Hydrodynamic and Temperature Modeling of a Linked Reservoir-River System to Support TMDL Development

Henry's Fork Watershed Council Meeting
November 18, 2025

PRESENTED BY:

ANNEAR WATER RESOURCES

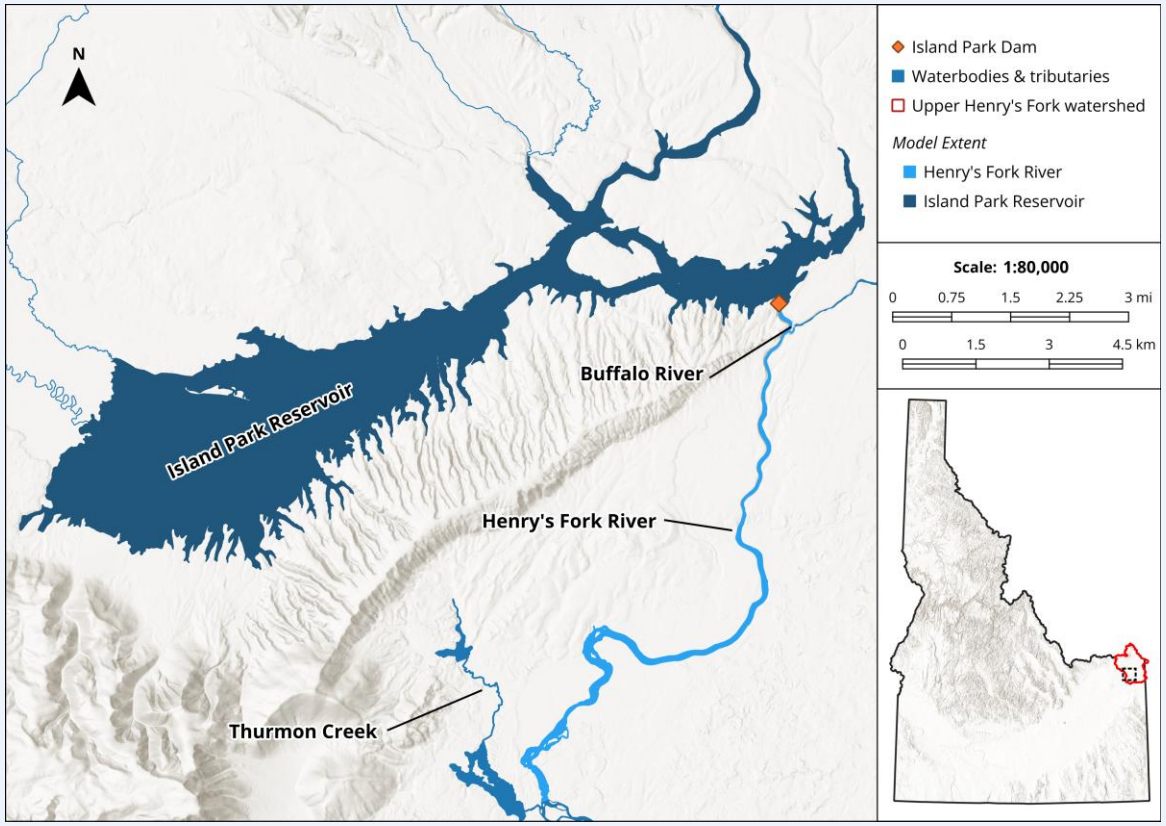
IDAHO DEPARTMENT OF ENVIRONMENTAL QUALITY

THE VOICE OF THE RIVER
SINCE 1984
HENRY'S FORK FOUNDATION

Introduction

Project Motivation

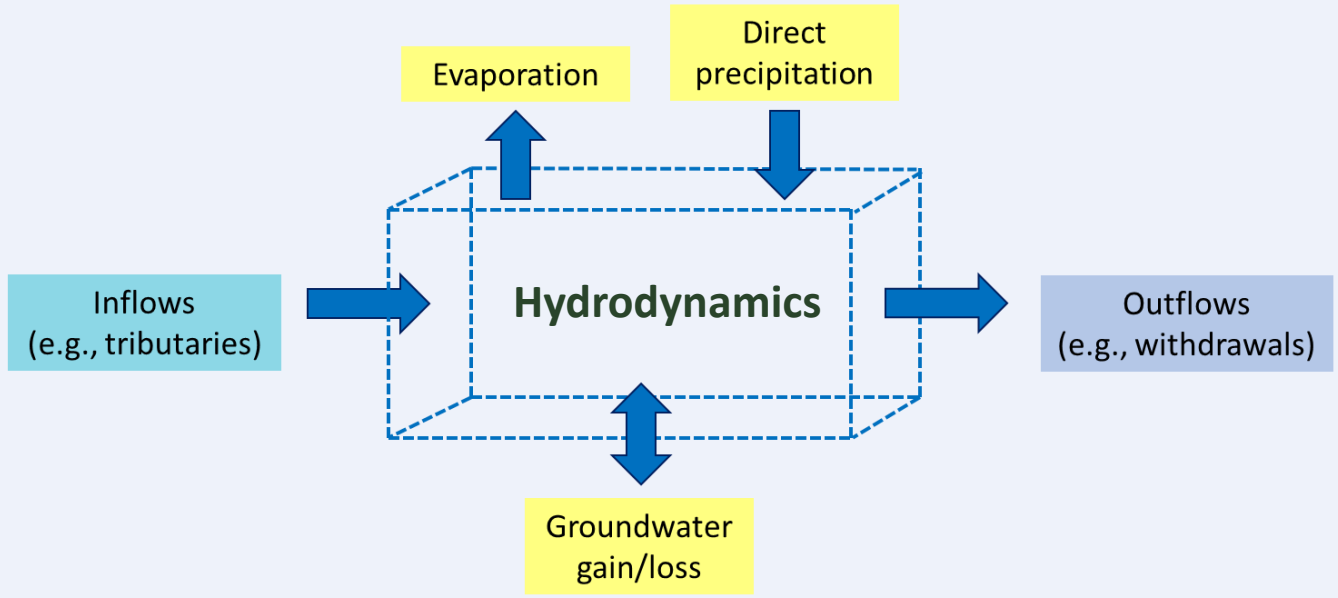
- Henry's Fork River (River) classified by State of Idaho Department of Environmental Quality (IDEQ) as an impaired water due to the frequent exceedance of water quality criteria for:
  - cold water aquatic life
  - salmonid spawning
- IDEQ expressed interest in developing a hydrodynamic and temperature model of the Island Park Reservoir (Reservoir) and 10-mile reach of the River.
- Model will inform the process of developing a potential total maximum daily load (TMDL) for the Reservoir and River.

