I. INTRODUCTION

condition 30 (which was also entitled “Flow Measures”). Numeration of Preliminary Conditions was changed for reasons not substantively related to either version of flow measures. The only substantive revisions in the revised Flow Measures are not directly relevant to this alternative condition. For simplicity and consistency, the Network hereinafter refers to the Condition to which it is recommending an alternative in part as “Condition 29”.

The Network does not believe that preliminary Condition 29 is adequate to protect the biological resources in the Middle Yuba River. Based on water temperature monitoring data obtained in 2008 and 2009, it is clear that many miles of potential good quality fish habitat exceed the 20°C threshold deemed acceptable for cold-water fish species. Water temperature modeling studies demonstrate that additional streamflow reduces water temperatures in the Middle Yuba River. Therefore, the Network offers an alternative Condition 29 that requires licensee to release up to 2,500 acre-feet of water into Middle Yuba River annually between June 15 and September 15 in Critically Dry (CD), Dry, Below Normal (BN), Above Normal (AN), and Wet water year types for the purpose of maintaining a mean daily water temperature of 19°C or less in the Middle Yuba River below Milton Diversion Dam as measured immediately upstream of Wolf Creek. The Network’s alternative condition is based on including the overall concept of a “block flow” that would require licensee to incrementally augment summer minimum flows in the Middle Yuba River when measured water temperatures warrant such an increase. The Network’s proposal will result in an increase in suitable habitat for coldwater fish species. The Network’s alternative will also increase fishing opportunities by moving suitable habitat downstream to areas of the Middle Yuba River that are more accessible to anglers than portions of the Milton Diversion Dam reach further upstream. As set forth more fully below, the Network’s alternative will provide a greater level of protection for the Forest Service reservation as compared to Condition 29. This alternative will also
enhance recreational values by increasing angler access to the Middle Yuba River. In order to ensure that the Network’s alternative measure generates more power than the Forest Service’s Condition 29, the Network proposes to reduce the minimum instream flow in the Middle Yuba River below Milton Diversion Dam in Below Normal and Above Normal water years. The Network explains below how its proposed alternative condition is more protective of the resource and provides for greater hydropower production and water supply reliability than Condition 29 proposed by the Forest Service.

II. PARTY STATUS

On July 31, 2012, the Foothills Water Network, as a coalition and distinct entity, and each of the individual member organizations of the coalition signatory to this document, filed a timely motion to intervene in the relicensing proceeding. (See e-Library no. 20120731-5146.) Because the motion was unopposed, the Network and these member organizations became parties in this proceeding by operation of law 15 days after its motion was filed. See 18 C.F.R. § 385.214. As licensing parties, the Network and the undersigned member organizations of the Network may file alternative conditions to Preliminary 4(e) conditions under 7 C.F.R. §1.671(a)(1)(i).

III. PRELIMINARY CONDITION FOR WHICH THE NETWORK IS SUBMITTING AN ALTERNATIVE CONDITION

The relevant portion of the Forest Service’s Condition 29 relates to the minimum flows required in the Middle Yuba Below Milton Main Diversion Dam reach and to the water year type designation also described in Condition 29. The relevant sections of Condition 29 read as follows:
**Condition No. 29 - Flow Measures**

**Minimum Flows**

<table>
<thead>
<tr>
<th>Month</th>
<th>October</th>
<th>November</th>
<th>December</th>
<th>January</th>
<th>February</th>
<th>March</th>
<th>April</th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>August</th>
<th>September</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Minimum</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10 or 15</td>
</tr>
<tr>
<td>Flows</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15 or 15</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>10 or 15</td>
<td>10 or 15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>35</td>
<td>35</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>70</td>
<td>70</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>40</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>60</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>70</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 Refer to Condition 29 regarding adjustment of Minimum Streamflows below Milton Diversion Dam in November, December and January of Wet WYs.
2 Refer to Condition 29 regarding Milton Diversion Dam spill cessation schedule.
3 Refer to Condition 29 regarding Milton Diversion Dam recreation streamflow events.

Also:

**Table 1. Water Year types for the Yuba-Bear Project.**

<table>
<thead>
<tr>
<th>Water Year Type</th>
<th>DWR Forecast of Total Unimpaired Runoff in the Yuba River at Smartville in Thousand Acre-Feet or DWR Full Natural Flow Near Smartville for the Water Year in Thousand Acre-Feet&lt;sup&gt;1&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extreme Critically Dry</td>
<td>Equal to or Less than 615</td>
</tr>
<tr>
<td>Critically Dry</td>
<td>616 to 900</td>
</tr>
<tr>
<td>Dry</td>
<td>901 to 1,460</td>
</tr>
<tr>
<td>Below Normal</td>
<td>1,461 to 2,190</td>
</tr>
<tr>
<td>Above Normal</td>
<td>2,191 to 3,240</td>
</tr>
<tr>
<td>Wet</td>
<td>Greater than 3,240</td>
</tr>
</tbody>
</table>

1 DWR rounds the Bulletin 120 forecast to the nearest 1,000 acre-feet. The Full Natural Flow is provided to the nearest acre-foot, and Licensee will round DWR’s Full Natural Flow to the nearest 1,000 acre-feet.

The Network’s proposed alternative condition would not delete the relevant text quoted above in the Forest Service’s Condition 29, but rather would add to the existing text, as described below.

**IV. ALTERNATIVE CONDITION PROPOSED BY THE NETWORK**

The Network proposes the following alternative condition to the portion of Condition 29 noted above.

*The Network’s Proposed Section 4(e) Alternative Conditions NID, Yuba-Bear Hydroelectric Project (P-2266)*
(A) Proposed Alternative Condition 29, Element 1: addition of the following language

Middle Yuba River - Supplemental Flow Release for Water Temperature Management

The licensee shall be required to release additional water into Middle Yuba River below Milton Diversion Dam annually between June 15 and September 15 in all water year types for the purpose of temperature control as follows. The Block of Water available for this purpose shall not exceed 2,500 acre-feet annually. The Block of Water specified shall be the total amount of additional water available for release in the specified time period. The Block of Water shall be made available concurrent with implementation of the initial minimum streamflows and through the remainder of the license term.

The objective of the is to maintain average daily water temperatures of 19°C or less in the Middle Yuba River below Milton Diversion Dam as measured immediately upstream of Wolf Creek at RM 26.9 and to proactively release additional water should a heat storm be predicted.

Real time telemetered temperature monitor in Middle Yuba River immediately upstream of Wolf Creek, and additional temp monitoring at National Gulch

During the first month of June after license issuance, licensee shall install a real time, telemetered temperature monitor in the Middle Yuba River immediately upstream of Wolf Creek. Additionally, the licensee shall install a temperature logger during June – August at National Gulch. This data does not need to be real time or telemetered, but should be downloaded monthly during the months of July and August.

Mean Daily Water Temperature Greater than 19°C

In the second half of June, in July and August, and in the first half of September in all water year types, the licensee shall promptly, but not later than within 1 business day, notify SWRCB, CDFG, BLM, and FS if the average daily water temperature in the Middle Yuba River immediately upstream of Wolf Creek exceeds 19°C. In such event, the licensee shall release from Milton Diversion Dam up to a total of 30 cfs, as necessary to reduce the average daily water temperature above Wolf Creek at RM 26.9 to 19°C or less. Licensee shall initially increase the flow by 10 cfs with additional increases made in 5 to 10 cfs increments spaced no less than 8 hours apart. Licensee shall maintain this flow until the mean daily water temperature in Middle Yuba River immediately upstream of Wolf Creek drops to 19°C. If after three days, the mean daily temperature is still greater than 19°C, licensee shall consult with SWRCB, CDFG, BLM, and FS to determine (1) whether the flow should be continued, (2) whether the flow should be increased to achieve the water temperature objective described above, and (3) the rate at which flows should be adjusted, either to increase or to return to the minimum streamflow if the water temperature objective has been achieved. Once a daily average water temperature of 19°C or less is achieved above Wolf Creek at RM 26.9, licensee may begin to decrease the supplemental flow release.
to the required minimum streamflow consistent with attempting to maintain an average daily water temperature of 19°C or less.

**Extreme Heat Events**

To address extreme heat events, between June 15 and September 15th in all water year types, the licensee will review the weather forecast for Blue Canyon by noon each Monday and Thursday. The licensee will provide an electronic copy of the weather forecast to SWRCB, CDFG, BLM, and FS. If maximum air temperatures of greater than 32°C \(^1\) (90°F) are forecast to occur for 2 or more days during the next 7-day period, licensee shall release from Milton Diversion Dam up to a total of 30 cfs, as necessary to reduce the average daily water temperature above Wolf Creek at RM 26.9 to 19°C or less. Licensee shall initially increase the flow by 10 cfs with additional increases made in 5 to 10 cfs increments spaced no less than 8 hours apart. During this 3-day period (business days), the licensee shall consult with SWRCB, CDFG, BLM, and FS to determine (1) whether the flow should be continued, (2) whether the flow should be adjusted to achieve the water temperature objective described above, and (3) the rate at which flows should be adjusted, whether to increase, or to decrease, or to return to the minimum streamflow if the water temperature objective has been achieved. Once a daily average water temperature of 19°C or less is achieved above Wolf Creek at RM 26.9, licensee may begin to decrease the supplemental flow release to the required minimum streamflow consistent with attempting to maintain an average daily water temperature of 19°C or less.

**Middle Yuba River Water Temperature Operations Group**

Within three months of license issuance, the licensee shall form an Operations Group that consists, at minimum, of FS, licensee, PG&E, CDFG, SWRCB, BLM and 2 NGOs. The Operations Group will be responsible for providing recommendations, based on monitoring, for modifications to the block flow release schedule if warranted by current information. The Operations Group will schedule regular phone conferences during the year as necessary for real-time operations, and meet at least once annually in May to discuss and review information related to anticipated project operations and biological issues for the coming year.

**Five Year Status Report and Recommendations**

Five years after license issuance, Licensee shall consult with the Operations Group and prepare a report that describes the five-year history of the data collected during water temperature management of the Middle Yuba River and recommend any modifications to procedures and requirements described in this measure. After approval by FS, CDFG, SWRCB, and BLM, licensee shall file this report with FERC.

---

\(^1\) The 32°C temperature indicator may be adjusted based on monitoring during the first 5 years after license issuance to more accurately reflect the air temperature at which the mean daily water temperature in the Middle Yuba River immediately upstream of Wolf Creek is expected to rise above 19°C. [This footnote is part of the proposed alternative condition].

*The Network’s Proposed Section 4(e) Alternative Conditions NID, Yuba-Bear Hydroelectric Project (P-2266)*

- 6 -
(B) Proposed Alternative Condition 29, Element 2: Reduce minimum flow requirements in the Middle Yuba River below Milton Diversion Dam in April and May of Below Normal and Above Normal years

In addition, the Network proposes to revise the minimum instream flow requirements contained in Condition 29 as shown in the table below:

<table>
<thead>
<tr>
<th>Month</th>
<th>Below Normal</th>
<th>Above Normal</th>
</tr>
</thead>
<tbody>
<tr>
<td>April</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>May</td>
<td>40</td>
<td>50</td>
</tr>
</tbody>
</table>

All flow requirements not shown here would remain unchanged. Compare these flow release requirements with the flows shown in the Middle Yuba Below Milton flow table from Condition 29, in Section III above.

(C) Change water year type designation so that back-to-back Critically Dry years become Extreme Critically Dry years

Finally, the Network proposes to modify the water year type designation in Condition 29. Under this modification, the second year of back-to-back critically dry years would become an “Extreme Critically Dry” year. In addition to changing the required minimum instream flow for the Middle Yuba River and other relevant Yuba-Bear reaches conditioned by the Forest Service in its 4(e) Condition 29, this would also mean that there would be no Middle Yuba Block Flow requirement in such years pursuant to this alternative condition. The table below reflects the proposed modification to water year type designation under this alternative condition.
Table 1. Water Year types for the Yuba-Bear Project.

<table>
<thead>
<tr>
<th>Water Year Type</th>
<th>DWR Forecast of Total Unimpaired Runoff in the Yuba River at Smartville in Thousand Acre-Feet or DWR Full Natural Flow Near Smartville for the Water Year in Thousand Acre-Feet¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extreme Critically Dry</td>
<td>Equal to or Less than 615 or second year of back-to-back Critically Dry Water Years (&lt;=900)</td>
</tr>
<tr>
<td>Critically Dry</td>
<td>616 to 900</td>
</tr>
<tr>
<td>Dry</td>
<td>901 to 1,460</td>
</tr>
<tr>
<td>Below Normal</td>
<td>1,461 to 2,190</td>
</tr>
<tr>
<td>Above Normal</td>
<td>2,191 to 3,240</td>
</tr>
<tr>
<td>Wet</td>
<td>Greater than 3,240</td>
</tr>
</tbody>
</table>

¹ DWR rounds the Bulletin 120 forecast to the nearest 1,000 acre-feet. The Full Natural Flow is provided to the nearest acre-foot, and Licensee will round DWR’s Full Natural Flow to the nearest 1,000 acre-feet.

