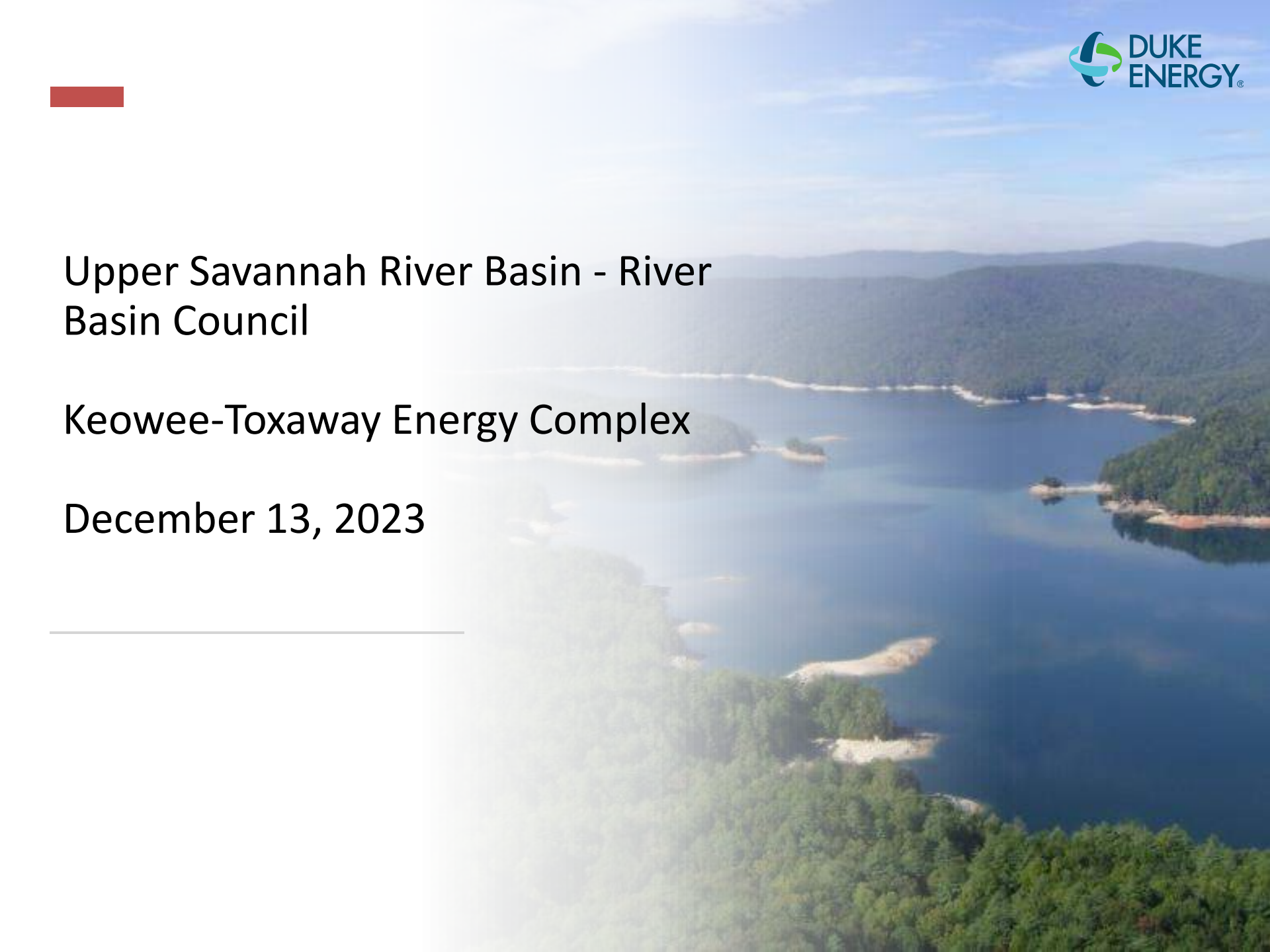
Upper Savannah River Basin - River Basin Council

