ANNEX 5

Annex 5.2.1 Design proposed by Pakistan for the spillway
Annex 5.2.2 Economic comparison between gated and ungated overflow chute spillway alternatives
Annex 5.2.3 Spillways of Dams commissioned since 1940
Annex 5.6.1 Section across sluice spillway right bay and elevation of power intake
Annex 5.6.2 Design of Intakes – Pakistan design with SET
Annex 5.6.3 Stabilized bed profile in the near field, according to India
Annex 5.6.4 Design proposed by Pakistan for the power intake
Annex 5.6.5 Extract from Les pierres sauvages, Fernand POUILLON
Annex 5.8.1 Flood routing using India’s rating curves
Annex 5.8.2 Flood routing using Pakistan’s rating curves
Annex 5.8.3 Flood routing using the rating curves defined by the NE
Annex 5.9.1 Flow duration curve of Chenab river at Baglihar
Annex 5.9.2 Pondage calculation done by Pakistan
Annex 5.9.3 Pondage calculation done by India
Design proposed by Pakistan for the spillway
Ungated Spillway Option A-2, extract from Memorial of Pakistan, Exhibit 2
Design proposed by Pakistan for the spillway
Ungated Spillway Option A-2, extract from Memorial of Pakistan, Exhibit 2
Design proposed by Pakistan for the spillway
Ungated Spillway Option A-2, extract from Memorial of Pakistan, Exhibit 2
Design proposed by Pakistan for the spillway
Ungated Spillway Option A-2, extract from Memorial of Pakistan, Exhibit 2
Design proposed by Pakistan for the spillway
Ungated Spillway Option A-2, extract from Memorial of Pakistan, Exhibit 2
Design proposed by Pakistan for the spillway
Ungated Spillway Option A-2, extract from Memorial of Pakistan, Exhibit 2
Design proposed by Pakistan for the spillway
Ungated Spillway Option A-2, extract from Memorial of Pakistan, Exhibit 2
Economic comparison between gated and ungated overflow chute spillway alternatives

The purpose of this note is to compare the economical conditions for decision making between a gated surface spillway alternative and an ungated free overflow spillway alternative, considering the shape of the valley and the flood discharge.

Following parameters are taken into consideration:

**Dam body geometry**
- Type of dam: gravity
- Dam height for NWL: 130 m (including freeboard)
- Valley profile:
  - Dam face batter: downstream: 1:0.85, upstream: 1:0.10
  - Crest length available for overflow spillway: ca 180 m
  - Crest length available for gated spillway: ca 120 m
- Design discharge \( Q = 16,000 \text{ m}^3/\text{s} \)

**Prices**
- For gates: A unit price of USD 15,000 per ton has been considered. It includes furniture, manufacturing and montage. Hoisting system and maintenance costs during 30 years life duration are also considered.
- For dam concrete: A unit price of USD 130.00 per m\(^3\) has been considered. This price is to be applied on the difference of concrete volume between two alternatives.

All other contingencies, such as energy dissipation arrangement, crest bridges, costs related to flood protection of reservoir shores, are not taken into consideration in this demonstration.

The volume of concrete can be estimated using the following formula:

\[
V = \frac{1}{6} \left( m_{US} + m_{DS} \right) H^2 \left[ b + \sqrt{\frac{1}{S_L} + \frac{1}{S_R}} \right] \cdot H
\]

where
- \( V \) Volume of concrete
- \( H \) Height of dam
- \( m_{US} \) Dam upstream face batter
- \( m_{DS} \) Dam downstream face batter
- \( b \) Width of riverbed – horizontal section of the dam in transversal section
- \( S_L \) and \( S_R \): left and right slope of foundation
The weight of a surface radial gate can be estimated using the following formula\(^1\):

\[
G = 0.64 \cdot (B^2 \cdot h \cdot H)^{0.682}
\]

where
\(G\) Weight of gate, in [kN]
\(B\) span of gate, in [m]
\(h\) height of gate, in [m]
\(H\) head on the sill, in [m]

This formulation is based on a statistical analysis of dozens of radial gates, built since 1960, with height from 6.0 to 22.3 m.