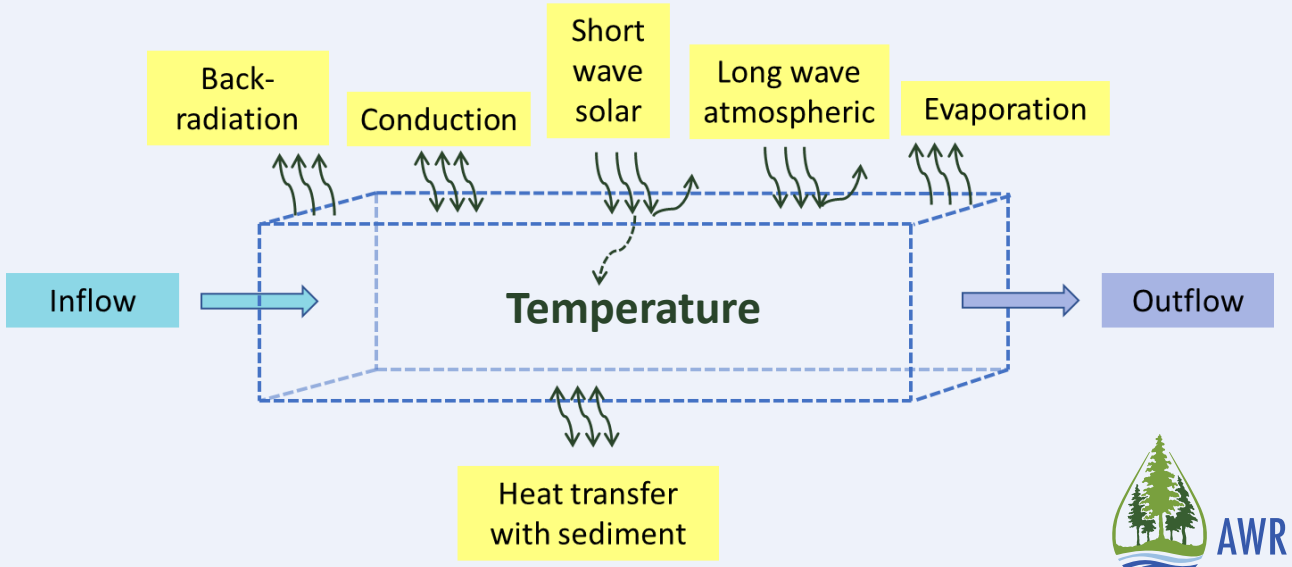



Aerial view of the Island Park Reservoir, Dam, and downstream Henry's Fork River (credit: USBR)

Introduction
CE-QUAL-W2

- A 2-D (vertical-longitudinal), unsteady finite difference model for hydrodynamics and water quality of rivers, reservoirs, lakes, and estuaries
    - Versatile hydrodynamic and water quality model with broad geographic application.
- Separate, linked models for the River and Reservoir.
    - Output of Reservoir model (flow and temperature) is the upstream boundary condition for the River model.





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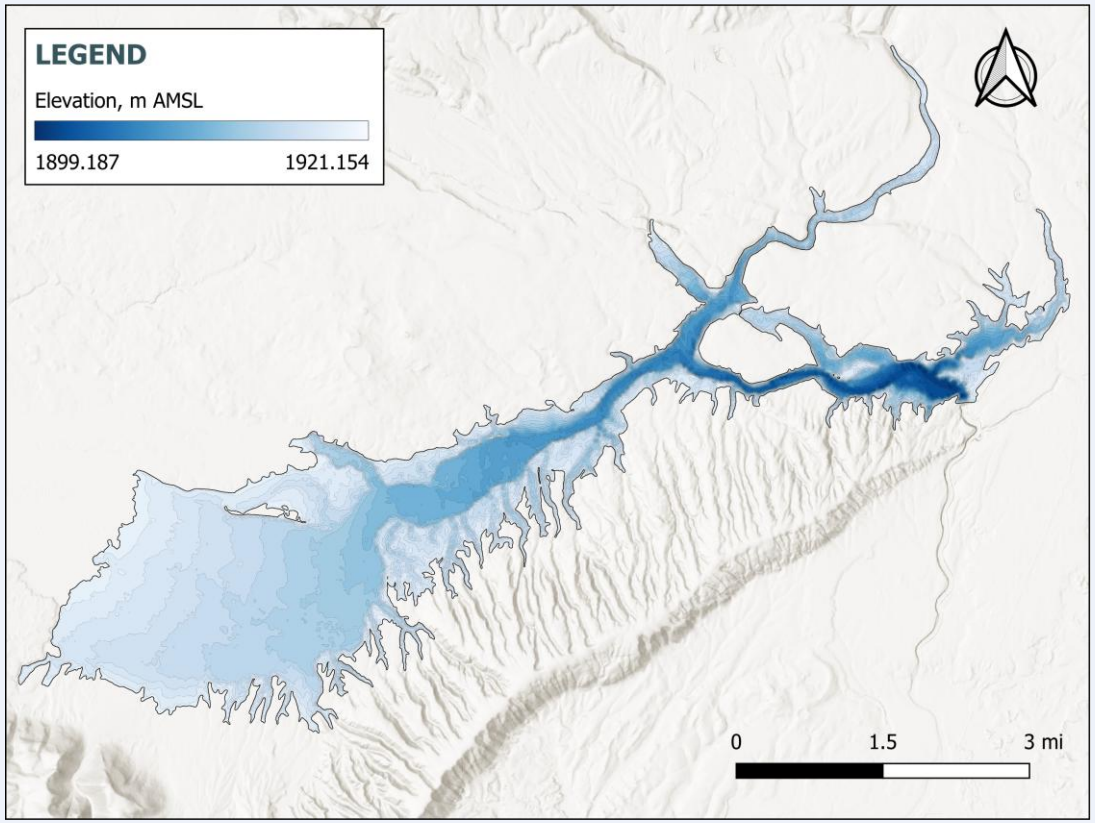
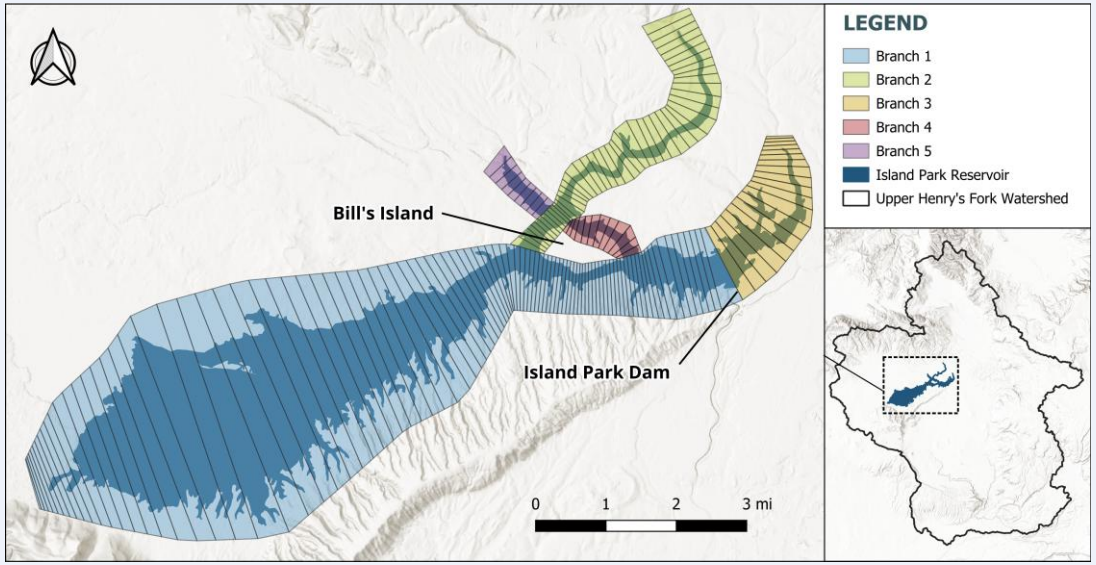
Model Development

