Edisto River Basin Council and Water Availability

Feb 2020

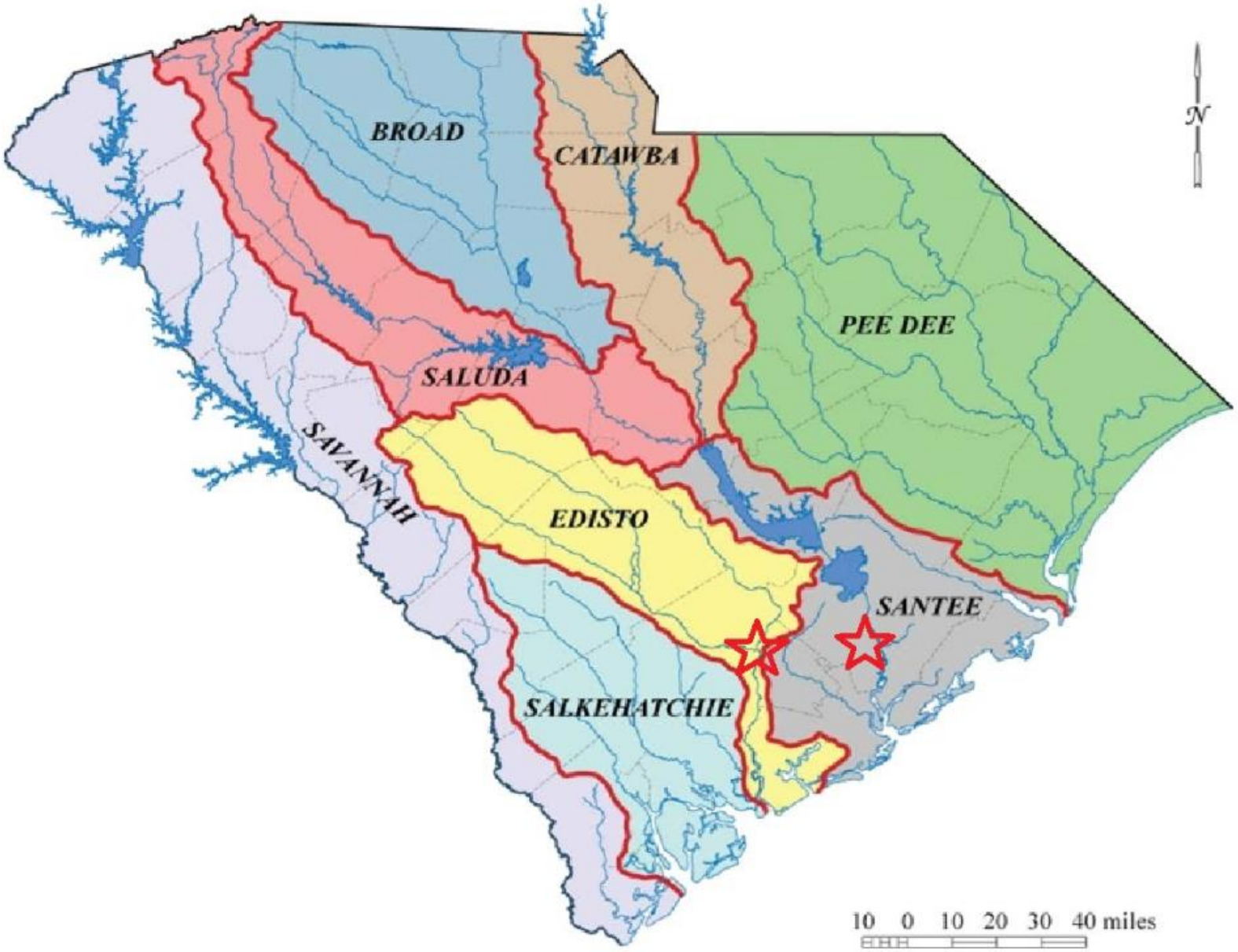


Figure 1. Map showing the eight major surface-water basins in South Carolina.

Surface and Ground Water Withdrawal

A Few Straws in this Cup

OUTLINE

- River Flow Trends and Patterns
- Availability and Allocation
- Recommendations Based on Above Data

**Most of this material isn't new, but is presented in a way that will hopefully be helpful as we consider the results of the basin scenarios and begin to think about the RBC plan we are developing*

MISSION, VISION AND GOALS

Misson - To develop, update, and support implementation of a River Basin Plan for sustainable management of water resources in the Edisto.

Vision - A resilient and sustainably managed Edisto River Basin where stakeholder and ecosystem needs are recognized, balanced and protected.

Goals 1. Develop water use strategies, policies, and legislative recommendations for the Edisto River Basin in order to:

- Ensure water resources are maintained to support current and future human and ecosystem needs.
- Improve the resiliency of the water resources and help minimize disruptions within the basin.
- Promote future development in areas with adequate water resources.
- Encourage responsible land use practices.

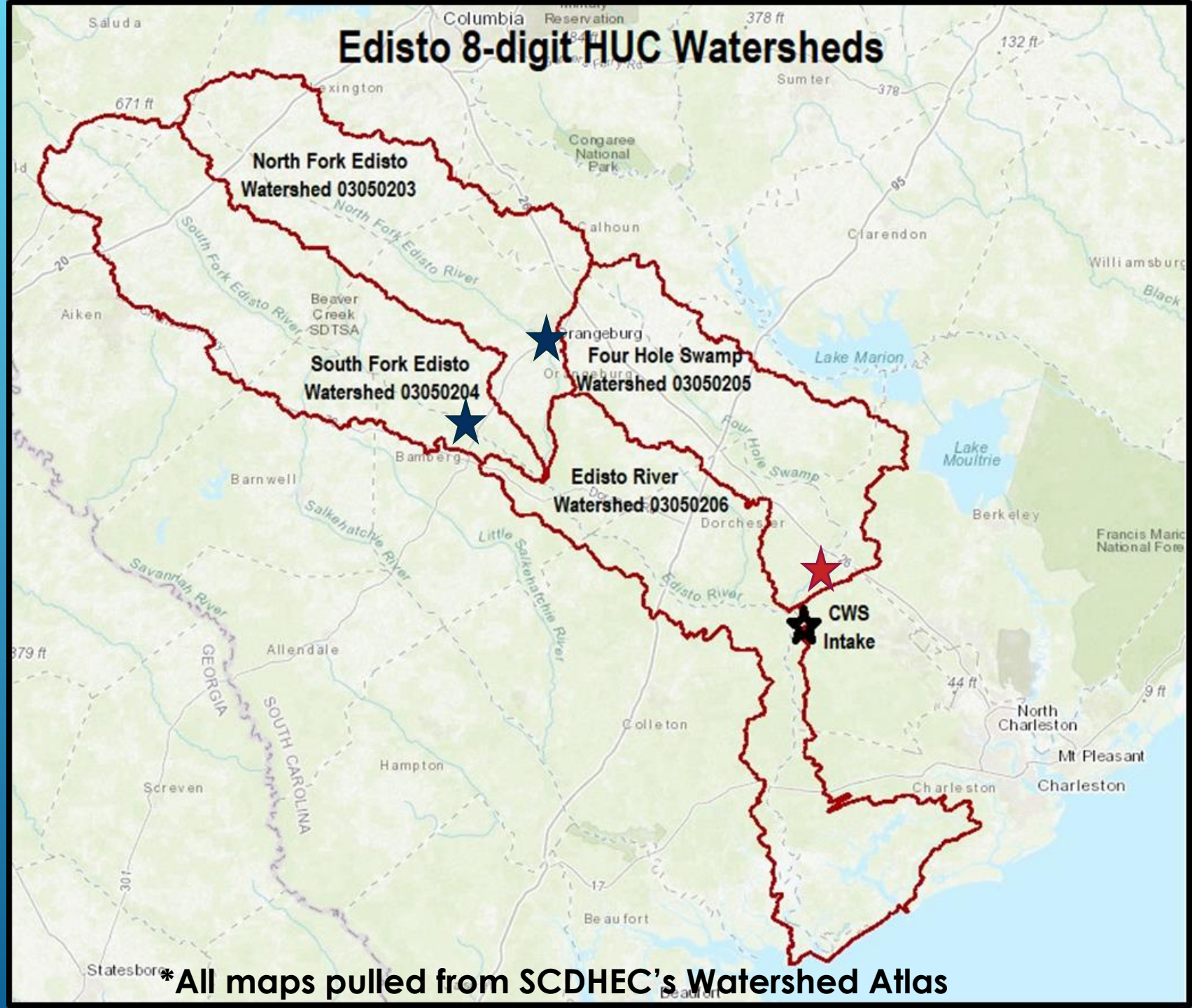
2. Develop and implement a communication plan to promote the strategies, policies and recommendations developed for the Edisto River Basin.

IMPORTANT POINTS OF AGREEMENT

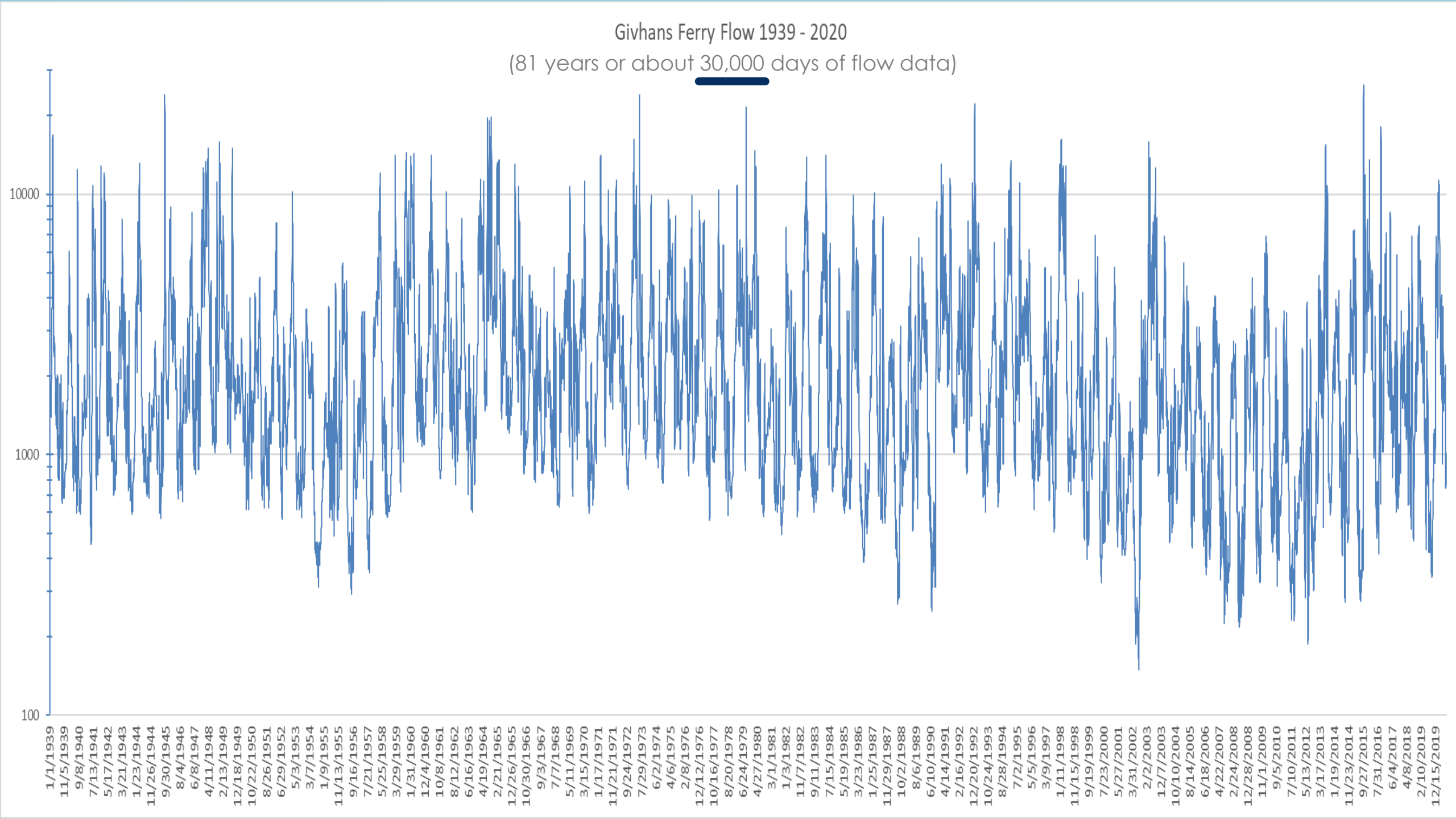
- Good or bad, the Edisto RBC will set a precedent for the other RBCs
- The RBC plans will inform a new state water plan
- The focus of the RBCs should be on what is right for their basins
- The problem isn't due to any one stakeholder or stakeholder group and focusing on a stakeholder group isn't conducive to creating a solution oriented and collaborative environment with the RBC
- "Sustainably managed" means a river flow sufficient to meet withdrawal demands while leaving adequate environmental flow
- All the stakeholders are in the same boat (i.e. basin)

