Instream Flows vs. Freshwater Inflows

How do example HEFR numbers compare to Freshwater Inflow Study recommendations for the Guadalupe Estuary?

Presentation to Science Advisory Committee
February 4, 2009

Texas Parks & Wildlife Department
Texas Water Development Board
# Tale of the Tape

<table>
<thead>
<tr>
<th>Instream Flows</th>
<th>vs</th>
<th>Freshwater Inflows</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>DOB</td>
<td>1975</td>
</tr>
<tr>
<td>Daily</td>
<td>Time Step</td>
<td>Monthly</td>
</tr>
<tr>
<td>feet³/sec</td>
<td>Units</td>
<td>acre-feet</td>
</tr>
<tr>
<td>Subsistence</td>
<td>Range</td>
<td>Min Q Sal</td>
</tr>
<tr>
<td>Base, High Pulse</td>
<td>Min Q</td>
<td>Min Q</td>
</tr>
<tr>
<td>Overbank</td>
<td>Max H</td>
<td>Max H</td>
</tr>
<tr>
<td>WQ, Habitat,</td>
<td>Objectives</td>
<td>Salinity, Harvest,</td>
</tr>
<tr>
<td>Processes,</td>
<td></td>
<td>Sediment, ...</td>
</tr>
<tr>
<td>...</td>
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</tr>
</tbody>
</table>
Objectives

Freshwater Inflow Patterns for Bays

- **Min Q Sal**: Minimum flow volume that meets salinity constraints.
- **Min Q**: Minimum flow volume that meets all constraints.
- **Max H**: Flow pattern that meets all constraints and maximizes harvest.

Instream Flow Components for Rivers

- **Subsistence**: Maintain water quality and sufficient population of organisms to support recovery.
- **Base**: Provide suitable habitat conditions.
- **High Flow Pulse**: Maintain physical habitat features and connectivity along the river.
- **Overbank**: Maintain riparian areas and provide connectivity with floodplain.
Possible Outcomes

- If you take care of the river, it’ll take care of the bay.
- If you take care of the bay, it’ll take care of the river.
- Recommendations for the bay and river will conflict.
- With some effort, bay and river recommendations can be reconciled.
Example: Guadalupe Estuary (San Antonio Bay)

- Completed Freshwater Inflow Study
  - Inflow recommendations based on historical harvest data
  - Subject to constraints

- Example HEFR Instream Flow Numbers
  - Subsistence, Base, High Pulse, Overbank Flows
Example:

Watershed Area: More than 10,000 square miles
Average Annual Flow: Almost 2 million acre-feet

San Antonio River at Goliad
USGS Gage 08188500 (22.7%)

Guadalupe River at Victoria
USGS Gage 08176500 (56.9%)

San Antonio River at Goliad
USGS Gage 08188500 (22.7%)

Guadalupe Estuary
(San Antonio Bay)

Legend
- USGS Gage
- River
- San Antonio Bay Shoreline
- Basins: San Antonio and Guadalupe
- Coastal Subbasins
Freshwater Inflows to the Bay

+ Guadalupe River @ Victoria, TX (56.9%)
+ San Antonio River @ Goliad, TX (22.7%)
+ Inflow from ungaged area
  - Diversions below gages
+ Return flows below gages

Total Freshwater Inflow to bay
Freshwater Inflow Recommendations

Yearly Total
1,150,000 ac-ft
1,030,000 ac-ft
663,000 ac-ft
Freshwater Inflows: Scaled to Gage Locations

Yearly Total
- Max H - Scaled: 913,000 ac-ft
- Min Q - Scaled: 819,000 ac-ft
- Min Q Sal - Scaled: 527,000 ac-ft

Monthly Inflows:
- January: 819,000 ac-ft
- February: 913,000 ac-ft
- March: 527,000 ac-ft
- April: 527,000 ac-ft
- May: 819,000 ac-ft
- June: 913,000 ac-ft
- July: 819,000 ac-ft
- August: 527,000 ac-ft
- September: 527,000 ac-ft
- October: 527,000 ac-ft
- November: 527,000 ac-ft
- December: 527,000 ac-ft
Guadalupe River at Victoria (1940-2007)

