Northwest **Power** and **Conservation** Council

March 6, 2018

MEMORANDUM

TO: **Power Committee**

FROM: **John Fazio, Tina Jayaweera**

SUBJECT: **Power System Value of Conserved Irrigation Diversions**

BACKGROUND:

Presenter: John Fazio, Senior Systems Analyst

Summary: An estimate of the power-system value of conserved irrigation diversions that stay in the hydroelectric system is presented. It should be noted that for certain watersheds in the region, conserved irrigation water may more likely be utilized by other water users and, therefore, not pass through the hydroelectric system. For these areas, there is no additional energy generated or increased revenue and thus no power-system benefit. For conserved diversions that stay in the system, however, for each thousand acre-feet of water that passes through Grand Coulee and all downstream dams generates 1,026 megawatt-hours of energy over the irrigation season. The same volume of water left in the system in the upper Salmon, the Walla Walla and the Deschutes areas generates 216, 147, and 46 megawatt-hours, respectively. Average revenues gained from conserved irrigation diversions at the sites listed above are roughly $57, $12, $8 and $3 per acre-foot, respectively (based on an average electricity price of $55 per megawatt-hour).

The Council will be deciding whether to release this white paper for public comment during Council business on Wednesday March 14.

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Relevance: The Regional Technical Forum has developed savings estimates for measures to reduce water usage for irrigation. These measures will not only save electricity but also water that in many cases will stay in the river and produce additional hydroelectric generation. The added power system value of water that stays in the system could be used by the RTF and others to more fully capture the benefits of these conservation measures. The attached report describes the methods used to assess the added power system benefit and provides results for various locations in the basin both in terms of gained energy and revenue.

Workplan: This work is in response to the Council's Seventh Power Plan Action item ANLYS-9, which is to conduct research to improve understanding of electric savings in water and wastewater facilities from reduction in water use.

Background: Irrigation withdrawals in the Columbia River Basin result in a net annual reduction in streamflow volume of about 14.4 million acre-feet (Maf) at McNary of which about 8.4 Maf is due to withdrawals in the Snake River Basin. For perspective, the annual average streamflow volume for the Columbia River is about 135 Maf (as measured at The Dalles Dam). Most irrigation withdrawals are made in late spring and summer, with a portion of withdrawn water returning to the river at downstream locations and at later dates. Conserving irrigation water and keeping it in the hydroelectric system increases both energy production and revenue, which can offset the costs of conservation.

Power System Value of Conserved Irrigation Diversions

John Fazio and Tina Jayaweera
Power Committee Meeting
Portland, Oregon
March 13, 2018

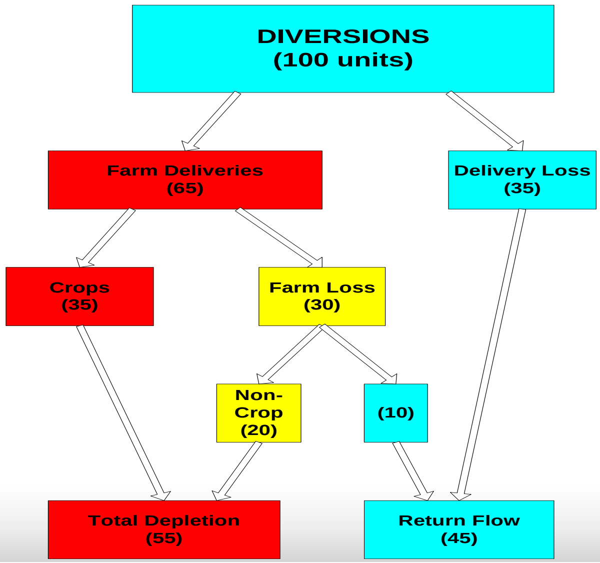
Caveats

- For certain areas in the basin, conserved irrigation water may more likely be utilized by other users.
- For these areas, conserved water has no power-system benefits.
- The power-system benefits for areas where conserved water is expected to return to the river are approximated using average return rates for that general area.

Power-Value of Conserved Water

- For areas where conserved water is expected to return to the river
- Using less water for irrigation leads to additional hydroelectric energy and increased revenues
- Which could be added as a benefit to irrigation measures (like an NEI)