Keowee-Toxaway Energy Complex

December 13, 2023

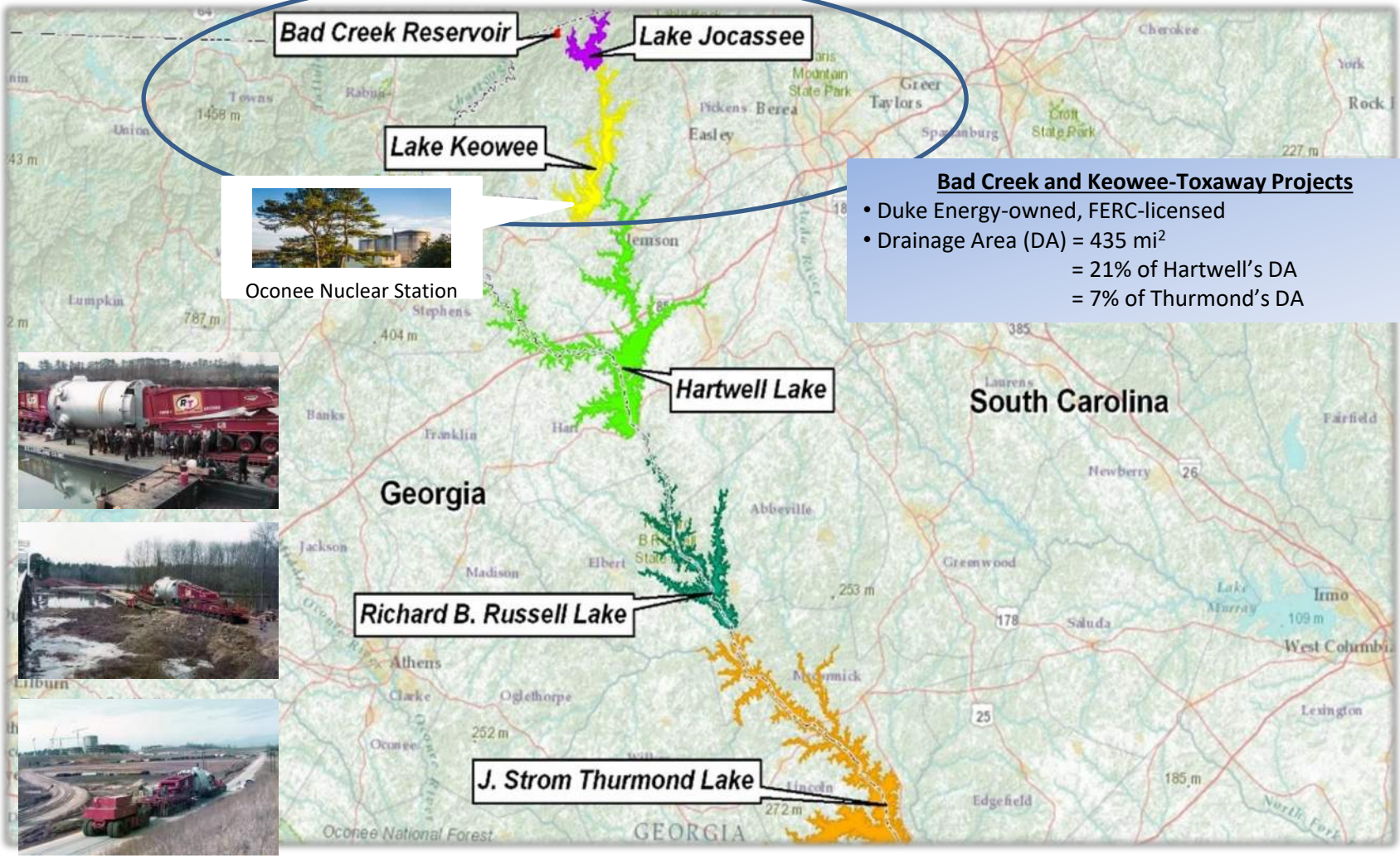


Keowee-Toxaway Energy Complex

Discussion Topics

- **Keowee-Toxaway Energy Complex Overview**
  - Keowee-Toxaway Hydroelectric Project (FERC Project No. 2503)
    - Keowee Hydroelectric Station
    - Jocassee Pumped Storage Station
  - Bad Creek Pumped Storage Project (FERC Project No. 2740)
  - Oconee Nuclear Station
- **Keowee-Toxaway and Bad Creek Project Operations**
