor and record dam behavior and the related hydro-meteorological, structural, and seismic factors. Costs for monitoring instrumentation is included in the project budget. The monitoring records will be

available via the digital information share system of DSI. Periodic safety inspections of the dam after completion will be undertaken by DSI.

Furthermore, an emergency preparedness plan, as outlined below (Section VIII.5.4) together with the management plans for the construction phase, will be established for construction and operation phases.

VIII.5.4. Emergency Preparedness Planning

VIII.5.4.1 Objective

Emergency preparedness plans (EPP) for hydropower projects specify the roles of responsible parties when dam failure is considered imminent, or when expected operational flow release threatens downstream life, property, or economic operations that depend on river flow levels. It includes statements on the responsibility for dam operations decision-making and for the related emergency communications; maps outlining inundation levels for various system characteristics; and procedures for evacuating threatened areas and mobilizing emergency and evacuation forces and their equipment.

An (EPP) shall be prepared, tested, issued and maintained for any dam whose failure could be expected to result in loss of life as well as for any dam for which advanced warning would reduce upstream or downstream damage. A notification process shall be initiated as specified in the EPP, immediately upon finding a hazardous condition that could lead to a dam breach, or upon discovering a potential dam breach or dam breach in progress. The dam owner or operator shall assess whether dam breach warnings should be issued directly to inhabitants in areas immediately downstream of a dam, due to the short period of time before the anticipated arrival of a flood wave. Where preventative actions are available, these actions shall be initiated, as appropriate, to prevent failure or to limit damages where failure is inevitable.

The EPP is a formal written plan that identifies the procedures and processes that the dam operators would follow in the event of an emergency at a dam. The emergency could be, for example, failure of essential equipment such as flood gates, slope failure having the potential to cause dam failure, or a complete failure of the dam caused by overtopping, earthquake or piping.

The EPP allows for planning by municipalities, local police, provincial agencies, telephone and transportation companies and other parties affected in the event of a dam break flood, and the coordination of efforts between provincial and municipal levels of government. In the event of an emergency, an effective, comprehensive, well-tested EPP will save lives and has the potential to reduce property damage.

The detailed EPP for Yusufeli Project will be prepared during project construction and will be completed one year before the projected date of initial filling of the reservoir. The initial cost estimation for preparing this detailed plan is about 200,000 USD. This budget will be included in Yusufeli Project implementation budget of DSI of the

respective financial year. At the present stage of project development a broad framework outline of the Emergency Preparedness Plan is provided below.

VIII.5.4.2. Framework for Emergency Preparedness

Requirements set by Turkish legislation
The minimum requirements are outlined by the provisions in relevant Turkish laws and regulations. This legal and regulatory framework comprises the following mainly relevant legislation:

- Law No. 4373 on protection against floodwaters and flood
- Law No. 6200 on DSI General Directorate's organization and duties
- Law No. 7269 on Precautions and Aids in Case of Disasters Affecting Public, which was changed by Law No. 1051 and which was further amended by Law No. 5511 which added sub-clauses to Clause 40 and appended an Additional Clause no.12 to Law No.7269.
- Municipality Law No. 5272
- Law No. 5302 on Special Provincial Administration
- Law No. 1593 on General Public Health Protection

Policy requirements:
As required by the DSI policy guide, the detailed EPPs for dam projects are prepared as regional emergency preparedness plans (since the impacts of a failure in these projects can extend to a regional scale) based on the framework presented here. With this approach, all dams, or other structures, in a basin is integrated in emergency preparedness planning. This will also be the case for Yusufeli and downstream projects.

In the course of DSI's efforts to address the dam safety topic for all it's operations the DSI's Dam Safety Section plans to study Coruh River basin as case specific projects for emergency preparedness and it also has planned to establish a countrywide inventory list of the potential risks of the existing and planned dams. A dam safety information sheet will be prepared for each dam, which is planned/in construction/in operation. Within the framework of emergency preparedness, DSI has standing instructions to all of it's regional directorates for the actions to be taken in case of floods and failures, and in this respect the line of communications are already defined.

In addition, there is also an ongoing UNDP sponsored program being executed by the Ministry of Public Works and Settlement (General Directorate of Disaster Affairs) regarding disaster management, namely Improvement of Turkey's Disaster Management System - TUR/94/06. A "Disaster Management and Research Center" was established within the Middle East Technical University in Ankara in the scope of this program to institutionalize the concept of disaster management in Turkey and to build and strengthen national capacity in this regard.

