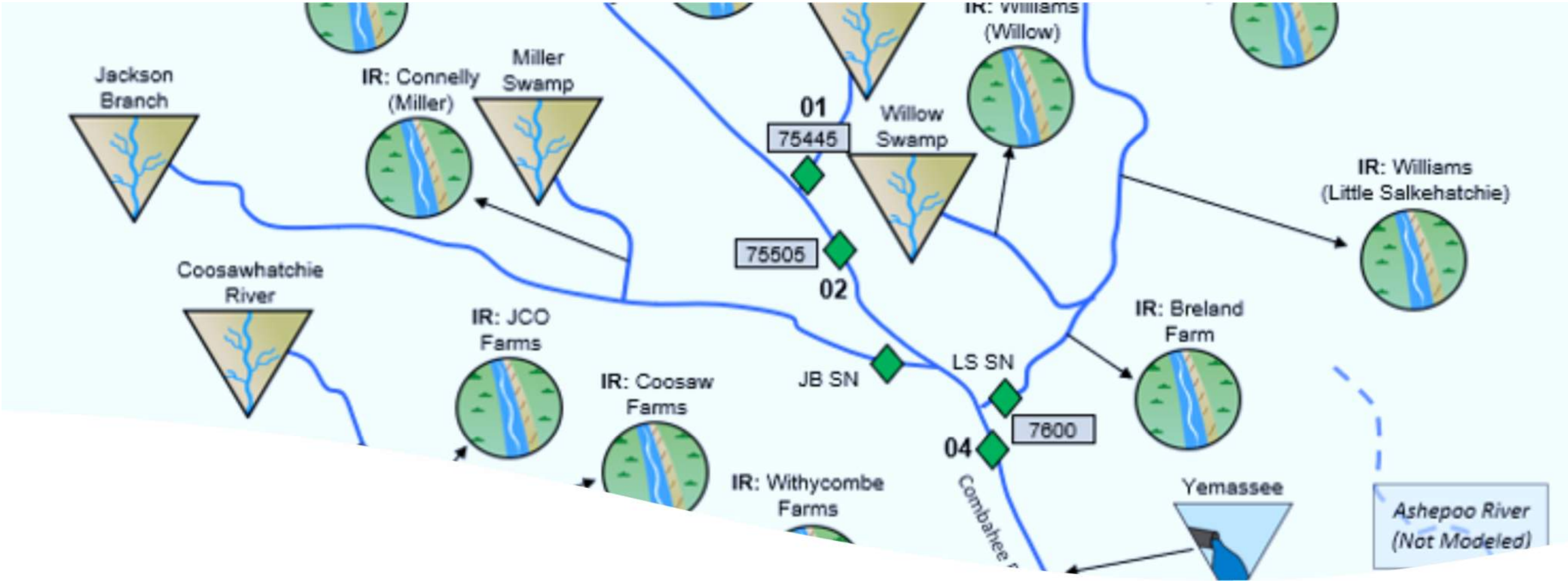


Surface Water Availability Modeling UIF, Current Use, P&R, 2070 Moderate and 2070 High Demand Scenario Results

John Boyer

Agenda Item 5

Surface Water Scenarios

Base Scenarios

- Current Surface Water Use Scenario
  - *Uses most recent 10-yr average withdrawals (as reported by month) in most cases*
- Permitted and Registered (P&R) Surface Water Use Scenario
  - *Uses current fully-permitted and registered amounts*
- Moderate Water Demand Projection Scenario
  - *Future water demand projection based on moderate growth and normal climate*
- High Water Demand Projection Scenario
  - *Future water demand projection based on high growth and hot/dry climate*

Additional Scenarios

- Unimpaired Flow (UIF) Scenario
  - *Naturalized conditions (no surface water withdrawals, discharges, or reservoirs)*

Lower Savannah River Basin - Summary of Average Annual Surface Water Demands by Scenario

All values in million gallons per day

Surface Water Use Sector	Current Use	2070 Moderate Demand	2070 High Demand	Permitted and Registered (P&R)
Thermoelectric/Nuclear Power[1]	102.8	89.6	149.7	217.2
Public Water Supply	45.2	54.9	87.1	304.4
Industrial	18.7	21.0	47.0	881.6
Golf Courses	0.6	0.6	1.2	13.2
Agricultural	0.0	0.0	0.0	0.00023
Mining	0.0	0.0	0.0	0.0
GA-Side Water Users	171	219	219	461
Total all Sectors*	338	385	504	1,877
Total without Thermoelectric/Nuclear Power	236	295	354	1,660

** Rounded to nearest MGD*

[1] Most of the power withdrawals are returned.

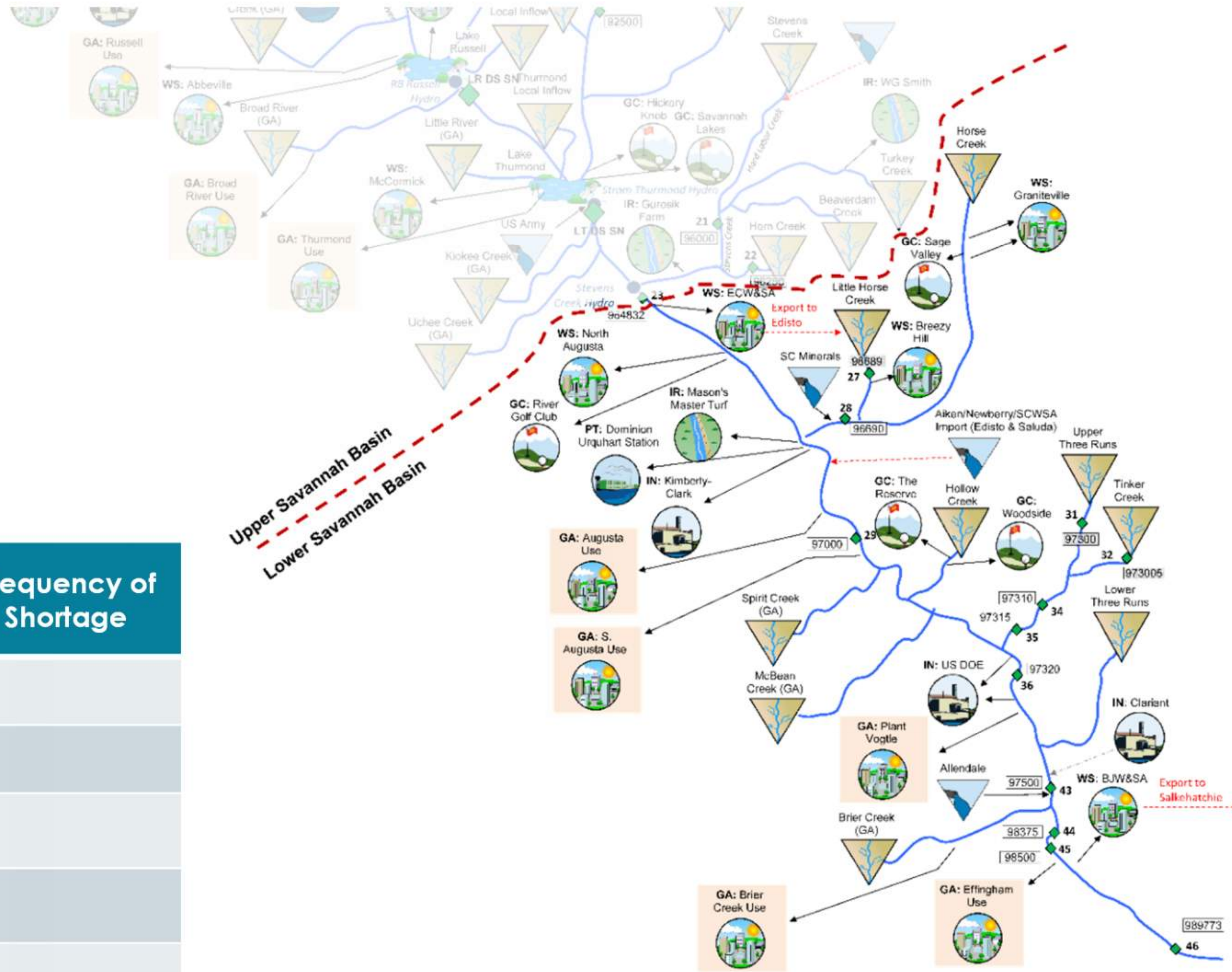
Lower Savannah River Basin
Current Use Scenario

1 Physical Shortage

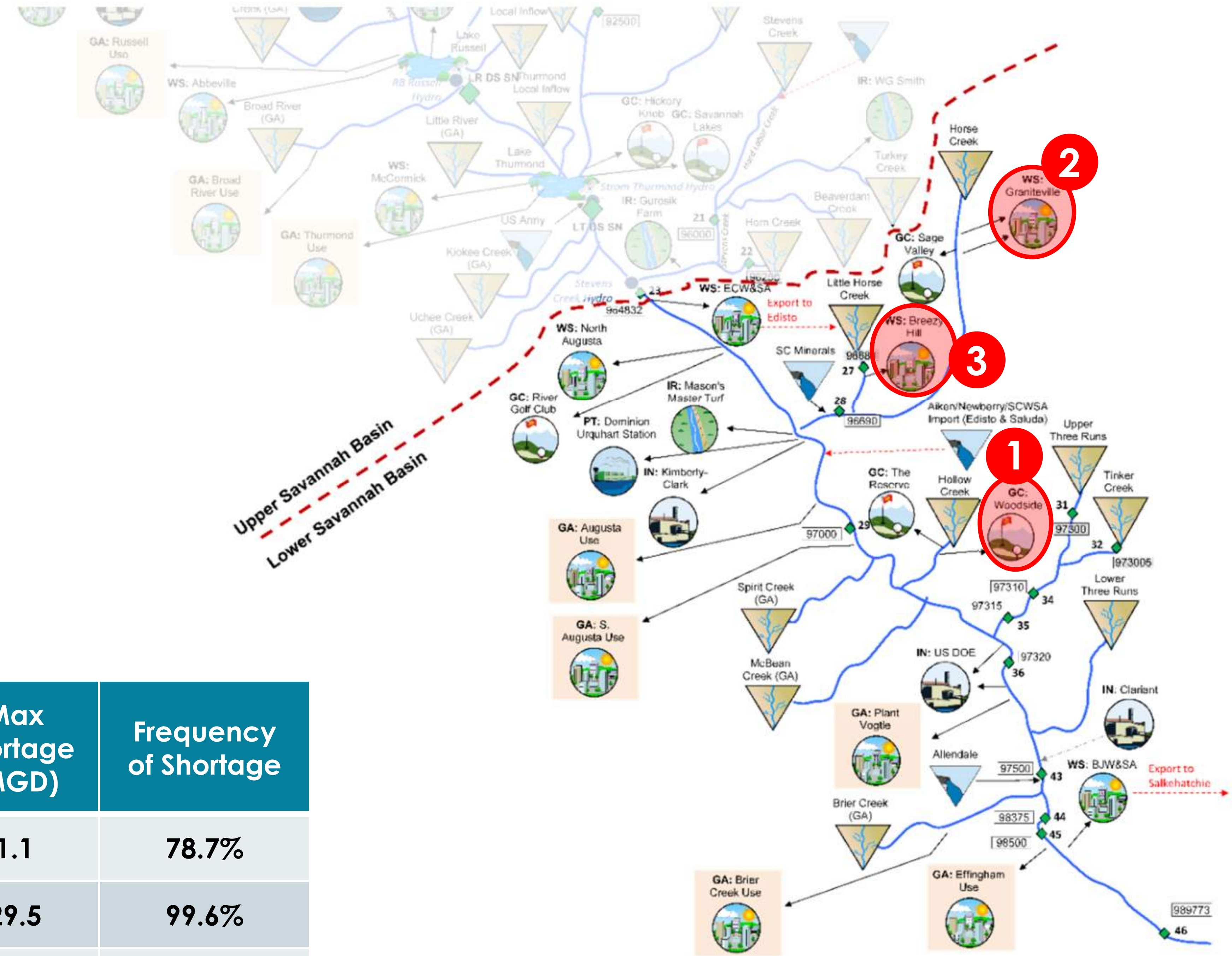
Surface Water Shortage Table

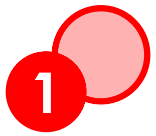
Map ID	Water User	Max Shortage (MGD)	Frequency of Shortage

No Shortages



Lower Savannah River Basin
Permitted & Registered Scenario





Physical Shortage

Surface Water Shortage Table

Map ID	Water User	Minimum Available Supply (MGD)	Max Shortage (MGD)	Frequency of Shortage
1	GC: Woodside	2.7	1.1	78.7%
2	WS: Breezy Hill	3.8	29.5	99.6%
3	WS: Graniteville	9.1	0.2	4.9%