**Alternative I – gated spillway:**

\[
\begin{array}{c}
\text{Gates} \\
8 \text{ radial gates } W = 12 \text{ m}, H = 18.7 \text{ m} \\
\text{Piers} \\
7 \text{ piers, } W = 3.5 \text{ m}, K_p = 0.01, K_a = 0.08 \\
\text{Volume of concrete: } 1,390,000 \text{ m}^3 \text{ (estimate)} \\
\text{Cost of concrete: } Mio. USD 181.0 \\
\text{Weight of gates: } 8 \times 111 \text{ tons} = 888 \text{ tons} \\
\text{Cost of gates: } Mio. USD 13.5 \\
\text{Sum: } Mio. USD 194.5
\end{array}
\]

**Alternative II – free overflow spillway:**

\[
\begin{array}{c}
\text{Bays} \\
8 \text{ bays } W = 20 \text{ m} \\
\text{Piers} \\
7 \text{ piers, } W = 3.0 \text{ m}, K_p = 0.01, K_a = 0.08 \\
\text{Head above weir} \\
13.0 \text{ m} \\
\text{Dam height} \\
143 \text{ m} \\
\text{Volume of concrete: } 1,760,000 \text{ m}^3 \text{ (estimate)} \\
\text{Cost of concrete: } Mio. USD 229.0
\end{array}
\]

This simplified and approximate calculation shows that ungated spillway alternative leads to higher costs than the correspondent gated spillways alternative.

Taking into account the simplifications made, the difference is Mio. USD 34.5, corresponding to an increase of the costs by 17.7 % for the dam body.

This numerical result is evidently also tributary of the unit prices used for the calculation, but for a gravity type dam in a narrow valley, the cost comparison is always in favour of gated spillway alternative.
Spillways of Dams commissioned since 1940

ungated: only equipped with ungated overflow spillways

gated: only equipped with gated spillways (surface or orifice)
mixed: equipped with both type of spillways

---

**Reference:** ICOLD World Register of Dams, 2003
Section across sluice spillway right bay and elevation of power intake
Design submitted by India

Source: India’s Presentation on Intakes, London, 27th May, 2006 (powerpoint file)
Design of Intakes – Pakistan design with SET

Scenario 1 – Sediment level at elevation 818 m asl

Scenario 2 – Sediment level at elevation 825.5 m asl

Source: Pakistan’s Presentation on suspended sediments, Q_{ssm} 1 to 4, London, 25^{th} May, 2006 (powerpoint file)
Stabilized bed profile in the near field, according to India

Source: India’s presentation on suspended sediments, Q$_{sm}$ 1, London, 25$^{th}$ May, 2006 (powerpoint file)
Design proposed by Pakistan for the power intake
From Pakistan' reply, Part II, Annex II-D
Design proposed by Pakistan for the power intake
From Pakistan’s reply, Part II, Annex II-D
Design proposed by Pakistan for the power intake
From Pakistan’ reply, Part II, Annex II-D
Design proposed by Pakistan for the power intake
From Pakistan' reply, Part II, Annex II-D
Design proposed by Pakistan for the power intake
From Pakistan' reply, Part II, Annex II-D
Design proposed by Pakistan for the power intake
From Pakistan' reply, Part II, Annex II-D
Design proposed by Pakistan for the power intake
From Pakistan' reply, Part II, Annex II-D
Design proposed by Pakistan for the power intake
From Pakistan’ reply, Part II, Annex II-D
Design proposed by Pakistan for the power intake
From Pakistan' reply, Part II, Annex II-D
Extract from *Les Pierres Sauvages*

Fernand POUILLON

*Translated from the French text by Alison Bartle*

"How can those masters of the profession know in advance that a building designed in this way will not collapse?", he asked me.

That is how we established unity in the design of schemes; the cornerstone of our art. Already, in the previous observation of Bernard, I had observed that technical issues seemed to be set apart in his mind from the design of shapes.