V. THE ALTERNATIVE PROVIDES FOR ADEQUATE PROTECTION AND UTILIZATION OF THE RESOURCES OF THE RESERVATION

The Network’s alternative Condition 29 will provide a greater level of protection to the Forest Service reservation than Preliminary Condition 29 proposed by the Forest Service. Preliminary Condition 29 is inadequate, most notably because it will leave summer water temperatures in the Middle Yuba River too warm to provide suitable habitat for coldwater fish species. In contrast, the Network’s alternative Condition 29 utilizes a “block flow” construct to ensure that flow increases over the otherwise required minimum flow will be required when water temperatures warrant that increase. The benefit of a “block flow” concept is clear not only for water supply but for other aquatic biota. It benefits the biological resources that need it most when appropriate and at minimal cost to other public interest values. Such a construct ensures more effective results and less unintended consequences.

(A) The Network’s alternative will provide more adequate protection for the biological resources in the Middle Yuba River as compared to Preliminary Condition 29.

The Network’s alternative condition ensures that adequate habitat is available to coldwater species in the Middle Yuba River by reserving an annual quantity of water for real-time water temperature management. In terms of instream resources, the Network’s alternative condition
ensures two things: 1) that the Project’s impacts on existing coldwater species are properly mitigated by providing thermally suitable habitat in the Middle Yuba River with minimal cost or with a benefit to biota; and 2) that rainbow trout are able to exist and thrive in a key section of the Middle Yuba River that is more readily accessible to anglers and members of the public than portions of the Milton Diversion Dam reach further upstream.

(1) The Network’s alternative will protect the quality rainbow trout fishery in the middle section of the Middle Yuba River that is not protected by Preliminary Condition 29

As noted above, the Network’s alternative condition will improve the habitat for aquatic species in the Middle Yuba River by cooling water temperature in the summer.

The Forest Service’s combined Rationale Report for the preliminary 4(e) Conditions for the Drum-Spaulding and Yuba-Bear projects describes the condition of the existing fishery and the methods used by the Forest Service to determine the new flow regime. (See e-Library No. 20120731-5121, Forest Service Rationale Report for Preliminary License Conditions and Recommendations for the Drum-Spaulding Project and the Yuba-Bear Project, pp 36-47; hereinafter, “Forest Service Rationale Report”.)

The Forest Service Rationale Report characterizes the condition of the rainbow trout fishery in the Middle Yuba River at the “upper site” (~RM 43.6) downstream of Milton Diversion dam as suffering direct effects from the project. At the middle site (near Wolf Creek), the rainbow trout population was “the best out of all the project affected reaches.” However, “rainbow trout populations and biomass in the Middle reach site were still well below those in the unimpaired reference reaches.” (See ibid, p. 42.)
The Forest Service Rationale Report describes how the resource agencies including the Forest Service determined the flow regime for the Middle Yuba River below Milton. Rather than seeking to protect and enhance the remarkably good quality trout fishery near Wolf Creek (as advocated throughout the relicensing by the Network), the agencies emphasized the fishery in the upper reach. The agencies based their flow rationale almost exclusively on Weighted Usable Area (WUA) for rainbow trout in that upper reach. (See ibid, pp. 43-46.) However, the WUA for adult trout in the middle section of the Middle Yuba River that would be provided by the summer release from Milton alone is extremely low, ranging from about 12% of maximum at 6 cfs (conservatively interpolated percentage) and 20% of maximum at 10 cfs. At the highest required August flow (15 cfs in AN and Wet years), adult WUA in the middle reach is 29% of maximum. (For table of WUA at upper Middle Yuba below Milton site, see e-Library No. 20120817-5135, Supplement No. 3 to Nevada Irrigation District’s Amended Final License Application, p. 23. Hereinafter “NID Supplement No. 3”.)

Based on these figures, the Forest Service appears to have done little to protect or enhance the rainbow trout fishery in the middle reach of the Middle Yuba River.

The Forest Service notes in its Rationale: “Several large tributaries partially moderate the effects further down the river” and connects this fact with the quality of the fishery near Wolf Creek. (See ibid, p. 42.) However, the table of average unimpaired flow reproduced by the Forest Service shows almost no accretion in August and September even in wet years, and very little in July in BN and drier years. (See ibid, p. 43.) Thus the Forest Service appears to rely on accretion to protect fish in the summer when there is little accretion, but provides high spring flows for spawning in the reach even when there is copious accretion.
The figure below is a representative five year output from the operations modeling that was performed to support this alternative; modeling is described later in this document. The red lines show the alternative condition; the green lines show Preliminary Condition 29. The figure shows large amounts of accretion in April and May in the Middle Yuba River upstream of East Fork Creek, the most upstream major tributary of the Middle Yuba River below Milton Diversion Dam. Note that there is no discernible difference in April and May flows in BN year 1981 and AN year 1984. The small red bumps in the summer represent block flows as modeled; modeling assumed that the block flow quantity in any given year was spread out evenly over July and August.

The Network’s alternative condition cannot restore the lack of physical habitat in the Middle Yuba River, but it will improve the quality of that habitat. This alternative is a low cost measure that protects high value fishery resources that have otherwise been overlooked by the Forest Service. As it stands, Condition 29 requirements are out of balance on the Middle Yuba River, because no weight has been given to the fishery resources in its middle reach.

(2) The Network’s alternative will provide thermally suitable habitat for coldwater fish species.
In addition to providing inadequate physical habitat for trout in the middle reach of the Middle Yuba River, Condition 29 allows thermal conditions that are too warm to support them. As noted in the Forest Service Rationale Report, a mean daily water temperature of 20°C is a threshold that FERC has accepted in California proceedings as a benchmark above which thermal conditions for rainbow trout become unacceptably stressful. (See Forest Service’s Rationale Report, ibid, p. 280.) The 19°C benchmark at Wolf Creek was selected because the location is reasonably accessible by road. As stated in the Rationale Report filed by the California of Fish and Game (DFG) in support of its Section 10(j) recommendations, “this 19°C threshold serves as a surrogate for a more inaccessible downstream location that maintains average daily water temperatures above 20°C (generally between RM 23 and RM 24) yet ensures that temperatures remain at or above 17°C at National Gulch.” (See DFG Rationale Report, e-Library No. 20120730-5181, Enclosure C, p. 280.)

The DFG Rationale Report demonstrates that a block flow approach to moderate high summer water temperatures in the Middle Yuba River would effectively increase reliable coldwater habitat in the Middle Yuba River by up to 8 miles. A modest supplemental release of 10 cfs on July 15, 2008, would have increased thermally suitable habitat by over 5 miles. In no cases in 2008 or 2009 was a total flow of over 30 cfs required to meet the 19°C threshold at Wolf Creek. (See ibid.)

Supplement No. 3 to licensee Nevada Irrigation District’s Amended Final License Application provides water temperature modeling of the Middle Yuba River under flows required by Condition 29. (See NID Supplement No. 3, Figure 3.1-3, p. 15, reproduced below.) This modeling demonstrates exceedences of both 19°C and 20°C during 2009.
Under modeled conditions, water temperatures in the Middle Yuba River at Wolf Creek would have exceeded 20° C. in 2009 in two separate two-day events, around July 18-19 and July 29-30, and would have exceeded 19° C. from about July 15 through August 3. A second short exceedence of 19° would have taken place on about August 17.

The summer of 2009 overall was a hot summer. In order to consider the effects of more severe meteorological conditions, the Network analyzed the meteorological data from the hotter year 2006. Meteorological data from 2006 was used in the DeSabla – Centerville relicensing to represent particularly hot conditions, since this year was among the hottest on record. The Network compared summer air temperatures at Blue Canyon (BLC) in 2006 and 2009. The meteorological station at BLC was chosen by the Department of Fish and Game to formulate part of the block flow
measures, since air temperatures of 90°F at BLC correlated well to water temperature exceedences of 19°C. in the Middle Yuba River at Wolf Creek.

![2006 vs. 2009 Blue Canyon Maximum Air Temperature Comparison](image)

Source: [http://cdec.water.ca.gov/cgi-progs/staMeta?station_id=BLC](http://cdec.water.ca.gov/cgi-progs/staMeta?station_id=BLC)

From July 14 through July 27, 2006, maximum air temperatures at Blue Canyon were at least 87°F.; for five consecutive days, July 22-26, 2006, maximum BLC air temperatures exceeded 95°F. By comparison, the hottest days of 2009 saw maximum temperatures at BLC on July 17-19, of 95°, 95°, and 94° F. and on July 28-29 maximum temperatures of 94° and 93°, respectively.

By comparing the 2009 meteorology data with the water temperature modeling output, the Network drew the conclusion that there is a time lag of about a day between high air temperatures (over 90°F.) and elevated water temperatures. A measure that exclusively reacts to temperatures monitored at Wolf Creek will likely allow elevated water temperatures to persist for two days: one day to identify an exceedence, and another day for water released from Milton Diversion Dam to reach Canyon Creek.
In comparing the 2006 and the 2009 meteorological data, it is clear that a summer flow of 6 to 15 cfs in the Middle Yuba River will not cool the river to 19° C. (or even to 20° C.) at Wolf Creek during a prolonged heat storm such as what occurred in the second half of July, 2006. The best estimate is that a flow of 20 to 30 cfs would have been required from July 15, 2006 to about July 27, 2006 to maintain the 19° C. water temperature threshold at Wolf Creek. This hot meteorology occurred during a Wet water year. The water cost might have been as much as 390 acre-feet, assuming a 30 cfs release throughout the period and a required Wet year release of 15 cfs pursuant to Condition 29. The water cost could have been greater in a drier year. However, it does not appear that other block flow releases would have been required in 2006.

Thus, the alternative condition proposed by the Network addresses the deficiencies of Condition 29 in several ways. First, it requires that supplemental water be released from Milton Diversion Dam when air temperatures are forecast to exceed 90° F. at Blue Canyon. This eliminates warm water conditions during the time lag caused by travel time of water moving downstream. Second, the alternative condition will effectively cool the Middle Yuba River both upstream and downstream of Wolf Creek in circumstances where the required instream flow release cannot. Third, the alternative condition protects coldwater habitat for more river miles, and better protects the habitat in river miles that are addressed Condition 29. The use of block flows provides the flexibility to use the required amount of water when needed and save water when minimum flows are sufficient. The alternative condition will directly and surgically solve water temperature problems as they arise.
(3) The Network’s alternative will enhance recreational opportunities along the Middle Yuba River

The Network’s alternative condition also has the added benefit of improving recreational opportunities along the Middle Yuba River. The upstream portions of the Middle Yuba River emphasized in Condition 29 have limited access opportunities for anglers and other members of the public seeking recreational opportunities. The areas emphasized by the Network’s alternative condition have better public access. The Middle Yuba River offers one of the best opportunities for angling improvements on the hundreds of miles of project-affected stream reaches.

(4) The Network’s alternative will minimally impact, or benefit, other native species in the Middle Yuba River.

(a) Native Warm Water Fish Species

According to the Gast fish survey that was performed for the Upper Yuba River Studies Program, “No smallmouth bass, adult pikeminnow, or hardhead were observed upstream of Our House Dam (RM 12.6) on the Middle Yuba River; however, a few minnow fry were observed a short distance upstream of the dam.” (See Gast et al., 2005. Middle and South Yuba Rainbow Trout Distribution and Abundance Dive Counts August 2004, p. 5.) Cooling the Middle Yuba River will not affect hardhead or pikeminnow.

(b) Foothill-Yellow Legged Frogs

Throughout this proceeding, the Forest Service has expressed particular concern that lowering the water temperatures in the Middle Yuba River through implementation of a block flow measure may negatively impact FYLF. The following sections explain how the best available scientific information supports the conclusions that (1) FYLF will substantially benefit from measures already included in Preliminary Condition 29; and (2) the Network’s alternative will benefit most subpopulations of FYLF in the Middle Yuba River.
(i) Improvements for FYLF are secured through other provisions in the preliminary 4(e) conditions

The section of Condition 29 entitled “Spill cessation in the Middle Yuba River” has already addressed the primary known adverse effect of project operations on FYLF in the Middle Yuba River. This measure requires a downramp of up to 21 days following late spring and summer spills at Milton Diversion Dam. This will reduce scouring and desiccation of egg masses and tadpoles based on precipitous flow fluctuations due to dam operations.

This spill cessation measure was championed by the Network, and much of the hydrologic analysis that led to its development was performed by Network members. Overall conditions for FYLF in the Middle Yuba River will already greatly improve because of the spill cessation measures.