Data Sources

- River and Reservoir bathymetry developed from surveys conducted by the Henry's Fork Foundation (HFF).
- Input meteorology compiled from monitoring stations stations in the Upper Henry's Fork Watershed.
- River flows and temperatures derived from U.S. Geological Survey (USGS) gauge stations and HFF sampling sites.

Source / Site ID	Meteorological Parameter
NRCS SNOTEL Island Park (546) NRCS SNOTEL White Elephant (860)	Air temperature
USBR AgriMet Weather Station (ahti)	Dewpoint temperature, wind speed, wind direction, and solar radiation.
NASA-Prediction of Worldwide Energy Resources (POWER) Dataset	Cloud cover





Model Calibration

Data Sources and Results

Models simulate hydrodynamics and water temperature between January 1 and December 31, 2023.

Reservoir calibration

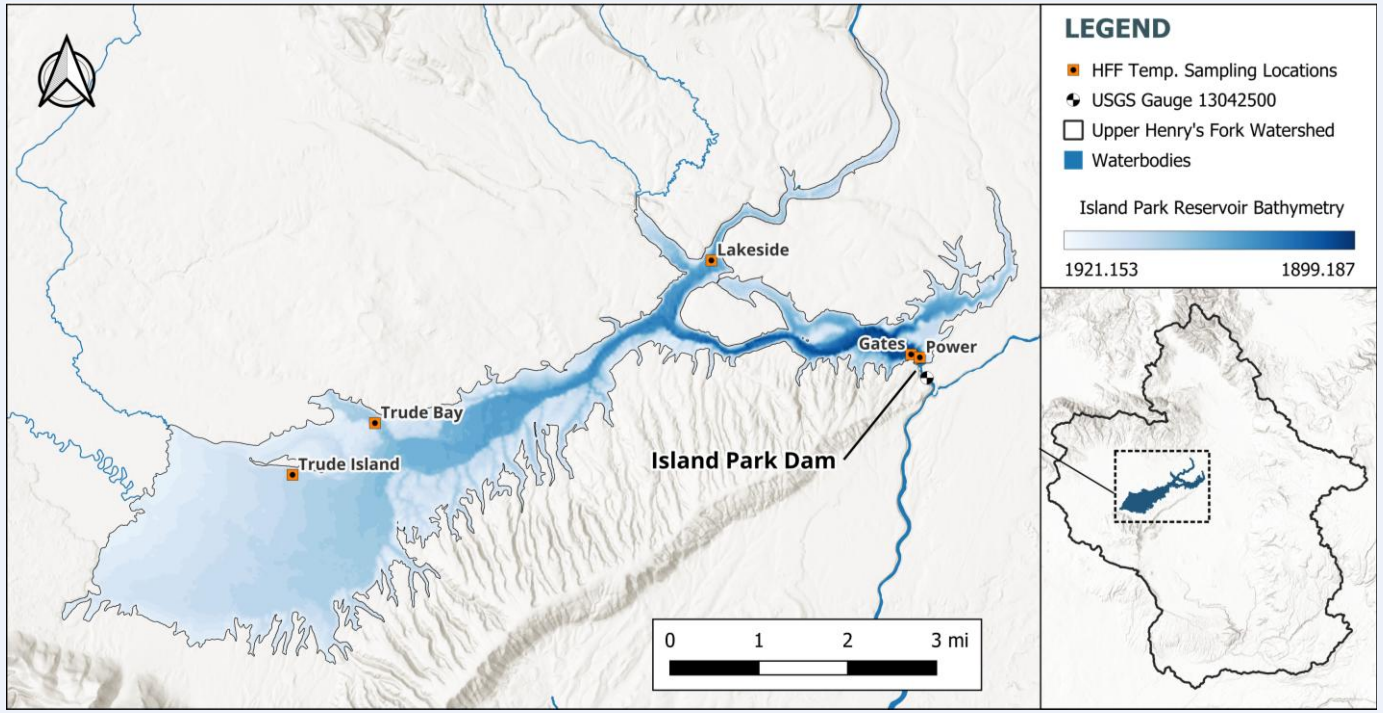
- Temperature: HFF discrete sampling sites, USGS gauge downstream of the Island Park Dam
- Flow: USGS gauge downstream of the Dam

River calibration

- Temperature: HFF continuous sampling sites along and downstream of the model extent.
- Flow: Daily flow estimates downstream of Buffalo River and 4.6 miles downstream of the model extent.

Model-data statistics at the end of model calibration.

Model	Parameter	Location	RM	ME	MAE	RMSE
River	Flow (cms)	Box Canyon	90.6	0.17	0.46	1.53
	Flow (cms)	Pinehaven	76.7	-0.07	0.29	1.06
	Temperature (°C)	**Across model**	**-**	**-0.10**	**0.51**	**0.65**
Reservoir	Flow (cms)	USGS below Dam	-	-0.01	0.63	2.14
	Water level (m)	USBR above Dam	-	0.00	0.01	0.01
	Temperature (°C)	**Across model**	**-**	**0.13**	**0.90**	**1.00**



Scenario Development
Overview

Cold Water Aquatic Life	Salmonid Spawning
22 °C or less daily maximum	13 °C or less daily maximum
19 °C or less daily average	9 °C or less daily average

- Three (toy) scenarios developed:
  - ± 2 °C change in air temperature
  - Maximum restoration effort (riparian shading)
    - **Reservoir**: 0% shading to 10% shading from tree planting along Reservoir banks
    - **River**: 0% shading to 75% shading along River bank.
  - Conservation of Reservoir cold water for summer release
- Scenario outputs compared to IDEQ temperature water quality standards for the Henry's Fork watershed.

