KYRGYZ REPUBLIC
DEPARTMENT OF WATER RESOURCES

WATER MANAGEMENT IMPROVEMENT PROJECT
REVIEW OF DAM SAFETY ISSUES
(JULY-AUGUST 2005)

MISSION REPORT

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Prepared for: Department of Water Resources
Kyrgyz Republic

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1. INTRODUCTION

The Mission took place between July 29 to August 11, 2005, for a total of 14 days spent in Kyrgyzstan collecting information and inspecting dams. The scope of the mission was to inspect 13 dams (see Table 1) in order to identify the main pending safety issues, propose activities to improve dam safety, define priorities and provide preliminary cost estimates, where appropriate. With the exception of Kirov, which is a concrete buttress structure, all the inspected dams are earth embankments.

We had the opportunity to visit a first time 6 of the 13 inspected dams (i.e., Papan, Naiman, Orto Tokoi, Ala-Archa (off-line), Ala-Archa (impounding), Kirov) in the year 2001, and to visit again, for the second time, Orto Tokoi dam in the year 2002. The FAO/World Bank report prepared by Mr. Hinks in 1997 provides information on 11 out of the 13 inspected dams (all of them except Issyk-Ata and Tort-Kul), whereas for some of the dams more detailed examination reports were prepared, at a later stage, by Temelsu/Gibb. As far as the latter reports are concerned, during the mission we were able to get hold of only a few of them: Papan, Orto Tokoi, Kirov, Bazar-Korgon, and Ala-Archa (impounding). For 2 out of the 13 inspected dams (Issyk-Ata and Tort-Kul) no previous reports were available.

We were also given 13 reports, one for each inspected dam, prepared by the local Oblast offices of the Department of Water Resources. These reports contain proposals for the rehabilitation works to be carried out at each dam, and cost estimates are also provided for most items.

Due to the very limited time available, in this report emphasis is placed on the most relevant issues, and in particular on those aspects which were not reported before by other consultants. An effort was also made to update the cost estimates presented in the 1997 FAO/WB inspection report for those items which are still pending.

The cost estimates in US Dollars presented in this report are often uncertain and should be regarded as preliminary only. As far as the gates/valves are concerned, no specific manufacturer quotations were available and therefore preliminary evaluations based on known or assumed steel weight were performed. Where the valves are supposed to require repair works, a fraction of the estimated cost for replacement was allowed for. Occasionally the estimates provided in the 1997 FAO/WB report were updated applying a tentative increase factor of the order of 1.5. The costs of earthworks for reservoir de-siltation, construction of compacted earthfill and provision of rock rip-rap depend largely on transportation, and therefore on the distance from the borrow pit/disposal site to the dam/reservoir. A distance within 2.5km from the reservoir/dam was assumed for the soil borrow pit and for the disposal site, whereas a distance in excess of 50km was assumed for quarry rock (i.e., rip-rap). A number of unit costs applicable to Kyrgyzstan were provided by a KDI cost engineer. They were not applied strictly, though, especially in those cases where an international contractor may have to be involved.
## TABLE 1: INSPECTED DAMS

<table>
<thead>
<tr>
<th>Reservoir</th>
<th>Reservoir volume [Mm$^3$]</th>
<th>Dam height [m]</th>
<th>Year of construction</th>
<th>Impounding reservoir</th>
<th>Catchment area [km$^2$]</th>
<th>ICOLD risk category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Papan</td>
<td>260.000</td>
<td>120.00</td>
<td>1985</td>
<td>Yes</td>
<td>2420</td>
<td>IV</td>
</tr>
<tr>
<td>Naiman</td>
<td>39.50</td>
<td>40.50</td>
<td>1966</td>
<td>No</td>
<td>-</td>
<td>IV</td>
</tr>
<tr>
<td>Torgul</td>
<td>90.00</td>
<td>34.00</td>
<td>1971</td>
<td>No</td>
<td>-</td>
<td>IV</td>
</tr>
<tr>
<td>Bazar-Korgon</td>
<td>22.50</td>
<td>25.00</td>
<td>1962</td>
<td>No</td>
<td>-</td>
<td>III</td>
</tr>
<tr>
<td>Spartak</td>
<td>22.80</td>
<td>15.00</td>
<td>1978</td>
<td>Yes</td>
<td>600</td>
<td>III</td>
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<tr>
<td>Sokuluk</td>
<td>11.50</td>
<td>22.50</td>
<td>1968</td>
<td>Yes</td>
<td>500</td>
<td>III</td>
</tr>
<tr>
<td>Orto Tokoi</td>
<td>470.00</td>
<td>52.00</td>
<td>1956</td>
<td>Yes</td>
<td>5970</td>
<td>IV</td>
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<tr>
<td>Kirov</td>
<td>570.00</td>
<td>86.00</td>
<td>1975</td>
<td>Yes</td>
<td>7940</td>
<td>IV</td>
</tr>
<tr>
<td>Tort-Kul</td>
<td>1.41</td>
<td>19.00</td>
<td>1972</td>
<td>No</td>
<td>-</td>
<td>II-III</td>
</tr>
<tr>
<td>Issyk-Ata</td>
<td>3.00</td>
<td>31.00</td>
<td>1979</td>
<td>No (?)</td>
<td>-</td>
<td>II</td>
</tr>
<tr>
<td>Ala Archa (off-line)</td>
<td>51.00</td>
<td>24.50</td>
<td>1966</td>
<td>No</td>
<td>-</td>
<td>III</td>
</tr>
<tr>
<td>Ala Archa (impounding)</td>
<td>90.00</td>
<td>35.00</td>
<td>1986</td>
<td>Yes</td>
<td>233</td>
<td>IV</td>
</tr>
<tr>
<td>Stepninski</td>
<td>0.80</td>
<td>3.50</td>
<td>1932</td>
<td>No</td>
<td>-</td>
<td>II</td>
</tr>
</tbody>
</table>
2. MAIN CONCLUSIONS AND RECOMMENDATIONS

Many of the safety issues highlighted in this report are not new as they were reported by other consultants several years ago. A number of them, however, are still to be solved. Other issues, on the other hand, can be regarded as new in that they were not reported before. The main objective of this report is to bring to the attention of the DWR these new safety issues, some of which require immediate action in order to prevent possible deterioration of the safety conditions of the dams.

In general it is observed that most urgent problems affecting some of the dams are related to lack of funds which didn’t allow satisfactory maintenance activities to be carried out for a number of years. Gates and valves often require to be replaced or at least repaired after a few decades of service, piezometers are often out of order and need to be cleaned or replaced, surface embankment protection and drain systems occasionally need rehabilitation, steel works and electric equipment are often in need of replacement. In some cases the safety criteria adopted in the original design need to be reviewed in light of the current state of the practice, whereas occasionally modifications to the design scheme performed during construction or after several years of operations need be re-evaluated from a safety standpoint. All dams were operated successfully for several decades, although at least one incident with no major consequences was reported. Some of the dams are now affected by seepage problems which need be investigated and solved with no delay in order to prevent or stop erosion processes which, if neglected, may lead to serious distress or even failure of the embankments. The frequent presence or fine low-plasticity loess-like soils in the dam foundations and in the abutments, the use of the same soil type as construction material for the embankments and the lack of adequate filter zones in some of the dams may encourage development of suffosion and pseudokarst sink-holes.

The reservoir hydrology of Papan, Orto Tokoi, Kirov, Bazar-Korgon, Spartak and Ala-Archa (impounding) has been reviewed a few years ago by Temelsu/GIBB in their dam examination reports. The same type of study should be carried for the other dams in order to verify the magnitude of the floods which can be expected to occur at the dam site for a range of annual probabilities of occurrence, and to establish proper remedial measures, where needed. Attention should also be paid to the seismic stability of the dams and to the resistance to earthquake-induced liquefaction of both the embankments and the foundations. Kyrgyzstan is a seismically active country, and the studies carried out so far on this topic (i.e., Temelsu/GIBB - dam examination reports) leave room for concern in a number of cases. Probabilistic seismic hazard analyses and specific soil investigations should be carried out at all dam sites where such information is not yet available.

A brief summary of the main new safety issues highlighted in the report are summarized in the following lines.

According to what we were told by local engineers, Spartak dam and Sokuluk dam are both affected by a 50% reduction of the draw-off works capacity due to gate jamming in the closed position. This is a very serious problem given that Spartak has no emergency spillway and that the emergency spillway at Sokuluk is suspected to be insufficient to discharge the 1:10,000 year flood. In addition Sokuluk dam is located upstream of the Spartak reservoir, and therefore its safety affects also the safety of Spartak. The gates need to be lifted, inspected and repaired/replaced immediately.
The emergency spillway at Tork-Kul dam was buried in order to increase the FSL by 1.5m to make up for what is said to be heavy reservoir siltation. This modification, which was implemented in 1997, appears to expose the dam to an unacceptable risk level. The spillway should be re-activated with no delay and the concrete works shall be repaired as needed. The original FSL shall be restored. At the same time the hydrology of the reservoir should be reviewed. The upstream face of the 2nd stage embankment is not protected from waves and is deeply eroded and scoured. It should be restored using well compacted granular soil, and its surface should be protected by means of good quality rip-rap. The downstream face was found to be affected by seepage and shallow instability. Some drainage measures are needed and piezometers should be placed to evaluate the seepage regime in the dam body. Toe berms may also be required to increase dam stability to an acceptable level, and specific analyses both in static and seismic conditions should be carried out.

