

STREAMFLOW TRENDS IN WISCONSIN

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PURPOSE

- To determine changes in streamflow characteristics in Wisconsin as related to precipitation and land use
- Select a period of record for future low studies that represents current conditions

BACKGROUND

- A study on streamflow trends in Southwestern Wisconsin stream raised questions about how well previous low flow reports represent current streamflow conditions.
- Earlier study found significant trends in low and high flow characteristics for many streams.
- Where the land use was agricultural the low flow characteristics were increasing and flood peaks decreasing.
- Similar trends were not found for forested streams

APPROACH

- Compute streamflow characteristics at gaging stations to determine if changes have occurred.
- Fifteen gaging stations were selected for analysis that represent the twelve major river basins in the State.
- Stations selected were on streams with no or minimal regulation.

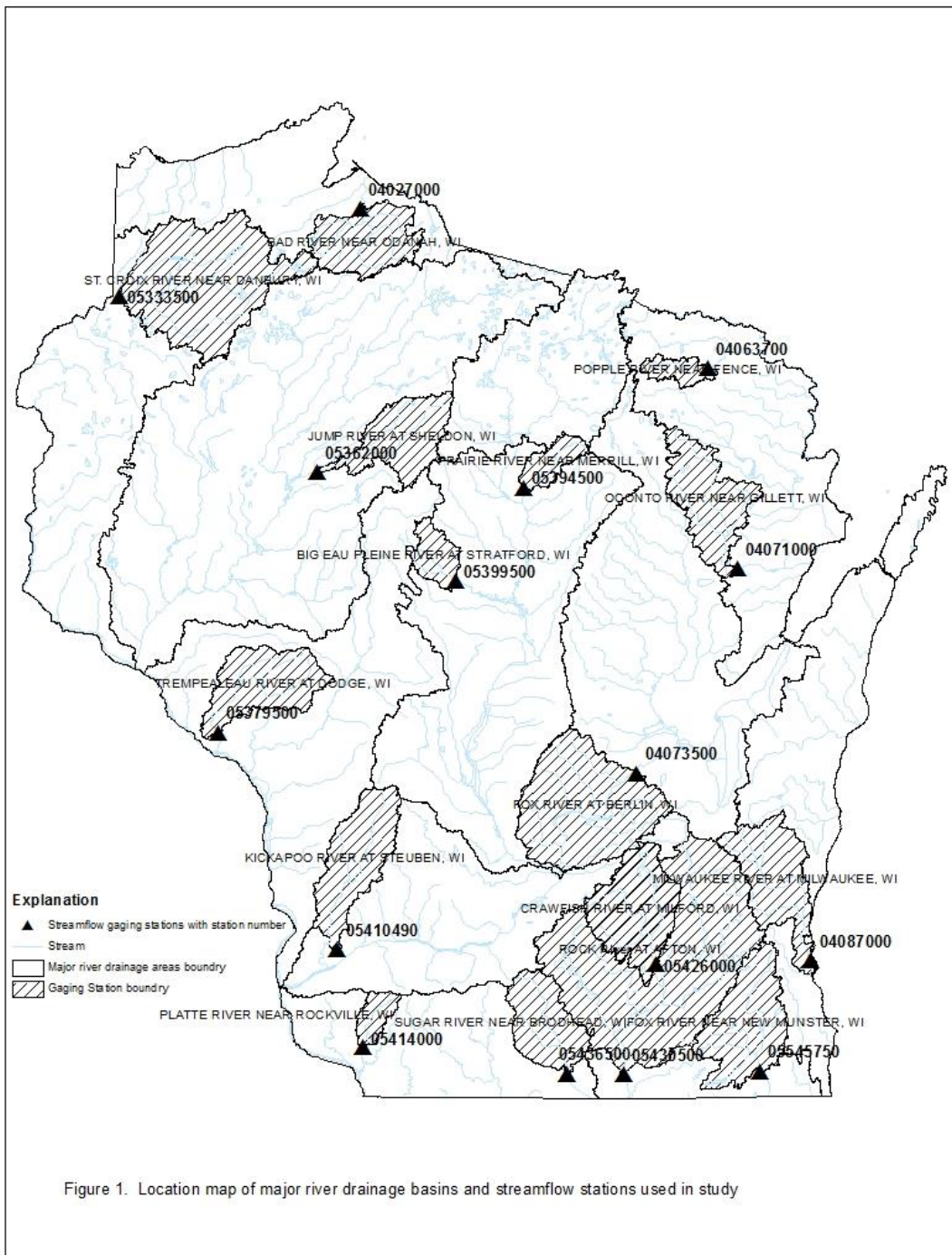


Figure 1. Location map of major river drainage basins and streamflow stations used in study

DATA ANALYSIS

- The streamflow characteristics selected were the annual seven day low flow, annual average flow and annual flood peaks.
- The 1915-2008 period was selected since it represents longest period where most of the 12 major river basins had data available for analysis.
- Missing record at several stations was estimated by correlation analysis with nearby gaging stations.
- Precipitation data were obtained for the 1915-2008 period from National Weather Service.

