Hydrology 101 - Fundamentals of Surface Water Hydrology and Hydrologic Data

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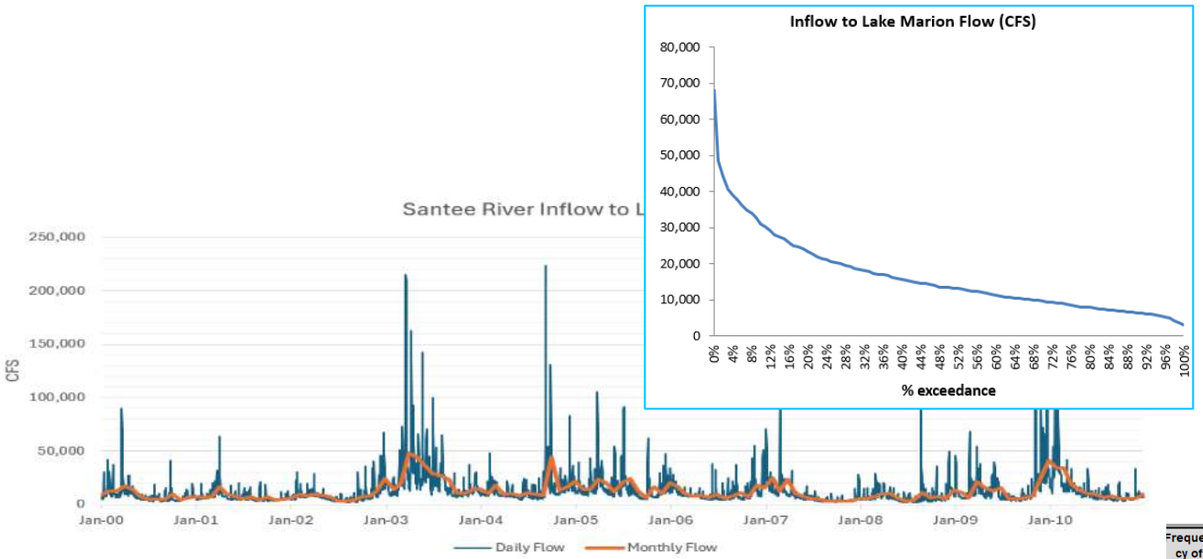
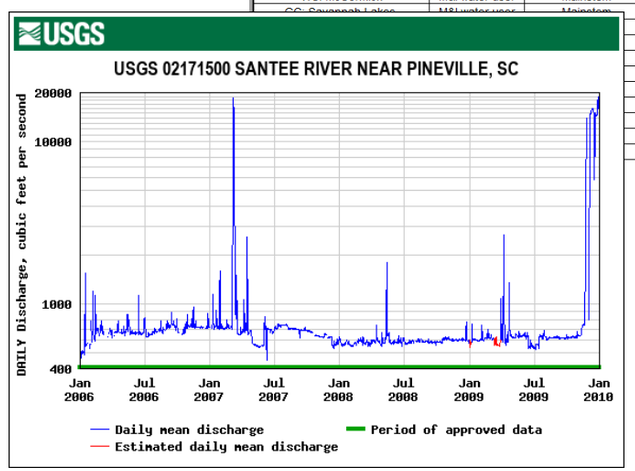
Agenda Item 5

Purpose of this information

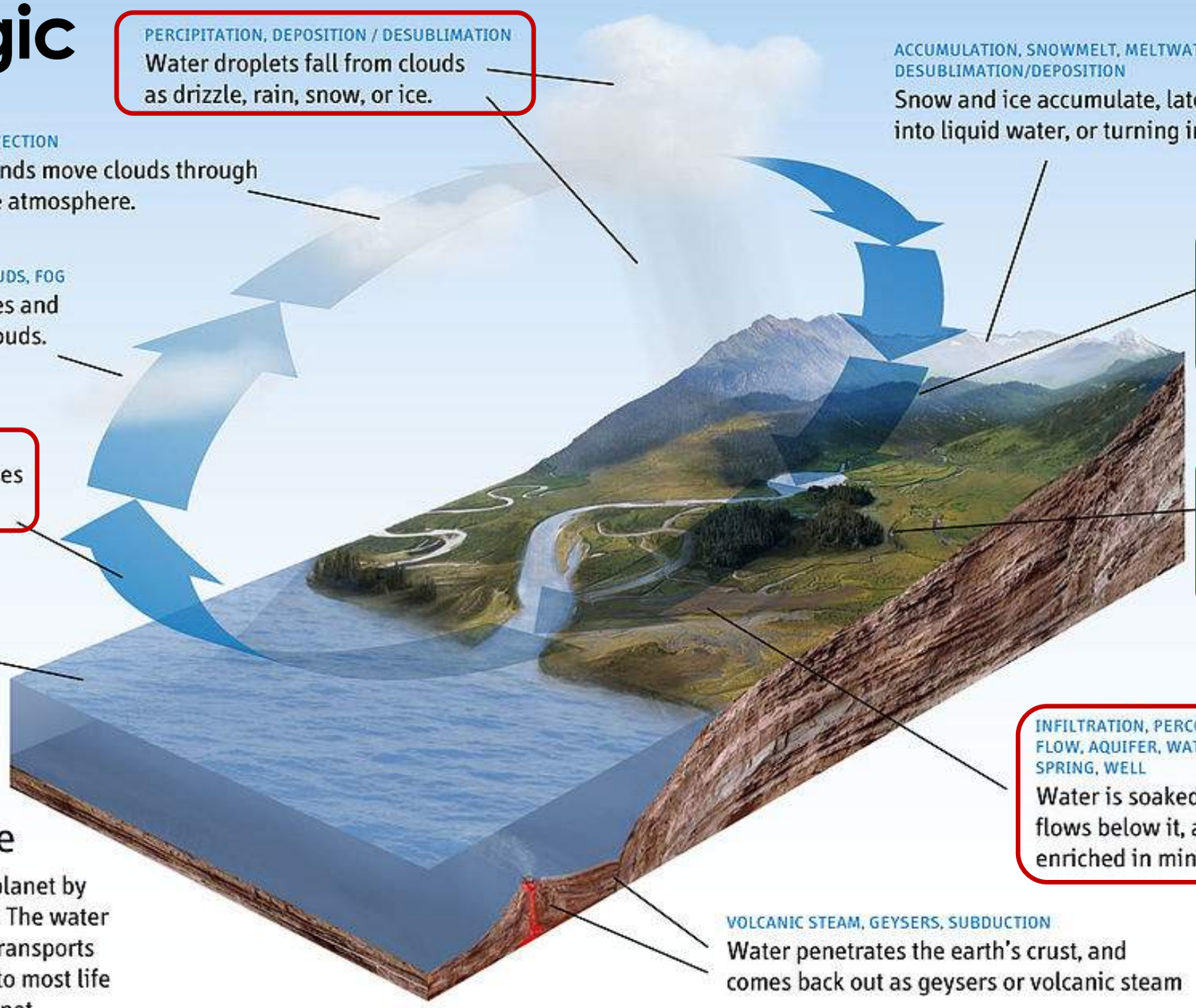
- For the next 12 months, you will be viewing a lot of hydrologic data in various formats, and for many purposes
- Other RBCs have noted that a brief introduction to hydrologic information would be helpful
- We can refer back to this information at any time throughout the process