- **Low Inflow Protocol and USACE/SEPA Operating Agreement**
- **Oconee Nuclear Station Water Use**

Keowee-Toxaway Energy Complex



Bad Creek and Keowee-Toxaway Projects

- Duke Energy-owned, FERC-licensed
- Drainage Area (DA) = 435 mi^2
  = 21% of Hartwell's DA
  = 7% of Thurmond's DA

Keowee-Toxaway Energy Complex

Station Capacities

Keowee Hydroelectric Station – 157.5 MW

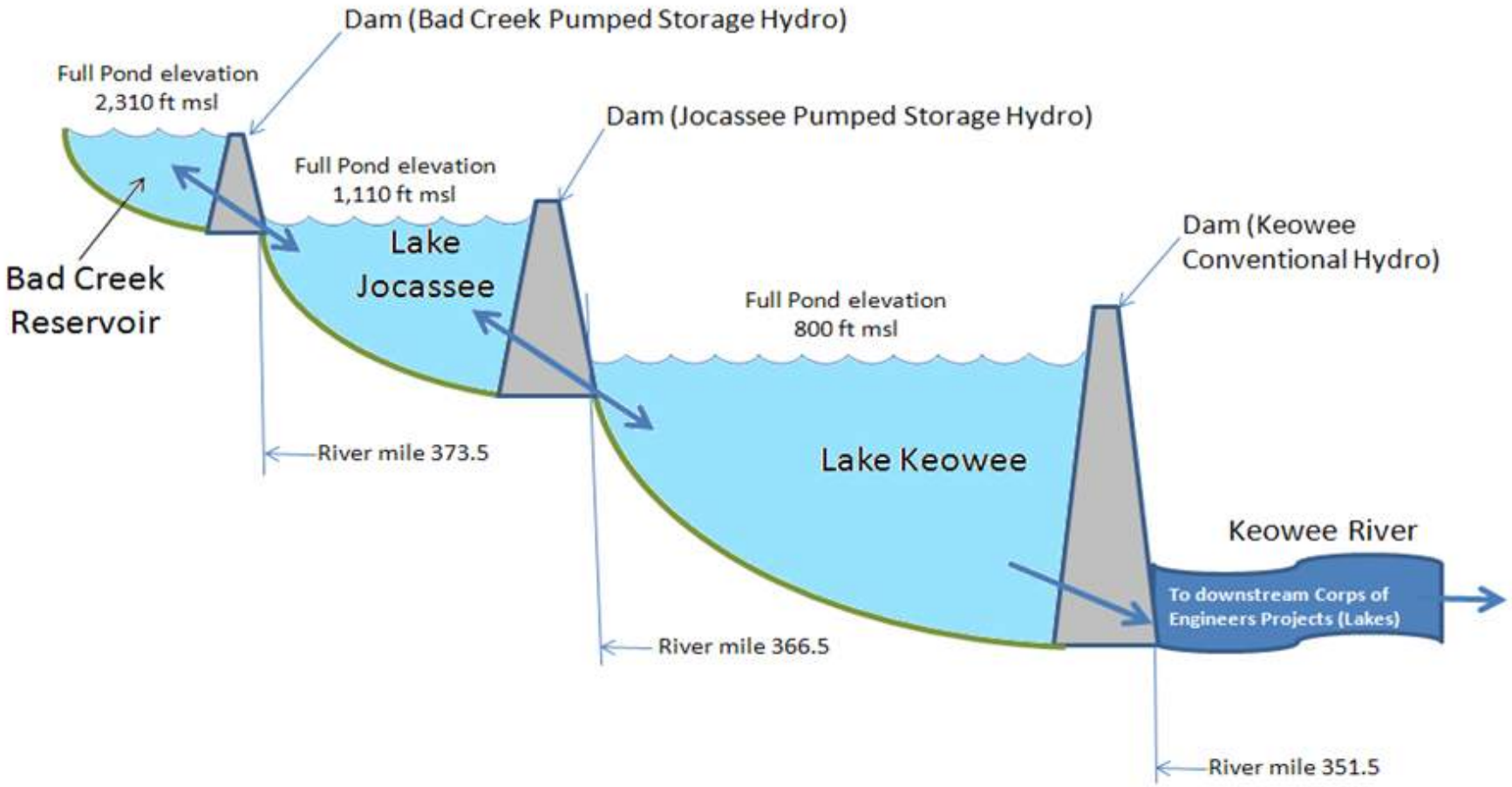
Jocassee Pumped Storage Station – 710.1 MW