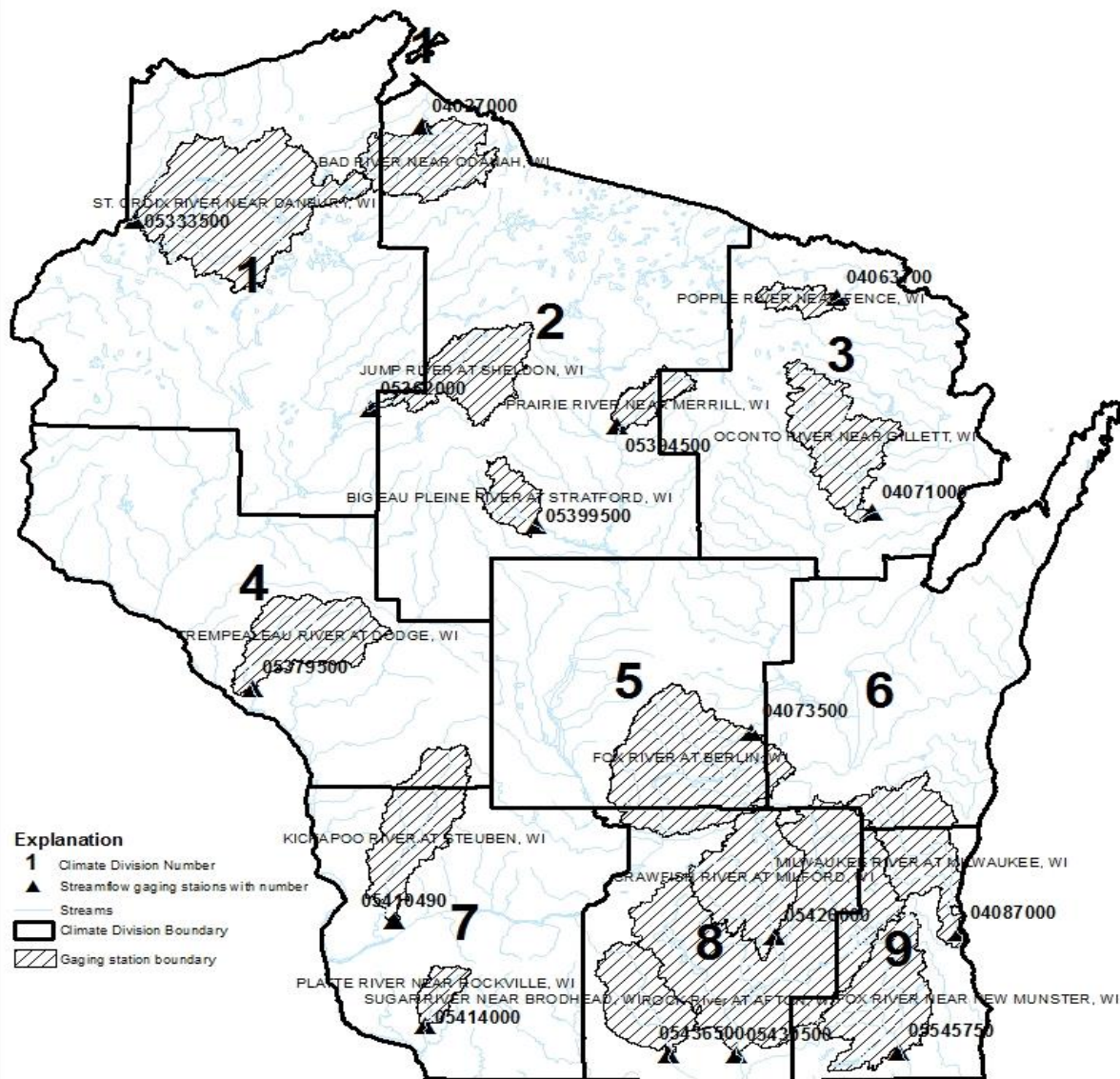
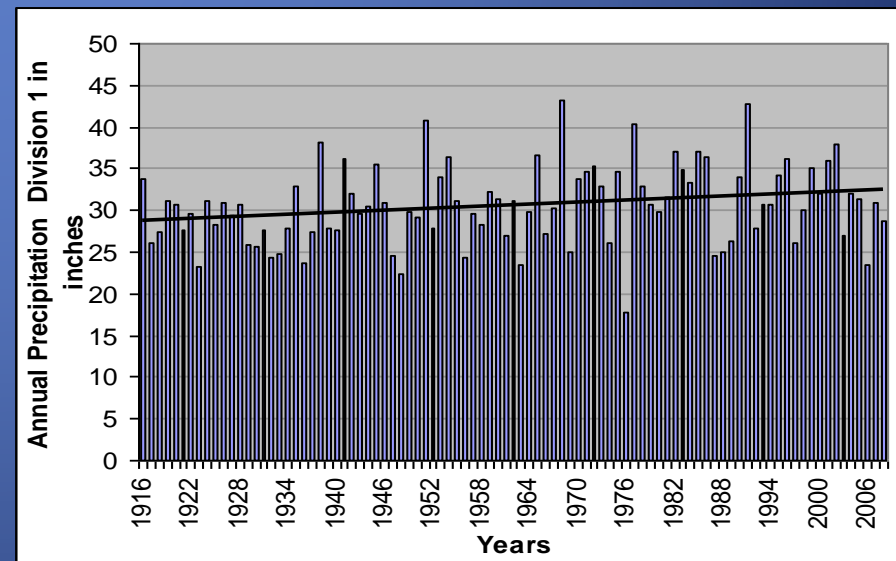
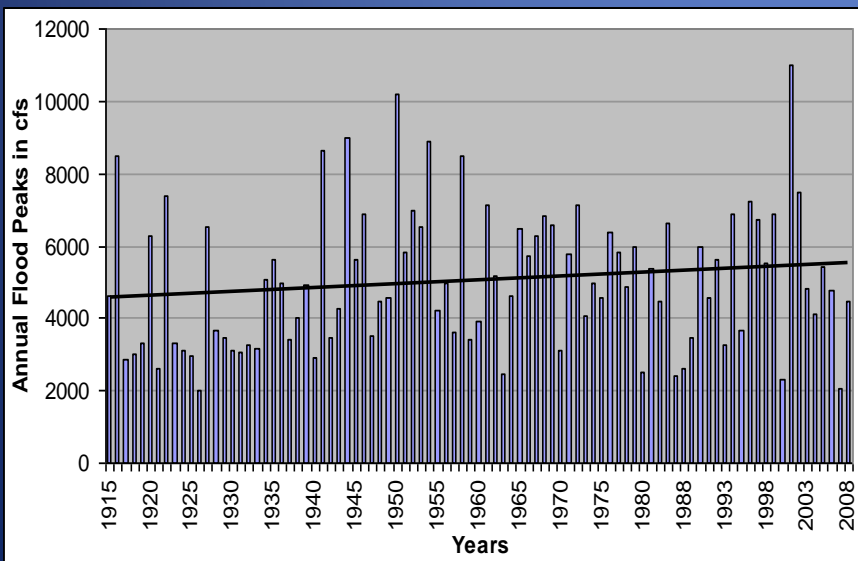
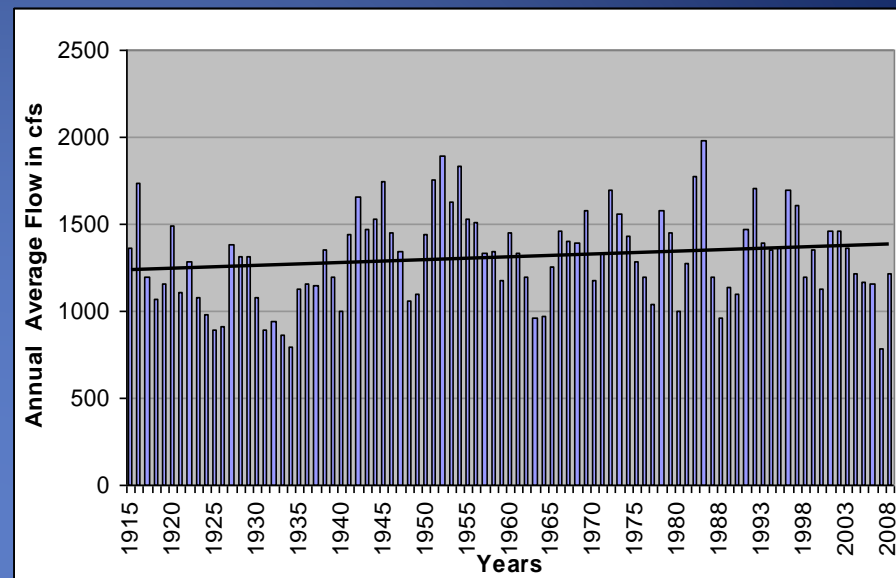
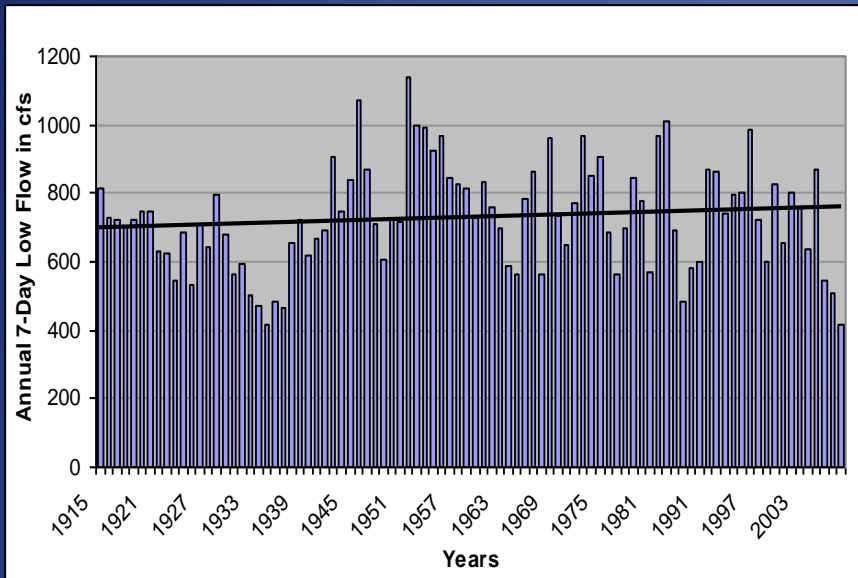


Figure 2. Map of Wisconsin showing nine climatic divisions determined by the National Weather Service and Streamflow gaging stations used in study.