Yearly Total
- 1,460,000 ac-ft
- 1,370,000 ac-ft
- 766,000 ac-ft
- 459,000 ac-ft
San Antonio River at Goliad (1940-2007)

Yearly Total
- 601,000 ac-ft
- 498,000 ac-ft
- 268,000 ac-ft
- 168,000 ac-ft
Example HEFR Numbers

Caveats

• **Preliminary numbers** based only on daily flow data from gages and default criteria in IHA/HEFR.

• **No site or river basin specific knowledge** was used to adjust the numbers.

• Considering only **a few possible combinations of conditions** for the two rivers (both subsistence, both dry, both average, both wet).

• **Evaluating the HEFR numbers only**, not how they might be implemented in a water rights permit.
# Example HEFR Numbers at Victoria

<table>
<thead>
<tr>
<th>Overbank Flows</th>
<th>Return Period (R) : 0.7 (years)</th>
<th>Duration (D) : 26 (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume (V) : 318645 (ac-ft)</td>
<td>Peak Flow (Q) : 17400 (cfs)</td>
<td></td>
</tr>
<tr>
<td><strong>High Flow Pulses</strong></td>
<td><strong>F</strong> : 0 <strong>D</strong> : 8</td>
<td><strong>F</strong> : 0 <strong>D</strong> : 7</td>
</tr>
<tr>
<td><strong>Q</strong> : 4098 <strong>V</strong> : 38916</td>
<td><strong>Q</strong> : 3685 <strong>V</strong> : 34059</td>
<td></td>
</tr>
<tr>
<td><strong>F</strong> : 1 <strong>D</strong> : 5</td>
<td><strong>F</strong> : 1 <strong>D</strong> : 5</td>
<td></td>
</tr>
<tr>
<td><strong>Q</strong> : 2875 <strong>V</strong> : 22156</td>
<td><strong>Q</strong> : 2210 <strong>V</strong> : 17296</td>
<td></td>
</tr>
<tr>
<td><strong>F</strong> : 1 <strong>D</strong> : 4</td>
<td><strong>F</strong> : 0 <strong>D</strong> : 3</td>
<td></td>
</tr>
<tr>
<td><strong>Q</strong> : 1973 <strong>V</strong> : 12136</td>
<td><strong>Q</strong> : 1605 <strong>V</strong> : 7171</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Base Flows (cfs)</th>
<th>1150</th>
<th>1190</th>
<th>1263</th>
<th>1230</th>
<th>1280</th>
<th>1250</th>
<th>1150</th>
<th>1020</th>
<th>1030</th>
<th>1130</th>
<th>1020</th>
<th>1050</th>
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<tbody>
<tr>
<td>866</td>
<td>880</td>
<td>867</td>
<td>860</td>
<td>860</td>
<td>970</td>
<td>878</td>
<td>740</td>
<td>742</td>
<td>796</td>
<td>782</td>
<td>812</td>
<td></td>
</tr>
<tr>
<td>631</td>
<td>640</td>
<td>641</td>
<td>610</td>
<td>610</td>
<td>608</td>
<td>608</td>
<td>608</td>
<td>608</td>
<td>608</td>
<td>608</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Subsistence Flows (cfs) | 608 | 608 | 608 | 608 | 608 | 608 | 608 | 608 | 608 |

<table>
<thead>
<tr>
<th>Hydrologic Conditions</th>
<th>Wet</th>
<th>Average</th>
<th>Dry</th>
<th>Subsistence</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>High Flow Pulse Characteristics</th>
<th>F = Frequency (per season)</th>
</tr>
</thead>
<tbody>
<tr>
<td>D = Duration (days)</td>
<td>Q = Peak Flows (cfs)</td>
</tr>
<tr>
<td>V = Volume (ac-ft)</td>
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</table>
## Example HEFR Numbers at Goliad