VIII.5.4.3. Outline of the Emergency Preparedness Plan (EPP) for the Project

VIII.5.4.3.1. Implementation Outline

The Emergency Response Plan for the Yusufeli Project and the downstream dams will be prepared by the relevant regional directorate of DSI (for Yusufeli the 26th DSI Regional Directorate in Artvin) and it will executed by an emergency committee. This committee is composed of:; the regional director (as chairman of the committee), deputy regional directors, heads of operation and maintenance, machinery and supplies, survey and planning, design and construction, and relevant departments, and assigned staff from these departments of the regional directorate.

An outline of the preparation and contents of the EPP is given in Appendix R-2.

The following issues are included in the scope of the regional emergency preparedness plan:

- The areas likely to be flooded in case of an extreme flood event (discharge via spillway), or in case of failure of the dam (or other structures) are identified based on the estimation of maximum flows in case of such a failure and using 1:25,000 or relevant scale maps.
- The structures (other dams, etc.) located downstream of the dam that will serve for minimizing this flood are listed together with their characteristics. Periodic maintenance of these structures is performed in order to keep the relevant equipment (e.g. diversion gates, spillway gates) functioning.
- A system is established for transferring data/records to the regional directorate and radio transmitter are provided to relevant sections and staff for communication. Necessary measures are taken for functioning of radios and telephones 24 hours a day.
- Mobile emergency teams are established for taking immediate action in case of an emergency. The number of teams, members of each team, relevant equipments for these teams, and their spatial areas of responsibility are identified.
- Lists are prepared showing the staff who will be on duty in case of an emergency in the regional directorate, departments and plants, which include the name, post, home address and telephones (including cellular phones) of these staff.
- The emergency telephone numbers are made available for all responsible parties and local governorship and all relevant governmental agencies are informed as soon as possible using all available means.
- A communication system is established through local governorship for evacuating settlements if it becomes necessary.
- The access to certain materials and material sites, which would be needed in case of an emergency, to the regional directorate, departments and plants are estimated as kilometer and minutes.

DSI's Regional Emergency Response Plans are composed of three main sections:

- Actions to be taken before a failure / emergency conditions
- Actions to be taken during a failure / emergency conditions
- Actions to be taken after a failure / emergency conditions

The basic sections of the emergency preparedness plans of DSI and the scope of actions planned for an emergency case can be summarized as follows.

VIII.5.4.3.2. Actions to be Taken Before a Failure

- Establishment of gauging and observation stations (for flow, seismicity, etc.) by DSI Artvin Regional Directorate.
- Installation of measurement and monitoring instruments in dams and relevant structures.
- Preparation of maps outlining inundation zones for various conditions.
- Training of staff.
- Establishment of procedures for mobilization of emergency forces and equipment.
- Establishment of warning systems by DSI Artvin Regional Directorate (as a standard, installation of audio and visual warning signs is required by the Regulation on Health and Safety Signs as per Labor Law No.4857) in the downstream area of Yusufeli Dam with due consideration of the characteristics of the region.
- Establishment of a communication and data transfer system between the gauging and warning stations and the operation centers of all the dams on the Coruh River as well as the Artvin Regional Directorate.
- Establishment of procedures and access / escape routes for evacuation of potentially threatened areas.

VIII.5.4.3.3. Actions to be Taken During a Failure

In case of an emergency warning, the emergency committee immediately meets. The committee reviews the information about the severity of the emergency situation and decides on the specific emergency measures, as identified in the emergency preparedness plan. This committee coordinates the implementation of these relevant measures as long as the emergency conditions prevail. For this purpose following generic steps are followed:

- With the emergency warning the designated staff for emergency response take their places of duty as planned.
- The information obtained from gauging and observation stations is evaluated by the committee to estimate the peak flood conditions and how long would it take before these conditions are reached. Also, estimations for how long the whole event would last are made.
- On the outset of the failure an alarm is given to the dams in the downstream.