At Bazar-Korgon the dam appears affected by internal erosion, most likely due to migration of the fine loess particles into the highly permeable gravel-pebble foundation unit. Pseudokarst sinkholes were observed both in the left abutment and in the downstream dam face near the left abutment. Bubbling of the reservoir water was also observed, which could be due to localized downward seepage of water through the dam upstream shell and loess blanket. A detailed surface survey should be carried out immediately to locate the holes which were observed during the past few year and try to identify the most troublesome area. This is probably near to the left abutment were abnormal settlements were noted in the past leading to an overtopping incident. The water level in the reservoir should be lowered to inspect the upstream face of the dam removing the concrete slabs where needed. Then a geotechnical investigation should be planned and implemented and piezometers should be installed to investigate seepage in the dam body, in the dam foundation and in the left abutment. The crest level should be checked by a topographical survey and measures to restore the original freeboard should be adopted. Finally measures to prevent further erosion should be adopted. As a first step the sink-holes should be filled down to the bottom of the loess layer either with silt, cement-bentonite mixtures or other suitable materials. The downstream slope of the dam will be protected from running water by placing concrete or steel surface channels of suitable size.

Seepage problems which were not reported before were also seen or reported at Stepninski dam and at Torgul west dam. In the first case cleaning of the downstream face of the dam is required to allow more reliable inspection of wet spots and springs on the dam body. Some drainage systems and a gravel toe may also need to be provided near the outlet works. In the second case a large wet spot is said to become visible on the downstream side of the left abutment when the water surface in the reservoir exceeds a critical level. In both cases piezometers need to be placed in the very short term to monitor such processes, evaluate dam stability and define further action.

The priorities established for the works recommended in this report (see following sections) are summarized in Table 2. Note, however, that all recommended works shown in Table 2 are deemed necessary for dam safety.
<table>
<thead>
<tr>
<th></th>
<th>PRIORITY</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Papan</strong></td>
<td>1</td>
</tr>
<tr>
<td>Plunge pool</td>
<td></td>
</tr>
<tr>
<td>Increase capacity of air vent to decrease gate vibrations</td>
<td></td>
</tr>
<tr>
<td>Rehabilitate outlet tunnel</td>
<td></td>
</tr>
<tr>
<td><strong>Naiman</strong></td>
<td>2</td>
</tr>
<tr>
<td>Piezometers and settlements stations</td>
<td></td>
</tr>
<tr>
<td>Gate and butterfly valves</td>
<td></td>
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<tr>
<td><strong>Torgul</strong></td>
<td>3</td>
</tr>
<tr>
<td>Replace/repair gates and startors</td>
<td></td>
</tr>
<tr>
<td>Install new piezometers</td>
<td></td>
</tr>
<tr>
<td>Provide drainage</td>
<td></td>
</tr>
<tr>
<td><strong>Bazan Korgon</strong></td>
<td>4</td>
</tr>
<tr>
<td>Replace concrete slabs</td>
<td></td>
</tr>
<tr>
<td>Repair/replace gates at the dam</td>
<td></td>
</tr>
<tr>
<td>Install piezometers and settlement stations</td>
<td></td>
</tr>
<tr>
<td>Carry out surface survey and geotechnical investigation</td>
<td></td>
</tr>
<tr>
<td>Repair sinkholes and provide measures to prevent water infiltration</td>
<td></td>
</tr>
<tr>
<td><strong>Spartak</strong></td>
<td>5</td>
</tr>
<tr>
<td>Install new piezometers</td>
<td></td>
</tr>
<tr>
<td>Inspect and repair gates and service actuators</td>
<td></td>
</tr>
<tr>
<td>Raise crest level in low areas</td>
<td></td>
</tr>
<tr>
<td>Construct independent spillway</td>
<td></td>
</tr>
<tr>
<td>Provide emergency generator</td>
<td></td>
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<tr>
<td><strong>Sokuluk</strong></td>
<td>6</td>
</tr>
<tr>
<td>Install new piezometers and settlement stations</td>
<td></td>
</tr>
<tr>
<td>Inspection and repair/replacement of the gates and actuators</td>
<td></td>
</tr>
<tr>
<td>Repair concrete slabs on the upstream face</td>
<td></td>
</tr>
<tr>
<td>Provide radio communication system.</td>
<td></td>
</tr>
<tr>
<td>Fix downstream drainage system</td>
<td></td>
</tr>
<tr>
<td>Prevent erosion of the outlet channel</td>
<td></td>
</tr>
<tr>
<td><strong>Orto Tokoi</strong></td>
<td>7</td>
</tr>
<tr>
<td>Replace gates</td>
<td></td>
</tr>
<tr>
<td>Install new piezometers</td>
<td></td>
</tr>
<tr>
<td><strong>Kirov</strong></td>
<td>8</td>
</tr>
<tr>
<td>Stabilise landslip</td>
<td></td>
</tr>
<tr>
<td>Repair/replace cone valves</td>
<td></td>
</tr>
<tr>
<td>Shotcrete left abutment</td>
<td></td>
</tr>
<tr>
<td>Stabilise landslip</td>
<td></td>
</tr>
<tr>
<td>Repair/replace cone valves</td>
<td></td>
</tr>
<tr>
<td><strong>Tort-Kul</strong></td>
<td>9</td>
</tr>
<tr>
<td>Reactivate emergency spillway</td>
<td></td>
</tr>
<tr>
<td>Replace/repair gates and outlet canal</td>
<td></td>
</tr>
<tr>
<td>Repair and protect upstream face of 2nd phase dam</td>
<td></td>
</tr>
<tr>
<td>Provide drainage downstream</td>
<td></td>
</tr>
<tr>
<td>Install piezometers and settlement stations</td>
<td></td>
</tr>
<tr>
<td><strong>Issyk-Ata</strong></td>
<td>10</td>
</tr>
<tr>
<td>Repair/replace gates and fix outlet lining</td>
<td></td>
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<tr>
<td>Protect upstream face with rip-rap</td>
<td></td>
</tr>
<tr>
<td>Install piezometers</td>
<td></td>
</tr>
<tr>
<td>Prevent erosion due to running water</td>
<td></td>
</tr>
<tr>
<td><strong>Ala Archa (off-line)</strong></td>
<td>11</td>
</tr>
<tr>
<td>Install new piezometers</td>
<td></td>
</tr>
<tr>
<td>Inspect and repair gates</td>
<td></td>
</tr>
<tr>
<td>Repair erosion at dam toes</td>
<td></td>
</tr>
</tbody>
</table>

(continue)
<table>
<thead>
<tr>
<th>Priorities</th>
<th>Ala Archa (impounding)</th>
<th>Stepninski</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Install new piezometers, survey monuments, settlement stations, weir</td>
<td>Drop structure</td>
</tr>
<tr>
<td>2</td>
<td>Inspect and repair/replace gates</td>
<td>Rip-rap at upstream face locations</td>
</tr>
<tr>
<td>3</td>
<td>Inspect and repair cone valves</td>
<td>Install new piezometers</td>
</tr>
<tr>
<td>4</td>
<td>Construct the ends of the dam to the current crest level</td>
<td>Clean downstream face</td>
</tr>
<tr>
<td></td>
<td>Repair radio station</td>
<td>Repair/replace gates at outlet works and spillway and repair stilling basin</td>
</tr>
<tr>
<td></td>
<td>Repair cranes and renew ventilation system</td>
<td>Provide downstream drainage in the areas affected by seepage</td>
</tr>
<tr>
<td></td>
<td>Provide emergency spillway</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Provide emergency generator</td>
<td></td>
</tr>
</tbody>
</table>
3. ALA-ARCHA (OFF-LINE)

3.1 General

The Ala-Archa off-line dam was inspected on August 2, 2005.

The Ala-Archa off-line reservoir is located in the Chui Oblast, Alamedin Rayon, about 10km north of Bishkek. The reservoir is fed by an incoming canal 11.2 km long with a nominal capacity of 18 m$^3$/s although this has been reduced to some extent by siltation. The extension of the irrigated area is 17,300 ha.

The reservoir is retained by an east dam and by a west dam and has a capacity of 51.6 Mm$^3$. The day of the inspection the reservoir volume was 28 Mm$^3$. The east dam is 24.5m high and of fairly short length, whereas the west dam is 21m high and 7.2km long. The dam was constructed in 1965 and undertook some rehabilitation works in 1980. There is no emergency spillway at the dam.

It is reported that 14,500 people live downstream of the dam.

In the FAO/WB 1997 report a risk class III (second highest category) is proposed for this dam based on ICOLD Bulletin 72. An operating manual with emergency procedures is available.

3.2 Dam

The crest elevation of the dams is 690.5 masl and the Full Storage Level (FSL) is 689.0 masl, with a 1.5m freeboard. The Dead Storage Level (DSL) is 676 masl. The dam embankments are reported to be made of homogeneous loam.