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Scenario Development

Conservation of IPR Winter Temperatures for Summer Release

This scenario simulates a cold-water conservation program that preserves cold bottom depth temperatures for later summer release.

Water is withdrawn from a new proposed gate while surface temperatures are less than 16 degrees Celsius (~68 degrees Fahrenheit, the avg limit of trout's comfortable temperature range).

- Gate is collocated with the USBR/FRREC gates in segment 99 of the IPR model.
- Withdrawal elevation set to 3 meters (~10 feet) below the average water elevation of the IPR in 2023
  - Average elevation of IPR in 2023: 1920.1 meters AMSL
  - Elevation of withdrawal: 1917.1 meters AMSL

***Note**: Total daily flow from the IPR gates (USBR, FRREC, imaginary) remains constant.*

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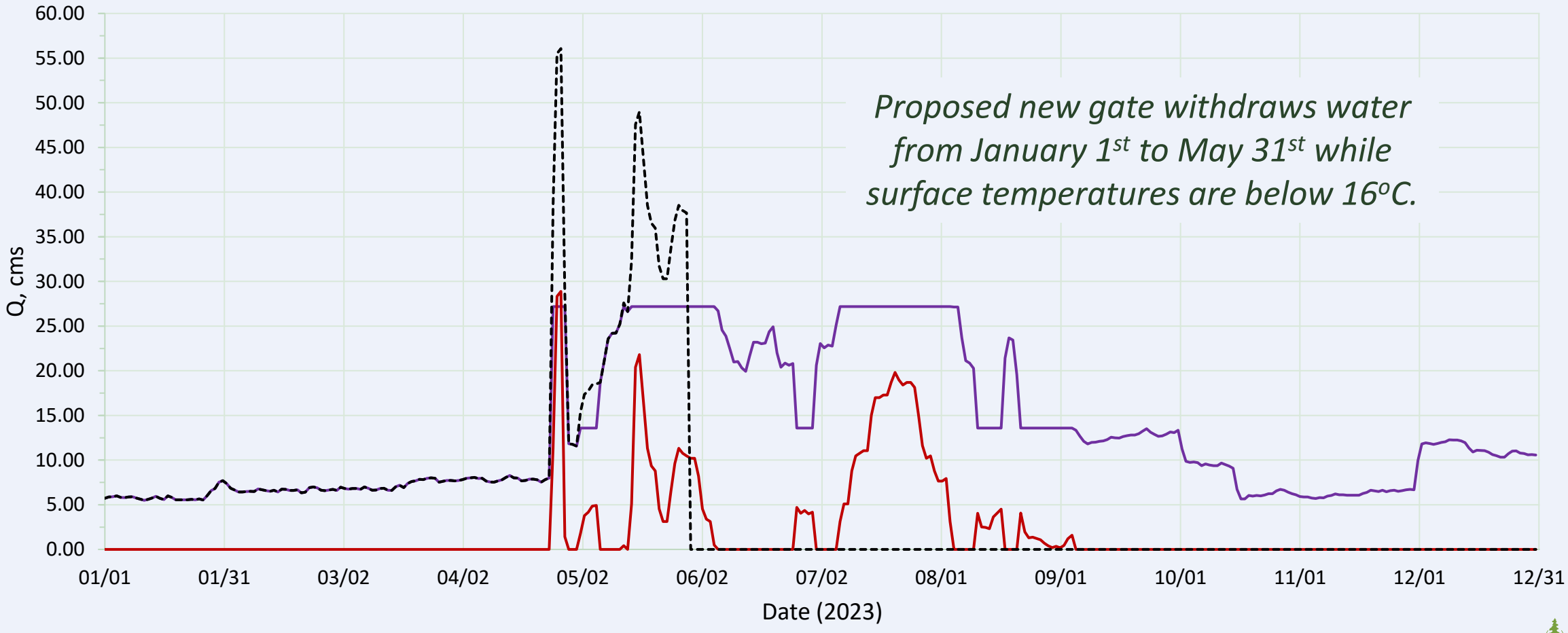
Scenario Development

Cold Water Conservation



Scenario Results

Overview

Scenario results for IPR and HFR are presented as follows:

- **Island Park Reservoir (IPR):**
  - Instantaneous (15-minute) temperature.
  - Instantaneous outflow temperature is derived from the **flow-weighted average of all gate outflow temperatures**.
- **Henry's Fork River (HFR):**
  - 7-day moving average of daily maximum (7DADM) temperature.
  - 7DADM outflow temperature is derived from the **furthest downstream segment of the HFR model (segment 56).**

Relevant temperature water quality standards are also depicted in each plot.

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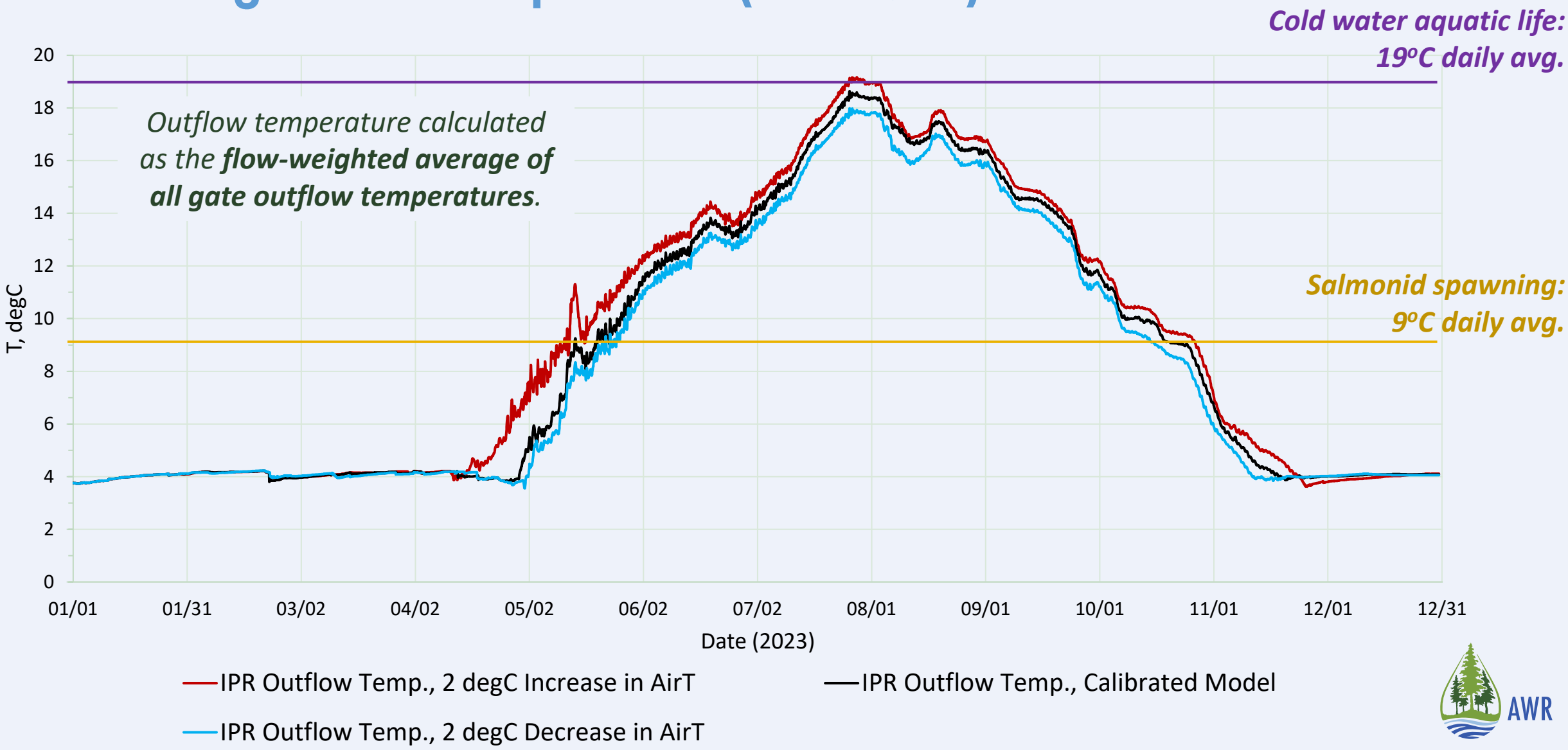
Scenario Results

