IFAS AGENCY for the GEF PROJECT

ARAL SEA BASIN PROGRAM
WATER & ENVIRONMENTAL MANAGEMENT PROJECT

COMPONENT C:
DAM SAFETY AND RESERVOIR MANAGEMENT

CHIMKURGAN DAM

SAFETY ASSESSMENT REPORT

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GIBB
LAWGIBB Group Member

In association with

SMEC

CHIMKURGAN DAM
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CONTENTS

UNITS AND ABBREVIATIONS

ASBP	Aral Sea Basin Program
CA	Central Asia
CMU	Component Management Unit
EA/EIA	Environmental Assessment/Environmental Impact Assessment
EC-IFAS	Executive Committee of IFAS
FSL	Full Storage Level
FSU	Former Soviet Union
FAO/CP	Food and Agriculture Organisation/World Bank Co-operative Programme
GDP	Gross Domestic Product
GEF	Global Environment Facility
ICB	International Competitive Bidding
ICOLD	International Commission on Large Dams
ICWC	Interstate Commission for Water Coordination
IDA	International Development Association of the World Bank
IFAS	International Fund to Save the Aral Sea
JSC	Joint Stock Company
LDL	Lowest Drawdown Level
M & E	Monitoring and Evaluation
NCB	National Competitive Bidding
NGO	Non-governmental Organisation
O & M	Operation and Maintenance
PIP	Project Implementation Plan
PIU	Project Implementation Unit
PMCU	Project Management and Coordination Unit
PMF	Probable Maximum Flood
RE	Resident Engineer
TA	Technical Assistance
TOR	Terms of Reference
SIC	Scientific Information Centre (of the ICWC)
SU	Soviet Union
SW	Small Works
VAT	Value Added Tax
WARMAP	Water Resource Management and Agricultural Production in CA Republics

masl	metres above sea level
Mm^3	million cubic metres
km^3	cubic kilometres = 1000 Mm^3
m^3/s	cubic metres per second
ha	hectare
hr	hour

1 INTRODUCTION

This report is one of ten reports prepared under Component C: Dam and Reservoir Management, of the Water and Environmental Management Project (WAEMP). The WAEMP is supported by a variety of donors, such as the Global Environment Facility (GEF) via the World Bank, the Dutch and Swedish Governments and the European Union, and is being implemented by the IFAS Agency for the GEF Project under the Aral Sea Basin Program.

1.1 Background to Project

In general, the WAEMP aims at addressing the root causes of overuse and degradation of the international waters of the Aral Sea Basin, and to start reducing water consumption, particularly in irrigation. The project also aims to pave the way for increased investment in the water sector by the public and private sectors as well as donors. The project addresses this aim in several components. Dam and Reservoir Management, the assignment with which this report is concerned, is one of them. The other components are: Water and Salt Management, the leading component, to prepare common policy, strategy and action programs; Public Awareness to educate the public to conserve water; Transboundary Water Monitoring to create the capacity to monitor transboundary water flows and quality; Wetlands Restoration to rehabilitate a wetland near the Amu Darya delta; and Project Management. The components have close links with each other.

The Dam and Reservoir Management Component focuses on four activities as follows:

a) Continuing an independent dam safety assessment in the region, improve dam safety, address sedimentation and prepare investment plans;
b) Upgrading of monitoring and warning systems at selected dam sites on a pilot basis;
c) Preparing detailed design studies for priority dam rehabilitation measures; and
d) Gathering priority data and preparation of a program for Lake Sarez.

The activities are grouped for work process purposes into two packages and will be executed simultaneously, according to an agreed schedule of works:

- Dam safety and reservoir management (including activities "a", "b" and "c");
- Lake Sarez safety assessment (covering activity "d").

The Dam Safety and Reservoir Management package covers the following areas: dam safety, natural obstructions, silting of reservoirs, control of river channels etc.

The activity covers the following 10 dams, two in each country:

Kazakhstan: Chardara and Bugun dams;
Kyrgyzstan: Uchkurgan and Toktogul dams;
Tajikistan: Kayrakkum and Nurek dams;
Turkmenistan: Kopetdag and Khauzkhan dams; and
Uzbekistan: Akhangaran and Chimkurgan dams.

Because of the need to safeguard human life, early priority is being given to safety reviews at each of the dams, which is the subject of this report.

1.2 Safety Assessment Procedures

The dam safety assessments are the first stage in the evaluation (including costing and economic justification), analysis, design and implementation of measures aimed at ensuring safe operation of the selected dams. They have been prepared based on a brief reconnaissance visit to each dam, discussions with the operating staff and a perusal of such information and data as was found to be readily available. No attempt has been made at this stage to analyse any of the data. A data collection and cataloguing procedure was initiated before commencement of the assignment but this process (to be carried out by National Teams) is still at an early stage in implementation.

The field visits were made and the reports prepared by a team of international experts specialising in dam engineering and dam safety procedures. The team comprises experts from GIBB Ltd (United Kingdom) and its associate for this assignment, Snowy Mountains Engineering Corporation (SMEC) from Australia, together with members of a team of regional experts who have been contracted as individuals to work with the Consultants for this project. This team is referred to here as the International Consultants (IC). The International Consultants have been supported during the field visits by members of National Teams appointed for this project from each of the five Central Asian republics.

The principal members of the international team, who are the authors of this report, are the following: -

- Jim Halcro-Johnston (GIBB Ltd) – Team Leader
- Gennady Sergeyevich Tsurikov (Uzbekistan) – deputy Team Leader
- Edward Jackson (GIBB Ltd) – Dam Engineering Specialist
- Ljiljana Spasic-Gril (GIBB Ltd) – Geotechnical Engineer/Dam Structures Specialist
- Pavel Kozarovski (SMEC) – Hydrologist/Hydraulic Engineer
- E.V. Gysyn – Dams Specialist (Kazakhstan)
- E.A . Arapov – Hydraulic Structures Specialist (Turkmenistan)
- G.T . Kasymova – Energy Expert (Kyrgyz Republic)
- R. Kayumov – Hydrostructures Specialist (Tajikistan)
- R.G. Vafin – Hydrologist, specialising in reservoir silting (Uzbekistan)
- V.N. Pulyavin – Dam Instrumentation Specialist (Uzbekistan)
- N.A. Buslov – Dam Specialist (Turkmenistan)
- Y.P. Mityulov – Cost and Procurement Expert (Uzbekistan)
- N. Dubonosov – Mechanical Equipment Expert (Kyrgyz Republic)

Most of the above team members have contributed in the preparation of this report.