Main Branch Data and Statistics

1. This presentation focus only on what the main branch flow data may be telling us
2. Currently, no flow station near the bottom of Four Hole Swamp
3. The flow at a station isn't just reflective of withdrawal at or near that station, but rather, reflects all withdrawal, precipitation and groundwater inflow in the upstream watersheds

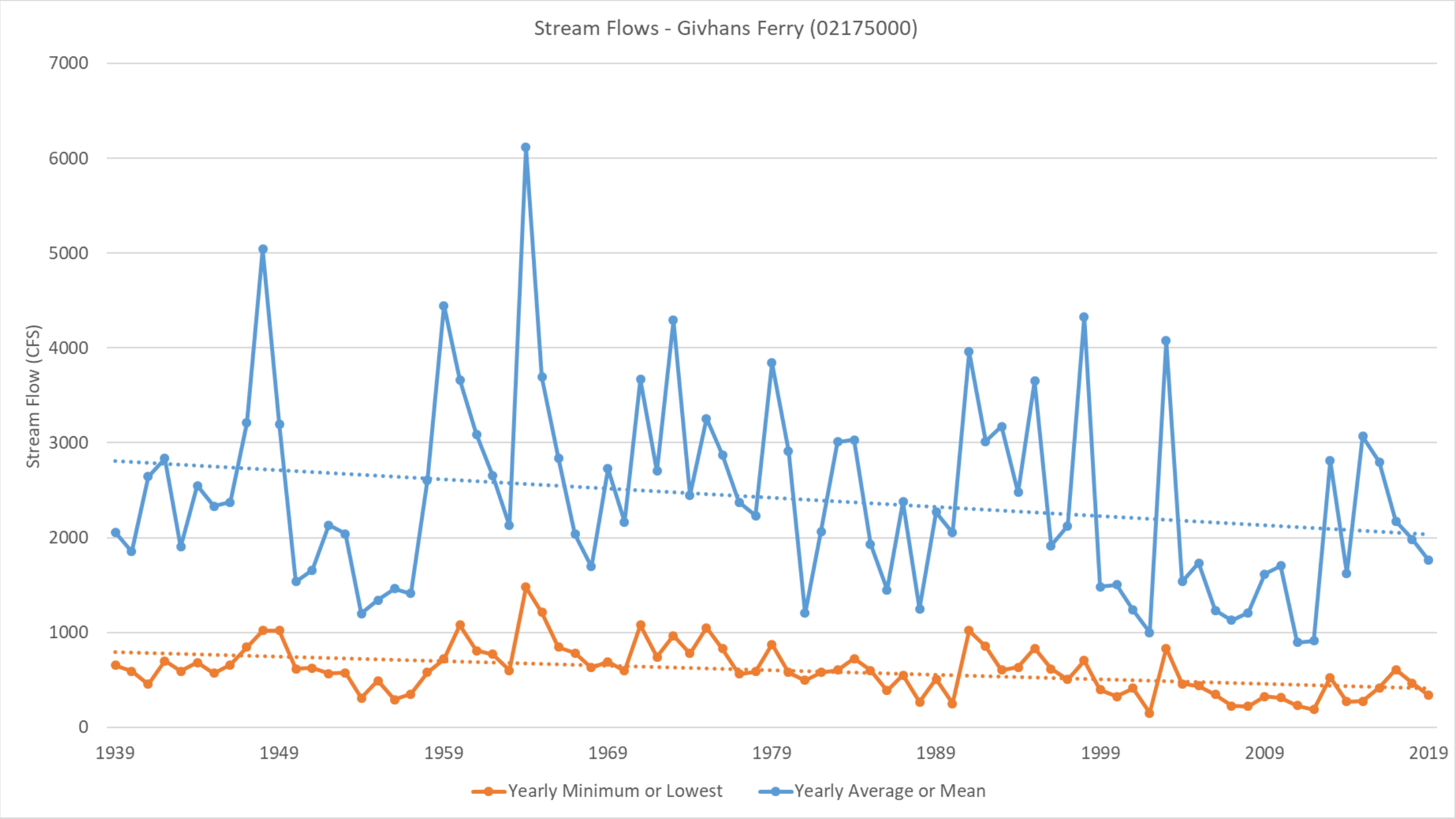


*All maps pulled from SCDHEC's Watershed Atlas


Givhans Ferry Flow 1939 - 2020
(81 years or about 30,000 days of flow data)
10000
1000
100
1/1/1939
11/5/1939
9/8/1940
7/13/1941
5/17/1942
3/21/1943
1/23/1944
11/26/1944
9/30/1945
8/4/1946
6/8/1947
4/11/1948
2/13/1949
12/18/1949
10/22/1950
8/26/1951
6/29/1952
5/3/1953
3/7/1954
1/9/1955
11/13/1955
9/16/1956
7/21/1957
5/25/1958
3/29/1959
1/31/1960
12/4/1960
10/8/1961
8/12/1962
6/16/1963
4/19/1964
2/21/1965
12/26/1965
10/30/1966
9/3/1967
7/7/1968
5/11/1969
3/15/1970
1/17/1971
11/21/1971
9/24/1972
7/29/1973
6/2/1974
4/6/1975
2/8/1976
12/12/1976
10/16/1977
8/20/1978
6/24/1979
4/27/1980
3/1/1981
1/3/1982
11/7/1982
9/11/1983
7/15/1984
5/19/1985
3/23/1986
1/25/1987
11/29/1987
10/2/1988
8/6/1989
6/10/1990
4/14/1991
2/16/1992
12/20/1992
10/24/1993
8/28/1994
7/2/1995
5/5/1996
3/9/1997
1/11/1998
11/15/1998
9/19/1999
7/23/2000
5/27/2001
3/31/2002
2/2/2003
12/7/2003
10/10/2004
8/14/2005
6/18/2006
4/22/2007
2/24/2008
12/28/2008
11/1/2009
9/5/2010
7/10/2011
5/13/2012
3/17/2013
1/19/2014
11/23/2014
9/27/2015
7/31/2016
6/4/2017
4/8/2018
2/10/2019
12/15/2019

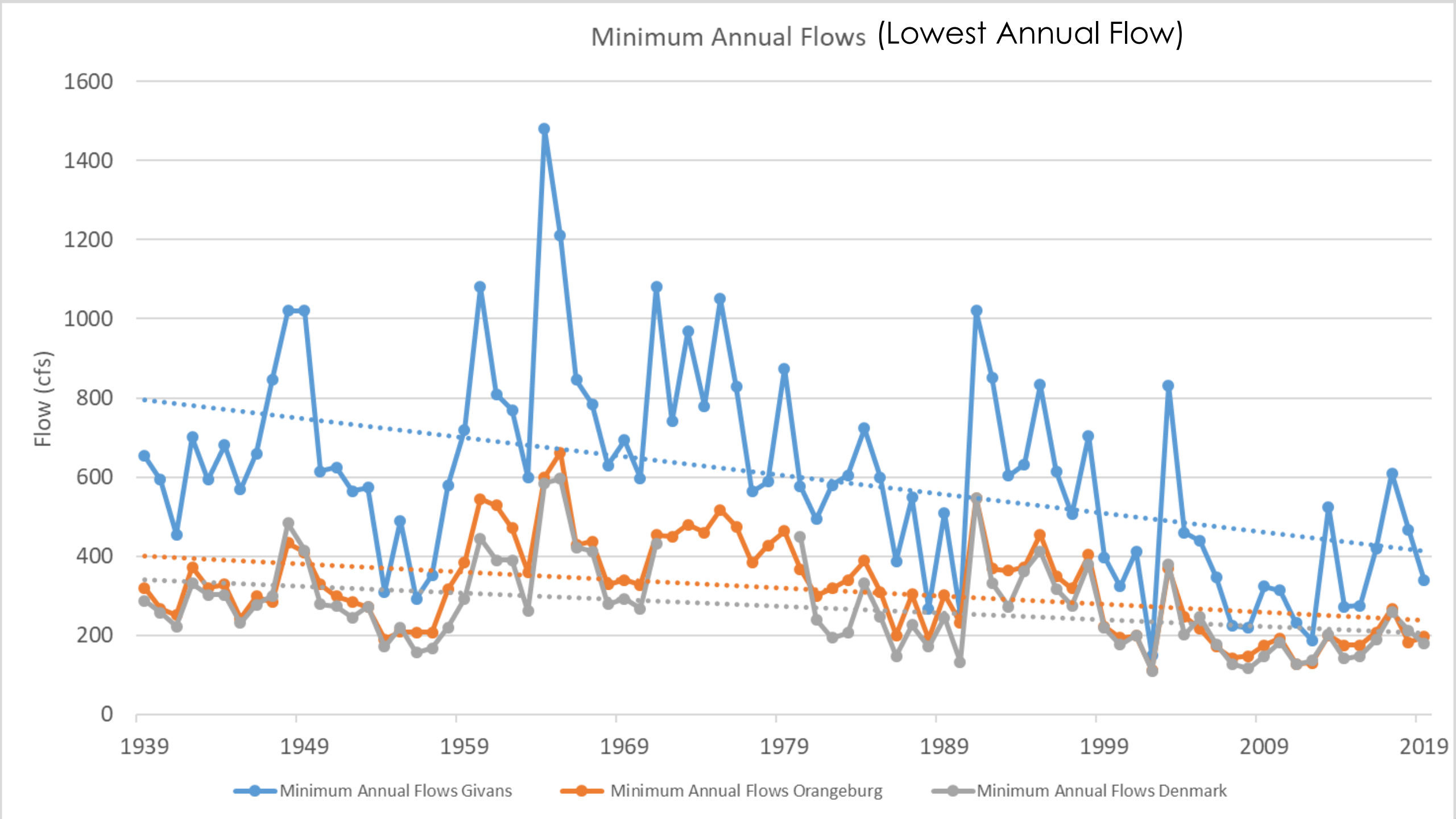
ANNUAL FLOWS

- Important to understand historical flows before attempting to understand the potential impacts of future demands
- The river sees many extremes in flow every year
- Plotting the average and lowest flow from each year can help when comparing one year to the rest
- It also simplifies the data enough to potentially reveal trends and patterns that may not otherwise be apparent


Stream Flows - Givhans Ferry (02175000)
Stream Flow (CFS)
7000
6000
5000
4000
3000
2000
1000
0
1939
1949
1959
1969
1979
1989
1999
2009
2019
Yearly Minimum or Lowest
Yearly Average or Mean