±2°C Change in Air Temperature (Reservoir)



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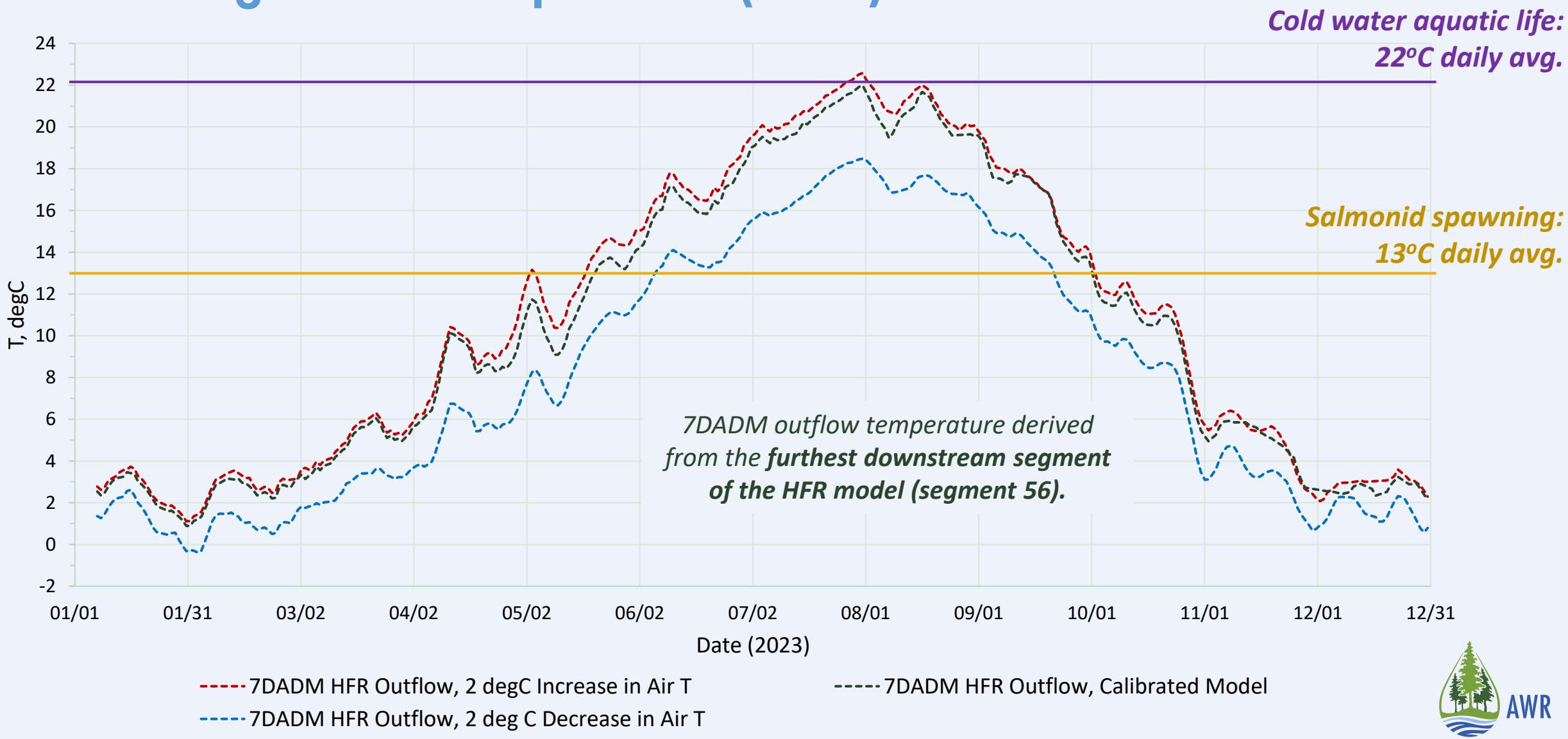
Scenario Results

±2°C Change in Air Temperature (River)