- Appointed personnel is alerted and transferred to the flooded area.
- Emergency response teams are mobilized to the area with necessary supplies and equipment.
- Public Administration supreme officers, such as the Governors in provinces, Kaymakam in the township, are immediately notified.
- In case of a flood due to the failure of a dam (or due to any other reason) the local governorships have the authority (given by Law of Precautions and Aids in Case of Disasters Affecting Public, May 25, 1959) to take all necessary actions using all necessary equipment, vehicles and staff of the local governmental agencies. Thus, the emergency committee will establish communication with the Yusufeli District governorship and relevant governmental agencies as quick as possible.
- An emergency center will be formed in the 26th Regional Directorate of DSI and another one will be established in the Artvin governorship, which will be the central points of communication and coordination, as well as information disclosure to the public.
- Constant information exchange is provided between the Region and General Directorates of DSI about the outset and progress of the flood.
- To minimize the damages due to dam failure personnel and equipment is used in a most effective way. For example, helicopters are used to evacuate the affected people from the flooded area.

VIII.5.4.3.4. Actions to be Taken After a Failure

The governorship will establish a committee for identification and assessment of the damages and losses due to the event. This committee will be formed from the representatives of various local governmental agencies, but only the presence of DSI representatives in this committee is obligatory. This committee prepares a fact-finding report to be submitted to the Ministry of Interior and DSI General Directorate. In addition, DSI regional directorate prepares a separate report regarding the event and its consequences, which will serve for the improvement of the future studies and providing information for further planning. Flooded areas are depicted on maps and reports are sent to the General Directorate of DSI, to the Department of Investigation and Planning, and the Department of Operation and Maintenance.

VIII.5.4.4. Scenarios and Preliminary Consequences Estimation

The details of the EPP including detailed failure scenarios will be developed as a separate planning step during the construction period of the dam. At the present stage of project planning, a broad outline of possible scenarios and likely consequences can be given for the Yusufeli Project relating to catastrophic floods, plunging of landslide into the reservoir creating a floodwave, and failure of dam structures or facilities / dam break

Catastrophic Floods

The hydrological probable ten-thousand year flood ($HQ_{10,000}$) for Yusufeli is 4,000 m^3/sec. For the final design, the probable maximum flood (catastrophic) inflow with a peak discharge of 9,000 m^3/sec was computed. Such catastrophic floodwaters, which may reach the Yusufeli Reservoir as inflow, would be attenuated in the reservoir and discharged though the gated spillway. To facilitate this, the spillway is designed for a peak discharge capacity of 8,000 m^3/sec when the gates are fully opened. This corresponds to a reservoir water level at elevation 712.20 m ASL. In response to a flood inflow, the spillway gates will be operated to release the flood wave. The method of operation of the spillway gates shall be such that the reservoir water level normally is maintained at high water level of elevation 710.00 m ASL, except for the case of uncontrollable rise of water level due to heavy floods (in the event of catastrophic flood of 9,000 m^3/sec the water level will inevitably rise to elevation 712.20 m ASL with the gates fully opened). In the operation of the spillway gates, care shall be exercised to open or close the gates sequentially and at the rate of 0.50 m/hr according to a schedule at increments of 0.50 m. In order to maintain the reservoir water level nearly constant at 710 m ASL, the discharges from the spillway will be augmented by the discharges from the bottom outlet and through the turbines, if deemed necessary.[4]

A flood wave, which results from a scenario above, will directly reach the Artvin reservoir located downstream . As Artvin reservoir is long and narrow, the water level in Artvin reservoir will rise with a flood wave spillway discharge from Yusufeli, but not above M.W.L. 511.60 m ASL. At this level the Artvin spillway discharge capacity is 8,200 m^3/sec, 200 m^3/sec more than the peak outflow of flood from Yusufeli spillway which is 8,000 m^3/sec. Artvin dam has free flow spillway with no gates, therefore as soon as the water rises above elevation 500.50 m ASL it will spill through the spillway. Regardless of the shape or length of its reservoir any flood entering the reservoir will eventually be attenuated depending on the discharge capacity of the spillway. With its crest elevation at 515.00 m ASL, Artvin Dam has a freeboard of 3.40 m, which would enable passing of much greater discharges through its spillway. It will take 78 hours for the flood hydrograph to reach peak inflow discharge of 9,000 m^3/sec at Yusufeli at which time the discharge from Yusufeli spillway will be 7604 m^3/sec. However, the maximum discharge of 8,000 m^3/sec from Yusufeli will take place at the 86^{th} hour from the start of the flood event.