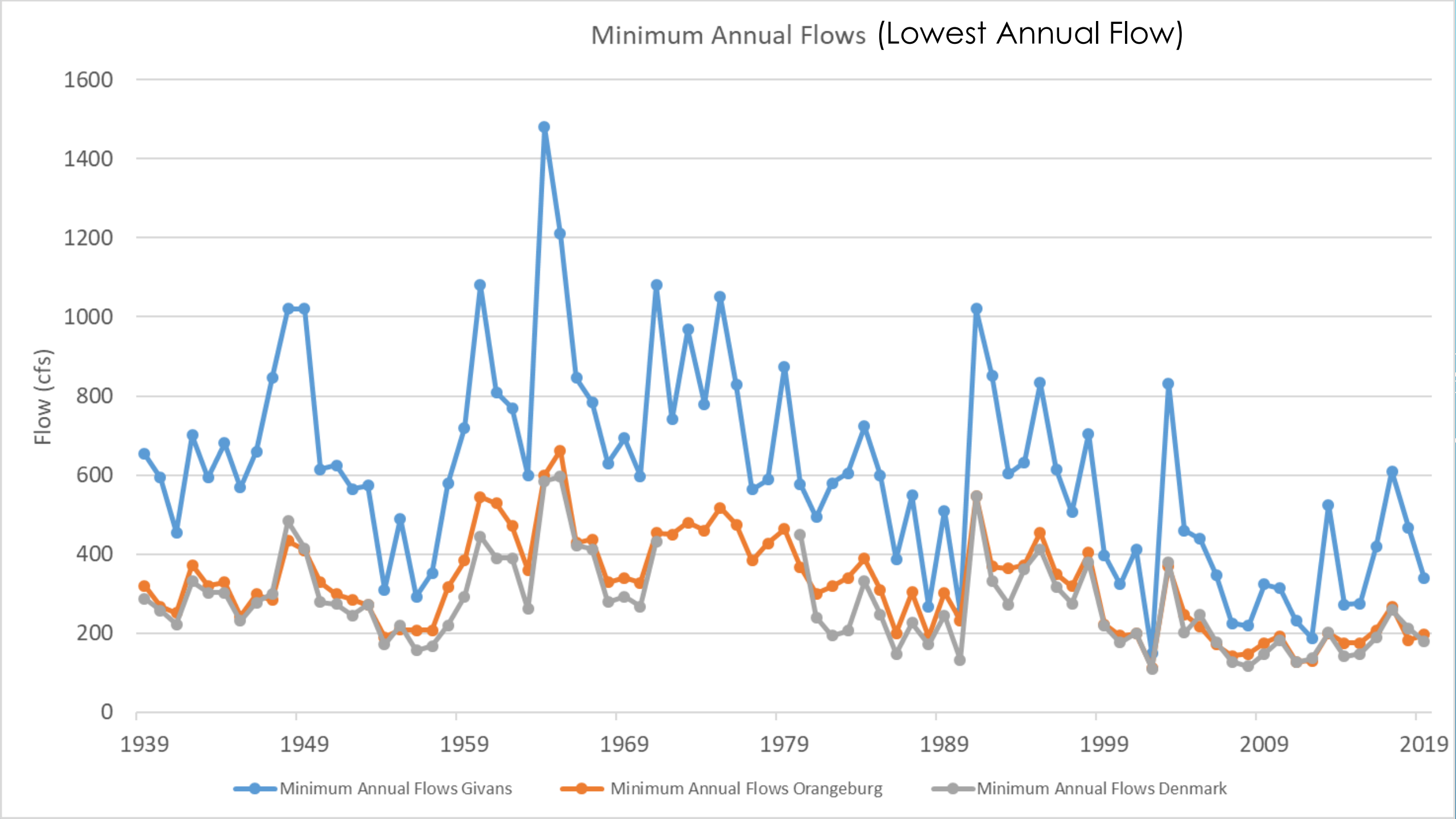
ANNUAL LOW FLOWS

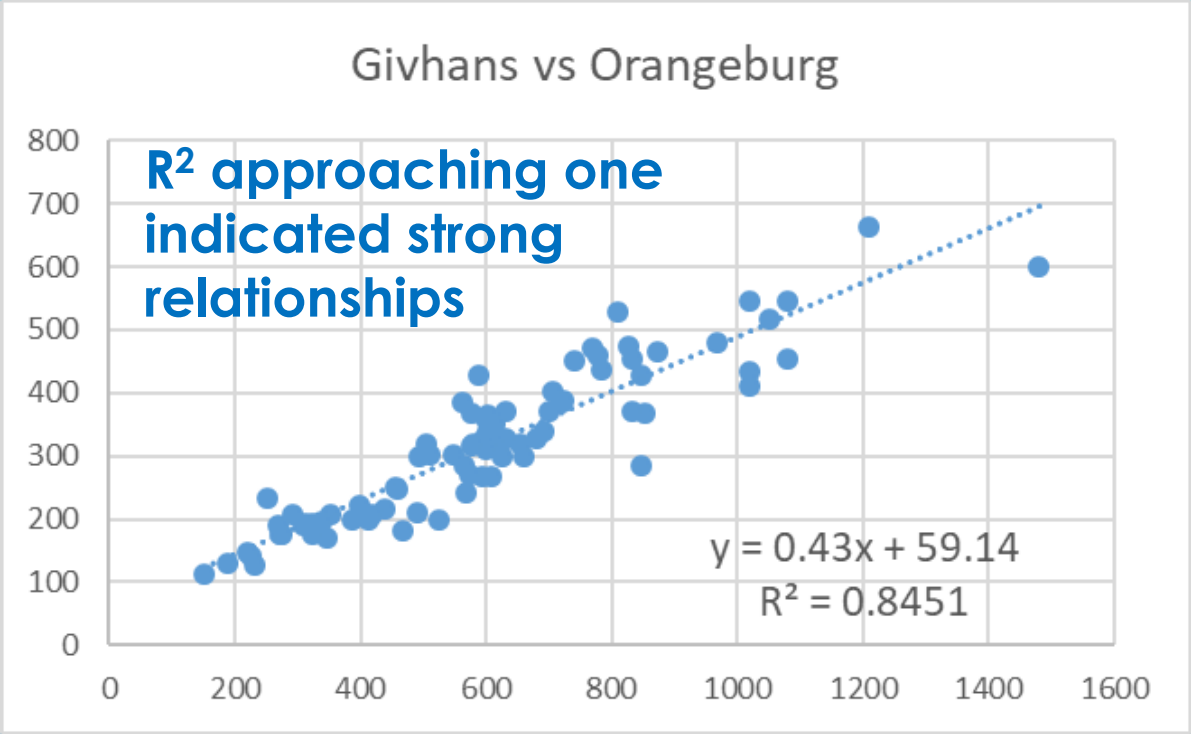
- Not every lowest annual flow is of concern (i.e. both withdrawal demand and minimum instream met)
- Low flow statistics (like 7Q10) can help determine which low flows are lower than usual
- Also important to see if the low flows have an increasing or decreasing trend

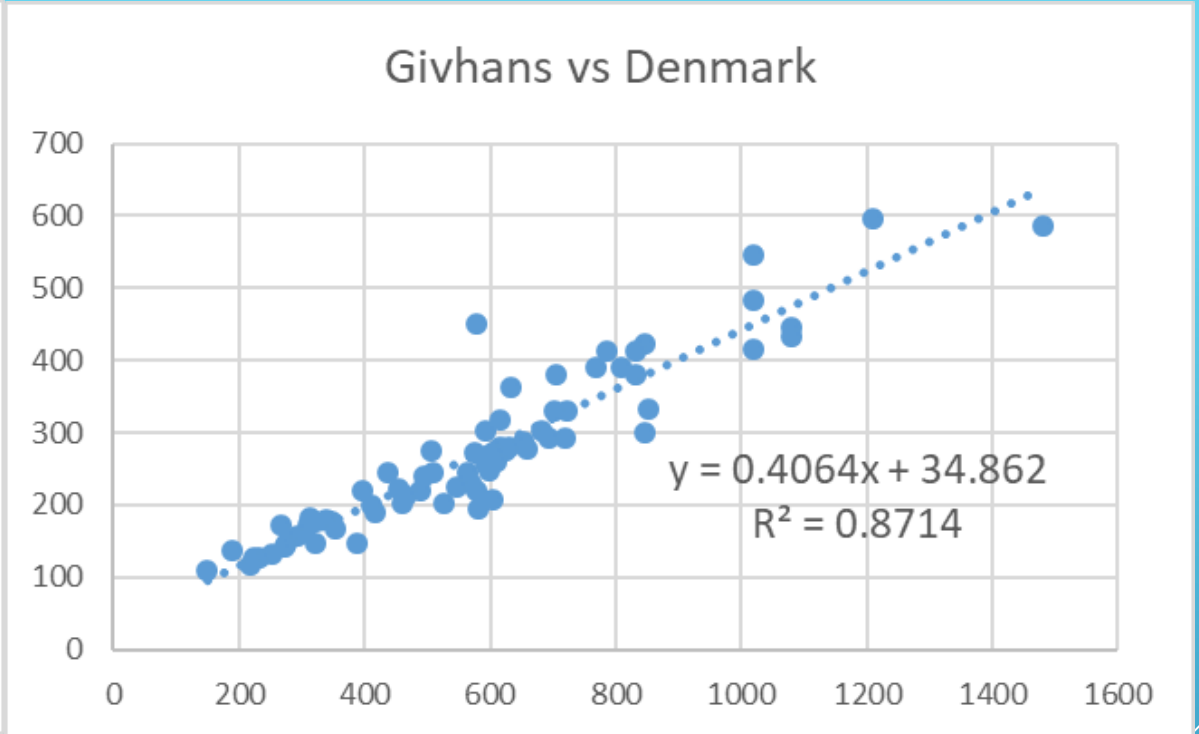

Minimum Annual Flows (Lowest Annual Flow)
Flow (cfs)
1600
1400
1200
1000
800
600
400
200
0
1939
1949
1959
1969
1979
1989
1999
2009
2019
Minimum Annual Flows Givans
Minimum Annual Flows Orangeburg
Minimum Annual Flows Denmark