Since when have we separated, even just in the mind, modelling from technique, or structural shapes from construction materials? Architect and project manager are not simply titles, they are clearly defined and absolute functions. Shapes, volumes, weights, strengths, pressures, deformations, equilibrium, movement, outlines, loads and overloads, humidity, dryness, warmth and cold, sound, light, shade and half-light, perceptions, earth, water and air: each one of these is contained in the sovereign set of functions, in the unique brain, of an ordinary human builder.

This man, the builder, is all: clay and sand, stone and wood, iron and bronze. He becomes as one with his construction materials, and assumes their identity; all the elements, and all the tangible and spiritual forces. He will carry them within him, evaluate them, measure them, view them through his soul, as if he were holding them in his hands. I don’t intend these to be poetic images: they are material facts, which for me are unquestionable, and I even regard them as quite prosaic.

If I were a wooden beam resting between two supports twenty feet apart, I would estimate the strength of the fibres of my back, and broaden myself sufficiently to allow my body to resist the bending caused by my own weight, and by the forces I should have to withstand. Simultaneously, I would consider my external appearance: the effect of my trajectory and my colour; thus I would determine my material composition, considering whether I should be made of oak or pine. These considerations are sparked off during the early stage of a study, with unconditional simultaneity.

This simple example, which I have just described, can be carried through to all other aspects of the work: the beam can represent a simplified image of a flying buttress and its aerial structure; a solid buttress; an arch. I can, and I must, be capable of breaking myself down...
into the individual stones of the arch; feel myself to be the keystone of the arch, the cross beam or the voussoir. I must recognize the stone in my flesh, regard it as my own skin, make it follow a chosen profile, and fit in with the resulting volume. The ultimate shape will be defined by this choice. Structure is all; shape is all; matter is all.

How can one explain this mystery, without recognizing that man contains all of this within himself? Why speak of calculations, which are nothing, which create nothing, when technical problems are contained in the final shape? Why is it necessary to check volumes when they have been determined? No doubt it is for the satisfaction, for the pleasure, of answering ‘yes’ to oneself. But if the answer is ‘no’, what then? Is it necessary to start all over again, returning to the initial study?

Calculations are the proof, but they will never be a means in themselves. Did the very first builder know how to count? Certainly he did not. But he did have a clear objective: to create shelter. This basic necessity assumed a certain beauty, because this man saw before him nature, the sky, light and colour, mountains with their particular profile, stones and the material of which they were made.

The first collapse of a building represented the first failure, and probably the first anxiety, the first calculation. To sanctify calculations would amount to recognizing failure as an original work of art. Should we allow that? Any theory can be defended, but I leave it to men of the faith to reply to this question.

In conclusion, I think that duality, plurality in the design of a work of art is worse than a weakness; it is a vice. Beauty cannot exist without equilibrium, nor technique without material, equilibrium without beauty.
Flood routing using India’s rating curves

**Inflow : PMF (or 10'000-years flood)**

**Outlets :**
- 5 sluice spillways
- 3 chute spillways
- 1 auxiliary spillway

<table>
<thead>
<tr>
<th>Elevation</th>
<th>Auxiliary</th>
<th>Chute</th>
<th>Sluice</th>
</tr>
</thead>
<tbody>
<tr>
<td>835</td>
<td>3607</td>
<td>9130</td>
<td></td>
</tr>
<tr>
<td>836</td>
<td>4003</td>
<td>9336</td>
<td></td>
</tr>
<tr>
<td>837</td>
<td>4412</td>
<td>9541</td>
<td></td>
</tr>
<tr>
<td>838</td>
<td>4831</td>
<td>9739</td>
<td></td>
</tr>
<tr>
<td>839</td>
<td>5260</td>
<td>9934</td>
<td></td>
</tr>
<tr>
<td>840</td>
<td>5698</td>
<td>10125</td>
<td></td>
</tr>
<tr>
<td>841</td>
<td>6144</td>
<td>10313</td>
<td></td>
</tr>
<tr>
<td>842</td>
<td>6598</td>
<td>10497</td>
<td></td>
</tr>
<tr>
<td>843</td>
<td>7059</td>
<td>10678</td>
<td></td>
</tr>
</tbody>
</table>