Depending on the water level in Deriner reservoir at the time of the flood incident, spillway discharge from Artvin Dam will reach either the downstream channel in case of low water level in Deriner, or the reservoir directly in case of high water level in Deriner. Regardless of the reservoir water level of Deriner at the time of incidence, the peak flood flow from Yusufeli (through the Artvin reservoir) will take about 4 days before it reaches the Deriner reservoir during which time all necessary measures will have been taken, such as slow and steady release of water through the spillway to make room for the incoming flood if the reservoir level was high.

[4] Details of the operation of the spillway gates are described in Vol.12 “Reservoir Operation” of the Final Design Report.

As a general principle, at each dam site on a Coruh cascade scheme, the maximum probable flood scenarios of the upstream project are taken into consideration when determining the flood discharging capacity of its spillway. Therefore, Deriner spillway structure is capable of passing the peak flood flows reaching its reservoir. Future upstream dam projects will also need to consider possible flood wave incidents to their downstream including Yusufeli Reservoir.

At present stage, based on the information of the Design Report, a preliminary estimate can be made about possible consequences for settlements in the downstream of Yusufeli Dam for the maximum flood case (HQ_{Max} and $HQ_{10,000}$). Computations using a hydrodynamic model (Hec-Ras, cf. Appendix I) were carried out for the two flood cases (HQ_{Max} and $HQ_{10,000}$) in two scenarios (with/without Artvin Dam). The computed water level heights of the flood waves in the considered scenarios can be compared with the elevation of the settlements and their agricultural fields. The results for the situation where Artvin Reservoir will be in place at the same time as Yusufeli as planned are shown in Table VIII.8 and for a situation without Artvin in Table VIII.9.

Based on information available from topographic maps and satellite image, the elevation distribution of houses in relation to flood levels provided in Tables VIII.8 and Table VIII.9 were analyzed and estimates regarding the population under risk of the floodwave were made.

When Artvin reservoir is established all the settlements below 500 m ASL will be inundated. Therefore, only lower settlement parts of Sebzeciler would be affected by the floodwave and based on the number of houses, the number of inhabitants at risk is estimated to be < 25.[5]

In case when there is no Artvin Dam, some quarters, hamlets and fields close to the bottom of the valley may still be utilized by the their inhabitants and owners. Based on the calculations and analysis as before, it is estimated that < 25 inhabitants from Sebzeciler (incl. Sinevrat Qrt.), < 50 inhabitants in Inanli village and < 50 people in Bez Qrt. may be affected. It should be noted, however that for these valley sections the flood hazards of extremely rare emergencies like $HQ_{10,000}$ or HQ_{max} are the same with or without Yusufeli Dam.

Flood Waves from Landslides

There are two landslide areas in the Yusufeli reservoir, i.e. the Gorgulu on the Tortum River and the Vecanket on the Barhal River. Two landslide areas exist in the Artvin reservoir basin, i.e. the Havuzlu and Demirkent, both located on the main stem of the Coruh River (cf. Chapter 5.2). The Havuzlu landslide is considered to be unstable based on site reconnaissance made in 1988.

[5] Depending on whether the population of Sebzeciler village resettles after impoundment of Artvin reservoir.

Besides a flood wave to the downstream, a landslide in Artvin reservoir might adversely affect Yusufeli Dam. Possible conditions have been studied and the countermeasures have been investigated as safety measures. Blocking of the reservoir at the Havuzlu site is likely in case of landsliding because of the small volume of Artvin reservoir at this location compared with potential volume of sliding mass. More in depth investigations during the construction phase of Yusufeli Project will be undertaken by DSI. If the results of the new investigations indicate that there actually is a high risk of a Havuzlu landslide, as a countermeasure, diversion tunnels may be provided to maintain the function of reservoir Artvin even under such blocking. Based on topography and volume calculations, under the assumption that lower part of the sliding mass plunges into the reservoir earlier than the other parts and initiates the wave action, the wave height at the plunged site has been estimated to be 25 – 30 m by several empirical equations during the final design. These waves will propagate in the reservoir with certain attenuation and the wave height at Artvin dam site has been estimated to be around 12 m judging from calculated results based on several empirical equations. In consequence the crest elevation of Artvin Dam has been set at 515.00 m ASL, i.e. 15 meters higher than high water level 500.00 m ASL.

According to the geological field reconnaissance made up to present, Demirkent landslide appears to be stable. The potential wave height due to landslide is estimated to be around 33 m at the plunging site resulting in around 13 m wave height at Artvin dam site, which is also taken in consideration by setting the Artvin crest elevation at 515 m ASL as a safety measure.