The upstream face of the east dam is protected by reasonably good quality concrete slabs (Photo 3.1), and there is a 1.0m high wavewall which is interrupted at the access bridge (Photo 3.2). The embankment appears in a good state, and no relevant seepage was observed during the inspection or reported by the dam personnel (Photo 3.3).

The crest of the west dam carries a road which is in fairly bad conditions. There is a 1.0 m high wavewall. The upstream face of the dam (Photo 3.4) is protected by means of good quality rip-rap, except immediately beneath the wavewall (Photo 3.5). The embankment appears in a good state, and no relevant seepage was observed during the inspection (Photo 3.6) or reported by the dam personnel. According to the 1997 FAO/WB report the toe of the west dam undertook significant settlements (up to 1.0 m) during the first 2 to 3 years after construction. Such event may raise some concern on the stability of the embankment.

None of the 70 piezometers which were installed during construction are currently in working order.

3.3 Outlet Works

The outlet works are in the east dam and are reported to have a design capacity of 18m$^3$/s, but current outflow is on the order of 10m$^3$ (Photo 3.7). They are equipped with four 1600mm gate valves (Photos 3.8 and 3.9) which can be operated from an upstream shaft.
(Photo 3.10). It is understood that these gates were never replaced since dam construction and were not properly maintained for the past 20 years due to lack of funds. The electric drives are out of order and the gates must be operated manually. The gates are reported to be corroded. No emergency generator is available, and most electric cables are said to be out of order and need be replaced.

3.4 Recommended Works

The following works are deemed necessary to provide the required margin of safety at the dam:

1) Install 30-35 new piezometers ($110,800).
2) Complete rip-rap protection on the upstream face of the west dam (at a later stage – not estimated).
3) Repair 4 gates ($46,000) and electric actuators (not estimated).
4) Provide emergency generator (not estimated).
5) Repair erosion at toe of both dams ($40,000).

3.5 Recommended Studies and Monitoring Activities

a) Monitor settlements of embankment.
b) Monitor piezometers.
c) Monitor drainage water.
d) Arrange expert review of monitoring data.

Site investigation and stability analyses should also be considered, including seismic stability analyses.
4. ALA-ARCHA (IMPOUNDING)

4.1 General

The Ala-Archa impounding dam was inspected on August 2, 2005.

The Ala-Archa impounding reservoir is located in the Chui Oblast, Alamedin Rayon, about 10 km north of Bishkek. The dam was designed by Kyrgyzgiprovodhoz; its construction was started in 1978 and completed to its present state in 1986, when construction was terminated with the embankment crest about 5.5m below its final design elevation. The dam undertook some rehabilitation works (i.e., replacement of 1800m electric cables of cone valves) in 2003-2004.

The current reservoir capacity is limited to about 80.0 Mm$^3$ because of the risk of overtopping at the right end of the embankment where the crest level is low. A catchment area of 405 km$^2$ and a reservoir water surface of 0.7 km$^2$ at FSL is reported Temelsu/GIBB (1999), whereas the extension of the irrigated area is 18,933 ha. It is reported that 24,000 people live downstream of the dam. There is no emergency spillway at the dam.

In the FAO/WB 1997 report a risk class IV (highest category) is proposed for this dam based on ICOLD Bulletin 72. An operating manual with emergency procedures is said to be available.

4.2 Dam

The dam is 35m high and its length at crest level is 1.2 km. The present crest elevation of the dam is 665.5 masl with rip-rap on the upstream face (Photo 4.1) placed to level 660.4 masl. At each abutment of the dam the current crest level is considerably lower than the general crest level (see right abutment in Photo 4.2). The Full Storage Level (FSL) is 658.0 masl, whereas the Dead Storage Level (DSL) is 636.0 masl. The dam embankment is made of homogeneous loess-like loam.

Between levels 664.0 and 652.0 masl the upstream face of the dam has a 1:5 slope protected by rip-rap, whereas below level 652.0 masl the upstream face of the dam has a 1:10 slope protected by a 50cm thick cobble layer. There is no wavewall. The downstream face of the dam is grassed, and has a 1:3.5 slope above 662.0 masl, and 1:4.5 to 1:5 slope below 662.0 masl (Photo 4.3). The embankment appears in a good state, and no relevant abnormal seepage was observed during the inspection or reported by the dam personnel. A total seepage of 25 l/s has been reported.

None of the piezometers which were installed during construction are currently in working order.

4.3 Outlet Works

The outlet works have a maximum design capacity of 50m$^3$/s, but discharges are normally limited to 9-10m$^3$/s. They comprise twin reinforced concrete culverts 3.3m x 4.75m in cross section beneath the dam, each housing a 1.6m diameter pipe (Photo 4.4). A chamber at the upstream end of each culvert houses 2 gates per pipe (Photo 4.5). The only means of access to the gate chambers is up the culverts which are 400m long. The ventilation
system of the culverts is not working properly and should be fixed. The two traveling cranes are also in poor conditions and should be repaired. The 1.6m diameter cone valves (Photo 4.6) also have a number of problems and need be repaired.

Provision of a new emergency spillway was recommended by Temelsu/GIBB (1999) in order to decrease the risk of overtopping.

No emergency generator is available at the dam.

4.4 Recommended Works

1) Install 40 piezometers, survey monuments and settlement stations. ($ 227,000)
2) Install weirs for seepage monitoring (not estimated).
3) Construct the ends of the dam to the current crest level. ($ 1,000,000)
4) Radio station black-out problems should be solved. (not estimated)
5) 2 gates should be inspected and repaired ($ 23,000).
6) 2 cone valves should be inspected and repaired ($ 55,000).
7) Cranes needed in outlet culverts ($ 97,500)
8) Renew forced ventilation system. ($ 50,700)
9) Provide emergency spillway (not estimated).
10) Provide emergency generator (not estimated).

4.5 Recommended Studies and Monitoring Activities

a) Monitor settlements of embankment.
b) Monitor piezometers.
c) Monitor seepage.

Site investigation and updated analyses should be considered in order to update the seismic stability analyses of the embankment and soil resistance to liquefaction.
5. SPARTAK

5.1 General

The Spartak dam was inspected on August 3, 2005.

Spartak reservoir is located in the Chui Oblast, Moskovski Rayon, about 45km northwest of Bishkek. The reservoir is located on the Sokuluk river, a short distance downstream of Sokuluk dam. The dam was designed by Kyrgyz giprovodhoz, and it was completed to its present state in 1979. A further stage will involve, some time in the future, raising the embankment by additional 4m. At present the dam is about 12m high above the original riverbed, and 2.6 km long. The reservoir has a surface area of 5.9 km$^2$, a capacity of 22.8 Mm$^3$ and an irrigation area of 3,129 ha. The catchment area is about 704km$^2$.

In the FAO/WB 1997 report a risk class III (second highest category) is proposed for this dam based on ICOLD Bulletin 72. An operating manual with emergency procedures is said to be in place. A radio communication system is said to be available.

5.2 Dam

The dam is composed of composite compacted silt and gravel embankment. Beneath the dam there is a 7m layer of pebbles and clay which is intersected by the cut-off trench. Beneath the cut-off trench is slightly permeable clay.

The crest of the dam is about 8m wide. The upstream face (Photo 5.1) above 601.0 mASL is protected by rip-rap and slopes at 1:3.0, whereas below 601.0 mASL it is protected by a gravel layer and slopes and at 1:7. The downstream face slopes at 1:2.75 to 1:4.0, and appears in reasonably good conditions (Photo 5.2). The actual crest elevation and freeboard should be checked.

5.3 Outlet Works

The outlet works have a maximum design capacity of 40m$^3$/s. They comprise twin reinforced concrete culverts 1.75m x 2.20m in cross section beneath the dam (Photo 5.3), each controlled by two 1.6m diameter cast iron slide gates equipped with drive motors and gearboxes (Photo 5.4). All this equipment needs to be repaired. Two out of four gates are said to be jammed in the closed position, and therefore the actual maximum discharge does not exceed 50% of the design value. This situation is unacceptable from a safety standpoint as the dam relies completely on draw-off works to prevent discharge floods from causing dam overtopping. All valves need to be lifted out when the reservoir is empty in order to inspect them and establish suitable remedial measures. Each of the gate valves weighs 6 t.

The shaft structure appears to be in reasonable conditions, but the steelwork in the shaft is corroded. The gate house structure on top of the gate shaft has a temporary cover, pending completion of the dam to its full weight.

Evaluations presented in the FAO/WB inspection report (1997) show that the discharge capacity may be insufficient to pass a flood of long return period. In addition, the flood hydrology study carried out by Temelsu/GIBB (1999) led to the conclusion that an
emergency spillway should be provided in order to obtain and acceptable level of safety as far as hydrologic risk is concerned.

No emergency generator is available at the dam.

5.4 Recommended Works

1) Inspection and repair of gates ($69,000) and service actuators (not estimated).
2) Install 25 piezometers and settlement stations ($56,000).
3) Raise crest level in low areas and adjust profile to true line and level at nominal +605.5masl ($205,000).
4) Construct independent spillway (not estimated).
5) Provide emergency generator (not estimated).