**Hydrograph Nr:** 1
**Inflow Hydrograph:** PMF
**Peak discharge:** 16200

**Initial water level:** 840 masl

**Auxiliary spillway**
- Number bays: 1
- Bay width: 6 m
- Seal level: 837 masl
- Hd: 3 m
- Cd: 0.42
- Ka: 0.10
- Gate opening level: 840 masl

**Chute spillway**
- Number bays: 3
- Bay width: 12 m
- Seal level: 821 masl
- Gate opening level: 840 masl
- Delta gate opening: 0.002 m
- Hd: 19 m
- Cd: 0.494
- Ka: 0.1
- Kp: 0.01

**Sluice spillway**
- Number Outlets: 5
- Height: 10.5 m
- Width: 10 m
- Elevation: 813.25 masl
- Ki: 1.411
- Orifice operation level: 840.05
- Delta orifice opening: 0

**Data**

- Max WL: 840.22 masl
- Max auxiliary: 57 m3/s
- Max chute spillways: 5793 m3/s
- Spec. Discharge: 161 m2/s
- Max sluice spillways: 10'166 m3/s
- Max outflow: 16'017 m3/s
- Max inflow: 16'195 m3/s
Flood routing using India’s rating curves

*Inflow*: PMF (or 10’000-years flood)

**Outlets**: 5 sluice spillways  
*2 chute spillways*  
1 auxiliary spillway

<table>
<thead>
<tr>
<th>Elevation</th>
<th>Auxiliary</th>
<th>Chute</th>
<th>Sluice</th>
</tr>
</thead>
<tbody>
<tr>
<td>835</td>
<td>2312</td>
<td>9130</td>
<td></td>
</tr>
<tr>
<td>836</td>
<td>2558</td>
<td>9338</td>
<td></td>
</tr>
<tr>
<td>837</td>
<td>2810</td>
<td>9541</td>
<td></td>
</tr>
<tr>
<td>838</td>
<td>3066</td>
<td>9739</td>
<td></td>
</tr>
<tr>
<td>839</td>
<td>3327</td>
<td>9934</td>
<td></td>
</tr>
<tr>
<td>840</td>
<td>3592</td>
<td>10125</td>
<td></td>
</tr>
<tr>
<td>841</td>
<td>3860</td>
<td>10313</td>
<td></td>
</tr>
<tr>
<td>842</td>
<td>4130</td>
<td>10497</td>
<td></td>
</tr>
<tr>
<td>843</td>
<td>4403</td>
<td>10678</td>
<td></td>
</tr>
</tbody>
</table>

| Hydrograph Nr. | 1 |
| Inflow Hydrograph | PMF* |
| Peak discharge | 6200 |
| Initial water level | 840 masl |

**Auxiliary spillway**

- Number bays: 1
- Bay width: 6 m
- Seal level: 837 masl
- $H_d$: 3 m
- $C_d$: 0.42
- $K_a$: 0.10
- Gate opening level: 840 masl

**Chute spillway**

- Number bays: 2
- Bay width: 12 m
- Seal level: 821 masl
- Gate opening level: 840 masl
- Delta gate opening: 0.002 m
- $H_d$: 19 m
- $C_d$: 0.494
- $K_a$: 0.1
- $K_p$: 0.01

**Sluice spillway**

- Number Outlets: 5
- Height: 10.5 m
- Width: 10 m
- Elevation: 813.25 masl
- $K_i$: 1.411
- Orifice operation level: 840.05 masl
- Delta orifice opening: 0

Max WL: 843.92 masl
Max auxiliary: 156 m³/s
Max chute spillways: 4'655 m³/s
Spec. Discharge: 194 m³/s
Max sluice spillways: 10'842 m³/s
Max outflow: 15'653 m³/s
Max inflow: 16'195 m³/s

---

### Graph

- Inflow
- Auxiliary
- Total chute
- Total sluices
- Total outflow
- Water level

- Reservoir level [m a.s.l.]
- Discharge [m³/s]
- Time [h]
Flood routing using India’s rating curves