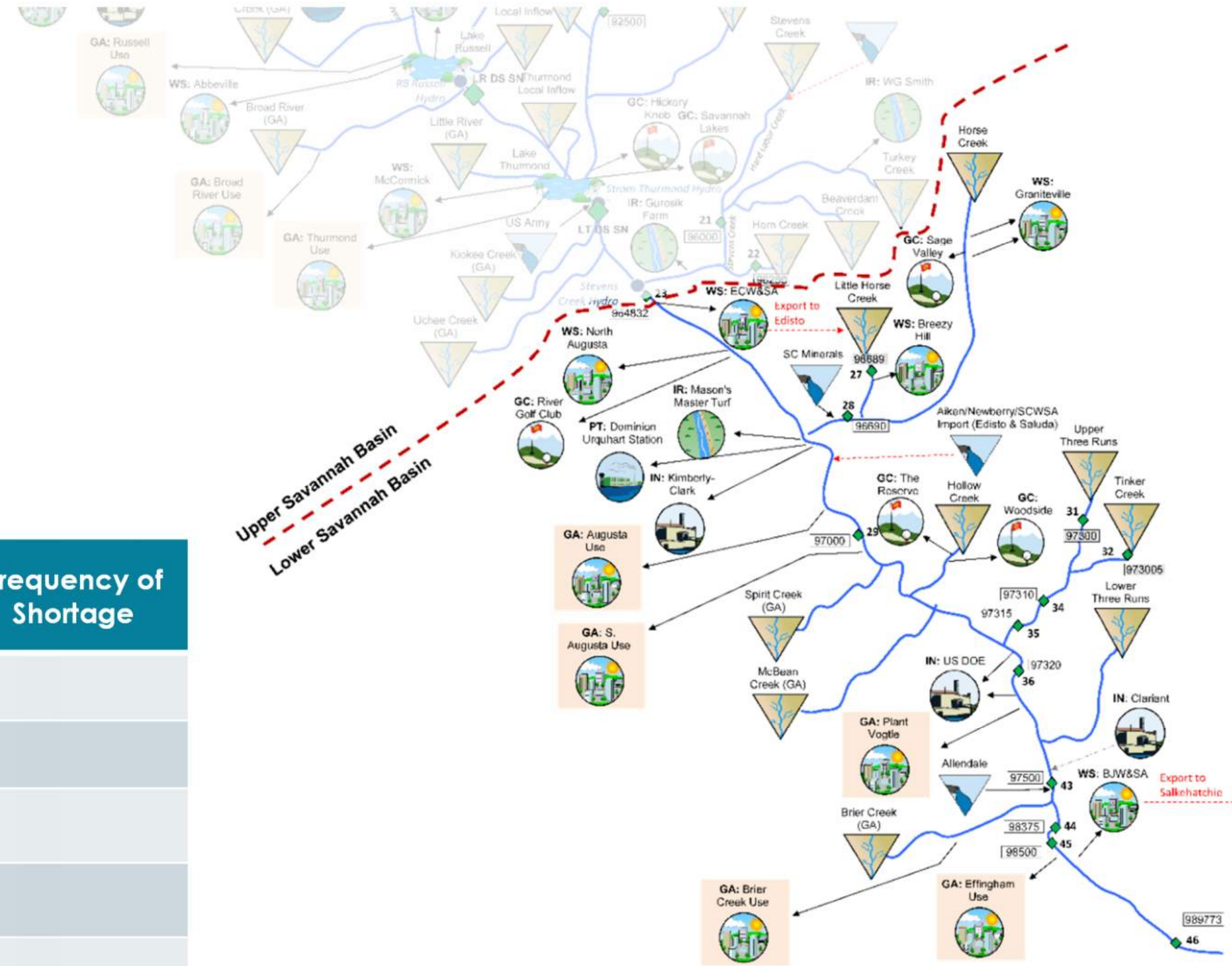
Lower Savannah River Basin
2070 Moderate Demand Scenario

1 Physical Shortage

Surface Water Shortage Table

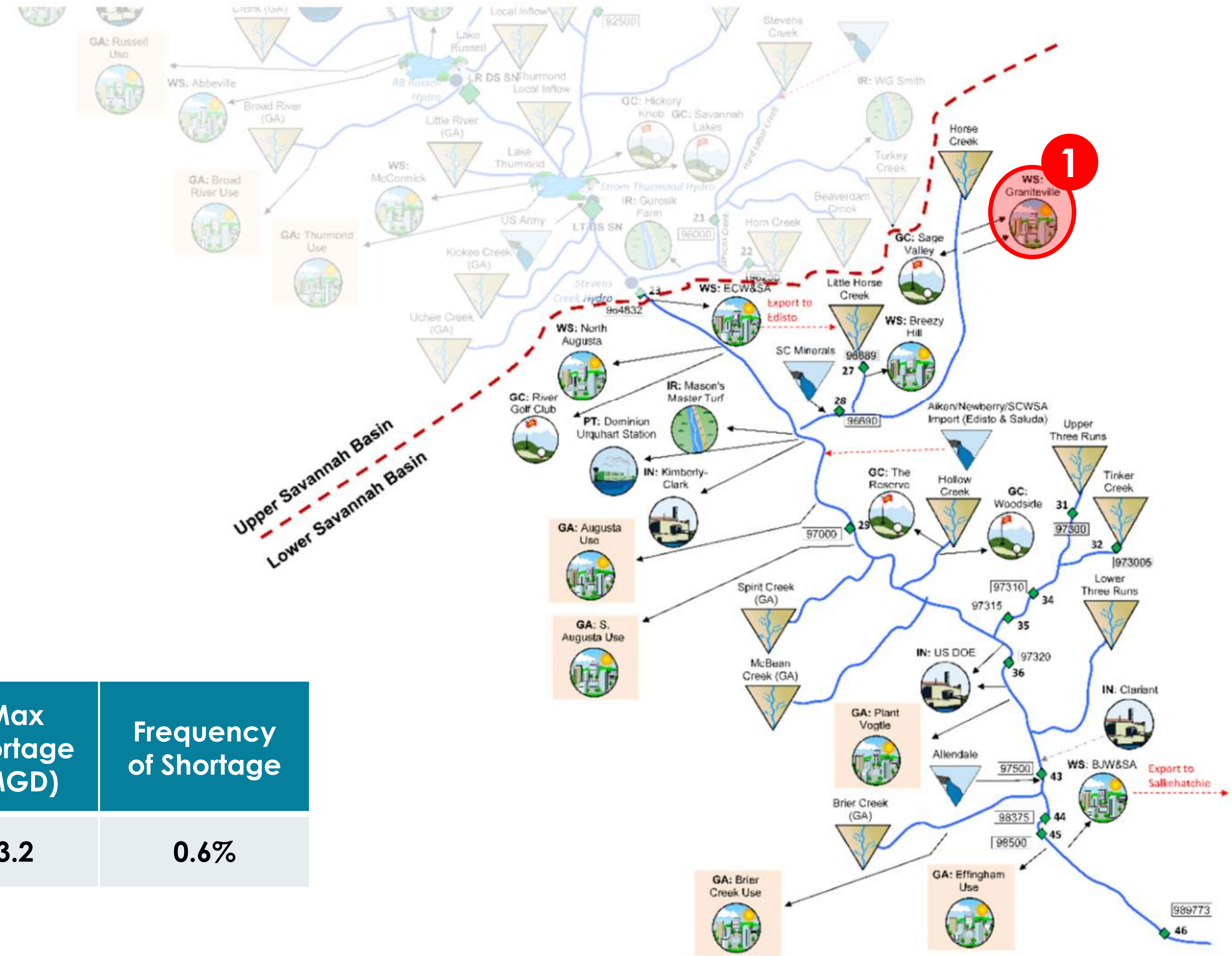
Map ID	Water User	Max Shortage (MGD)	Frequency of Shortage

No Shortages



Lower Savannah River Basin

2070 High Demand Scenario



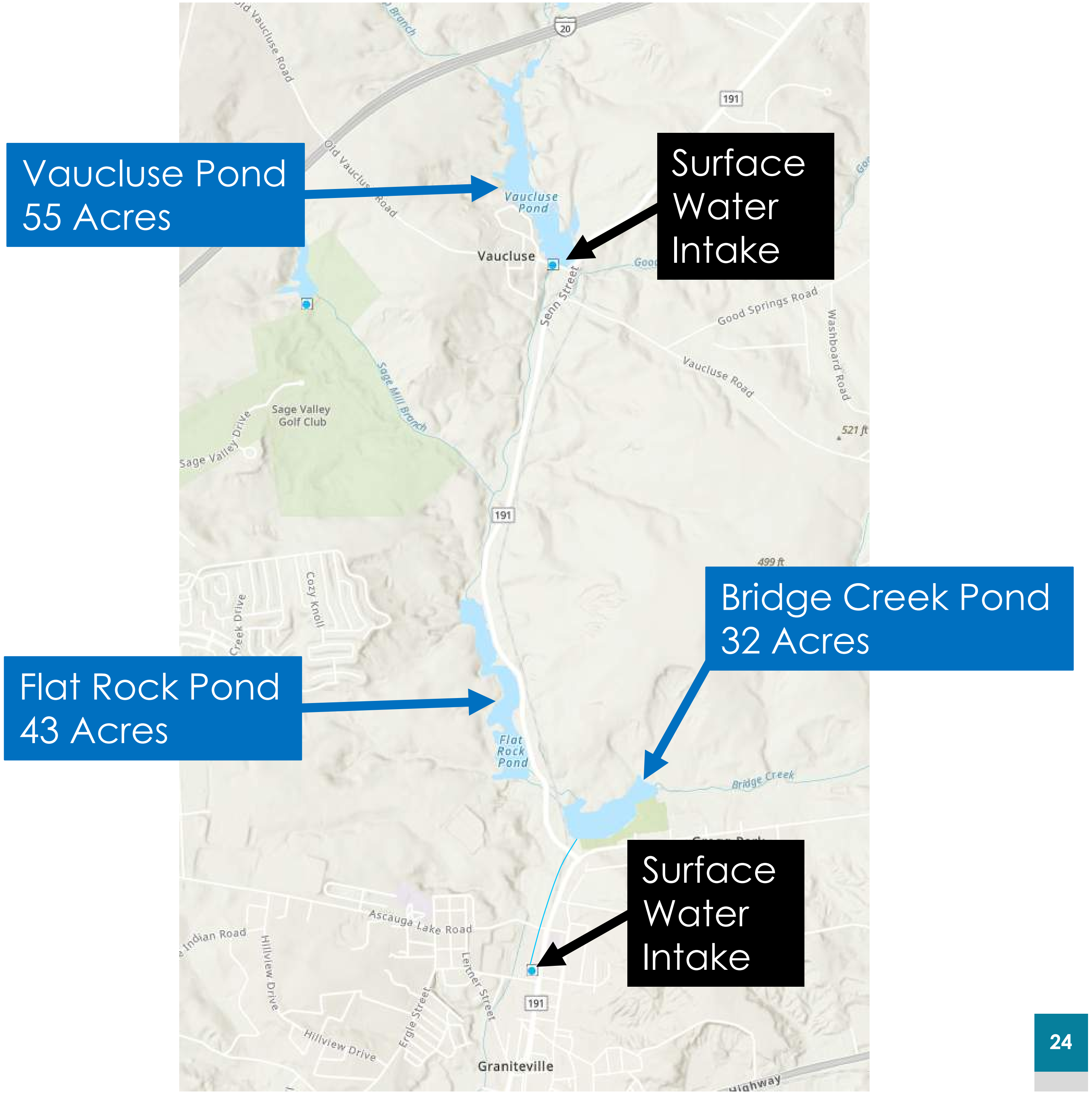
1 Physical Shortage

Surface Water Shortage Table

Map ID	Water User	Minimum Available Supply (MGD)	Max Shortage (MGD)	Frequency of Shortage
1	WS: Graniteville	9.1	3.2	0.6%

WS: Graniteville

Vaucluse Pond, **Flat Rock Pond** and **Bridge Creek Pond** are not represented in the SWAM model. They provide storage that would reduce or eliminate the frequency of simulated shortages.



Salkehatchie River Basin - Summary of Average Annual Surface Water Demands by Scenario

All values in million gallons per day

Surface Water Use Sector	Current Use	Permitted and Registered (P&R)	2070 Moderate Demand	2070 High Demand
Agricultural	2.75	47.58	3.58	5.26
Thermoelectric Power	0.00	0.00	0.00	0.00
Public Water Supply	0.00	0.00	0.00	0.00
Industrial	0.00	0.00	0.00	0.00
Golf Courses	0.00	0.00	0.00	0.00
Mining	0.00	0.00	0.00	0.00
Total all Sectors	2.75	47.58	3.58	5.26