Table VIII.8. Settlements between Yusufeli and Artvin Dams Possibly Affected from Flood Waves

Flood scenario with Artvin			Settlement		Fields		$HQ_{10,000}$ = 4,000 m^3/s	HQ_{max} = 8,000 m^3/s	Havuzlu landslide wave	Demirkent landslide wave
			Elevation (m ASL)		Elevation (m ASL)					
Settlement	**Downstream distance from Yusufeli Dam (km)**	**Total Population According to 2000 census**	**Min**	**Max**	**Min**	**Max**	**Water Level (m ASL)**	**Water Level (m ASL)**	**Water Level (m ASL)**	**Water Level (m ASL)**
Sebzeciler	4.3	78	**480**	550	**480**	620	508.2	513.7		
Sinevrat Qrt.*	7.7		**480**	*510*	**470**	520	507.5	511.7		
Inanli	11.3	76	**450**	**490**	**440**	**500**	507.4	511.4		
Havuzlu	11.5	92	650	900	**440**	1,040	507.4	511.4	ca. 525 – 530***	
Demirkent	13.3	495	710	840	**440**	870	507.4	511.4		ca. 533***
Esenkaya	15.6	387	660	890	**420**	1,060	507.4	511.4		
Tarakcilar	16.4	76	740	920	680	950	507.4	511.4		
Bez Qrt.	18.0		**400**	**440**	**400**	**480**	507.4	511.4		
Artvin dam site							*507.3*	*511.4*	*ca. 512*	*ca. 513*

* Sinevrat Qrt. is a hamlet of Sebzeciler Village.
** Bez Qrt. is a hamlet of Tarakcilar Village.
*** Assuming 500 m operational level in Artvin Reservoir and maximum wave height at plunging site. Expected attenuation of the propagating waves will cause the indicated water levels at Artvin Dam site, respectively.

	Flooded by Artvin impoundment
500	Impacted by HQ_{max}, but NOT by $HQ_{10,000}$
500	Impacted by HQ_{max} AND by $HQ_{10,000}$
	Impacted by landslide waves

Table VIII.9. Settlements between Yusufeli Dam Site and Deriner Reservoir affected from Flood Waves when Artvin Reservoir is not in Place

Flood scenario without Artvin			**Settlement**		**Fields**		**$HQ_{10,000}$ = 4,000 m^3/s**	**HQ_{max} = 8,000 m^3/s**
			Elevation		**Elevation**			
			(m ASL)		**(m ASL)**			
Settlement	**Downstream distance from Yusufeli Dam (km)**	**Total Population According to 2000 census**	**Min**	**Max**	**Min**	**Max**	**Water Level (m ASL)**	**Water Level (m ASL)**
Sebzeciler	4.3	78	**480**	550	**480**	620	492.0	500.6
Sinevrat Qrt.*	7.7		*480*	510	**470**	520	477.0	484.1
Inanli	11.3	76	**450**	490	**440**	500	450.5	457.0
Havuzlu	11.5	92	650	900	**440**	1,040	449.7	456.2
Demirkent	13.3	495	710	840	*440*	870	433.7	440.1
Esenkaya	15.6	387	660	890	**420**	1,060	425.5	431.3
Tarakcilar	16.4	76	740	920	680	950	418.2	429.2
Bez Qrt.	18.0		**400**	440	**400**	480	410.0	416.7
Artvin dam site							*349.3*	*354.0*

Flood Wave from Dam failure

Failure of rock fill dams can basically occur as a consequence of internal erosion (piping, earthquake) or crest erosion, as may be caused by overtopping (design flood failure, failure of an upstream structure)[6]. Internal erosion might cause a dam breach by piping through the dam embankment. This can potentially occur in case of structural deficit of a dam body or external force such as an earthquake and usually under high water pressure, i.e. at deeper reservoir levels. There are various danger indicators for internal erosion (piping) failure: (a) wet or saturated areas along the downstream slope, (b) seepage emerging on the downstream slope or from abutments and foundations, (c) changes in seepage rate or in the pore pressure distribution within the dam, (d) clogged drains, or seepage which bypasses the drainage system, (e) seepage carrying fines, (f) cracks on the crest, the outer slopes, or within the abutments, (g) sink-holes or unexpected depressions, (h) increased settlement with time. With the periodic observance for these signs, internal erosion (piping), if any, can be remedied and stopped before a failure occurs. During a piping failure the finer embankment material is washed away with the seepage which would increase in time but this would not entail a flood wave as in the case of an incision starting from the crest and subsequent erosion of the embankment. Erosion of the dam crest can be triggered by an uncontrolled and rapid overflow. An erosion channel incises starting from the dam crest and the shape of this structural gap in the dam body is widening and deepening as erosion of the dam body progresses. This is resulting in an increasing outflow of the reservoir causing a flood wave in the downstream.