**Inflow**: PMF (or 10’000-years flood)

**Outlets**: 4 sluice spillways  
3 chute spillways  
1 auxiliary spillway

---

| Hydrograph Nr. | 1 |
| Inflow Hydrograph | PMF* |
| Peak discharge | 16200 |
| Initial water level | 840 masl |

**Auxiliary spillway**

- Number bays: 1
- Bay width: 6 m
- Seal level: 837 masl
- Hg: 3 m
- Cd: 0.42
- Ka: 0.10
- Gate opening level: 840 masl

**Chute spillway**

- Number bays: 3
- Bay width: 12 m
- Seal level: 821 masl
- Gate opening level: 840 masl
- Delta gate opening: 0.002 m
- Hg: 19 m
- Cd: 0.494
- Ka: 0.1
- Kp: 0.01

**Sluice spillway**

- Number Outlets: 4
- Height: 10.5 m
- Width: 10 m
- Elevation: 813.25 masl
- Ki: 1.411
- Orifice operation level: 840.05 masl
- Delta orifice opening: 0

---

<table>
<thead>
<tr>
<th>Elevation</th>
<th>Auxiliary</th>
<th>Chute</th>
<th>Sluice</th>
</tr>
</thead>
<tbody>
<tr>
<td>835</td>
<td>3867</td>
<td>7304</td>
<td></td>
</tr>
<tr>
<td>836</td>
<td>4003</td>
<td>7470</td>
<td></td>
</tr>
<tr>
<td>837</td>
<td>4412</td>
<td>7633</td>
<td></td>
</tr>
<tr>
<td>838</td>
<td>4831</td>
<td>7792</td>
<td></td>
</tr>
<tr>
<td>839</td>
<td>5260</td>
<td>7947</td>
<td></td>
</tr>
<tr>
<td>840</td>
<td>5698</td>
<td>8100</td>
<td></td>
</tr>
<tr>
<td>841</td>
<td>6144</td>
<td>8250</td>
<td></td>
</tr>
<tr>
<td>842</td>
<td>6598</td>
<td>8398</td>
<td></td>
</tr>
<tr>
<td>843</td>
<td>7059</td>
<td>8542</td>
<td></td>
</tr>
</tbody>
</table>

---

Graph showing hydrograph and reservoir level over time.
Flood routing using Pakistan's rating curves

**Inflow**: PMF (or 10'000-years flood)

**Outlets**: 5 sluice spillways
3 chute spillways
1 auxiliary spillway

---

**Hydrograph Nr.**

<table>
<thead>
<tr>
<th>Hydrograph Nr.</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inflow Hydrograph</td>
<td>PMF*</td>
</tr>
<tr>
<td>Peak discharge</td>
<td>16200</td>
</tr>
</tbody>
</table>

| Initial water level | 840 masl |

**Auxiliary spillway**

| Number bays | 1 |
| Bay width | 6 m |
| Seal level | 837 masl |
| Hd | 3 m |
| Cd | 0.42 |
| Ka | 0.05 |
| Gate opening level | 840 masl |

**Chute spillway**

| Number bays | 3 |
| Bay width | 12 m |
| Seal level | 821 masl |
| Gate opening level | 840 masl |
| Delta gate opening | 0.002 m |
| Hd | m |
| Cd | |
| Ka | |
| Kp | |

**Sluice spillway**

| Number Orifices | 5 |
| Height | 10.5 m |
| Width | 10 m |
| Elevation | 813.25 masl |
| xi | |
| Orifice operation level | 840.005 masl |
| Delta orifice opening | 0.001 m |

---

**Graph**

- **Inflow**
- **Auxiliary**
- **Total chute**
- **Total sluices**
- **Total outflow**
- **Water level**
Flood routing using Pakistan’s rating curves

**Inflow**: PMF (or 10’000-years flood)

**Outlets**: 5 sluice spillways  
2 chute spillways  
1 auxiliary spillway

---

**Max WL** 841.83 masl  
**Max auxiliary** 100 m³/s  
**Max chute spillways** 6'452 m³/s  
**Spec. Discharge** 269 m²/s  
**Max sluices spillways** 9'396 m³/s  
**Max outflow** 15'947 m³/s  
**Max inflow** 16'195 m³/s