Sample Irrigated Water Routes



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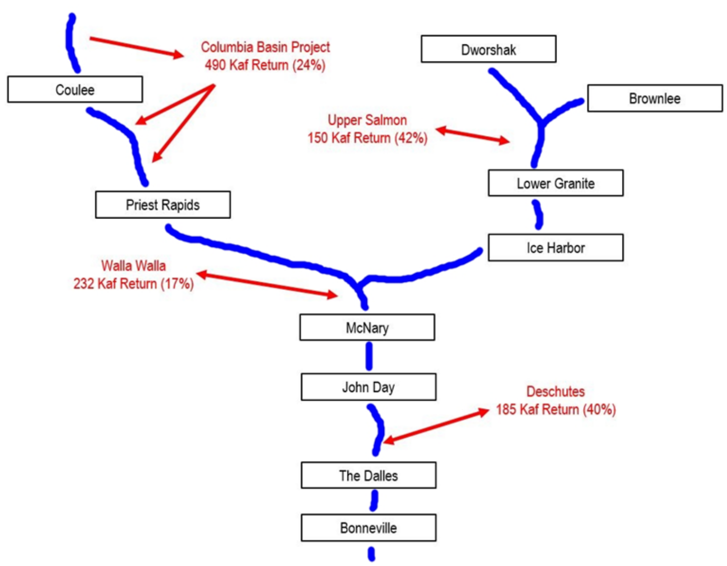
Return Flow Locations and Percentages



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Monthly Average Power Factors (MW/Kcfs)

Period	GCL	PRS	LWG	MCN	TDL
AP2	57.2	15.7	28.3	13.4	5.9
MAY	49.9	13.4	27.4	11.9	5.7
JUN	43.7	12.8	24.9	11.5	5.0
JUL	58.1	17.0	28.7	15.2	6.3
AG1	64.7	17.4	24.2	15.0	5.8
AG2	69.8	17.1	31.8	13.2	4.7
SEP	83.4	27.7	51.6	22.7	10.8

Pumping Loads at Coulee (MW-Hours/Kaf)

Month	MW-Hours per Kaf
Apr2	460
May	400
June	340
July	340
Aug1	340
Aug2	340
Sep	295

Net Average Energy Gained per unit Volume of Conserved Irrigation Water (MW-Hours/Kaf)

Period	Col Basin[1]	Up Salmon	Walla Walla	Deschutes
AP2	1102	198	134	42
MAY	961	191	119	41
JUN	828	174	115	36
JUL	989	200	151	46
AG1	1068	169	149	42
AG2	1129	222	132	34
SEP	1218	360	227	78
AVG	**1026**	**216**	**147**	**46**

[1]Includes pumping energy saved at Grand Coulee

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Average Electricity Price ($/MW-Hours)
(from 7th Plan 2B Scenario)

Period	Col Basin	Up Salmon	Walla Walla	Deschutes
AP2	52	52	52	52
MAY	52	52	52	52
JUN	53	53	53	53
JUL	55	55	55	55
AG1	59	59	59	59
AG2	59	59	59	59
SEP	58	58	58	58
AVG	**55**	**55**	**55**	**55**

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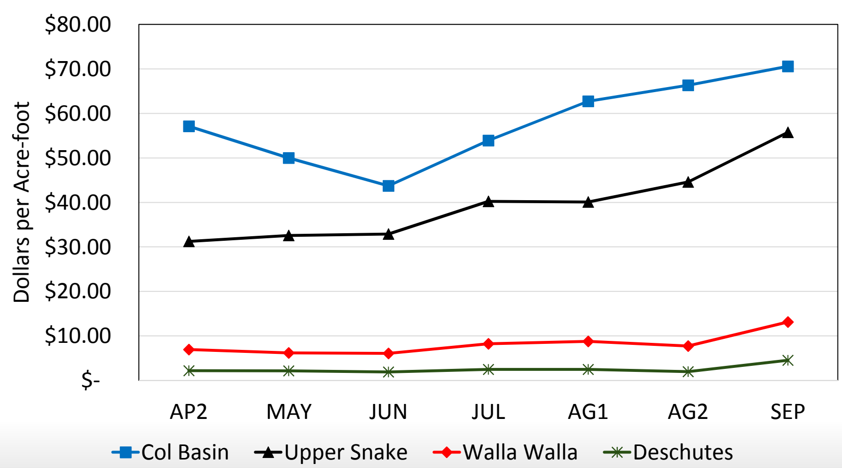
Monthly Average Revenue Gain by Area ($/Acre-Foot)

Period	Col Basin	Up Salmon	Walla Walla	Deschutes
AP2	$ 57.10	$ 10.23	$ 6.94	$ 2.19
MAY	$ 50.00	$ 9.92	$ 6.20	$ 2.15
JUN	$ 43.73	$ 9.18	$ 6.08	$ 1.92
JUL	$ 53.92	$ 10.91	$ 8.25	$ 2.49
AG1	$ 62.74	$ 9.91	$ 8.78	$ 2.47
AG2	$ 66.34	$ 13.01	$ 7.75	$ 1.98
SEP	$ 70.59	$ 20.84	$ 13.15	$ 4.52
AVG	**$ 56.60**	**$ 12.00**	**$ 8.16**	**$ 2.53**

Monthly Average Revenue Gain by Area ($/Acre-Foot)