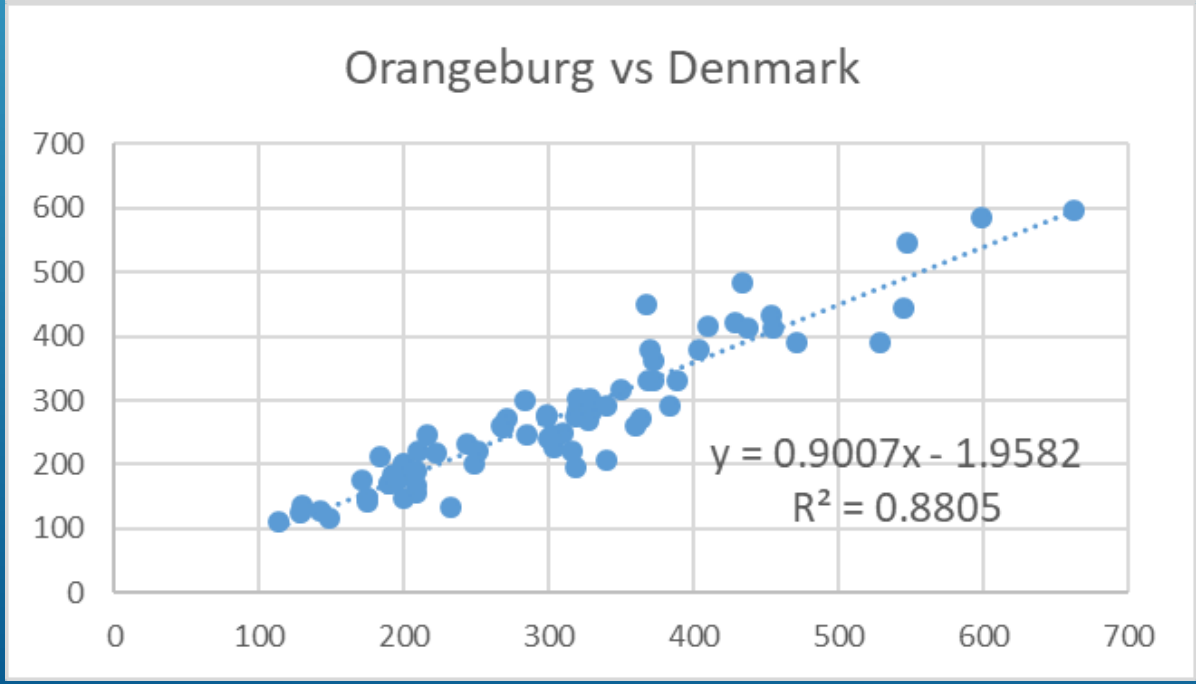
ANNUAL LOW FLOWS

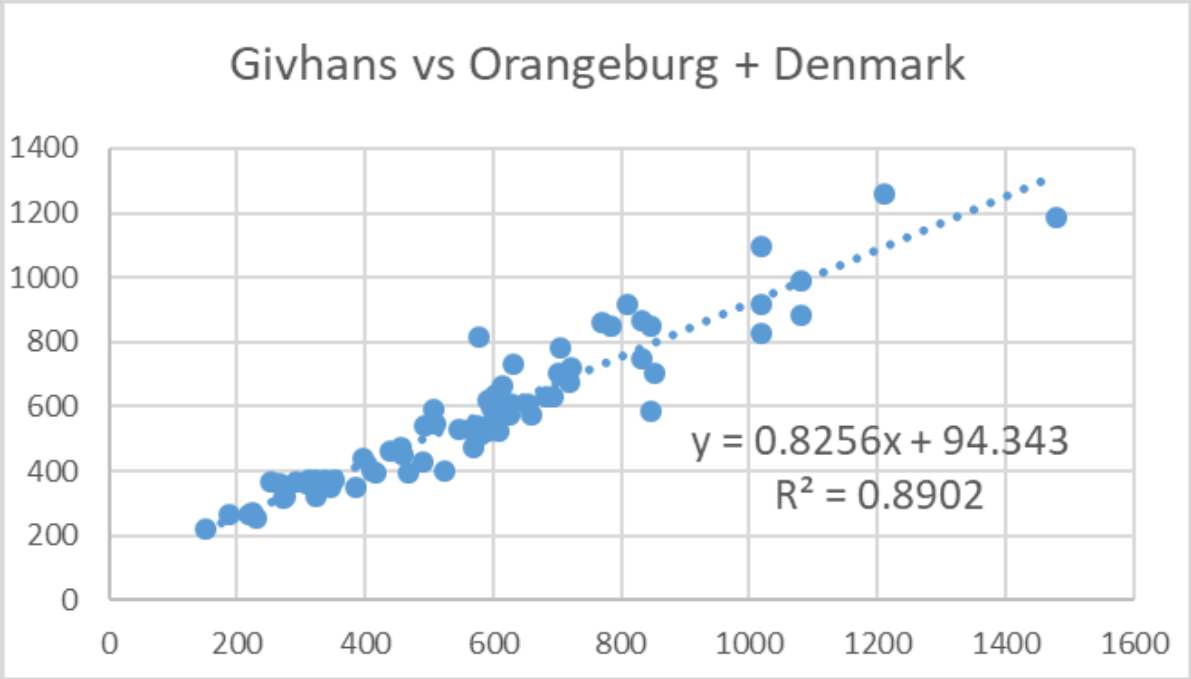
- The decreasing pattern in flows is a data based fact regardless of the cause
- The decreasing trend in low flows across the basin was corroborated by the latest USGS Low Flow Study (2017)
- Though they used an older statistic (7Q10) that may not be as familiar to some (or as easy to explain), the decreasing trend in 7Q10 is no less significant
- **7Q10** - the lowest 7-day average flow that occurs (on average) once every 10 years

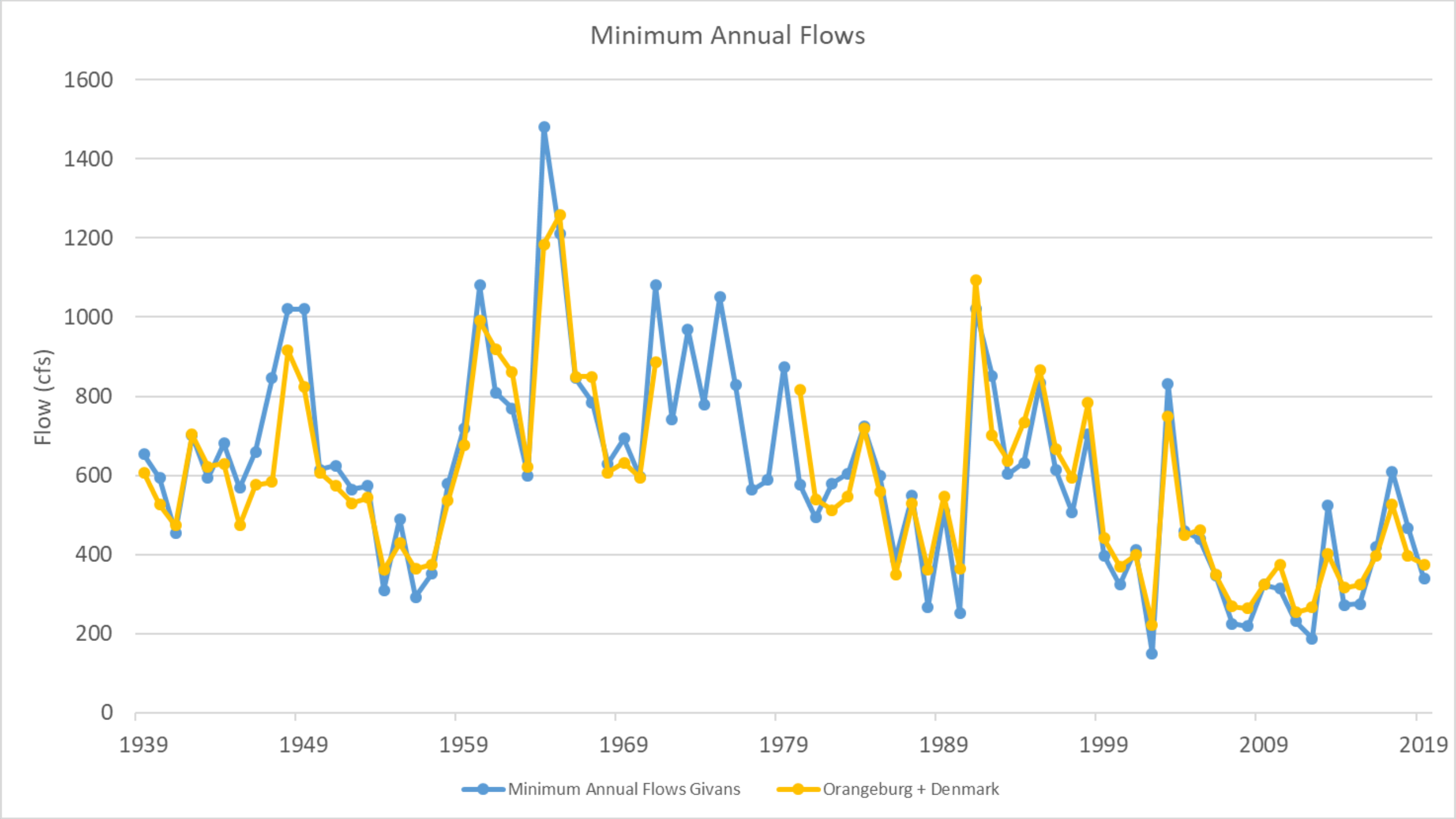

Minimum Annual Flows (Lowest Annual Flow)
Flow (cfs)
1600
1400
1200
1000
800
600
400
200
0
1939
1949
1959
1969
1979
1989
1999
2009
2019
Minimum Annual Flows Givans
Minimum Annual Flows Orangeburg
Minimum Annual Flows Denmark


Givhans vs Orangeburg
R² approaching one indicated strong relationships
y = 0.43x + 59.14
R² = 0.8451
0
100
200
300
400
500
600
700
800
0
200
400
600
800
1000
1200
1400
1600


Givhans vs Denmark
y = 0.4064x + 34.862
R² = 0.8714
0
100
200
300
400
500
600
700
0
200
400
600
800
1000
1200
1400
1600

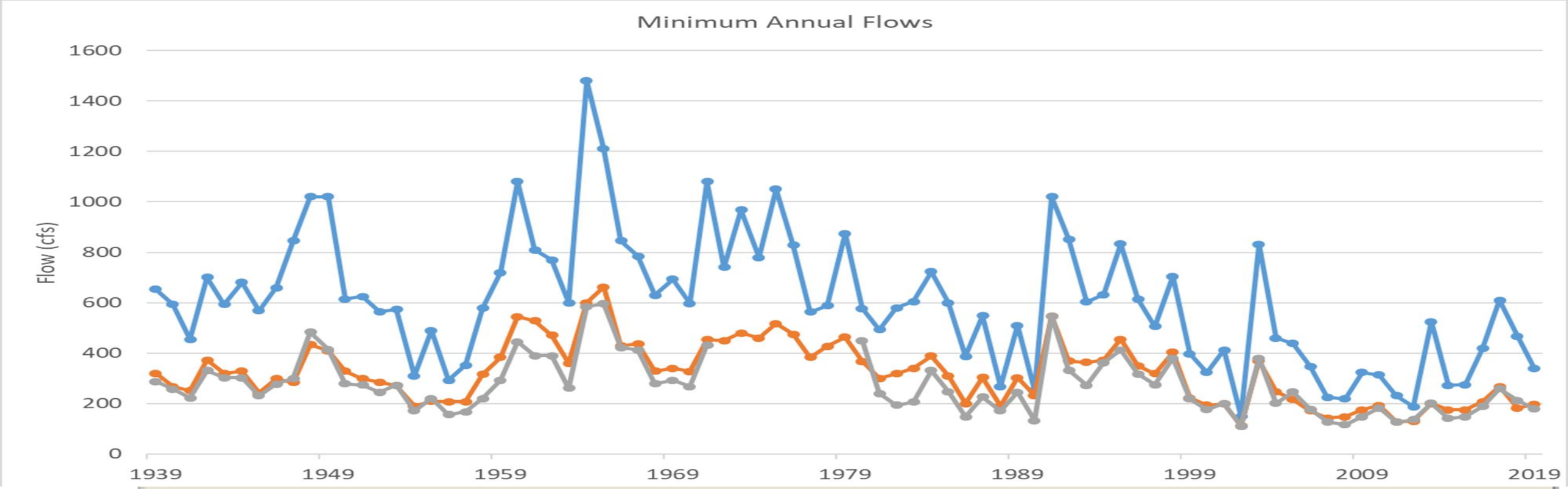

Orangeburg vs Denmark
y = 0.9007x - 1.9582
R² = 0.8805
0
100
200
300
400
500
600
700
0
100
200
300
400
500
600
700

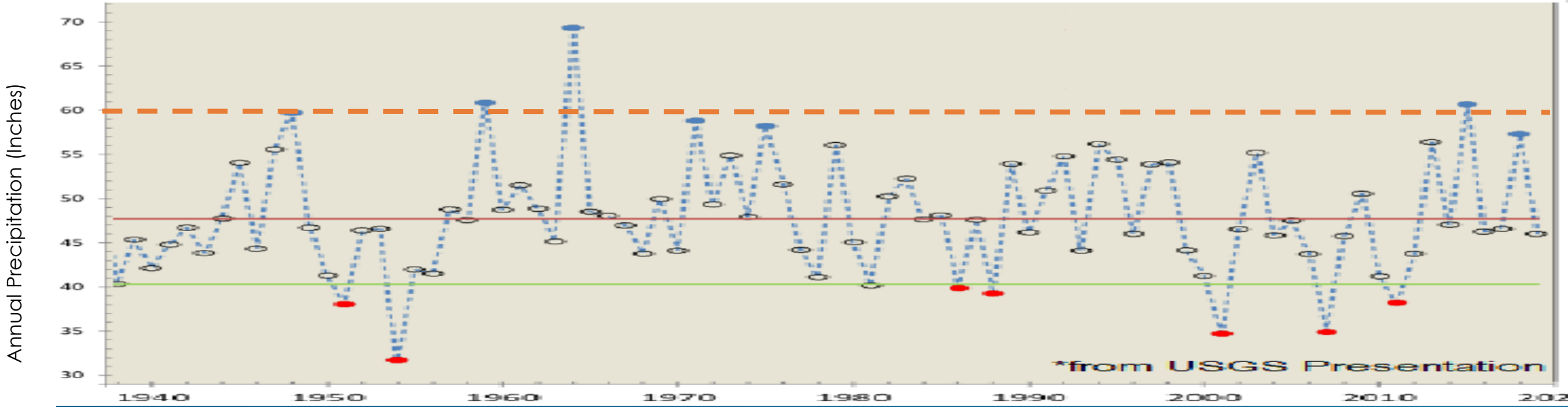

Givhans vs Orangeburg + Denmark
y = 0.8256x + 94.343
R² = 0.8902
0
200
400
600
800
1000
1200
1400
0
200
400
600
800
1000
1200
1400
1600