Water User Name	User Type	Source Water	Location (mi)	Demand (MGD)	Available Flow (MGD)	r Pumping (MGD)	Reservoir Storage (%)	Shortage (MGD)	Shortage (MGD)	Frequency of Shortage (%)
WS: Seneca	M&I water user	Mainstem	24	7	0	0	0%	0.0	0.0	0.0%
WS: Walhalla	M&I water user	Mainstem	24	2	0	0	0%	0.0	0.0	0.0%
PN: Oconee	M&I water user	Mainstem	24	2,587	0	0	0%	0.0	0.0	0.0%
WS: Greenville	M&I water user	Mainstem	24	23	0	0	0%	0.0	0.0	0.0%
GC: Reserve at Keowee	M&I water user	Mainstem	24	0	0	0	0%	0.0	0.0	0.0%
GC: Keowee Vineyards	M&I water user	Mainstem	24	0	0	0	0%	0.0	0.0	0.0%
GC: Keowee Springs	M&I water user	Mainstem	24	0	0	0	0%	0.0	0.0	0.0%
GC: Keowee Key	M&I water user	Mainstem	24	0	0	0	0%	0.0	0.0	0.0%
GC: Keowee Falls	M&I water user	Mainstem	24	0	0	0	0%	0.0	0.0	0.0%
GA: Tugaloo-Hartwell Use	M&I water user	Mainstem	65	11	85	0	0%	0.0	0.0	0.0%
IN: Clemson Energy	M&I water user	Mainstem	65	1	0	0	0%	0.0	0.0	0.0%
WS: Pioneer	M&I water user	Mainstem	65	2	0	0	0%	0.0	0.0	0.0%
GC: Walker	M&I water user	Mainstem	65	0	0	0	0%	0.0	0.0	0.0%
WS: ARJWS	M&I water user	Mainstem	65	18	0	0	0%	0.0	0.0	0.0%
IN: ARJWS	M&I water user	Mainstem	65	5	0	0	0%	0.0	0.0	0.0%
PT: SC Rainey Station	M&I water user	Mainstem	68	2	86	0	0%	0.0	0.0	0.0%
GA: Russell Use	M&I water user	Mainstem	94	1	0	0	0%	0.0	0.0	0.0%
WS: Abbeville	M&I water user	Mainstem	94	2	0	0	0%	0.0	0.0	0.0%
GA: Thurmond Use	M&I water user	Mainstem	131	6	0	0	0%	0.0	0.0	0.0%
WS: McCormick	M&I water user	Mainstem	131	1	0	0	0%	0.0	0.0	0.0%
GC: Savannah Lakes	M&I water user	Mainstem	131	0	0	0	0%	0.0	0.0	0.0%
			131	0	0	0	0%	0.0	0.0	0.0%
			145	4	2,403	0	0%	0.0	0.0	0.0%
			150	4	2,406	0	0%	0.0	0.0	0.0%
			153	0	2,405	0	0%	0.0	0.0	0.0%
			156	0	2,421	0	0%	0.0	0.0	0.0%
			157	9	2,423	0	0%	0.0	0.0	0.0%
			157	103	2,413	0	0%	0.0	0.0	0.0%
			165	56	2,429	0	0%	0.0	0.0	0.0%
			169	47	2,409	0	0%	0.0	0.0	0.0%



Hydrologic Cycle



PERCIPITATION, DEPOSITION / DESUBLIMATION
Water droplets fall from clouds as drizzle, rain, snow, or ice.

ACCUMULATION, SNOWMELT, MELTWATER, SUBLIMATION, DESUBLIMATION/DEPOSITION
Snow and ice accumulate, later melting back into liquid water, or turning into vapor.

Functions of
- Land Use
- Slope
- Soils

ADVECTION
Winds move clouds through the atmosphere.

SURFACE RUNOFF, CHANNEL RUNOFF, RESERVOIRS
Water flows above ground as runoff, forming streams, rivers, swamps, ponds, and lakes.

CONDENSATION, CLOUDS, FOG
Water vapor rises and condenses as clouds.

EVAPORATION
Heat from the sun causes water to evaporate.

PLANT UPTAKE, INTERCEPTION, TRANSPIRATION
Plants take up water from the ground, and later transpire it back into the air.

HYDROSPHERE, OCEANS
The oceans contain 97% of Earth's water.

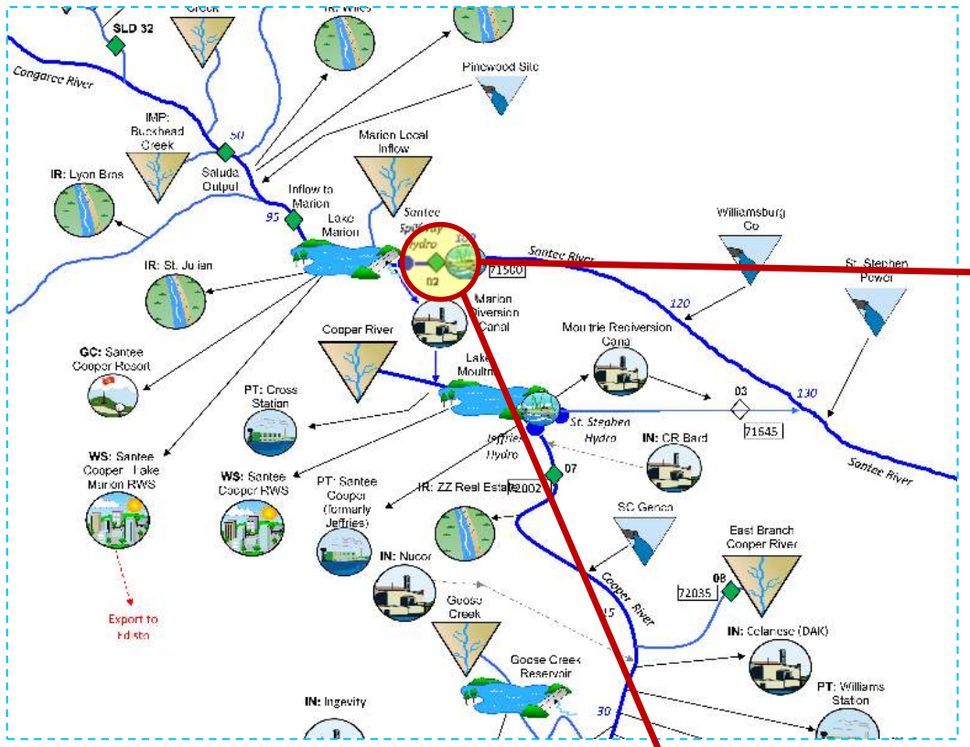
INFILTRATION, PERCOLATION, SUBSURFACE FLOW, AQUIFER, WATER TABLE, SEEPAGE, SPRING, WELL
Water is soaked into the ground, flows below it, and seeps back out enriched in minerals.