Salkehatchie River Basin

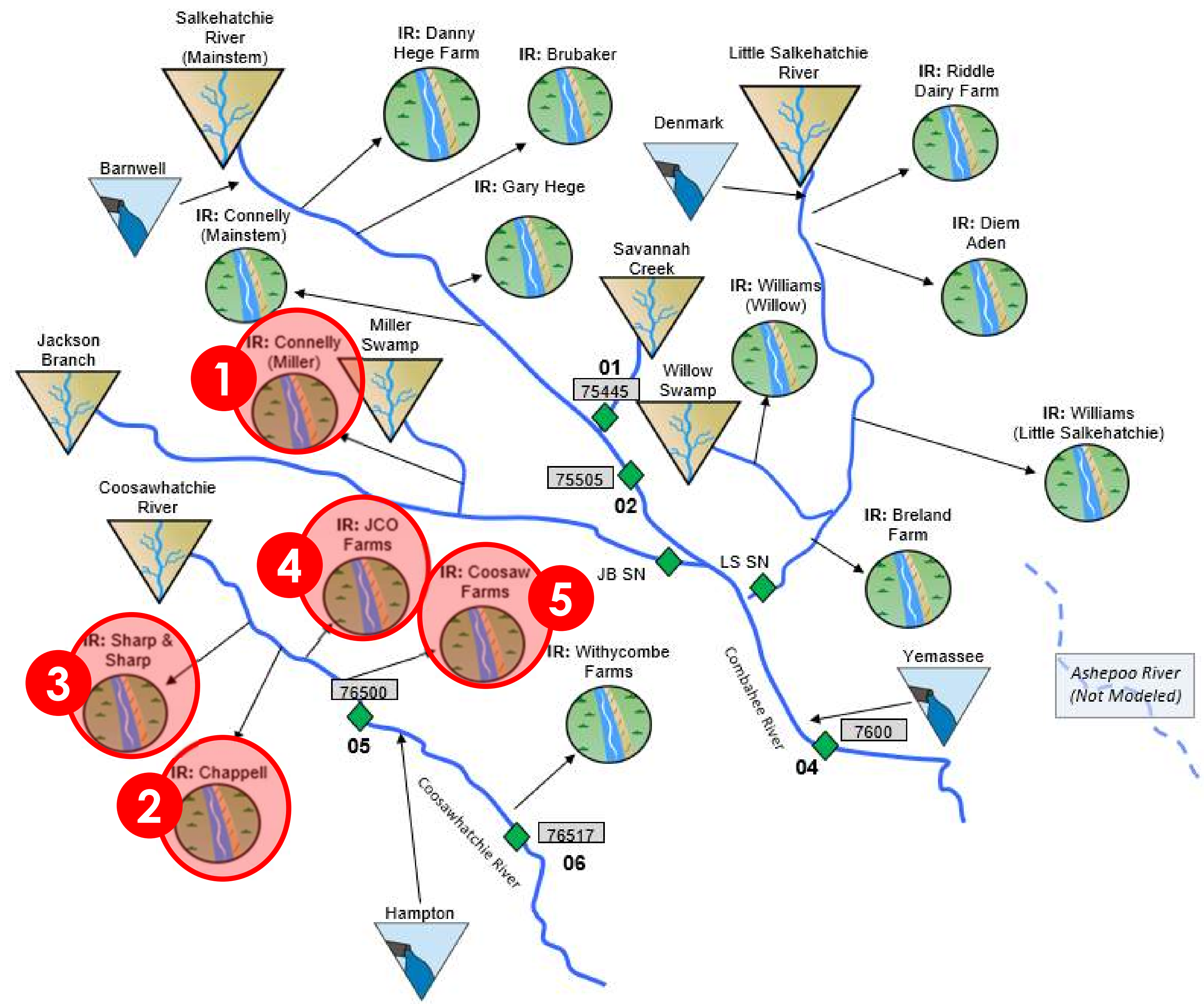
Current Use Scenario

1 Physical Shortage

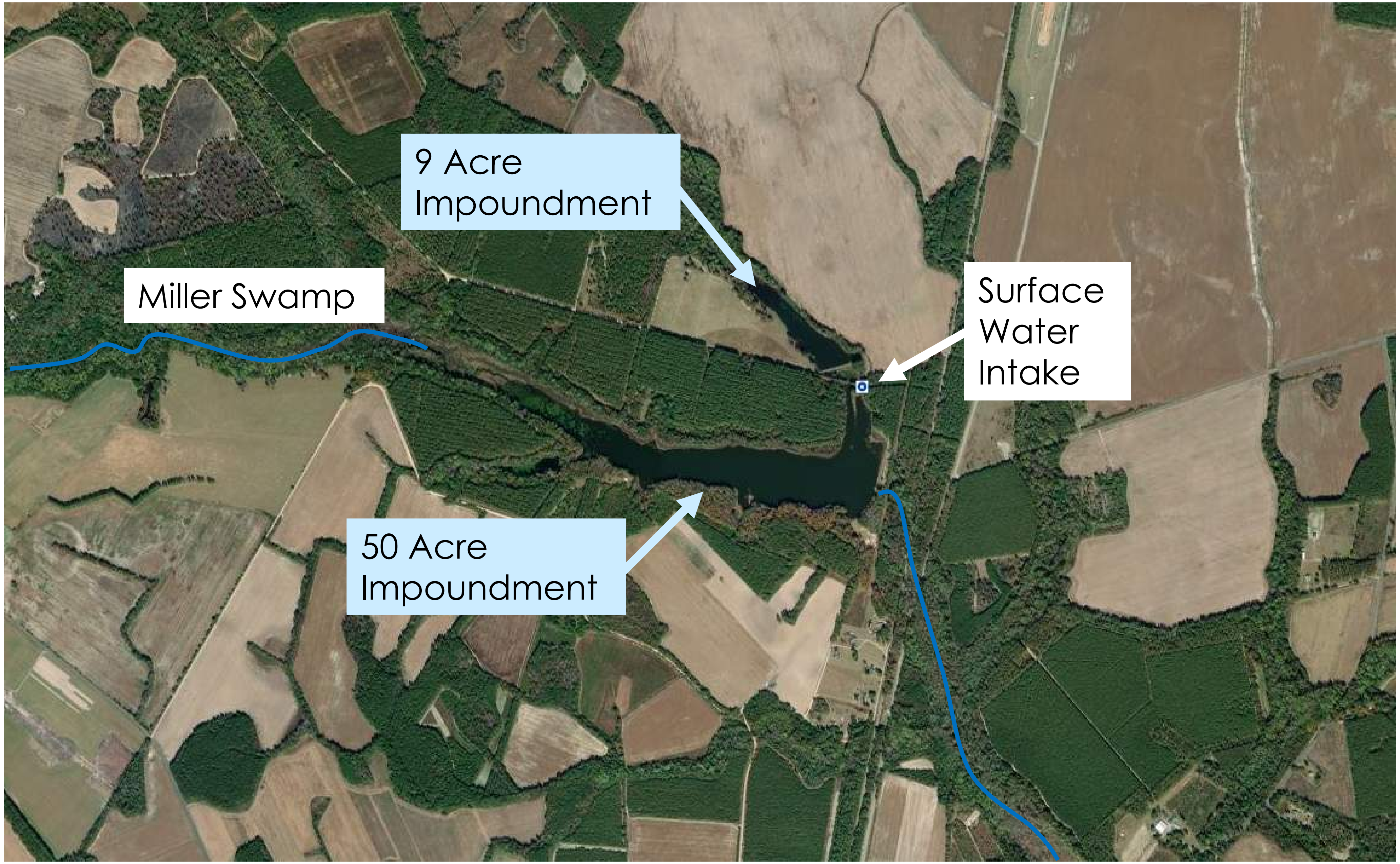
Surface Water Shortage Table

Map ID	Water User	Minimum Available Supply (MGD)	Max Shortage (MGD)	Frequency of Shortage
1	IR: Connelly (Miller)	0.003	1.6	11%
2	IR: Chappell	0.0	0.05	6%
3	IR: Sharp & Sharp	0.0	2.2	13%
4	IR: JCO Farms	0.0	0.07	7%
5	IR: Coosaw Farms	0.0	0.5	6%

User has an impoundment which was not included in the model and may eliminate the modeled shortage.



IR: Connolly (Miller)



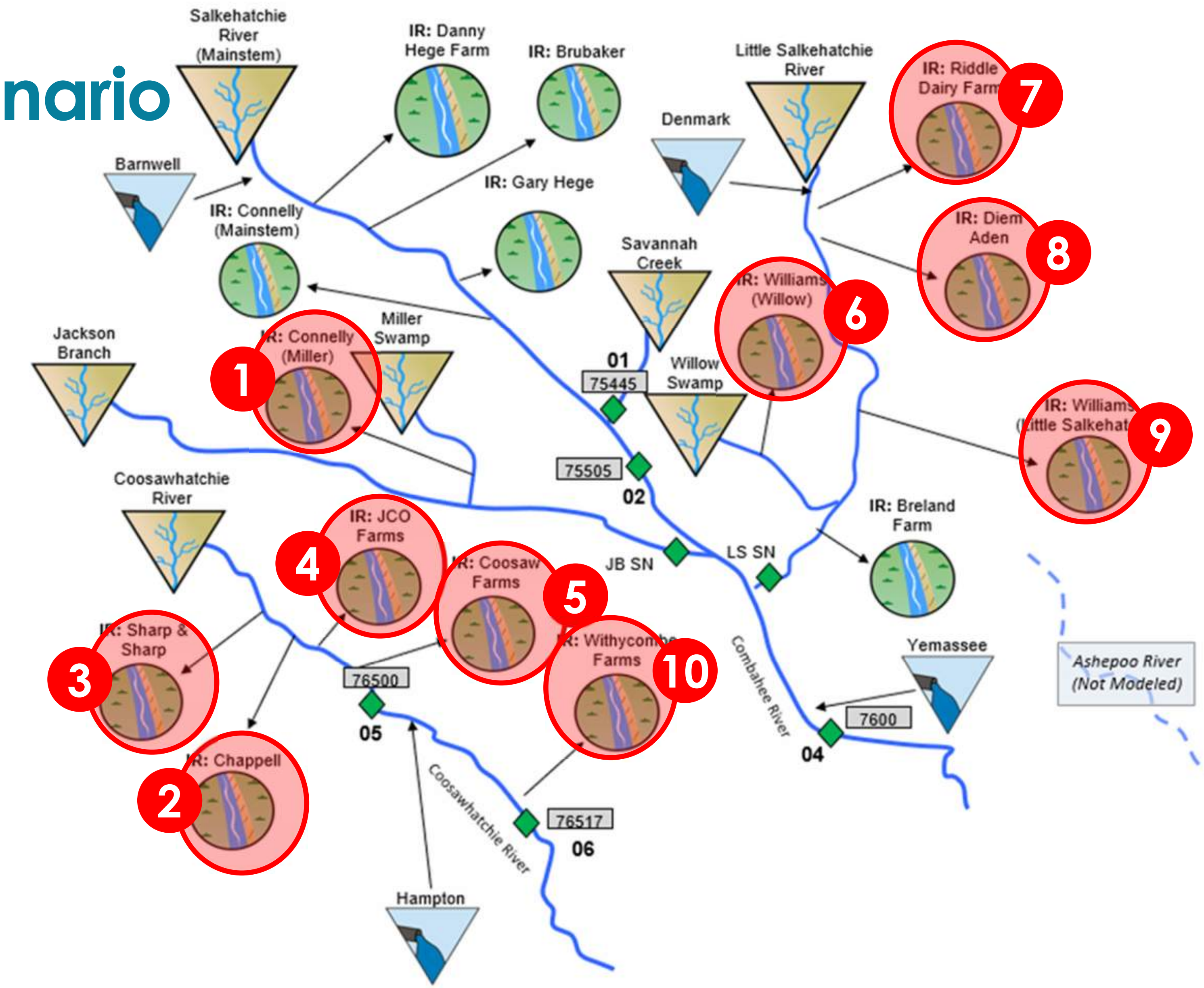
Salkehatchie River Basin

Permitted & Registered Scenario

1 Physical Shortage

Surface Water Shortage Table

Map ID	Water User	Minimum Available Supply (MGD)	Max Shortage (MGD)	Frequency of Shortage
1	IR: Connelly (Miller)	0.003	3.5	68%
2	IR: Chappell	0.0	1.4	37%
3	IR: Sharp & Sharp	0.0	6.8	45%
4	IR: JCO Farms	0.0	21.8	73%
5	IR: Coosaw Farms	0.0	0.9	17%
6	IR: Williams (Willow)	0.3	3.3	20%
7	IR: Riddle Dairy Farm	0.7	0.01	0.1%
8	IR: Diem Aden	0.1	0.4	0.5%
9	IR: Williams (Little Salk.)	0.9	0.1	0.1%
10	IR: Withycombe Farm	0.7	0.6	1%



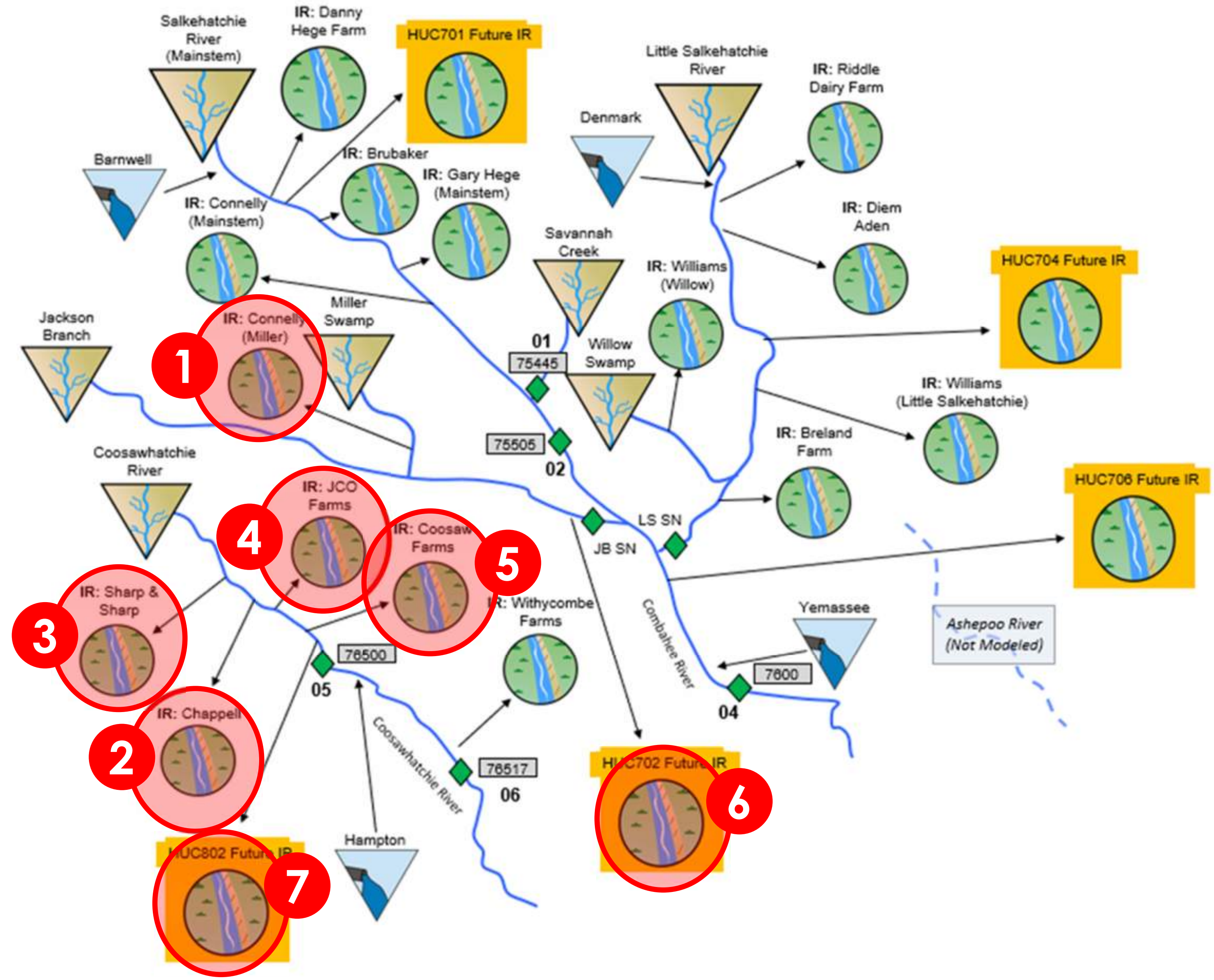
User has an impoundment which was not included in the model and may eliminate the modeled shortage.