The setting up of the detailed dam safety and emergency response plan, which will be developed during implementation, will include studying the range of failure scenarios relevant to Yusufeli. Various dam failure scenarios are normally studied and these cover rapid failure times, large breach sizes and conservative antecedent conditions to gain a realistic picture on the maximum extent of downstream flooding consequences and the necessary preparedness measures.

For the purpose of the present EIA, a simplified scenario of a flood as a consequence of a complete failure of Yusufeli dam, which is started by crest erosion following overtopping was modeled (cf. Appendix R-1). This provides for a preliminary estimate of the downstream consequences. The scenario assumes that the implementation of Artvin dam and reservoir was delayed. With respect to flooding this scenario is of particular relevance for the 4 downstream settlements located in the valley bottom and lower slopes between Yusufeli dam and Artvin dam site (which is at the end of Deriner reservoir). With the establishing of Artvin reservoir, these settlements will be impounded.

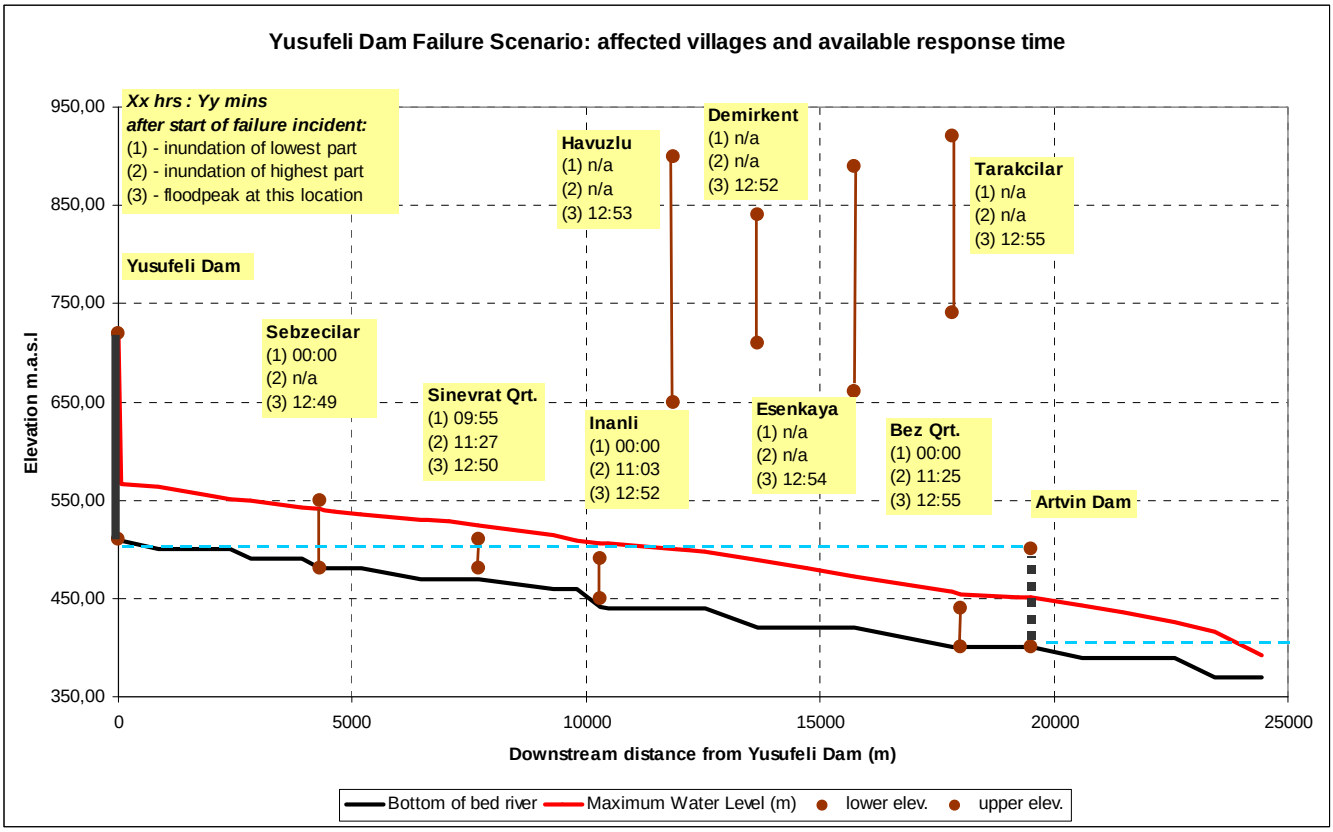
The model[7] results provide information on the flood propagation and evolution of resulting water levels and discharge in the downstream section of the dam (cf. Appendix R-1). The progressing erosion of the dam results in an increase of the flood