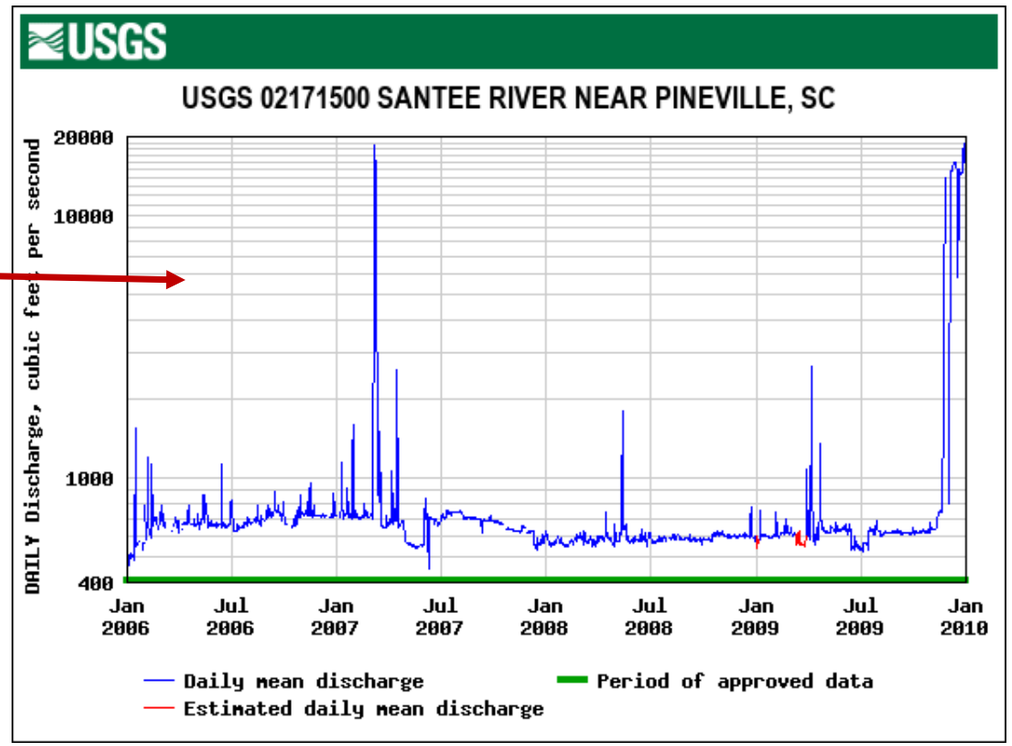
VOLCANIC STEAM, GEYSERS, SUBDUCTION
Water penetrates the earth's crust, and comes back out as geysers or volcanic steam

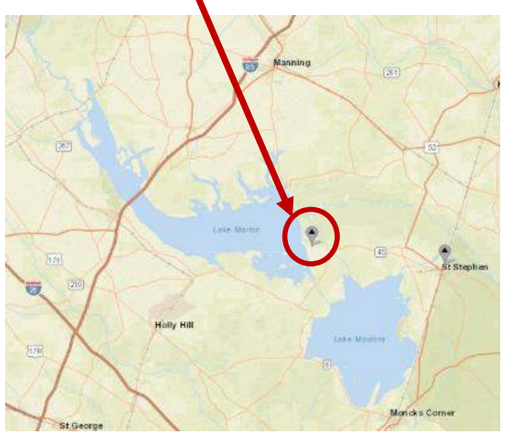
The Water Cycle

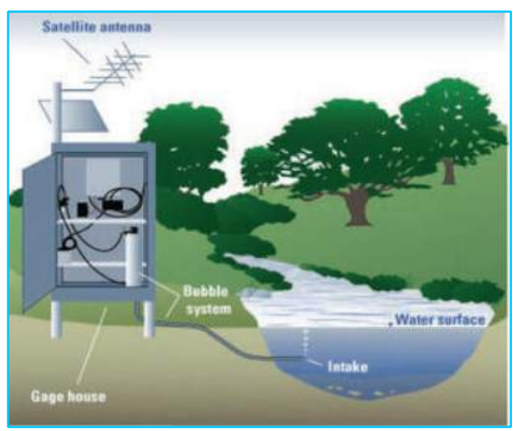
Water moves around our planet by the processes shown here. The water cycle shapes landscapes, transports minerals, and is essential to most life and ecosystems on the planet.