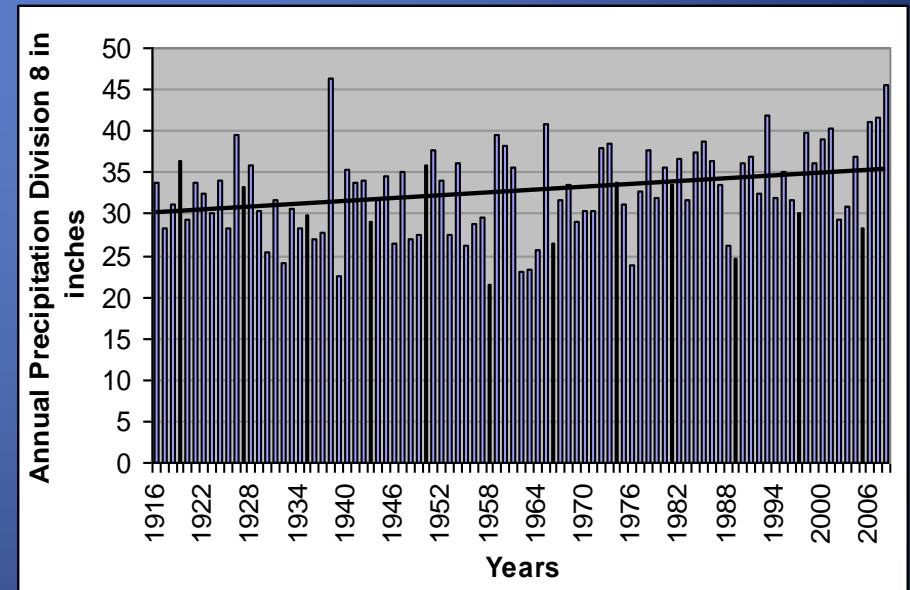
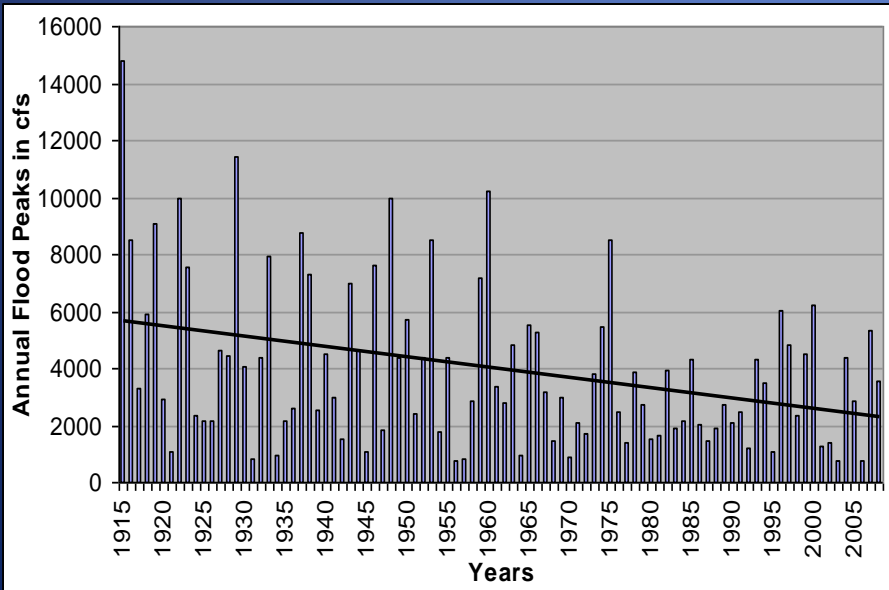
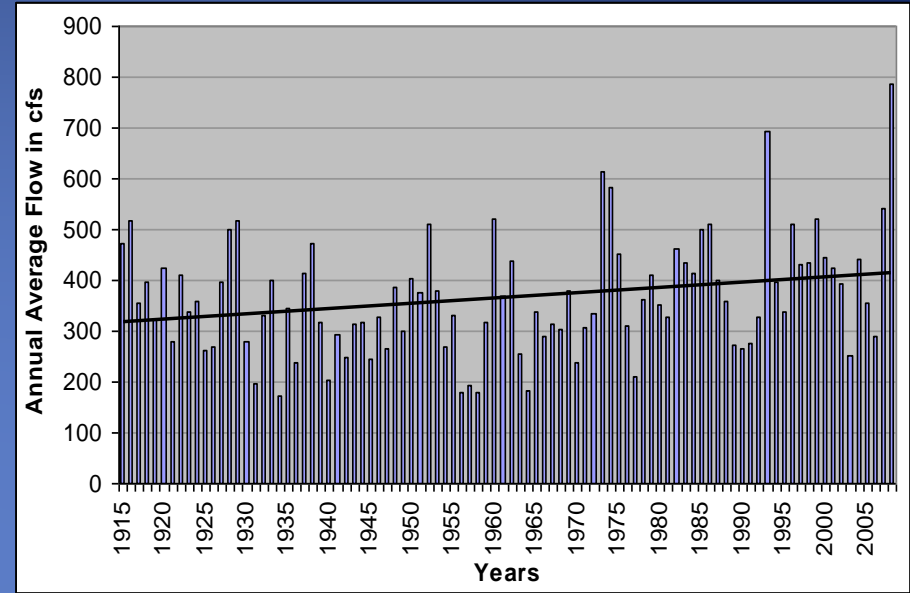
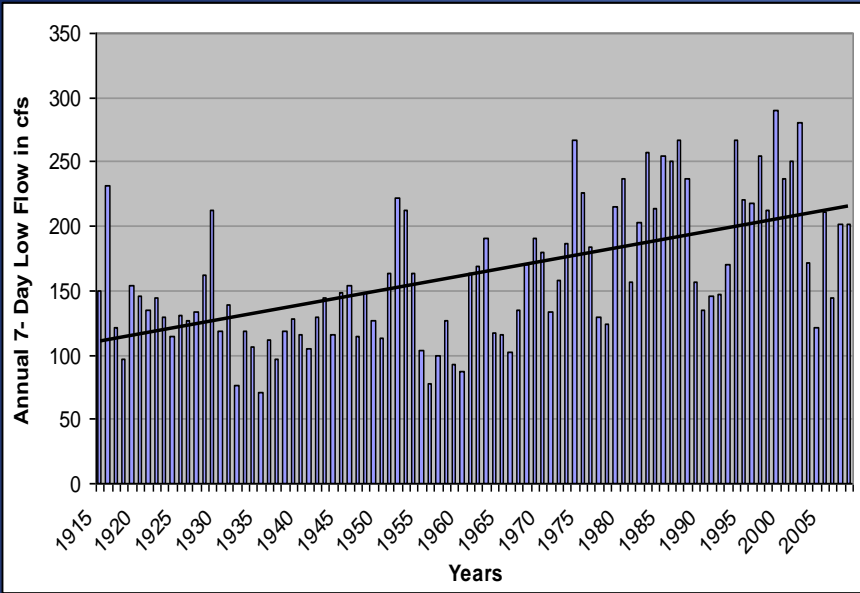
GRAPHICAL EVALUATION

- Plots of annual streamflow characteristics and annual precipitation were made for 1915-2008 for all fifteen gaging stations
- Visual inspection showed similar pattern as previous study
- For agricultural areas low flows increasing and flood peaks decreasing
- For forested areas had little change