(ii) General distribution of FYLF on the Middle Yuba River

In order to compare the effects on FYLF from Condition 29 with the effects from the proposed alternative condition, the Network assembled two tables from VES surveys on the Middle Yuba River. The Network set aside the table based on egg masses, because anomalies in survey dates and problems with accessibility caused VES surveys to show no egg masses in the Middle Yuba River at many sites where tadpoles were later detected. The table presented below that shows VES detections of other lifestages of FYLF is designed to provide a snapshot of the spatial distribution of FYLF on the Middle Yuba River today, clearly organized by river mile.
Middle Yuba River FYLF VES Detections, all life stages except egg masses
(from YBDS Technical Memo 3-6, Table 3.4-2)

<table>
<thead>
<tr>
<th>Sites where FYLF Found, all life stages</th>
<th>Estimated Site River Miles</th>
<th>Total non-egg mass FYLF Detections at Site Survey 1</th>
<th>Total non-egg mass FYLF Detections at Site Survey 2</th>
<th>Total non-egg mass FYLF Detections at Site Survey 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>MY-2 Main</td>
<td>13.8</td>
<td>80</td>
<td>827</td>
<td>874</td>
</tr>
<tr>
<td>MY-4A Main</td>
<td>14.8</td>
<td>398</td>
<td>1859*</td>
<td>2319</td>
</tr>
<tr>
<td>Tributary</td>
<td>14.8</td>
<td>20</td>
<td>7</td>
<td>171</td>
</tr>
<tr>
<td>MY-5 Main</td>
<td>27</td>
<td>85</td>
<td>141</td>
<td>345</td>
</tr>
<tr>
<td>Tributary</td>
<td>27</td>
<td>14</td>
<td>8</td>
<td>52</td>
</tr>
<tr>
<td>MY-6 Main</td>
<td>29.4</td>
<td>2</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>Tributary</td>
<td>29.4</td>
<td>2</td>
<td>2</td>
<td>0</td>
</tr>
</tbody>
</table>

*average of two dates’ results

The table shows that the vast majority of FYLF in the Middle Yuba River occur at or downstream of Wolf Creek (RM 27). The largest number of FYLF detections occurred in the area of Indian Creek (RM 13.8 and 14.8). These data suggest a FYLF population in the Middle Yuba River that extends at least 13 miles, with a marginal subpopulation upstream of Wolf Creek at National Gulch (RM 29.4).

(iii) **Middle Yuba Water Temperature Management does not affect the egg mass lifestage of FYLF**

The Network’s alternative will not affect the egg mass lifestage of FYLF. Almost all breeding and ovipositing by FYLF on the Middle Yuba River occurs earlier in the season than the summer period when temperature measures might be required to maintain water temperatures at less than 19° C. at the confluence with Wolf Creek. In addition, accretion in the reach is a large factor during the breeding season in most years at FYLF sites. By far the greatest threat to egg masses on the Middle Yuba River is rapid flow fluctuations. To the extent that the project can control these fluctuations, Condition 29 has addressed this threat in the spill cessation measure for the Middle Yuba River, as noted above.
(iv) Thermal effects of Middle Yuba Water Temperature Management on FYLF tadpoles at and downstream of Wolf Creek

The Network’s alternative will provide a thermal benefit to all subpopulations of FYLF downstream of Wolf Creek. In a document circulated in both the Middle Fork American Project relicensing and in this proceeding, Forest Service amphibian biologist Amy Lind describes known temperature preferences and conditions for FYLF. (See Summary of FYFL Tadpole Water Temperature Effects from Recent Studies, compiled by Lind, 2010; internal cites are given below.) Notable in this summary document are the following notes (bulleted in the original):

- 15-16 C (59-60.5 F) water temperatures that occur throughout the rearing season (June-August) appear to result in very low survival rates.
- 16.5 - ~20 C (62-68 F) had the highest survival rates.
- Summer rearing temperatures above 21 C (~70 F) also appear to result in reduced survival. However, direct effects of temperature may be confounded with increases in parasite numbers and loads at these higher temperatures.
- Tadpole growth rates are lower in low (<16C, 60.5F) and high (>20C, 68F) water temperatures than in moderate water temperatures (~18-20C, 64-68F)

(Internal cite: S. Kupferberg to Amy Lind, personal communication, April 2010.)

Given this frame of reference and temperature modeling for the Middle Yuba River, the Network concludes that the alternative condition will increase the amount of time that optimal temperatures for FYLF will be present in the Middle Yuba River in the vicinity of Wolf Creek (site MY-5) compared to Condition 29. The 19° C. threshold proposed in the alternative condition will put temperatures in this reach in the optimal FYLF rearing range at times when the water temperatures would otherwise be above optimal. For these FYLF subpopulations, the Network’s alternative is more of a benefit than Condition 29.

For the larger subpopulations of all FYLF downstream of Site MY-5 (RM 27), there is a thermal benefit from the alternative condition in that temperatures greater than optimal will be
brought closer to optimal. As noted by Lind as quoted above, tadpole growth rates are lower in high and low water temperatures than in moderate water temperatures; also, “Temps below 17 C and > 20 C result in lower survival rates.” (Lind, ibid, p. 2.)

(v) Viability of FYLF subpopulations upstream of Canyon Creek and criteria for evaluation.

The question remains whether or not either the Network’s alternative or Condition 29, or any reasonable and complete flow measure for the Middle Yuba River, will support a viable FYLF subpopulation on the Middle Yuba River near National Gulch (sites MY-6 at RM 29.4). In order to evaluate this question, the Network first references the marginal nature of this subpopulation based on the survey data summarized in the table above. While 6 adults were observed at MY-6 on September 4, 2008, no tadpoles were found during the season. There is very little evidence of successful breeding, even in a year with no spill from project facilities. (See Technical Memo 3-6, Table 3.4-2.) This subpopulation appears to be extremely marginal, and is likely an artifact of a historic regulated flow regime that for decades has been below unimpaired in July and at or below unimpaired in August. (For impaired flow in Middle Yuba River, see Table MY-1, Forest Service Rationale Report, ibid, p. 43.) The Forest Service does not protect the reservation by basing fundamental flow decisions for 32 miles of river based on a very small subpopulation of amphibians that is a potential outlier artificially maintained by conditions that cause severe impacts to other aquatic biota. This is all the more pertinent in that the other aquatic biota include diverse and more abundant subpopulations of FLYF in the affected watershed.

If the subpopulation at National Gulch is in fact viable going forward, then the Forest Service, in order to support management decisions for the benefit of this subpopulation, including the decision not to require a block flow for the Middle Yuba River, needs to quantify the impacts of various actions, events, and factors, and their relative importance. The Forest Service Rationale
Report for the original 4(e) conditions discussed potential effects on FYLF, but provided no clarity on how it had made evaluations to date or how it would make evaluations in the future. The Forest Service must at minimum consider the following:

- How will statistically defensible conclusions about viability, variability, and effects to very small subpopulations of FYLF upstream of Wolf Creek be generated with very small data sets?
- How will stochastic events be evaluated and taken into account in analyzing upstream subpopulations?
- How will the population-level effect to FYLF in the entire Middle Yuba River be weighed in managing for thermally favorable conditions for the upstream-most subpopulation of FYLF?
- How will thermal effects on downstream subpopulations be evaluated in managing for thermally favorable conditions for upstream FYLF?

As noted above, the best available scientific information in the record does not support the Forest Service’s decision to base fundamental flow decisions for 32 miles of river on very small subpopulations of amphibians, especially when such critical questions regarding those small subpopulations remain unanswered and when such decisions will cause known impacts to other aquatic biota.

(vi) Middle Yuba Water Temperature Management effects on physical habitat for FYLF

The Network’s alternative will not limit the amount of physical habitat available to FYLF. Technical Memo 3-7, FYLF Habitat Modeling, describes habitat modeling that licensee’s consultants performed at RM 27, just upstream of Wolf Creek. Technical Memo 3-7 shows on p. 26, Table 3.1.1-1, the Tadpole Weighted Usable Area (WUA) at RM 27 for various flow values.
The WUA includes both depth and velocity components. Overall, as flow increases, WUA decreases. However, WUA at a flow of 45 cfs is about 85% of WUA at a flow of 11 cfs. Since flows at issue in the Water Temperature Management proposals do not exceed 45 cfs, the largest physical habitat loss from block flow management therefore appears to involve a loss of 15% of physical habitat.

Table 3.1.1-3 on p. 34 equally demonstrates that the change in effective habitat from 29 cfs to 11 cfs (assuming little or no accretion) or from 45 cfs to 29 cfs (assuming accretion on top of releases from Milton Diversion Dam) still leaves effective WUA for tadpoles at 80-85% of maximum. This bears comparison with WUA for adult trout at the same location, which under Condition 29 summer flows is 12% to 29% of maximum, plus whatever is added by accretion.

Simply put, a case cannot be made that supplemental summer flows for temperature management cause limitations on physical habitat for FYLF.

(vii) On a watershed-wide basis, the alternative condition will benefit FYLF

As DFG carefully analyzed in its Rationale Report, actions to reduce water temperatures in the Middle Yuba River at Wolf Creek will not reduce temperatures below 17° C. at National Gulch. (See DFG Rationale Report, pp. 279-280.) Nonetheless, the Forest Service, in declining to include a block flow measure in Condition 29, acted to avoid a potential impact to FYLF at National Gulch at the known expense of subpopulations further downstream, and at the known expense of other coldwater species. This decision is unsupported and unbalanced, and should be reversed.

The Network’s alternative, on the other hand, does balance the value to coldwater aquatic species with the effects to other species. Its block flow construct ensures that the most thermally stressed species receive benefit when required at minimal cost to other biota. Most FYLF
subpopulations will benefit from the Network’s alternative, and on a watershed-wide basis, the Network’s alternative will benefit FYLF as a whole.

(5) The alternative condition protects the reservation

Avoiding unknown risk to a marginal upstream subpopulation of FYLF by inadequately cooling the Middle Yuba River is not worth the resulting more certain and quantifiable negative effects on viable FYLF subpopulations further downstream, or on other coldwater species such as trout. The Network’s alternative condition ensures that thermally suitable habitat is available to coldwater species in the Middle Yuba River. The Network’s alternative condition will provide a greater level of protection to the Forest Service reservation than Condition 29 will provide without the block flow requirement.

VI.

THE NETWORK’S ALTERNATIVE WILL PROVIDE FOR MORE HYDROPOWER GENERATION THAN THE FOREST SERVICE’S REVISED CONDITION 29

Alternative Condition 29 proposed by the Network will allow licensee to generate more hydropower than would the Forest Service’s Condition 29.

A. Water cost of Network alternative condition block flows

The Network compared the annual water cost to implement the Forest Service’s Condition 29 and the annual water cost to implement the Network’s alternative condition.

In order to calculate the water cost of the Network’s alternative, the Network relied on information contained in DFG’s Rationale Report for Section 10(j) recommendations as well as its own analysis. The DFG report calculated that the annual water cost of its proposed measure “Flows for Temperature in Middle Yuba River” (which is identical to the Network’s alternative) would have been 830 AF in 2008 (a Dry year) and 490 AF in 2009 (a BN year). (See DFG Rationale...
The Network’s Proposed Section 4(e) Alternative Conditions

NID, Yuba-Bear Hydroelectric Project (P-2266)

The Network assumes that these calculations are representative water costs for the Network’s alternative condition in Dry and BN years, and can be used to calculate a representative water cost for flows that are determined by a threshold water temperature. As a further simplifying assumption, the Network assumes that the maximum volume of water proposed in the Network’s alternative (2500 AFA) will be entirely used in CD years. Finally, the Network assumes as a conservative estimate that the water cost for AN and Wet years will be the same as in BN years. This is a very conservative assumption, since additional water can be taken from storage in Jackson Meadows Reservoir in AN and Wet years in order to make up for any generation that might otherwise be lost by flow increases into the Middle Yuba River to meet the Network’s alternative measure requirements.

The annual water cost of the Network’s alternative measure as compared to required 4(e) minimum flows is thus:

CD years: 2500 AF
Dry years: 830 AF
BN years: 490 AF
AN: 490 AF
W: 490 AF

B. Reduction of minimum flows in the Middle Yuba River in February and March

In order to ensure that the Network’s alternative measure generates more power than the Forest Service’s Condition 29, the Network proposes to reduce the minimum instream flow in the Middle Yuba River in April and May in Below Normal and Above Normal water years, in accordance with the table below. For comparison, see flow Condition 29 flow release, reproduced in Section III above.

Middle Yuba River Below Milton Diversion Dam:

<table>
<thead>
<tr>
<th>Month</th>
<th>Below Normal</th>
<th>Above Normal</th>
</tr>
</thead>
<tbody>
<tr>
<td>April</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>May</td>
<td>40</td>
<td>50</td>
</tr>
</tbody>
</table>

The Network’s Proposed Section 4(e) Alternative Conditions
NID, Yuba-Bear Hydroelectric Project (P-2266)
C. Change water year type designation so that back-to-back Critically Dry years become Extreme Critically Dry years

Finally, the Network proposes to change Forest Service’s Condition 29 to modify the water year type designation. Under this modification, the second year of back-to-back critically dry years would become an “Extreme Critically Dry” year. In addition to changing the required minimum instream flow for the Middle Yuba River and other relevant Yuba-Bear reaches conditioned by the Forest Service in its 4(e) Condition 29, this would also mean that there would be no Middle Yuba Block Flow requirement in such years pursuant to this alternative condition. The table below reflects the proposed modification to water year type designation under this alternative condition.

<table>
<thead>
<tr>
<th>Water Year Type</th>
<th>DWR Forecast of Total Unimpaired Runoff in the Yuba River at Smartville in Thousand Acre-Feet or DWR Full Natural Flow Near Smartville for the Water Year in Thousand Acre-Feet¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extreme Critically Dry</td>
<td>Equal to or Less than 615 or second year of back-to-back Critically Dry Water Years (&lt;=900)</td>
</tr>
<tr>
<td>Critically Dry</td>
<td>616 to 900</td>
</tr>
<tr>
<td>Dry</td>
<td>901 to 1,460</td>
</tr>
<tr>
<td>Below Normal</td>
<td>1,461 to 2,190</td>
</tr>
<tr>
<td>Above Normal</td>
<td>2,191 to 3,240</td>
</tr>
<tr>
<td>Wet</td>
<td>Greater than 3,240</td>
</tr>
</tbody>
</table>

¹ DWR rounds the Bulletin 120 forecast to the nearest 1,000 acre-feet. The Full Natural Flow is provided to the nearest acre-foot, and Licensee will round DWR’s Full Natural Flow to the nearest 1,000 acre-feet.

