TVA Clinch River SMR Project

Plant Water Balance and Hydrothermal Evaluation

Agenda

Plant Water Balance

- Model and Water Use Data

Hydrothermal Studies

- Model
- Input Conditions and Acceptance Criteria

Steady State Flow Results

Unsteady Flow Results

Purpose

Discuss Hydrothermal Studies Performed to Asses Impacts on Clinch River from SMR Operations to Assess Environmental Compliance for Different Plant and Seasonal Conditions

Plant Water Balance

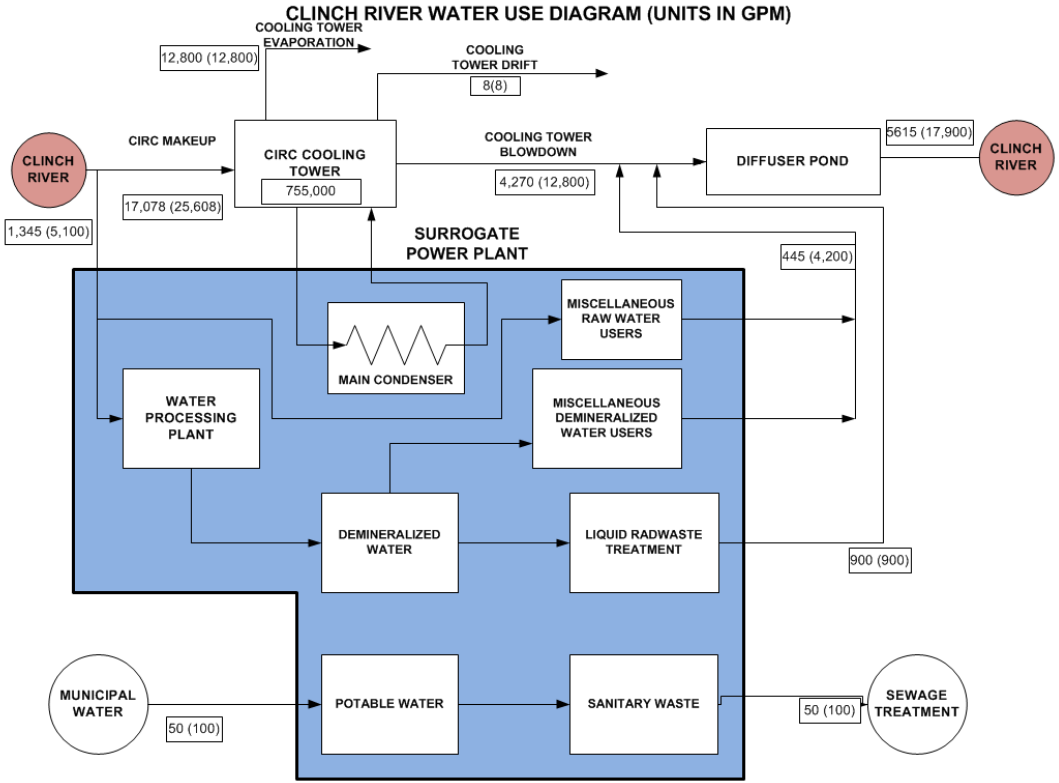
Plant Water Balance

Plant water balance module considered:

- Water from Clinch River
- Water to Clinch River
- Plant and Cooling Tower Processes
- Water from Municipal Sources
- Water to Sewage Treatment

Plant water balance developed as part of Plant Parameter Envelope development for 2420 MW_t

Plant Water Balance Model



Plant Water Use Data

Parameter	Value
Plant Makeup Flow - Normal	17,078 gpm
Plant Makeup Flow - Maximum	**25,608 gpm**
Condenser Inlet Temperature	90 °F
Condenser Outlet Temperature	108 °F
Plant Waste Heat Generated	5,593 M Btu/hr
Cooling Tower Total Flow Rate - Maximum	755,000 gpm
Cooling Tower Cycles of Concentration - Normal	4
Cooling Tower Cycles of Concentration - Maximum	2
Cooling Tower Evaporation Rate - Normal	12,800 gpm
Cooling Tower Evaporation Rate - Maximum	12,800 gpm
Cooling Tower Drift	8 gpm
Cooling Tower Blowdown Flow - Normal	4,270 gpm
Cooling Tower Blowdown Flow - Maximum	**12,800 gpm**
Cooling Tower Blowdown Temperature - Maximum	90 °F

