Extreme Low and High Flow Analysis of the Various Regions of the United States

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Abstract

Water resource management is crucial during low flow periods, whereas high flow estimation is essential for the prevention against flooding during high flow periods. In this study, we analyzed the long term historical data from the Hydro-Climatic Data Network (HCDN) from 1700 stations within the 21 regions across the entire 50 states of the United States. The tool developed by Environmental Protection Agency (EPA), DFLOW, was utilized to estimate 7Q10 low flows, and PeakFQ software was utilized to systematically estimate 100-year and 500-year floods within 95% confidence interval. We found a general pattern when comparing the 7Q10 values to the 100-year and 500-year return period peak flow indicating higher 7Q10 values may correlate to 100-year and 500-year return period flows. For example, the data analysis from Region 6 has a minimum 7Q10 value of 0.5882 ft^3/sec corresponding 100-year and 500-year flow estimate of 1183 ft^3/sec and 1469 ft^3/sec respectively, whereas the max 7Q10 value is 406.62 ft^3/sec, corresponding to a 100-year and 500-year flow of 239200 ft^3/sec and 285300 ft^3/sec, respectively. We also came to a general equation to estimate 500-year data based on 100 year return period as follows $Q_{500} = 1.1736*Q_{100}+7589.6$

Definitions

- 7Q10 is the lowest 7-day average flow with a minimum of 10 years of data.
- 100-year data means that there is a 1 in 100 probability of the flow value occurring in any given year.
- 500-year data means that there is a 1 in 500 probability of the flow value occurring in any given year.
- 95% Confidence Interval means that 95% of the time, the flow values will fall within that range.
- (cfs) is cubic feet per second

Objectives and Methods

Objective

- To analyze the flow data from 1700 stations within 21 basins across the United States
- To estimate the region wise lowest and highest flow

Methodology

- Download station data from the U.S Geological Survey database (USGS.gov)
- Run the information in DFLOW, BASINS 4.2, and PeakFQ to estimate lowest flows (7Q10) and 100-year and 500-year return period flows
- Conduct the statistical analysis to find any correlation with 100-year vs. 500-year and high flow vs. 7Q10 low flows

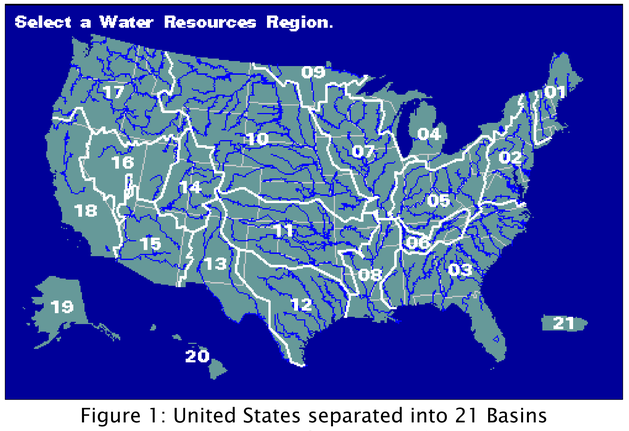


Figure 1: United States separated into 21 Basins (Source: pubs.usgs.gov)