D. Water operations modeling

In order to verify that the proposed alternative condition allows the Yuba-Bear Project to generate more power than Condition 29 will allow, the Network sought assistance from the Department of Fish and Game to comparatively model the two measures using the HEC-ResSim operations model. Copies of the sheets that display the model output are included as an appendix to this document. A DVD with the model runs is available on request.
VII. THE NETWORK’S ALTERNATIVE WILL PROVIDE GREATER WATER SUPPLY RELIABILITY AND WILL NOT NEGATIVELY AFFECT OTHER PUBLIC INTEREST VALUES

(A) Water supply

The Network’s alternative provides greater water supply reliability than Condition 29 proposed by the Forest Service. By changing the water year type designation to make back-to-back Critically Dry water years Extremely Critically Dry years, the alternative condition allows greater storage of water under one of the few circumstances that operations modeling showed that there is a known water supply deficit.

(B) Other public interest values.

The Network’s alternative will have no effect on energy supply, distribution, cost, and use; flood control; navigation; air quality; or any other aspects of environmental quality.

VIII. REFERENCES

In conformity with 7 CFR §1.671(b)(5), the Network identifies that it has relied on the following studies and documents to support its proposal for its alternative condition.

1. California Department of Fish and Game, Notice of Intervention in the Relicensing of Yuba-Bear Hydroelectric Project (FERC Project No. 2310) and Submission of Recommended Conditions Fish & Wildlife Protection, Mitigation and Enhancement Provided Under Federal Power Act Section 10(j), 10(a)(2) 18 C.F.R. 4.34(b)(2) (e-Library No. 20120730-5174).


4. The Foothills Water Network et al., Comments and Recommendations, Ready for Environmental Analysis, Final License Application, Yuba-Bear Hydroelectric Project (FERC No. 2310), (e-Library No. 20120731-5132).
The Foothills Water Network, American Rivers, American Whitewater, California Sportfishing Protection Alliance, Friends of the River, Gold Country Fly Fishers, Northern California Council Federation of Fly Fishers, Sierra Club, South Yuba River Citizens League, and Trout Unlimited respectfully submit this alternative condition for consideration as addition and modification to the relevant portions of the Forest Service’s 4(e) Condition 29. The Network requests that the Forest Service and Nevada Irrigation District undertake, with us and other parties,
to resolve these and other remaining disputes by settlement. In the absence of settlement, the Network respectfully requests that the Secretary accept the Network’s alternative condition because it better protects the reservation at less cost to hydropower, and order its inclusion in the final 4(e) conditions for the Yuba-Bear Project.

Dated: August 29, 2012

Respectfully submitted,

Julie Leimbach
Coordinator, Foothills Water Network
PO Box 713
Lotus, CA 95651
julie@foothillswaternetwork.org

Chris Shutes
FERC Projects Director
California Sportfishing Protection Alliance
1608 Francisco St, Berkeley, CA 94703
blancapaloma@msn.com
(510) 421-2405

*The Network’s Proposed Section 4(e) Alternative Conditions
NID, Yuba-Bear Hydroelectric Project (P-2266)*
Steve Rothert  
Science Program Director  
American Rivers  
432 Broad St.  
Nevada City, CA 95959  
srothert@americanrivers.org

Dave Steindorf  
California Stewardship Director  
American Whitewater  
4 Baroni Dr.  
Chico, CA 95928  
dave@americanwhitewater.org

Ronald Stork  
Senior Policy Advocate  
Friends of the River  
1418 20th Street, Suite 100  
Sacramento, CA 95811-5206  
(916) 442-3155 x 220  
rstork@friendsoftheriver.org

The Network’s Proposed Section 4(e) Alternative Conditions  
NID, Yuba-Bear Hydroelectric Project (P-2266)
Frank Rinella
Northern California Council Federation of Fly Fishers and
Gold Country Fly Fishers
303 Vista Ridge Dr.
Meadow Vista, CA 95722
530-878-8708
sierraguide@sbcglobal.net

Allan Eberhart
Sierra Club – Mother Lode Chapter
24084 Clayton Road
Grass Valley, CA 95949
vallialli@wildblue.net
Gary Reedy  
Science Program Director  
South Yuba River Citizens League  
216 Main St.  
Nevada City, CA 95959  
gary@syrcl.org

Chandra Ferrari  
California Water Policy Director  
Trout Unlimited  
2239 5th Street Berkeley, CA 94710  
(916) 214-9731  
(510) 528-7880 (fax)  
cferrari@tu.org

The Network’s Proposed Section 4(e) Alternative Conditions  
NID, Yuba-Bear Hydroelectric Project (P-2266)
VERIFICATION

I hereby certify that I have read this document; to the best of my knowledge, information, and belief, the statements contained herein are true; and this document is not being filed for the purpose of causing delay.

Dated: August 29, 2012

Respectfully submitted,

Megan Hooker
American Whitewater
Associate Stewardship Director
503-928-7711 (office)
503-358-0140 (cell)
megan@americanwhitewater.org
CERTIFICATE OF SERVICE

I hereby certify that I filed and served this “FOOTHILLS WATER NETWORK, AMERICAN RIVERS, AMERICAN WHITENETWORK, CALIFORNIA SPORTFISHING PROTECTION ALLIANCE, FRIENDS OF THE RIVER, GOLD COUNTRY FLY FISHERS, NORTHERN CALIFORNIA COUNCIL FEDERATION OF FLY FISHERS, SIERRA CLUB, SOUTH YUBA RIVER CITIZENS LEAGUE, AND TROUT UNLIMITED SUBMIT ALTERNATIVE CONDITIONS TO THE PRELIMINARY SECTION 4(E) CONDITIONS FOR YUBA-BEAR HYDROELECTRIC PROJECT” as stated below.

FILING

I filed these Alternative Conditions via overnight delivery, sent August 29, 2012 for delivery the next day, to:

Deputy Chief
National Forest Systems, Forest Service
Washington Office Lands Staff
Mail Stop 1124
1400 Independence Avenue, S.W.

SERVICE

I served the Alternative Condition as indicated to each representative on the attached primary service list on August 29, 2012, according to 7 CFR 1.63(c)(2) via express mail where no electronic address was available, and 7 CFR 1.63(c)(4), via e-mail with return verification requested and a hardcopy via regular U.S. mail. I further served the Alternative Condition to each representative on the attached secondary service list on August 29, 2012, via electronic mail or via regular U.S. mail.

__________________________
Megan Hooker
American Whitewater
Associate Stewardship Director
503-928-7711 (office)
503-358-0140 (cell)
megan@americanwhitewater.org

The Network’s Proposed Section 4(e) Alternative Conditions
NID, Yuba-Bear Hydroelectric Project (P-2266)
<table>
<thead>
<tr>
<th>Party</th>
<th>Primary Person or Counsel of Record to be Served</th>
<th>Other Contact to be Served</th>
</tr>
</thead>
</table>
| California Department of Fish and Game | Nancee Murray  
Senior Staff Counsel  
California Department of Fish and Game  
Office of General Counsel  
1416 Ninth St., 12th Floor  
Sacramento, CALIFORNIA 95814  
UNITED STATES  
nmurray@dfg.ca.gov | MaryLisa F. Lynch  
Senior Environmental Scientist  
California Department of Fish and Game  
1701 Nimbus Road, Suite A  
Rancho Cordova, CALIFORNIA 95670  
mlynch@dfg.ca.gov |
| Department of the Interior, Office of the Solicitor | Rob Schroeder  
Drew Lessard  
7794 Folsom Dam Road  
Folsom, CALIFORNIA 95630  
UNITED STATES                     | James M Eicher  
MR James M. Eicher  
5152 Hillsdale Circle  
El Dorado Hills, CALIFORNIA 95762  
jeicher@blm.gov |
| Department of the Interior, Fish and Wildlife Service | Field Supervisor  
ATTN: FERC Coordinator  
U.S. Fish and Wildlife Service  
Sacramento Field Office, W-2605  
2800 Cottage Way,  
Sacramento, CA 95825 |  |
| Forest Service | Beth Paulson  
Hydro Coordinator  
Individual  
100 Forni Road  
Placerville, CALIFORNIA 95667  
UNITED STATES  
bapaulson@fs.fed.us |  |
| Nevada Irrigation District | Nevada Irrigation District  
Attn Ron Nelson  
1036 W Main St  
Grass Valley CA 959455424  
Phone 530273 6185  
Facsimile 5304772646  
Email nelson@nidwatercom |  |
| Nevada Irrigation District | Jeffrey Meith  
Partner  
Meith, Soares & Sexton, LLP  
1681 Bird Street  
Oroville, CALIFORNIA 95965  
UNITED STATES  
jmeith@minasianlaw.com |
|--------------------------|--------------------------------------------------|
| NOAA Fisheries Service, Southwest Region | Richard Wantuck  
Regional Fisheries Bioengineer  
NOAA Fisheries Service, Northeast Region  
777 Sonoma Ave Ste 325  
Santa Rosa, CALIFORNIA 95404  
UNITED STATES  
Richard.Wantuck@noaa.gov |
|-----------------------------------------|--------------------------------------------------|
| Pacific Gas and Electric Company | Richard J Doble  
Senior License Coordinator  
Pacific Gas and Electric Company  
PO Box 770000  
San Francisco, 94177  
RJD2@pge.com |
| Pacific Gas and Electric Company | Steve Peirano  
Sr. Project Manager  
Pacific Gas and Electric Company  
PO Box 770000  
San Francisco, 94177  
slp2@pge.com |
|-----------------------------------------|--------------------------------------------------|
| Pacific Gas and Electric Company | **Randal S Livingston  
Lead Director  
Pacific Gas and Electric Company  
PO Box 770000  
San Francisco, 94177-0001  
San Francisco |
|-----------------------------------------|--------------------------------------------------|
| Pacific Gas and Electric Company | Jennifer Sharon Abrams, ESQ  
Attorney  
Pacific Gas and Electric Company  
77 Beale Street B30A  
San Francisco, CALIFORNIA 94105  
jsad@pge.com |
| Placer County | Janet K Goldsmith, Esq.  
Scott Morris,Esq. |
<table>
<thead>
<tr>
<th>Water Agency</th>
<th>Placer County Water Agency</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Placer County Water Agency</td>
</tr>
<tr>
<td></td>
<td>DAVID A BRENINGER</td>
</tr>
<tr>
<td></td>
<td>GEN. MANAGER</td>
</tr>
<tr>
<td></td>
<td>PO Box 6570</td>
</tr>
<tr>
<td></td>
<td>Auburn, 95604-6570</td>
</tr>
<tr>
<td></td>
<td>Placer</td>
</tr>
<tr>
<td></td>
<td><a href="mailto:dbreninger@pcwa.net">dbreninger@pcwa.net</a></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Placer County Water Agency</th>
<th>Katharine M. Mapes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Attorney</td>
</tr>
<tr>
<td></td>
<td>Spiegel &amp; McDiarmid LLP</td>
</tr>
<tr>
<td></td>
<td>1333 New Hampshire Ave, N.W.</td>
</tr>
<tr>
<td></td>
<td>2nd Floor</td>
</tr>
<tr>
<td></td>
<td>Washington, DISTRICT OF COLUMBIA 20036</td>
</tr>
<tr>
<td></td>
<td><a href="mailto:katharine.mapes@spiegelmcd.com">katharine.mapes@spiegelmcd.com</a></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Placer County Water Agency</th>
<th>Rebecca J Baldwin</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Attorney</td>
</tr>
<tr>
<td></td>
<td>Spiegel &amp; McDiarmid LLP</td>
</tr>
<tr>
<td></td>
<td>1333 New Hampshire Ave, NW</td>
</tr>
<tr>
<td></td>
<td>Washington, DISTRICT OF COLUMBIA 20036</td>
</tr>
<tr>
<td></td>
<td><a href="mailto:rebecca.baldwin@spiegelmcd.com">rebecca.baldwin@spiegelmcd.com</a></td>
</tr>
</tbody>
</table>

| Placer, County of |
| William Huang, Esq. | Gerald O. Carden, Esq. |
| Katharine M. Mapes, Esq. | County Counsel |
| SPIEGEL & MCDIARMID LLP | Deputy County Counsel |
| 1333 New Hampshire Avenue, NW | COUNTY OF PLACER |
| Washington, DC 20036 | 175 Fulweiler Ave. |
| Phone: (202) 879-4000 | Auburn, CA 95603 |
| Fax: (202) 393-2866 | Phone: (530) 889-4044 |
| Email: william.huang@spiegelmcd.com | Email: gcarden@placer.ca.gov |
| katherine.mapes@spiegelmcd.com | rsandman@placer.ca.gov |