[6] Also other factors like ice jam formation in winter conditions is a potential cause for failure.

[7] Dam break module of MIKE 11.

flow and within about 12 hrs 50 min after the start of the erosion of the dam crest, the flood would rise to the max. water levels, which are about 65 to 25 meters above the river bed (decreasing from the dam site downstream). In the model, the gap in the dam erodes from the crest at 719 m ASL to a level of about 580 m ASL, as the eroding force is decreasing with the emptying of the reservoir behind the dam and the dam is wider towards its base, leaving a remainder of about 80 meters of dam structure below the gap The simulation results show that the flood peak would propagate through the V-shaped valley between Yusufeli and Artvin dam sites at a velocity of about 33 m/sec (~120 km/h). The hypothetical peak discharge, which will never occur as explained in footnote "9", reaches a figure of 164,000 m³/sec which is 18 times the probable maximum flood (HQ_{max} = 9,000 m³/sec). The dam break would release a volume of about 2.4 x 10^9 m³ of water to the downstream (this is approx.100% of the Yusufeli Storage Volume at elevation 719 m ASL).

The model output information together with information from the topographic maps and the high resolution satellite images which show the location of the houses, is used to assess the flooding risk and consequences for the settlements located in the downstream. Also the available response time for warning evacuation after the dam failure incident starts can be derived. Results are summarized in Figure VIII.1.



Note: flood elevations and times given are indicative and the result of a preliminary model

Figure VIII.1. Flood Level and Settlement Inundation times

As can be seen from Figure VIII. 1 The resulting flood wave would completely inundate the 3 of the 4 settlements located in the valley bottom in the downstream of Yusufeli between Yusufeli dam and Deriner reservoir (Sebzeciler village will be

affected partially and Sinevrat, Inanli and Bez Quarter will be fully affected by the flood wave due to dam failure). In total, a population less than 250 inhabitants[8] would be affected.

Table VIII.10. Inundation Time of settlements after start of dam failure (no Artvin reservoir)

Settlement impact and time after failure starts	Sebzeciler	Sinevrat Q.	Inanli	Bez Qrt.
inundation of lowest part after hh/mm :	immediately	09:55	immediately	immediately
inundation of highest part after hh/mm :	n/a	11:27	11:03	11:25
Flood peak at this location after hh/mm :	12:49	12:50	12:52	12:55

Note: times given are indicative and the result of a preliminary model

The other settlements (Havuzlu, Demirkent, Esenkaya and Tarakcilar) in the downstream between Yusufeli dam and Deriner reservoir are located at higher, flood safe elevations and would not be affected by a flood from a dam failure. Due to the steep V-shaped valley morphology, the flooding has no significant spatial extend as it affects the low valley parts only which fill up with water by 65 – 25 meters high.

With Arvin dam and reservoir in place at the same time as Yusufeli as planned, a dam break of Yusufeli Dam would result in a flood spill into the Artvin reservoir. The maximum discharge at flood peak is 164,000 m³/sec, while the Artvin spillway capacity is 8,200 m³/sec at elevation 511.60 m. The spillway is capable to discharge larger flows, e.g. for reservoir level of 514.0 m the spillway discharge is 11,000 m³/sec. This flood would overtop the Artvin dam (crest elevation is at 515 m ASL) but its magnitude will be determined after a flood routing study, which is part of the detailed EPP studies to be further undertaken during project implementation. However, also in this case, the villages at the much higher elevations between Yusufeli and Artvin dams (Havuzlu, Demirkent, Esenkaya and Tarakcilar) would not be affected (cf. Fig. VIII.1).

