POTENTIAL RESOURCE ISSUE:

- Aquatic habitat quantity and quality.
- Basin Plan objectives compliance.

PROJECT NEXUS:

- Project operations modify the flow regime in the bypass river reaches thereby influencing instream water temperatures.

POTENTIAL LICENSE CONDITION:

- Instream flow releases.

STUDY OBJECTIVES:

- Characterize the relationship between flow and water temperature in bypass river reaches using an appropriate model supported by existing water temperature data.
- Assess the potential effects of increased air temperature due to global warming on water temperatures over the term of the new Federal Energy Regulatory Commission (FERC) license.
- Document the availability of cold water temperature refugia in bypass river reaches.

EXTENT OF STUDY AREA:

- The study area for water temperature modeling includes the Kaweah River and East Fork Kaweah River bypass river reaches (Table AQ 4-1 and Map AQ 4-1).

STUDY APPROACH:

General Modeling

- Summarize water temperature and meteorological data (relative humidity, wind speed, solar radiation, air temperature) collected as part of SCE's early data collection (2016), including seasonal patterns and daily averages, minimums, and maximums as a function of time and location in the bypass river reaches and comparison reaches. Continue to collect water temperature and meteorological data through the summer of 2017 to provide boundary conditions and model calibration data for water temperature modeling.
- Establish a Water Temperature Modeling Group (WTMG) to provide oversight and technical review of modeling procedures/decisions.
- Select and develop appropriate river water temperature models with seasonal, daily, and within-day temperature modeling capability, as necessary for specific study reaches. HEC-RAS (Brunner 2010) or RMA-2 and RMA-11 (King 1994; King 1997) are proposed for the river temperature modeling. Both have dynamic flow routing capability and within-day temperature modeling capability. HEC-RAS will be investigated in collaboration with the WTMG as the primary modeling platform
- The water temperature model(s) will be developed to simulate average, maximum, and minimum daily water temperature during the summer months when water temperature are of most concern to aquatic species. Modeling development steps to be completed in collaboration with the WTMG include:

- Collect/develop model inputs including channel geometry data, solar shading data (topographic and riparian), meteorological data (air temperature, wind speed, relative humidity, solar radiation), hydrology data, and boundary condition flow and water temperature data for the modeled river reaches.
  - Develop channel slopes and reservoir geometry using United States Geological Survey (USGS) Digital Elevation Model (DEM) data.
  - Generate daily and seasonal topographic solar shading data using Geographic Information System (GIS) algorithms and USGS DEM data.
  - Use the measured Project meteorological data and, if possible, extend the measured meteorological data to a longer period of record through correlation with a long-term meteorological station. Suitable meteorological stations will be identified and the correlation results will be evaluated as part of this study.
  - Hydrology data will be generated from the operating flow gages during the study period and the Project Operations modelling.
  - Channel cross-section data will be collected in the AQ 1 - Instream Flow Technical Study Plan (TSP) and extended to the study river segments, as appropriate, using mesohabitat mapping data collected as part of the AQ 1 - Instream Flow TSP.
- Calibrate and validate the hydrodynamics and heat budget portions of the water temperature model(s) with empirical water temperature and meteorological data. Calibrate water travel time in the bypass reach using any flow fluctuation travel time data available in the gaging records.

Characterize modeled water temperatures (i.e., seasonal, daily, within-day temperatures) for existing and alternative flow conditions. For alternative flow conditions, model a range of flow releases determined by the WTMG.

Climate Change

Incorporate available literature predictions of changes in air temperature as a result of global warming into a limited number of model runs (2-3) to evaluate the resulting effect on water temperature over the anticipated term of the new FERC license period (30-50 years).

Cold Water Refugia

In selected bypass reaches of the Kaweah River and East Fork Kaweah River collect water temperature data at tributary inflows and in deep pools to identify the potential availability of water temperature refugia for trout. In particular, review the 2014-2015 water temperature data to identify river reaches with summer temperatures above 20°C. Within these reaches, identify any potential groundwater or tributary cold water inflows and characterize the extent of the cold water refugia (e.g., amount of tributary habitat, extent of influence in the main channel). Identify two deep pools upstream and two downstream of the tributary and collect water temperature profiles to examine potential thermal stratification.

SCHEDULE:

Date	Activity
November 2017–March 2018	Develop and validate preliminary temperature model in collaboration with the WTMG
April–October 2018	Analyze data, develop the water temperature analysis in collaboration with the WTMG, and prepare draft report
November 2018	Distribute draft report to the stakeholders
December 2018–February 2019	Stakeholders review and provide comments on draft report (90 days)
March–May 2019	Resolve comments and prepare final report
August 2019	Distribute final report in Draft License Application

REFERENCES:

Brunner, G. W. 2010. HEC-RAS River Analysis System User's Manual (Version 4.1). US Army Corps of Engineers Hydrologic Engineering Center (HEC).

King, I.P. 1994. RMA-2: A Two-Dimensional Finite Element Model for Flow in Estuaries and Streams, Version 5.1. Department of Civil and Environmental Engineering, University of California, Davis.