1.3 Scope of Safety Assessment

The safety assessments are made based on superficial evidence observed during the site visits, discussions with operating staff and subsequent discussions with members of the National Teams (NT) and an examination of such supporting design and construction documents as have been made available to the IC for review (A full list of the documents reviewed is included as Appendix A).

The safety evaluation of the dam has required an assessment of the following factors:

(1) The **characteristics of the reservoir and dam site**, which includes the flood regime
for the river, and the geological conditions at the site;
(2) The **characteristics of the dam,** covering its design and present condition;
(3) The expected **standards of operation and maintenance** of the dam, its performance, and the implications for safety;
(4) The **effects on the downstream** area resulting from a failure of the dam or an excessive release of water.

The structure of this report reflects the scope of safety assessment. Chapter 2 presents a general description of the dam, including location, purpose, principal dimensions and assessment of its hazard rating in relation to the impact that a safety incident would have on the adjacent community. Chapter 3 discusses the design factors that principally affect the safety of the dam.

Comments on the condition and performance of the dam are given in Chapter 4 and in Chapter 5 an assessment of its safety is given.

Chapter 6 gives recommendations for studies, works and supplies to be undertaken in the interests of ensuring the safety of the dam and the downstream community. Conclusions and recommendations are summarised in Chapter 7.

The recommendations for safety measures given in this report must be regarded as tentative as their precise scope will depend on the outcome of further studies which are outside the scope of the present assignment. No attempts has therefore been made at this stage to evaluate the cost of the required remedial works or to carry out an economic justification for the works proposed, which will be necessary to support an application for funding. This will be carried out when the necessary studies and detail designs have been completed.

2 PRINCIPAL FEATURES AND DIMENSIONS OF THE DAM

2.1 Location, Purpose, and date of Construction

Chimkurgan dam is located in the Kamashinsk region of the Kashka Darya Oblast, on the middle part of the Kashkadarya river of the Amu Darya basin, and is about 20 km North East of Makashi village (Figure 1). The reservoir is used for seasonal regulation of the Kashka Darya catchment in order to provide water for irrigation.

The dam was designed by Sredazgyprovodhlopok Institute in Tashkent and was constructed between 1957-1960. It was commissioned in 1963.

2.2 Description of the Dam

The dam comprises an earthfill embankment, draw-off works with the emergency spillway incorporated in the valve tower and the head works for the left bank and right bank irrigation canals. (Figure 2).

The embankment dam comprises a wide compacted silt clay core with shoulders of sandy-gravel. The upstream slope of the embankment is protected by concrete slabs.

The draw-off works together with the emergency spillway discharge floods and water for irrigation canals.

The draw-off works comprise:

- intake with vertical maintenance roller gates 3mx3m,
- three conduits under pressure
- draw-off tower consisting from the low level outlet , spillway and the upper part of the tower.

The low level outlet houses working and maintenance gates (2mx3m) which are hydraulically operated. Middle part of the tower consists of a vertical shaft and three low level outlets which discharge water downstream of the dam.

Downstream of the tower water is discharged into 3 conduits and then directly into a plunge pool with a variable width. In front of the plunge pool wall, on the right hand and left hand sides there are intakes with vertical lift gates that control water inflow into the right bank and left bank irrigation canals.

Beyond the plunge pool wall, the plunge pool widens into a sloping drop structure. The end part of the plunge pool comprises energy dissipators and rip-rap scour protection.

Significant scouring of the riverbed occurred in 1964 downstream of the plunge pool and was related to extensive use of gravel borrow area. Strengthening works of the end part of the plunge pool were undertaken in 1966. The strengthening works comprised lengthening of the concrete slab and construction of anti-scour protection from concrete blocks and rip-rap. In 1993 further strengthening works to the end part of the pool were undertaken which comprised construction of a concrete wall and strengthening with rip-rap.

The principal dimensions of the reservoir and the various components of the dam are given in Table 2.1.

2.3 Hazard Assessment

In many countries a formal classification system is used to define the risk a dam represents, in terms of the potential for loss of life and/or damage to property which could result in the event of flooding caused by failure of the dam or an extensive release of water. The magnitude of the risk depends partly on the characteristics of the dam and reservoir and partly on the conditions downstream of the dam. Risk factors based on the procedure set out in ICOLD Bulletin 72 (Reference 1) are shown in Tables B1 and B2 in Appendix B.

Based on the Tables in Appendix B, the total risk factor of 34 points (Table 2.2) puts the Chimkurgan dam in Risk Class IV, that is the highest risk category.

Table 2.2 Chimkurgan Dam – Risk Factor

		Points
Reservoir Capacity (Mm^3)	500	6
Dam Height (m)	33	4
Downstream Evacuation Requirements	>1000	12
Potential Damage Downstream	High	12
	TOTAL	34

Table 2.1 Chimkurgan Dam – Principal Dimensions

Principal Dimensions of the Water Reservoir

Total storage capacity	Design	500 Mm^3
	1996 Survey	400 Mm^3
Active storage capacity	Design	450 Mm^3
	1996 Survey	370 Mm^3
Dead storage capacity	Design	50 Mm^3
	1996 Survey	30 Mm^3
Full storage level	(FSL)	488.2 masl
Maximum water level	(MWL)	489.25 masl
Dead storage level	(DSL)	471.00 masl
The reservoir surface area at FSL	Design	50 km^2
	1996 Survey	43 km^2

Principal dimensions of Chimkurgan embankment

Crest length		7,500 m
Crest level		440.9 masl
Parapet level		442.1 masl
Maximal height of the embankment		33.0 m
Crest width		6 – 10 m
Slopes:	Upstream slope	1:2.28 –1:3.0
	Downstream slope	1:2.25 – 1:2.75

Maximum capacity of all structures at 0,01 % flood

Outlet - spillway	350 m^3/s

3 DESIGN CONSIDERATIONS

3.1 Hydrology

Chimkurgan reservoir has been in operation since 1963. The reservoir is located on the middle part of the Kashkadarya river. The river rises in a mountain massive located at the junction of the Zerafshon and Gissar ridges. Absolute heights at the watershed reach 4,100 – 4,300 masl. The maximal height level is 4,500 masl. The largest tributaries of the river are : Djinni-Darya, Aksu, Tanhaz, Yakkabag, and there is Guzardarya river downstream of the dam. The highest elevations are of Aksu river. Here glaciers named Severtzov and Batirbay are located. The total area of glaciation is 2.68 km^2. Kashkadarya river is fed from snow-glacier and snowfall and rainfall.

The length of the river up to the dam site is 112 km, catchment area up to Chirakchi gauge: F = 4,970 km^2 and weighed mean height: Hwm. = 1,720 masl. There are four reservoirs upstream of the dam site, the largest of them being Gissarak reservoir with 180 Mm^3, the others being less than 10 Mm^3.