<table>
<thead>
<tr>
<th>Overbank Flows</th>
<th>Return Period (R) : 0.8 (years)</th>
<th>Duration (D) : 22 (days)</th>
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</thead>
<tbody>
<tr>
<td>High Flow Pulses</td>
<td>Volume (V) : 121032 (ac-ft)</td>
<td>Peak Flow (Q) : 9060 (cfs)</td>
</tr>
<tr>
<td>F: 1 D: 7</td>
<td>F: 1 D: 7</td>
<td>F: 1 D: 8</td>
</tr>
<tr>
<td>Q: 1603 V: 13324</td>
<td>Q: 1828 V: 13684</td>
<td>Q: 1363 V: 10096</td>
</tr>
<tr>
<td>F: 1 D: 5</td>
<td>F: 1 D: 5</td>
<td>F: 1 D: 5</td>
</tr>
<tr>
<td>Q: 1005 V: 6226</td>
<td>Q: 964 V: 6267</td>
<td>Q: 785 V: 4756</td>
</tr>
<tr>
<td>F: 1 D: 4</td>
<td>F: 1 D: 3</td>
<td>F: 1 D: 4</td>
</tr>
<tr>
<td>Q: 705 V: 4137</td>
<td>Q: 674 V: 3171</td>
<td>Q: 510 V: 2452</td>
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</table>

<table>
<thead>
<tr>
<th>Base Flows (cfs)</th>
<th>432</th>
<th>451</th>
<th>451</th>
<th>428</th>
<th>398</th>
<th>371</th>
<th>346</th>
<th>357</th>
<th>367</th>
<th>367</th>
<th>395</th>
<th>433</th>
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<td>336</td>
<td>344</td>
<td>330</td>
<td>318</td>
<td>303</td>
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<td>239</td>
<td>244</td>
<td>247</td>
<td>261</td>
<td>287</td>
<td>324</td>
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<tr>
<td></td>
<td>230</td>
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<td>240</td>
<td>219</td>
<td>219</td>
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<td>219</td>
<td>219</td>
<td>219</td>
<td>219</td>
<td>224</td>
<td>254</td>
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<th>Average</th>
<th>Dry</th>
<th>Subsistence</th>
</tr>
</thead>
</table>

| High Flow Pulse Characteristics | F = Frequency (per season) | D = Duration (days) | Q = Peak Flows (cfs) | V = Volume (ac-ft) |
Subsistence vs. Min Q Sal - Scaled

- Subsistence Flow Scenario:
  - Guadalupe River 7Q2 = 608 cfs
  - San Antonio River 7Q2 = 219 cfs
  - Combined River Flow = 827 cfs

- Total Yearly Flow Volumes:
  Subsistence = 599,000 ac-ft
  Min Q Sal - Scaled = 527,000 ac-ft
Subsistence vs. Min Q Sal - Scaled

Yearly Total

Min Q Sal - Scaled: 527,000 ac-ft
Subsistence: 599,000 ac-ft
Base Habitat vs. Min Q, Max H - Scaled

- HEFR Base Habitat Flow Scenarios:
  - Wet, Average, and Dry Conditions
  - Same condition assumed for both rivers

- Total Yearly Flow Volumes:
  
  Base Flow (Wet) = 1,120,000 ac-ft
  (Average) = 818,000 ac-ft
  (Dry) = 610,000 ac-ft
  Max H – Scaled = 913,000 ac-ft
  Min Q – Scaled = 819,000 ac-ft
Base Dry and Average vs. Min Q - Scaled

Yearly Total:
- Min Q - Scaled: 819,000 ac-ft
- Base - Dry: 610,000 ac-ft
- Base - Average: 818,000 ac-ft
Base Wet vs. Min Q & Max H - Scaled