5.5 Recommended Studies and Monitoring Activities

The design of a new emergency spillway should be undertaken in order to evaluate its cost and propose possible technical solutions. Site investigation and updated analyses should be considered in order to evaluate seismic stability of the embankment and soil resistance to seismic liquefaction.
6. SOKULUK

6.1 General

The Sokuluk dam was inspected on August 3, 2005.

Sokuluk reservoir is located in the Chui Oblast, Sokuluk Rayon, about 30 km northwest of Bishkek. The reservoir is located on the Sokuluk river, a short distance upstream of Spartak dam. The dam, which was completed in 1968 and undertook some rehabilitation works in 2002, is about 22.5m high and 3 km long. The reservoir has a surface area of 1.77 km$^2$ and a capacity of 11.5 Mm$^3$. It serves an irrigation area of 4,130 ha. The catchment area is 547km$^2$.

The dam has not a reliable communication (e.g., radio) system to connect the dam with the oblast office.

In the FAO/WB 1997 report a risk class III (second highest category) is proposed for this dam based on ICOLD Bulletin 72. An operating manual with emergency procedures is said to be not available, and the emergency procedures are reported to be insufficient to face emergency situations.

6.2 Dam

The dam includes a homogeneous embankment made of loess-like loam.

The crest of the dam is about 8m wide. The crest level is at 660 mASL whereas the FSL is reported to be 658m. Therefore the freeboard at FSL is 2m. The upstream face above 646.0 mASL is protected by concrete slabs (Photo 6.1) and slopes at 1:2.75 to 1:4.0, whereas below 646.0 mASL it is protected by a gravel layer and slopes and at 1:5. At the main cross section the downstream face slopes at 1:2.75 to 1:4.0, and its conditions appear reasonably good (Photo 6.2).

Part of the concrete slabs on the upstream face have suffered some damage and need be repaired or replaced. There is non wavewall on top of the dam which carries a 7.5m wide road.

Part of the drainage system downstream of the dam need to be repaired. In particular the buried pipes evacuating drainage water from the embankment toe is partly clogged and induce significant seepage at the downstream toe of the dam. According to the local dam engineer the seepage pattern in the embankment is not significantly affected by the downstream leakage.

6.3 Outlet Works and Spillway

The outlet works have a maximum design capacity of 40m$^3$/s. They comprise four 1.2m diameter gate valves (Photo 6.3). Two out of four gates are said to be jammed in the closed position, and therefore the actual maximum discharge does not exceed 50% of the design value. This situation is unacceptable from a safety standpoint as the dam relies considerably on draw-off works to prevent discharge floods from causing dam overtopping. All valves need to be lifted out when the reservoir is empty in order to inspect them and establish suitable remedial measures. The shaft structure appears to be
in reasonable conditions, but the steelwork in the shaft is corroded, and dangerous for operation personnel.

The spillway (Photo 6.4) can probably discharge up to 25 m$^3$/s. In the FAO/WB 1997 report it was estimated that the capacity of the spillway and of the draw-off works may be sufficient to discharge the 1000 year flood but not the 10,000 year flood. Safety implications derive not only for Sokuluk dam, but also for Spartak dam which is located downstream of Sokuluk.

The outlet channel downstream of the dam is affected by significant erosion (Photo 6.5). It could not be observed in detail due to very high vegetation and difficult accessibility. Although it didn’t seem to pose an immediate threat to the dam it should be repaired to prevent future retrogressive erosion.

6.4 Recommended Works

1) Repair or replacement of concrete slabs. ($ 52,000)
2) Inspection and repair of the gates ($ 69,000) and actuators (not estimated).
3) Provide communication system. (not estimated)
4) Clean, repair and install new piezometers and settlement stations ($ 39,000).
5) Fix downstream drainage system. ($ 50,000)
6) Prevent erosion in the outlet channel ($ 120,000).

6.5 Recommended Studies and Monitoring Activities

An operation manual with emergency procedures should be prepared with no delay. Site investigation and analyses should be considered in order to evaluate static and seismic stability of the embankment and soil resistance to liquefaction. An hydrology study will be performed.
7. STEPNINSKI

7.1 General

The Stepninski dam was inspected on August 3, 2005.

Stepninski reservoir is located in the Chui Oblast, Jaiyl Rayon, northwest of Bishkek. The reservoir is filled by a canal from the Kara-balta river. The dam was completed in 1932 and undertook some rehabilitation works in 1999. The reservoir has a surface area of 0.35 km$^2$ at FSL and a capacity of 0.842 Mm$^3$, which went down to 0.674 Mm$^3$ due to silting. It serves an irrigation area of 1,880 ha.

In the FAO/WB 1997 report a risk class II is proposed for this dam based on ICOLD Bulletin 72. A manual with emergency procedures is said to be not available, and a communication radio system is said to be available.

7.2 Dam

The dam is only a few meters high (up to 10m) and 1.2km long and the outlet pipe is about 6m below the crest. The dam crest is about 3m wide. The minimum freeboard is said to be 1m when the reservoir is full. Because of the small freeboard the reservoir is usually filled only up to 80% its nominal capacity. The upstream face (Photo 7.1) of the dam is protected with gravel and pebbles only.

Most of the downstream face (Photo 7.2) is also hidden by very high vegetation which should be cut in order to permit better inspection of seepage and erosion problems. Next to the outlet works (Photo 7.3) the dam is affected by some seepage and clear water springs are said to appear when the reservoir level is high.

7.3 Outlet Works and Spillway

There is a 1m diameter outlet pipe (Photo 7.3) with a capacity of about 5m$^3$/s, equipped with a valve on the upstream end (Photos 7.4 and 7.5) which can be opened and closed manually. The outlet pipe discharges into a concrete lined channel. In the 1997 FAO/WB report the presence of at least another outlet located only 1.8m below the crest of the dam is mentioned. We found no evidence of such outlets during our visit to the dam. In the rehabilitation proposal prepared by the local DWR engineers it is mentioned that “valves” were replaced in 1999, but this information was not confirmed during the site visit.

The spillway has a nominal capacity of 25m$^3$/s, and comprises three 1.4 x 2.0m gates which can be opened manually (Photo 7.6). The gates are corroded and one of them is bulged and stuck in the closed position. There are stoplogs 3.5m long by 800 mm high on both sides of the structure. The concrete stilling basin is cracked and leaking.

The spillway channel is unlined and badly eroded (Photo 7.7). The erosion area is a few hundred meters downstream of the dam and is said to move towards the reservoir due to a retrogressive mechanism. A drop structure was designed several years ago in order to stop the erosion process, but up to now it was not constructed.
7.4 Recommended Works

1) Install piezometers ($17,700).
2) Inspection and repair/replacement of the gates at the outlet works and at the spillway and repair of the stilling basin ($15,000).
3) Clean downstream slope to allow better seepage monitoring ($16,000).
4) Assume to provide localized downstream drainage in the areas affected by seepage ($30,000).
5) Protect most exposed areas of upstream face with rip-rap ($42,800).
6) Protect from erosion the outlet channel ($200,000).

7.5 Recommended Studies and Monitoring Activities

a) Monitor piezometers.
b) Check hydrology.
c) Check static and seismic dam stability.
d) Provide emergency procedures and instruct personnel accordingly.
e) Monitor erosion process in the spillway channel.

Site investigation and analyses should also be considered in order to evaluate static and seismic stability of the embankment and soil resistance to liquefaction.
8. BAZAR-KORGON

8.1 General

The Bazar Korgon dam was inspected on August 4, 2005.

The Bazar Korgon reservoir is located in the Jalal-Abad Oblast, Bazar Korgon Rayon, about 20 km northwest of Jalal-Abad. The reservoir is fed by a canal from an intake of the Kara Ungur river, about 15 km north of the dam. It is regarded as being an off-line reservoir although it has a catchment area of about 130 km².

The dam was designed by Kyrgyzgiprovodhoz, construction was completed in 1962 and the most recent rehabilitation works were carried out in 1975. The total reservoir capacity is 22.5 Mm³, but due to siltation the actual total capacity is about 17.0 Mm³. The dam has no emergency spillway. The day of the inspection the water level in the reservoir was 5.9m below the dam crest. The reservoir water surface area at FSL is 2.67 km², and the extension of the irrigation area is 3,978 ha.

After construction about 250 suffosional pseudokarst sinkholes were observed at the bottom of the reservoir with large seepage in the dam foundation. These cavities are due to migration of the loess-like soil particles at the bottom of the reservoir into the deeper, highly permeable, gravel-pebble unit. Cracks were also observed and one of them was detected across the dam body near the left abutment. In 1967 a 0.5m thick layer of local silt was laid down to prevent reservoir leakage, by the attempt proved unsuccessful. Subsequently, in 1973, the bottom of the reservoir was lined with a polyethylene membrane (thickness about 0.3mm) from 702.5 to 712.0 masl in order to prevent leakage trough the reservoir bottom. The membrane was protected with a 1m layer of compacted silt. Today the membrane is said to be damaged and considerable leakage (about 2.4-2.5m³/s) is reported to cause high ground water levels in Uzbekistan, about 12-15 km downstream of the dam.