St Croix River near Danbury 1915-2008



Sugar River near Broadhead 1915-2008

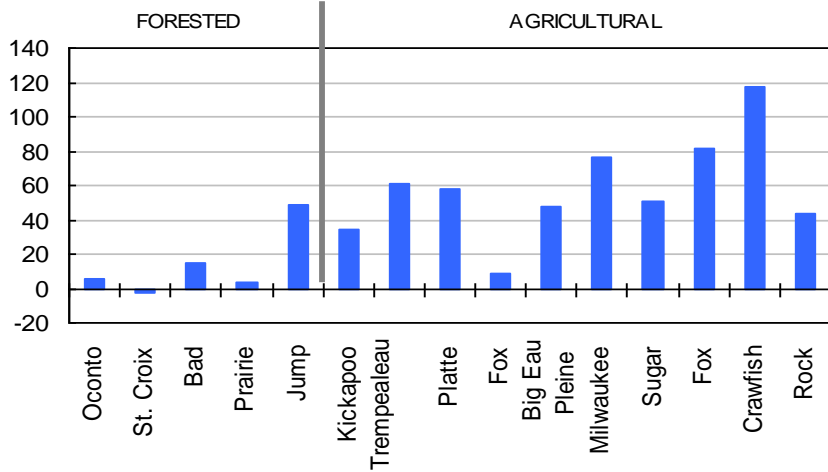


ANNUAL FLOW CHARACTERISTICS

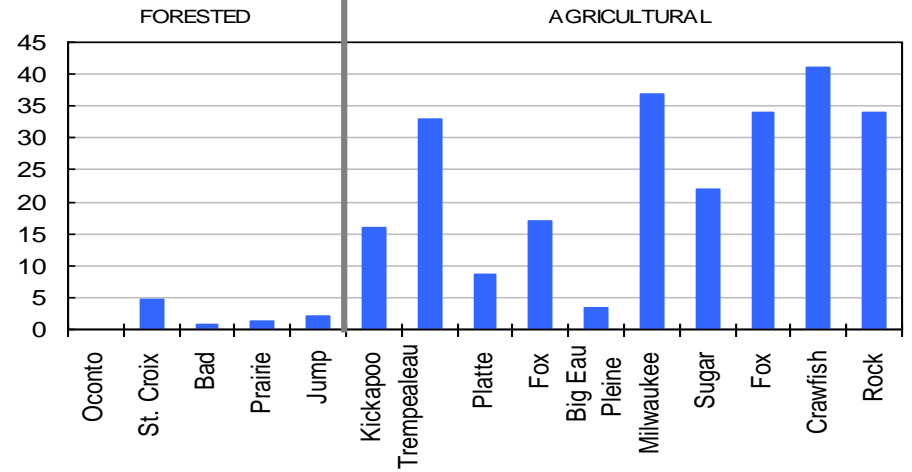
- **Changes in flow characteristics were compared for the 1915-1968 period to the selected period 1969-2008 for future low flow reports**
- **Streamflow characteristics for the 15 gaging stations were compared by forest cover or agriculture as dominant land use.**