Salkehatchie River Basin
2070 Moderate Demand Scenario

1 Physical Shortage

Surface Water Shortage Table

Map ID	Water User	Minimum Available Supply (MGD)	Max Shortage (MGD)	Frequency of Shortage
1	IR: Connelly (Miller)	0.003	1.7	12%
2	IR: Chappell	0.0	0.05	6%
3	IR: Sharp & Sharp	0.0	2.2	13%
4	IR: JCO Farms	0.0	0.1	13%
5	IR: Coosaw Farms	0.0	0.7	6%
6	HUC702 Future IR	0.03	0.4	0.1%
7	HUC802 Future IR	0.0	0.9	2%



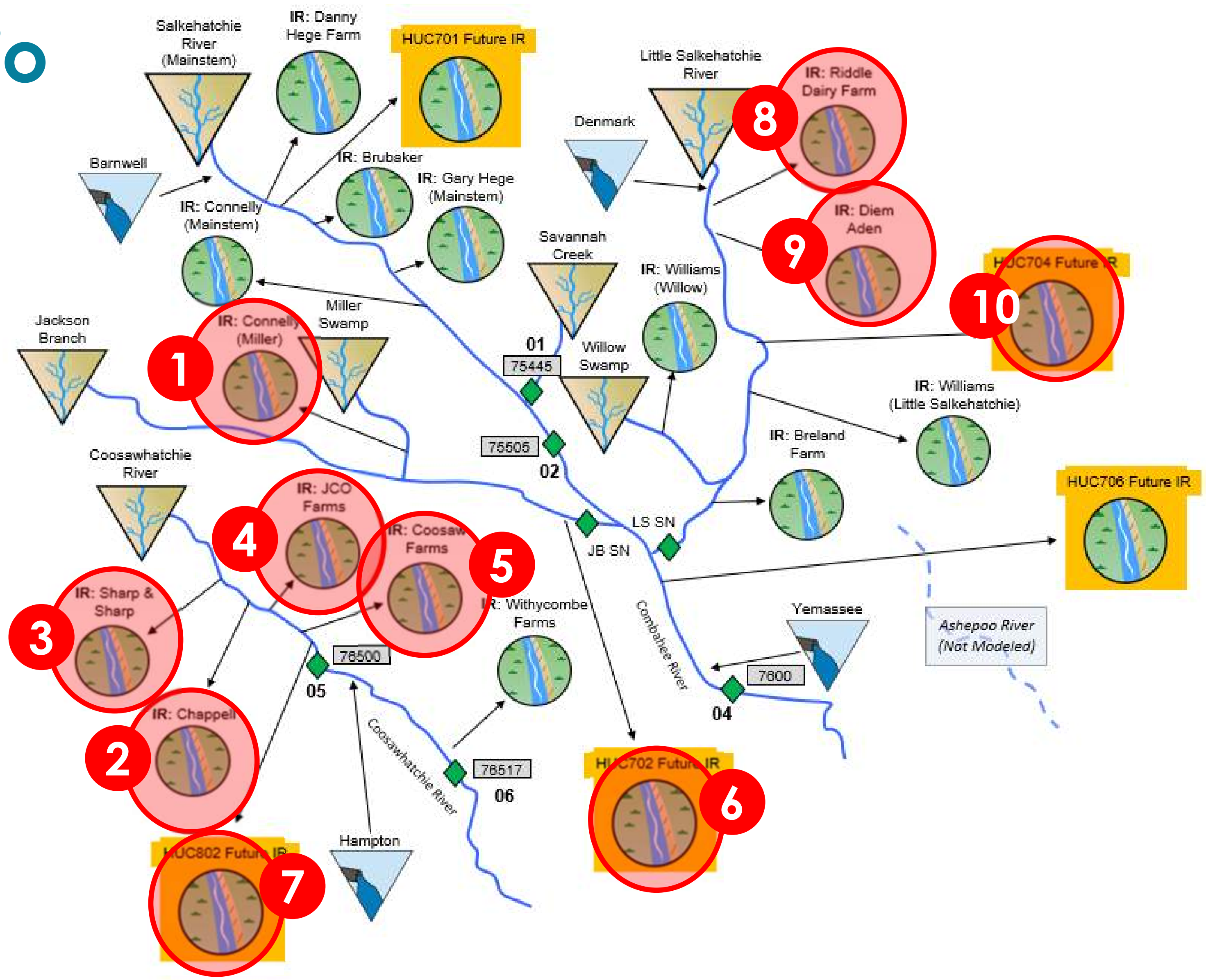
User has an impoundment which was not included in the model and may eliminate the modeled shortage.

Salkehatchie River Basin
2070 High Demand Scenario

1 Physical Shortage

Surface Water Shortage Table

Map ID	Water User	Minimum Available Supply (MGD)	Max Shortage (MGD)	Frequency of Shortage
1	IR: Connelly (Miller)	0.003	3.0	20%
2	IR: Chappell	0.0	0.1	6%
3	IR: Sharp & Sharp	0.0	2.2	13%
4	IR: JCO Farms	0.0	0.1	13%
5	IR: Coosaw Farms	0.0	0.7	8%
6	HUC702 Future IR	0.03	1.0	0.2%
7	HUC802 Future IR	0.0	1.2	2%
8	IR: Riddle Dairy Farm	0.7	0.01	0.1%
9	IR: Diem Aden	0.1	0.2	0.2%
10	HUC704 Future IR	0.4	0.1	0.1%



User has an impoundment which was not included in the model and may eliminate the modeled shortage.

Extended Drought Analysis Results for the Savannah River Basin

John Boyer

Agenda Item 5c

Resequencing Historical Flows to Investigate Potential Future Droughts

Methods

- Supply-side investigation to quantify sensitivities to hydrologic non-stationarity (aka “the past may not be a good predictor of the future”)
- Each scenario constructed with repeating sequences of monthly flows and reservoir evaporation rates extracted from historical hydrology
- Used **2070 High Demand Scenario** projections
- Used current reservoir operation rules

Resequencing Historical Flows to Investigate Potential Future Droughts

Methods

Three (3) constructed scenarios:

1. Repeating 5-year drought constructed by splicing together the **five driest water years** in the hydrologic period of record with respect to mainstem total annual flow. These were **2001**, **2008**, **1981**, **1988**, and **2017**.

2. **Repeating single year drought** corresponding to the **second driest water year (2008)** and identified as the critical single year drought with respect to Lake Thurmond water supply availability.

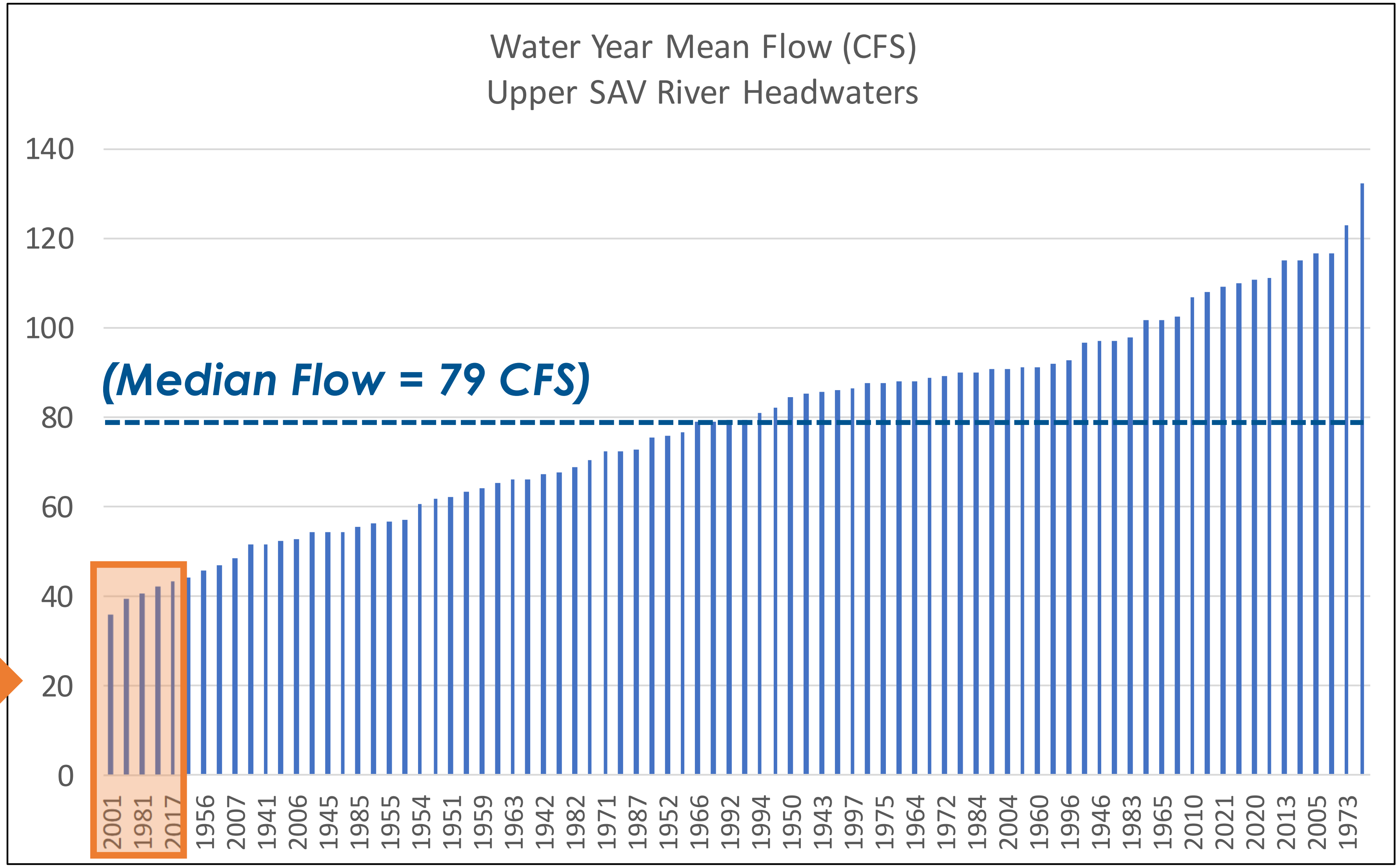
3. **Repeating synthetic drought year** constructed by splicing together the **twelve driest calendar month flows** in the hydrologic period of record.