Measuring Hydrologic Data





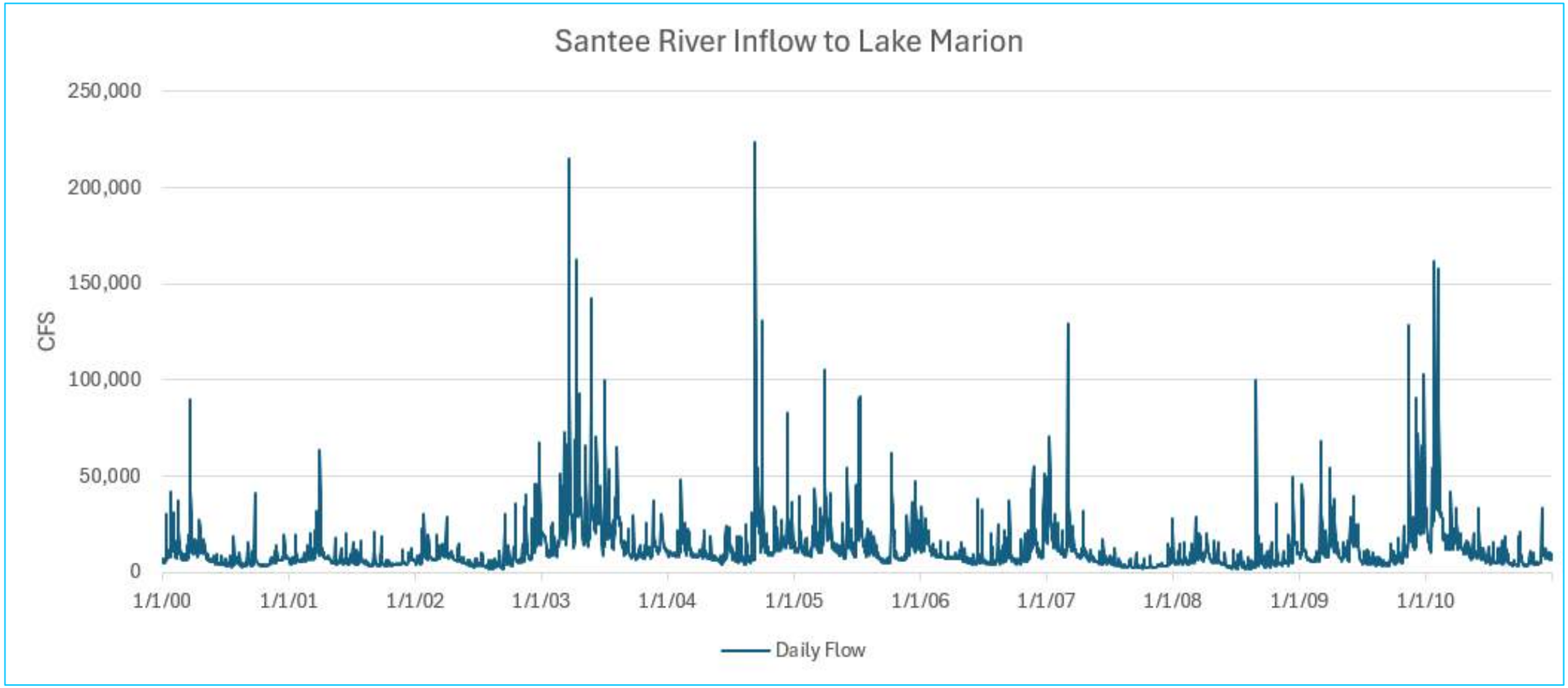




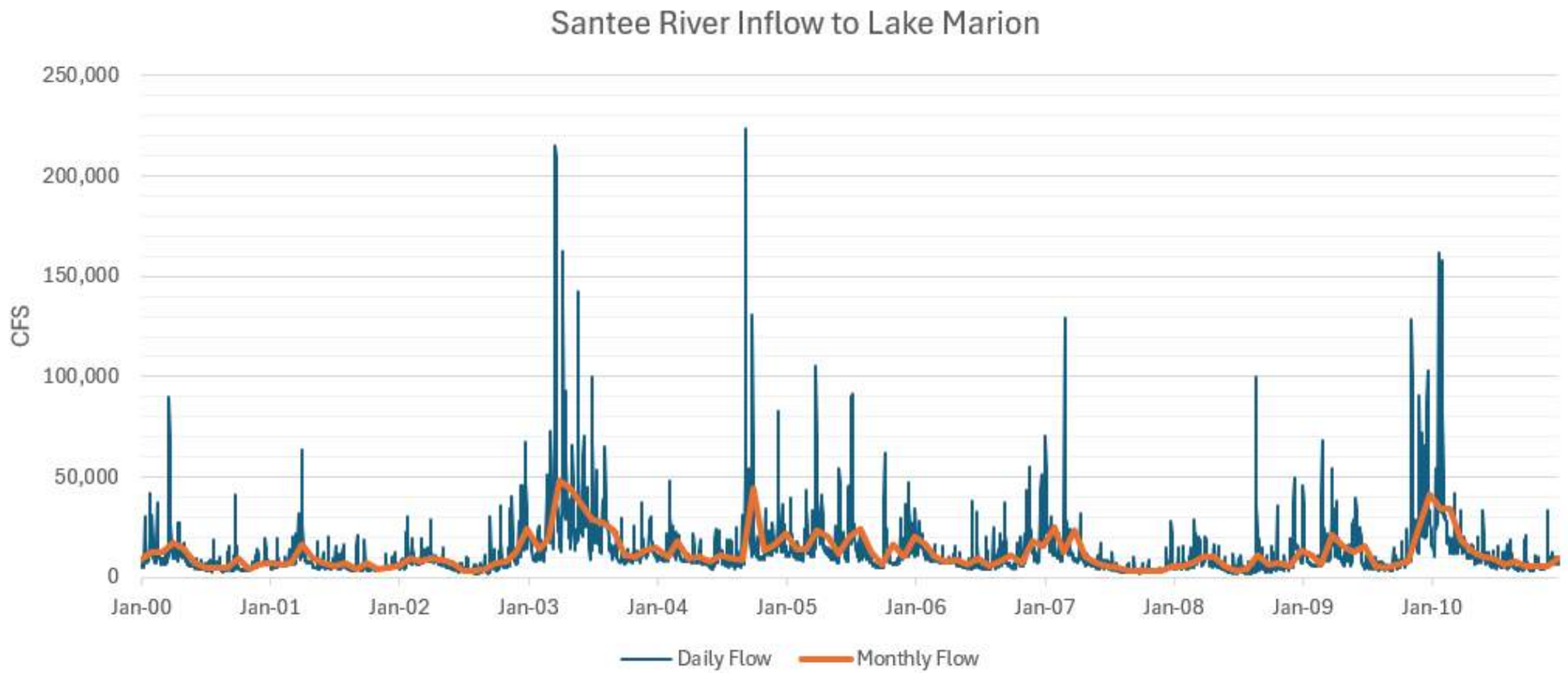
waterdata.usgs.gov

[Streamgaging Basics | U.S. Geological Survey (usgs.gov)]

Displaying Simulated Hydrologic Data:
Basic Streamflow Hydrograph (SWAM)