Bad Creek Pumped Storage Project – 1,400 MW

Oconee Nuclear Station – 2,554 MW

The total is 25 percent of Duke Energy Carolinas Generating Capacity

Bad Creek and Keowee-Toxaway Hydro Projects

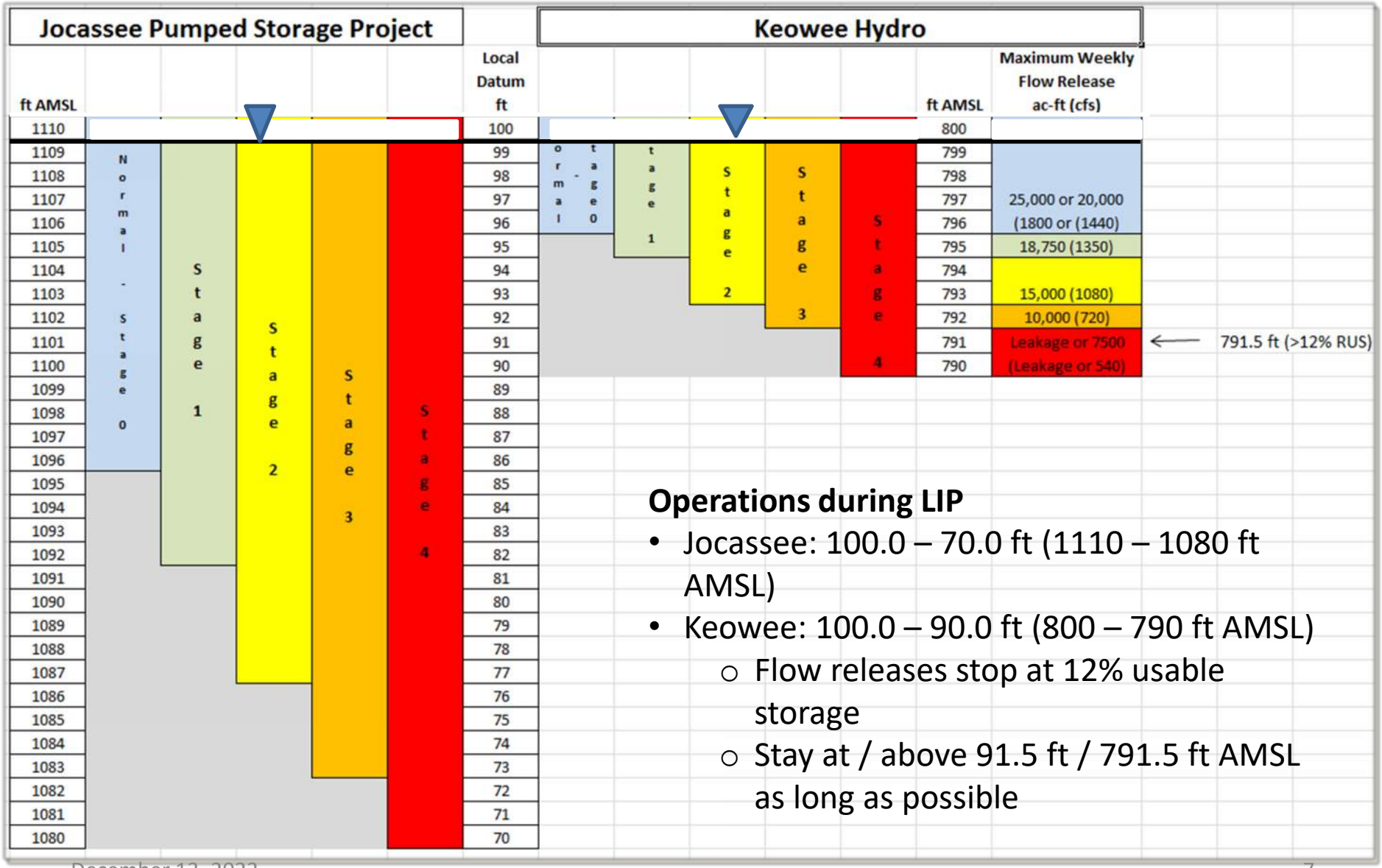


Keowee-Toxaway Hydroelectric Project Operations

Project Operations controlled by:

- FERC License
- Low Inflow Protocol (contained in FERC License)
- New Operating Agreement with USACE and SEPA

Keowee-Toxaway Project Operations



Operations during LIP

- Jocassee: 100.0 – 70.0 ft (1110 – 1080 ft AMSL)
- Keowee: 100.0 – 90.0 ft (800 – 790 ft AMSL)
  - Flow releases stop at 12% usable storage
  - Stay at / above 91.5 ft / 791.5 ft AMSL as long as possible

Keowee-Toxaway Project Operations

Low Inflow Protocol Triggers

LIP Stage Triggers					
Stage	**Trigger**		**US Drought Monitor[2] (12-wk avg)**	**Streamflow (LTA versus previous 4 months)[3]**	
0	Duke Energy Storage Index[1] < 90% & USACE Storage Index[4] < 90%	and one of the following	>=0	< 85%	
1	USACE in DP 1		1	< 75%	
2	USACE in DP 2		2	< 65%	
3	USACE in DP 3		3	< 55%	
4	Duke Energy Storage Index < 25%		4	< 40%	