Hydrothermal Studies

Hydrothermal Studies

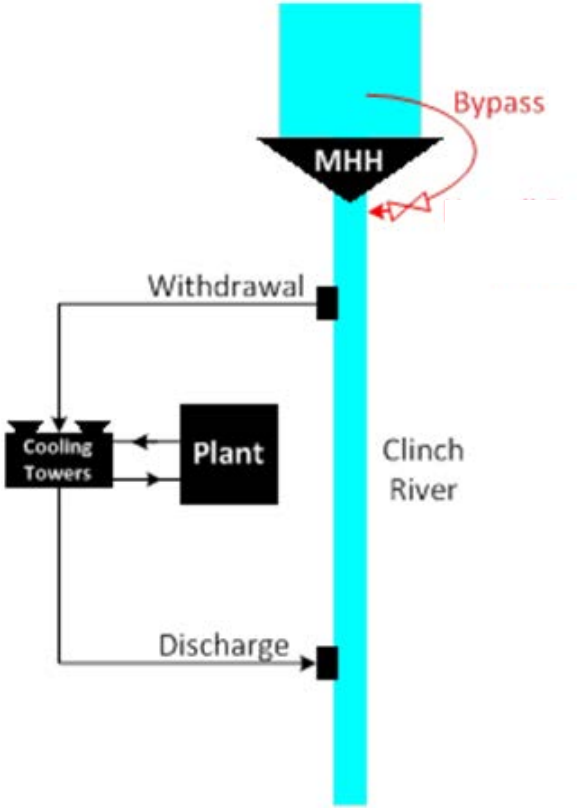
TVA examined alternatives for managing discharge of blowdown from Clinch River Small Modular Reactor (SMR) plant to Clinch River

Steady flow conditions modeled using CORMIX (US EPA – supported mixing zone model)

Unsteady flow conditions modeled using ANSYS Fluent (3-D flow modeling software)

Preferred alternative includes continuous, minimum release (bypass) in river during periods of idle operation of Melton Hill Hydro (MHH) plant

Hydrothermal Model



Evaluated Several Scenarios:

- Extreme Winter Conditions
- Extreme Summer Conditions
- Unsteady Flow Cases
  - Extreme Winter
  - Extreme Summer

Input Conditions

Supplemental Simulation	Season	River			CRSMR Plant						
		QBYPASS	TR	WSEL	Water Balance	Power	QIN	QDIS	TWB	TDIS	ΔTP
1	Extreme Winter	400 cfs	38°F	735.5 ft msl	PPE	800 MWe (100% Plant)	25,600 gpm 57.0 cfs	12,800 gpm 28.5 cfs	40°F	69°F	31 F°
2	Extreme Summer	400 cfs	78°F	740.0 ft msl	PPE	800 MWe (100% Plant)	25,600 gpm 57.0 cfs	12,800 gpm 28.5 cfs	80°F	93°F	15 F°

Notes:
(1) QBYPASS=Release from Melton Hill Dam in the absence of Melton Hill Hydro operation
(2) TR=River ambient water temperature
(3) WSEL=River water surface elevation
(4) QIN=Plant intake flow
(5) QDIS=Plant discharge flow from diffuser
(6) TWB=Wetbulb temperature
(7) TDIS=Plant discharge temperature
(8) DTP=Rise (delta) in water temperature between plant intake (ambient) and plant discharge

