Outline of key note speech

- Probability of failure of a portfolio of dams
- Reservoir Conservation
- Infrastructure Asset Management
- Financing dam rehabilitation: snapshots of international practice
- Taking stock
Probability of Failure

- There are approximately 84,000 dams in the U.S. National Inventory of Dams.
- Dams are a critical piece of the nation’s infrastructure.
- There are currently over 4,400 unsafe dams across the U.S.
- From 2005 through 2009, the states reported 132 dam failures.
- The need for rehabilitation of many dams in the U.S. is critical and tops $51.46 billion.
- It is estimated that $16 billion is needed to rehabilitate the nation’s most critical dams.

Statistic on Small Reservoir Failures in China


*Figure 2-3 Average annual dam failure rate of small reservoirs (Type II)*
Probability of Failure, some numbers

Observations on the Bulgaria’s context:
- Over the next decades, 10 or more failures of small dams could occur.
- Failures of large dams would be at least one order of magnitude less, but higher consequences justify preventive measures.
Emerging Trends in Dam Safety Regulations: we already heard from Satoru

- WB publication on Regulatory Frameworks for Dam Safety: A Comparative Study (2002)
- Series of ICOLD Bulletins, such as
  - #130 Risk Assessment in Dam Safety Management: A Reconnaissance of Benefits, Methods and Current Application (2005)
  - #154 Dam Safety Management: Operation Phase of Dam Life Cycle (2011)
  - ICOLD European Club: Dam Legislation (2012), etc.
- Technical guidelines (USACE, FEMA, Canada, Australia, UNECE etc.)
Reservoir Conservation
Reservoir Conservation: Sustainable World Bank’s interest on the subject

Year 2003

Reservoir Conservation
Volume I

The RESCON Approach
economic and engineering evaluation of alternative strategies for managing sedimentation in storage reservoirs

Alessandro Palmieri - Farhad Shah
George W. Annandale - Ariel Dinar

June 2003

A CONTRIBUTION TO PROMOTE CONSERVATION OF WATER STORAGE ASSETS WORLDWIDE

Year 2016

Extending the Life of Reservoirs
Sustainable Sediment Management for Dams and Run-of-River Hydropower

George W. Annandale, Gregory L. Morris, and Pravir Karki
Sedimentation and Dam Safety

• Sedimentation effects, in addition to having far ranging social and economic impacts, may have safety implications also. If no sediment removal is practiced and the dam is ultimately decommissioned, impacts may be severe. An example of this is the removal of Fort Edwards dam in New York. The process released over 400,000 m³ of sediment and resulted in partial blockage of the east channel of the Hudson River as well as increased risk of flooding of the town of Fort Edward.

• Sedimentation may also clog dam outlets and greatly accelerate abrasion of surface spillways. Increased loads on a the dam wall by sediment build up may also lead to reductions in safety factors against sliding and overturning.
Including sedimentation management actions in a dam rehabilitation program is an opportunity for improving that program’s economic efficiency.
Infrastructure Asset Management
Infrastructure Asset Management

- Infrastructure asset management is a specific term of asset management focusing on physical, rather than financial assets.
- Infrastructure is a wide term denoting road and rail, water, power, etc. assets.
- Physical assets, producing revenues, can be used as collateral to raise financial resources.

Application of the asset management concept to dam-reservoir systems.

<table>
<thead>
<tr>
<th>Renewal period</th>
<th>Facility etc.</th>
<th>Management Priorities</th>
<th>Remarks</th>
</tr>
</thead>
</table>
| Short (a few years to a few decades) | - Machinery & equipment  
- Electrical equipment  
- Buildings | - Reducing total cost of inspections, improvement, repair, and renewal | - Improving the service level  
- Responding to technological progress |
| Long (a few decades to a few centuries) | - Reservoir (sedimentation) | - Prolonging service lifetime  
- Lowering life cycle costs | - If appropriate measures are taken, renewal period is prolonged |
| Super long (unclear)  | - Dam body                         | - Inspections  
- Reducing maintenance costs  
- Risk assessments | - If appropriate management is performed, renewal is unnecessary for a very long time, and the present value of renewal costs cannot be assessed |
| Contingent            | - Reservoir slopes  
- Landslides  
- Earthquake response etc. | - Inspections  
- Emergency response | - Response when constructing to a stipulated level |

Asset Management Systems

• Asset management systems determine in a systematic way the maintenance and related budget needs, both annually and longer-term, and monitor in a transparent manner the actual versus planned maintenance expenditures.

• Asset Management Plans permit to establish dam-specific needs-based O&M systems that aim to ensure sufficient funds for the dedicated use by the dam operator.

• The results of the asset management plan (i.e. a fully costed maintenance plan) facilitate discussions with Finance Departments to create non-fungible budget lines.