Notes:					
LTA - long-term average; DP - Drought Plan					
[1] The Duke Energy Storage Index is based on the usable storage for Keowee, Jocassee, and Bad Creek as specified in the LIP					
[2] The US Drought Monitor area-weighted average					
[3] Streamflow gages are composite averages of Twelvemile Creek near Liberty, SC; Chattooga River near Clayton, GA; French Broad River near Rosman, NC					
[4] USACE Storage Index includes usable storage for Hartwell, Russell, and Thurmond					

Keowee-Toxaway Project Operations

Low Inflow Protocol Parameters
(Appendix D of the Keowee-Toxaway Relicensing Agreement)

LIP Stage	Duke Energy Storage Index[1]	Minimum Reservoir Elevation ft AMSL		Maximum Weekly Keowee Water Flow Release ac-ft (cfs)	Public Water Supplier Withdrawal Reductions
		Jocassee	Keowee		
0	85% <= Storage Index < 90%	1096	796	25,000 (1800)	na
	80% <= Storage Index < 85%			20,000 (1440)	
1	na	1092	795	18,750 (1350)	3-5% (goal)
2	na	1087	793	15,000 (1080)	5-10% (goal)
3	na	1083	792	10,000 (720)	10-20% (goal)
4	12% < Storage Index < 25%	1080	791.5	7,500 (540)[2]	20-30%
	Storage Index < 12%		790	Leakage	