Minimum Annual Flows
Flow (cfs)
1600
1400
1200
1000
800
600
400
200
0
1939
1949
1959
1969
1979
1989
1999
2009
2019
Minimum Annual Flows Givans
Orangeburg + Denmark

BASIN-WIDE PATTERN FOR ANNUAL LOW FLOWS

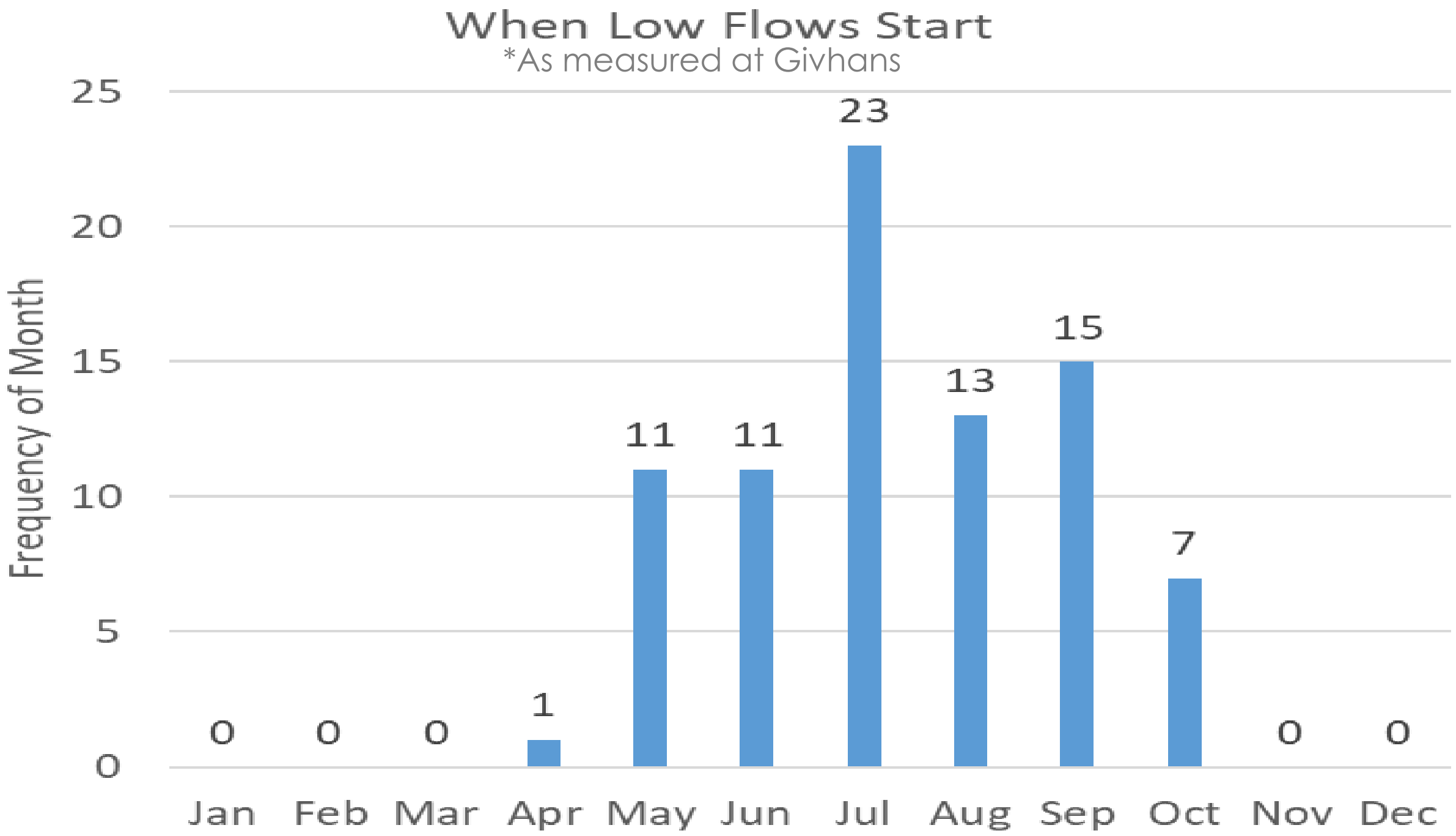
- Patterns and trends in low flows mirrored in all of the main branches point to a dependent variable capable of affecting the entire basin
- Withdrawal from one user(s) would not explain this nearly identical pattern across the basin and certainly not in parallel basins (North and South Fork)
- If surface withdrawal is not the primary reason for the patterns and trends in low flows, what is?

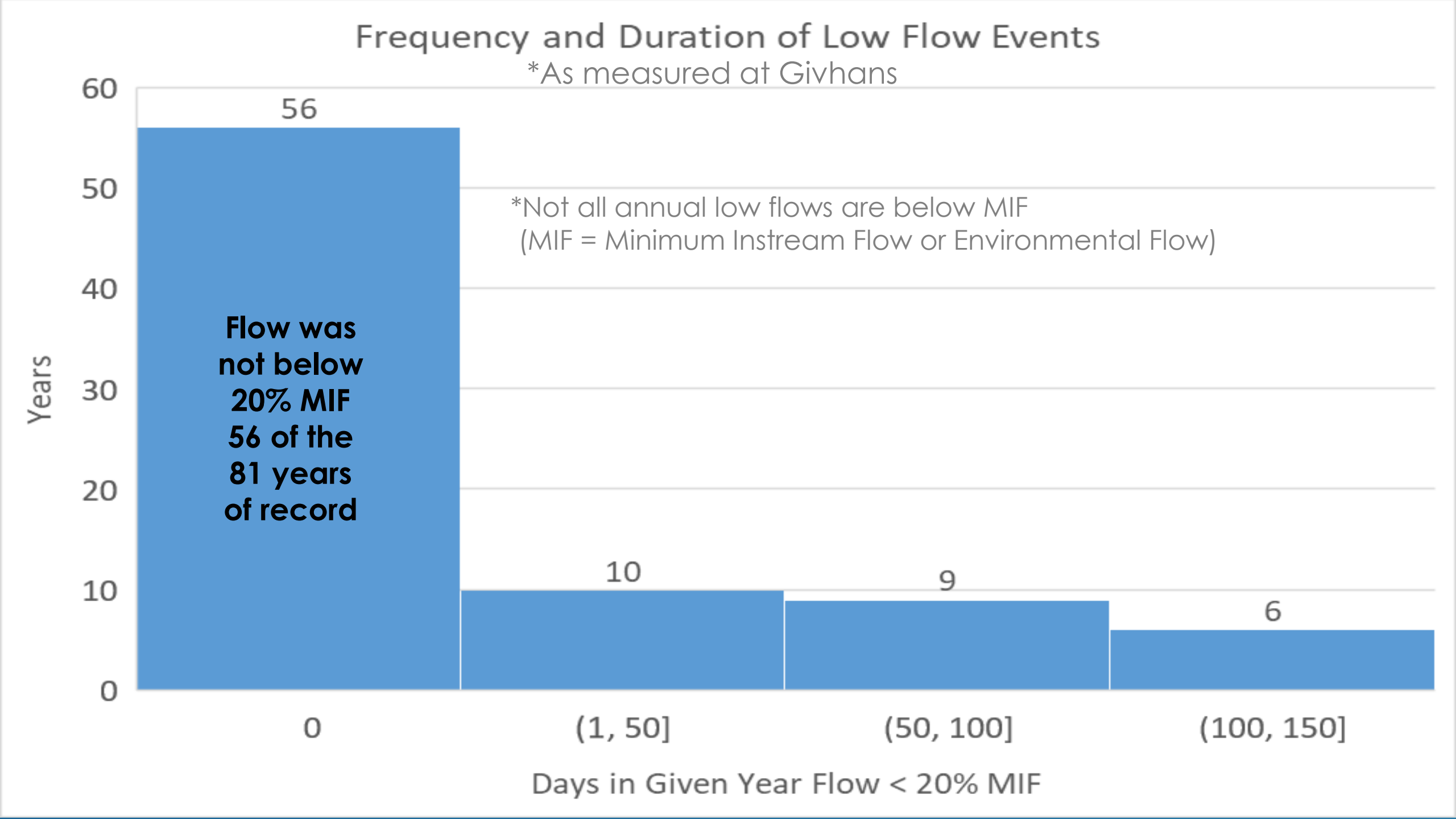

Minimum Annual Flows
Flow (cfs)
1600
1400
1200
1000
800
600
400
200
0
1939
1949
1959
1969
1979
1989
1999
2009
2019

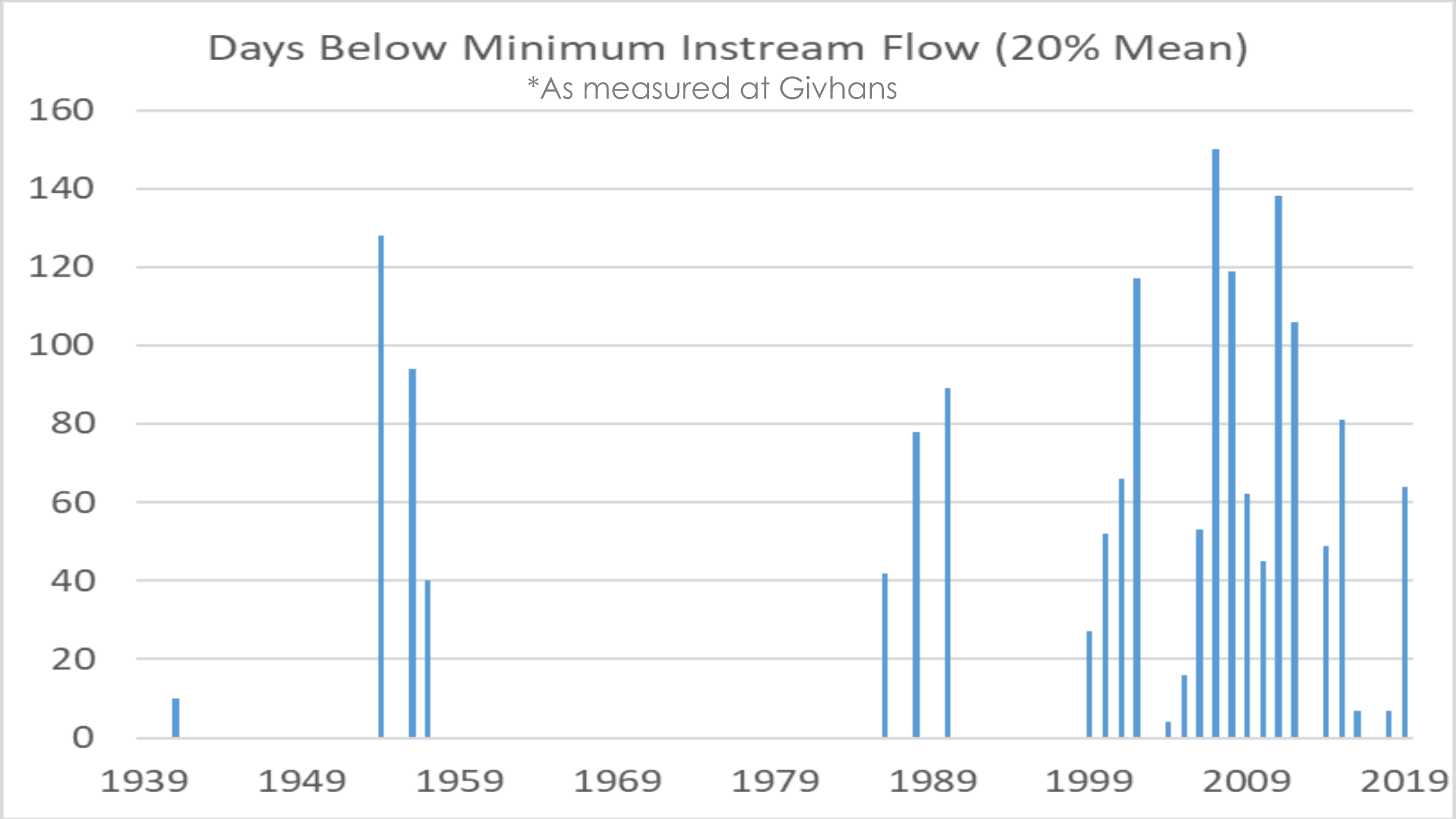

Annual Precipitation (Inches)
70
65
60
55
50
45
40
35
30
1940
1950
1960
1970
1980
1990
2000
2010
*from USGS Presentation

ANNUAL LOW FLOWS

- Basin wide patterns and trends in low flows are primarily due to changes in annual precipitation and changes in the precipitation patterns within each year (similar annual amounts occurring in fewer, but bigger events)
- Patterns and trends are further complicated by changes in surficial ground water drawdown, land use/cover and cumulative surface withdrawals across the basin
- Though withdrawals are not likely the most significant cause of the lower flows, the river is more susceptible to drawdown during prolonged dry spells
- River basin plans should focus on what we can do during the extreme low flows
- If our plan is going to focus on management of the resource during low flow periods, we need to better understand them:
  - When do they occur?
  - How long do they last?
  - Are they occurring less or more frequently?