CHANGE IN ANNUAL STREAMFLOW CHARACTERISTICS BETWEEN 1915-1968 AND 1969-2008 PERIODS

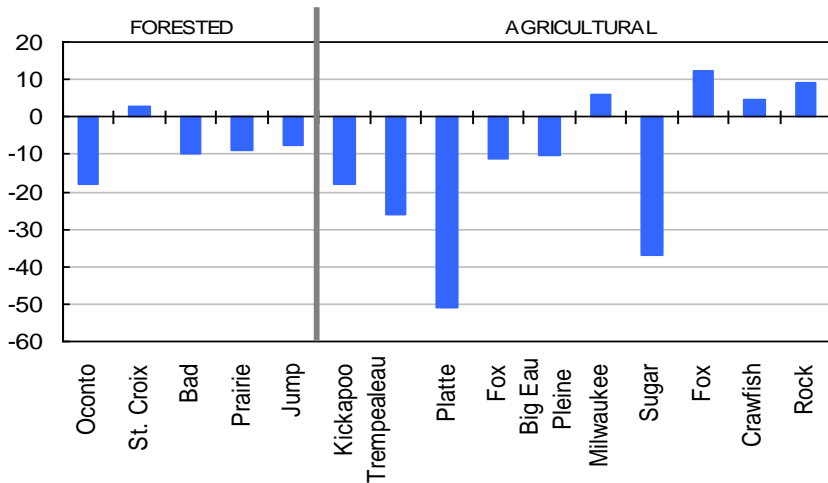
PERCENT CHANGE IN 7-DAY LOW FLOW



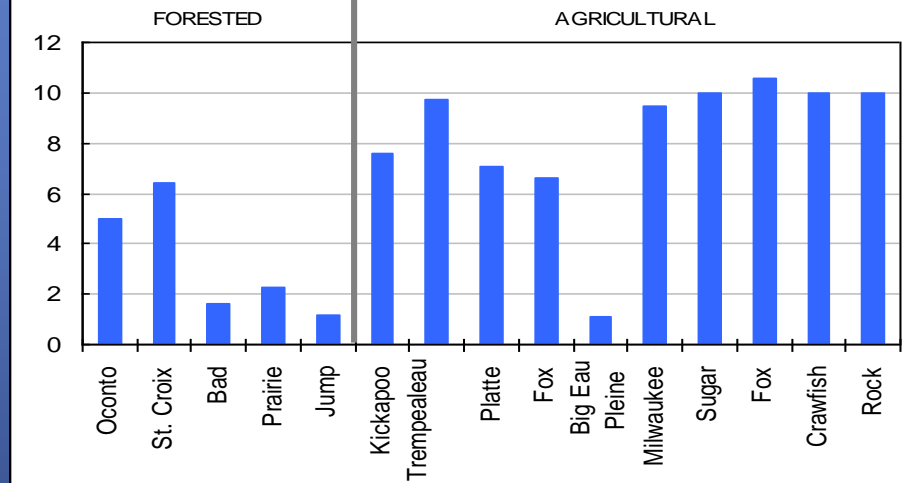
PERCENT CHANGE IN AVERAGE FLOW



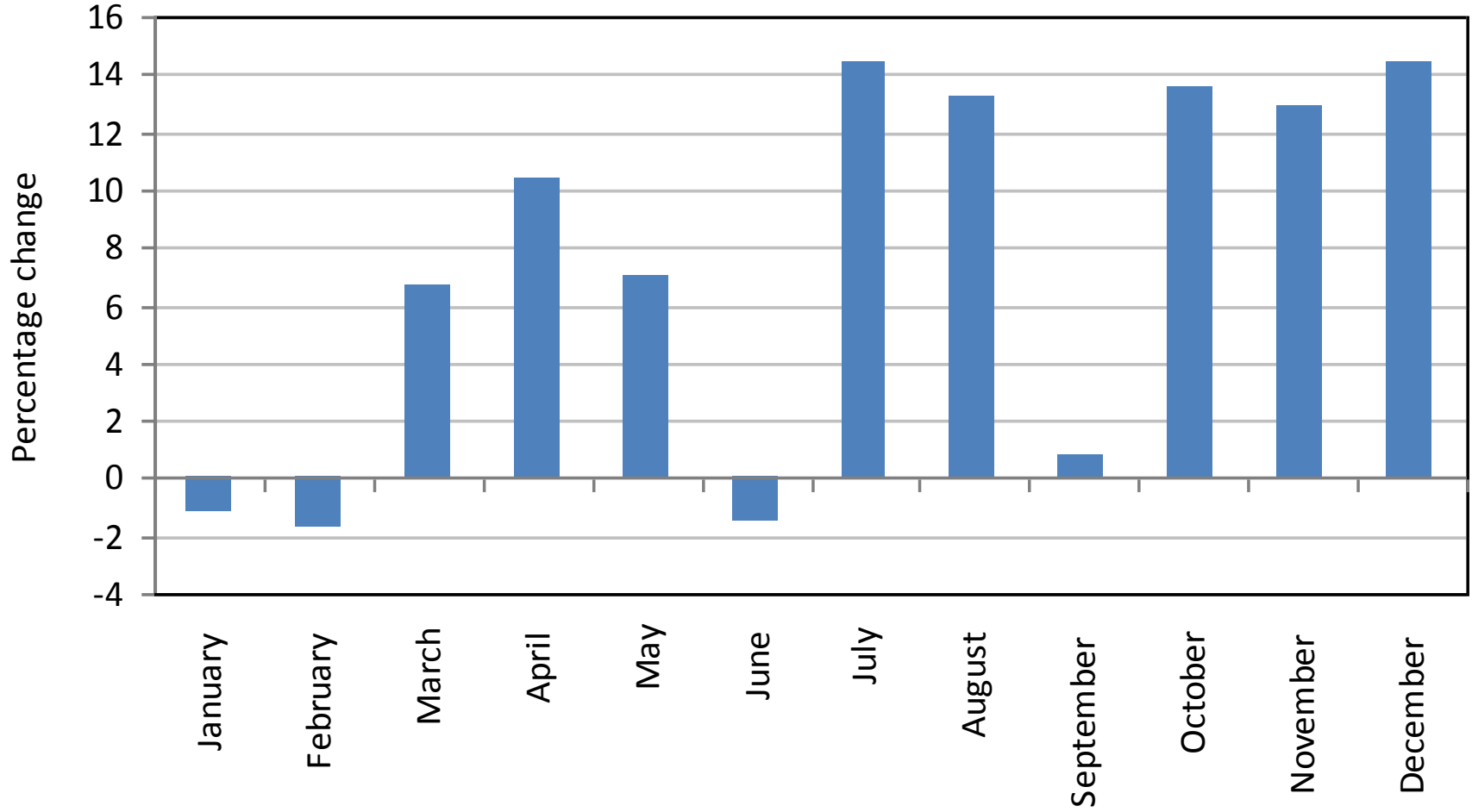
PERCENT CHANGE IN ANNUAL FLOOD PEAK



PERCENT CHANGE IN ANNUAL PRECIPITATION



Average percentage change in precipitation for 14 sites from 1916 - 68 to 1969 - 2008



TREND ANALYSIS

- Time trends of streamflow characteristics and precipitation were investigated by computing Kendall tau
- Kendall test is a nonparametric or distribution free test for trends
- The test computes p-values corresponding to Kendall tau
- A trend was considered significant if p-value was 0.05 or less

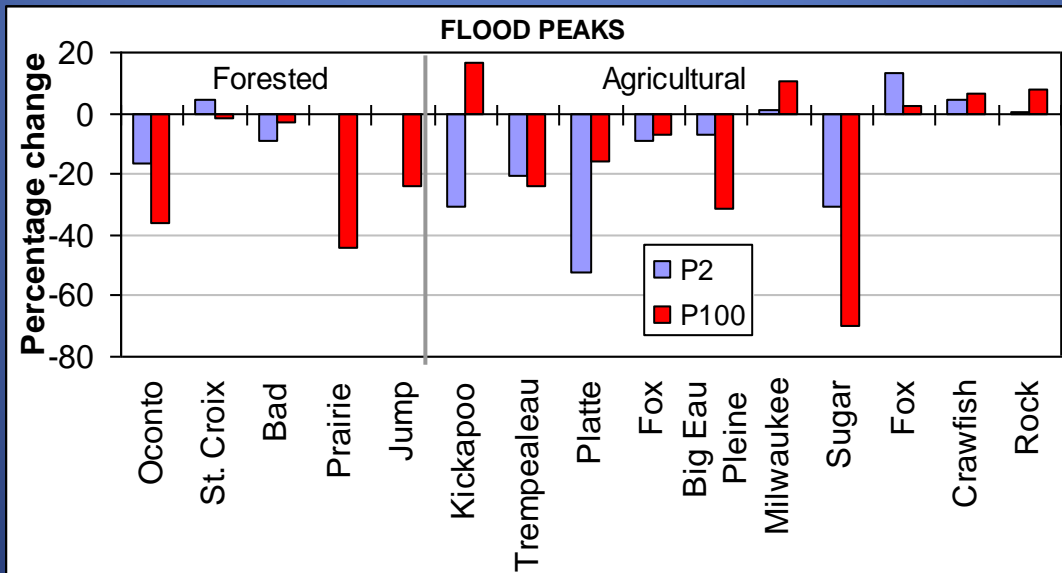
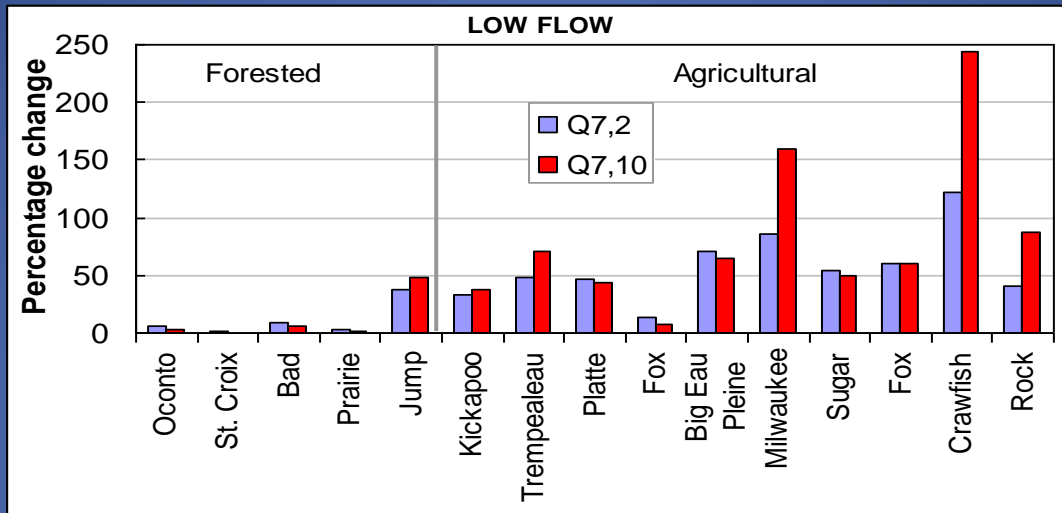
KENDALL TAU RANK CORRELATION AND P VALUES FOR STREAMFLOW CHARACTERISTICS AND PRECIPITATION FOR PERIOD 1915-2008

Stream name and location	Period of	Drainage	Forest	7-day low flow		Average flow		Annual peak flow		Annual Precipitation	
	Record	Area	Cover	Tau	P value	Tau	P value	Tau	P value	Tau	P Value
	(years)	(mi ²)	(percent)								
Forested streams											
Oconto River near Gillett	99	678	88	-0.017	0.804	-0.115	0.102	-0.166	0.019	0.120	0.090
St. Croix River near Danbury	92	1,558	83	0.078	0.278	0.091	0.206	0.130	0.069	0.170	0.014
Bad River near Odanah	61	597	80	0.135	0.056	0.099	0.160	-0.064	0.445*	0.037	0.602
Prairie River near Merrill	87	184	74.6	-0.047	0.524	-0.143	0.055	-0.052	0.478	0.060	0.399
Jump River at Sheldon	94	574	62	0.311	<0.001	-0.009	0.897	-0.021	0.765	0.024	0.737
Agricultural streams											
Kickapoo River at Steuben	76	690	37.2	0.338	<0.001	0.145	0.041	-0.191	0.015*	0.161	0.022
Trempealeau River - Dodge	81	643	25.8	0.500	<0.001	0.265	<0.001	-0.113	0.140*	0.184	0.009
Platte River near Rockville	74	142	22.3	0.355	<0.001	0.023	0.746	-0.360	0.000*	0.141	0.046
Fox River at Berlin	111	1,430	22	-0.0016	0.984	0.058	0.412	-0.178	0.011	0.135	0.055
Big Eau Pleine River at Stratford	83	224	21.2	0.147	0.038	-0.048	0.496	0.009	0.906*	0.021	0.770
Milwaukee River at Milwaukee	95	696	12	0.378	<0.001	0.167	0.018	-0.013	0.860	0.197	0.005
Sugar River at Brodhead	95	523	12	0.375	<0.001	0.145	0.038	-0.191	0.007	0.198	0.005
Fox River - New Munster	69	868	10	0.316	<0.001	0.155	0.030	0.103	0.214*	0.200	0.005
Crawfish River - Milford	78	762	7.4	0.310	<0.001	0.142	0.045	-0.010	0.898*	0.199	0.005
Rock River at Afton	95	6,363	7.9	0.145	0.040	0.188	0.008	-0.057	0.418	0.200	0.005

STREAMFLOW FREQUENCY CHARACTERISTICS

- Streamflow frequency characteristics are used for many design purposes.
- To determine changes in streamflow characteristics log Pearson analysis was done for the three streamflow characteristics for the 15 stations.
- Comparison was made between 1915-1968 and 1969-2008 period.