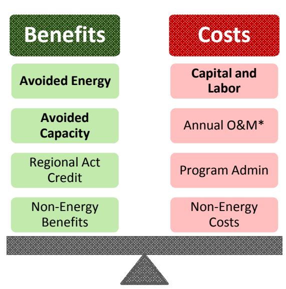


APPROACH TO INCORPORATING POWER VALUE OF CONSERVED WATER FOR ENERGY EFFICIENCY IRRIGATION MEASURES

Reminder: Approach

- Quantify the incremental benefits and costs for a given measure

Additional benefits may include: Other fuel benefits, avoided periodic replacement, risk mitigation



Additional costs may include: Other fuel costs, periodic replacement

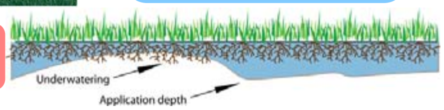
- But, quantifying cost and (especially) benefits can sometimes be challenging...

Measure Application Types

Replace leaking equipment

For all applications:
- Water savings from removing leaks and reducing the amount of water needed to irrigate
- Translated into energy savings of not pumping this water

Replace worn out sprinklers to improve water application uniformity



Upgrade systems to improve water application efficiency (i.e., reduce evaporative and other losses)

An Example: Replacing Leaking Sprinklers

Reduce leaks –> reduce pumping needs

- Incremental Costs:
  - Capital cost
  - Labor Costs
  - Program administration
- Incremental Benefits:
  - Energy savings
  - Capacity savings
  - Saved water - Increased power generation

RTF will be reviewing consistency of applying costs and benefits to all measures in July

Background Slides

Calculating Power System Value

1. For each withdrawal site, calculate the energy generated from leaving one unit volume of irrigation water in the river

2. For each return flow site, calculate the energy generated from the return flow from one unit volume of irrigated water

3. Net energy gain = Energy from conserved water minus energy from return flow plus saved pumping load (if available)

4. Revenue gain = Net energy gain times the market electricity price

Net Energy Gain per unit Volume of Conserved Irrigation Water

1. Calculate average flow per unit volume
   1,000 acre-feet (1 Kaf) released over 30 days produces a flow rate of 0.0167 thousand cubic feet/sec (Kcfs)
2. Calculate the power (rate of generation in MW)
   Flow times the power factor
3. Calculate the energy produced (MW-hours)
   Power times the hours in 30 days (720)
4. Subtract the return flow energy
   Same calculation but use the power factor for the return site and multiply by the return percentage

Example for Lower Granite
(Return Flow is at Lower Granite)

- 1 KAF released over 30 days yields a flow of 0.0167 Kcfs
- Power is 0.6 MW (0.0167 Kcfs times 39 MW/Kcfs)
- Energy is 469 MW-hours (0.6 MW times 720 hours)

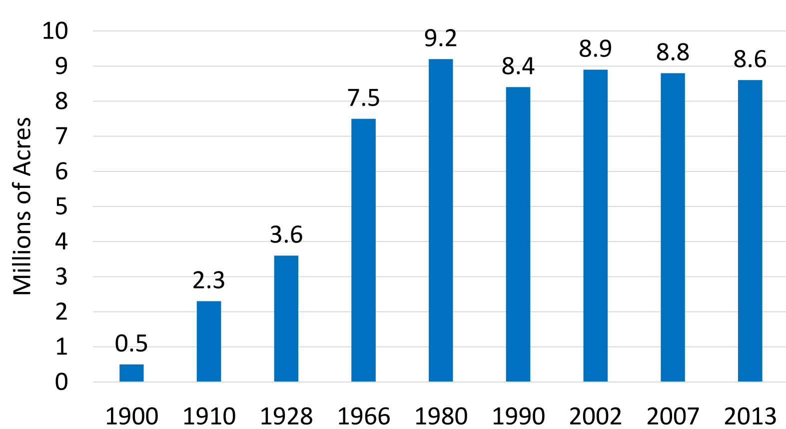
- Return percentage is 42%
- Return flow energy is 197 MW-hours (469 times 0.42)

- Total net energy gain is 272 MW-hours (469 – 197)

Example for Grand Coulee
(Return Flow is at Priest Rapids)