Guzardarya river joins the Kashkadarya river downstream of the dam site, on which are located Pachkamar (260 Mm^3) and Dehkanabad (27,2 Mm^3) reservoirs.

There are ten gauging stations in the river basin. The water inflow into the reservoir is measured at Chirakchi gauge, the downstream gauge is destroyed. The average discharge at Chirakchi gauge is 25.3 m^3/s, or about 800 Mm^3 .

The average duration of the flood period is 155 days from March up to July. Maximum discharges are usually observed in March - May. The maximum recorded discharge of 731 m^3/s occurred on 15 April 1969. Up to 70 % of annual runoff occurs during the flood season (March - July). Summer monthly mean minimal discharges are about 2.0 m^3/s, and the discharges for a winter period - 8.0 m^3/s. Absolute daily average minimum is 0.5 m^3/s.

The annual runoff volume with 50% of reliability is 760 Mm^3, including a flood period volume of water of 500 Mm^3. The adopted maximal discharges are: for 0.1% of exceedance probability - 1,260 m^3/s, for 1% of exceedance probability - 740 m^3/s, actual volume of a flood of 1969 was close to 1% of reliability and that was 1,480 Mm^3. The statistical analysis of annual maximum has to be revised and re-fined with the extension of the available data and because of changing of the normatives.

The annual runoff of sediments based on Hydrometservice data is 2,235,000 t, which gives 1,655,000 m^3 for γ = 1,35 t/m^3. The actual silting volume for the period 1963-1996, i.e. 33 years, is 99.54 Mm^3, or 3,016,000 m^3 / year. The actual silt volume exceeds the designed 1.82 times, so the silting regime should be also revised. 12 Mm^3 of the total silt volume is coming from the erosion of the reservoir banks.

3.2 Geology and Seismicity

The dam is situated in Kashkadarya river valley on the riverbed and five river terraces consisting of Quarternary Deposits (Figure3).

The central part of the dam is founded on the alluvium of the riverbed and three upper terraces. Alluvial sandy-gravel deposits of the riverbed and the three terraces are very heterogeneous (comprising all soil types from fine sands to gravels) and occasionally are interbedded with layers and lenses of clay, silts and sandy silts. The top part of the alluvial deposits consists of a thin layer of silts and sandy silts with bands of sands. Coefficient of permeability of the alluvial deposits varies significantly between 0.5 m/day to 33 m/day.

The dam abutments are founded on silts and loess of the fourth and fifth river terrace.

According to the Russian seismic code (Reference 2), Chimkurgan dam is located in seismic intensity zone VII according to MSK Intensity scale (Medvedev, Sponheuer and Karnik).

3.3 Construction Materials and Properties

The silt for construction of the core was obtained from borrow areas located downstream of the dam and within the reservoir. The sandy-gravel material that was used for the dam shoulders was obtained from borrow areas in the riverbed.

The properties of the various embankment materials and zones are summarised in Table 3.1

Table 3.1 – Chimkurgan Dam – Material Properties

Material	Density t/m^3	Strength parameter	
		tanØ	c (kg/cm^2)
Dam Core			
1. Silt	1.78-1.48	0.45-0.53	0.01-0.05
Shoulders 2.Sandy gravel	1.72-2.06	0.51-0.65	-

Materials in the embankment and its foundations have not been checked for susceptibility to liquefaction during the original design.

3.4 Seepage Control Measures

In order to reduce seepage through the dam foundation noted after the first impoundment, the following anti-seepage protection measures were constructed in the middle part of the dam:

- sandy-gravel ballast on downstream slope
- partial sheet pile cut-off wall constructed from the berm on the downstream slope, total length 200m,
- drainage blanket constructed from compacted silt on upstream slope, total length 900m,
- two rows of drainage relief wells on the downstream slope.
- grout curtain 30m deep was constructed in 1973 in the middle part of the dam to reduce further extensive seepage through the foundations.

3.5 Reservoir Draw-off Works

Operation of the reservoir is governed by the amount of water inflow and outflow dictated by the users. Reservoir operational procedures are given in the ”Operational Manual for Chimkurgan reservoir, (Tashkent,1987)” and they have been reviewed in accordance with the users requirements.

The main use of water is for irrigation and according to the design, the reservoir should provide 75% of water for irrigation.

Present reservoir water balance studies are inaccurate and do not allow the data to be used for analysis.

Permissible reservoir draw-down rates have been set in order to provide slopes safety in case of rapid draw down. The draw - down rates do not exceed 0.3 m/day in the upper parts of the reservoir, 0.5 m/day for the middle parts and 1 m/d for the lower parts of the reservoir.

Operational procedures in the case of floods are given in the Operational Manual. In accordance to the procedure, a Flood Expert Committee is formed when floods take place. The Committee checks condition of the structures and it is in contact with local Representatives which control water discharges in downstream parts of Kashkadarya river.

In the case of a maximum flood, the water is discharged through the low level outlets and spillway. The total discharge during maximum floods is limited to 350 m^3/s.

When floods of 200 m^3/s and more are registered at Chirakchi hydropost , a release of water from the reservoir is at the maximum draw-down rate of 0.3m/day.

3.6 Performance Monitoring Instrumentation

For control of dam performance a network of survey benchmarks and piezometers was installed (see Appendix C). Monitoring of seepage through the dam and its foundation and interpretation of the results is carried out on a regular basis.

13 monitoring profiles where 110 piezometers would be installed were proposed in the original design. 146 survey benchmarks (122 surface and 24 deep) and 22 extensometers were envisaged to be installed. Piezometers and benchmarks were to be installed in the dam and extensometers on the outlet conduits.

Seepage is currently measured at individual collector drains downstream of the dam. There is also one measuring point at the end of the summary collector for measuring of total seepage.

3.7 Hydropower Facilities

The dam has a low hydropower potential and was never intended for hydropower production.

4 DAM CONDITION AND PERFORMANCE

4.1 Comments Arising out of Inspection

The IC together with the regional and national experts visited Chimkurgan dam on 25 September 1999. The reservoir was empty at the time of the visit, and that gave an opportunity to inspect all the structures in detail.

It was found, that there were cracks and damage to facing slabs on the upstream slope, there were cracks in the gate tower and outlet pipes, the cracks were noted as well at the escape structure. About 50 piezometers were out of order.

The mechanical equipment of the outlet works was obsolete and required technical re-equipment. The gates and lifting mechanisms of the inlet were worn out and were corroded. The seals were not tight.