Irrespective if Artvin was in place or not, a full dam breakage as modeled, would result in an enormous amount of water (2.4×10^9 m³ during 42 hours) which was stored in Yusufeli to flow into Deriner reservoir within about 2 days. The reservoir volume of Deriner at maximum operation water level (392.0m) is $1.969 \times 10^9 m^3$; and the volume at minimum operation level (347,83 m) is $1.006 \times 10^9 m^3$. Deriner has two (2) overflow spillways with sill elevation at 386.0 m equipped with flap gates and eight (8) low level orifice spillway arrangements of 5.60m x 2.80 m cross section each equipped with slide gates. The intakes are at ca. 217 m ASL. The capacity of the spillways (all operating) is 7,818 m3/sec, 8,239 m3/sec, 8,682 m3/sec and 9,200 m3/sec at reservoir elevations 392 m, 393 m, 394 m and 395 m, respectively. For Deriner to take up any excess water depends on how much drawdown it can

[8] Cumulated and roughly rounded up census figures.

accomplish in case of a failure alarm within more than 2 days and the extent of attenuation achieved along the route and by flood routing. Consequences of and response mechanisms for a flood from a dam breakage at Yusufeli for the water levels and flood discharges at Deriner and downstream dams will be determined as part of the detailed studies.

VIII.5.4.5. Preliminary Findings and Recommendations

The general scope of the EPP to be developed until one year before dam completion is outlined in sections VIII.5.4.3.1.- VIII.5.4.3.4 above. Based on the findings of the preliminary analysis of emergency and failure scenarios, particular attention should to be paid to following aspects when the EPP is developed:.

For the downstream section between Yusufeli and Artvin, in case the Artvin Project should be delayed 4 settlements would be affected. Due to the built in design safety flood release margins, it can be concluded that considerable time is available before overtopping occurs (almost 2 days after the normal reservoir water level is exceeded [9]) to warn and evacuate the downstream population. Should a dam failure occur as a consequence of overtopping as modeled in the scenario, the time for inundation of the 4 downstream settlements varies from less than 1 up to 11 hours after start of incision at the dam crest depending on elevation location of houses (cf. Table VIII.10). With the model assumptions used, even the settlements located at some kilometers downstream distance would experience immediate flooding of the lowest located houses. The full modeling of failure scenarios and inundation maps will provide for reliable results for detailed emergency response planning. An important factor for feasibility of evacuation measures is the accessibility via roads. Depending on the location, the main road in the valley would be flooded within minutes to hours after a large flood. If Artvin is completed as planned at the same time as Yusufeli, only 1 settlement (Sebzeciler) is at risk.

For the downstream section after Artvin, the EPP needs to consider the effects of a dam break on the water level in Deriner reservoir and the discharge from Deriner to the downstream, to describe the consequences and set up appropriate emergency response mechanisms. The regional early flood warning system should also include arrangements with Georgia as any dam break on the cascade will ultimately show an effect in the river flow past the last dam of the cascade.

[9] The dam break scenario calculation has assumed no outflow from the reservoir until the dam is overtopped. In order for the reservoir level to rise from the normal operation level at El. 710m to the dam crest at 719masl when the dam would be overtopped, it will take 38~39 hours assuming no discharge from the reservoir (as per Probable Maximum Flood hydrograph), However, there will be in any case release through the spillway: Even if the spillway gates could not be operated (failure, jammed, blocked), water will still be spilling over the gates, as the top elevation of the spillway radial gates is at 710.50 m ASL while the dam crest is at 719 m ASL. This is resulting in an attenuation of an incoming flood and thus increases the time until the reservoir level would actually reach the crest level and overtop the dam.

Note: The Environmental Management Plan (i.e. EIA Section VIII) is expanded by the following new section:

VIII.3.13 Emergency Preparedness Plan

Under the responsibility of DSI and advised by the Project Engineer, a detailed Emergency Preparedness Plan (EPP) covering flood and dam break scenarios will be prepared during project implementation (cf. Section VIII. 5 Dam Safety and Emergency Response):

- This EPP will be completed at the latest one year before initial filling of the reservoir;
- The EPP will consider inter alia the effects of a dam break on the water level in Deriner reservoir and the discharges from Deriner to the downstream (including consequences and appropriate emergency response mechanisms);
- DSI's regional early flood warning system for the Coruh will be revised and amended accordingly; to the extent possible the system will include relevant arrangements with Georgia.

Development of the EPP is added as a new item (37) to Table VIII.2 with funding from the project budget.