Resequencing Historical Flows to Investigate Potential Future Droughts

Methods

Ranked data based on mainstem headwater flows

5 Driest Years in terms of mainstem flow:
2001
2008
1981
1988
2017

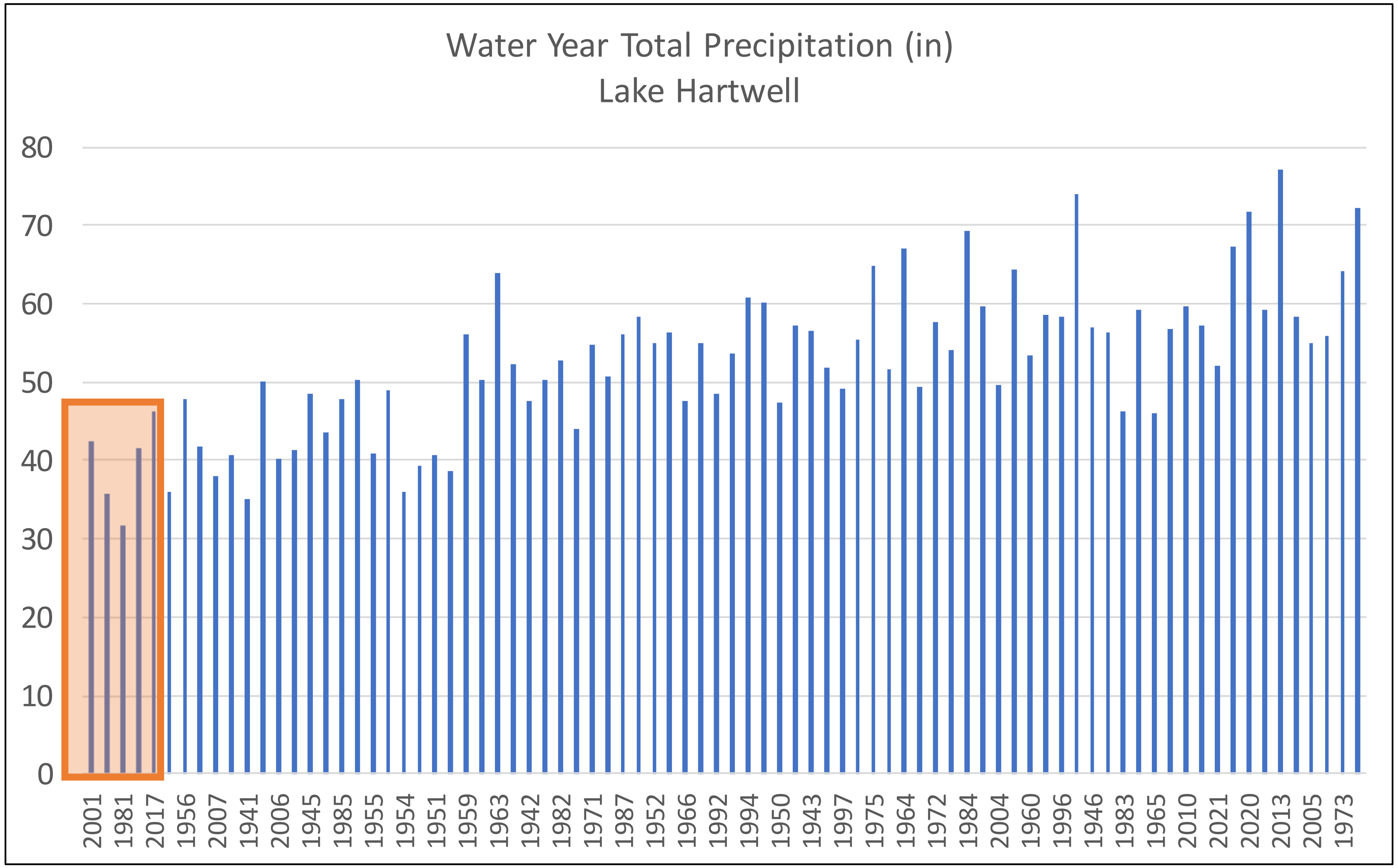


Resequencing Historical Flows to Investigate Potential Future Droughts

Methods

Reference data

Precip



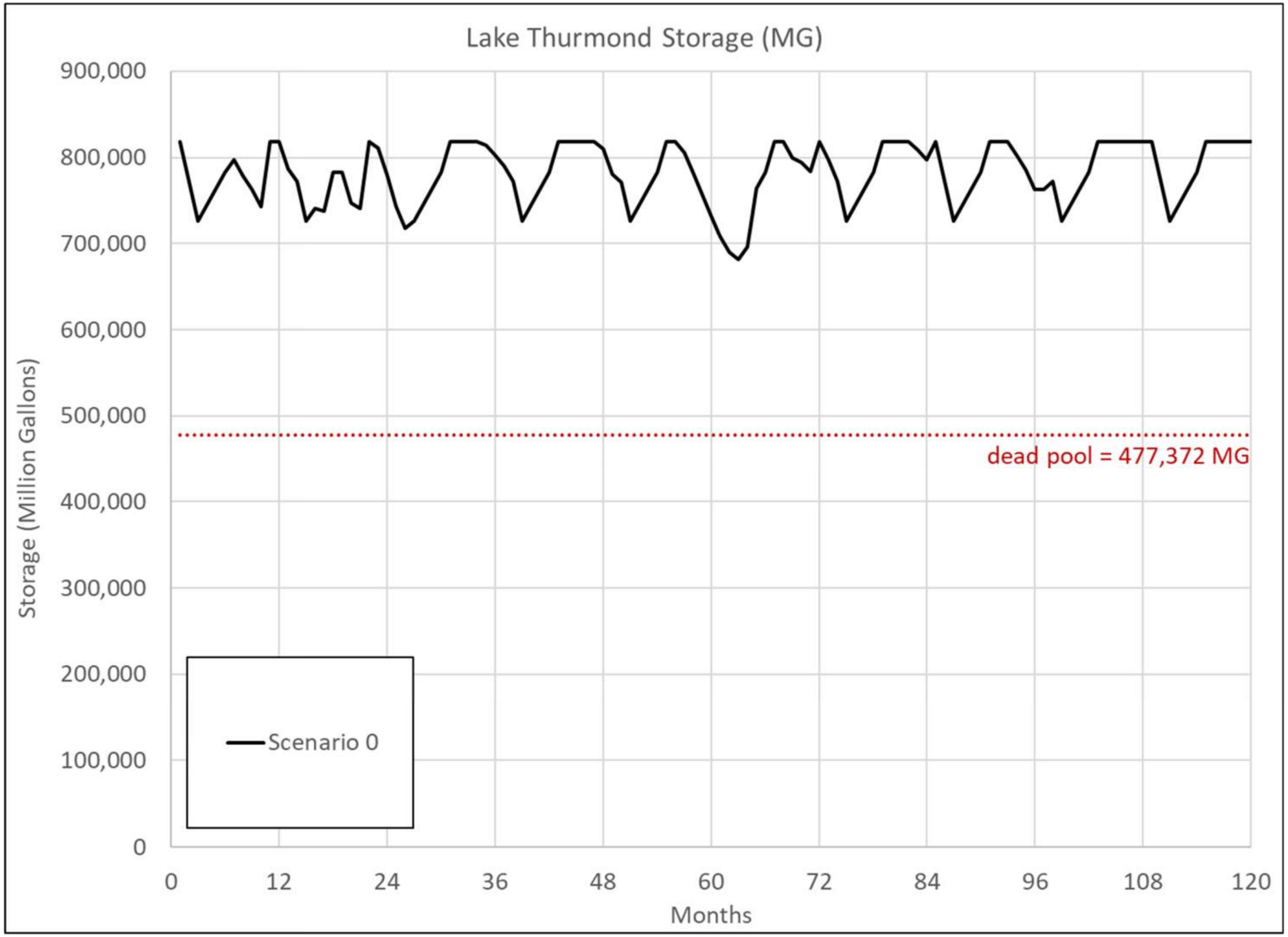
Resequencing Historical Flows to Investigate Potential Future Droughts

Methods

Scenario 3: 12 driest calendar months (Mainstem headwater flow)

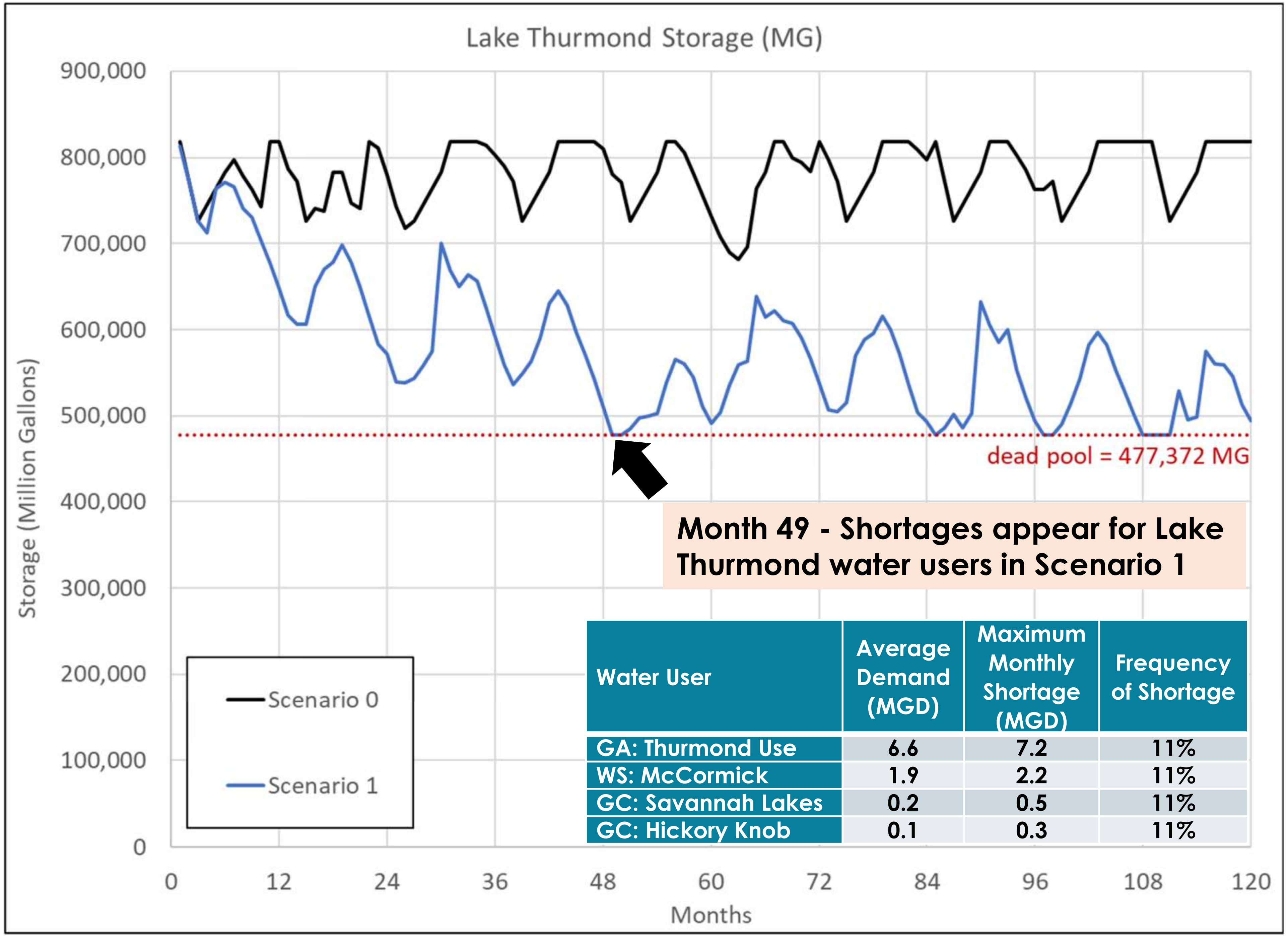
Mean annual flow = 22.5 CFS

Jan 1956
Feb 2017
Mar 2017
Apr 1986
May 2001
Jun 2008
Jul 2008
Aug 2007
Sep 1954
Oct 1954
Nov 2016
Dec 1955



Resequencing Historical Flows to Investigate Potential Future Droughts

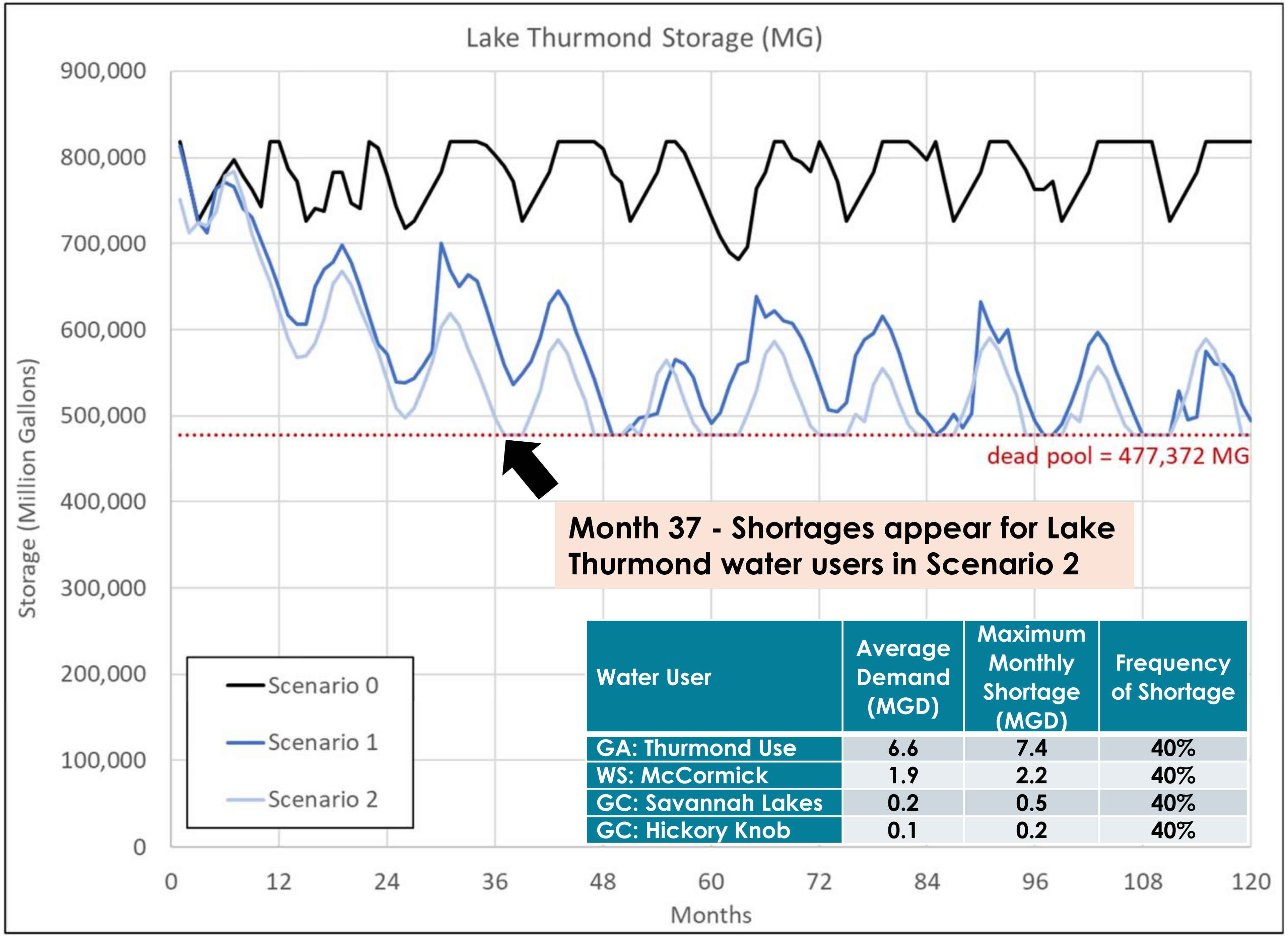
Resequencing Historical Flows to Investigate Potential Future Droughts