When Low Flows Start
*As measured at Givhans
Frequency of Month
25
20
15
10
5
0
0
0
0
1
11
11
23
13
15
7
0
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec


Frequency and Duration of Low Flow Events
*As measured at Givhans
*Not all annual low flows are below MIF
(MIF = Minimum Instream Flow or Environmental Flow)
Flow was not below 20% MIF 56 of the 81 years of record
Years
60
50
40
30
20
10
0
56
10
9
6
0
(1, 50]
(50, 100]
(100, 150]
Days in Given Year Flow < 20% MIF

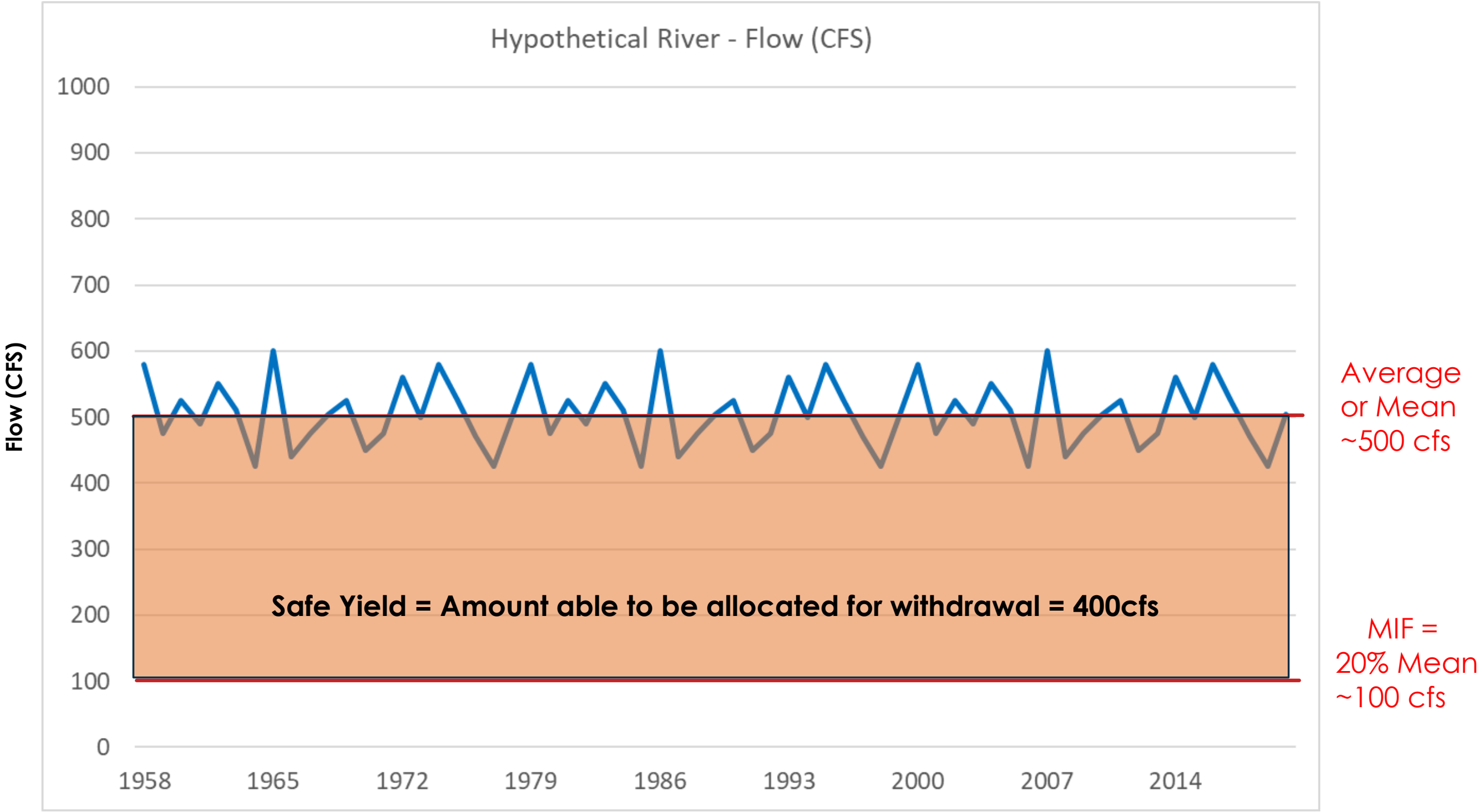

Days Below Minimum Instream Flow (20% Mean)
*As measured at Givhans
160
140
120
100
80
60
40
20
0
1939
1949
1959
1969
1979
1989
1999
2009
2019

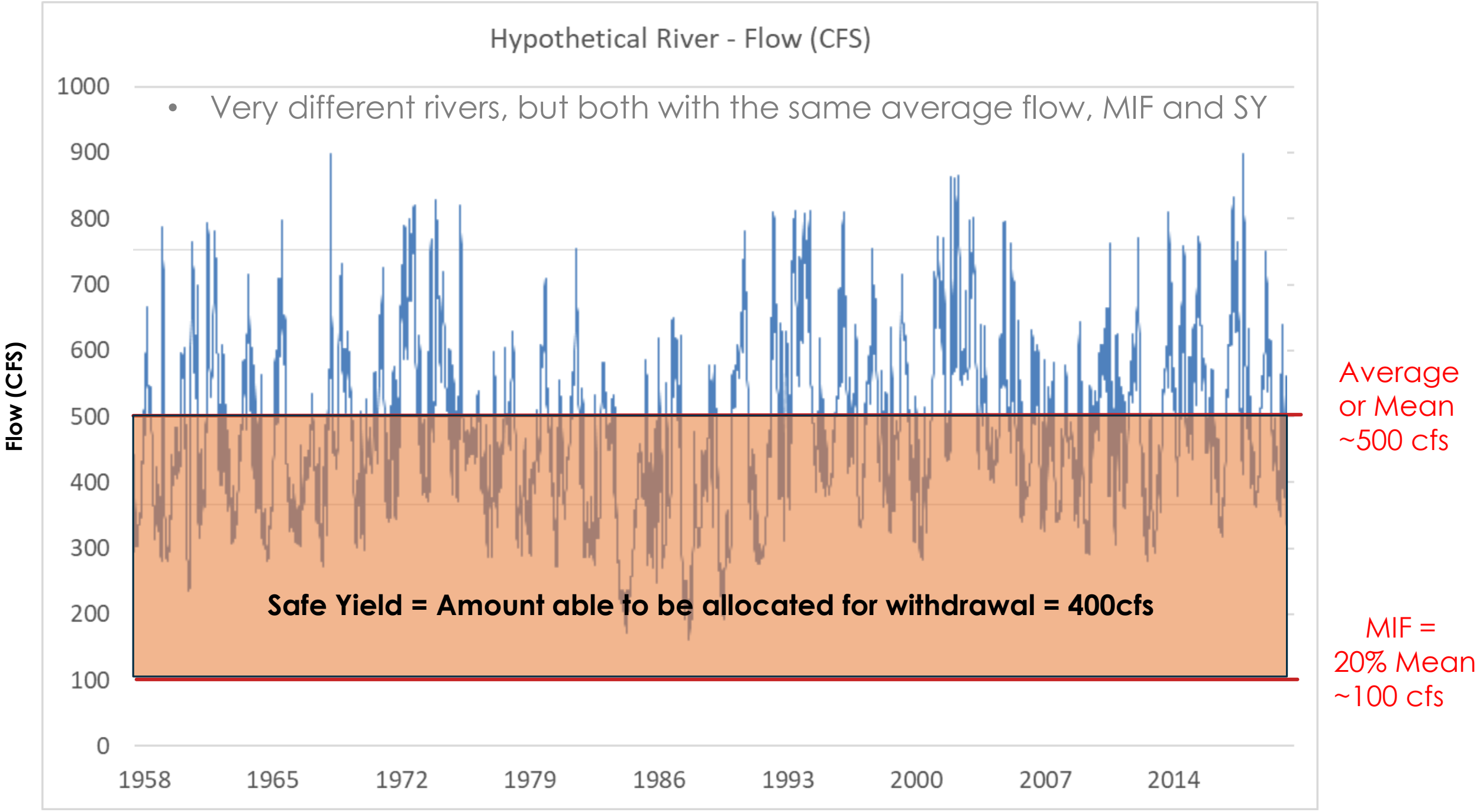
MIF INCREASINGLY NOT AVAILABLE

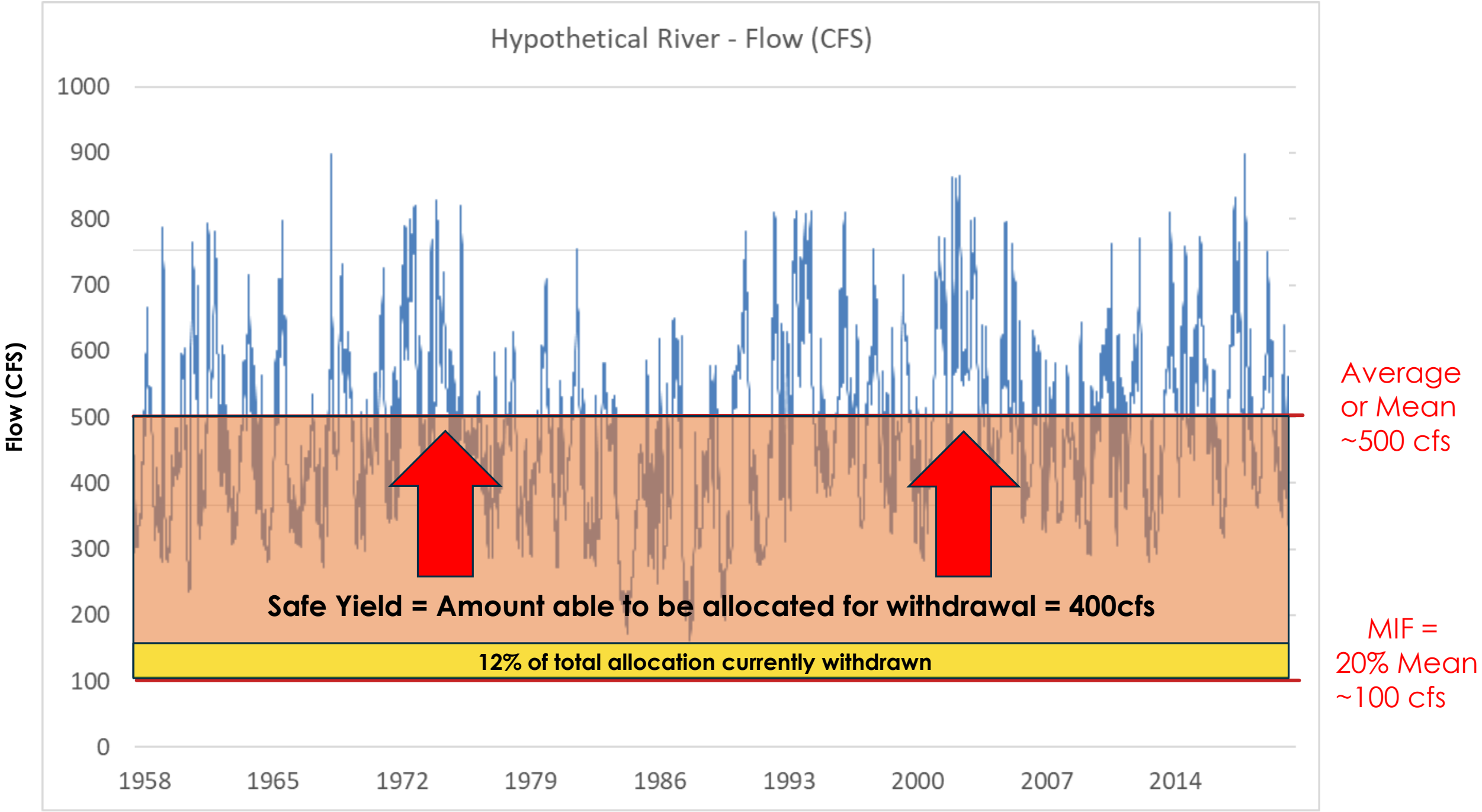
- The flows at Givhans Ferry reflect precipitation, inflow and withdrawal of the entire Edisto Basin above Givhans Ferry
- The lower annual low flows at Givhans Ferry (despite CWS withdrawing less water) would point to the basin wide changes previously discussed (precipitation patterns, increased drought, ground water drawdown, land use/cover and cumulative withdrawals)
- Regardless of the causes, the decreasing trend in low flows supports that the basin is indeed strained during drought and increasingly so, even during more typical annual low flows
- This supports that there is not much surficial capacity left in the basin
- Shifting surficial withdrawers to ground sources may compound surficial low flows by further reducing ground water inflow during drier times