CHANGE IN STREAMFLOW FREQUENCY CHARACTERISTICS BETWEEN 1915-1969 AND 1969-2008



CONCLUSIONS

Low Flow

The annual 7-day low flow had significant increasing trends for 10 of 15 streams

-increases occurred mainly for streams in agricultural areas

-increases for the 10 streams averaged 58 percent ranging from 8.3 - 117 percent between two periods

The Q7,10 discharge increased 82% for ag streams and only 12% for forested streams

The increases are probably the result of changes in agricultural practices, land use and increased precipitation

CONCLUSIONS

Annual Average Flow

- 8 of 15 streams had significant increasing trends
- seven of eight increases occurred in agricultural areas
- increases averaged 17 percent ranging from 0 to 41 percent between two periods
- increases are probably result of increased precipitation and changes in precipitation patterns

CONCLUSIONS

Flood Peaks

The annual flood peaks had significant decreasing trends for 5 of 15 streams

- 4 of the 5 streams that decreased were in agricultural areas

- decreases averaged 11 % ranging from 0 to 51% with forested streams decreasing 22% and ag streams 10%

The 100 year flood peak decreased an average of 14% ranging from 2 to 70%.

Decrease in flood peaks, in spite of increased precipitation, is probably result of increased infiltration

IMPLICATIONS

- Increased Q7,10 means many sewage treatment plants were oversized providing an extra margin of safety
- This also could mean with the new lower phosphorus limits that are being enacted, some sewage treatment plants upgrades may be minimized
- Decreased P100 means bridges and floodways were oversized
- Increased low flow/base flow resulted in significant increase in trout fishery, especially in SW Wisconsin.
- If the increase in annual precipitation is a result of climate change the impact on flood peaks was overshadowed by changes in agricultural practices

INTERESTING QUESTIONS

- Why did flood peaks decrease for forested streams?
- Why did annual average flow increase more than the increase in annual average precipitation?

Comparison of Streamflow Characteristics for 1969-2008 with Streamflow Characteristics from Previous Published Reports

		LOW FLOW						FLOOD PEAKS						
Station Number	Station Name and location	Drainage Area	1969-2008		Previous Reports		Percent Change		1969-2008		Previous Reports		Percent Change	
		sq. mi	Q7,2	Q7,10	Q7,2	Q7,10	Q7,2	Q7,10	P2	P100	P2	P100	P2	P100
			cfs	cfs	cfs	cfs			cfs	cfs	cfs	cfs		
	Forested Streams													
4071000	Oconto River near Gillett	678	261	190	247	185	5.7	2.7	2,170	4,880	2,590	6,640	-16.2	-36.1
5333500	St. Croix River near Danbury		735	541	721	541	1.9	0.1	4,920	10,700	4,720	10,900	4.2	-1.9
4027000	Bad River near Odanah	597	109	68.7	100.0	65	9.0	5.7	7,230	21,500	7,950	22,100	-9.1	-2.8
5394500	Prairie River near Merrill	184	73.0	61.3	71.0	60.0	2.8	2.2	1,420	3,150	1,420	4,550	0.0	-44.4
5362000	Jump River at Sheldon	574	52.2	31.2	38.0	21.0	37.4	48.6	8,230	20,700	8,240	25,600	-0.1	-23.7
	Average for five gaging stations						11.4	11.8					-4.2	-21.8
	Agricultural streams													
5410490	Kickapoo River - Steuben	690	331	261	248	190	33.5	37.4	2,240	18,400	3,240	15,400	-30.9	16.3
5379500	Trempealeau River - Dodge	643	264	211	179	124	47.5	70.2	3,200	13,500	4,030	16,700	-20.6	-23.7
5414000	Platte River - Rockville	142	50.0	31.5	34.0	22.0	47.1	43.2	2,340	19,500	4,880	22,600	-52.0	-15.9
4073500	Fox River at Berlin	1430	525	362	462	339	13.6	6.8	3,120	7,260	3,440	7,790	-9.3	-7.3
5399500	Big Eau Pleine River - Strat	224	4.8	1.3	2.8	0.8	71.4	64.6	7,510	24,000	8,070	31,500	-6.9	-31.3
4087000	Milwaukee River at Milwaukee	696	102	62.2	55.0	24	85.5	159.2	4,840	15,600	4,790	14,000	1.0	10.3
5436500	Sugar River - Brodhead	523	200	141	130	94.0	53.8	50.0	2,550	9,880	3,690	16,800	-30.9	-70.0
5545750	Fox River - New Munster	868	160	95.7	100.0	60	60.0	59.5	2,980	7,130	2,630	6,960	13.3	2.4
5426000	Crawfish River - Milford	762	73.2	34.4	33.0	10.0	121.8	244.0	2,280	6,600	2,180	6,170	4.6	6.5
5430500	Rock River at Afton	6,363	588.0	374.0	416.0	200.0	41.3	87.0	6,390	16,000	6,350	14,700	0.6	8.1
	Average for ten gaging stations						57.5	82.2					-13.1	-10.5
	Average for fifteen gaging stations						42.1	58.7					-10.1	-14.2

CHANGE IN STREAMFLOW FREQUENCY CHARACTERISTICS BETWEEN 1915-1969 AND 1969-2008

LOW FLOW

-Q7,10 increased an average of 110% for the 10 agricultural streams and 18% for the 5 forested streams

AVERAGE FLOW

-Annual average flow increased an average of 25% for the 10 agricultural streams and 2% for the 5 forested streams