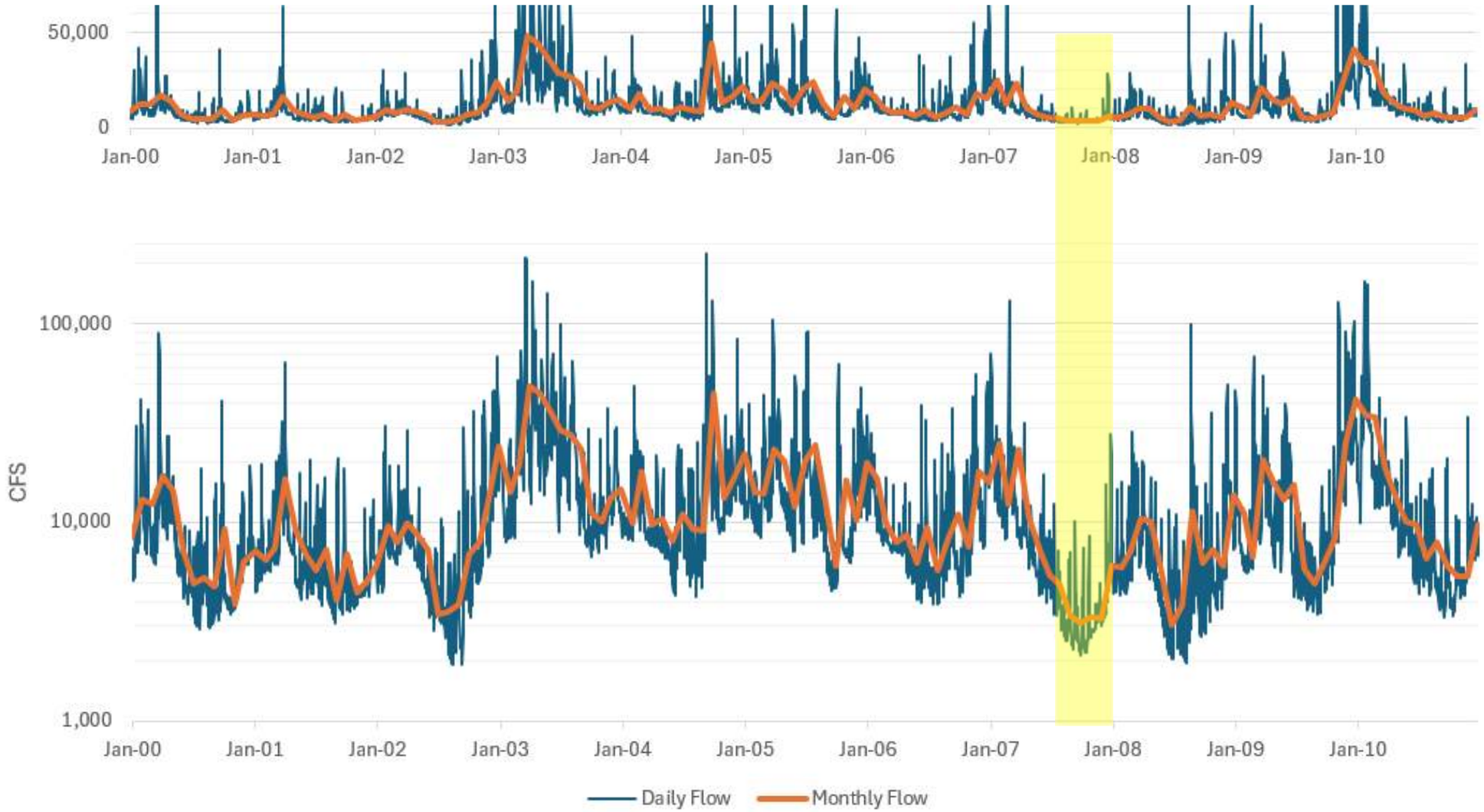


Daily vs. Monthly Simulated Flow in SWAM



Visualizing Small Differences:

Log Scale

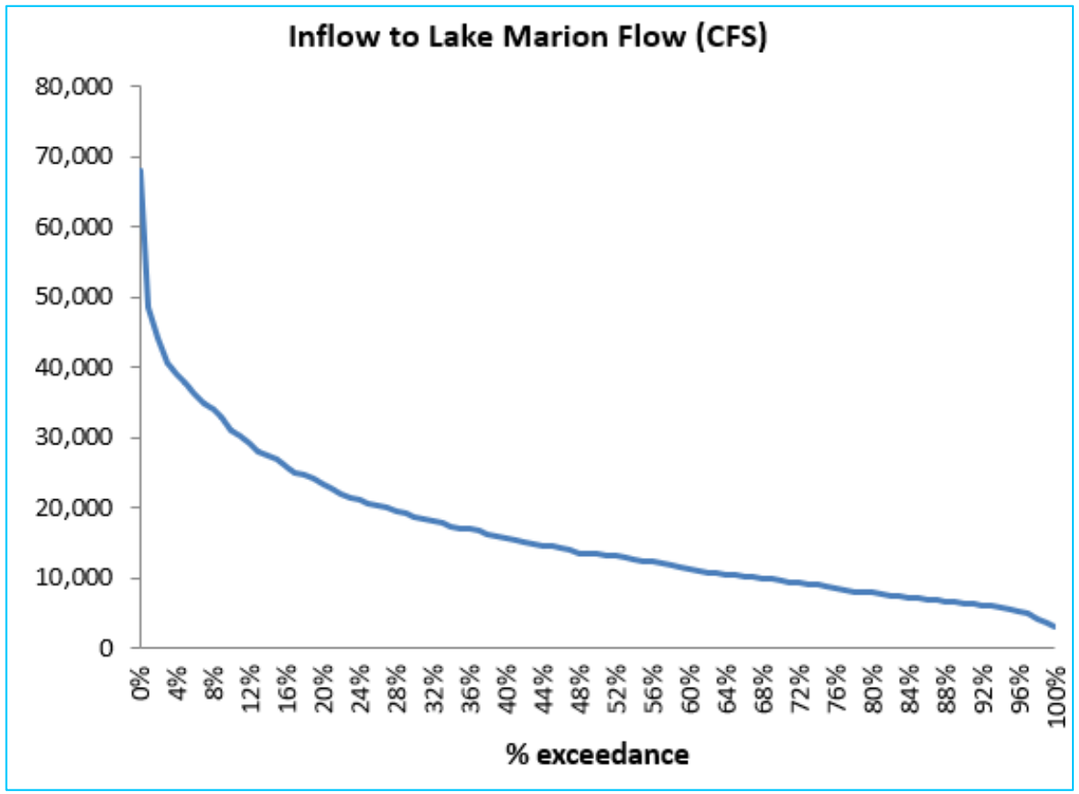


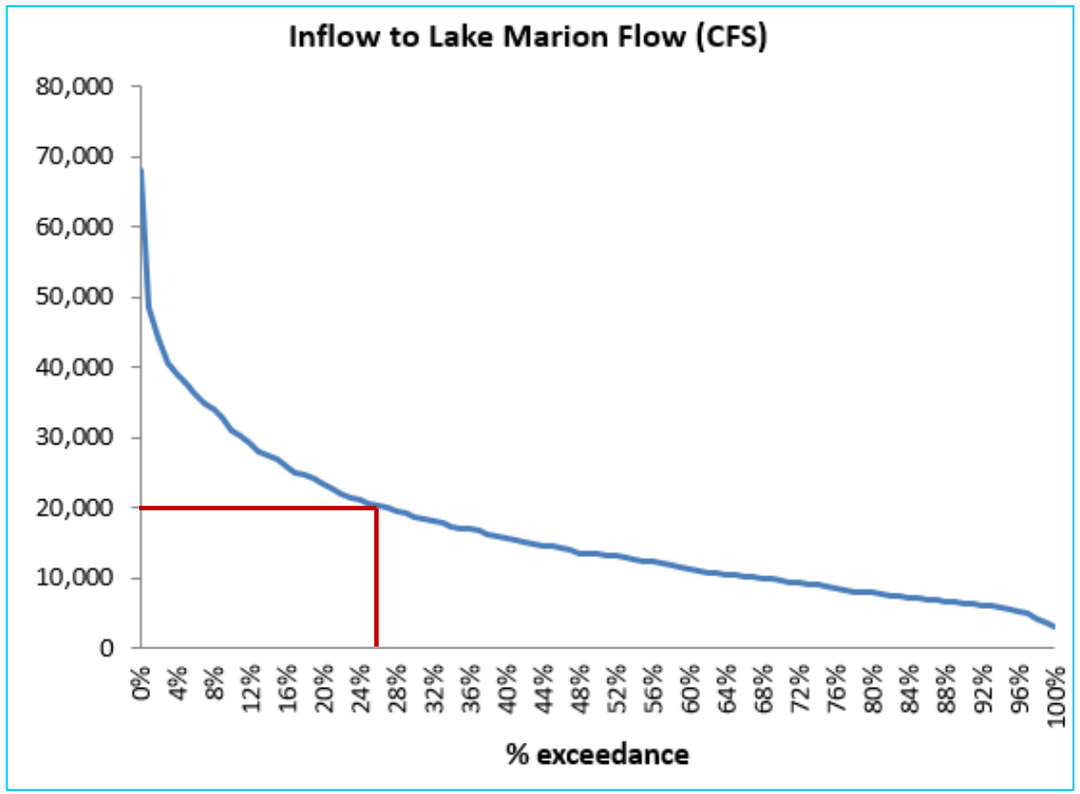
Standard Scale

Log Scale

Displaying Hydrologic Data:

Flow Exceedence Curve / Flow Duration Curve



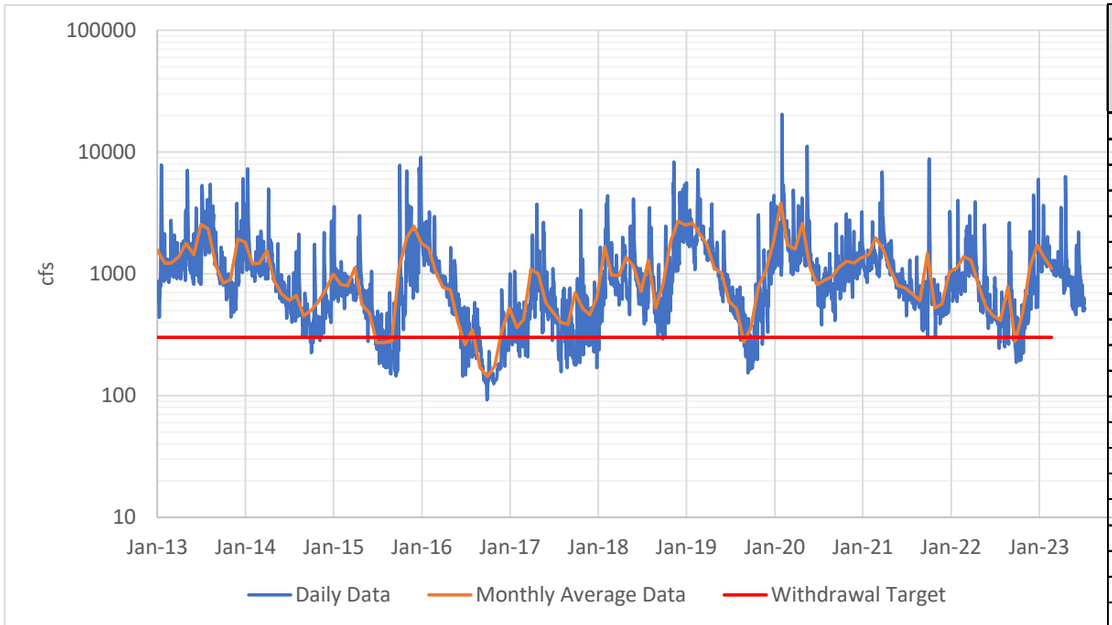


River flow is higher than 20,000 cfs ~25 % of the time

Other Information and Interpretative Guidance

Borrowing some water stats from the Saluda Basin

Frequency and Magnitude of Shortage



User Type	Source Water	Location (mi)	Average Annual Demand (MGD)	Minimum Physically Available Flow (MGD)	Average Groundwater Pumping (MGD)	Minimum Reservoir Storage (%)	Average Shortage (MGD)	Maximum Shortage (MGD)	Frequency of Shortage (%)
M&I water user	Mainstem	6	9	152	0	0%	0.0	0.0	0.0%
M&I water user	Mainstem	41	7	232	0	0%	0.0	0.0	0.0%
M&I water user	Mainstem	52	1	231	0	0%	0.0	0.0	0.0%
M&I water user	Mainstem	52	3	230	0	0%	0.0	0.0	0.0%
M&I water user	Mainstem	78	1,994	401	0	0%	300.0	2,640.1	31.6%
Ag water user	Mainstem	101	0	346	0	0%	0.0	0.0	0.0%
M&I water user	Mainstem	105	67	358	0	0%	0.0	0.0	0.0%
M&I water user	Cherokee Creek	2	26	0	0	0%	0.2	27.8	1.3%
M&I water user	North Pacolet River	1	1	1	0	0%	0.0	0.0	0.0%
M&I water user	North Pacolet River	2	0	0	0	100%	0.0	0.0	0.0%
M&I water user	North Pacolet River	22	11	18	0	0%	0.0	0.0	0.0%
M&I water user	Lawsons Fork Creek	21	0	23	0	0%	0.0	0.0	0.0%
Ag water user	Pacolet River	1	0	3	0	0%	0.0	0.0	0.0%
M&I water user	Pacolet River	6	0	7	0	0%	0.0	0.0	0.0%
M&I water user	Pacolet River	18	64	0	0	0%	0.1	36.7	0.4%
M&I water user	Pacolet River	42	0	41	0	0%	0.0	0.0	0.0%
M&I water user	Turkey Creek	1	5	0	0	0%	0.9	5.6	31.1%
Ag water user	Middle Tyger River	11	0	4	0	0%	0.0	0.0	0.0%
M&I water user	Middle Tyger River	22	26	9	0	0%	0.1	18.3	0.6%
M&I water user	South Tyger River	11	23	1	0	0%	0.5	17.9	7.4%

In this generic example, the frequency that river flow is less than the withdrawal target is difficult to count.