Water User	Average Demand (MGD)	Maximum Monthly Shortage (MGD)	Frequency of Shortage
GA: Thurmond Use	6.6	7.2	11%
WS: McCormick	1.9	2.2	11%
GC: Savannah Lakes	0.2	0.5	11%
GC: Hickory Knob	0.1	0.3	11%

Scenario 1 Shortages

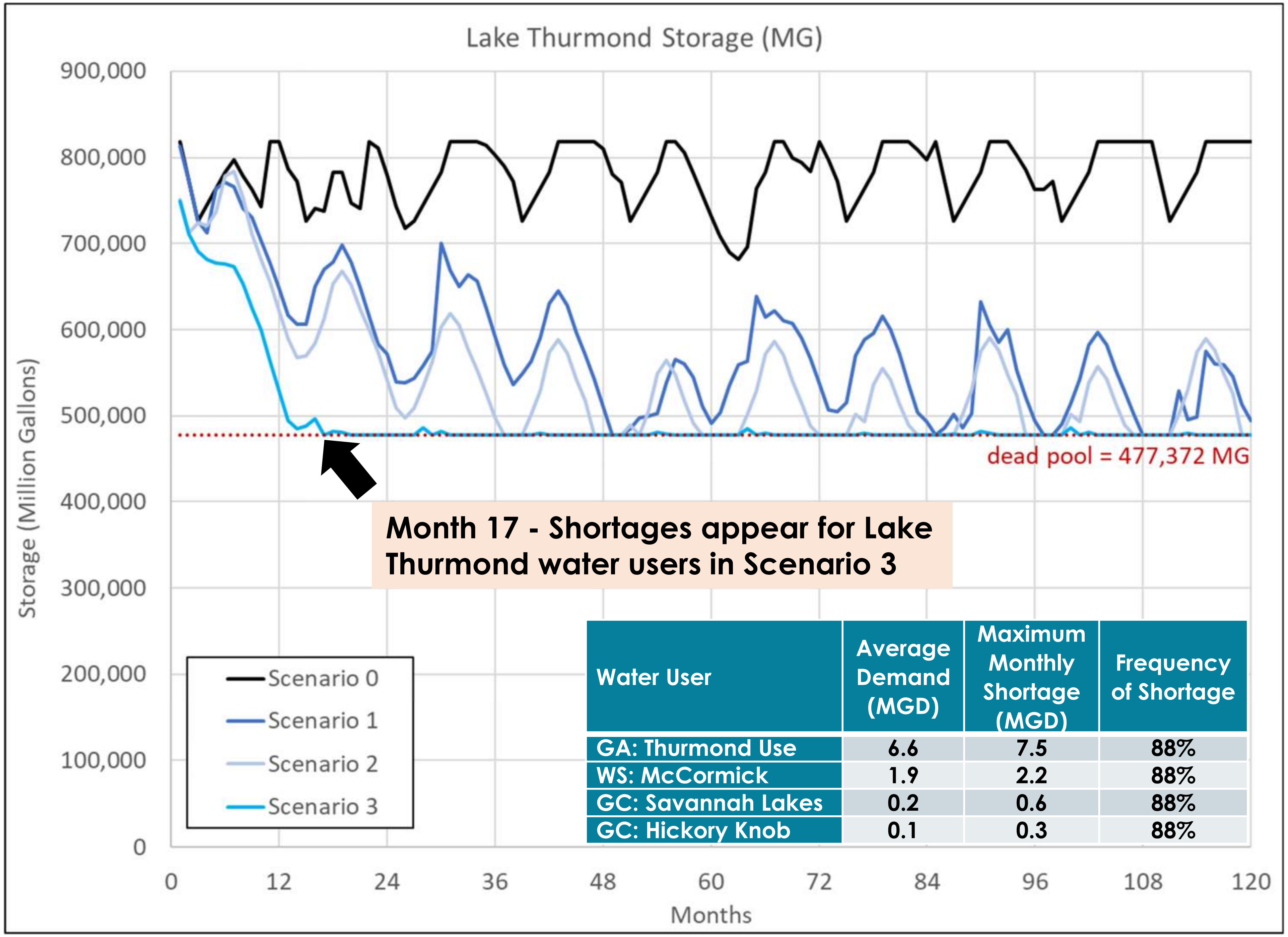
Resequencing Historical Flows to Investigate Potential Future Droughts



Water User	Average Demand (MGD)	Maximum Monthly Shortage (MGD)	Frequency of Shortage
GA: Thurmond Use	6.6	7.4	40%
WS: McCormick	1.9	2.2	40%
GC: Savannah Lakes	0.2	0.5	40%
GC: Hickory Knob	0.1	0.2	40%

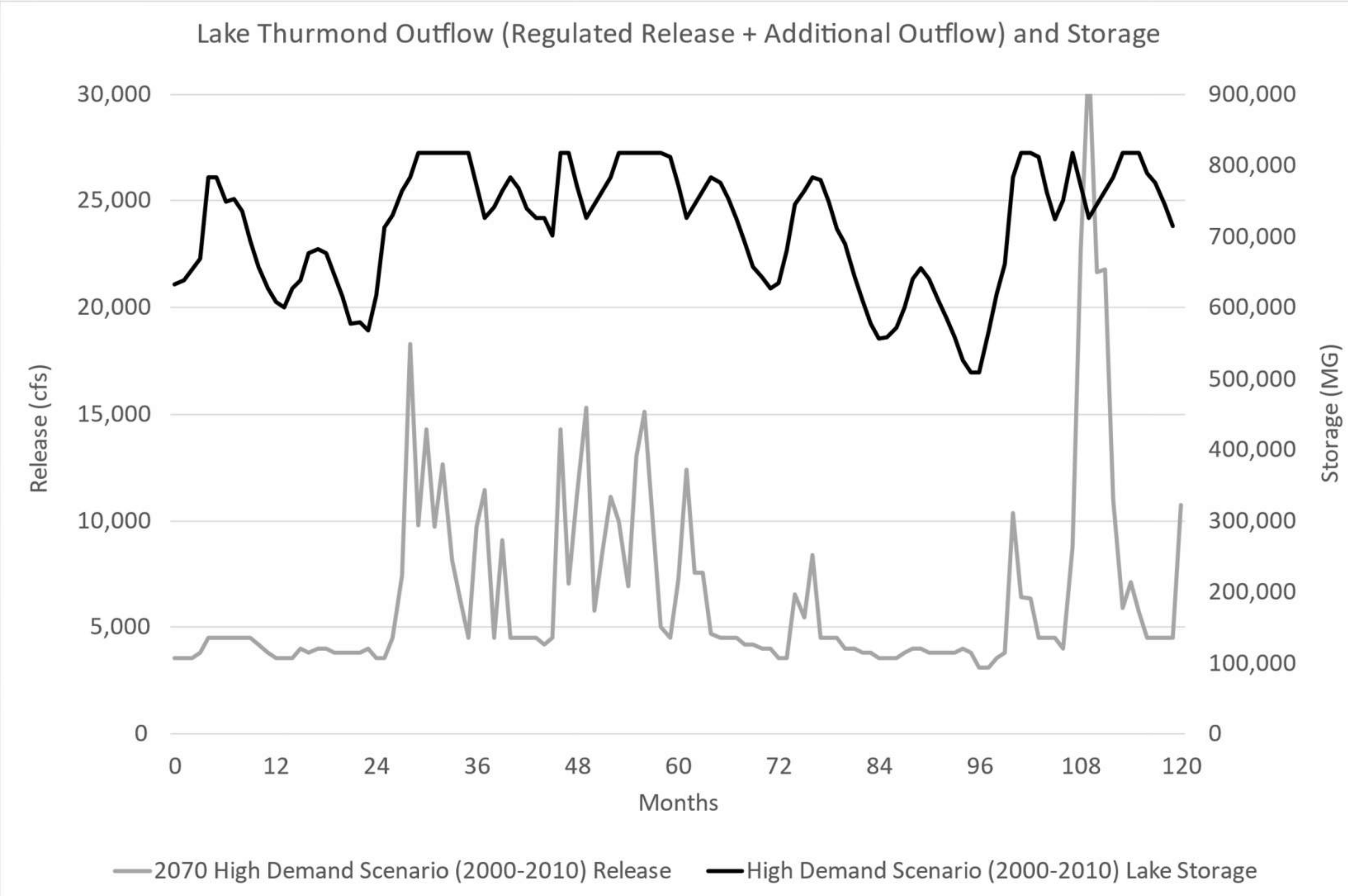
Scenario 2 Shortages

Resequencing Historical Flows to Investigate Potential Future Droughts



Water User	Average Demand (MGD)	Maximum Monthly Shortage (MGD)	Frequency of Shortage
GA: Thurmond Use	6.6	7.5	88%
WS: McCormick	1.9	2.2	88%
GC: Savannah Lakes	0.2	0.6	88%
GC: Hickory Knob	0.1	0.3	88%

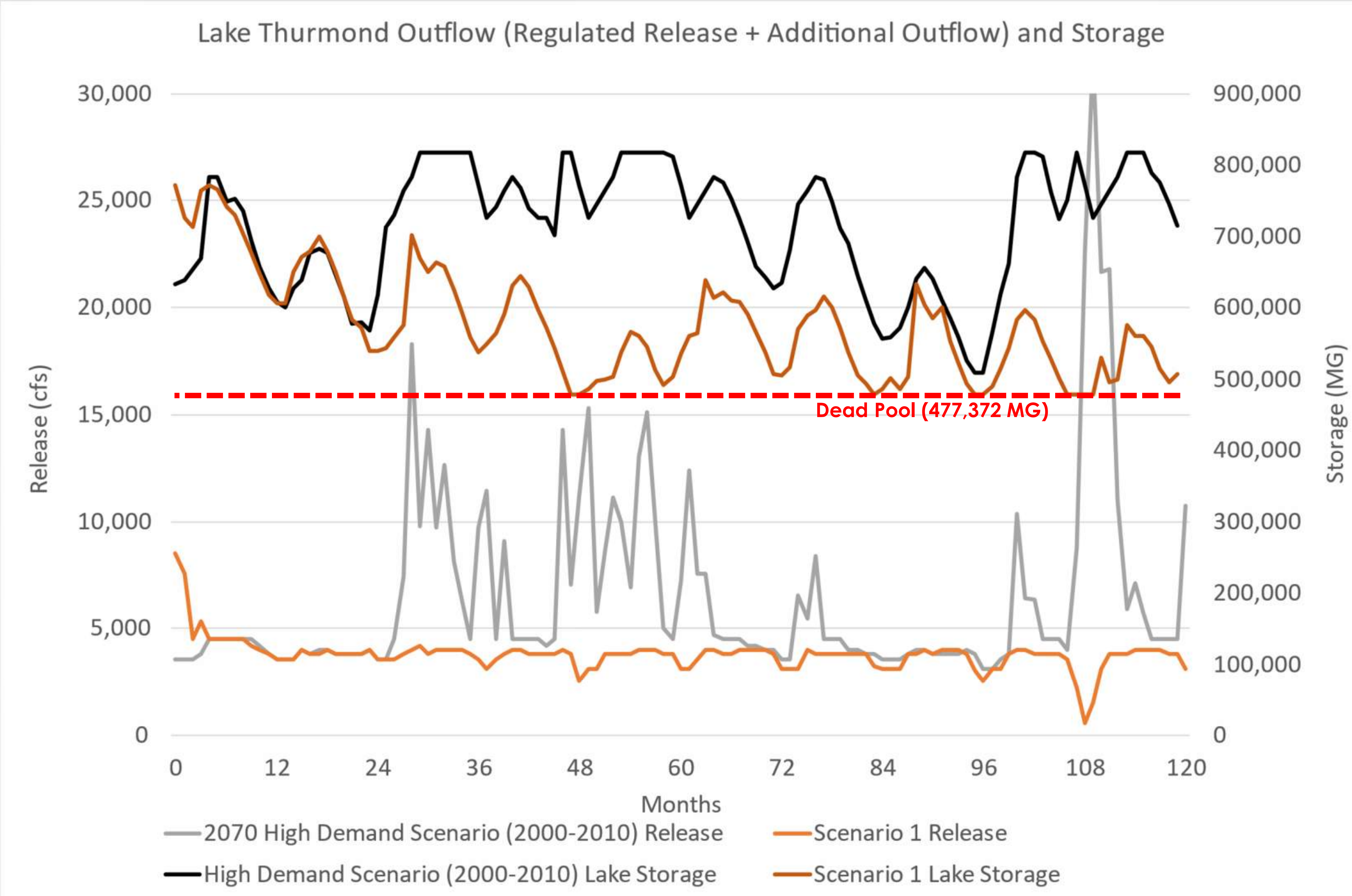
Scenario 3 Shortages



Resequencing Historical Flows to Investigate Potential Future Droughts

This graph plots Lake Thurmond storage and releases (monthly timestep)