The gates and the lifts in the tower of the outlet and the crane equipment were worn out and were obsolete. There were found holes with diameter up to 15 cm in the valve house at the sills of the working gates, and concrete scour under the facing of depth up to 20 cm.

The electric equipment was malfunctioning.

4.2 Assessment of Performance Monitoring Results

Monitoring of the dam is carried out by the Dam Operational Unit and the Department for full-scale observations of the Ministry of Agriculture and Water Resources (MOAWR). The instruments observations were not carried out regularly since the dam was commissioned. Only since 1992 the inspections of the dam and regular instruments observations were renewed.

At present, from 110 piezometers, stipulated by the project, only 58 of them are operational. The gauge at Kashkadarya river downstream of the reservoir, and also two gauges of the drainage network were destroyed.

The water levels recorded on the piezometers installed in the middle part of the dam have increased in recent years, and measured seepage discharges decreased. That indicates disturbance of drainage works. In 1998 - 1999 the drainage works were partially reconstructed.

Observation of settlements and displacements, that restarted after a long break, show that the settlement have not stabilized yet and that the dam still settles 3 - 5 mm per year.

The average total seepage is about 550 l /s.

4.3 Dam Safety Incidents

During inspection and discussion with the chiefs of the Dam Operational Unit it was found out that there were no safety incidents during the period of operation of the dam.

In 1963 when the reservoir was temporarily impounded, there was an emergency at the site due to high mechanical suffosion noticed in the material in the foundations. The following remediation measures were implemented in order to reduce the suffosion:

- construction of a berm on the downstream slope
- construction of a cut-off sheet pile wall
- construction of the grout curtain

4.4 Maintenance Procedures and Standards

The Operation Manual of Chimkurgan dam was worked out in 1987, but it had not been considered and had not been approved by higher organization, and its requirements are only recommendational in character. Decisions made by the Dam Operational Management connected with the reservoir operation in normal conditions, or connected with operation during maximum discharges, are based on Hydromet forecasts which actually either lack data or contain insufficient data. Such incomplete data do not permit the Management to carry out a proper planning of the reservoir operational regime.

4.5 Existing Early Warning and Emergency procedures

An early warning system for the early notification of the population of nearby areas of an emergency situation exists. However the system is unreliable and does not comply with international norms and standards.

The Management of the Operational Unit is connected by telephone with oblast organizations and a siren for notification of the population in extreme situations was established.

5 SAFETY ASSESSMENT

5.1 General

The safety assessment is based on the following general criteria:

(1) Structural safety
The dam, along with its foundations and abutments, shall have adequate stability to withstand extreme loads as well as normal design loads.

(2) Safety against floods
The reservoir level shall not rise above the critical level (maximum flood level) for the largest possible flood. Gate mechanism and power units must remain fully operational and accessible at all times.

The dam should have adequate facility for rapid lowering of the reservoir level in case of emergency.

(3) Safety against earthquakes
The dam shall be capable of withstanding ground movements associated with the maximum design earthquake (MDE) without release of the reservoir. The selection of the appropriate value of MDE is based on an assessment of the consequences of dam failure (Section 2.3).

(4) Surveillance
Arrangements for inspection, surveillance and performance monitoring of the dam should ensure that a danger arising from damage, defect in structural safety or an external threat to safety is recognized as soon as possible, so that all necessary measures can be taken to control the danger.

Adequate emergency planning, early warning and communications facilities shall be in place to ensure the safety of the downstream population in case of emergency.

In the light of the review of the design and performance of the Chimkurgan dam, the findings of the condition assessment, and the review of the hydrological and geological conditions, the following conclusions are drawn regarding the safety of the dam.

5.2 Structural Safety

Embankment

The embankment itself appears to be sound.

Piezometers installed in the embankment indicate that the measured phreatic surface is below that designed. However, a lack of piezometers in the upper part of the downstream shoulder and flanks was noted and therefore it is recommended to reinstate the piezometers in these areas.

The 1998 survey results showed high rates of settlement of downstream berms that appeared to be unrealistic. It is understood that a new set of the latest survey results is available and it is recommended that the settlements are reassessed and reviewed.

It is recommended to inspect the dam when the reservoir is at its lowest level and carry out repairs to the embankment upstream face where it is necessary. It is also recommended to carry out repairs to the embankment downstream face protection and surface water drainage system in order to avoid slope erosion.

Draw-off/Spillway works

There are a number of cracks evident in the gate tower, and although these are unsightly, and give rise to calcitic deposits and some leakage at high reservoir levels, they do not appear to be of any significance in terms of structural stability. Possibly of more significance is a report that there is a noise of 'running water' evident at low level on the right hand side of the valve tower, associated with a damp area on the floor of the valve chamber. This could be an indicator of possible cavities and seepage along the outside face of the culvert, possibly associated with under compacted fill where the weight of the embankment is partially carried by the rigid structure of the culvert. It is understood that grouting of the culvert/embankment interface has been carried out in the past.

5.3 Safety against Floods

5.3.1 Discussion on the exceedance probability of design hydrographs

The aim of this Section is to discuss the conservatism involved in the derivation of design hydrographs in accordance with SNIP and how these hydrographs compare with PMF.

Chimkurgan outlet structure was designed using 0.1% exceedance probability hydrograph and checked against 0.01% hydrograph. The 0.01% hydrograph routing commences at FSL level and is passed through $50*10^6$ m^3 storage dedicated for flood routing only. The routing is controlled by the stage-discharge function of the outlet structure and the stage-storage curve. The outlet structure comprises a bottom outlet and an emergency spillway. The capacity of the bottom outlet is 350 m^3/s and the capacity of the emergency spillway is 49 m^3/s, totalling 399 m^3/s.

The design hydrographs are determined through a statistical analysis of historical records. A theoretical curve, based on a 3-parameter gamma distribution, is fitted to maximum annual peak discharge values, and design peak discharges for various exceedance probabilities are determined. The 0.01% discharge value is subject to a correction, which is approximately 20% higher than the original value. The correction itself brings the exceedance probability of the obtained value to 0.005% or 1 in 20,000 years.

The volume of the hydrograph is also defined through frequency analysis of annual maxima. The coincidence of all historical peaks and maximum flood volumes would require the two variables (peak discharge and flood volume) to be totally dependent, with the exceedance probability of the combined hydrograph equal to the exceedance probability of the peak discharge value. However, the historical peak discharge values do not necessarily coincide with the maximum volumes. In other words these two variables are partially dependent, resulting in a hydrograph with exceedance probability lower than the exceedance probability of the peak discharge.