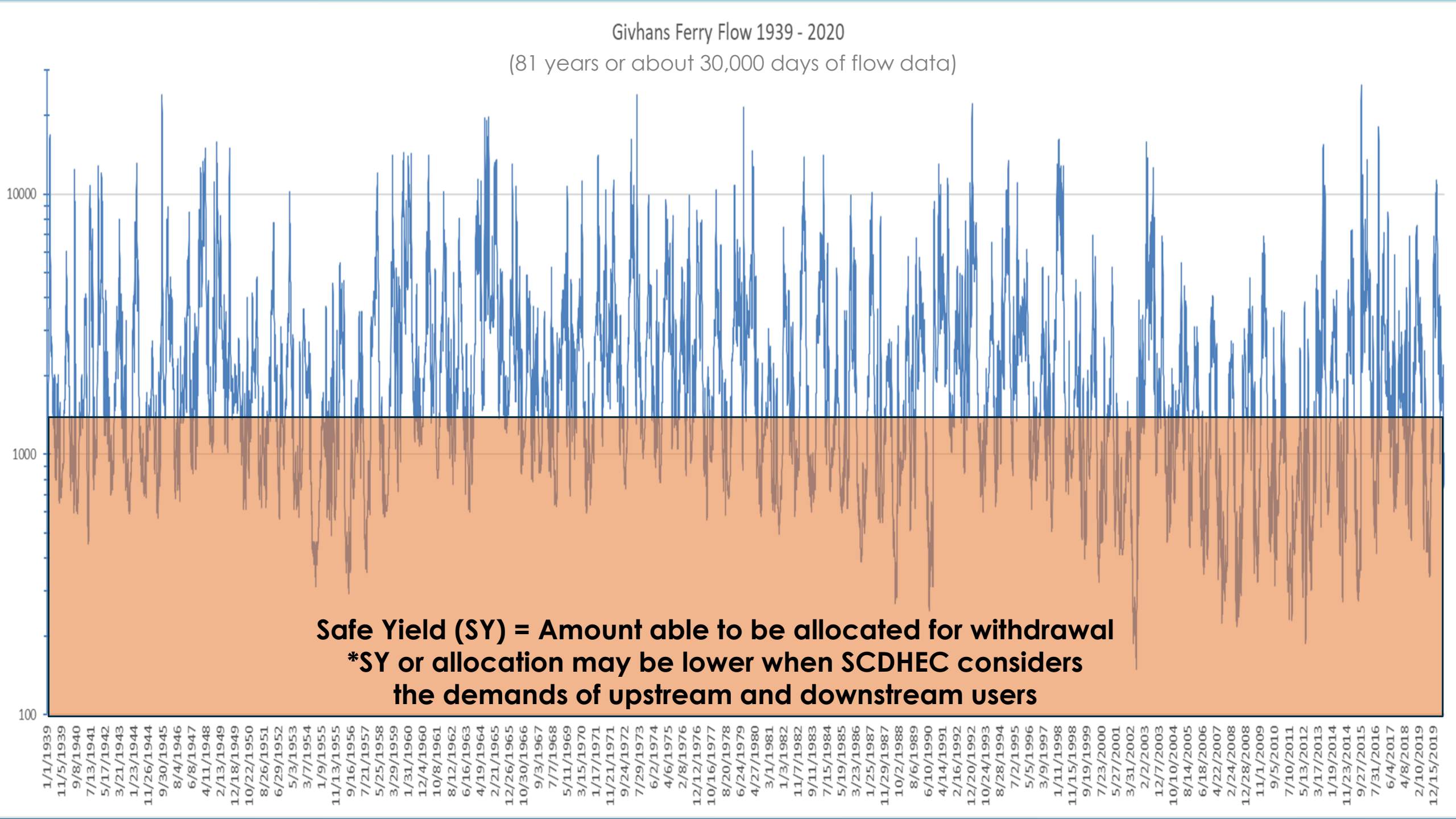
CHALLENGE OF CURTAILING

- Low flows occur during Summer, when drinking water, power and agricultural generally have higher withdrawals
- It is hard for these stakeholders to drastically curtail their withdrawals during the lower flow years (drought)
- It's unrealistic to expect them to curtail during the annual low flow period
- Adding new permits and/or registrations will require the lower flows be divided between more users increasing the likelihood:
  - there won't be enough water for all users during annual low flows, let alone during drought
  - minimum instream flows will be further pressured
  - there will be insufficient capacity for current users to withdrawal more of their allocation or increase their allocation as needed


Hypothetical River - Flow (CFS)
Flow (CFS)
1000
900
800
700
600
500
400
300
200
100
0
1958
1965
1972
1979
1986
1993
2000
2007
2014
Safe Yield = Amount able to be allocated for withdrawal = 400cfs
Average or Mean ~500 cfs
MIF = 20% Mean ~100 cfs

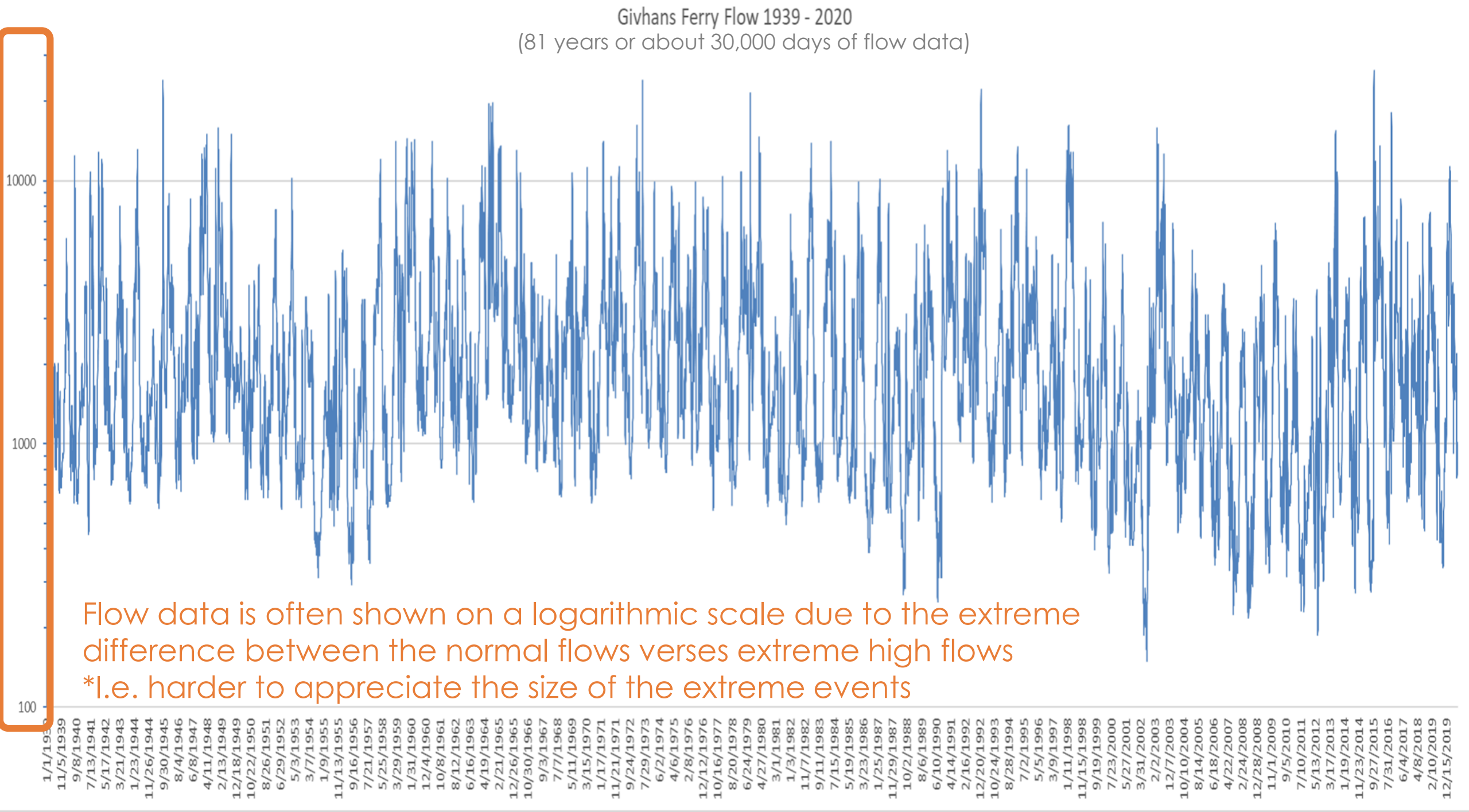

Hypothetical River - Flow (CFS)
• Very different rivers, but both with the same average flow, MIF and SY
Flow (CFS)
1000
900
800
700
600
500
400
300
200
100
0
1958
1965
1972
1979
1986
1993
2000
2007
2014
Safe Yield = Amount able to be allocated for withdrawal = 400cfs
Average or Mean ~500 cfs
MIF = 20% Mean ~100 cfs