TDEC Acceptance Criteria

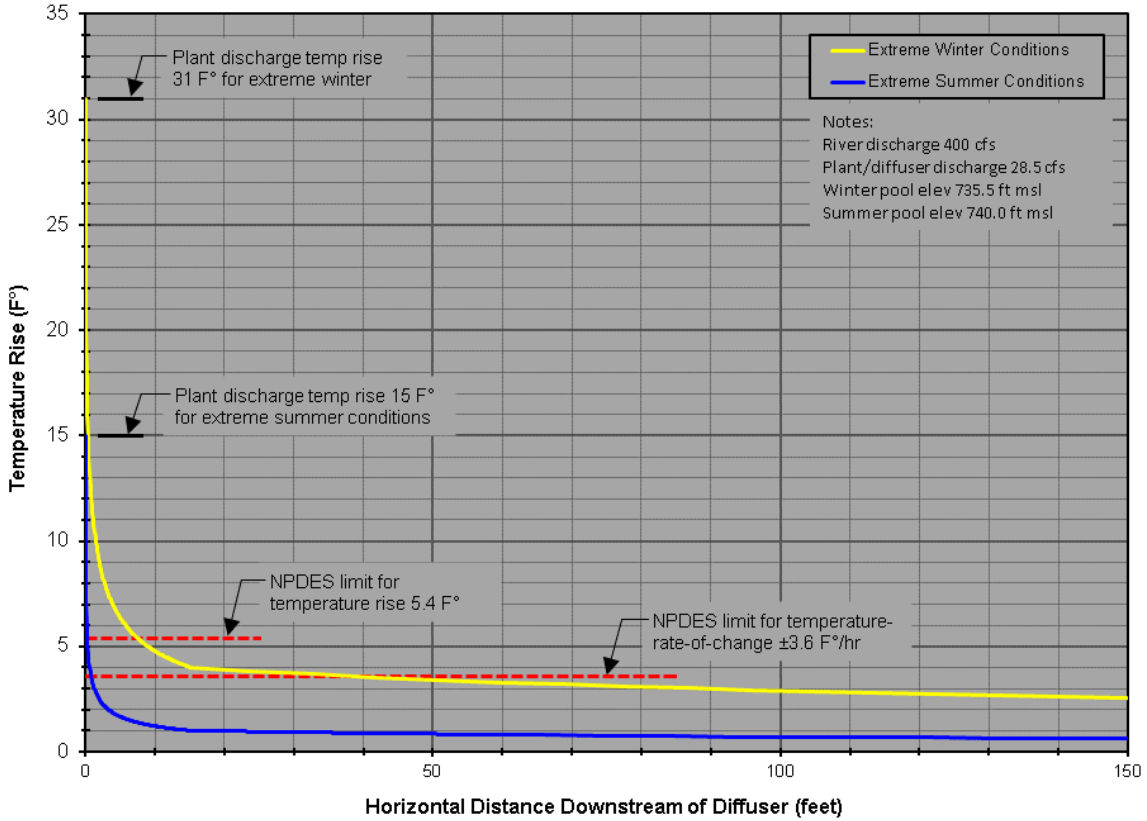
Maximum change in river water temperature (**ΔTR**) ≤ 3 °C (5.4 °F)

Maximum river water temperature (TR) ≤ 30.5 °C (86.9 °F)

Maximum water temperature-rate-of-change (TROC) ≤ ±2 °C per hour (±3.6 °F per hour)

Temperature of impoundments where stratification occurs will be measured at a depth of 5 feet or mid-depth, whichever is less (5 ft for Clinch River site)

Steady Flow Results (1/2)



Plume Temperature Rise from CORMIX

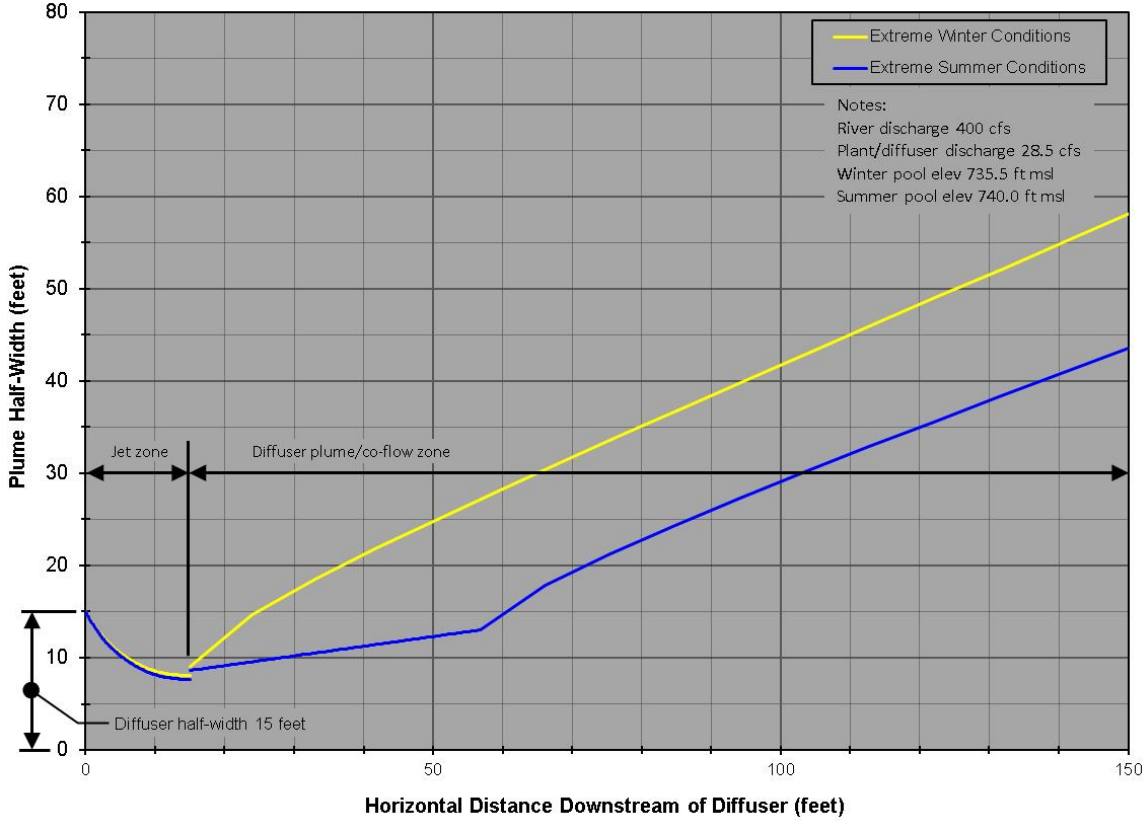
For extreme winter condition:

- **ΔTR** in limit within 10 feet of diffuser
- TROC in limit within 50 feet of diffuser
- TR below limit at point of discharge

For extreme summer condition:

- **ΔTR** and TROC in limit within 10 feet of diffuser
- TR in limit within 10 feet of diffuser

Steady Flow Results (2/2)



Plume Half-Width from CORMIX

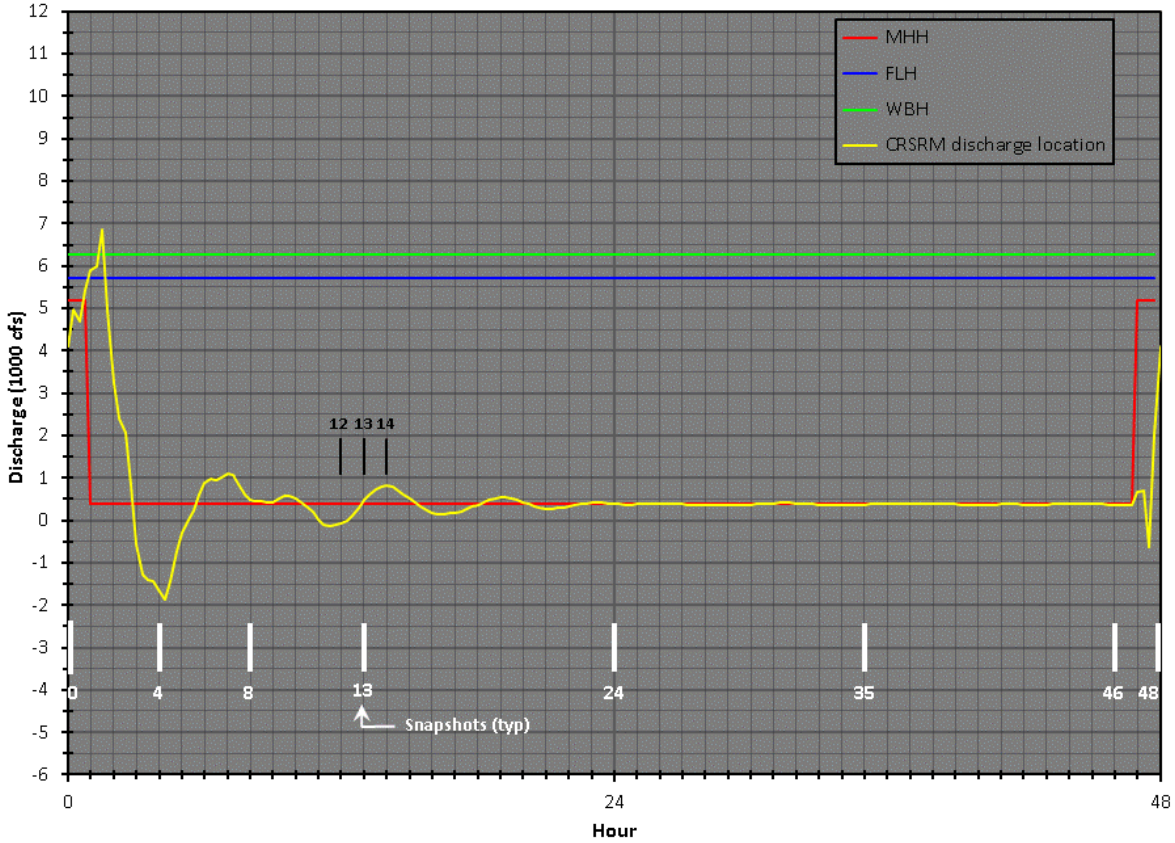
For extreme winter condition:

- Plume half width is ~ 25 feet at longest distance to compliance

For extreme summer condition:

- Plume half width is ~8 feet at longest distance to compliance
- All thermal effluent is assimilated downstream

Unsteady Flow Results (1/6)

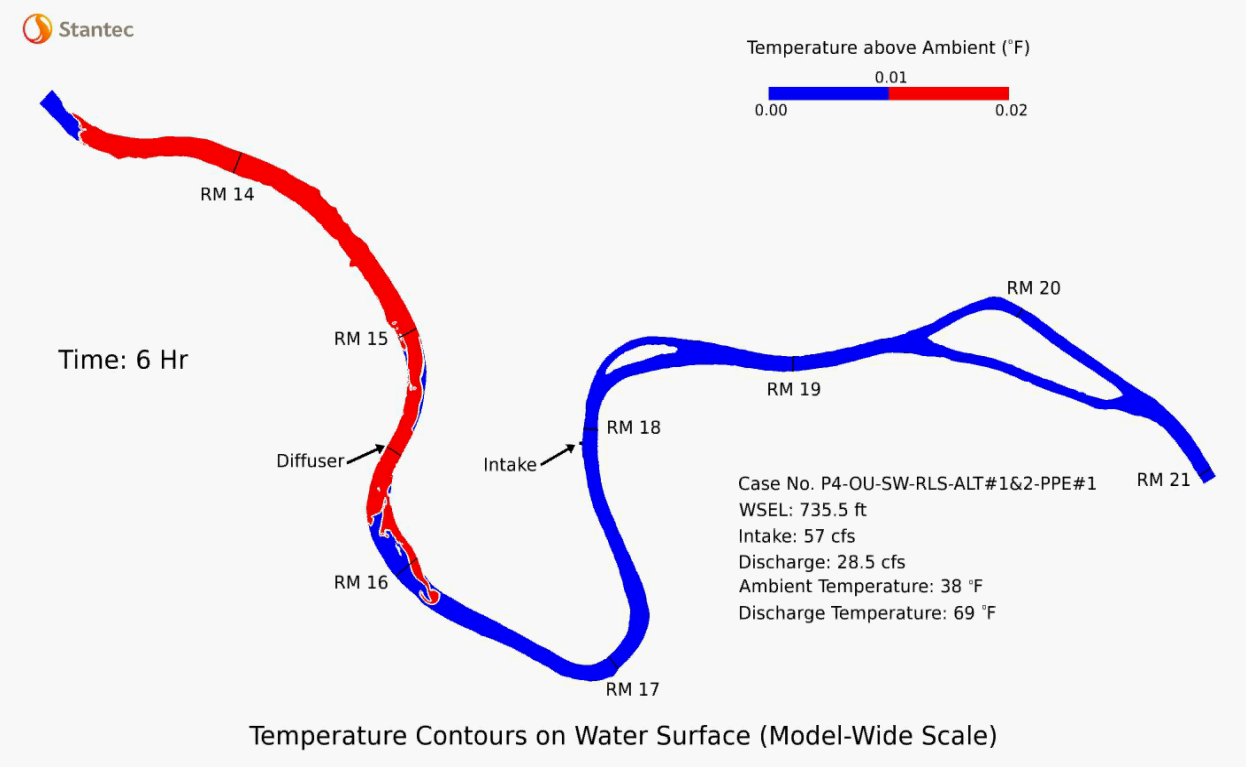


River Flows for Extreme Winter Conditions (Full Power)

After MHH operation suspended:

- Flow reverses and sloshes upstream
- Flow then reverses back downstream direction
- Flow reversals continue for ~24 hours
- Settles out to ~400 cfs
  When operation at MHH resumes flow accelerates in downstream direction

Unsteady Flow Results (2/6)