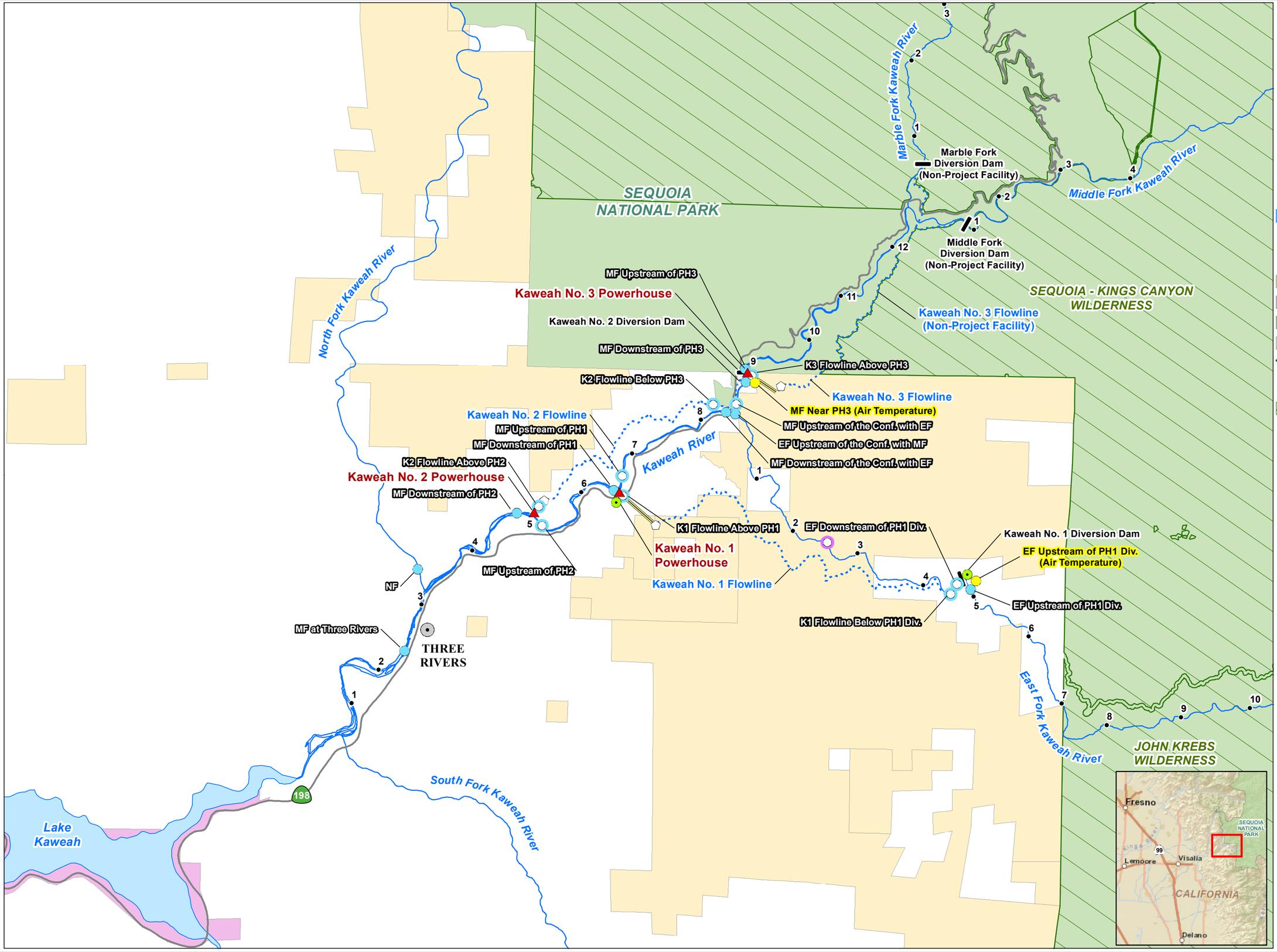
King, I.P. 1997. RMA-11: A Three Dimensional Finite Element Model for Water Quality in Estuaries and Streams – Documentation Version 2.5. Department of Civil and Environmental Engineering, University of California, Davis.

TABLE

Table AQ 4-1. Water Temperature Modeling Reaches.

Study Reach	Bypass Reaches	Reaches Upstream of Project Facilities or Comparison Reaches	Water Temperature Modeling
Kaweah River			
Kaweah River Upstream of Kaweah No. 3 Powerhouse		●	No
Kaweah River Downstream of Kaweah No. 3 Powerhouse and Upstream of the East Fork Kaweah River Confluence	●		Yes
Kaweah River Downstream of East Fork Kaweah Confluence and Upstream of Kaweah No. 1 Powerhouse	●		Yes
Kaweah River Downstream of Kaweah No. 1 Powerhouse and Upstream of Kaweah No. 2 Powerhouse	●		Yes
Kaweah River Downstream of Kaweah No. 2 Powerhouse		●	No
East Fork Kaweah River			
East Fork Kaweah River upstream of the Kaweah No. 1 Diversion		●	No
East Fork Kaweah River downstream of the Kaweah No. 1 Diversion	●		Yes

MAP



Facilities

- Powerhouse
- Diversion
- Forebay
- Flowline
- Penstock

Other Features

- City/Town
- Highway/Road
- Watercourse
- Water Body
- River Mile

Land Jurisdiction*

- Bureau of Land Management
- U.S. Army Corps of Engineers
- National Park Service
- Private

*SOURCE: BLM 2012

Land Management

- National Wilderness Area

Monitoring Locations

- Water Quality and Water Temperature Monitoring (exisiting water temperature data site)
- Water Quality and Water Temperature Monitoring
- Water Temperature Monitoring (only)
- Meteorological Monitoring Location
- Air Temperature Monitoring Location

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Map AQ 4-1

Kaweah Project
Water Quality, Water Temperature and Meteorological Monitoring Locations

0 0.25 0.5 1 Miles

Projection: UTM Zone 11
Datum: NAD 83

Date: 12/8/2015

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