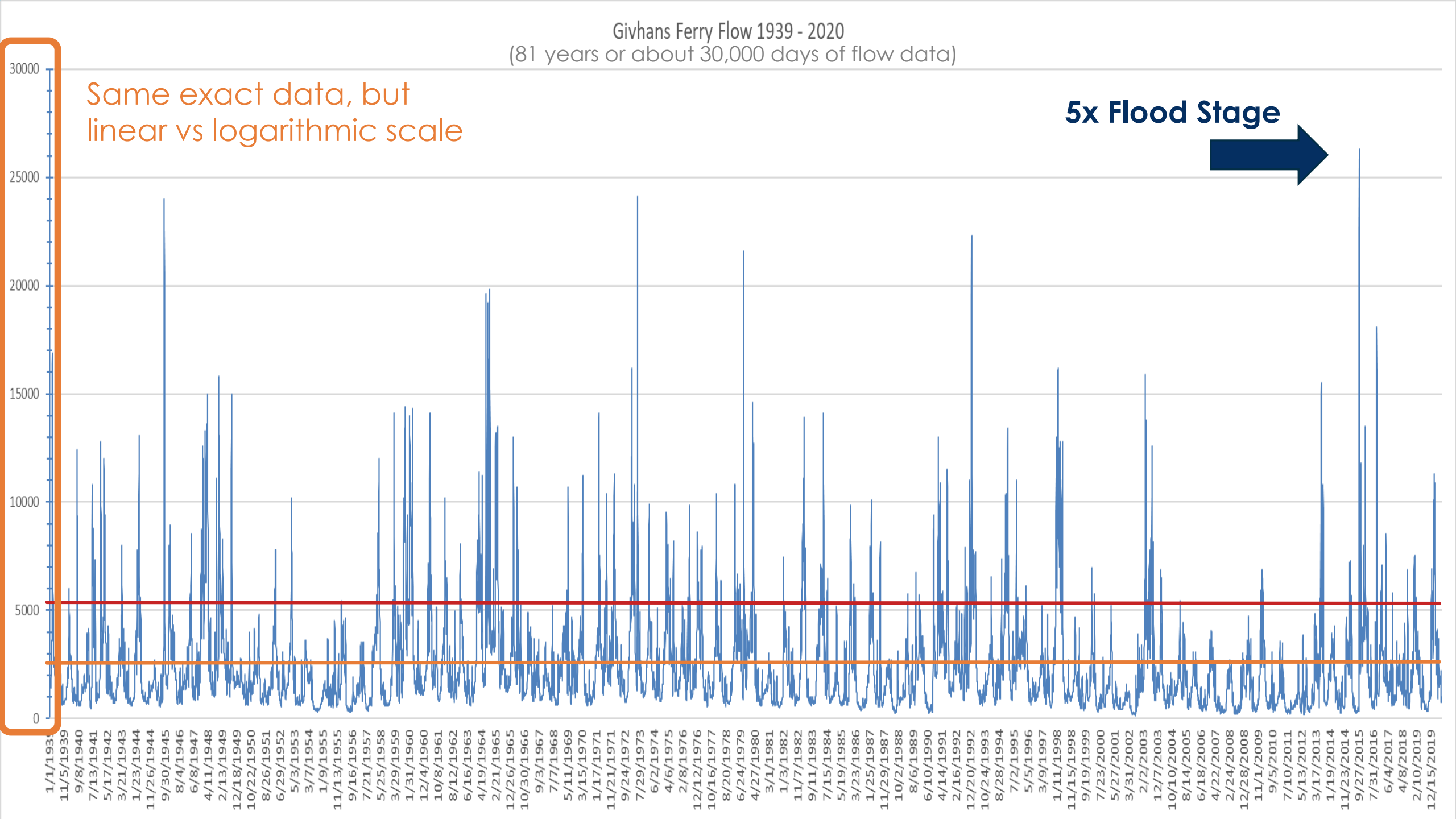

Hypothetical River - Flow (CFS)
Flow (CFS)
1000
900
800
700
600
500
400
300
200
100
0
1958
1965
1972
1979
1986
1993
2000
2007
2014
Safe Yield = Amount able to be allocated for withdrawal = 400cfs
12% of total allocation currently withdrawn
Average or Mean ~500 cfs
MIF = 20% Mean ~100 cfs


Givhans Ferry Flow 1939 - 2020
(81 years or about 30,000 days of flow data)
10000
1000
100
Safe Yield (SY) = Amount able to be allocated for withdrawal
*SY or allocation may be lower when SCDHEC considers
the demands of upstream and downstream users

CHALLENGES WITH SAFE YIELD

- Extreme variations in flow within a year complicates allocation
- Safe yield plus minimum instream flow is by definition the river flow available 50% of the time
- However, examination of the 81 years of flow data at Givhans Ferry indicates safe yield + MIF is actually only available 34% of the time
- Why is the mean flow only available 34% of the time instead of 50% of the time?


Givhans Ferry Flow 1939 - 2020
(81 years or about 30,000 days of flow data)
10000
1000
100
Flow data is often shown on a logarithmic scale due to the extreme difference between the normal flows verses extreme high flows
*I.e. harder to appreciate the size of the extreme events


Givhans Ferry Flow 1939 - 2020
(81 years or about 30,000 days of flow data)
Same exact data, but
linear vs logarithmic scale
5x Flood Stage
30000
25000
20000
15000
10000
5000
0

FLOODS AFFECT SAFE YIELD ALLOCATION

- How do floods affect safe yield (allocation) and/or MIF?
- Floods can be 10x higher than the mean flow which skews or biases the mean high
- Since both SY and MIF are calculated based on mean, both SY (allocation) and MIF are similarly biased high
- When data sets contain outliers or skewed data (like flood events), median (rather than mean) is often used to represent a more typical central value
- Using median (rather than mean) flow to calculate the safe yield and MIF will result in a more realistically available safe yield and an MIF calculation more representative of the low flows

MEAN IS BIASED HIGH ACROSS THE ENTIRE BASIN

Percent Availability (%)

***Similar concept as DNR's Percent Exceedance Graphs**

	Typical Flows		Estimated Safe Yield		Estimated MIF	
	Mean	Median	80% Mean	80% Median	20% Mean	20% Median
Givhans	34	50	43	61	95	99
Orangeburg	38	50	57	67	100	100
Denmark	37	50	54	67	100	100

- The difference between the mean and median is the bias
- Unlike mean flows, median flows are available 50% of the time
- The allocation (or Safe Yield) is available more often (i.e. safer) when using median rather than mean
- 20% Minimum Instream Flow (MIF) is actually available 99% of the time at Givhans Ferry if MIF is calculated based on median

CURRENT VS PROPOSED SAFE YIELD AND MIF

(Approximate)

- **Givhans Ferry**

  Based on Mean, SY = 1943 cfs, MIF = 486 cfs

  Based on Median, SY = 1328 cfs, MIF = 332 cfs

- **Orangeburg**

  Based on Mean, SY = 574 cfs, MIF = 143 cfs

  Based on Median, SY = 498 cfs, MIF = 124 cfs

- **Denmark**

  Based on Mean, SY = 570 cfs, MIF = 143 cfs

  Based on Median SY = 477 cfs, MIF = 119 cfs

CURRENT VS PROPOSED SAFE YIELD AND MIF

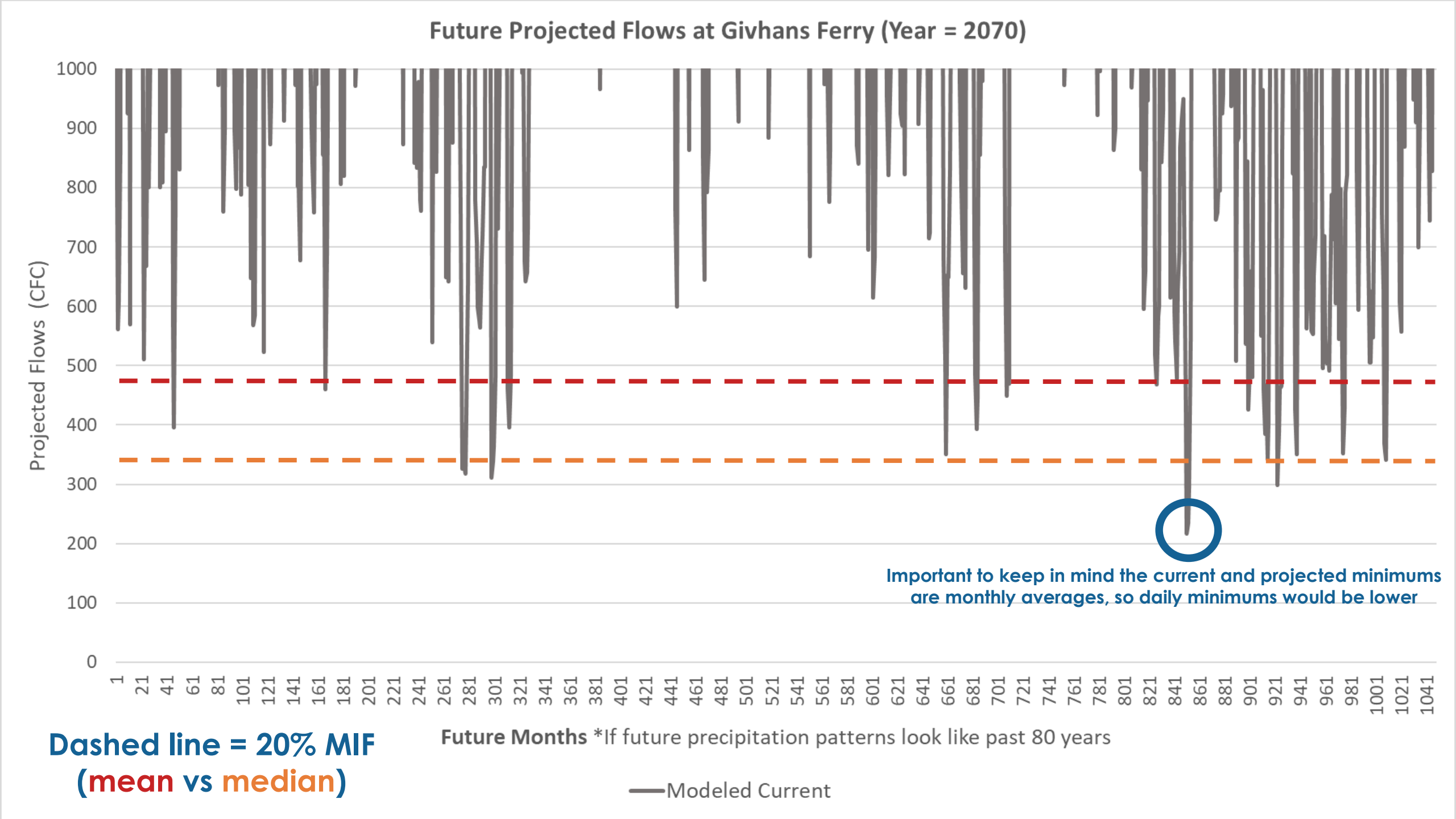
- Basins that are heavily flow controlled (i.e. more dams) should only see a negligible difference in safe yield and MIF based on mean vs median
- In other words, if the average or mean isn't biased by extremes in flow, there won't be much of a change in safe yield or MIF
- A safe yield and MIF based on median is a way to keep true to the current legislation, while accounting for the flow characteristics unique to the each basin
- Using median statistics is more protective of the Edisto Basin (longest free flowing black water river) and the users that rely on it

CURRENT VS PROPOSED SAFE YIELD AND MIF

- As long as discussions on allocation are based on "mean" availability, "full allocation" may actually be "over allocation"
- Conversely, as long as discussions on ecosystem impacts (minimum instream flow or MIF) are based on "mean" availability, the environmental impacts from withdrawals are likely exaggerated
- All definitions and discussions around allocation and ecosystem impacts should use "median" in order to reflect true availability
- Using this more robust statistic is more likely to help get more buy-in for MIF surface conditions from more stakeholder groups

SWAM Model Projections vs Historical Data

- The SWAM model projections are based on the same historical data I covered
- The model essentially says, "if the next ## of years looks like the last 81 years, this is what we can expect flows to look like given said projections (business as usual or high demands, etc.)"
- However, the more optimistic SWAM scenario results show only minor "shortages" even with "high demands" by 2070 because they were run in the absence of MIF considerations per the framework guidance
- In other words, as long as there is still 1 CFS of flow after all withdrawals, there are no "shortages"
- Let's look at the modeled current, business as usual 2070, high demand 2070 and full allocation to make my point


Future Projected Flows at Givhans Ferry (Year = 2070)
Projected Flows (CFC)
1000
900
800
700
600
500
400
300
200
100
0
1 21 41 61 81 101 121 141 161 181 201 221 241 261 281 301 321 341 361 381 401 421 441 461 481 501 521 541 561 581 601 621 641 661 681 701 721 741 761 781 801 821 841 861 881 901 921 941 961 981 1001 1021 1041
Important to keep in mind the current and projected minimums are monthly averages, so daily minimums would be lower
Future Months *If future precipitation patterns look like past 80 years
Dashed line = 20% MIF
(mean vs median)
Modeled Current

Conclusions

- Main branch low flows have been decreasing across the basin due primarily to changes in precipitation patterns, but exacerbated by drought frequency, ground water drawdown, changes in land use/cover and cumulative withdrawals across the basin
- Decreased flow at Givhans Ferry is indicative of the state of water availability (surface and ground) across the basin
- The RBC should consider legislative recommendations such as revising SY and MIF definitions to reference median rather than mean statistics
- To accurately quantify the potential impacts of the low flow events on availability (i.e. shortages), the basin scenarios, strategic nodes and Edisto RBC plan need to take into account MIF conditions (based on median)

Questions