<table>
<thead>
<tr>
<th>Sackheim Consulting</th>
<th>Kelly Sackheim</th>
</tr>
</thead>
<tbody>
<tr>
<td>Principal</td>
<td>Principal</td>
</tr>
<tr>
<td>Sackheim Consulting</td>
<td>Sackheim Consulting</td>
</tr>
<tr>
<td>5096 Cocoa Palm Way</td>
<td>5096 Cocoa Palm Way</td>
</tr>
<tr>
<td>Fair Oaks, CALIFORNIA 95628-5159</td>
<td>Fair Oaks, CALIFORNIA 95628-5159</td>
</tr>
</tbody>
</table>
| **Sackheim Consulting**  
| Kelly Sackheim  
| Principal  
| Sackheim Consulting  
| 5096 Cocoa Palm Way  
| Fair Oaks, CALIFORNIA 95628-5159  
| UNITED STATES  
| ferce@sackheimconsult.com | **State Water Resources Control Board (CA)**  
| David Rose  
| Staff Counsel  
| California Department of Water Resources  
| 1001 I St.  
| Sacramento, CALIFORNIA 95814  
| UNITED STATES  
| drose@waterboards.ca.gov | Jeffrey Parks  
| Water Resources Engineer  
| PO Box 2000  
| Sacramento, CALIFORNIA 95812-2000  
|jparks@waterboards.ca.gov |
| **U.S. Department of Agriculture**  
| Dennis Smith  
| Regional Hydropower Assistance Team  
| Regional Forester’s Office  
| 1323 Club Drive  
| Vallejo, CA 94592 | Jeffrey Parks  
| Water Resources Engineer  
| PO Box 2000  
| Sacramento, CALIFORNIA 95812-2000  
|jparks@waterboards.ca.gov |
| **U.S. Department of Agriculture**  
| Joshua S. Rider  
| Office of the General Counsel, USDA  
| 33 New Montgomery, 17th Floor  
| San Francisco, CA 94105-4511  
| Joshua.rider@ogc.usda.gov | Jeffrey Parks  
| Water Resources Engineer  
| PO Box 2000  
| Sacramento, CALIFORNIA 95812-2000  
|jparks@waterboards.ca.gov |
| **U.S. Department of the Interior**  
| Kevin Tanaka  
| Office of Regional Solicitor  
| U.S. Department of Interior  
| 2800 Cottage Way, Room E 1712  
| Sacramento, CA 95825 | Jeffrey Parks  
| Water Resources Engineer  
| PO Box 2000  
| Sacramento, CALIFORNIA 95812-2000  
|jparks@waterboards.ca.gov |
| **Kerry O’Hara** | Jeffrey Parks  
| Water Resources Engineer  
| PO Box 2000  
| Sacramento, CALIFORNIA 95812-2000  
<p>|<a href="mailto:jparks@waterboards.ca.gov">jparks@waterboards.ca.gov</a> |</p>
<table>
<thead>
<tr>
<th>Entity</th>
<th>Contact Details</th>
</tr>
</thead>
</table>
| U.S. Department of Interior | Regional Environ. Officer  
U.S. Department of Interior  
333 Bush St, Ste 515  
San Francisco, CALIFORNIA 94104  
UNITED STATES |
| Yuba County Water Agency | Joshua Horowitz  
Attorney  
Bartkiewicz, Kronick & Shanahan  
1011 22nd Street  
Sacramento, CALIFORNIA 95816-4907  
UNITED STATES  
jmh@bkslawfirm.com  |
| Yuba County Water Agency | Curt Aikens  
General Manager  
Yuba County Water Agency  
1220 F Street  
Marysville, CALIFORNIA 95901  
caikens@ycwa.com  |
| Yuba County Water Agency | Michael Swiger  
Member  
Van Ness Feldman, PC  
1050 Thomas Jefferson Street, NW  
7th Floor  
Washington, DISTRICT OF COLUMBIA 20007  
UNITED STATES  
mas@vnf.com  |
| Yuba County Water Agency | Julia Scarpino Wood  
Van Ness Feldman, PC  
1050 Thomas Jefferson Street, NW  
Washington, DISTRICT OF COLUMBIA 20007  
jsw@vnf.com  |
| American River Watershed Institute | Otis Wollan  
P.O. Box 1750  
23440 Milk Ranch Rd  
Colfax, CA 95713  
otiswollan@gmail.com  |
| American River Watershed Institute | David Wright  
Architect  
David Wright Associates  
563-B Idaho Maryland Road  
Grass Valley, CA 95945-7062  
david@davidwrightarchitect.com  |
| Foothill Angler Coalition | William Carnazzo  
5209 Crestline Dr.  
Foresthill, CA 95631  |
<table>
<thead>
<tr>
<th>Organization</th>
<th>Contact Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>North Fork American River Alliance, California Flyfishers Unlimited, Granite Bay Flycasters, Spring Creek Flycraft and Guide Service and Gold Country Fly Fishers</td>
<td><a href="mailto:bcarnazzo@ftcnet.net">bcarnazzo@ftcnet.net</a></td>
</tr>
<tr>
<td>Grace Hubley Foundation</td>
<td>Nancy Hagman</td>
</tr>
<tr>
<td></td>
<td>Co-Founder and Agent</td>
</tr>
<tr>
<td></td>
<td>Grace Hubley Foundation</td>
</tr>
<tr>
<td></td>
<td>24820 Ben Taylor Road</td>
</tr>
<tr>
<td></td>
<td>Colfax, California 95713</td>
</tr>
<tr>
<td></td>
<td><a href="mailto:nhagman@gracehubleyfoundation.org">nhagman@gracehubleyfoundation.org</a></td>
</tr>
<tr>
<td>Placer Sierra Railroad Heritage Society</td>
<td>John Gardiner</td>
</tr>
<tr>
<td></td>
<td>13103 Bradford Drive</td>
</tr>
<tr>
<td></td>
<td>Grass Valley, CA 95945</td>
</tr>
<tr>
<td></td>
<td><a href="mailto:john@johngardiner.com">john@johngardiner.com</a></td>
</tr>
<tr>
<td>Placer Sierra Railroad Heritage Society</td>
<td>Jim Wood</td>
</tr>
<tr>
<td></td>
<td>President</td>
</tr>
<tr>
<td></td>
<td>Placer Sierra Railroad Heritage Society</td>
</tr>
<tr>
<td></td>
<td>P.O. Box 1776</td>
</tr>
<tr>
<td></td>
<td>Colfax CA 95713</td>
</tr>
<tr>
<td>Party</td>
<td>Primary Person or Counsel of Record to be Served</td>
</tr>
<tr>
<td>------------------------------</td>
<td>------------------------------------------------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| Tyrone Gorre                 | Tyrone Gorre  
Ty Gorre  
Pacific Gas and Electric Company  
po box 1538  
Meadow Vista, CALIFORNIA  
95722  
UNITED STATES  
tyfish@juno.com                                                |                                                                                             |
| Commanding Officer           | **Commanding Officer  
Commanding Officer  
Sector San Francisco Prevention  
CG Island, Building 14  
Alameda, CALIFORNIA 945015102                                      |                                                                                             |
| County of Placer             | Scott Finley  
Supervising Deputy County Coun  
County of Placer  
County Administrative Center  
175 Fulweiler Ave.  
Auburn, CALIFORNIA 95603  
UNITED STATES  
sfinley@placer.ca.gov                                               |                                                                                             |
| County of Placer, California | E Service  
Spiegel & McDiarmid LLP  
1333 New Hampshire Ave., NW  
Washington, DISTRICT OF COLUMBIA 20036  
eService@spiegelmcd.com                                             |                                                                                             |
| County of Placer, California | Robert K Sandman  
Deputy County Counsel  
175 Fulweiler Ave.  
Auburn, CALIFORNIA 95603                                           |                                                                                             |
<table>
<thead>
<tr>
<th><strong>R. PAUL WILLIAMS</strong>&lt;br&gt;Nevada Irrigation District&lt;br&gt;4280 Mount Pleasant Rd&lt;br&gt;Lincoln, CALIFORNIA 956489721 Placer</th>
<th><strong>RICHARD EIKENBURG</strong>&lt;br&gt;Nevada Irrigation District&lt;br&gt;28311 Secret Town Rd&lt;br&gt;Colfax, CALIFORNIA 957139473 Placer</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Les Nicholson</strong>&lt;br&gt;Hydro Manager&lt;br&gt;Nevada Irrigation District&lt;br&gt;28311 Secret Town Rd&lt;br&gt;Colfax, CALIFORNIA 957139473 UNITED STATES</td>
<td><strong>Richard Eikenburg</strong>&lt;br&gt;Nevada Irrigation District&lt;br&gt;28311 Secret Town Rd&lt;br&gt;Colfax, CALIFORNIA 957139473 Placer</td>
</tr>
<tr>
<td><strong>ARLA BARAGAR</strong>&lt;br&gt;OFFICE ADMIN&lt;br&gt;Nevada Irrigation District&lt;br&gt;PO Box 1019&lt;br&gt;Grass Valley, CALIFORNIA 95945-1019 UNITED STATES</td>
<td><strong>TERRY MAYFIELD</strong>&lt;br&gt;MANAGER&lt;br&gt;Nevada Irrigation District&lt;br&gt;PO Box 1019&lt;br&gt;Grass Valley, CALIFORNIA 95945-1019 Nevada</td>
</tr>
<tr>
<td><strong>George Leipzig</strong>&lt;br&gt;President&lt;br&gt;Nevada Irrigation District&lt;br&gt;13303 SE McGillivary Blvd Apt 220&lt;br&gt;Vancouver, WASHINGTON 98683 UNITED STATES</td>
<td><strong>DAVID E SOUTHERN</strong>&lt;br&gt;DIRECTOR&lt;br&gt;Nevada Irrigation District&lt;br&gt;PO Box 1019&lt;br&gt;Grass Valley, CA 95945-1019 Nevada</td>
</tr>
<tr>
<td>Jeffrey Meith&lt;br&gt;Partner&lt;br&gt;Minasian, Minasian, Minasian, ET AL.&lt;br&gt;1681 Bird Street&lt;br&gt;Oroville, CALIFORNIA 95965 UNITED STATES&lt;br&gt;<a href="mailto:jmeith@minasianlaw.com">jmeith@minasianlaw.com</a></td>
<td>Larry D Thompson&lt;br&gt;Fisheries Biologist&lt;br&gt;NOAA Fisheries Service, Northeast</td>
</tr>
</tbody>
</table>
| Southwest Region | Region 650 Capitol Mall  
          Suite 8-300  
Sacramento, CALIFORNIA 95814  
larry.thompson@noaa.gov |
|------------------|--------------------------------------------------------------------------------------------------|
| Placer County Water Agency | E Service  
Spiegel & McDiarmid LLP  
1333 New Hampshire Ave., NW  
Washington, DISTRICT OF  
COLUMBIA 20036  
eService@spiegelmcd.com |
| Placer County Water Agency | Rebecca J Baldwin  
Spiegel & McDiarmid LLP  
1333 New Hampshire Ave. NW  
Washington, DISTRICT OF  
COLUMBIA 20036  
rebecca.baldwin@spiegelmcd.com |
| SIERRA, COUNTY OF | **EARL WITHYCOMBE  
CHAIRMAN  
SIERRA, COUNTY OF  
PO Box 530  
Downieville, 95936-0530  
Sierra |
| UNION PACIFIC RESOURCES COMPANY | **DAVID MINASIAN  
MINASIAN, MINASIAN, MINASIAN, ET AL.  
PO Box 1679  
Oroville, CALIFORNIA 95965-1679  
UNITED STATES |
| Yuba County Water Agency | **GARY R KALSBEEK  
MGR.  
UNION PACIFIC RESOURCES COMPANY  
PO Box 1019  
Grass Valley, CALIFORNIA 95945-1019  
Nevada |
| Yuba County Water Agency | Curt Aikens  
General Manager  
Yuba County Water Agency  
1220 F Street  
Marysville, CALIFORNIA 95901  
caikens@ycwa.com |
Assumptions for Yuba-Bear Alternative Condition Flow Model Runs

**General:**

1. Used L061812 Run as the basis for modeling. This run includes existing water supply needs (not projected), buffer flows, and NO recession limb flows.

2. Although we support the inclusion of recession flows, those flows were post-processed by the Licensee and cannot be included in iterative model trials. Running these models without recession flows should be a conservative assumption though, when considering block flows, because sometimes recession flows will continue later into summer and may supersede the need for block flows on those days.

**Middle Yuba:**

1. Assume FS 4(e) conditions for all streamflow reaches as the baseline. No provision for back-to-back CD years (B2B) Water Year (WY) type turning to EC year are currently listed in FS 4(e) conditions. FS 4(e)s are included in the run on the DS project, including B2B on DS project reaches.

2. FS run contains no MY block flows. (green line on hydrology plots)

3. Alternate run contains Block flows on MY (EC - none, CD - 2500, D - 830, BN - 490, AN – 490, W - 490). Alternate run also adds in B2B WY on all YB reaches where it applies: Trap and Texas below BS Canal, Canyon Creek below Bowman, MY below Milton. B2B not included for Rollins and below the Bear River Canal Diversion dam, since, FS 4(e)s do not apply there.