During the practical fitting of the theoretical frequency curve, a coefficient of asymmetry Cs is calculated from the recorded series of annual maxima. This coefficient is then used to fit an appropriate curve. The higher the coefficient, the more skewed is the theoretical curve, resulting in higher discharge values for low probabilities of exceedance. In practice, the obtained value of Cs was not used, but Cs equal to k*Cv was often adopted. The k value obtained from longer records of similar rivers was adopted instead. The adopted value usually exceeded the calculated value of Cs resulting in higher design peak discharges for lower probabilities of exceedance. This practice introduced an additional conservatism into the derivation of the design discharge values, which results in the overestimation of the design discharge value.

The above three factors result in the design discharge hydrograph with exceedance probability significantly lower than 0.01% (1 in 10,000 years). It is expected that the resulting exceedance probability of the design hydrograph would be in the range of 0.001% or 1 in 100,000 years. Further investigations into this matter are required to support this statement. If the results confirm the above statement it can be concluded that the conservatism introduced during the design calculations results in the outlet structures of the dams to have been designed for a 1 in 100,000 years event instead of a 1 in 10,000 years event, which in general approaches the exceedance probability of a PMF event.

The local Bureau of Meteorology provides forecasts of expected streamflows at the beginning of the wet season (early spring), based on the snow deposits in the catchments of particular rivers. Based on the forecast, the central authority, which regulates the dam operation, issues a request for the initial level in the reservoir prior to the beginning of the melting season. In the case of wet years the requested initial level can be lower than the FSL. This mechanism introduces an additional storage available for flood routing, increasing the dam safety during extreme floods.

5.3.2 Factors which reduce the dam safety during floods

There are several factors that affect the performance of the Chimkurgan dam during large flood events. These are related to the relatively high exceedance probability of the design flood, change in the magnitude of the design peak discharge, presence of other reservoirs upstream of the dam, the reduced storage due to sedimentation and limitation to the maximum discharge downstream.

Chimkurgan Dam has been designed for a 1% event and checked against a 0.1% event. It is expected that the conservatism involved in definition of the design flood will reduce the exceedance probability from 0.1% to 0.01% or 1 in 10,000 years. Further more, the design of the flood storage and outlet structure capacity was undertaken using a 0.1% event with a peak of 855 m^3/s. This value has been revised by the local experts, extending the pre-dam series of annual maxima with new records. The revised 0.1% exceedance probability peak discharge value is 919 m^3/s. The designers are currently considering a solution to accommodate this increase. The solutions they are looking at are introduction of an emergency spillway and raising the dam to provide a larger flood storage. The increase in design discharge value due to longer records is a typical example of the shortcomings of the frequency analysis based on short records. The exceedance probability of the design event is chosen in accordance with SNIP. However, in accordance with ICOLD this dam falls into the category IV, which requires that the dam safety be checked against extreme floods with much lower exceedance probability or preferably a PMF.

There are several large reservoirs upstream of the dam. The largest reservoir is Gissarak Reservoir with a total volume of impounded water of $180*10^6$ m^3, with remaining reservoir storages less than $10*10^6$ m^3. The safety of the Chimkurgan dam will be significantly affected in a case of a dambreak of the larger reservoirs, but a dambreak of a smaller reservoir during an extreme flood might also affect the the safety of the dam. It will therefore be necessary to identify the impact of a dambreak of any of the reservoirs upstream on the Chimkurgan safety. If the investigations indicate that the dambreak of smaller reservoirs might affect the dam safety it will be necessary to define the necessary means to upgrade those reservoirs to a level which will guarantee the safety of Chimkurgan.

Design hydrographs, discussed in Section 5.3.1, were developed by analysing the recorded streamflows at the gauging station Chirakchi. The catchment area of the station is 4,920 km^2, whilst the catchment area of the dam is 5,590 km^2, which is approximately 13% more. The average height of the additional area is below the snow line and the streamflows are affected by various irrigation structures and diversion channels. The designers of the dam assumed that this area will not significantly increase the peak nor the volume of the design flood hydrograph, so this part of the catchment was ignored during the definition of the design hydrograph. It can be concluded at this stage that the design hydrograph might be underestimated. The real extent of the underestimation will be determined during the calibration and verification of the hydrologic model and PMF investigations.

The reduction in storage can affect the dam safety. The total storage of the reservoir (including the flood storage) has been reduced from 550 Mm^3 to 450 Mm^3. The storage dedicated to flood routing has not been changed and is still 50 Mm^3. A political pressure might force the dam operators to encroach into the flood storage aiming to store more water for irrigation during the late spring, when combined rainfall/snowmelt floods are still a reality. The requirement for more water to be stored could be expected during dryer years, however the high rainfall events can still endanger the dam safety. A hydrological study utilizing PMP combined with snowmelt from reduced areas might provide an answer to how much of the flood storage can be used depending on the deposits of snow in the catchment.

The maximum capacity of the outlet structure is 399 m^3/s. A flood exceeding 550 m^3/s can cause flooding problems downstream of the dam at Karshi and Buhara. The maximum discharge value at Chimkurgan is therefore limited to 350 m^3/s, allowing 200 m^3/s to be discharged from Pachkamar dam, which is located on a tributary downstream of Chimkurgan. It is obvious that during extreme floods a full discharge of 399 m^3/s will have to be released to minimize any risk of overtopping of the dam.

5.3.3 Conclusions and recommendations

It can be concluded in general that the design discharge hydrograph has a relatively high exceedance probability of occurrence, which is not acceptable. A new, revised design hydrograph must be derived, representative of a PMF. Even if a SNIP method is adopted and the design hydrograph is defined with exceedance probability of 0.01%, it will still be necessary to determine a PMF and compare it to the SNIP design hydrograph.

The smaller reservoirs upstream are designed to a higher exceedance probability flood and it is most likely that their dambreak would seriously affect the safety of the

Chimkurgan Dam. Hydrological investigations of PMF can incorporate these reservoirs and determine their impact on dam safety.

Larger dam catchment and reduced storage due to siltation will definitely have an impact on dam safety during extreme floods, which further reinforces the need for a PMF study.

In order to assess the Chimkurgan dam safety during floods it is necessary to establish and calibrate a hydrologic model and to derive a PMF based on a combined snow melt and PMP events. Only then it will become possible to assess the dam safety and recommend appropriate measures.

5.4 Provision for Emergency Draw-down

Draw-down of the reservoir in case of emergency can be achieved using the low level outlet, giving a total flow of 350 m^3/s at full reservoir storage level. The reservoir area at full storage level is about 50 km^2, thus the initial maximum draw-down rate is around 0.57 m/day. It is reported that the reservoir could be fully drained in about 15 days.