Radio connection between dam and rayon office is available. An operation manual with emergency procedures is also available.

The risk class III (second highest category) was proposed for this dam (see FAO-WB 1997 report) based on ICOLD Bulletin 72.

8.2 Dam

The dam is 25m high and 2.4 km long at the crest. It consists of a composite compacted silt (loess-like loam) and gravel embankment. At present the crest level is 722.5 masl, although a 3m height increase is planned for the future. The FSL and the DSL are 720.5 and 709.0 masl, respectively; therefore the freeboard at FSL is 2m.

The upstream face of the dam has a 1:3 to 1:5 slope and is protected by concrete slabs above level 717.75 masl (Photo 8.1). A number of these slabs are in poor conditions and should be replaced. Below level 717.75 the dam face is protected with cobble/stone rip-rap 0.25-0.30m thick.

The downstream face of the dam has a 1:3 to 1:5 slope and is grassed (Photos 8.2 and 8.3). The crest of the dam is about 10m wide, and there is no wavewall (Photo 8.4).
It is reported that a short section of the embankment on the extreme left flank was overtopped by waves and washed out several years ago, possibly due to locally insufficient freeboard. It is suspected that the loss of freeboard may be due to collapse of internal erosion cavities. Although that incident did not have serious consequences, the freeboard should be checked by proper measurements and restored wherever needed.

In general the dam body appears to be in reasonable conditions, but at the left abutment a number of pseudokarst sinkholes were observed during the inspection. The left end of the dam is also said to have settled by about 1.5m relative to the nominal crest level. Bubbling water could also be seen upstream, a few meters away from the water line and probably close to the upper edge of the polyethylene liner, and this is thought to be indication of localized downward seepage, probably associated with pseudokarst sinkholes or open cracks in the loess-like material. Inhabitants of the area reported that such phenomena were observed for at least the past two years. Some 20 cavities (diameter of 1m or more at ground surface) were also reported in the downstream dam face, next to the left abutment, by Mr. V. Chukin who spent most of his time at the site inspecting the downstream area. Based on this evidence, it appears that the dam is affected by vertical migration of fine loess-like particles into the highly permeable gravel-pebble unit, and that the loam foundation layer is affected. The upstream blanket of the dam may also be damaged; note, however, that from the available drawings (Temelsu/GIBB, 1999) it appears that no blanket is provided near the abutments where the dam embankment is relatively low. These observations should not be overlooked and a detailed surface survey should be carried out immediately to locate the holes which were observed by the local engineers during the past few year and try to identify the most troublesome area, where the latter is probably near to the left abutment. The water level in the reservoir should be lowered to inspect the upstream face of the dam removing the concrete slabs where needed. The existing holes should be inspected carefully to the maximum possible depth trying to evaluate diameter variations and direction changes with depth. Than a geotechnical investigation should be planned and implemented and piezometers will be installed to investigate the seepage regime in the dam body, in the dam foundation and in the left abutment. The crest level should be checked by a topographical survey and measures to restore the original freeboard should be adopted, where required.

Measures to prevent further erosion should be adopted. The sink-holes on the abutment and on the downstream face of the dam may be caused by rain water seeping from the surface into the deeper pervious units or into localized cracks present in the foundation soil. On the other hand, collapse of erosion-induced underground cavities or cracks cannot be ruled out as a possible triggering mechanism. As a minimum the sink-holes should be filled down to the bottom of the loess layer either with silt, cement-bentonite mixtures or other suitable materials. The downstream slope of the dam will be protected from running water by placing concrete or steel surface channels of suitable size.

In the upstream shell, the reservoir water may be flowing downwards into a highly pervious un-saturated soil unit. Furthermore the elevation of the upper edge of the polyethylene membrane appears to be at a higher level than the dam upstream toe and this may cause some hydraulic back-pressure and liner displacement during draw-down. Even in this case sink-holes should be filled and, as an additional measure, water circulation in the upstream shell of the dam could be restricted raising the membrane up to the crest and providing the dam, at the back of the impervious facing, with a substantial drainage system.
8.3 Outlet works

The dam has no emergency spillway and the only outlet is the gated draw-off comprising a reinforced concrete culvert with a design capacity of around 12m$^3$/s at low reservoir operating level (i.e., 711.0 masl). The culvert is 137m long and the intake invert level is at 707.2 masl. The outlet is controlled by means of two 1.75 x 2.2 m gates operated from a valve chamber on dam axis (Photo 8.5).

The gates are leaking and the blades probably need to be replaced. It is understood that gear boxes and electric drives are out of order, and the gates must be operated manually.

The downstream section of the draw-off culvert is submerged (Photo 8.6). The outlet canal is said to be silted to a very significant degree (Photo 8.7).

8.4 Recommended Works

1) Repair or replace damaged concrete slabs ($300,000).
2) Inspection and repair of the gates at the dam ($6,000).
3) Inspection and repair/replacement of the 2 gates at intake and repair of damaged concrete (not inspected during the mission, refer to the 1997 FAO/WB report).
4) Carry out surface surveys and geotechnical/geophysical investigation on the dam body and in the left abutment, including boreholes with continuous core recovery, field and laboratory tests, install in the boreholes 16 couples of Casagrande-type piezometers in the embankment, in the dam foundation and in the left abutment ($225,000), install settlement stations (not estimated).
5) Fill sinkholes on the upstream and on the downstream faces of the embankment (near left abutment) and in the left abutment and provide preliminary measures to improve surface drainage and prevent water infiltration in the most troublesome sections of the downstream slope and of the left abutment ($440,000).
6) Placement of new membrane in the reservoir ($6,900,000 – probably not cost-effective).
7) De-silt outlet canal ($460,000).

8.5 Recommended Studies and Monitoring Activities

a) Carry out topographic survey to establish elevations of the dam crest and of the abutments (not estimated).
b) Carry out study to analyze the results of the geotechnical investigation and to interpret the piezometer records. Based on this information design measures to prevent further erosion in the dam body and in the left abutment will be evaluated.

Based on the site investigation results updated analyses should be considered in order to evaluate seismic stability of the embankment and soil resistance to seismic liquefaction.
9. PAPAN

9.1 General

The Papan dam was inspected on August 5, 2005.

The Papan reservoir is located in the Osh Oblast, Karasui Rayon, about 20 km south by southeast of Osh. The dam was built in 1981 and is in a deep gorge. It has a height of 120m and a crest length of about 90m. Access to the crest of the dam is via a road tunnel to the left abutment. At FSL of 1282 masl the volume of the reservoir is 260 Mm$^3$ and the reservoir area is 7.1 km$^2$.

The dam was constructed of gravel/pebble fill on a foundation of alluvium about 22m thick. The crest level of the dam is 1290 masl. The dam was first built to a height of 45m from which level a grout curtain was constructed through the dam and alluvium into the bedrock. A tunnel was also constructed at this level presumably to allow supplementary grouting, and was grouted up at the end of construction. The grout curtain was completed to crest level from the crest of the dam. The upstream face of the dam slopes at 1:2.5 and the downstream face at 1:2.25 down to a berm at 1205 masl. Below 1205 masl the downstream face slopes at 1:1.5.

The dam is currently undertaking major rehabilitation works. In particular construction of a 70m deep - 1m thick slurry wall is being carried out from the dam crest, using a specially equipped hydromill (Photo 9.1), in order to prevent abnormal seepage through the dam embankment. At the same time additional grouting and drainage is being provided at the abutments (Photo 9.2) and additional piezometers were installed in the embankment (Photo 9.3). Grouting was also performed from the dam crest to prevent bentonite mud to leak out of the trench endangering excavation stability.

Connection between dam and rayon office is available. An operation manual with emergency procedures is also available.

The risk class IV (highest category) was proposed for this dam (see FAO-WB 1997 report) based on ICOLD Bulletin 72.

9.2 Dam

The crest of the dam is about 25m wide and has no wavewall. It is understood that up to a few years ago very minor settlements, on the order of 30mm, had been monitored since dam construction (e.g., see 1997 FAO/WB report). However during our recent inspection local dam engineers reported that recent measurements showed an increased rate of deformation at several locations. Although several if not all such anomalies may be due to damage of the monuments and sometimes to their replacement with new ones, a thorough analysis of such data should be carried out promptly also to establish any relation between the works currently in progress and the observed movement.

During the inspection the water level in the reservoir was low (1261 masl) as required for the construction activities.

The toe of the dam appears to be in good conditions but the plunge pool is affected by extensive erosion (see next subsection).
Seismic hazard analyses and stability analyses in both static and seismic conditions were carried out by Temelsu/GIBB (1999).

9.3 Plunge Pool

Erosion is observed around the exit portal of the outlet tunnel (Photo 9.5) which appears undermined. The plunge pool (Photo 9.6) appears small relative to the design discharge of 345 m$^3$/s and there is some concern that for large discharges the toe of the dam could be damaged. Rehabilitation works in this area should be aimed at protecting the toe of the dam and at reinforcing the tunnel portal and the rock face on the two sides of the plunge pool, where most erosion is present. The role of the wing-walls and more generally the hydraulics of the plunge pool at high discharges should be investigated based also on physical modeling.