2070 High Demand Scenario
For years 2000 – 2010

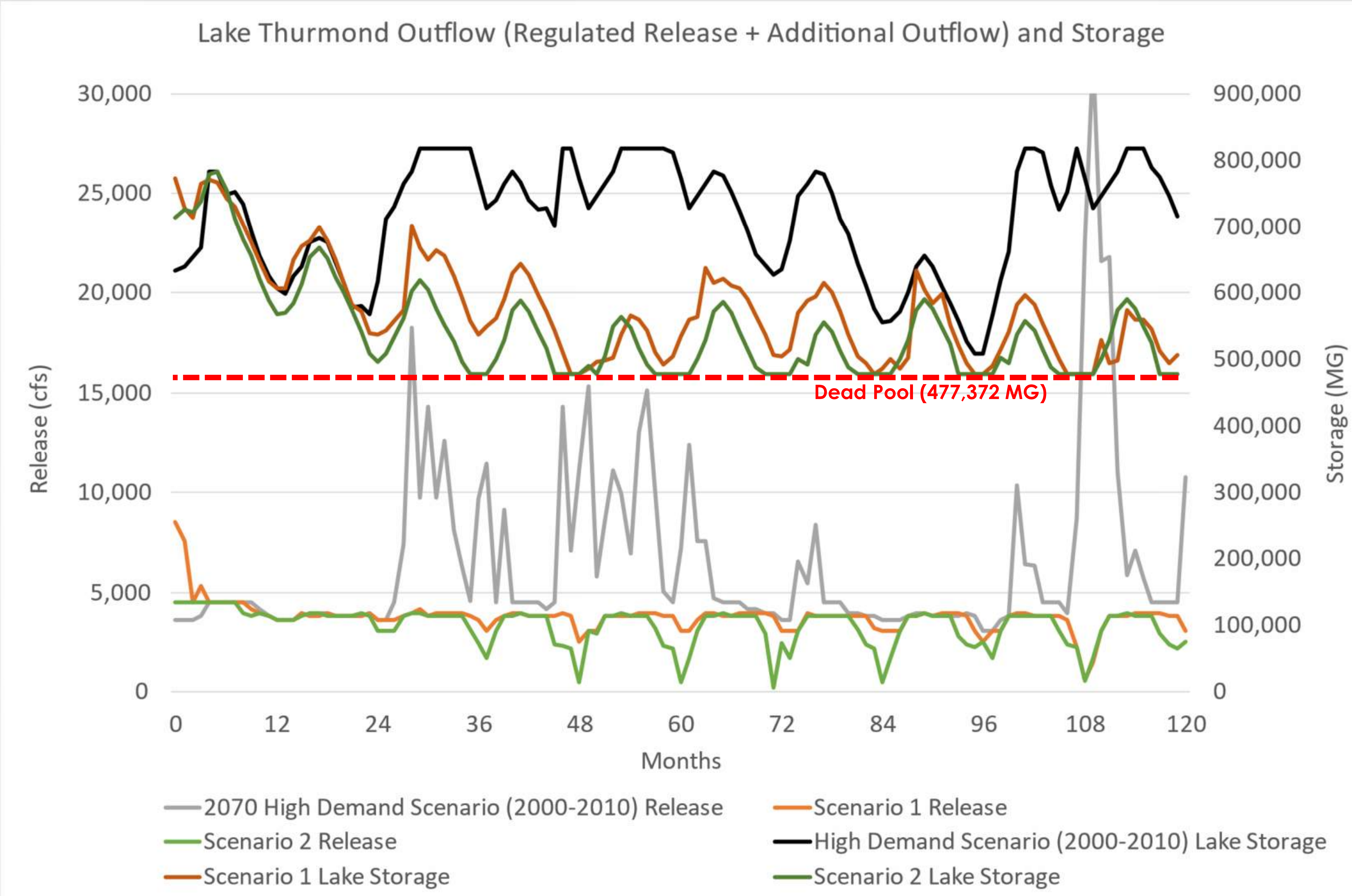


Resequencing Historical Flows to Investigate Potential Future Droughts

This graph plots Lake Thurmond storage and releases (monthly timestep)

2070 High Demand Scenario
For years 2000 – 2010

Drought Scenario 1



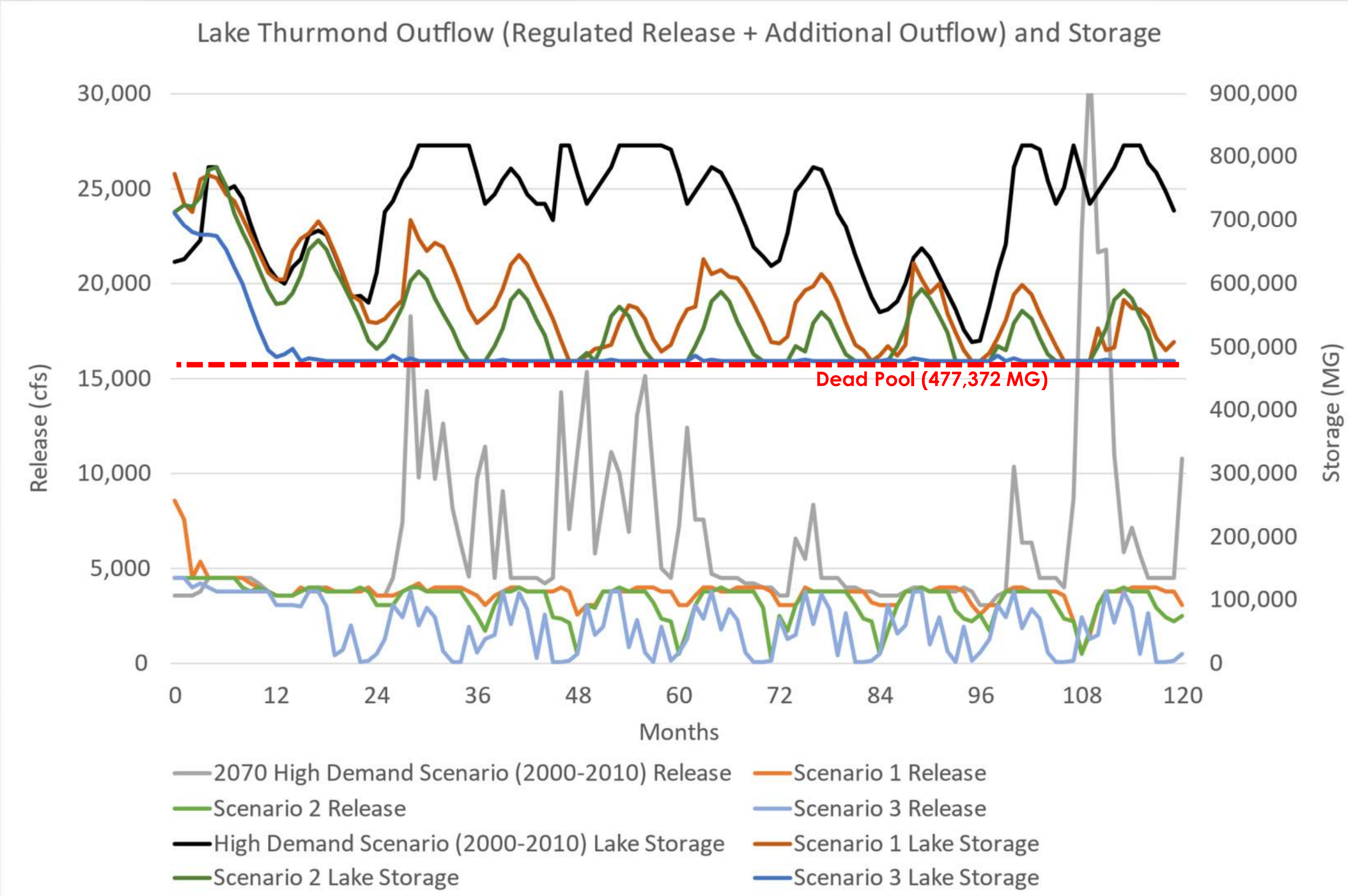
Resequencing Historical Flows to Investigate Potential Future Droughts

This graph plots Lake Thurmond storage and releases (monthly timestep)

2070 High Demand Scenario
For years 2000 – 2010

Drought Scenario 1

Drought Scenario 2



Resequencing Historical Flows to Investigate Potential Future Droughts

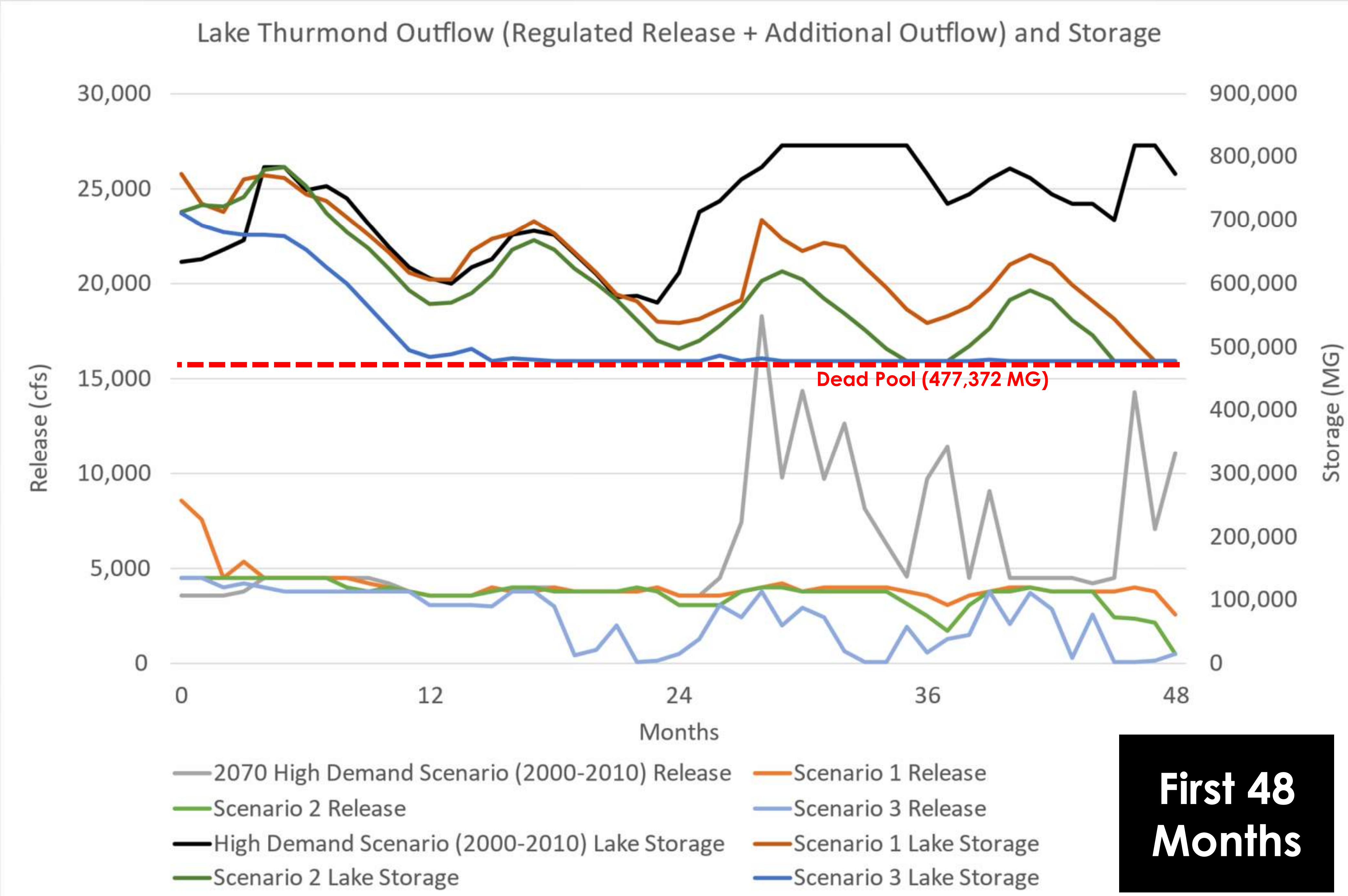
This graph plots Lake Thurmond storage and releases (monthly timestep)

2070 High Demand Scenario
For years 2000 – 2010

Drought Scenario 1

Drought Scenario 2

Drought Scenario 3



Resequencing Historical Flows to Investigate Potential Future Droughts

This graph plots Lake Thurmond storage and releases (monthly timestep)