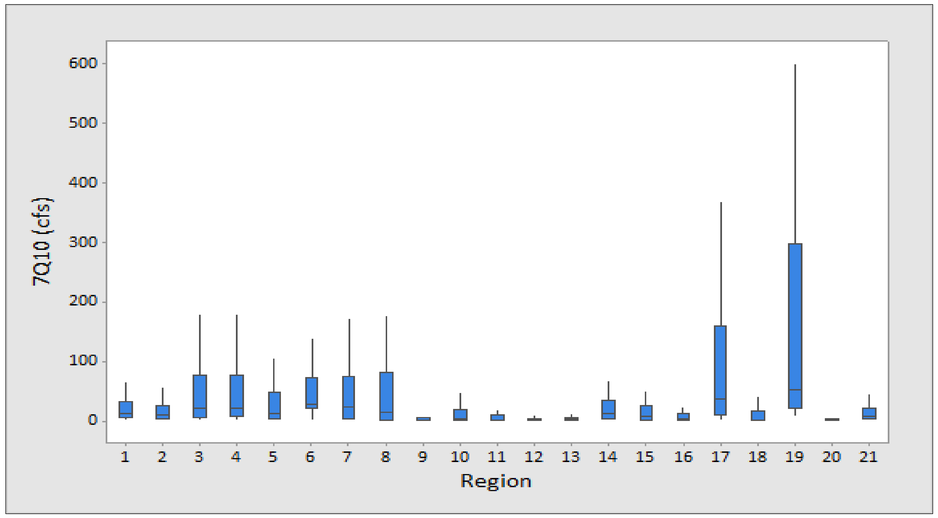
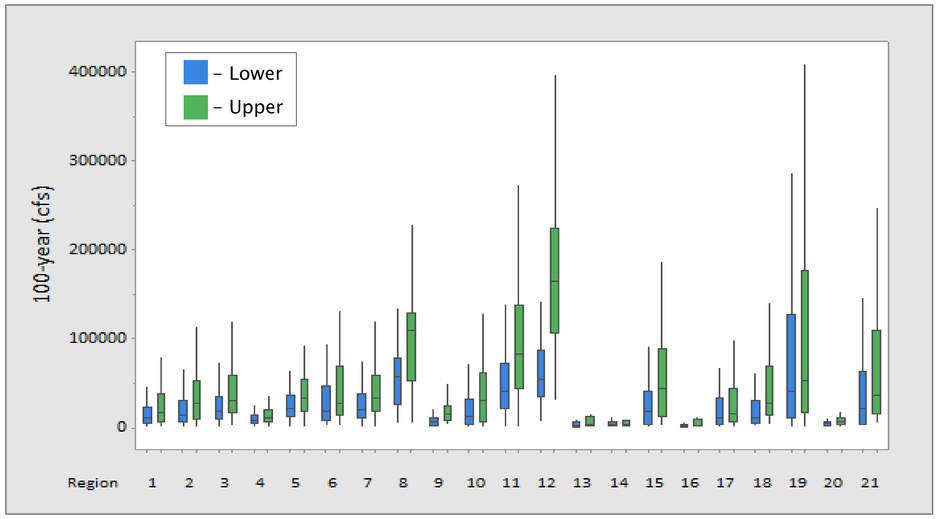


Figure 2: 7Q10 Values for Regions Across the Nation



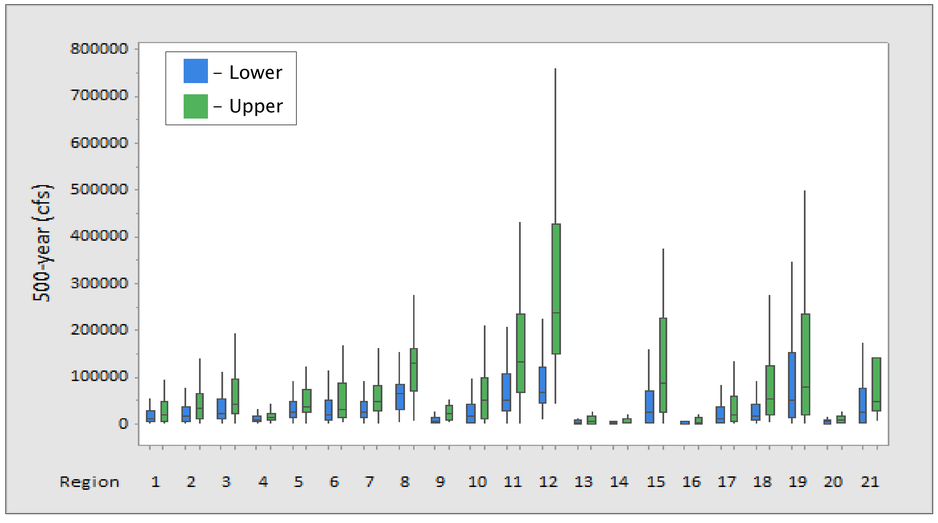


Figure 3: a) 100-year Return Period Flow with 95% Confidence Interval
b) 500-year Return Period Flow with 95% Confidence Interval

