Macro Invertebrate Flow Experiment
Financial Impact on Hydropower: Process and Methods

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TWG Meeting, October 12, 2021
“Request that WAPA provide additional information regarding purchase power cost estimates, including assumptions and uncertainty, such that effects to hydropower are minimized if Bug Flows are implemented in the future.”
Goal: Provide a general understanding of how CRSP hydropower financial impacts are estimated.

- Hydropower model overview
- Modelling process
- Bug Flow modelling
- Previous Estimates
- Looking forward
- Questions
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GTMax SuperLite

- Modified version of original GTMax Model and customized for the SLCA/IP system
- Models flow of electricity, water, and money
- Maximizes economic or financial value of electrical power generation while adhering to user-defined inputs and restrictions
- Produces “optimal” hourly generation patterns for 1 week each month
- Two formulations
  - Flaming Gorge
  - Other CRSP units
- Can optimize “bug flows”
Goal: Provide a general understanding of how CRSP hydropower financial impacts are estimated.

- Hydropower model overview
- Modelling process
  - Inputs and assumptions
  - Model outputs
  - Model accuracy
- Bug Flow modelling
- Previous Estimates
- Looking forward
- Questions
Power System Physical Properties
- Unit efficiency
- Max release
- Plant capacity
- Losses (8%)
- Outages
- Ancillary services

Energy Prices
- Palo Verde Hub
- Monthly on and off peak
- Convert to hourly prices

Operating Criteria
- Water laws
- Ops plans
- Environmental laws

Endangered Species Act

Hydrology Forecasts
- 24-month study
- CRSS
- Monthly volumes
- Reservoir elevations

Operating Criteria
- Water laws
- Ops plans
- Environmental laws

Electric Demand
- Hourly average customer schedule 2006-2018
- Project use

GTMax SL
Example: GTMax SL Output

Example GTMax SL Output with SHP Purchases

Genres (MWh)

Total Load (MWh)

FN  CY  GC  FG  BM  MP  Other  Total Load
GTMax SL Accuracy

- Used observed hydrologic data for WYs 2009 – 2016
- Compared model predicted generation to observed generation (PO&M 59)
- Actual generation was less than modelled in all but one year

<table>
<thead>
<tr>
<th>Water Year</th>
<th>Modelled Generation (MWh)</th>
<th>Observed Generation (MWh)</th>
<th>% Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>4,799,959</td>
<td>4,711,766</td>
<td>1.9%</td>
</tr>
<tr>
<td>2010</td>
<td>4,655,393</td>
<td>4,575,425</td>
<td>1.7%</td>
</tr>
<tr>
<td>2011</td>
<td>6,925,842</td>
<td>6,855,827</td>
<td>1.0%</td>
</tr>
<tr>
<td>2012</td>
<td>5,345,123</td>
<td>5,219,578</td>
<td>2.4%</td>
</tr>
<tr>
<td>2013</td>
<td>4,109,416</td>
<td>4,003,033</td>
<td>2.7%</td>
</tr>
<tr>
<td>2014</td>
<td>3,923,947</td>
<td>3,873,198</td>
<td>1.3%</td>
</tr>
<tr>
<td>2016</td>
<td>4,996,324</td>
<td>5,011,928</td>
<td>-0.3%</td>
</tr>
<tr>
<td>Total</td>
<td>34,756,005</td>
<td>34,250,756</td>
<td>1.5%</td>
</tr>
</tbody>
</table>
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- Hydropower model overview
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- Bug Flow modelling
  - 2021 Example
- Previous Estimates
- Looking forward
- Questions
June 2021 Bug Flows

- Base
- H750
- Energy Price

Release (cfs)

Energy Price

0 10,000 20,000 30,000 40,000 50,000 60,000 70,000 80,000

Sun Mon Tue Wed Thu Fri Sat
Goal: Provide a general understanding of how CRSP hydropower financial impacts are estimated.

- Hydropower model overview
- Modelling process
- Bug Flow modelling
- Previous Estimates
  - 2018 – 2021
  - Observed 2018 - 2019
- Looking forward
- Questions
Previous “Bug Flow” Estimates

<table>
<thead>
<tr>
<th>Year</th>
<th>Estimate</th>
<th>Observed</th>
</tr>
</thead>
<tbody>
<tr>
<td>2018</td>
<td>$336,000</td>
<td>$166,000</td>
</tr>
<tr>
<td>2019</td>
<td>$332,000</td>
<td>$327,000</td>
</tr>
<tr>
<td>2020</td>
<td>$408,000</td>
<td></td>
</tr>
<tr>
<td>2021</td>
<td></td>
<td>$1,022,000</td>
</tr>
</tbody>
</table>

250% increase from 2020 to 2021
2018 Monthly Cost of Bug Flows

- **May**: Estimate $15,000, Observed -$160,000
- **June**: Estimate $135,000, Observed -$19,000
- **July**: Estimate $210,000, Observed $0
- **August**: Estimate $135,000, Observed $121,000
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• Hydropower model overview
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• Bug Flow modelling
• Previous estimates
• Looking forward
  • 2022
    • Beyond 2022
• Questions
Looking ahead to 2022
Ideas for reducing bugflows impacts to hydropower

Things we have learned:

- **H-value**: Higher = expensive
- **Number of days**: Saturday = weekday, 5 weekends/month
- **Daily fluctuation level**: Is limiting movement of onpeak water
- **Type of month**: Power months = expensive
- **Power prices & onpeak/offpeak spread**: Higher = expensive
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