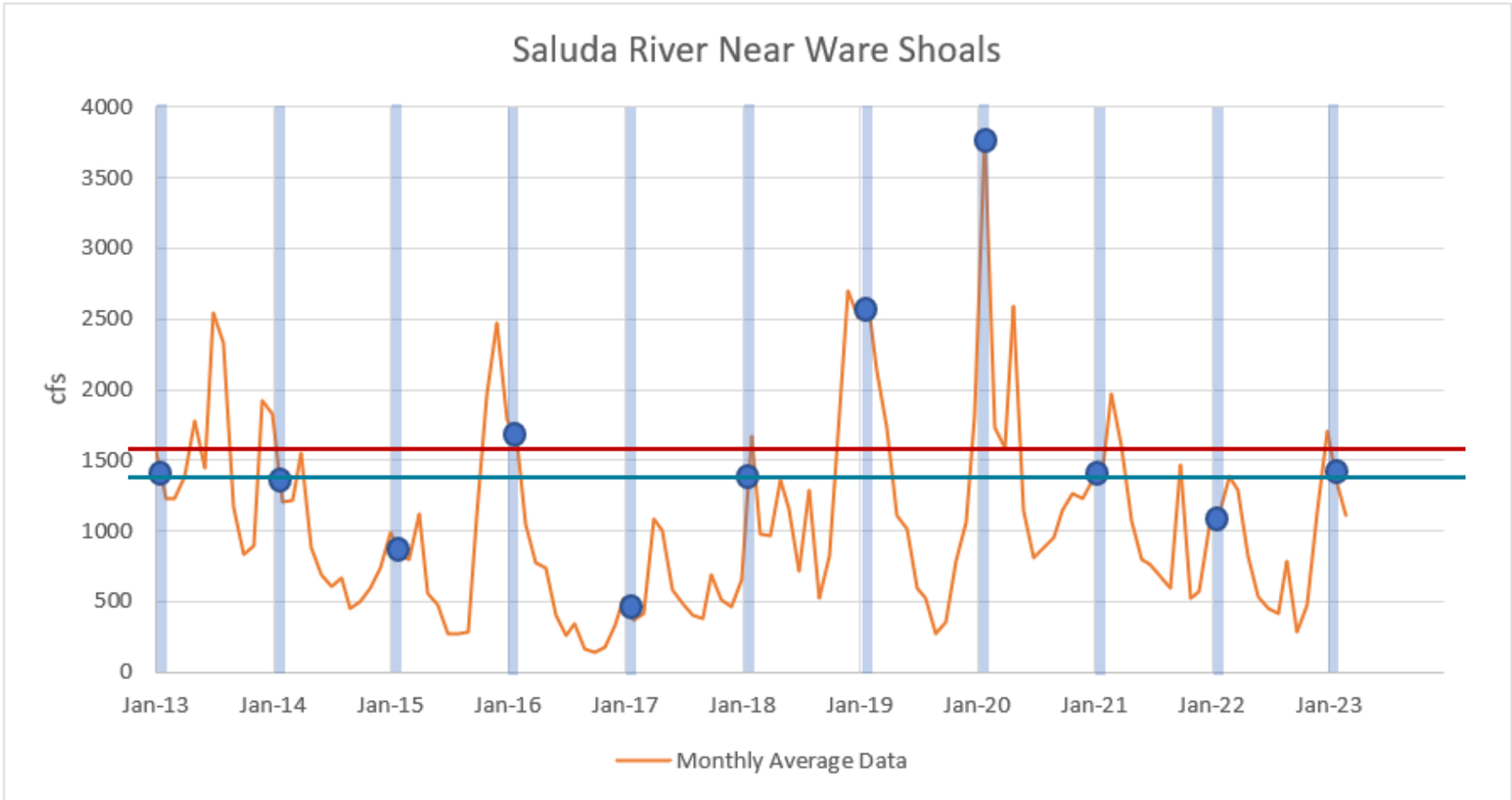
The answer is different with monthly vs. daily data.

(Note that this example does not include storage)

You will have the benefit of summary tables that can be developed for daily and monthly data.

Important Hydrologic Statistics

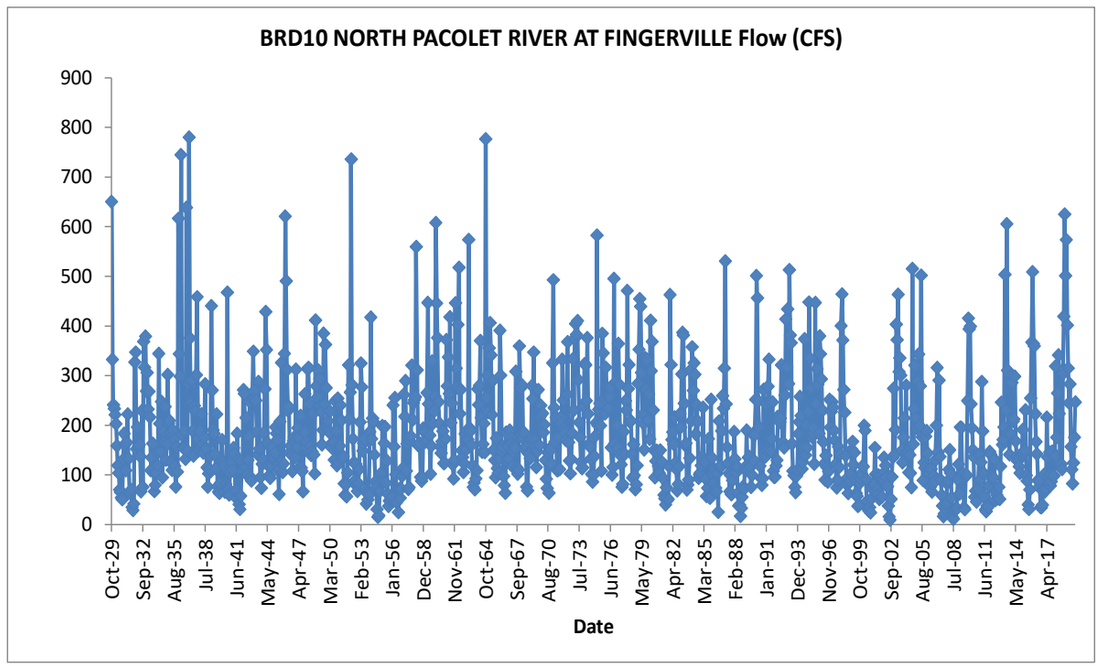
- **7Q10:** Low flow metric, representing the lowest 7-day average flow that occurs once every 10 years.
- **Median Monthly Flow:** Median value of all monthly average flows for a given month (Jan illustrated by blue dots):
  - *Half the points higher, half lower*
- **Mean Monthly Flow:** Average value of all monthly average flows for a given month (Jan illustrated by blue dots)
  - *Usually higher than the median, since high points "stretch" the average.*