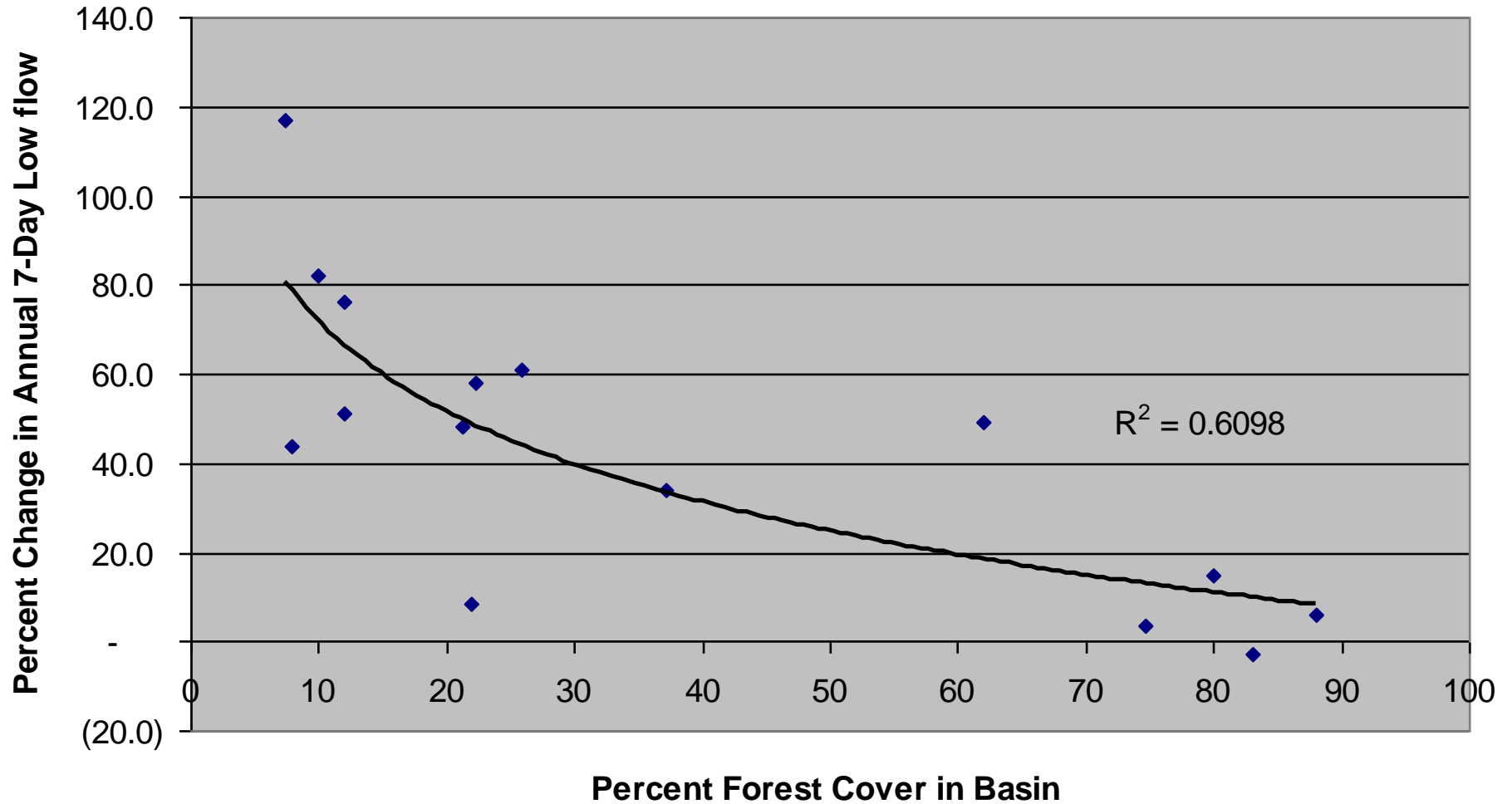
FLOOD PEAKS

-P100 decreased an average of 15% for the 10 agricultural streams and 28% for the 5 forested streams

DISCUSSION

- The significant increasing trends were found at 10 of 15 gaging stations appear to be result of changes in agricultural practices and land use.
- Low flow characteristics are used for design for a variety water facilities including sewage treatment plants and industrial outfalls
- The 100-year flood peak is used for the design of bridges and flood plain mapping.

Change in annual 7-day low flow at fifteen gaging station for period 1915-1968 to 2008 as related to forest cover.



COMPARISON OF STREAMFLOW CHARACTERISTICS AT FOUR STREAMFLOW GAGING STATIONS

Streamflow Characteristics	Streamflow in Cubic Feet Per Second for Indicated Period of Record			Percent Change Between 1915-1968 and 1969-2008	Forest Cover %
	1915-2008	1915-1968	1969-2008		
	St Croix River nr Danbury				83
Q7,2 (ft3/s)	720	707	735	3.9	
Q7,10 (ft3/s)	539	531	541	1.8	
P2 (ft3/s)	4,610	4,740	4,920	3.8	
P100 (ft3/s)	12,200	11,300	10,700	-5.3	
Qavg (ft3/s)	1,310	1,286	1,346	4.6	
Baseflow(ft3/s)	1,054	1,035	1,074	3.7	
Avg Annual Precipitation(inches)	31	29.8	31.7	6.4	
	Oconto River near Gillett				88
Q7,2 (ft3/s)	248	238	261	9.7	
Q7,10 (ft3/s)	185	181	190	4.5	
P2 (ft3/s)	2,380	2,560	2,170	-15	
P100 (ft3/s)	6,250	7,250	4,880	-33	
Qavg (ft3/s)	565	567	565	0	
Baseflow(ft3/s)	424	413	445	7.7	
Avg Annual Precipitation(inches)	30.3	29.8	31.2	4.7	
	Milwaukee River at Milwaukee				12
Q7,2 (ft3/s)	70.8	52.0	102	96	
Q7,10 (ft3/s)	29.5	23.2	62.2	168	
P2 (ft3/s)	4,650	4,540	4,840	6.6	
P100 (ft3/s)	15,300	15,000	15,600	4.0	
Qavg (ft3/s)	442	382	525	37	
Baseflow(ft3/s)	211	163	277	70	
Avg Annual Precipitation(inches)	31.1	29.9	32.8	9.7	
	Sugar River at Brodhead				12
Q7,2 (ft3/s)	154	128	200	56	
Q7,10 (ft3/s)	101	92.4	141	53	
P2 (ft3/s)	3,130	3,730	2,550	-32	
P100 (ft3/s)	14,600	16,800	9,880	-41	
Qavg (ft3/s)	366	334	409	22	
Baseflow(ft3/s)	237	197	291	48	
Avg Annual Precipitation(inches)	32.6	31.3	34.4	9.9	

CHANGE IN STREAM FLOW FREQUENCY CHARACTERISTICS BETWEEN 1915-1969 AND 1969-2008

LOW FLOW

-Q7,10 increased an average of 110% for the 10 agricultural streams and 18% for the 5 forested streams