5.5 Safety against Earthquakes

5.5.1 Seismic design criteria

In the original design seismic input parameters and stability analysis in seismic condition were carried out in accordance with procedures given in the Russian Seismic Standard (Reference 2). According to the Russian Seismic Sandard, a seismic design coefficient (k_g) is derived for a site based on MSK scale earthquake intensity. The coefficients are derived based on the one in 500 year earthquake. The required minimum factor of safety in seismic condition is always greater than unity.

However, the current practice based on the guidelines given in ICOLD Bulletin 72 (Reference 1) is to assess dam safety against two representative design earthquakes that are as follows:

OBE - Operating Basis Earthquake
MDE - Maximum Design Earthquake

Where:

- OBE, or “no damage earthquake” is the earthquake which is liable to occur on average not more than once during the expected life of the structure (of not less than 100 years). During an OBE, the dam and its ancillary works should remain functional but may need repair. The required minimum factor of safety for the OBE earthquake should be greater than unity.

- MDE or “no failure earthquake” is the earthquake that will produce the most severe level of ground motion under which the safety of the dam against catastrophic failure should be ensured. For dams which are classified to be Risk Class IV a recommended return period of MDE is 30,000 years

(Reference 3). For this earthquake displacements of the crest are assessed and compared with the allowable wave freeboard

Since the dam safety has not been assessed for OBE and MDE earthquakes it is recommended to carry out additional engineering studies (see Section 6.2.4) to evaluate dam performance in those conditions.

5.5.2 Liquefaction of fill and foundation materials

The risk that the material in the dam and its foundations might liquefy during a strong seismic event has to be assessed as a part of dam safety assessment for dams in areas with higher seismicity .

Embankment fill
Bearing in mind that the material in the Chimkurgan embankment has been placed in layers and compacted by roller, it is believed that there would be only a small risk that that material would liquefy.

Foundations
As regards the alluvium in the central part of the dam foundation, taking into account that the material has been well consolidated and densified by the weight of the embankment itself and also probably well graded with sufficient presence of fines, it is believed that there would be only a small risk that the alluvium in the foundation would liquefy. There is, however a risk of possible partial loss of strength due to material liquefaction during strong earthquakes. It is therefore recommended to carry out some in-situ testing (see Section 6.2.3) to verify properties of the embankment and foundation materials in order to assess the risk.

5.6 Safety Assessment – Summary

5.6.1 Principal matters of concern

The IC see the following as the principal matters of concern with regard to the safety of the Chimkurgan dam:

1) Doubts as to the adequacy of the flood handling capacity of the outlet works and spillway, and the increasing and adverse effect of reservoir sedimentation.
2) The possibility that damaging seepage is occurring through the embankment fill adjacent to the gate tower, which could lead to the development of cavities in the fill and local collapse.
3) Deficiencies in the embankment performance monitoring installation.
4) Am emergency situation could arise due to natural cause (e.g. floods), human error or unauthorized activity, and could endanger the downstream population. There is, however, no emergency plan or early warning system for dealing with such circumstances. Guidance is also needed to assist the supervising staff to recognize when the monitoring process indicates that a dangerous situation is developing.

5.6.2 Safety Statement

From examination of the dam and the data made available, discussions with the engineers responsible for the dam and their site studies the IC are at present unable to state with confidence that the Chimkurgan dam meets all internationally recognized safety standards.

The principal dangers facing the dam are from:

1) Floods

Hydrological studies carried out by the IC indicate that further study is needed to be confident that the spillway/draw-off works are of sufficient capacity to control the probable maximum flood (PMF) inflow to the reservoir.

The ability of the dam to control floods depends almost wholly on the hydromechanical plant. The present situation is satisfactory but a high standard of future maintenance is essential to keep the ageing equipment in 100% reliable order. Adequate standby power generation facilities are essential.

2) Structural Instability

It is probable that the embankment is not at risk from structural instability under normal conditions, but the present monitoring system does not allow its behaviour to be sufficiently closely monitored:

Possible seepage adjacent to the gate tower could be causing internal erosion, which if left unchecked could result in the formation of cavities and possible local collapse of the embankment.

The IC are presently not satisfied that the stability of the embankment under the effects of a large earthquake is assured, due to the possibility of loss of strength due to liquefaction of the saturated silt material in the embankment and foundations.

6 RECOMMENDED STUDIES, WORKS AND SUPPLIES

6.1 General

The review of the design of the dam, information obtained during the site inspections, and discussions with the site manager has enabled the IC to arrive at certain conclusions regarding the safety of the dam, which are discussed in Section 5. These conclusions, along with considerations of requirements for emergency management have provided the basis for an assessment of the need for additional studies, investigations, construction works and supplies necessary to bring the dam to an acceptable and sustainable standard of safety. However, it must be recognized that the need for further work might still become evident as an outcome of this work, as the preliminary conclusions are refined.

A more detailed specification and methodology for the work described in this Section is presented in the report `Methodology for Design of Priority Rehabilitation Measures'.

6.2 Additional Surveys, Investigations, Inspections and Studies

6.2.1 General

To provide the basic data for designing the works described below and for refining the conclusions of the safety assessment, additional information is required which is outside the scope of the present study. This work is described under the following headings:

- surveys
- ground investigations and inspections
- engineering studies

In addition, it is recommended that a dossier of 'as constructed' record drawings and other essential information relating to the design, construction and performance of the dam be assembled, and regularly updated.

Where original drawings have deteriorated they should be retraced or preferably re-drawn using a computer system. The dossier would comprise the basic source of information to be referred to when carrying out inspections or undertaking modifications in the future

6.2.2 Surveys

(1) Reservoir Bed Survey

It is understood that the last reservoir bed survey was undertaken in 1996. To provide firm data for an updated review of reservoir sedimentation and its effect on reservoir management it is recommended that a new reservoir bed (bathymetric) survey be carried out within five years. Project funding for this work is not required.

(2) Topographic Surveys

The preliminary study drawings that have been prepared for emergency spillway options are dated 1975. If these designs are to be developed further it is recommended that an updated ground survey of the area downstream of the dam be carried out.

It is understood that surveys of the embankment longitudinal crest profile and cross sections at appropriate intervals are already carried out as a routine.

6.2.3 Ground Investigations and Inspections

The following investigations and inspections are recommended:

(1) The possible existence of cavities and seepage along the concrete/embankment fill junction at the gate tower should be investigated by drilling and in-situ testing from inside the tower. The drilling would be carried out through sleeves built into the tower walls, fitted with suitable sealing devices to prevent water inflow. Cavities would be detected during the drilling process, and zones of low effective stress which might lead to hydraulic fracture in the fill adjacent to the tower would be investigated by means of multi-stage water pressure tests.