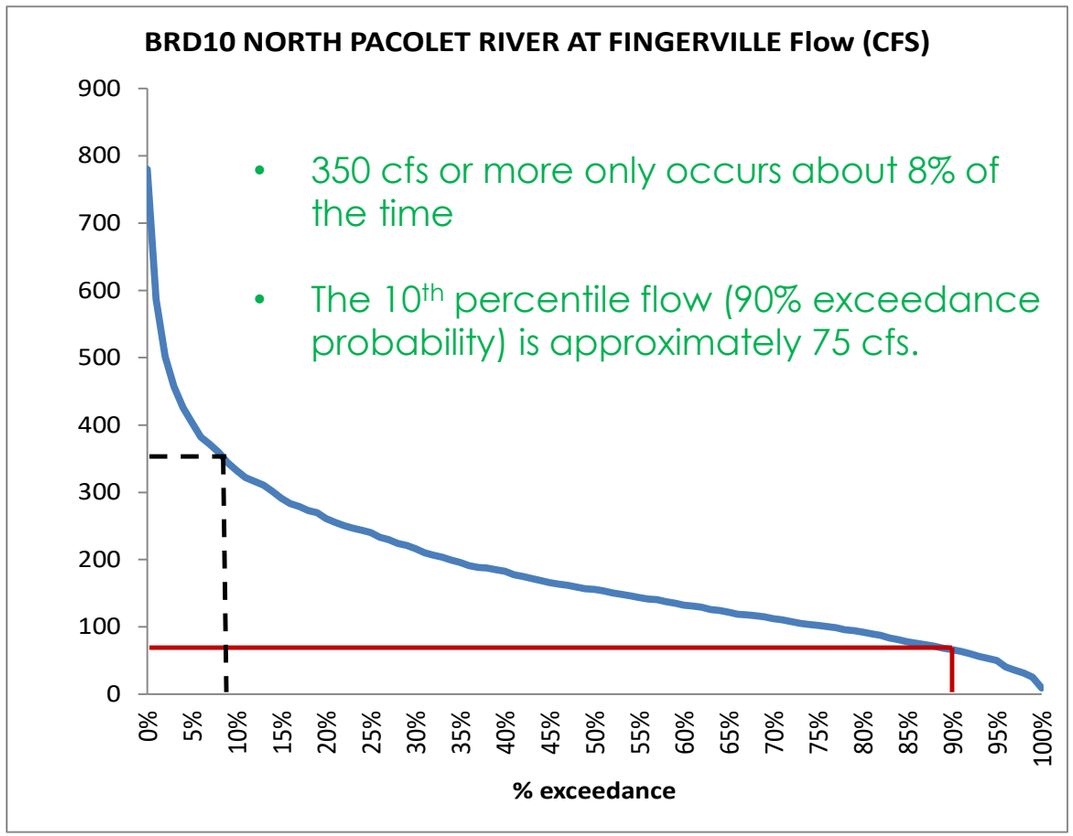
Mean and median estimated visually

Other Flow Statistics:

Statistics vs. Patterns



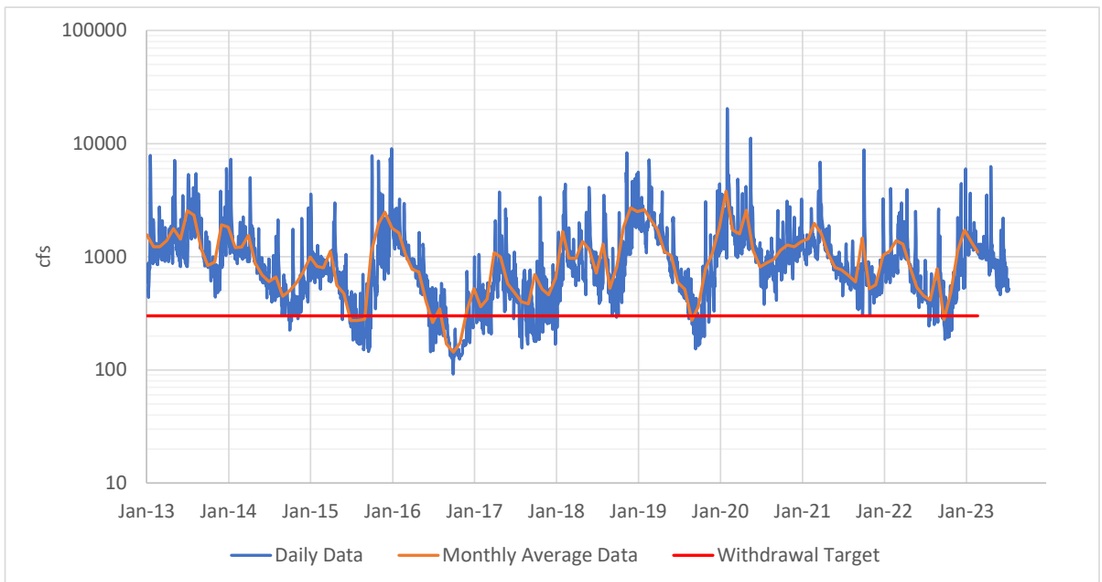
Here we can see patterns but not statistics



Here we can see statistics but not patterns

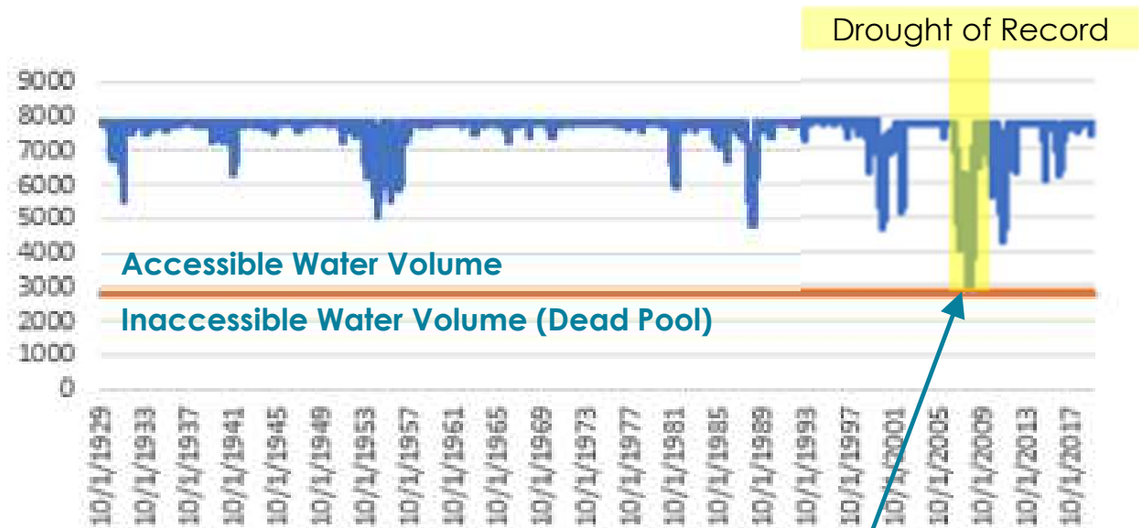
Water Availability

Direct River Withdrawal



Water is limited to the flow in the stream at any point in time

Reservoir Withdrawal



"Safe Yield" is the amount of water that can be continuously withdrawn from a reservoir through the period or record without depletion. Generally higher than river withdrawals because storage buffers low flows.

New View of the Hydrologic Cycle