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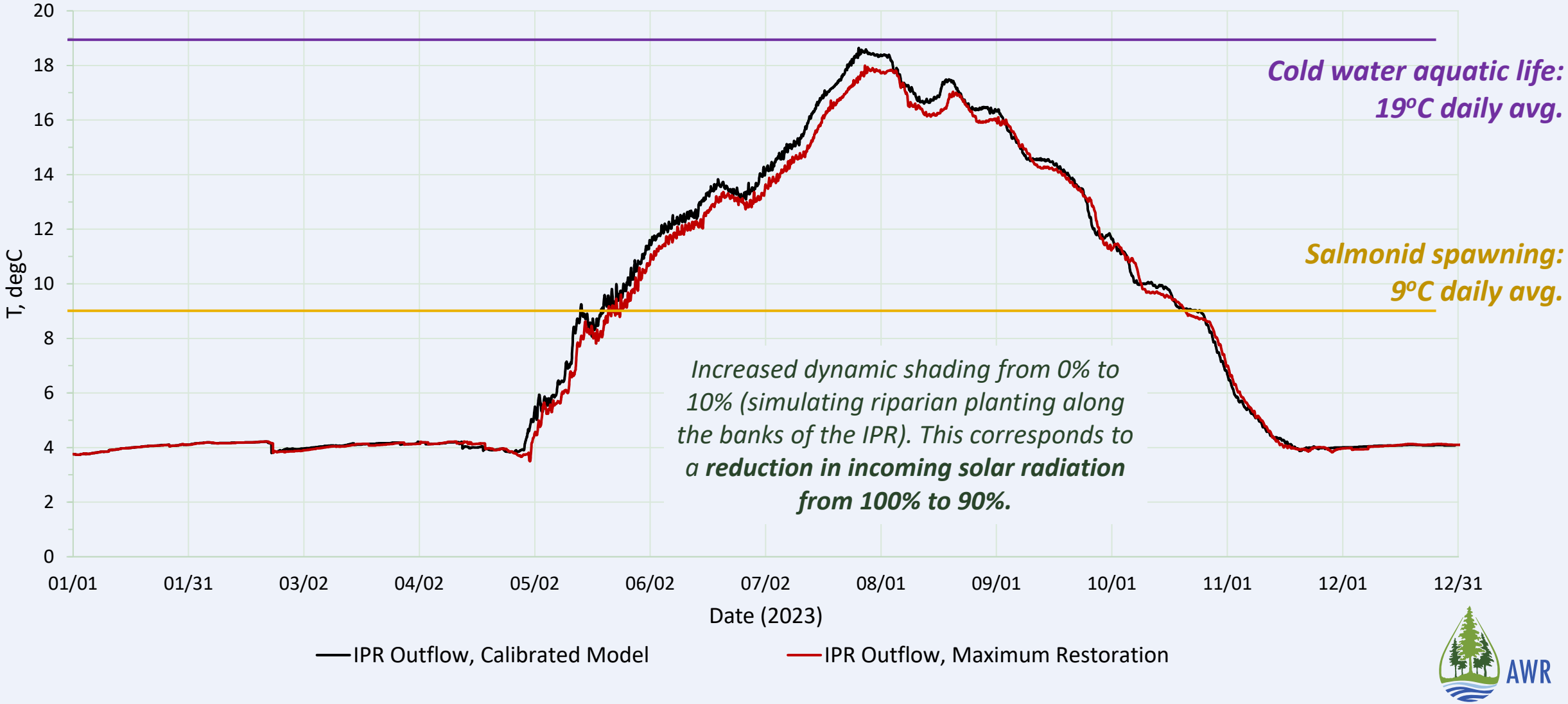
Scenario Results

Maximum Restoration Effort, Riparian Shading (Reservoir)



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Scenario Results

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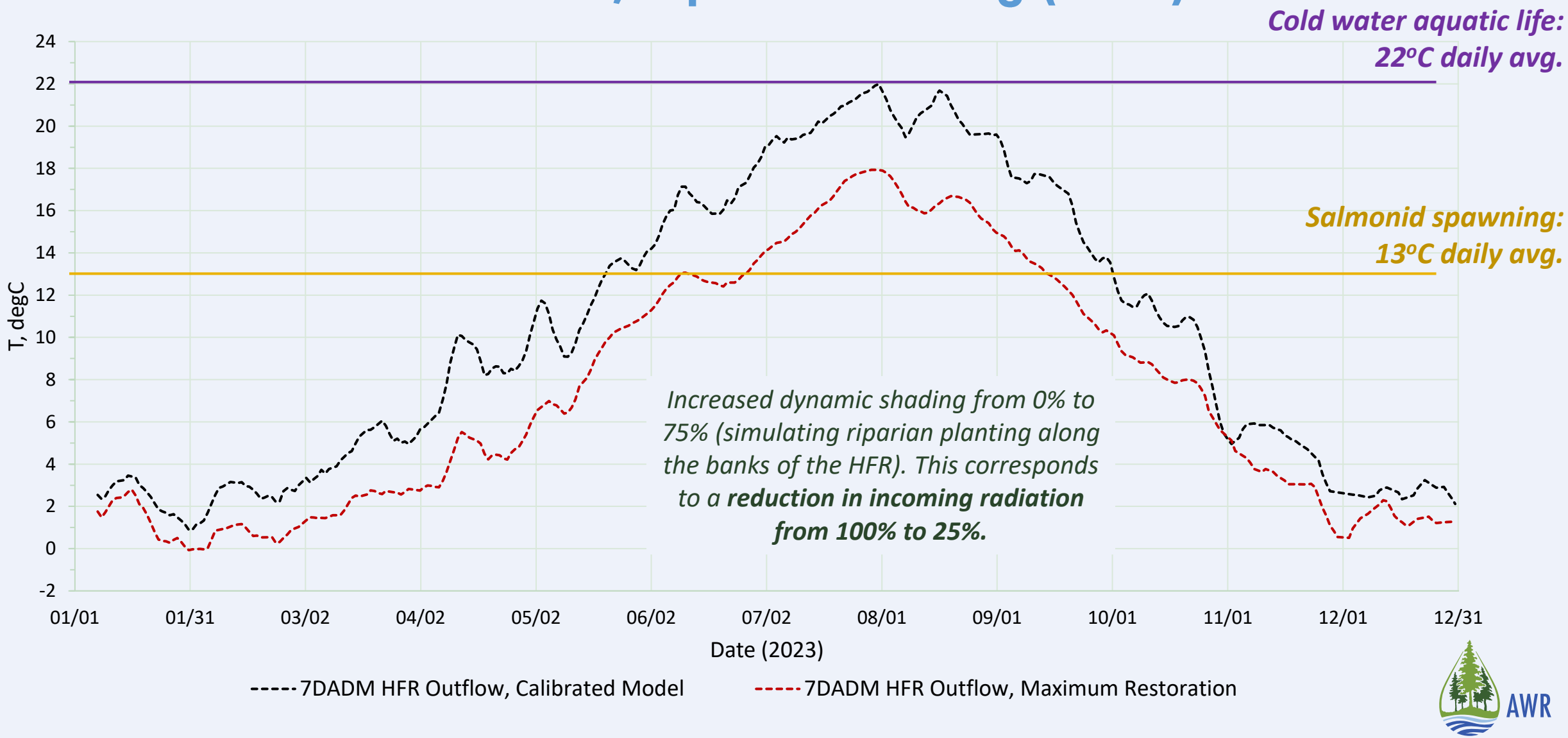