---

**Hydrograph Nr.** 1  
**Inflow Hydrograph** PMF*  
**Peak discharge** 16200  
**Initial water level** 840 masl

**Auxiliary spillway**  
**Number bays** 1  
**Bay width** 6 m  
**Seal level** 837 masl  
**Hd** 3 m  
**Cd** 0.42  
**Ka** 0.05  
**Gate opening level** 840 masl

**Chute spillway**  
**Number bays** 2  
**Bay width** 12 m  
**Seal level** 821 masl  
**Gate opening level** 840 masl  
**Delta gate opening** 0.002 m  
**Hd** m  
**Cd**  
**Ka**  
**Kp**

**Sluice spillway**  
**Number Orifices** 5  
**Height** 10.5 m  
**Width** 10 m  
**Elevation** 813.25 masl  
**Orifice operation level** 840.005 masl  
**Delta orifice opening** 0.001 m

---

**Elevation**  
835  
836  
837  
838  
839  
840  
841  
842  
843

**Auxiliary**  
4'565  
5'168  
5'836  
6'575  
7'391

**Chute**  
8'915  
9'088  
9'257  
9'423  
9'587

**Sluice**

---

![Graph showing flood routing](image-url)
Flood routing using Pakistan's rating curves

*Inflow: PMF* (or 10'000-years flood)

**Outlets:**
- 4 sluice spillways
- 3 chute spillways
- 1 auxiliary spillway

---

**Hydrograph Nr. 1**

Inflow Hydrograph: PMF*
Peak discharge: 16200 m³/s
Initial water level: 840 m a.s.l.

**Auxiliary spillway**
- Number bays: 1
- Bay width: 6 m
- Seal level: 837 m a.s.l.
- Hd: 3 m
- Cd: 0.42
- Ka: 0.05
- Gate opening level: 840 m a.s.l.

**Chute spillway**
- Number bays: 3
- Bay width: 12 m
- Seal level: 821 m a.s.l.
- Gate opening level: 840 m a.s.l.
- Delta gate opening: 0.002 m
- Hd
- Cd
- Ka
- Kp

**Sluice spillway**
- Number Orifices: 4
- Height: 10.5 m
- Width: 10 m
- Elevation: 813.25 m a.s.l.
- Orifice operation level: 840.005 m a.s.l.
- Delta orifice opening: 0.001 m

---

**Max WL:** 840.54 m a.s.l.
**Max auxiliary:** 66 m³/s
**Max chute spillways:** 8'624 m³/s
**Spec. Discharge:** 240 m³/s
**Max sluice spillways:** 7'344 m³/s
**Max outflow:** 16'034 m³/s
**Max inflow:** 16'195 m³/s

---

**Graph**

- Inflow
- Auxiliary
- Total chute
- Total sluices
- Total outflow
- Water level

---

**Table**

<table>
<thead>
<tr>
<th>Elev.</th>
<th>Auxiliary</th>
<th>Chute</th>
<th>Sluice</th>
</tr>
</thead>
<tbody>
<tr>
<td>835</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>836</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>837</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>838</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>839</td>
<td>4'565</td>
<td>8'915</td>
<td></td>
</tr>
<tr>
<td>840</td>
<td>5'168</td>
<td>9'088</td>
<td></td>
</tr>
<tr>
<td>841</td>
<td>5'836</td>
<td>9'257</td>
<td></td>
</tr>
<tr>
<td>842</td>
<td>6'575</td>
<td>9'423</td>
<td></td>
</tr>
<tr>
<td>843</td>
<td>7'391</td>
<td>9'587</td>
<td></td>
</tr>
</tbody>
</table>

---

**Graph Details**

- Discharge [m³/s]
- Reservoir level [m a.s.l.]
- Time [h]
Flood routing using the rating curves defined by the NE

Inflow: PMF (or 10'000-years flood)