Notes:

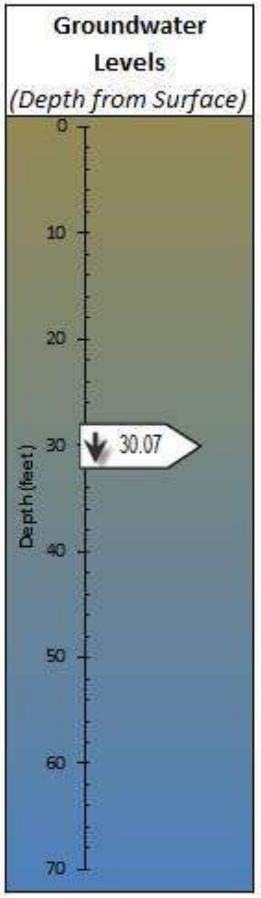
[1] Storage Index includes remaining usable storage in Keowee, Jocassee, and Bad Creek

[2] No releases that would cause Keowee to fall below 791.5 ft AMSL

Keowee-Toxaway Project Operations

Keowee-Toxaway Project LIP Trigger Status Summary for 11/05/23 and Changes Compared to 10/31/23

LIP Stage	Reservoir Storage	% of 4-Month Long-Term Avg. Streamflow	12-Week Avg. of US Drought Monitor
Normal	Normal	>=85%	<0 (-0.35)
LIP Stage 0	DE and USACE <90%	<85%	>=0
LIP Stage 1	DP = 1	<75%	>=1
LIP Stage 2 (Nov 5, 2023)	DE 71.8%, USACE 73.4%, DP 2	DP = 2 <65%	>=2
LIP Stage 3	DP = 3	47% <55%	>=3
LIP Stage 4	DE <25%	<40%	4



Recovery under this LIP as conditions improve will be accomplished by reversing the staged approach outlined above, except the only trigger to recover from a stage is for either the storage index for the Licensee's Reservoirs or the USACE drought trigger to be exceeded for the current stage.

Keowee-Toxaway Drought Management Advisory Group (KT-DMAG)

- Defined in the Low Inflow Protocol (Appendix D of the Relicensing Agreement)
- Voluntary advisory group to work with the Licensee when the LIP is initiated
- Designated Members:
  - SCDNR
  - SCDHEC
  - USGS
  - USACE
  - SEPA
  - Large Water Intake Owners on Keowee-Toxaway Project reservoirs
  - Other Large Water Intake Owners downstream
  - Licensee
  - Others are participating (e.g., Georgia EPD)

New Operating Agreement (NOA)

Many things have changed since the initial 1968 agreement:

- The Richard B. Russell and Bad Creek Projects have been developed
- New droughts-of-record have occurred:
  - 1998 – 2002
  - 2007 – 2008
  - 2011 – 2013
- The USACE Drought Plan (DP) was implemented in the 1980s and last updated in 2012
- NRC requirements for certain ONS systems have resulted in requiring more restrictive Lake Keowee lake levels
- Relicensing Agreement includes operating provisions

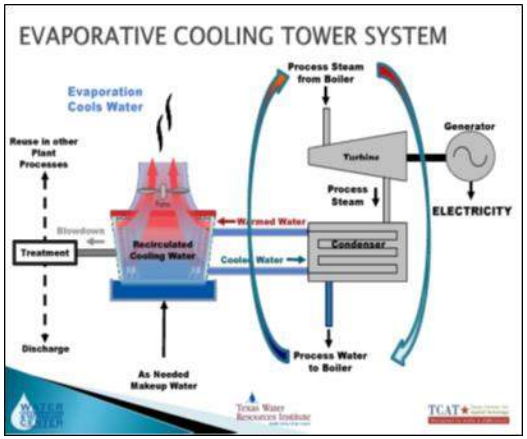
New Operating Agreement (NOA)