4. To increase power generation (alternate condition run), lower minimum flows in the MY were run in April (BN- 20 cfs and AN -40 cfs) and May (BN- 30 cfs and AN -50 cfs). (red line on hydrology plots)

5. Water was taken from Jackson Meadows reservoir using the “water delivery” rule. Additional flow needed for block flows was added to the rule to account for additional water needed in the MY river, while still keeping the same volume of water in the Milton-Bowman tunnel.
<table>
<thead>
<tr>
<th>Powerhouse</th>
<th>GWh/yr</th>
<th>Plant Factor</th>
<th>GWh/yr</th>
<th>Plant Factor</th>
<th>Difference</th>
<th>Max Capability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bowman</td>
<td>12.1</td>
<td>0.33</td>
<td>11.1</td>
<td>0.31</td>
<td>-8.5%</td>
<td>36.3</td>
</tr>
<tr>
<td>Spaulding 3</td>
<td>34.8</td>
<td>0.62</td>
<td>31.1</td>
<td>0.55</td>
<td>-10.7%</td>
<td>56.5</td>
</tr>
<tr>
<td>Spaulding 1</td>
<td>32.4</td>
<td>0.53</td>
<td>29.5</td>
<td>0.48</td>
<td>-8.9%</td>
<td>61.3</td>
</tr>
<tr>
<td>Spaulding 2</td>
<td>10.9</td>
<td>0.28</td>
<td>10.8</td>
<td>0.28</td>
<td>-0.4%</td>
<td>38.5</td>
</tr>
<tr>
<td>Deer Creek</td>
<td>22.6</td>
<td>0.45</td>
<td>22.5</td>
<td>0.45</td>
<td>-0.6%</td>
<td>49.9</td>
</tr>
<tr>
<td>Drum 3</td>
<td>93.2</td>
<td>0.20</td>
<td>80.4</td>
<td>0.17</td>
<td>-13.7%</td>
<td>473.0</td>
</tr>
<tr>
<td>Drum 2</td>
<td>266.2</td>
<td>0.61</td>
<td>242.8</td>
<td>0.56</td>
<td>-8.8%</td>
<td>433.6</td>
</tr>
<tr>
<td>Alta</td>
<td>5.1</td>
<td>0.58</td>
<td>5.1</td>
<td>0.59</td>
<td>0.9%</td>
<td>8.8</td>
</tr>
<tr>
<td>Dutch Flat 1</td>
<td>128.9</td>
<td>0.64</td>
<td>115.9</td>
<td>0.58</td>
<td>-10.1%</td>
<td>201.5</td>
</tr>
<tr>
<td>Dutch Flat 2</td>
<td>48.4</td>
<td>0.21</td>
<td>42.1</td>
<td>0.18</td>
<td>-13.1%</td>
<td>227.8</td>
</tr>
<tr>
<td>Chicago Park</td>
<td>139.5</td>
<td>0.38</td>
<td>124.4</td>
<td>0.34</td>
<td>-10.8%</td>
<td>363.5</td>
</tr>
<tr>
<td>Rollins</td>
<td>66.2</td>
<td>0.59</td>
<td>61.9</td>
<td>0.55</td>
<td>-6.5%</td>
<td>112.1</td>
</tr>
<tr>
<td>Halsey</td>
<td>51.3</td>
<td>0.55</td>
<td>48.5</td>
<td>0.52</td>
<td>-5.4%</td>
<td>92.9</td>
</tr>
<tr>
<td>Wise 1</td>
<td>69.2</td>
<td>0.56</td>
<td>64.5</td>
<td>0.53</td>
<td>-6.8%</td>
<td>122.6</td>
</tr>
<tr>
<td>Wise 2</td>
<td>7.6</td>
<td>0.27</td>
<td>6.6</td>
<td>0.23</td>
<td>-14.2%</td>
<td>28.0</td>
</tr>
<tr>
<td>Newcastle</td>
<td>27.4</td>
<td>0.27</td>
<td>23.3</td>
<td>0.23</td>
<td>-14.8%</td>
<td>100.7</td>
</tr>
</tbody>
</table>

**COMBINED TOTAL**

<table>
<thead>
<tr>
<th>Base Case -EBF</th>
<th>Combined Total</th>
<th>Difference</th>
<th>Max Capability</th>
</tr>
</thead>
<tbody>
<tr>
<td>GWh/yr</td>
<td>1015.84</td>
<td>0.42</td>
<td>920.52</td>
</tr>
</tbody>
</table>

**Sub-Total: NID Yuba-Bear**

<table>
<thead>
<tr>
<th>Total - Critically Dry Years - YB</th>
<th>266.25</th>
<th>0.36</th>
<th>239.52</th>
<th>0.32</th>
<th>-10.04%</th>
<th>740</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total - Dry Years - YB</td>
<td>98.98</td>
<td>0.13</td>
<td>83.71</td>
<td>0.11</td>
<td>-15.43%</td>
<td>740</td>
</tr>
<tr>
<td>Total - Below Normal Years - YB</td>
<td>175.32</td>
<td>0.24</td>
<td>157.57</td>
<td>0.21</td>
<td>-10.12%</td>
<td>740</td>
</tr>
<tr>
<td>Total - Above Normal Years - YB</td>
<td>280.02</td>
<td>0.38</td>
<td>255.90</td>
<td>0.35</td>
<td>-8.61%</td>
<td>740</td>
</tr>
<tr>
<td>Total - Wet Years - YB</td>
<td>325.08</td>
<td>0.44</td>
<td>291.43</td>
<td>0.39</td>
<td>-10.35%</td>
<td>740</td>
</tr>
<tr>
<td>Total - Critically Dry Years - DS</td>
<td>404.22</td>
<td>0.24</td>
<td>349.60</td>
<td>0.21</td>
<td>-13.51%</td>
<td>1667</td>
</tr>
<tr>
<td>Total - Dry Years - DS</td>
<td>622.23</td>
<td>0.37</td>
<td>556.05</td>
<td>0.33</td>
<td>-10.64%</td>
<td>1667</td>
</tr>
<tr>
<td>Total - Below Normal Years - DS</td>
<td>803.72</td>
<td>0.48</td>
<td>733.11</td>
<td>0.44</td>
<td>-8.79%</td>
<td>1667</td>
</tr>
<tr>
<td>Total - Above Normal Years - DS</td>
<td>847.38</td>
<td>0.51</td>
<td>768.95</td>
<td>0.46</td>
<td>-9.26%</td>
<td>1667</td>
</tr>
<tr>
<td>Total - Wet Years - DS</td>
<td>913.69</td>
<td>0.55</td>
<td>846.60</td>
<td>0.51</td>
<td>-7.34%</td>
<td>1667</td>
</tr>
</tbody>
</table>
### Yuba-Bear/Drum-Spauilding Operations Model - Alternative Run Summary

<table>
<thead>
<tr>
<th>Powerhouse</th>
<th>Base Case - EBF GWh/yr</th>
<th>Plant Factor</th>
<th>L061812 - EBF with FS 4(e)s GWh/yr</th>
<th>Plant Factor</th>
<th>% Difference</th>
<th>GWh/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bowman</td>
<td>12.1</td>
<td>0.33</td>
<td>11.1</td>
<td>0.31</td>
<td>-8.5%</td>
<td>36.3</td>
</tr>
<tr>
<td>Spaulding 3</td>
<td>34.8</td>
<td>0.62</td>
<td>31.0</td>
<td>0.55</td>
<td>-10.8%</td>
<td>56.5</td>
</tr>
<tr>
<td>Spaulding 1</td>
<td>32.4</td>
<td>0.53</td>
<td>29.5</td>
<td>0.48</td>
<td>-8.9%</td>
<td>61.3</td>
</tr>
<tr>
<td>Spaulding 2</td>
<td>10.9</td>
<td>0.28</td>
<td>10.8</td>
<td>0.28</td>
<td>-0.4%</td>
<td>38.5</td>
</tr>
<tr>
<td>Deer Creek</td>
<td>22.6</td>
<td>0.45</td>
<td>22.5</td>
<td>0.45</td>
<td>-0.5%</td>
<td>49.9</td>
</tr>
<tr>
<td>Drum 1</td>
<td>93.2</td>
<td>0.20</td>
<td>80.4</td>
<td>0.17</td>
<td>-13.7%</td>
<td>473.0</td>
</tr>
<tr>
<td>Drum 2</td>
<td>266.2</td>
<td>0.61</td>
<td>242.7</td>
<td>0.56</td>
<td>-8.8%</td>
<td>433.6</td>
</tr>
<tr>
<td>Alta</td>
<td>5.1</td>
<td>0.58</td>
<td>5.1</td>
<td>0.59</td>
<td>0.9%</td>
<td>8.8</td>
</tr>
<tr>
<td>Dutch Flat 1</td>
<td>128.9</td>
<td>0.64</td>
<td>115.8</td>
<td>0.57</td>
<td>-10.1%</td>
<td>201.5</td>
</tr>
<tr>
<td>Dutch Flat 2</td>
<td>48.4</td>
<td>0.21</td>
<td>42.1</td>
<td>0.18</td>
<td>-13.0%</td>
<td>227.8</td>
</tr>
<tr>
<td>Chicago Park</td>
<td>139.5</td>
<td>0.38</td>
<td>124.4</td>
<td>0.34</td>
<td>-10.8%</td>
<td>363.5</td>
</tr>
<tr>
<td>Rollins</td>
<td>66.2</td>
<td>0.59</td>
<td>61.9</td>
<td>0.55</td>
<td>-6.5%</td>
<td>112.1</td>
</tr>
<tr>
<td>Halsey</td>
<td>51.3</td>
<td>0.55</td>
<td>48.5</td>
<td>0.52</td>
<td>-5.4%</td>
<td>92.9</td>
</tr>
<tr>
<td>Wise 1</td>
<td>69.2</td>
<td>0.56</td>
<td>64.5</td>
<td>0.53</td>
<td>-6.8%</td>
<td>122.6</td>
</tr>
<tr>
<td>Wise 2</td>
<td>7.6</td>
<td>0.27</td>
<td>6.6</td>
<td>0.23</td>
<td>-14.2%</td>
<td>28.0</td>
</tr>
<tr>
<td>Newcastle</td>
<td>27.4</td>
<td>0.27</td>
<td>23.3</td>
<td>0.23</td>
<td>-14.9%</td>
<td>100.7</td>
</tr>
</tbody>
</table>

**COMBINED TOTAL**

- **Sub-Total: NID Yuba-Bear**
  - **Base Case - EBF**
    - GWh/yr: 266.25
    - Plant Factor: 0.36
  - **L061812 - EBF with FS 4(e)s**
    - GWh/yr: 239.50
    - Plant Factor: 0.32
    - % Difference: -10.05%
    - GWh/yr: 740

- **Total - Critically Dry Years - YB**
  - GWh/yr: 98.98
  - Plant Factor: 0.13
  - GWh/yr: 83.54
  - Plant Factor: 0.11
  - % Difference: -15.60%
  - GWh/yr: 740

- **Total - Dry Years - YB**
  - GWh/yr: 175.32
  - Plant Factor: 0.24
  - GWh/yr: 157.55
  - Plant Factor: 0.21
  - % Difference: -10.14%
  - GWh/yr: 740

- **Total - Below Normal Years - YB**
  - GWh/yr: 280.02
  - Plant Factor: 0.38
  - GWh/yr: 255.74
  - Plant Factor: 0.35
  - % Difference: -8.67%
  - GWh/yr: 740

- **Total - Above Normal Years - YB**
  - GWh/yr: 325.08
  - Plant Factor: 0.44
  - GWh/yr: 291.46
  - Plant Factor: 0.39
  - % Difference: -10.34%
  - GWh/yr: 740

- **Total - Wet Years - YB**
  - GWh/yr: 374.82
  - Plant Factor: 0.51
  - GWh/yr: 337.83
  - Plant Factor: 0.46
  - % Difference: -9.87%
  - GWh/yr: 740

- **Sub-Total: PG&E Drum-Spauilding**
  - **Base Case - EBF**
    - GWh/yr: 749.60
    - Plant Factor: 0.45
    - GWh/yr: 680.86
    - Plant Factor: 0.41
    - % Difference: -9.17%
    - GWh/yr: 1667

- **Total - Critically Dry Years - DS**
  - GWh/yr: 404.22
  - Plant Factor: 0.24
  - GWh/yr: 348.85
  - Plant Factor: 0.21
  - % Difference: -13.70%
  - GWh/yr: 1667

- **Total - Dry Years - DS**
  - GWh/yr: 622.23
  - Plant Factor: 0.37
  - GWh/yr: 555.96
  - Plant Factor: 0.33
  - % Difference: -10.65%
  - GWh/yr: 1667

- **Total - Below Normal Years - DS**
  - GWh/yr: 803.72
  - Plant Factor: 0.48
  - GWh/yr: 733.02
  - Plant Factor: 0.44
  - % Difference: -8.80%
  - GWh/yr: 1667

- **Total - Above Normal Years - DS**
  - GWh/yr: 847.38
  - Plant Factor: 0.51
  - GWh/yr: 768.96
  - Plant Factor: 0.46
  - % Difference: -9.25%
  - GWh/yr: 1667

- **Total - Wet Years - DS**
  - GWh/yr: 913.69
  - Plant Factor: 0.55
  - GWh/yr: 846.71
  - Plant Factor: 0.51
  - % Difference: -7.33%
  - GWh/yr: 1667
Inland Fishes of California

Revised and Expanded

PETER B. MOYLE

Illustrations by Chris Mari van Dyck and Joe Tomelleri

UNIVERSITY OF CALIFORNIA PRESS
Berkeley  Los Angeles  London
Life History. Not much is known about Clear Lake splittail because there was little interest in them until after they became extinct. Their most distinctive features are adaptations for lake living. They once apparently schooled in large numbers over most of the lake, concentrating in littoral areas. Summer die-off of large splittail and other Clear Lake minnows seems to have been an annual event, although its exact cause is not known. Clear Lake splittail were more pelagic in feeding habitats than Sacramento splittail. They were observed eating ovipositing gnats and gnat egg rafts on the surface, as well as bottom-living gnat larvae and emerging pupae (2, 3). Of the diet of 22 splittail examined by Cook (7), 76 percent was zooplankton; the rest was insects or detritus.