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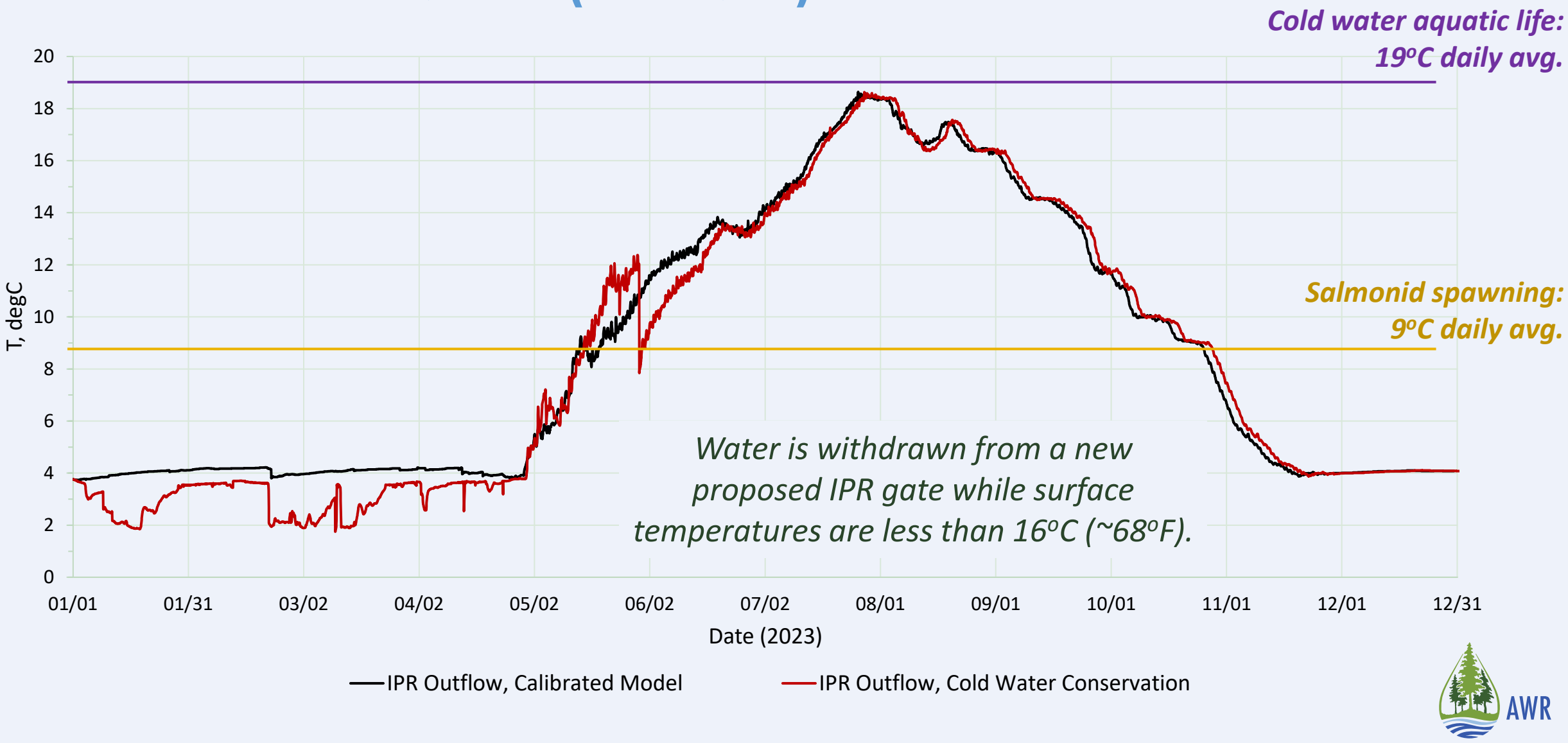
Scenario Results

Cold Water Conservation (Reservoir)



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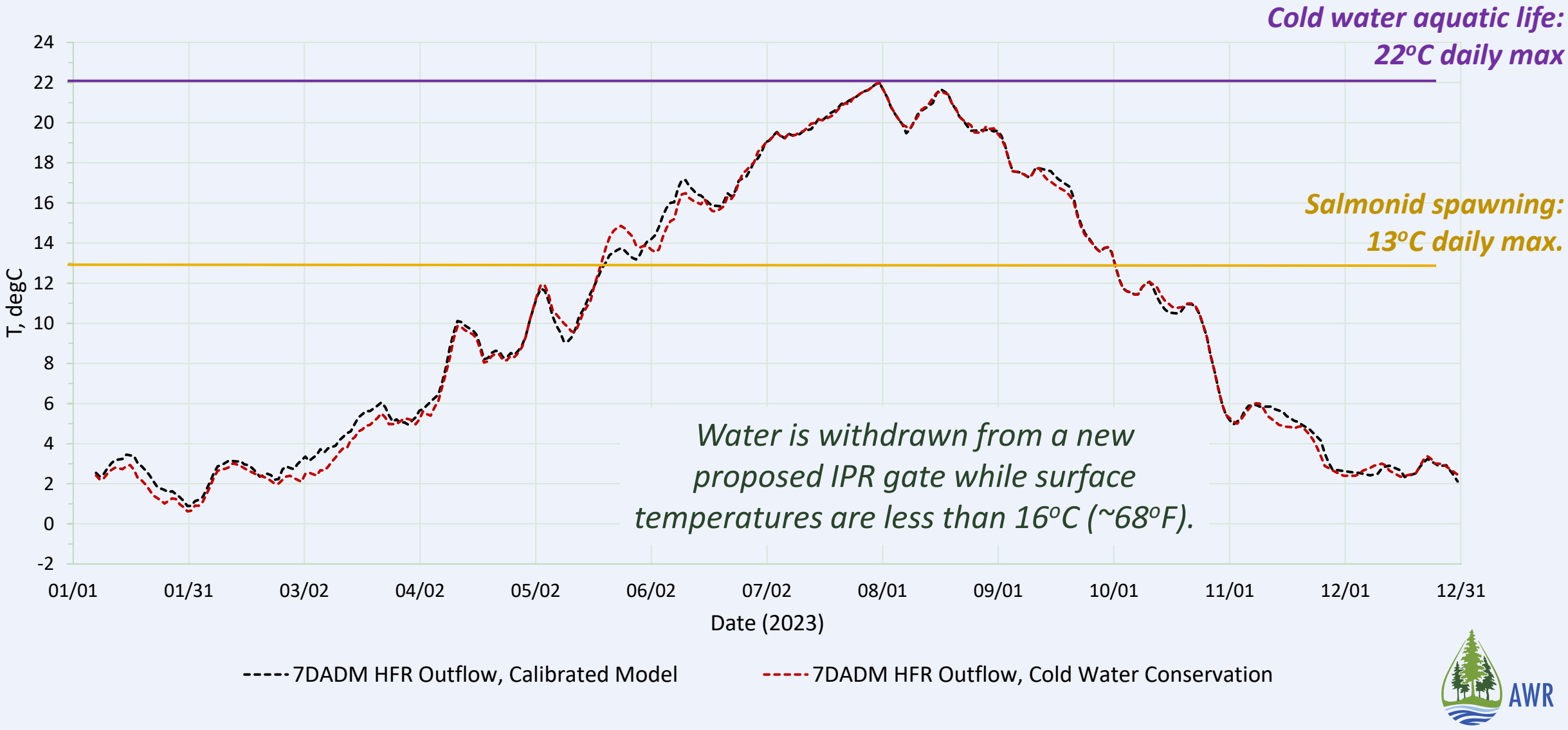
Scenario Results