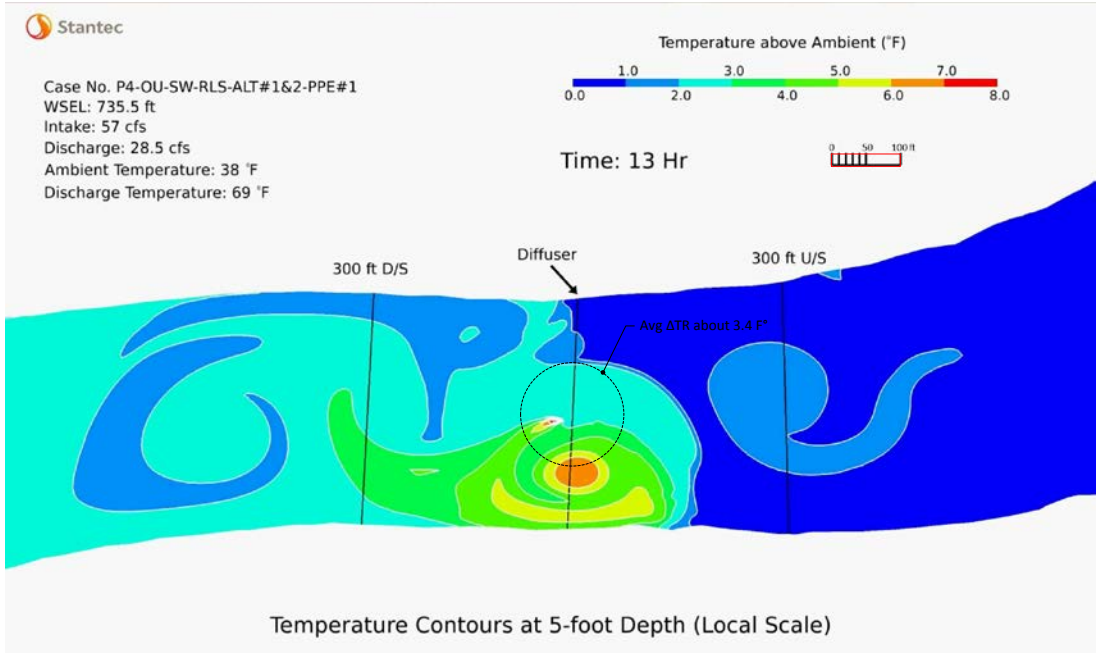


Temperature Contours on Water Surface (Model-Wide Scale)

Approximate Zone of Influence for Extreme Winter Conditions (Full Power)

- SMR plant effluent does not reach the plant intake.

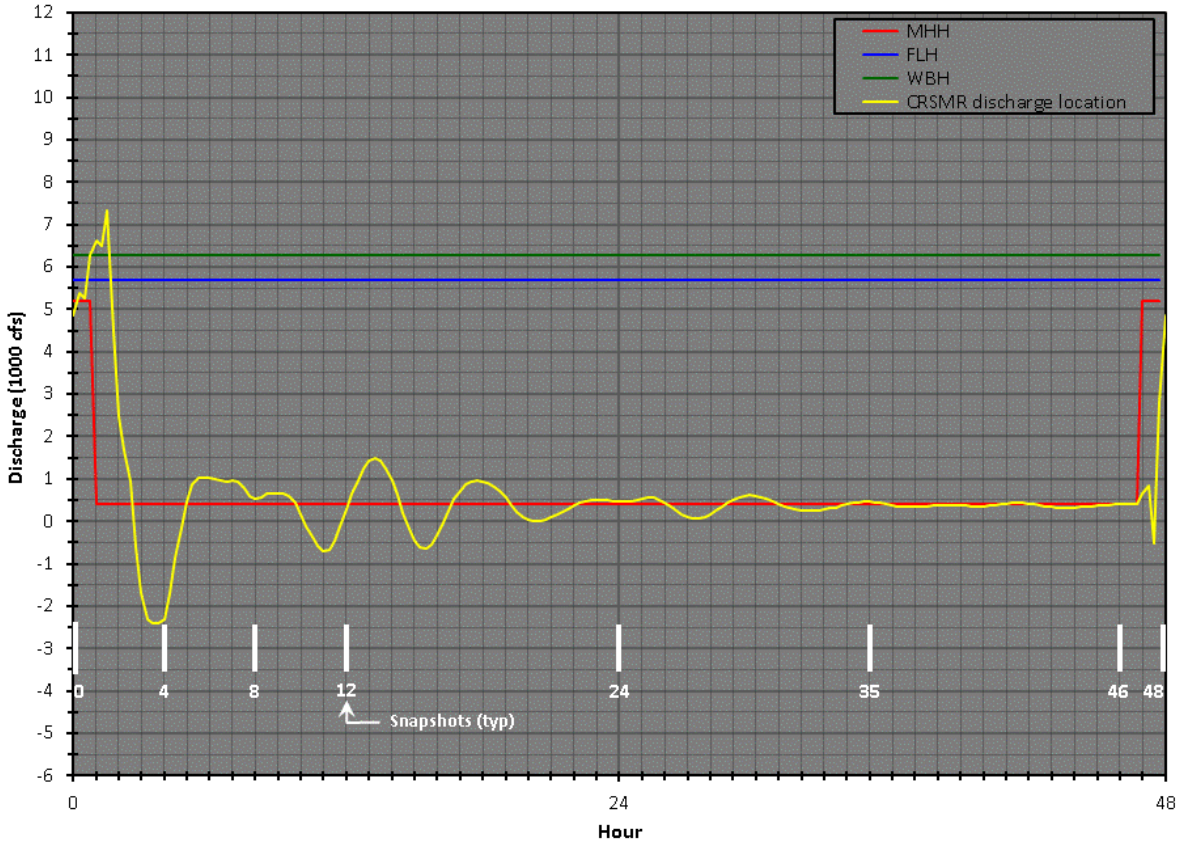
Unsteady Flow Results (3/6)