Yearly Total
- Min Q - Scaled: 819,000 ac-ft
- Max H - Scaled: 913,000 ac-ft
- Base - Wet: 1,120,000 ac-ft
Base with High Pulse Flows vs. Min Q and Max H - Scaled

• Total Yearly Flow Volume:

  Base (Wet) w/ High Pulse = 1,200,000 ac-ft
  (Average) w/ High Pulse =  879,000 ac-ft
  (Dry) w/ High Pulse =     638,000 ac-ft

  Max H – Scaled = 913,000 ac-ft
  Min Q – Scaled =  819,000 ac-ft
Base Dry with High Pulse Flows vs. Min Q - Scaled

Yearly Total
- Min Q - Scaled: 819,000 ac-ft
- Base - Dry: 610,000 ac-ft
- with High Pulse: 638,000 ac-ft

Month
- Jan
- Feb
- Mar
- Apr
- May
- Jun
- Jul
- Aug
- Sep
- Oct
- Nov
- Dec
Base Average with High Pulse Flows vs. Min Q - Scaled

Yearly Total:
- Min Q - Scaled: 819,000 ac-ft
- Base - Average: 818,000 ac-ft
- with High Pulse: 879,000 ac-ft
Base, High Pulse, and Overbank Flows vs. Max H - Scaled

- Total Yearly Flow Volume:
  - Base (Wet) w/ High Pulse = 1,200,000 ac-ft
  - (Average) w/ High Pulse = 879,000 ac-ft
  - (Dry) w/ High Pulse = 638,000 ac-ft

Overbank
- Guadalupe at Victoria = 319,000 ac-ft
- San Antonio at Goliad = 121,000 ac-ft
- Max H – Scaled = 913,000 ac-ft
Base Wet, High Pulse & Overbank Flows vs. Max H - Scaled

Yearly Total
- Max H - Scaled: 913,000 ac-ft
- Base - Wet: 1,120,000 ac-ft
- with High Pulse: 1,200,000 ac-ft
- Overbank: 440,000 ac-ft
Example HEFR Numbers vs. Spring Freshwater Pulse to Bay

- NWF’s Spring Pulse Assessment:
  \[ \sum \text{Max } H \text{ (Apr-Jul)} = 526,000 \text{ ac-ft} \]
  \[ \sum \text{Max } H \text{ (Apr-Jul)} - \text{Scaled} = 419,000 \text{ ac-ft} \]
Example HEFR Numbers vs. Spring Freshwater Pulse to Bay

- **Example HEFR Numbers, Apr-Jul:**

<table>
<thead>
<tr>
<th></th>
<th>Base Conditions</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dry</td>
<td>Average</td>
<td>Wet</td>
</tr>
<tr>
<td>No High Flow Pulse</td>
<td>200,000</td>
<td>285,000</td>
<td>390,000 ac-ft</td>
</tr>
<tr>
<td>With Spring</td>
<td>210,000</td>
<td>302,000</td>
<td>422,000 ac-ft</td>
</tr>
<tr>
<td>High Flow Pulses</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>W/ Spring &amp; Summer</td>
<td>211,000</td>
<td>313,000</td>
<td>434,000 ac-ft</td>
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<tr>
<td>High Flow Pulses</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>San Antonio Overbank</td>
<td></td>
<td>+121,000 ac-ft</td>
<td></td>
</tr>
<tr>
<td>Guadalupe Overbank</td>
<td></td>
<td>+319,000 ac-ft</td>
<td></td>
</tr>
</tbody>
</table>
Conclusions from Example

- River subsistence flow is in the ballpark of bay flow targets for Min Q Sal.
- Wet base flow with high pulses exceeds Min Q targets but is well below May targets for Max H.
- Overbank flows in combination with most river scenarios exceed Min Q and Max H targets.
- Timing of river flows to meet (but not exceed) bay targets throughout the year may take some work.
Conclusions from Example

- With some effort, bay and river recommendations can be reconciled.