A proposal was prepared by the local rayon engineers which is said to be based on a discharge capacity of 180 m$^3$/s as opposed to the design capacity of 345 m$^3$/s. The reasons for this reduction could not be ascertained during the mission and should be looked at carefully. Note that because of safety reasons, working at the plunge pool will require preliminary detachment of unstable rock blocks from the rock face.

9.4 Outlet Works and Draw-off Tower

Concern was expressed about vibration of the gates at large discharges, and it was proposed to increase the size of the air intake.

There is some concern about the stability of the draw-off tower which hosts both the low outlet tunnel and the spillway. Doubts were raise on the stability of the rock face the tower in anchored to and to the current state of the tie-backs. No evidence of distress of the structure or of the left abutment could be seen, or were reported by other consultants.

9.5 Fault in the Dam Foundation

A few years ago discussion came up on whether the fault crossing the dam foundation had to be considered seismically active. It is unclear to the consultant if a conclusion was reached on this issue.

9.6 Recommended Works

1) Reinforce exit portal of outlet tunnel, enlarge plunge pool and protect dam toe from erosion at large discharges ($718,000 – tentative value).
2) Increase capacity of air vent to decrease gate vibrations (not estimated).
3) Fixed liner of outlet tunnel (not estimated).

9.7 Recommended Studies and Monitoring Activities

a) Verify settlement and deformation measurements.
b) Design plunge pool modification, also by means of physical modeling, in order to prevent further erosion at the exit portal of the tunnel and damage of the dam toe at high discharges.
c) Carry out detailed structural survey of the rock mass at the left abutment both upstream (location of draw-off tower) and downstream (location of exit portal of the outlet tunnel and plunge-pool).
10. NAIMAN

10.1 General

Naiman dam was inspected on August 5, 2005. Unfortunately it was not possible to talk to the local dam engineers as nobody showed up for the inspection. For the same reason it was not possible to enter into the gate tower.

The Naiman reservoir is located in the Osh Oblast, Nookat Rayon, about 40 km southwest of Osh. The dam was built in 1961-1966. At FSL of 1201.6 masl the volume of the reservoir is 39.5 Mm$^3$.

The dam is constructed of gravel/pebble fill with a wide core of low permeability loamy soil. Beneath the clay there is a grout curtain into the permeable conglomerate foundation. In addition there is an upstream slurry wall of about 10-14m depth.

The risk class IV (highest category) was proposed for this dam (see FAO-WB 1997 report) based on ICOLD Bulletin 72.

10.2 Dam

The dam is about 40.5m high and 265m long at crest. The crest elevation is 1204 masl and the crest width is about 5m (Photo 10.1). There is a 750mm wavewall with some cracks. The upstream face slopes at 1:2.5 to 1:4.0 and is protected by concrete slabs in reasonable conditions (Photo 10.2). The freeboard is 2.4 meters plus the wave wall. Drawings of the dam cross section could not be seen, but it is reported that no or very thin filters are provided between the core and the dam shells, depending on elevation. This lack of filter could induce fines migration and erosion of the core material.

The downstream face (Photo 10.3) appears in good conditions and has a drainage toe.

10.3 Outlet Works

There is no emergency spillway at the dam. The reservoir is filled by a canal having a capacity of 35 m$^3$/s and the incoming water is diverted when the reservoir is full. The direct catchment area of the reservoir is said to be negligible.

The draw-off works consist of a 181m long - 2.2m diameter pipe (Photo 10.4) equipped with a 1400mm diameter gate valve upstream and a 1600mm butterfly valve downstream. The outlet has a nominal capacity of 8.5 m$^3$/s but at present cannot discharge more than 6 m$^3$/s due to vibrations of the butterfly valve. It is understood that provision of a larger diameter air pipe was proposed by the Oblast engineers and is currently being considered. It is also understood that the butterfly valve is known to be corroded and should be replaced.

10.4 Recommended Works

1) Replace gate valve and butterfly valve ($48,000).
2) Install piezometers ($69,120).
3) Install settlement markers.
10.5 Recommended Studies and Monitoring Activities

a) Check crest elevation by topographic survey.
b) Check hydrology.
c) Perform probabilistic seismic hazard analysis.
d) Perform stability analyses in both static and seismic conditions.
e) Monitor settlements of embankment.
f) Monitor piezometers.
11. TORGUL

11.1 General

The Torgul dam was inspected on August 6, 2005.

The Torgul reservoir is located in the Batken Oblast, Batken Rayon, about 12 km west of Batken. The reservoir is retained by two dams (west and east dams) which were constructed in 1971. There are irrigation outlets in both dams.

The reservoir has a capacity of 90 Mm$^3$ and a surface area of 6.57 km$^2$ at FSL. The dam has no emergency spillway. The day of the inspection the water level in the reservoir was relatively low, probably about 8 m below the dam crest. The extension of the irrigation area is 9000 ha.

The direct catchment area is reported to be small and the reservoir is filled by flows abstracted from the Isfara River and conveyed to the reservoir by means of a canal 19.5 km long with a capacity of 30 m$^3$/s.

The bed of the reservoir is composed of gravel-pebble deposits with fines and is known to be highly permeable. Therefore the whole surface was lined with a polyethylene membrane (about 0.3 mm thick) buried to a depth of 800 mm. The membrane is now damaged and the resulting leakage from the reservoir is very considerable.

The risk class IV (highest category) was proposed for this dam in the 1997 FAO/WB report based on ICOLD Bulletin 72.

Radio connection between dam and rayon office is not available. An operation manual with emergency procedures is also not available.

11.2 Dam

The east dam is about 21 m high and 545 meters long at crest level. The dam crest level (Photo 9.1) is about 1148.0 masl and the crest width is about 8 m. It is a gravel-pebble embankment with an inclined core and an upstream blanket. Both core and blanket are made of loamy soil. The upstream face slopes at 1:3.5 to 1:4.0 and is protected by a layer of stone resting on a sand filter (Photo 9.2). The downstream face of the dam (Photo 9.3) slopes down at 1:2 to 5 m wide berm below which the slope is 1:3. The minimum freeboard is 1.2 m only and is just sufficient to accommodate waves (FAO/WB, 1997). There is no allowance for settlements.

The west dam is about 34 m high and 1094 m long at crest level. The dam crest level is about 1148.3 masl and the crest width is about 4 m. It is a gravel-pebble embankment with an inclined core and an upstream blanket. Both core and blanket are made of loamy soil. The upstream face slopes at 1:3.5 to 1:5.0, and protection from waves is not in a very good state (Photo 9.4). The downstream face of the dam slopes down at 1:2 to a 3 m wide berm below which the slope is 1:3, and includes a toe drain (Photo 9.5).

The minimum freeboard is 1.5 m only which appears tight considering the expected wave run-up (FAO/WB, 1997).
We were told that downstream of the left abutment of the west dam (Photo 9.6) a large wet spot (270x20m; about 10 l/s leakage) appears when the reservoir level exceeds 1143.5m (70Mm3). Seepage measured at the toe drain is about 10-30 l/s.

There are 125 piezometers at the dam site but it is understood that no piezometer records were taken during the past 5 years and that the state of the piezometers must be checked. The piezometers should be inspected, cleaned and replaced with new piezometers where required. The new piezometers will be installed both in the dam body of the two dams and in the left abutment of the west dam.

11.3 Outlet Works

There are four outlet gates at the east dam which are said to require replacement/repair (Photos 9.7 and 9.8). Seeping clear water (about 5-10 l/s) was observed around the outlet in the eastern dam (Photo 9.9) for the past 5 years. At maximum design level and with closed gates the water is said to be seeping into the outlet tunnel. This phenomenon should be investigated immediately and proper instrumentation should be installed at the dam to monitor any developments.

There are four 2.5 t outlet gates at the west dam (Photos 9.10 and 9.11) which are also said to require replacement. Two of them are currently jammed in the closed position and therefore the outlet cannot discharge more than 50% of the design capacity. One of the two winches is out of order and need a new startor and both winches need some repair.

11.4 Recommended Works

1) Inspect and replace/repair 4 gates and winch startor at west dam ($ 27,750).
2) Inspect and replace/repair 4 gates at east dam ($ 22,500).
3) Install 25 piezometers in the embankments and in the left abutment of the west dam ($ 100,000).
4) Headworks (not inspected during the mission – refer to 1997 FAO/WB report).
5) Feeder canal (not inspected during the mission – refer to 1997 FAO/WB report).
6) Provide drainage system downstream of the east dam and sealing of outlet joints to prevent erosion of fines ($ 250,000).
7) Replace reservoir lining ($ 15,100,000- probably not cost effective).
8) Provide radio communication system (not estimated).

11.5 Recommended Studies and Monitoring Activities

a) Check crest elevation by topographic survey.
b) Check hydrology.
c) Perform probabilistic seismic hazard analysis.
d) Perform stability analyses in both static and seismic conditions.
e) Monitor settlements of embankment.
f) Monitor piezometers.
g) Investigate seepage problems in the left abutment of the west dam and at the outlet of the east dam.
h) Prepare operation manual with emergency procedures and instruct personnel accordingly.
12. ISSYK-ATA

12.1 General

The Issyk-Ata dam was inspected on August 8, 2005.