Outlets:
- 5 sluice spillways
- 3 chute spillways
- 1 auxiliary spillway

<table>
<thead>
<tr>
<th>Elevation</th>
<th>Auxiliary</th>
<th>Chute</th>
<th>Sluice</th>
</tr>
</thead>
<tbody>
<tr>
<td>835</td>
<td>3'774</td>
<td></td>
<td></td>
</tr>
<tr>
<td>836</td>
<td>4'196</td>
<td>9'512</td>
<td></td>
</tr>
<tr>
<td>837</td>
<td>4'629</td>
<td>9'940</td>
<td></td>
</tr>
<tr>
<td>838</td>
<td>5'076</td>
<td>10'147</td>
<td></td>
</tr>
<tr>
<td>839</td>
<td>5'534</td>
<td>10'350</td>
<td></td>
</tr>
<tr>
<td>840</td>
<td>6'003</td>
<td>10'549</td>
<td></td>
</tr>
<tr>
<td>841</td>
<td>6'483</td>
<td>10'744</td>
<td></td>
</tr>
<tr>
<td>842</td>
<td>6'972</td>
<td>10'936</td>
<td></td>
</tr>
<tr>
<td>843</td>
<td>7'471</td>
<td>11'125</td>
<td></td>
</tr>
</tbody>
</table>

Max WL: 840.00 masl
Max auxiliary: 53 m³/s
Max chute spillways: 6'003 m³/s
Max sluice spillways: 10'138 m³/s
Max outflow: 16'195 m³/s
Max inflow: 16'195 m³/s

Graph with inflow and outflow data.
Flood routing using the rating curves defined by the NE

*Inflow*: PMF (or 10,000-years flood)

**Outlets:**
- 5 sluice spillways
- 2 chute spillways
- 1 auxiliary spillway

<table>
<thead>
<tr>
<th>Elevation</th>
<th>Auxiliary</th>
<th>Chute</th>
<th>Sluice</th>
</tr>
</thead>
<tbody>
<tr>
<td>835</td>
<td>2'442</td>
<td>9'512</td>
<td></td>
</tr>
<tr>
<td>836</td>
<td>2'708</td>
<td>9'726</td>
<td></td>
</tr>
<tr>
<td>837</td>
<td>2'981</td>
<td>9'940</td>
<td></td>
</tr>
<tr>
<td>838</td>
<td>11</td>
<td>3'260</td>
<td>10'147</td>
</tr>
<tr>
<td>839</td>
<td>30</td>
<td>3'546</td>
<td>10'350</td>
</tr>
<tr>
<td>840</td>
<td>53</td>
<td>3'837</td>
<td>10'549</td>
</tr>
<tr>
<td>841</td>
<td>80</td>
<td>4'133</td>
<td>10'744</td>
</tr>
<tr>
<td>842</td>
<td>108</td>
<td>4'433</td>
<td>10'936</td>
</tr>
<tr>
<td>843</td>
<td>138</td>
<td>4'738</td>
<td>11'125</td>
</tr>
</tbody>
</table>

**Max WL**: 842.53 masl

**Max auxiliary**: 124 m³/s

**Max chute spillways**: 4'595 m³/s

**Spec. Discharge**: 191 m²/s

**Max sluice spillways**: 11'037 m³/s

**Max outflow**: 15'755 m³/s

**Max inflow**: 16'195 m³/s

**Hydrograph Nr.**: 1

**Inflow Hydrograph**: PMF*

**Peak discharge**: 16200

**Initial water level**: 840 masl

**Auxiliary spillway**
- **Number bays**: 1
- **Bay width**: 6 m
- **Seal level**: 837 masl
- **Hd**: 3 m
- **Cd**: 0.42
- **Ka**: 0.08
- **Gate opening level**: 840 masl

**Chute spillway**
- **Number bays**: 2
- **Bay width**: 12 m
- **Seal level**: 821 masl
- **Gate opening level**: 840 masl
- **Delta gate opening**: 0.002 m
- **Hd**: 15 m
- **Cd**: 0.494
- **Ka**: 0.08
- **Kp**: 0.01