Cold Water Conservation (River)



Scenario Results

Outflow Temperatures from Reservoir

Cold Water Aquatic Life	Salmonid Spawning
22 °C or less daily maximum	13 °C or less daily maximum
19 °C or less daily average	9 °C or less daily average

Scenario (2023 Model Run)	Instantaneous Temperature (°C)			
	Min	Max	Avg.	Change from baseline avg. (%)
Baseline (calibrated model)	3.74	18.64	8.62	-
2°C increase in air temperature	3.62	19.17	9.03	+0.40 (4.66%)
2°C decrease in air temperature	3.56	17.99	8.32	-0.30 (3.52%
Maximum restoration	3.50	17.99	8.40	-0.22 (2.60%)
Cold water conservation	1.75	18.63	8.31	-0.31 (3.64%)

Conclusions

- Cold water conservation results in the greatest reduction in outflow temperatures (0.31°C). Implementation of a maximum restoration effort, a 2°C reduction in air temperature, and the implementation of a cold-water conservation program (and supporting infrastructure) result in similar changes in average outflow temperature (-0.3 °C).
- Temperature reductions are substantial.

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Scenario Results

Furthest Downstream Temp. of River

Cold Water Aquatic Life	Salmonid Spawning
22 °C or less daily maximum	13 °C or less daily maximum
19 °C or less daily average	9 °C or less daily average

Scenario (2023 Model Run)	Daily Maximum Temperature (°C)			
	Min	Max	Avg.	Change from baseline avg. (%)
Baseline (calibrated model)	-0.21	22.28	10.37	-
2°C increase in air temperature	0.04	22.90	10.81	+0.45 (4.33%)
2°C decrease in air temperature	-1.82	18.70	7.86	-2.50 (24.12%)
Maximum restoration	-1.27	18.28	7.61	-2.75 (26.57%)
Cold water conservation	-0.47	22.31	10.34	-0.02 (0.21%)

Conclusions

- Cold water conservation results in the lowest reduction (0.02°C).
- Implementation of a maximum restoration effort results in a 2.75°C reduction in the average daily maximum water temperature.
- Riparian planting also reduced the maximum of the daily maximum temperature to within the temperature water quality standard for cold water aquatic life (22°C daily max).

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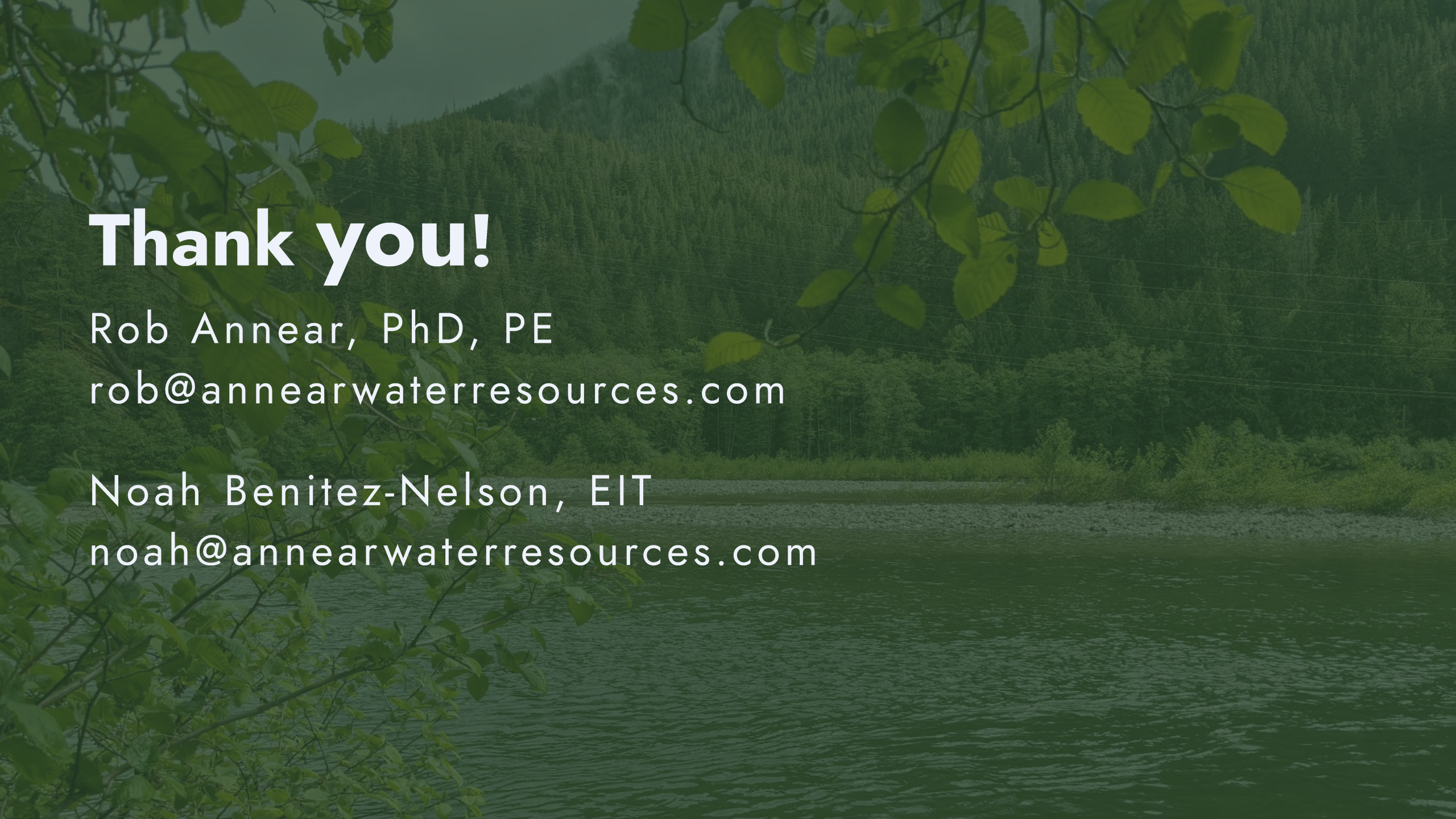

Thank you!

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