The Issyk-Ata reservoir is located in the Chui Oblast, Issyk-Ata Rayon, about 30 km east of Bishkek. The dam was designed by Kyrgyzgiproprovodhoz and construction was completed in 1979. The total reservoir capacity is 3.0 Mm$^3$ with a 2.5 Mm$^3$ useful capacity. Due to siltation the actual total capacity is about 2.66 Mm$^3$. The dam has no emergency spillway. The day of the inspection the water level in the reservoir was 8m below the dam crest. The reservoir water surface area at FSL is 0.277 km$^2$, the catchment area is reported to be 546 km$^2$, and the extension of the irrigation area is 3,978 ha.

Radio connection between dam and office is available. No operation manual with emergency procedures is available. It is reported that 1,500 people live downstream of the dam.

The risk class II is proposed for this dam based on ICOLD Bulletin 72.

12.2 Dam

The dam is reported to be a zoned embankment with sand-gravel shells and a central core made of low permeability loam. The available design drawings show 3 meter thick filter zones between the core and the shells of the dam, and a drainage system is located in the dam foundation, near the downstream toe. The maximum dam height is 31m whereas the dam length at the crest is about 492m. According to the available design drawings the crest elevation of the dam is at 1227.50 masl and the design maximum reservoir level is 1226.0 masl, with a 1.5m minimum freeboard, whereas the freeboard at FSL is 2.5m. The width of the dam crest is about 6m.

At elevations above 1210.70 masl the upstream face of the embankment has a 1:3.0 slope, whereas below 1210.70 masl the slope is 1:4.0. The upstream face is protected only by means of gravel and pebbles (Photos 10.1 and 10.2), as no rip-rap was provided. There is no wavewall. The downstream face (Photo 10.3) has a 1:2.5 slope and no significant seepage was observed during the inspection or was reported by the local dam engineers. Most drainage wells located at the dam toe are virtually dry or carry limited seepage water (Photo 10.4). On the other hand, adjacent to the left abutment a considerable amount of water, probably 15-20 liters/s, was flowing on the dam surface to the downstream toe (Photo 10.5), seeping into the dam body and causing localized erosion phenomena. This surface water originates from a spring located in the left abutment, at an elevation higher than the dam crest’s (Photo 10.6), and according to the local dam engineers the flow is independent from the water level in the reservoir.

No piezometers are available at the dam.

12.3 Outlet Works

The outlet works are reported to have a maximum design capacity of 25 m$^3$/s. They comprise a twin concrete culvert (Photo 10.7) located at elevation 1,199.50 masl (i.e., 28m below crest level) equipped with four 1900 x 1900 mm gates. The gates, which were never replaced since dam construction, are operated from the gate house accessible from the dam crest (Photos
10.8 and 10.9) and are reported to need same repair. The bottom of the outlet is protected by granite 40cm thick slabs which are reported to be worn out.

Siltation of the reservoir does not seem to have a direct influence on dam safety in this specific case. It is understood that the draw-off works have been used in the past to flush the soil downstream, and that the coarse particles present in the sediment caused damage to the outlet lining.

The hydrology of the basin need be reviewed.

12.4 Recommended Works

1) Repair gates ($25,000), inspect outlet culvert. Replace granite slabs and steel casing where needed (not estimated).
2) Protect the dam upstream face with properly selected and placed rip-rap ($220,000).
3) Remove high vegetation adjacent to the left abutment, repair erosion on the embankment due to running water, provide surface canal to prevent water infiltration and erosion due to spring water running on the downstream shell ($25,000).
4) Install 12 piezometers ($59,000), monuments to monitor deformation, and two weirs to monitor seepage.
5) De-silt reservoir (250,000m$^3$) if cost effective ($840,000).

12.5 Recommended Studies and Monitoring Activities

a) Check crest elevation by topographic survey.
b) Check hydrology.
c) Perform probabilistic seismic hazard analysis.
d) Carry out geotechnical investigation to establish the soil parameters.
e) Perform stability analyses in both static and seismic conditions.
f) Monitor settlements of embankment.
g) Monitor piezometers.
h) Prepare operation manual with emergency procedures and instruct personnel accordingly.
13. ORTO TOKOI

13.1 General

The Orto-Tokoi dam was inspected on August 8, 2005.

The Orto-Tokoi reservoir is located in the Issyk-Kul Oblast, about 25 km southwest of Balykchy. The dam construction was completed in 1956. The total reservoir capacity is 470.0 Mm$^3$, with a surface area of 25 km$^2$. The extension of the irrigation area is 220,000 ha in Kyrgyzstan and 80,000 ha in Kazakhstan.

During the past few years the dam undertook rehabilitation works under the IRP project. In particular the emergency spillway was upgraded, the plunge pool was grouted to prevent scouring at the gate house, new instrumentation and new cone valves were installed. Grouting works were also performed along the outlet tunnel.

The risk class IV (highest category) was proposed for this dam in the 1997 FAO/WB report based on ICOLD Bulletin 72.

Radio connection between dam and rayon office is available. An operation manual with emergency procedures is also available.

13.2 Dam

The dam is 52m high and 365m long at crest. It is constructed of gravel/pebble fill compacted in layers. It is rendered impermeable by a grout core injected from vertical boreholes. Grouting extended to rock beneath the dam and into the left abutment.

Both the upstream face and the downstream face of the dam slope at 1:2.5 to 1:3.5. The upstream face is protected by hand placed rip-rap (Photo 13.1), whereas the downstream face is grassed. At the downstream toe a weir measure drainage water from the dam body and from the left abutment (Photo 13.2).

The crest of the dam is at 1767 masl and the crest of the spillway sill at 1762 masl. The freeboard during major spillway discharges (i.e. 240 m$^3$/s) is 2.8m.

When the reservoir level is high, total seepage reaches about 235 l/s, and about 110 l/s are drawn from the drainage pipe located along the spillway (Photo 13.3). Apparently seepage increases considerably when the reservoir level exceeds 1757 masl, probably because a long stretch of the drainage pipe on the left abutment is approximately at that elevation. It is reported that the ground water level in the left abutment increases very considerably when the reservoir level becomes high, and the drainage pipe section is insufficient under these conditions. In addition some minor content of fine particles is reported to be present in the leaking water, although it looks clear. Therefore the stability of the spillway under the action of the uplift pressures should be checked, and the effect of fines migration from the dam abutment should be investigated with reference to the rock characteristics in that area. If needed, the phenomenon could be kept under control by additional drainage measures in the spillway area, or some exclusion measures could also be considered. However the first step is the thorough analysis of the piezometer records, of seepage volumes and of solid transport relative to the water level in the reservoir. In this context, it is thought that installation of a few additional piezometers in the abutment area will be beneficial for a more informed
understanding of the phenomenon. Some additional soil investigation in the abutment is also deemed appropriate.

The abutment areas were grouted in 1983/1985 and reportedly this reduced leakage by about 90 l/s.

### 13.3 Outlet Works

The outlet tunnel is 567m long and has a diameter of 4.5m. At the upstream end of the tunnel there is a gate at 1725 masl. Apparently this gate is jammed in the open position. The gate chamber is in the right abutment and can be reached by a 4m diameter shaft. The gate chamber contains two 2.45 x 2.75 m gates weighting 24 tons each (Photo 13.4).

The valve house located at the downstream end accommodates two hollow cone valves having a diameter of 2.2m. The cone valves were replaced recently and the plunge pool was grouted to prevent scouring which was undermining the house itself. Apparently the plunge pool is again being eroded but it was not possible to inspect it during the visit (Photo 13.5).

### 13.4 Recommended Works

1) Replace gates ($ 138,000).
2) Install 5 new piezometers near the spillway ($ 27,700).

### 13.5 Recommended Studies and Monitoring Activities

a) Verify spillway stability under uplift pressure.
b) Analyze piezometer readings and drainage water with quantitative assessment of solid transport.
c) Investigate seepage patterns in the left abutment.

In order to evaluate possible measures to control seepage in the left abutment, carrying out a geotechnical investigation in the spillway area should be considered.
14. TORT-KUL

14.1 General

The Tort Kul dam was inspected on August 8, 2005. The Tort Kul reservoir is located in the Issyk-Kul Oblast, Ton Rayon, about 300 km east of Bishkek. A first design configuration (Phase 1) of the Tort Kul dam was designed by Kyrgyzgiprovodhoz in 1963 and constructed in 1972. In 1978 the reservoir capacity was increased to 1.41 Mm$^3$ (Phase 2). Part of the old embankment was breached and a new embankment was built at a different location. A new emergency spillway was also constructed as the old one could not be used any longer. Today the reservoir capacity is affected by silting, and the local engineers believe that the amount of silt exceeds 890,000 m$^3$. The day of the inspection the water level in the reservoir was quite low, and the reservoir volume was 560,000 m$^3$. The extension of the irrigation area is 1,658 ha.

The reservoir is fed by an incoming canal whose maximum capacity is said to be 3.5m$^3$/s. The headworks on the Ton river and the gate controlling flow into the feed canal are shown in Photos 14.1 and 14.2.