Model Snapshot at Hour 13 for Extreme Winter Conditions (Full Power)

- River flow is near zero
- Produced largest average **ΔTR** (~3.4 °F) around the circumference of mixing zone
- Thermal effluent is “pushed” into left-hand-side of the river creating a local pocket of warm water

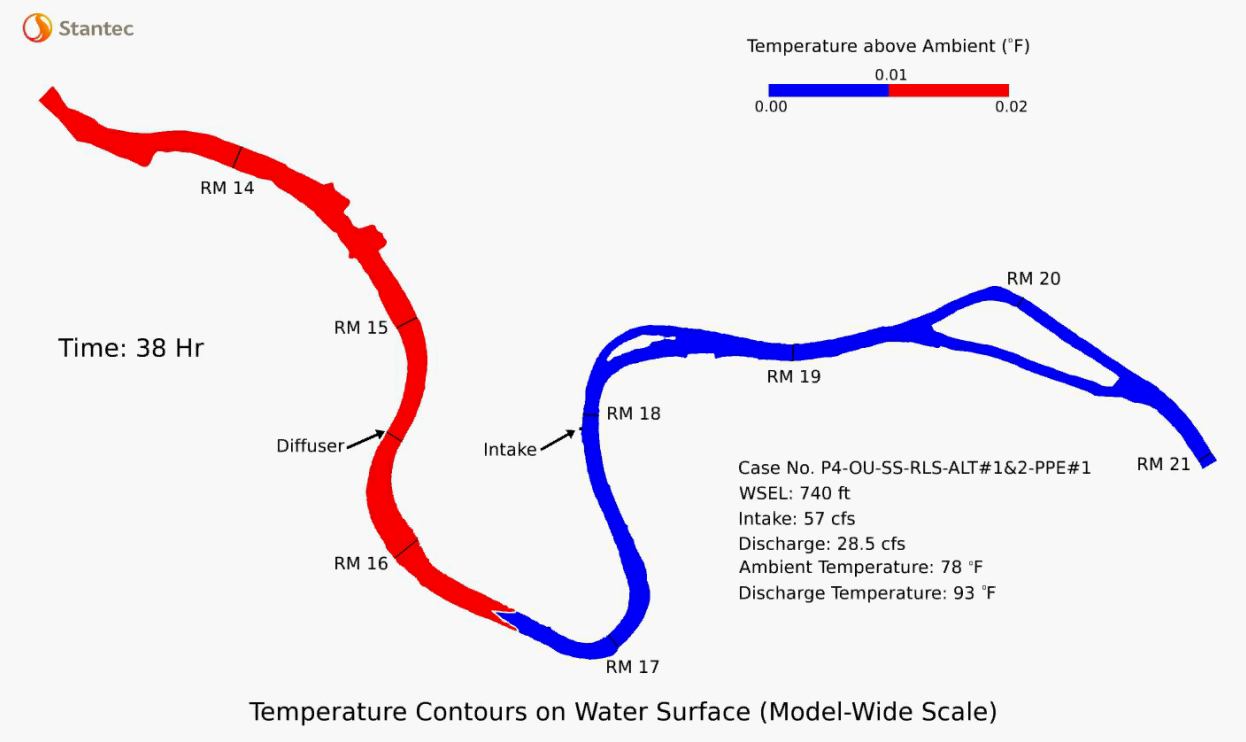
Unsteady Flow Results (4/6)