Clear Lake splittail spawned in inlet streams in April and May, frequently migrating several kilometers upstream to suitable gravel riffles or areas with flooded vegetation. It is not known how long newly hatched splittail remained in the streams before returning to the lake, but it was probably at least three weeks. Once in the lake they apparently spent the first few months in the littoral zone.

Status. IA. The species is globally extinct. Following a major, precipitous decline in the early 1940s (4), Clear Lake splittail managed to hang on until the mid-1970s. The most likely cause of their decline was diversion of streams during spawning and rearing seasons. Splittail apparently spawned later than hitch (which have managed to maintain populations in the lake) and seem to have reared longer in the streams. Likewise, pikeminnows also spawned later in the season (April) than hitch and are now largely absent from the lake (although they persist in tributary streams).

It is possible that channelization of lower reaches of most tributaries was a major contributor to the decline by eliminating flooded areas needed by splittail for spawning and larval rearing. These aspects of their life history may have been particularly critical in dry years, when sudden reduction in water flows either trapped spawning adults or prevented young fish from moving into the lake (5). Other factors contributing to extinction may have been predation, competition, or diseases from introduced fishes. Although splittail managed to coexist with nonnative fishes for about 100 years, negative interactions may have acted synergistically with poor spawning success. It may be significant that splittail were still fairly easy to collect in Clear Lake in the early 1960s (1) and that their disappearance followed the explosive establishment of inland silversides in 1967. Silversides completely dominate the littoral zone of the lake, once the main habitat of juvenile splittail. Ironically, the huge schools of minnows once present in the shallow waters of the lake were referred to by early residents as “silversides” (6).

Taxonomy Mylopharodon conocephalus was first described as Gila conocephala Baird and Girard (1) from a single specimen from the “Rio San Joaquin.” In 1855 Ayres (2) redescribed the species as Mylopharodon robustus. Girard (3) then reclassified G. conocephala as Mylopharodon conocephalus and placed M. robustus as a closely allied second species. Jordan (4) united both forms as Mylopharodon conocephalus (5). There appears to be little morphological variation among hardhead populations (6). Although it is related to the four species of pikeminnow (Ptychocheilus), it is different enough to be retained in a separate genus (7,8). Fossil evidence indicates that the genus has existed since at least the Miocene period (7,38).

Names The origin of the name hardhead is obscure, particularly because it was applied to Sacramento blackfish, Sacramento pikeminnow, and other large minnows in the early literature. Mylo-pharodon means mill-throat-teeth, referring to the molariform pharyngeal teeth; conocephalus means cone-shaped head, which is mildly descriptive.

Distribution Hardhead are widely distributed in low- to midelevation streams in the main Sacramento-San Joaquin drainage. They are also present in the Russian River (11). Their range extends from the Kern River, Kern County, in the south to the Pit River (south of the Goose Lake drainage), Modoc County, in the north (12,13). In the San Joaquin drainage, the species is scattered in tributary streams and absent from valley reaches of the San Joaquin River (8,9,10). In the Sacramento drainage, the hardhead is present in most larger tributary streams as well as in the Sacramento River. It is absent from San Francisco Bay streams except the Napa River.

Life History Hardhead are typically found in undisturbed areas of larger low- to midelevation streams (8,13), although they are also found in the mainstem Sacramento River at low elevations and in its tributaries to about 1,500 m (14). Most streams in which they occur have summer temperatures in excess of 20°C, and optimal temperatures for hardhead (as determined by laboratory choice experiments) appear to be 24–28°C (15). In a natural thermal plume in the Pit River, hardhead generally selected temperatures of 17–21°C, which were the warmest available (16). At higher temperatures hardhead are relatively intolerant of low oxygen levels, a factor that may limit their distribution to well-oxygenated streams and to surface water of reservoirs (17). They prefer clear, deep (>80 cm) pools and runs with sand-gravel-boulder substrates and slow velocities (20–40 cm/sec) (8,12,15,18,40). In streams adults often remain in the lower half of the water column (15,18), although in reservoirs they can occasionally be seen hovering close to the surface (19,20). Hardhead are always found in association with Sacramento pikeminnow and usually with Sacramento sucker. They tend to be absent from streams where introduced species, especially centrarchids, predominate (8,13) and from streams that have been severely altered by human activity (21), although they can persist below dams under certain conditions. Their relatively poor swimming ability at low temperatures may keep them from moving up streams with natural or human-made velocity barriers that permit the passage of salmonids (39).

Hardhead are abundant in a few midelevation reservoirs used largely for hydroelectric power generation, such as Redinger and Kerkhoff Reservoirs on the San Joaquin River (Fresno County) and Britton Reservoir on the Pit River (Shasta County). They are most abundant in the upstream half of Britton Reservoir, where habitat is more riverine, and
are less abundant in the more lacustrine habitat downstream, where introduced centrarchid basses are abundant (22). They are largely absent today from most warmwater reservoirs with high annual fluctuations in volume, although they can survive in such reservoirs in the absence of large populations of introduced predatory fishes.

In streams hardhead smaller than 150 cm SL often cruise about pools or slow runs during the day in small groups, rising to take insects from the surface, holding in areas of swifter current to eat insects and algae in the water column, or dropping to the bottom to browse (40). They are sedentary in streams, rarely moving more than a kilometer from home pools (23). Most movements away from home pools are presumably related to reproduction (23). Including such movements, the average home range of adult hardhead in a small foothill stream was estimated to be about 850 m (23). In Britton Reservoir large hardhead concentrate on warm summer days in surface waters (<1 m) and can often be seen remaining motionless close to the surface (19). This behavior makes them an important prey for bald eagles that nest in the area (20). In contrast, in streams adults will aggregate during the day in the deepest parts of pools or cruise about slowly well below the surface (40). They are most active in the early morning and evening when feeding.

Hardhead are omnivores that forage for benthic invertebrates and aquatic plant material on the bottom but also eat drifting insects and algae (40). In reservoirs they feed on zooplankton (24). Smaller fish (<20 cm SL) consume primarily mayfly larvae, caddisfly larvae, and small snails (14), whereas larger fish feed more on aquatic plants (especially filamentous algae), crayfish, and other large invertebrates. The ontogenetic changes in tooth structure are consistent with this dietary switch; juveniles have hooked teeth, characteristic of insectivores, whereas adults have large molariform teeth, needed for grinding hard prey and plants (14).

Hardhead typically reach 6–8 cm SL by the end of their first growing season, 10–12 cm in their second, and 16–17 cm in their third (14, 22, 25, 28). In the American River they can reach 30 cm SL in 4 years (14); in the Pit and Feather Rivers, it takes 5–6 years to reach that length (22, 25). In small streams resident hardhead rarely exceed 28 cm SL (28). Feather River fish measuring 44–46 cm SL were aged (using scales) at 9–10 years, but older and larger (to at least 60 cm SL) fish no doubt exist. If the older records are accurate, hardhead are capable of reaching up to 1 m TL (29).

Hardhead mature in their third year and spawn mainly in April and May (14, 23). Juvenile recruitment patterns suggest that spawning may extend into August in some foothill streams (26). Fish from larger rivers or reservoirs may migrate 30–75 km or more upstream in April and May, usually into tributary streams (24, 27). In small streams hardhead may move only a short distance from their home pools for spawning, either upstream or downstream (23). In Pine Creek (Tehama County) resident hardhead aggregate during spawning season in nearby pools; spawning hardhead from the Sacramento River move into downstream reaches that dry in summer (23).

Spawning behavior has not been documented, but large aggregations of fish found during the spawning season suggest that it is similar to that of hitch or pikeminnow, with fertilized eggs deposited on beds of gravel in riffles, runs, or the heads of pools. Females, depending on size, can produce 7,000–24,000 eggs per year (23, 28). Grant and Maslin (23) noted that there were small undeveloped eggs in each ovary along with mature eggs, indicating that eggs may take 2 years to mature.

The early life history of hardhead is poorly known (26). After hatching, the larval and postlarval fish presumably remain along stream edges in dense cover of flooded vegetation or fallen tree branches. As they grow they move into deeper habitats, where those spawned in intermittent streams are swept down into main rivers, perhaps concentrating in low-velocity areas near the mouth. In Deer Creek (Tehama County) I have observed large aggregations of small juveniles (2–5 cm SL) in shallow backwaters. In the Kern River small juveniles concentrate along edges among large cobbles and boulders (41). Hardhead measuring 5–2 cm SL select habitats similar to those of adult fish. In Deer Creek this means pools or runs that are 40–140 cm deep, with water column velocities of 0–30 cm/sec (18). Such pools invariably contain Sacramento pikeminnows and Sacramento suckers.

**Status** ID, but IC in the San Joaquin drainage. Historically hardhead have been regarded as widespread and abundant in central California (2, 14, 29, 30, 31, 32, 33, 34). They are still widely distributed in foothill streams, but their populations are increasingly isolated from one another, making them vulnerable to localized extinctions. As a consequence they are much less abundant than they once were, especially in the southern half of their range. Reeves (14) summarized historical records and noted that they were found in most streams in the San Joaquin drainage; but in the early 1970s I found them in only 9 percent of sites sampled (8). Resampling many of the same sites about 15 years later indicated that a number of the populations had disappeared (10). They have a discontinuous distribution in the Pit River drainage, being present mainly in canyon sections of the main river and in hydroelectric reservoirs (13, 36). They are apparently still fairly common in the mainstream Sacramento River, in the lower reaches of the American and Feather Rivers, in some smaller tributary streams (e.g., Deer, Pine, Clear Creeks), and in some river reaches above foothill reservoirs. They have become extremely rare in the Napa River (11) and are uncommon in the Russian River.

Hardhead were abundant enough in Central Valley...
Sacramento Pikeminnow, Ptychocheilus grandis (Ayres)

Identification Sacramento pikeminnows are large (potentially over 1 m TL) cyprinids with elongate bodies; flattened, tapered (pikelike) heads; and deeply forked tails. The mouth is large, the maxilla extending behind the front margin of the eye, and is without teeth. The pharyngeal teeth (2.5-4.2) are long and knifelike. There are 8 rays in the anal fin, 8 rays in the dorsal fin, 15-18 pectoral rays, 9 pelvic fin rays, 65-78 scales along the lateral line, 38-44 predorsal scales on the back of the head, and 12-15 scale rows above the lateral line. Large fish are generally a dark, brownish olive on the back and gold-yellow on the belly. Small fish tend to be silvery on the sides and belly and have a dark spot at the base of the tail. Fins of breeding adults are tinged with reddish orange. Spawning males develop tiny breeding tubercles on the base of the tail. Fins of breeding adults are tinged with reddish orange. Spawning males develop tiny breeding tubercles on the base of the tail.

Taxonomy Despite its wide distribution in California, no distinctive regional forms of Sacramento pikeminnow have been noted, presumably because it is a highly mobile species favoring large streams. The Sacramento pikeminnow is one of four species of Ptychocheilus. Others are P. lucius in the Colorado River, P. umugae from rivers in west-central Oregon, and P. oregonensis in the Columbia River basin (1, 2). Within this group Sacramento pikeminnow appears to be most closely related to Colorado pikeminnow. The hardhead is closely related to pike-
Sacramento pikeminnows but is distinct enough to be placed in its own genus (*Mylopharodon*) (2).

**Names** Pikeminnow, adopted in 1998 by the American Fisheries Society, is a replacement for the widely used name "squawfish." Squawfish is a derogatory name conferred by early settlers because pikeminnow was a common food fish of Native Americans and therefore regarded as inferior. Because the name insults Native Americans (and indirectly a fine fish), its replacement by pikeminnow as the official common name is highly appropriate. Many other names have also been applied to the species: Sacramento pike, chub, whitefish, hardhead, chappaul, bigmouth, boxhead, and yellowbelly. *Ptychocheilus* means folded lip, "the skin of the mouth behind the jaws being folded" (3, p. 224); *grandis* means large.

**Distribution** Sacramento pikeminnows are found in creeks and rivers throughout the main Sacramento–San Joaquin River system, Pajaro and Salinas Rivers, Russian River, Clear Lake basin, and upper Pit River. Sometime before 1975 they became established in Chorro and Los Osos Creeks (San Luis Obispo County); presumably via an aqueduct connecting these streams with the upper Salinas River. They have also been transferred via the California Aqueduct into reservoirs in southern California (4). In about 1979 they were introduced into Pillsbury Reservoir in the Eel River and have since spread throughout the drainage (5, 7).