(2) Reinstatement of the embankment piezometers will involve a considerable amount of drilling in the embankment. It is recommended that during the course of this work in-situ testing should be carried out to verify the properties of the embankment material and that samples are taken for laboratory testing.

(3) Inspections

To provide information on which to base a more detailed assessment of required repairs and equipment than is possible in the present report, it is recommended that a detailed inspection of the embankment and associated works should be carried out and an inventory of defects, materials and repairs required prepared, covering:

- the embankment upstream face (inspect when reservoir is at a low level);
- improvements to embankment drainage (inspect for seepages when reservoir is at high level);
- embankment downstream face protection and surface water drainage works;
- interior of draw-off culvert, upstream and downstream of gates;
- electrical wiring etc., and lighting;
- gates and hydraulic operating equipment;
- structural and concrete works;
- steelwork (e.g. gate tower stairs and landings).

6.2.4 Additional Engineering Studies

The following additional engineering/hydrological studies are recommended:

1) Review the estimates of extreme flood inflows to the reservoir, taking into account also:

- the effect of other reservoirs in the upstream catchment, under normal conditions;
- the effect of possible failure or malfunction of other reservoirs in the upstream catchment.

2) Review reservoir management procedures using updated flood estimates and reservoir sedimentation data, and freeboard allowance for wave run-up based on updated wind data.

3) If shown to be necessary by studies under (2) above, develop options for increasing flood control capacity, at the same time maintaining an acceptable level of downstream flood protection and maximising reservoir storage.

   Possible options are:-

   - construct an independent `emergency' spillway;
   - raise the embankment and/or modify the parapet wall to allow an increase in the permissible maximum flood level.

   Alternatively, the reservoir operating rules could be modified to maintain a larger flood storage volume at critical periods.

   The emergency spillway option has important implications which should be noted, as follows:

   - Under high floods the flow capacity of the river channel would be exceeded if the present design of the spillway were adopted, resulting in flooding of adjacent land. The IC are of the opinion, however, that for the dam to provide protection of downstream areas against floods of all possible magnitudes is too severe a requirement, and that consideration should be given to adopting, as the flood protection criterion for the downstream areas, such magnitude of flood as can be justified by economic analysis.

4) Review the seismicity of the site and derive estimates of peak ground accelerations and time history for Operating Basis Earthquake (OBE) and Maximum Design Earthquake (MDE)

   Assess susceptibility of the silt material in the embankment and foundations to liquefaction.

5) Review embankment static and seismic stability on the basis of measured properties of the in-situ materials and the potential for liquefaction, and determine deformations where factors of safety during seismic shaking are less than unity, especially for the flank sections.

6) Assess degradation rates in the downstream river channel and develop designs for future modifications to the energy dissipation and erosion protection works at the draw-off outlet.

7) To optimise/improve the performance of the existing spillway, carry out model studies for possible geometric modifications presently under consideration to improve the flow conditions in the spillway shaft.

6.3 Construction Works

A preliminary assessment of the required construction works is made on the basis of the safety assessment and available data. Final details will depend on the outcome of the studies described above.

1) Embankment

Although the embankment appears to be generally in good condition the Chimkurgan dam is a major structure and it is essential that its performance is properly monitored. The performance monitoring installation should be reinstated where necessary. The following is proposed:

- install new standpipe piezometers where the existing tubes are blocked;
- install additional electrical (remote reading) piezometers at critical locations;
- install a network of surface deformation measurement markers and fixed beacons, for precise measurement of horizontal and vertical displacements.

It was noted that the arrangements for monitoring seepage flows from the downstream drainage wells were being reinstated using local resources, and it is assumed that this will be completed.

In addition, based on installation of further piezometers in the vicinity of the outlet culvert to measure the phreatic surface in this area, the dam administration proposes to carry out grouting works on the line of the main grout curtain to reduce seepage losses. About 200m length of grouting, up to 30 m deep in the underlying alluvium, has been assumed. Grouting will be carried out both from the dam crest and from within the culvert.

2) Emergency Spillway

If studies under Section 6.2.4 indicate that an emergency spillway is needed, the detailed design should be developed and the construction carried out.

3) Gate Tower

It is reported that voids in the embankment fill adjacent to the upstream section of the draw-off culvert were grouted some years ago. However, the operators report that there still appears to be evidence that seepage is occurring alongside the gate tower. If investigations demonstrate that this is the case or that zones of low effective stress in the embankment exist, which could lead to hydraulic fracture under the reservoir head, a programme of grouting should be undertaken as a matter of urgency.

The brief inspection carried out during the IC’s visit revealed some defects in the steel lining of the draw-off culvert downstream of one gate, which require attention at an early date.

The model testing of the spillway shaft referred to in Section 6.2.4(7) may lead to a requirement to carry out structural modifications at the junction with the sluiceway.

4) Hydromechanical Equipment

The safety of the dam relies heavily on the proper operation of the hydromechanical equipment. Any necessary repairs electrical renewals, etc. should be undertaken immediately, and adequate standby electricity generating plant provided. Principal works comprise:

- Replace or completely refurbish service gates in gate tower;
- Repair steel lining to gate sill in tower;
- Refurbish hydraulic actuating equipment.

5) River Channel Downstream of Stilling Basin

It is proposed to carry out further works to stabilize the river channel immediately below the stilling basin, currently affected by scour.

6) Miscellaneous

Other matters requiring attention that are discovered during the detailed inspections described above should be rectified.

6.4 Equipment and Supplies

A preliminary assessment of supplies needed, based on the IC's inspection and discussions with the site manager and NT is as follows:

(1) 51 nr piezometers. At present all piezometers are standpipe type, but consideration should be given to installing a number of additional electrical (remote reading) type in critical locations;

(2) Standby generator and associated housing and wiring;

(3) Automatic gate operating equipment, including telemetry to allow remote operation in response to an incoming flood, as recorded at the upstream flow gauging station;

(4) Early warning and communications equipment.

The list will be refined following a more detailed inspection.

6.5 Emergency Planning Studies

Past experience warns that it might not be possible to control all flood events, and it is always possible that other exceptional circumstances, human error or structural failure could give rise to an emergency situation. For this reason a comprehensive emergency plan supported by an efficient organization, communication and alarm system, is essential. Inundation and flood hazard maps showing dambreak wave arrival time and duration of inundation should be prepared, based on dambreak modelling and simulation of dambreak wave propagation in the downstream areas.

Flood damage estimates and potential loss of life should be developed on the basis of the above results.

A detailed emergency plan and instruction document should be prepared as soon as possible, of the procedures to be followed and the responsibilities the dam site manager and regional engineers, and civil authorities.