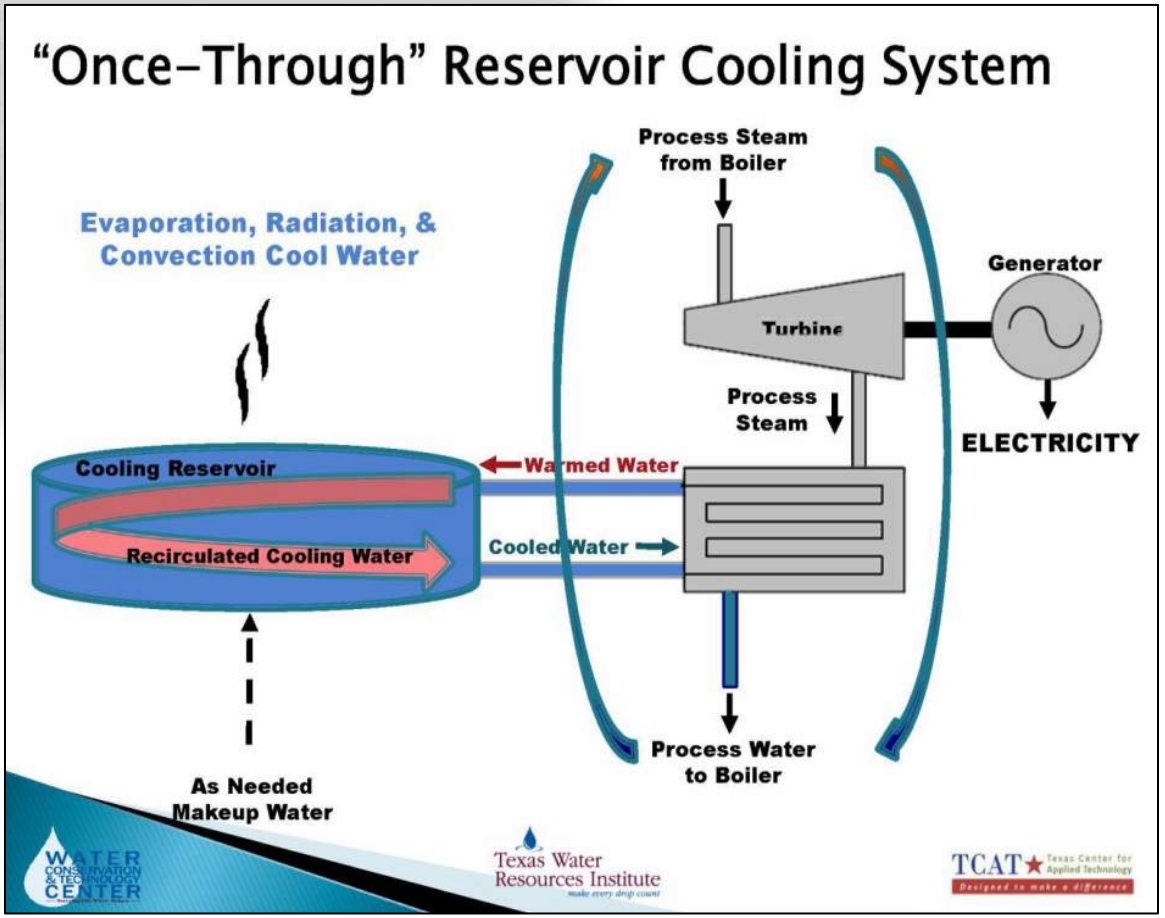
New Operating Agreement (NOA) became effective on October 17, 2014

The following are key improvements resulting from the NOA:

- The usable storage in Lake Keowee is based on a 10-ft maximum drawdown contemplated by the Relicensing Agreement
- A modification at ONS that allows the plant to operate normally at Lake Keowee elevations down to a ten-foot drawdown (during very severe drought periods)
- Inclusion of ratcheting limitations on the maximum weekly water release required from Lake Keowee, which allows Duke Energy to support regional water needs (on-reservoir and downstream) deeper into severe droughts
- Reduction in the risk of not having enough water to support operation of power plants totaling 13% of the company's generating capacity in the Carolinas (ONS)

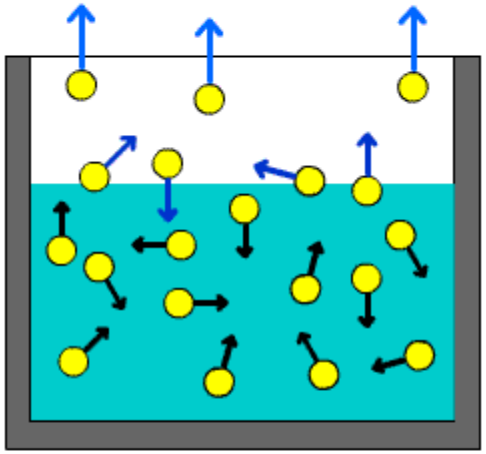
Oconee Nuclear Station Water Use





Oconee Nuclear Station Water Use

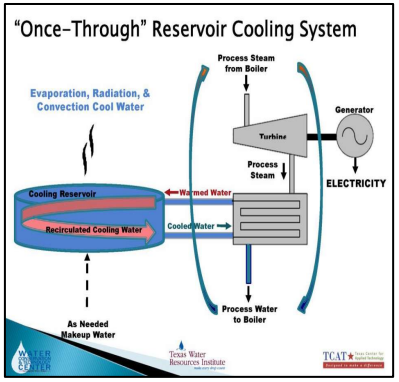
When these molecules acquire sufficient kinetic energy, they manage to escape liquid phase and move into gas phase, where the intermolecular forces of attraction that existed between them are assumed to be negligible.



High Energy:
Evaporating

Medium Energy:
Pulled back into water

Lower Energy:
Remain as liquid



http://www.school-for-champions.com/science/matter_states_evaporation.htm#.VfDGQ9LtlBc

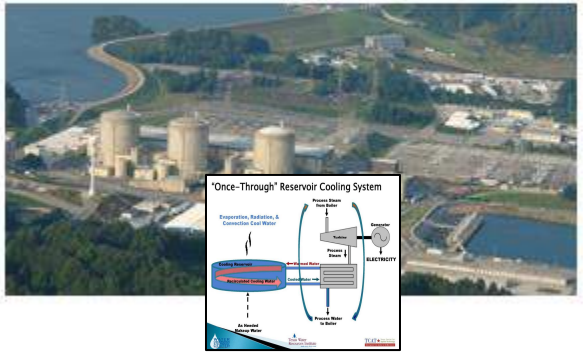
This is essentially what happens when you *heat liquid water*. As you provide more and more energy, an increasing number of water molecules will manage to break from the surface of the liquid.

In order for that to happen, the kinetic energy of the molecules must **overcome** the intermolecular forces of attraction.

Oconee Nuclear Station Water Use

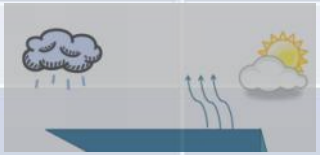
Estimated Oconee Nuclear Station Water Consumption Rate (MGD)

Current Month (December): 22.7
Next Month (January): 24.4
(Reflects average historical operational patterns updated through 2022)



Estimated Natural Evaporation From Duke Energy Reservoirs (MGD)

Reservoir	Current Month (MGD)	Next Month (MGD)
Bad Creek	0.3	0.3
Lake Jocassee	8.5	9.1
Lake Keowee	19.1	20.5
Total	27.9	29.9



Questions and Discussion