The local DWR office proposed to de-silt the reservoir and to provide an upstream sedimentation basin to control siltation. Note that according to the local dam engineers the amount of silt entering the reservoir is about 25-30 thousand m$^3$/year. The cost effectiveness of de-silting the reservoir should be evaluated carefully before any money is spent to this end, and the measures to prevent further siltation should be the subject of a careful study before any decision is made. Both technical and cost effectiveness of such measures should be investigated thoroughly, and the related future maintenance costs, where relevant, shall be estimated.

Radio connection between dam and office is available.

It is reported that 11,000 people live downstream of the dam. The emergency spillway was buried in 1997 in order to increase the FSL by 1.5m to make up for reservoir siltation.

The risk class III (second highest category) is proposed for this dam based on ICOLD Bullettin 72.

14.2 Dam

The dam is reported to be a homogeneous loam embankment with a toe drain. The maximum dam height is 19m whereas its length is about 380m. According to the available design drawings the crest elevation of the dam is at 2093.0 mASL and the design maximum reservoir level is 2092.20 mASL, with a 0.8m minimum freeboard, whereas the freeboard at FSL is 1.3m. Due to settlements the actual freeboard is probably less than envisaged during design. The width of the dam crest is about 5m.

The upstream face of the first stage embankment has a 1:3.0 to 1:3.5 slope and is protected by means of reasonably good quality concrete slabs (Photo 14.3). There is no wavewall. The downstream face is rather steep (1:2.0 to 1:2.5) and considerable seepage was observed during the inspection downstream of the dam toe (Photo 12.4). Springs are observed from which a fair amount of clear water (say 20 liters/s) comes to the surface. According to the
dam personnel these springs were there even before the dam was constructed, due to the very low elevation of the downstream area. The lining of the outlet channel is in poor conditions and should be repaired to prevent erosion at the dam toe (Photo 14.5).

The upstream face of the second stage embankment has a 1:3.0 slope, and since it is not sufficiently protected from the wave action (see Photos 14.6 and 14.7) it is eroded and scoured at several locations. The initial geometry of the dam shall be restored using additional, well compacted sand and gravel, and the soil surface shall be protected with good quality rip-rap. There is no wavewall. The downstream face (Photo 14.8) is rather steep (1:2) and considerable seepage was observed during the inspection on the face itself and at the toe. The downstream slope is also affected by sloughing (Photo 14.9), which was said to be occurred some 10 years ago, and cracks (Photo 14.10). Springs are observed from which a fair amount of clear water comes to the surface. A pipeline, which is said to be an aqueduct for potable water, discharges a considerable amount of water downstream of the dam toe (Photo 14.11). A considerable number of holes due to the activity of small burrowing animals was observed on the downstream dam face (Photo 14.12). The hole diameter is about 50mm and the hole depth, according to the dam personnel, would not exceed about 300mm.

No piezometers are available at the dam.

14.3 Outlet Works

The outlet works are reported to have a maximum design capacity of 7.5m$^3$/s, whereas the capacity of the outflow channel is 16 m$^3$/s. They comprise a 1m diameter pipe equipped with two 1200 x 1400 mm gate valves which can be operated from the upstream face of the first stage embankment (Photos 14.13 and 14.14). The gates, which were never replaced since dam construction, are operated manually and are reported to be in working order. The gates were inspected in March 2005 and are reported to be corroded. The outlet works are located 17.7m below the crest level.

The second stage dam is equipped with an emergency spillway with a maximum discharge capacity of 2.5 m$^3$/s. The weir is said to be located 2.5m below the dam crest. However the spillway is currently inactive as in 1997 it was partially buried in order to increase the FSL to make up for reservoir siltation (Photos 14.15 and 14.16). The right abutment was raised by 1m in 1997, and now it is reported to be 50cm higher than the crest. It appears that this modification exposes the dam and the downstream population to an unacceptable risk level, and therefore the spillway should be re-activated immediately and the concrete works shall be repaired as needed. The original FSL should be restored.

The hydrology of the basin need be reviewed in order to estimate the ability of the hydraulic works to pass the maximum probable flood without overtopping.

14.4 Recommended Works

1) Inspect and reactivate immediately the emergency spillway, repair the weir structure and the chute where required ($20,700).
2) Replace gates ($11,500), inspect outlet pipe and repair outlet canal to prevent dam toe erosion ($39,300).
3) Repair the upstream face of the second stage dam, filling erosion voids and scours with sand and gravel ($97,000), compacting and protecting the whole dam face with properly selected and placed rip-rap ($146,000).
4) Clean up downstream face and downstream area at the toe of the dam to allow more accurate inspections ($30,000). Provide drainage (e.g., drainage trenches) in the downstream area in order to keep under control springs and seepage water ($200,000 – tentative value). At the second stage embankment the area of the downstream face where a shallow instability took place will be repaired.

5) Install 16 piezometers to monitor seepage ($49,000), surface monuments to monitor deformation and two weirs to monitor seepage.

6) Provide traps for burrowing animals, monitor burrowing holes and repair them by excavating, filling and compacting (not estimated).

7) Carry out geotechnical investigation to establish the soil parameters ($40,000). Provide toe berms or other measures where required to assure stability (not estimated).

8) De-silt reservoir (800,000m$^3$) if cost effective ($3,970,000). Consider in design upstream measures to control future reservoir filling if economically sustainable (not estimated).

Studies and monitoring activities

a) Check crest elevation by topographic survey.
b) Check reservoir geometry by topographic survey.
c) Hydrology risk study, keeping into account reductions of the flood control pool due to sedimentation.
d) Probabilistic seismic hazard analysis.
e) Stability analyses in both static and seismic conditions.
f) Monitor settlements of embankment.
g) Monitor piezometers.
h) Monitor leakage.
15. KIROV

15.1 General

The Kirov dam was inspected on August 10, 2005.

The Kirov reservoir is located in the Talas Oblast, Kara-Bura Rayon, about 55 km west by northwest of Talas. The dam, which was completed in 1975, is said to be the first buttress dam built in the former Soviet Union (Photos 15.1 and 15.2). It is 86m high and impounds a reservoir with a capacity of 570 Mm$^3$. About 32,000 people are reported to live downstream in Kyrgyzstan, and 470,000 people in the city of Jambyl in Kazakhstan. The irrigated area is 215,000 ha and the total reservoir capacity is 550.0 Mm$^3$, with a surface area of 26.5 km$^2$.

During the past few years the dam undertook rehabilitation works under the IRP project, and some works were also sponsored by the Kazak government.

The risk class IV (highest category) was proposed for this dam in the 1997 FAO/WB report based on ICOLD Bulletin 72.

Radio connection between dam and rayon office is available. An operation manual with emergency procedures is also available.

15.2 Dam, Spillway and Outlet Works

A rather detailed description of the dam, of the spillway and of the outlet works is provided in previous reports and will not be repeated here.

Upstream of the dam, in the right abutment, some instability of the shallow incoherent ground layer endanger the integrity of the road leading to the guard house (Photo 15.3). The instability process doesn’t seem to treat the dam abutment which is believed to be embedded in sound rock. It is intention of the dam engineers to stabilize such slope by a reinforced concrete retaining wall founded on the sound rock and bolted to the rock mass. A similar structure was constructed right in front of the Lenin Monument (Photo 15.4).

On the downstream side of the dam the concrete works on the left flank, which were recently restored using Kazak funds, are again being underscoured and damaged by the outlet water. The access shelter, also provided by the Kazak government, appears to be vulnerable and subject to damage in case of high discharges. Only a very small discharge is currently being allowed from the left cone valve in order to prevent damage downstream, although we were told that in case of an emergency high discharges could be tolerated. The problem of consequences of high discharges of the left bank should be investigated thoroughly, evaluating the stability of the concrete works and of the retained rock face. Access problems to the valve house might also result as at present it can be reached only from downstream. However, a steel staircase joining the crest with the downstream toe of the dam is currently being constructed.

The stability of the right downstream bank should also be investigated to evaluate the possibility of massive rock falls into the river bed. As a first step a survey of the joint orientation and characteristics should be carried out, if not yet available.
The two cone valves were said to need repair and replacement. In particular the left valve, which is in relatively good conditions, is supposed to be repaired and transferred in the right outlet, whereas a new cone valve is considered necessary by the local engineers and would be installed in the left outlet. All we could see during the inspection is that the right valve leaks considerably.

We could not visit the dam inside because there was a power black-out at the time of the inspection.

**15.3 Recommended Works**

1) Stabilize landslip in the right abutment to prevent road disruption ($310,000).
2) Replace one cone valve and repair the other ($220,000).

**15.4 Recommended Studies and Monitoring Activities**

a) Check rock mass stability of the right abutment (downstream).
b) Check rock mass stability of the left abutment (downstream) in case concrete works are washed away.
c) Verify emergency procedures to reach the valve house in case the downstream access shelter is washed away.
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ALA – ARCHA (OFF-LINE)
Photo 3.9

Photo 3.10
ALA – ARCHA (IMPOUNDING)
SPARTAK
SOKULUK
STEPNISKI
BAZAR - KORGON
PAPAN
TORT - GUL
TORT - KUL
KIROV