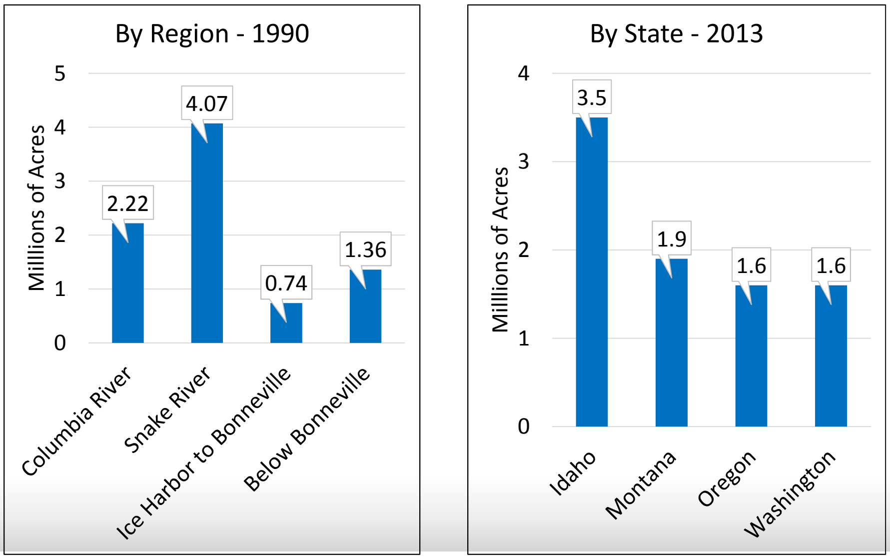
- For 1 KAF, power is 1.15 MW (0.0167 Kcfs times 69 MW/Kcfs)
- Gross energy is 830 MW-hours (1.15 MW times 720 hours)
- Return percentage is 24%
  but the return flow is at Priest Rapids (power factor is 21)
- Return energy is 58 MW-hours
  (0.0167 Kcfs times 21 MW/Kcfs times .24 times 720 hours)
- Net energy gain is 772 MW-hours (830 – 58)
- Add saved pumping load of 340 MW-hours
- Total net energy gain = 772 + 340 = 1,112 MW-hours

Irrigated Acres in the Pacific NW

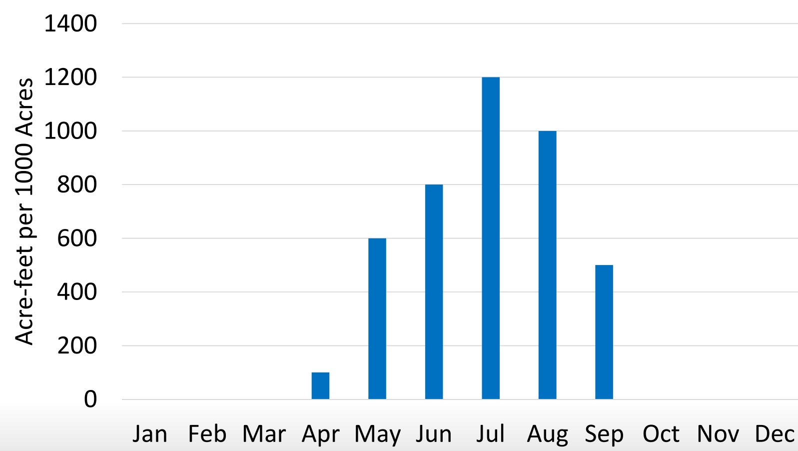


Source: 2013 Farm & Ranch Irrigation Survey

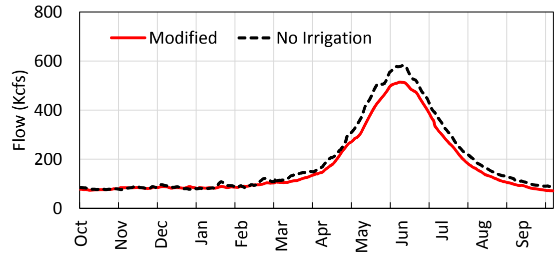
Irrigated Acres by Region and State



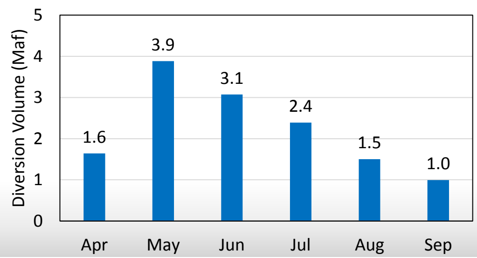
Timing and Amount of Irrigation Withdrawals



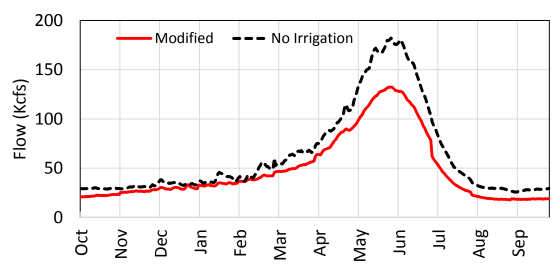
Average Streamflows at McNary
with and without irrigation withdrawals



Average Diversion Withdrawals at **McNary**



Average Streamflows at Lower Granite
with and without irrigation withdrawals



Average Diversion Withdrawals at Lower Granite