	7Q10		100-year Lower		100-year Upper		500-year Lower		500-year Upper	
Region	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
1	36.89	95.05	18548.15	25590.36	28216.53	34844.29	21617.11	28518.68	35021.20	41495.59
2	66.57	268.10	32467.01	69986.72	52688.16	97378.10	39744.34	83224.83	69191.85	122344.45
3	148.43	465.58	31179.62	38920.62	56550.48	131903.18	42110.66	49909.30	88729.64	256725.45
4	3085.99	23293.09	12405.88	15907.92	16874.67	20323.92	15184.71	18958.45	22065.36	25859.25
5	126.55	375.04	41790.35	85505.78	61980.33	119819.36	51281.32	97465.67	81500.34	151759.99
6	62.98	91.15	32292.60	35521.06	51973.69	57026.74	37935.42	41566.19	64298.58	70467.02
7	339.70	1721.97	31727.06	38619.12	49179.51	53317.65	40783.07	46069.21	68959.06	69501.83
8	14953.63	49041.70	315973.23	656940.73	517794.95	1085899.95	336328.14	686611.57	580708.18	1203299.39
9	109.21	560.84	9485.55	13622.00	1.0868E+10	6.7056E+10	13196.95	17543.70	1.0678E+12	6.5883E+12
10	123.12	1004.96	24603.91	55219.03	45962.04	77994.17	33952.20	67711.58	73776.66	107580.36
11	41.18	134.64	48393.98	36514.64	99496.82	75182.92	68636.03	51152.45	163250.72	132942.21
12	12.72	51.58	118615.95	195693.22	2367972.02	13139017.59	173902.42	382988.95	4423025.66	31233171.26
13	13.72	38.70	6510.69	12434.47	21510.08	42486.96	12174.97	25989.30	50789.62	107179.08
14	76.90	219.56	7200.73	12811.85	11645.43	21557.09	9124.96	16521.93	17294.70	34056.37
15	18.42	24.83	35049.52	45233.07	78504.05	96540.55	61006.54	82308.57	165102.94	204008.14
16	9.45	12.99	2509.20	3406.55	5240.47	6878.38	4262.11	5757.70	9449.06	13479.42
17	207.06	501.78	24837.07	39893.94	35213.27	55554.25	30286.54	48077.02	46333.83	72225.93
18	50.82	265.03	27718.39	54079.26	56981.35	84422.07	39209.06	71519.86	103076.43	149060.61
19	3095.60	7083.00	131624.08	230611.59	181356.28	306910.79	158182.06	274448.93	225105.41	386600.56
20	2.30	5.90	4684.18	3847.21	7866.14	6257.37	6362.82	5560.80	11936.22	10436.61
21	13.55	15.81	34634.89	40729.80	79760.13	100614.01	51190.13	62431.59	162900.33	233172.46

Table 1: Low flow (7Q10) and high flow (500-year) and Statistics of the 21 Regions

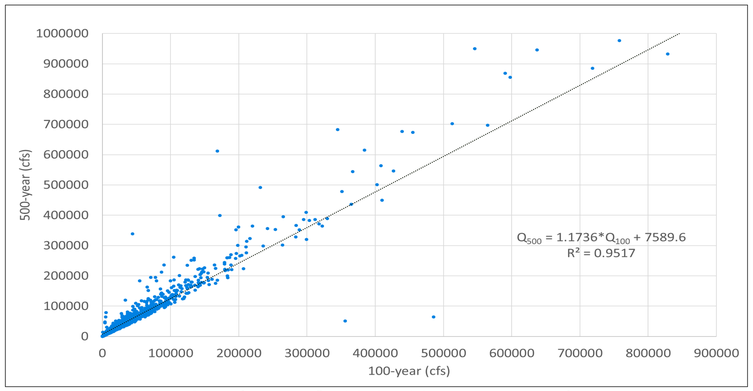


Figure 4: Correlation of 100 & 500 Year Across the Nation

Results

Figure 2:
- It shows the ranges of 7Q10 in all of the regions
- Region 9, 12, 13, and 20 have the smallest 7Q10 which refers the lowest flows in those regions

Figure 3:
- It shows the comparison of 100-year and 500-year flows within 95% Confidence interval throughout the 21 regions
- The graphs shows that 100 and 500-year flows is largest in regions 12 and 19 and smallest in 13 and 14.
- The blue boxes show the lower 100-year and 500-year flows, whereas the green boxes show the highest 100-year and 500-year flows.

Figure 4:
- It shows the correlation between 100-year and 500-year data points.
- We were able to find an equation to estimate 500-year flows based on 100-year flows as follows:
  $Q_{500} = 1.1736*Q_{100}+7589.96$

Table 1:
- It shows the mean and standard deviation of 7Q10, 100-year and 500-year flows with in 95% confidence interval.

Conclusion

We analyzed the streamflow data from 1700 stations of 21 regions across the nation. Our analysis indicates that 7Q10 low flows is not strongly correlated with 100 or 500-year high flows, whereas a noticeable correlation was detected for 100-year and 500-year flow values (R^2=0.9517). Regions 9, 12, 13 and 20 are some of the regions which offer the lowest 7Q10 flow values. Similarly, regions 11, 12, 15 and 19 are the regions which offer the highest 100-year and 500-year flows. Water resource managers and planners can use this information to manage their water resources during low and high flow periods.

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