River Flows for Extreme Summer Conditions (Full Power)

- Amplitude of sloshing events are higher
- Takes longer for sloshing to recede
- Higher summer pool elevation in Watts Bar Reservoir makes river velocities and dissipative action of channel friction smaller

Unsteady Flow Results (5/6)

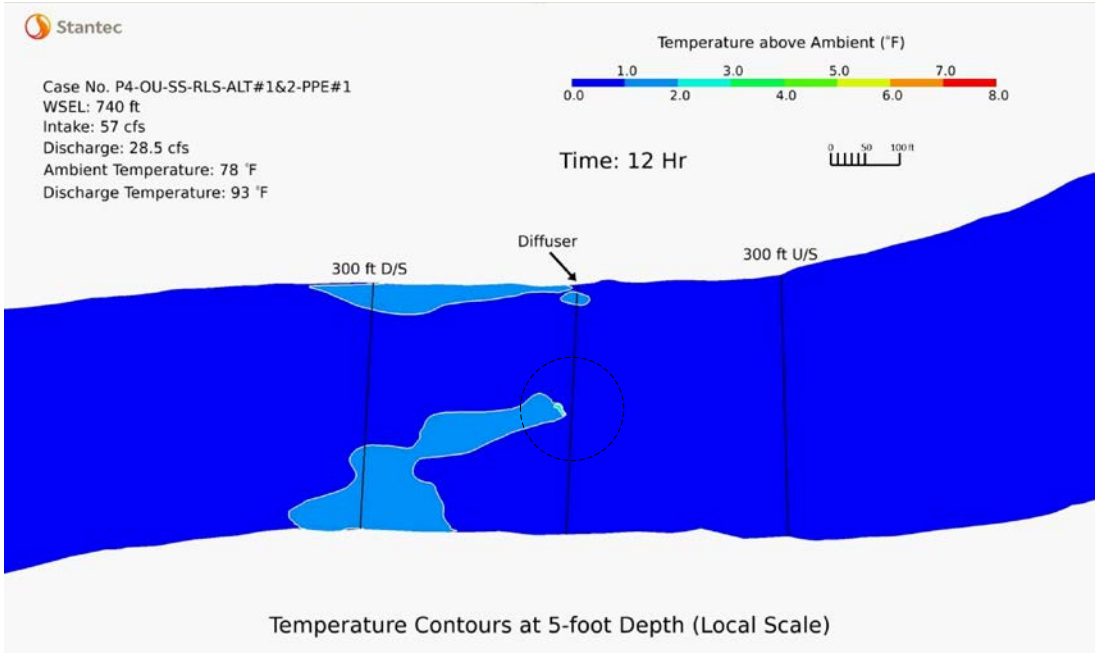


Temperature Contours on Water Surface (Model-Wide Scale)

Approximate Zone of Influence for Extreme Summer Conditions (Full Power)

- SMR plant effluent does not reach the plant intake.

Unsteady Flow Results (6/6)



Model Snapshot at Hour 12 for Extreme Summer Conditions (Full Power)

- Somewhat similar to hour 13 of Winter case
- In contrast, there is no warm spot
- Local **ΔTR** values do not exceed 2.0 °F

Summary

CORMIX results show SMR thermal effluent could be assimilated within limits at a distance of ~50 ft from plant diffuser

Unsteady simulations demonstrate that with 400 cfs bypass flow at MHH Dam SMR blowdown can be adequately assimilated

- Thermal compliance will require a mixing zone of ~150 ft diameter
- All SMR blowdown assimilated in downstream direction
- Plant intake far removed from threat of recirculation of plant blowdown

Based on geometry of river at diffuser, 150-ft mixing zone encompasses ~45 percent of river width

- Significant portion of river still available for passage of aquatic wildlife

Closing

Questions?

Follow-up Action Review