2070 High Demand Scenario For years 2000 – 2010

Drought Scenario 1

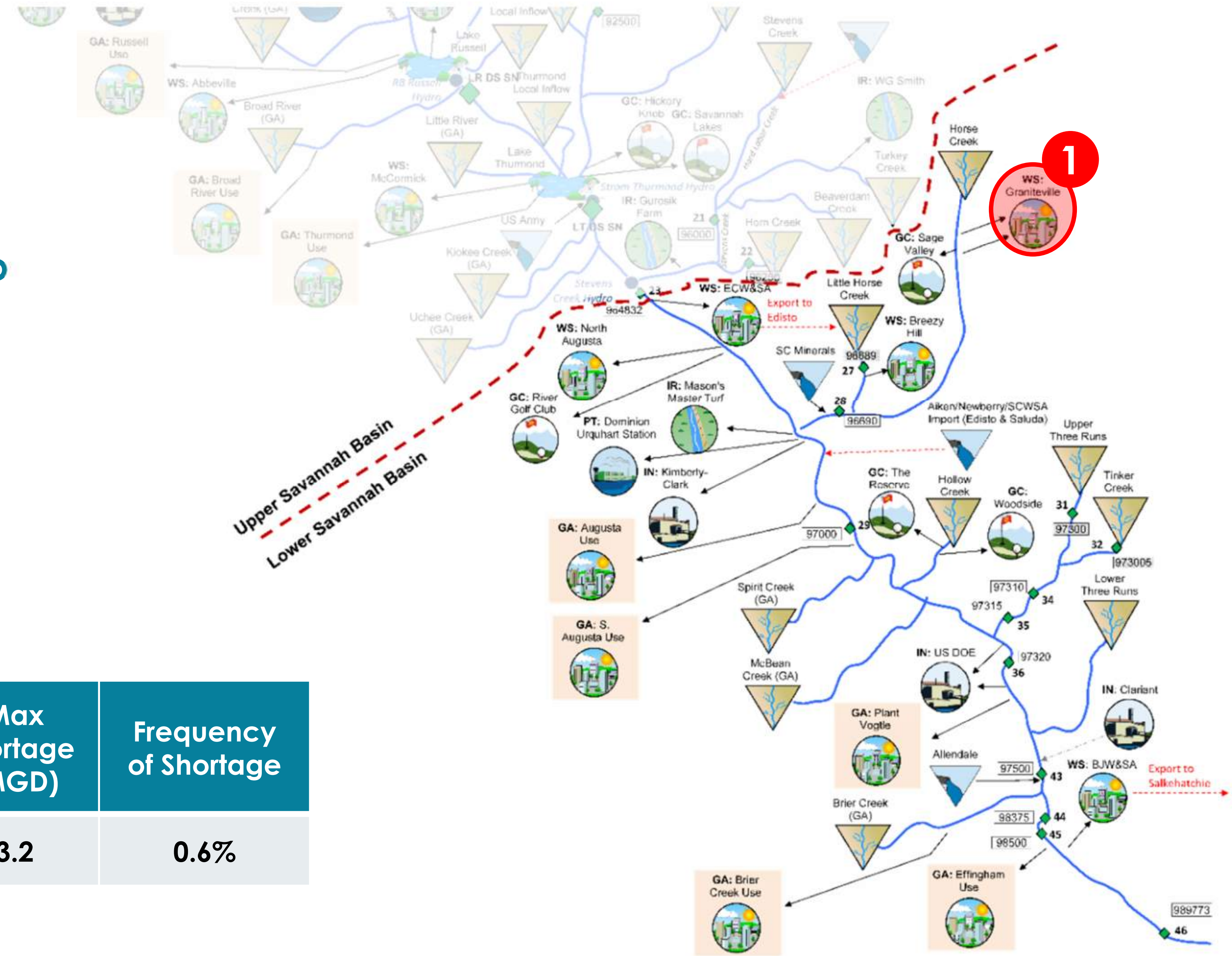
Drought Scenario 2

Drought Scenario 3

Lower Savannah River Basin

Drought Scenario 1

(uses 2070 High Demand Scenario demands)



1 Physical Shortage

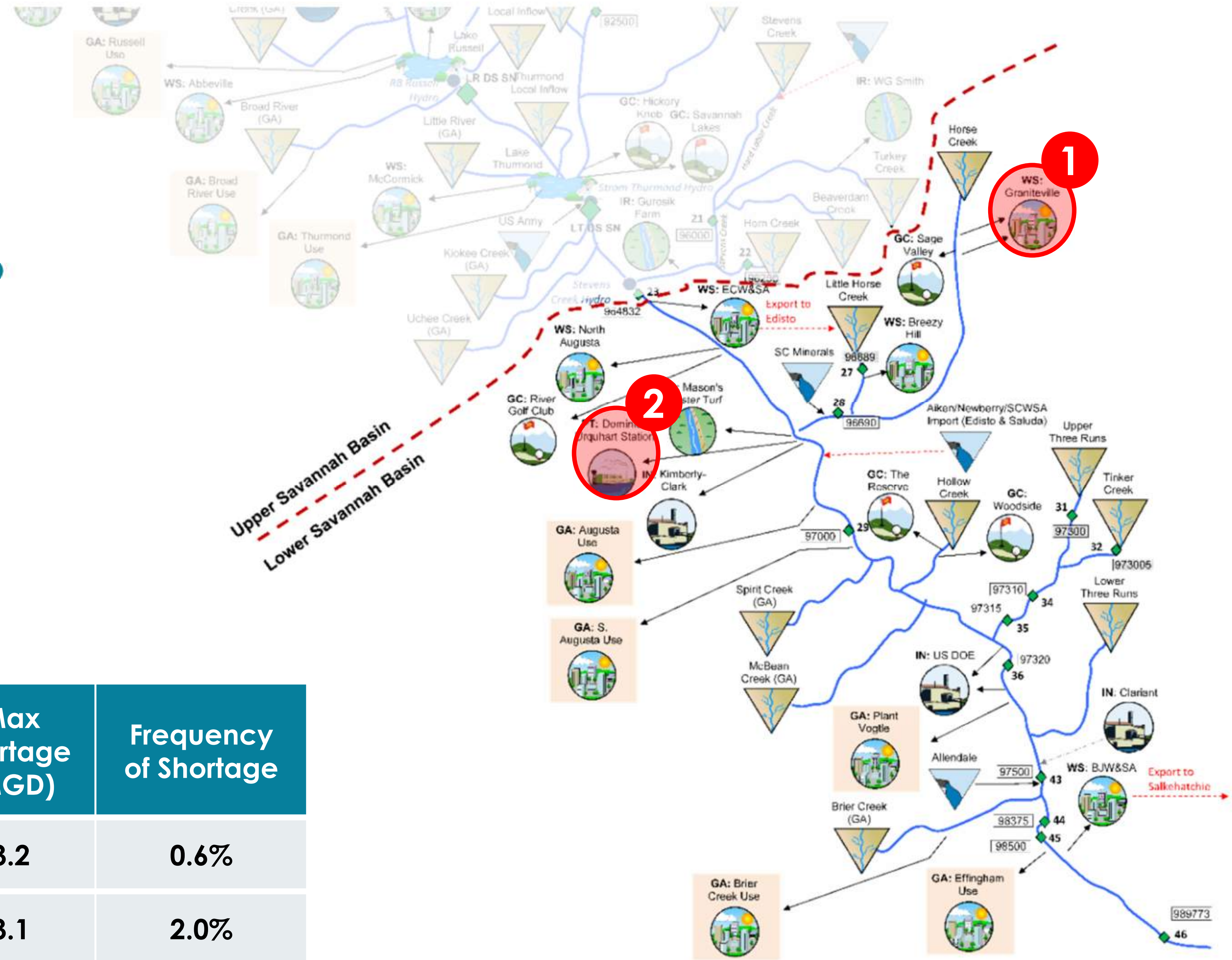
Surface Water Shortage Table

Map ID	Water User	Average Demand (MGD)	Max Shortage (MGD)	Frequency of Shortage
1	WS: Graniteville	19.5	3.2	0.6%

Lower Savannah River Basin

Drought Scenario 2

(uses 2070 High Demand Scenario demands)



1 Physical Shortage

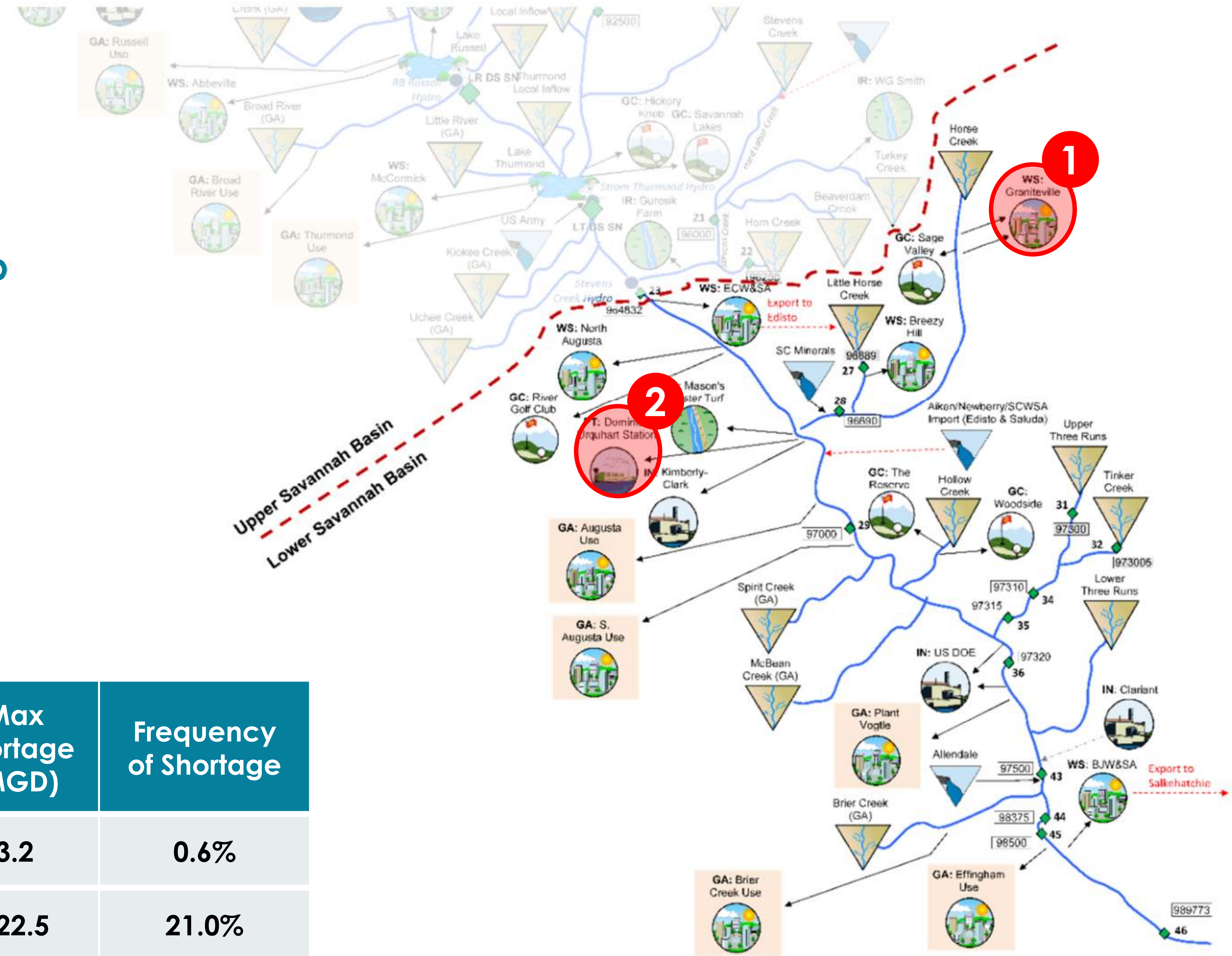
Surface Water Shortage Table

Map ID	Water User	Average Demand (MGD)	Max Shortage (MGD)	Frequency of Shortage
1	WS: Graniteville	19.5	3.2	0.6%
2	PT: Dominion Urquhart Station	149.8	3.1	2.0%

Lower Savannah River Basin

Drought Scenario 3

(uses 2070 High Demand Scenario demands)



1 Physical Shortage

Surface Water Shortage Table

Map ID	Water User	Average Demand (MGD)	Max Shortage (MGD)	Frequency of Shortage
1	WS: Graniteville	19.5	3.2	0.6%
2	PT: Dominion Urquhart Station	149.8	122.5	21.0%

Resequencing Historical Flows to Investigate Potential Future Droughts

Discussion & Limitations

- Reservoir operations play a role, primarily with respect to the *location* of shortages
    - Altered operational rules could, at least partially, mitigate shortages
- No attempts have been made to directly incorporate future hydrologic or climate projections (e.g. increased evap)
- Neglects changes in groundwater-surface water interactions (e.g. reduced baseflow due to aquifer depletions)

Resequencing Historical Flows to Investigate Potential Future Droughts

Discussion & Limitations

- USACE Drought Contingency Plan drought triggers conditioned upon flow in the Broad River (BR Index) would have some impact on the results, but the inability to meet release targets would still exist.

Trigger Level	Time of Year	Drought Response
1	Jan 1 - Dec 31	IF BR index >10%, Target 4200 cfs (daily average) release at Thurmond Dam IF BR index <10%, Target 4000 cfs (daily average) release at Thurmond Dam
2	Feb 1 - Oct 31	IF BR index >10%, Target 4000 cfs (daily average) release at Thurmond Dam IF BR index <10%, Target 3800 cfs (daily average) release at Thurmond Dam
	Nov 1 - Jan 31	Target 3600 cfs (daily average) release at Thurmond Dam
3	Feb 1 - Oct 31	Target 3800 cfs (daily average) release at Thurmond Dam
	Nov 1 - Jan 31 (Feb 1 – Feb 28 w/NMFS approval)	Target 3100 cfs (daily average) release at Thurmond Dam
4	Feb 1 - Oct 31	Target 3600 cfs (daily average) release at Thurmond Dam
	Nov 1 - Jan 31 (Feb 1 – Feb 28 w/NMFS approval)	Target 3100 cfs (daily average) release at Thurmond Dam