**Sluice spillway**
- **Number Outlets**: 5
- **Height**: 10.5 m
- **Width**: 10 m
- **Elevation**: 813.25 masl
- **Ki**: 1.3
- **Orifice operation level**: 840.05
- **Delta orifice opening**: 0

**Flood routing using the rating curves defined by the NE**

- **Inflow**: PMF (10,000-years flood)
- **Outlets**: 5 sluice spillways, 2 chute spillways, 1 auxiliary spillway
Flood routing using the rating curves defined by the NE

*Inflow: PMF (or 10'000-years flood)*

Outlets:
- **4 sluice spillways**
- 3 chute spillways
- 1 auxiliary spillway

<table>
<thead>
<tr>
<th>Elevation</th>
<th>Auxiliary</th>
<th>Chute</th>
<th>Sluice</th>
</tr>
</thead>
<tbody>
<tr>
<td>835</td>
<td>3'774</td>
<td>7'610</td>
<td></td>
</tr>
<tr>
<td>836</td>
<td>4'195</td>
<td>7'782</td>
<td></td>
</tr>
<tr>
<td>837</td>
<td>4'929</td>
<td>7'952</td>
<td></td>
</tr>
<tr>
<td>838</td>
<td>11</td>
<td>5'076</td>
<td>8'117</td>
</tr>
<tr>
<td>839</td>
<td>30</td>
<td>5'534</td>
<td>8'280</td>
</tr>
<tr>
<td>840</td>
<td>53</td>
<td>6'003</td>
<td>8'439</td>
</tr>
<tr>
<td>841</td>
<td>80</td>
<td>6'483</td>
<td>8'595</td>
</tr>
<tr>
<td>842</td>
<td>108</td>
<td>6'972</td>
<td>8'749</td>
</tr>
<tr>
<td>843</td>
<td>138</td>
<td>7'471</td>
<td>8'900</td>
</tr>
</tbody>
</table>

Max WL: 842.04 m asl
Max auxiliary: 109 m3/s
Max chute spillways: 6'994 m3/s
Spec. Discharge: 194 m2/s
Max sluice spillways: 8'756 m3/s
Max outflow: 15'859 m3/s
Max inflow: 16'195 m3/s

| Hydrograph Nr. | 1 |
| Inflow Hydrograph | PMF* |
| Peak discharge | 16'200 |
| Initial water level | 840 m asl |

**Auxiliary spillway**
- Number bays: 1
- Bay width: 6 m
- Seal level: 837 m asl
- Hd: 3 m
- Cd: 0.42
- Ka: 0.08
- Gate opening level: 840 m asl

**Chute spillway**
- Number bays: 3
- Bay width: 12 m
- Seal level: 821 m asl
- Gate opening level: 840 m asl
- Delta gate opening: 0.002 m
- Hd: 15 m
- Cd: 0.494
- Ka: 0.08
- Kp: 0.01

**Sluice spillway**
- Number Outlets: 4
- Height: 10.5 m
- Width: 10 m
- Elevation: 813.25 m asl
- Ki: 1.3
- Orifice operation level: 840.05
- Delta orifice opening: 0

Max WL: 842.04 m asl
Max auxiliary: 109 m3/s
Max chute spillways: 6'994 m3/s
Max sluice spillways: 8'756 m3/s
Max outflow: 15'859 m3/s
Max inflow: 16'195 m3/s

Flood routing using the rating curves defined by the NE

Inflow: PMF (or 10'000-years flood)
Outlets:
- 4 sluice spillways
- 3 chute spillways
- 1 auxiliary spillway
Flow duration curve
of Chenab river at Baglihar

(completed with months from 1979 and 1987, which are incomplete years): 4 years
1st semester 2005 and 2nd semester 1987: 1 year
Total: 25 years
Pondage calculation done by Pakistan

\[ \text{Pondage} = A + B = 3.11 \]

\[ \text{Pondage} = C = 8.02 \]
Pondage calculation done by India

\[
\text{Pondage} = A + B = 18.75
\]