**Life History** Sacramento pikeminnows are widespread in clear rivers and creeks of central California and present in small numbers in the Sacramento–San Joaquin Delta. They are largely absent from habitats that are highly turbid or polluted and tend to be found in low numbers (mainly as large adults) in lakes and reservoirs that contain centrarchid basses. They are most characteristic of low- to midelevation streams with deep pools, slow runs, undercut banks, and overhanging vegetation. Although they are fairly secretive, in large pools adults can be observed cruising about during the day. They are most abundant in lightly disturbed, tree-lined reaches that also contain other native fishes, especially Sacramento sucker and hardhead (6). The smaller the stream, the more likely pikeminnows are to be found only in pools. Typically during low-flow periods during the day, pikeminnow greater than 12 cm SL are found in water deeper than 1 m with mean water column velocity of less than 40 cm/sec, while smaller fish concentrate in shallower areas with lower velocities, presumably in part to avoid predation by larger individuals (8, 9, 10, 11).

They generally live in waters with summer temperatures of 18–28°C (7, 12, 13). Within this range pikeminnows often seek warmer temperatures if other aspects of the habitat are appropriate (12, 13). The maximum (acute) preferred temperature is around 26°C; temperatures above 38°C are invariably lethal (9). Temperatures lower than 38°C may also be lethal if the fish were previously living in cooler water. Metabolic rates of pikeminnows increase with temperature (14), although sustained swimming speeds cannot exceed 2–2.5 body lengths per second (15). While basically freshwater fish, Sacramento pikeminnows have been found in Suisun Marsh in salinities as high as 8 ppt, although they are rarely found at salinities higher than 5 ppt.

Juvenile pikeminnows are typically found in small schools, often mixed with other native cyprinids. The depth a school selects is related to the size of the fish, because of the dual threats of heron predation in shallow water and fish predation in deeper water, although large pikeminnows rarely pursue small fish during the day. Thus the smallest fish (<30 mm) are typically found in the shallowest water at stream edges. Larger fish may also school with other fishes;
I have observed mixed schools of pikeminnow and rainbow trout, all about 20–25 cm long, swimming about in tight formation in the Eel River. Schools of 15- to 25-cm pikeminnows in the Eel can contain several hundred individuals. Large pikeminnows typically cruise about in pools during the day in loose groups of 5–10 fish, although very large individuals may be solitary (11, 16). Often by midday, they become relatively inactive and return to cover (11, 17), although there are generally some still cruising about, feeding on surface insects or benthos (17). The largest fish emerge from cover and begin foraging as darkness falls, entering runs and shallow riffles to forage on small fish (40). Individual fish can move over 500 m during the night before returning to their "home" pools (40). Juveniles, in contrast, will forage actively during the day. The behavior of pikeminnows during colder months is not known, but they apparently seek deep cover (e.g., under submerged trees) that can serve as velocity refuges during high flows (16).

Pikeminnows are capable both of living a sedentary life style and of migrating long distances. In small streams adult pikeminnows may rarely leave a single pool or complex of pools (16, 17). Taft and Murphy (18) observed a tagged pikeminnow in the same pool for 3 years. However, in the Sacramento River pikeminnows move upstream past Red Bluff Diversion Dam during all months of the year; peak numbers (up to 10,000 per month) were typically observed in March, April, and May, when the fish were migrating to spawn (19). Some were tagged in the Delta, indicating an ability to migrate at least 400 km (20, 39). In the Eel River, although most adult fish are sedentary, individuals can move long distances; one radio-tagged pikeminnow was followed for 92 km, moving upstream (40). Most movement takes place at night.

As their pikelike appearance and sharp pharyngeal teeth suggest, pikeminnows are predators on large prey. Before the introduction of other predatory fishes such as large-mouth bass, large pikeminnows were undoubtedly at the top of the aquatic food chain throughout the Central Valley. They are opportunists, taking prey on the bottom, at the surface, or in between, depending on type, abundance, and time of day. The size and kind of prey depend on the size of the fish. Pikeminnows under 10 cm SL feed predominantly on aquatic insects, switching to fish and crayfish between 10 and 20 cm (5, 17, 18, 19, 20). In the regulated lower American River, juvenile pikeminnows feed on small aquatic insects, especially corixids (water boatmen) and chironomid midge larvae; they also feed on larval suckers when they are abundant (38). Fish larger than 20 cm SL feed almost exclusively on fish and crayfish, but large stoneflies, frogs, and small rodents have been found in their diets. In small streams the switch to fish may occur at a smaller size if potential prey (including smaller pikeminnows) are abundant (17). In the Eel River in the late 1980s, large pikeminnows fed on novel prey (lamprey ammocoetes, frogs), presumably because they were recent invaders to the system and were finding naive prey (5). In order to avoid predation by large pikeminnows, California roach, Sacramento suckers, and rainbow trout seek out shallower or faster water than they would in the absence of pikeminnows (7, 21). However, large pikeminnows move into these habitats to forage at night. Curiously, threespine sticklebacks seem to have a hard time changing behavior in the presence of pikeminnows and are likely to co-occur with them only if the stream contains large amounts of dense cover (7, 27).

Pikeminnows in the Eel River forage on outmigrating juvenile salmon in spring, predation also characteristic of large pikeminnows holding below Red Bluff Diversion Dam on the Sacramento River (20). Although pikeminnows may consume large numbers of juvenile salmon, they are likely to have significant impact on salmon populations only where humans have created situations in which the natural ability of salmon to avoid predation is reduced, such as below dams (22) or in locations where pikeminnows are introduced, such as the Eel River (5). At Red Bluff heavy predation on salmon occurs mainly when the dam gates are closed, aggregating pikeminnows and disorienting small salmon in turbulent flows (39). In the Columbia River northern pikeminnow predation below dams is regarded as a major factor contributing to salmon declines, and considerable effort is spent on pikeminnow control, although dams and not pikeminnows per se are the ultimate cause of the problems (23, 24). Under natural conditions pikeminnows feed largely on nonsalmonid fishes such as sculpins (25, 39). The fact that large pikeminnows have low metabolic and digestive rates and that they feed infrequently, especially at low temperatures, also reduces their ability to affect salmonid populations during migrations (26).

Peak feeding usually occurs in early morning (small pikeminnows) or at night (large pikeminnows) (11, 17, 19). Nighttime predation rates at Red Bluff Diversion Dam were apparently enhanced when lights on the dam made prey more visible (20).

Pikeminnows are long lived and slow growing, well adapted to persist through periods of extended drought when reproductive success is low. Growth is usually continuous during the warmer months of the year (17), although it may temporarily cease during periods of drought or in streams that become intermittent (18). For the most part, determining the age of pikeminnows by reading scales is unreliable for older fish, although specimens have been
aged at up to 12 years old by this method (28). Using opercular bones, pikeminnows measuring 66 cm SL from the Russian River have been aged at 16 years, suggesting that even older fish may not be unusual (29). Most populations of pikeminnows from rivers and reservoirs show fairly consistent growth rates for their first 5 years or so of life, reaching 50–85 mm SL at the end of their first year, 100–150 mm at the end of their second year, 170–250 mm at the end of their third year, 240–270 mm at the end of their fourth year, and 260–350 mm at the end of their fifth year (5, 16, 17, 28, 30, 39). Growth rates tend to be slowest in small streams and fastest in large, warm rivers. The highest growth rates on record are for the lower Sacramento River: 1.2–1.5 times higher than growth rates elsewhere after the first year (17, 39). There appear to be no differences in growth rates between the sexes. The largest Sacramento pikeminnow known, measuring 115 cm SL and weighing 14.5 kg, was caught in Avocado Lake, Fresno County, in an abandoned gravel pit just off the Kings River.

Sacramento pikeminnows typically become sexually mature at the end of their third or fourth year at 22–25 cm SL; males mature a year earlier than females. They may spawn annually thereafter, but they will not spawn in years when conditions are unfavorable (16, 28). Ripe fish move upstream during April and May (16, 18, 28), although larvae have been collected into July (31). Males usually arrive in the spawning area (gravel riffles or shallow flowing areas at the base of pools) first, when water temperatures rise to 15–20°C. Fish from large rivers or reservoirs usually move into small tributaries to spawn, whereas fish resident in small to medium-size streams typically just move into the nearest riffle (16, 18, 28).

The spawning behavior of pikeminnow has not been recorded in detail, presumably because they spawn largely at night (28). However, it is undoubtedly similar to that of other native cyprinids as well as northern pikeminnow (32). Males congregate in favorable spawning areas and wait for females (28). Any female swimming past a swarm of males is immediately pursued by one to six males. Spawning occurs when a female dips close to the bottom and releases a small number of eggs, which are simultaneously fertilized by one or more males swimming close behind her (32). Fertilized eggs sink to the bottom and adhere to rocks and gravel (31).

Fecundity is high (15,000–40,000 eggs per female, for fish measuring 31–65 cm SL) and related to size, although there is considerable variation in the estimates (16, 28, 33). In northern pikeminnow, the eggs hatch in 4–7 days at 18°C, and fry begin shoaling in another 7 days (33). These events are probably similar for Sacramento pikeminnow because, soon after spawning occurs, shoals of larvae or postlarvae can be observed in shallow pool edges or backwaters, often in association with larvae of other native fishes (31). As the small fish become more active swimmers, they enter deeper water, especially in runs and along riffles in cover. Juvenile pikeminnows can disperse widely in their first year of life, colonizing stream reaches that have been dried up by drought (27) or made available to them through introduction (5). Young-of-year typically disperse downstream, whereas yearlings are more likely to move upstream (41).

Status

IE. Sacramento pikeminnows are still common in central California and have expanded their range into the Eel River basin and creeks flowing into Morro Bay. Although they have become much less abundant in lowland habitats where they were once dominant predators, they have maintained large populations in the Sacramento River, foothill streams, and many regulated streams. When large reservoirs were created by damming Central Valley tributaries, pikeminnows and hardhead colonized the new reservoirs in high enough numbers to be considered a major management problem (34). However, after 10–15 years, the “rough fish problem” quietly went away on its own, presumably because of predation by centrarchid basses on naïve juveniles. Nevertheless, small populations of pikeminnows are still present in many reservoirs dominated by nonnative fishes, such as Pine Flat Reservoir (Fresno County), Anderson Reservoir (Santa Clara County), or Shasta Reservoir (Shasta County). They seem to persist by spawning in tributary streams, where juveniles remain during the vulnerable first 1–2 years of life. Pikeminnows still maintain large populations in hydropower reservoirs, which behave like giant riverine pools and are not drawn down annually (35).

As indicated previously, the ability of Sacramento pikeminnows to be significant predators on juvenile salmon is limited to unusual locations, such as those below Red Bluff Diversion Dam or in the Eel River (5, 22, 39). The degree of predation at Red Bluff Diversion Dam was greatly overestimated (20), resulting in a number of efforts to control pikeminnows. All—including annual “fish-outs” by anglers—failed. At one point an electrocution device, activated by a person viewing through a television camera, was installed in the fish ladder passing over the dam. The idea was to electrocute pikeminnows passing over the dam in order to reduce their population. The device worked for a short while, killing a number of pikeminnows, but then the pulse of migrants abruptly stopped. Apparently, the shocked fish had released fear substance, characteristic of cyprinids, which served to deter fish below the dam from proceeding. The migration was halted for several days, compounding whatever predation problem may have existed, because large fish then accumulated below the dam. The electrocution device was subsequently abandoned (36). The “problem” at Red Bluff Diversion Dam largely disappeared when gates were left open to allow safe salmon passage.
through the dam, coincidentally allowing pikeminnows to complete their spawning migration as well.

If the predatory nature of Sacramento pikeminnows gives them an undeservedly bad reputation, it also confers on them sporting qualities (18, 33, 37) recognized by every angler who hooks one (until he or she discovers that the struggling fish is not a trout or a bass). The culinary qualities of large pikeminnows are also underappreciated, although they fetch a good price in oriental markets and, like common carp, are excellent eating when properly prepared. More importantly, pikeminnows are a key component in many stream ecosystems and are fascinating to watch, cruising elegantly about their summer pools.

References

Colorado Pikeminnow, Ptychocheilus lucius Girard

Identification
Colorado pikeminnow are large (up to 2 m), small-scaled cyprinids with elongate bodies, flattened, tapered (pikelike) heads, and deeply forked tails. Their scales are embedded, and there are usually more than 80 in the lateral line (76–97) and 18–23 rows above the lateral line. The toothless mouth is large and horizontal, the maxilla extending behind the front margin of the eye. The pharyngeal teeth (2.5–4.2) are long and knife-like. There are 9 rays in the anal fin and 9 in the dorsal fin, 14–16 pectoral fin rays, and 8–10 pelvic fin rays. The body tends to be silvery, but larger fish become dark on the back and white to yellow on the sides and belly. Juveniles are bright silvery on the sides and belly and have a dark spot at the base of the tail. Breeding adults are silvery on the sides, flecked with gold, and creamy on the belly. Spawning males develop tiny breeding tubercles on the head and a row of tubercles on the side that can extend to the tail.

Taxonomy
See the account of Sacramento pikeminnow.

Names
The trivial name lucius means pike, referring to the superficial resemblance of pikeminnow to true freshwater pikes (Esocidae). Jordan and Evermann (1) listed its common name as "white salmon of the Colorado" or "whitefish." Other names, including the replacement of the common name "squawfish" with "pikeminnow," are discussed in the account of Sacramento pikeminnow.

Distribution
Colorado pikeminnows were once common in the Colorado River and its major tributaries from Wyoming (Green River), through Utah, Colorado, Arizona, New Mexico, Nevada, California, and Mexico. Today they are absent...