Sediment deficit

Sediment evacuation

Incision
Sediment deficit

Sediment evacuation

Incision
Because most of the water is moved to the lower basin, the primary changes in the flow regime are caused by flood control, changes in the season of high flow, and hydropeaking:

1) Reduce the magnitude of floods
2) Increase the magnitude of base flows
3) Introduce daily “tides” associated with hydropower production
4) Do not change the annual volume of stream flow

Natural floods < post-dam controlled floods
1934 – 25,300
1954 – 34,300
1931 – 34,600
1955 – 35,600
1959 – 38,900

(Topping et al., 2003)
### Postdam floods

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of consecutive days mean daily discharge exceeded 31,500 cubic feet per second</th>
<th>Dates</th>
<th>Instantaneous peak, in cubic feet per second</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>1965</td>
<td>34</td>
<td>May 21 - June 25</td>
<td>60,200</td>
<td>reservoir equalization and channel cleaning</td>
</tr>
<tr>
<td>1980</td>
<td>6</td>
<td>June 24 - July 1</td>
<td>44,800</td>
<td>spillway test</td>
</tr>
<tr>
<td>1983</td>
<td>68</td>
<td>June 3 - August 10</td>
<td>97,300</td>
<td>excess runoff</td>
</tr>
<tr>
<td>1984</td>
<td>76</td>
<td>May 5 - July 20</td>
<td>excess runoff</td>
<td></td>
</tr>
<tr>
<td>1985</td>
<td>39</td>
<td>May 17 - June 28</td>
<td>47,900</td>
<td>excess runoff</td>
</tr>
<tr>
<td>1986</td>
<td>46</td>
<td>May 8 - June 24</td>
<td>53,200</td>
<td>excess runoff</td>
</tr>
<tr>
<td>1996</td>
<td>8</td>
<td>March 26 - April 2</td>
<td>45,900</td>
<td>high-flow experiment</td>
</tr>
<tr>
<td>2004</td>
<td></td>
<td>November 22 - 24</td>
<td>42,500</td>
<td>high-flow experiment</td>
</tr>
<tr>
<td>2008</td>
<td>3</td>
<td>March 6 - 8</td>
<td>42,800</td>
<td>high-flow experiment</td>
</tr>
</tbody>
</table>

### Short duration high flows

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<th>Number of consecutive days mean daily discharge exceeded 31,500 cubic feet per second</th>
<th>Dates</th>
<th>Instantaneous peak, in cubic feet per second</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>1965</td>
<td>7</td>
<td>May 4 - May 11</td>
<td>60,200</td>
<td>reservoir equalization and channel cleaning</td>
</tr>
<tr>
<td>1980</td>
<td></td>
<td>June 24 - July 1</td>
<td>44,800</td>
<td>spillway test</td>
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</table>
Postdam floods

- Daily sediment loads
- Annual sediment loads

2-yr flood

Discharge (m$^3$/s)

Fine-sediment load (Mg/day)
Pre-dam mainstem Colorado River delivered 87% of the fine sediment that once was transported through Grand Canyon; modern Paria and Little Colorado Rivers delivery rate is 13% of the pre-dam total supply.

Average annual predam (1949-1962) fine sediment supply rate from upper Colorado River basin = 57,000,000 mt/yr (Topping et al., 2000)

~890,000 mt/yr (sand); ~1,300,000 mt/yr (silt/clay)

23,000,000 mt/yr (sand); 24,000,000 mt (silt/clay)

620,000 mt/yr (sand); 4,600,000 mt (silt/clay)

Paria and Little Colorado River values are for July 1, 2004–June 30, 2017

modern data GCMRC (Topping group)

Stream gaging and suspended sediment measurement of the Colorado River at Lees Ferry
scour and fill during annual floods of the Colorado River at Lees Ferry, AZ

What does this plot tell us?

Bed elevations in subsequent surveys
Range 20, 1.0 km downstream from Glen Canyon Dam

Range 19, 1.5 km downstream from Glen Canyon Dam

Range 18, 2.5 km downstream from Glen Canyon Dam

Range 17, 3.4 km downstream from Glen Canyon Dam
What do these plots tell us?

Degradation greater in pools
Greatest erosion in 1965 (2 yrs after dam completed)

Pattern of incision is actually variable
Explain this graph.
In Glen Canyon, sediment deficit, bed incision occurred ....

... and conversion of a sand bed to a cobble bed.

Grams et al., 2007
Bed degradation → Perched deposits on channel margins

These deposits are stabilized by riparian vegetation
What does this graph tell us?
Styles of channel adjustment in segments with degrading bed and **stable** stage-discharge relation: Bed Scour and bank deposition

Replication of X-Section R-4 derived from NOV 2004
Green “SHOALS” LiDAR (water-penetrating) data