6.6 Safety Measures-Priorities

The safety measures identified above are listed in Table 6.1 and are assigned to one of three priority levels (I, II or III).

The proposed Priority Levels are:

I - High priority; work to be carried out immediately
II - Intermediate priority; work to be completed within next three years
III - low priority; the need to be kept under review.

Table 6.1 Chimkurgan Dam - Dam Safety
Priorities for Studies, Works and Supplies

Item	Studies etc	Construction Works and Supplies		
		Priority I	Priority II	Priority III
1. Surveys (6.2.2)	□			
2. Investigations and Inspections (6.2.3)	□			
3. Engineering Studies (6.2.4)	□			
4. Construction Works (6.3)				
• Instrumentation		□		
• Emergency spillway	□			□
• Grouting of embankment beneath and adjacent to gate tower		□		
• Structural modifications to gate tower	□		□	
• Refurbish hydromechanical equipment				□
• Reconstruction of downstream drop structure	□			□
5. Supplies (6.4)				
• Piezometers and deformation monitoring equipment		□	□	
• Standby Generator(s)		□		
• Automated system of technological process control		□		
• Early warning and communications equipment		□		
6. Emergency Planning Studies (6.5)	□			

7 CONCLUSIONS

On the basis of the information received and a brief inspection the IC conclude that Chimkurgan dam is in a generally satisfactory state and can safely be filled to its normal full storage level of 488.20 masl, although past experience suggests that there could be a significant risk of overtopping in an extreme flood.

High priority should be given to the following activities;

(a) reinstatement of piezometers and installation of a comprehensive deformation and seepage monitoring system, and thereafter regular monitoring or pore pressures, deformations and seepages with clear presentation of the results and interpretation and analysis by experienced dam engineers;

(b) investigation, and if necessary, grouting of cavities in the embankment adjacent to the gate tower;

(c) review of flood estimates and flood management procedures and, if necessary, the eventual construction of an emergency spillway or other works;

(d) provision of reliable standby electrical power generation facilities.

(e) establishment of a reliable early warning system for the downstream population in the event of an emergency, supported by an efficient organization and communications system.

REFERENCES

1. ICOLD Bulletin 72, 1989
2. SNIP 11-7-81, Russian standard for Seismic Design
3. 'An Engineering Guide to Seismic Risk to dams in the United Kingdom', Building Research Establishment (BRE) UK, 1991

APPENDIX A

CHIMKURGAN DAM

LIST OF DATA EXAMINED

Chimkurgan Dam

Appendix A – List of Data Examined

1. Extracts from the Report on summary of design
2. Report on World Bank Mission, June 1997.
3. Extracts from the Report on inspection and monitoring results for 1998,
4. Hydrological conditions for Kashkadarya River upstream of Chimkurgan dam, Shahidor, Tashkent, 1999.
5. Summary report on proposed additional spillway, 1985, Glarsredazirsovhozstraj, Tashkent.
6. Report on efficiency of grout curtain, Institute SANIRI, Tashkent, 1978.
7. Safety legislation for hydraulic structures in Uzbekistan, August 1999, Tashkent.

APPENDIX B

DAM HAZARD ASSESSMENT PROCEDURE

APPENDIX B – HAZARD ASSESSMENT PROCEDURE

The following procedure is used to assess the overall risk class of the dam.

Table 2B.1 Dam and reservoirs Classification Factors

	Classification Factor			
Reservoir Capacity ($10^6 m^3$)	>120 (6)	120-1 (4)	1-0.1 (2)	<0.1 (0)
Dam Height (m)	>45 (6)	45-30 (4)	30-15 (2)	<15 (0)
Evacuation requirements in the event of an emergency (No of persons)	>1000 (12)	1000-100 (8)	100-1 (4)	None (0)
Potential for downstream damage	High (12)	Moderate (8)	Low (4)	None (0)

Table B.2 Dam Risk Class

Total Classification Factor	Risk Class
(0-6)	I
(7-18)	II
(19-30)	III
(31-36)	IV

Ref: ICOLD Bulletin 72, (1989)

APPENDIX C

CHIMKURGAN DAM INSTRUMENTATION

REPORT BY SPECIALIST MR V. N.PULYAVIN

OCTOBER 1999

Inspection of instrumentation condition and dam structures observations

Chimkurgan dam

Observations of seepage regime (phreatic surface location, seepage preassures in the dam and spillway structures foundation, seepage discharge), settlements and horizontal displacements were provided on the Chimkurgan dam. For that aim, in according with design, 110 piezometers, 14 weir gauges and 262 geodetic marks including 94 for measurement of horizontal displacement and 146 for settlement measurement, and 22 extensometers were installed on the dam.

During site inspection the following was ascertain :
-damaged geodetic marks used for measurement of dam foundation settlement - 21nos
-out of order piezometers (blocked, silted etc.) - 58nos
-out of order weir gauges - 2nos.
-one downstream gauge for measurement of water discharge in Karadariya river is damaged

Observations of seepage through the dam and foundations are carried out regularly (every 7-10 days) by means of available instrumentation. Geodetic observations for settlement and displacement of water reservoir structures were carried out in 1997 and 1998.

Full scale observations data are analyzed by experts of MOAWR of Uzbekistan. Analysis of full scale observations data determined the following**:**
- maximum position of the phreatic surface is lower than designed;
- maximum seepage discharge through the dam and foundations, measured in drainage works for the last years, including 1997-1998, came to 540-550 l/s which is 2 times more than designed. A tendency of reduction of seepage has been observed but that is due to malfunctioning of the drainage works;
- grouting curtain in the dam foundation discharges its function
- the first drainage line is out o order;
- dam settlements have not ceased yet, they increase by 3-5mm / year;

There is an intensive pulsation of hydrodynamic head during operation of the emergency spillway due to spillway design features. The water comes to undulation flow in the pipe that in its turn leads to head pressure regime on the single area and reduces capacity of the whole structure. The flow velocity at the maximum discharge reaches 20m/s which can lead to cavitation.

SUMMARY AND RECOMMENDATIONS

Quantity and technical condition of instrumentation used for dam monitoring at present does not allow control of Chimkurgan dam safety to the required standards. The following is recommended:

1. Rehabilitate survey bench marks used for settlement measurement - 1no
2. Install new piezometers - 8nos
3. Set weir gauges - 2nos
4. Construct a new gauge - 1no
5. For measurement of hydrodynamic head pulsation and concrete abrasion it is necessary to install
- sensor of pressure pulsation -20nos
- sensor of concrete destruction -12nos
6. Purchase of electrical piezometers - 3 nos

DRAWINGS