• Rather than having the funds for dams incorporated in overall O&M budgets, it is desirable to include separate line items for the aggregate number of large dams in view of the importance of adequately maintenance of dams.
Financing dam rehabilitation: snapshots of international practice
The Funding conundrum

• A dam safety program cannot be complete without a mechanism to address funding for the most critical dam repairs and rehabilitation.

• Introduction of a reserve fund to ensure timely and effective intervention in case of emergency on any dam other than the ones to be rehabilitated (Armenia DSP).

• Such emergency fund should allow to intervene in cases where further deterioration of any of the dams poses an imminent threat to human life (Vardakar spillway).

• Unfortunately, shortage of funds for dam rehabilitation, or even for O&M of water infrastructure is «international». 
Shortage of funds for O&M is «international»

Table 1: Median Operating Cost Coverage Ratio in Utilities

<table>
<thead>
<tr>
<th>Year</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ratio</td>
<td>1.11</td>
<td>1.13</td>
<td>1.10</td>
<td>1.11</td>
<td>1.08</td>
<td>1.07</td>
<td>1.07</td>
<td>1.08</td>
<td>1.05</td>
</tr>
<tr>
<td>SD</td>
<td>0.55</td>
<td>0.56</td>
<td>0.58</td>
<td>0.61</td>
<td>0.57</td>
<td>0.56</td>
<td>0.55</td>
<td>0.54</td>
<td>0.50</td>
</tr>
<tr>
<td>Num.</td>
<td>579</td>
<td>615</td>
<td>723</td>
<td>999</td>
<td>1,351</td>
<td>1,173</td>
<td>1,379</td>
<td>1,229</td>
<td>930</td>
</tr>
</tbody>
</table>

Note: The data collection cycle of 2008 was not yet complete at the time of publishing the source material. Reproduced from Van den Berg and Danilenko 2011.

Figure 4: Average Operating Cost Coverage Ratio by Region (2004–2008)

Source: IBNET (2012).

* 92 countries were included in this data set. Africa (32), EAP (8), ECA (24), LCR (15), MNA (8), and SA (5). All numbers are as of latest reporting year for each country. Latest reporting year varies from 2004–2009. The ratio is the average ratio for all utilities reporting, and also varies per country. See source for details.
1

- Rehabilitation & Uprating projects usually enjoy an attractive economic IRR, frequently above 20%.
- Financing arrangements should besought to exploit this partial self-financing potential.
- Support from multilateral funding institutions can be most needed at the beginning, with private financing taking over later on.
- The role of governments as facilitators of private investments must be stressed, especially when utilities are short of corporate funds.

2  **India**  **DRIP** (Dam Rehabilitation and Operation Improvement) – World Bank

Criteria for dam inclusion in DRIP comprehend the production of records pertaining to funds allocated to dam O&M in the last 10 years and an assessment of needed funds. Records and assessment should be broken down in key components such as staff salaries, labor, equipment, materials, external contracts, etc.

Retrofitting and uprating of hydro facilities, improved fisheries production and management are areas where new incentives for improved dam operations can be brought about.
3 United States

- Many dam owners, especially private ones, find it difficult to finance rehabilitation projects.
- Nearly half of all states have a grant or low-interest loan program to assist dam owners with repairs.
- In 2015, state programs spent over $49 million on their regulatory programs.
- The federal National Dam Safety Program was authorized in 2014, but has not seen a full appropriation at authorized levels.

Table 3. State Grants for Dam Rehabilitation as of October 2003

<table>
<thead>
<tr>
<th>State</th>
<th>Program Type</th>
<th>Program Name</th>
<th>Source and Amount of Funding</th>
<th>Eligibility</th>
<th>Loan/Grant Amount</th>
<th>Term of Loan</th>
</tr>
</thead>
<tbody>
<tr>
<td>AZ</td>
<td>Loan or grant</td>
<td>Dam Repair</td>
<td>Legislative, lien fund, inspection fees, filing fees, principal and interest from previous loans</td>
<td>State engineer determines if the dam is to be dangerous to life, not emergency</td>
<td>Loan for the cost of the project, or grant for a portion of project costs</td>
<td>Term of loan is up to 20 years at 3.6% interest depending on the knight</td>
</tr>
</tbody>
</table>
Snapshots on International Practice (cont.)

4 Brazil - Dam Safety RAS to ANA

<table>
<thead>
<tr>
<th>Score</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Not in place- totally unsatisfactory</td>
</tr>
<tr>
<td>1</td>
<td>Activities started, slow progress</td>
</tr>
<tr>
<td>2</td>
<td>Satisfactory progress, key issues identified</td>
</tr>
<tr>
<td>3</td>
<td>Fully satisfactory</td>
</tr>
</tbody>
</table>
Brazil - Dam Safety RAS to ANA

.... at the same time, it is too early to express judgements
How do we take stock of international practice?
Financing dam rehabilitation and modernization: *a range of options*
Concluding with some solace
Best practice maintenance of downstream face of a concrete dam Cingino Dam, Val Antrona, North Italy

Source: www.hydrelect.info/articles.php?lang=fr&pg=366