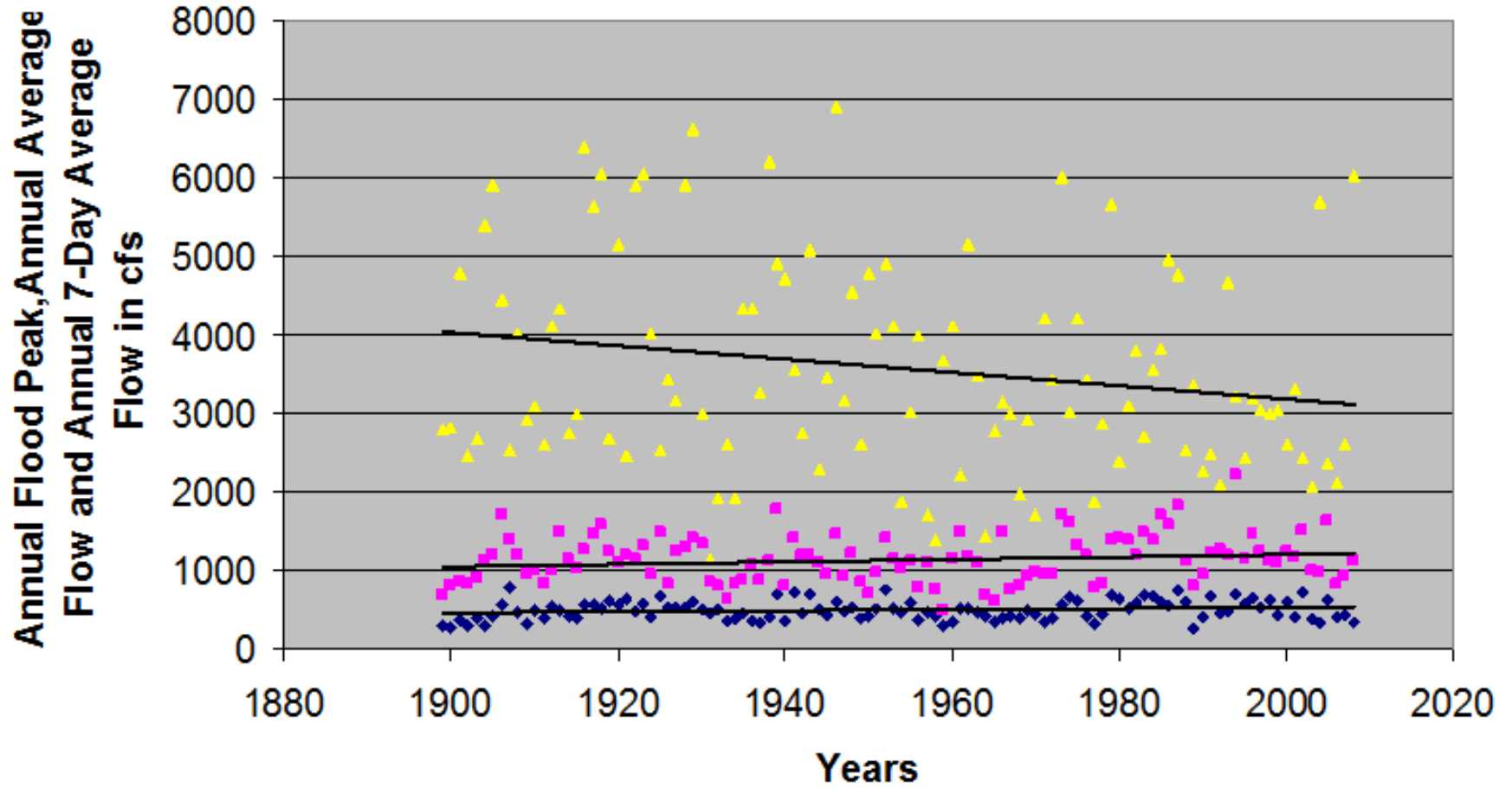
AVERAGE FLOW

-Annual average flow increased an average of 25% for the 10 agricultural streams and 2% for the 5 forested streams

FLOOD PEAKS

-P100 decreased an average of 15% for the 10 agricultural streams and 28% for the 5 forested streams

Fox River At Berlin



Annual Precipitation Characteristics

	Climatic Divisions	1915 - 1968	1969 - 2008	Percent increase	Forest cover
Forested Streams					
Oconto River	3	29.81	31.29	4.96	88.0
St. Croix River	1	29.78	31.68	6.38	83.0
Bad River	1, 2	31.55	32.07	1.64	80.0
Prairie River	2, 3	31.11	31.84	2.33	74.6
Jump River	1, 2	31.72	32.11	1.21	62.0
Average for five streams				3.30	
Agricultural Streams					
Kickapoo River	4, 7	31.69	34.10	7.63	37.2
Trempealeau River	4	30.30	33.24	9.68	25.8
Platte River	7	32.09	34.35	7.07	22.3
Fox River at Berlin	5, 6, 8	30.73	32.77	6.63	22.0
Big Eau Pleine River	2	31.77	32.12	1.10	21.2
Milwaukee River	6, 8, 9	29.94	32.80	9.54	12.0
Sugar River	8	31.30	34.43	10.00	12.0
Fox River st New Munster	9	30.78	34.03	10.56	10.0
Rock River	5, 6, 8, 9	30.95	34.06	10.05	7.9
Crawfish River	5, 6, 8	31.30	34.42	9.98	7.4
Average for 10 streams				8.22	
Average for 15 streams				6.58	

COMPARISON OF STREAMFLOW CHARACTERISTICS AT FOUR GAGING STATIONS

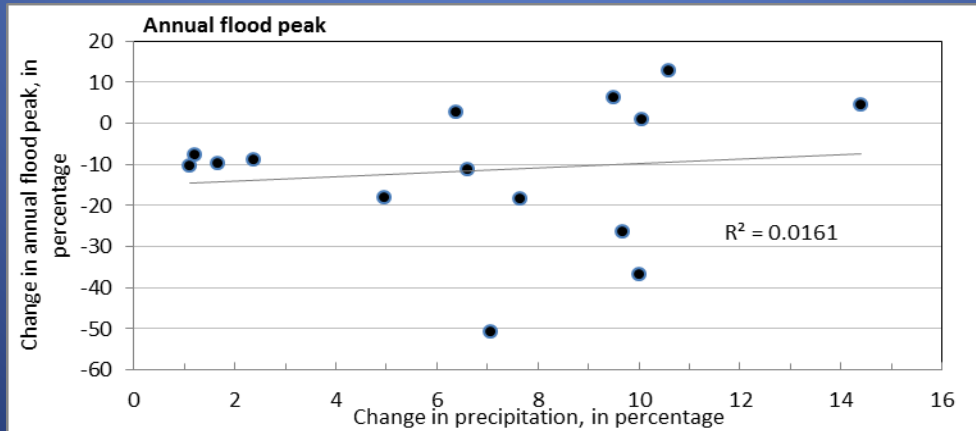
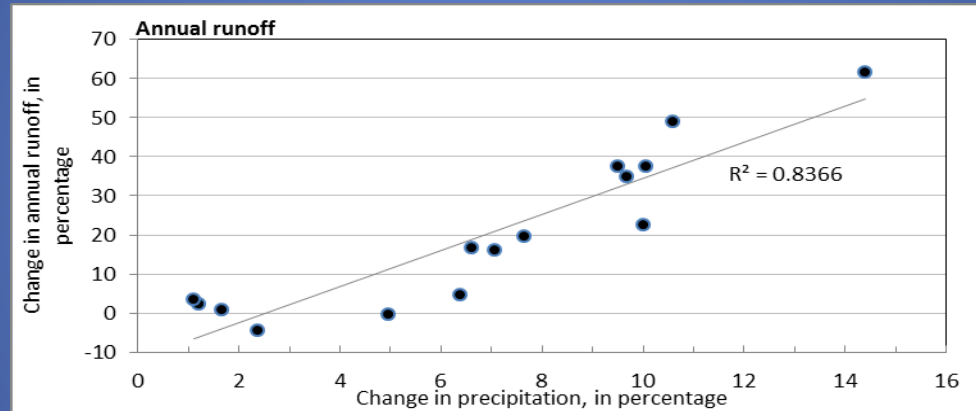
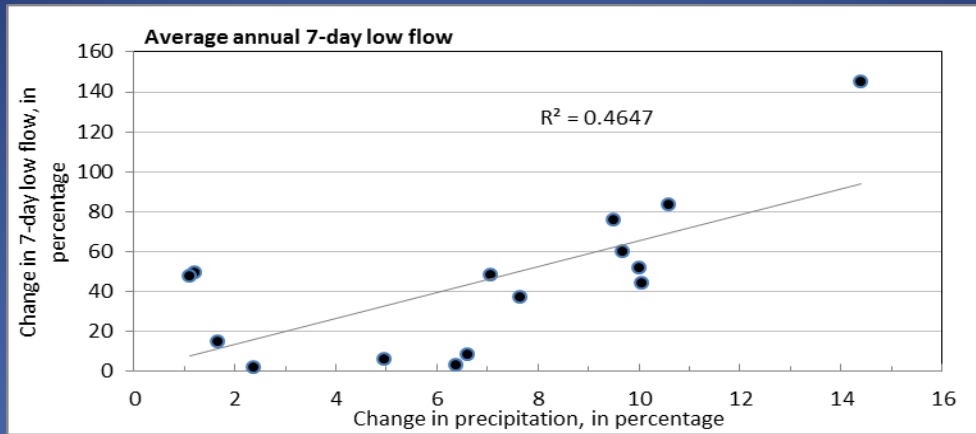
Streamflow Characteristics	CHARACTERISTIC		PERCENT CHANGE
	1915-1968	1969-2008	1915-68 TO 1969-2008
St Croix River nr Danbury			
Q7,2 (ft3/s)	707	735	3.9
Q7,10 (ft3/s)	531	541	1.8
P2 (ft3/s)	4,740	4,920	3.8
P100 (ft3/s)	11,300	10,700	-5.3
Qavg (ft3/s)	1,286	1,346	4.6
Baseflow((ft3/s)	1,035	1,074	3.7
Avg Annual Precipitation (in.)	29.8	31.7	6.4
Oconto River near Gillett			
Q7,2 (ft3/s)	238	261	9.7
Q7,10 (ft3/s)	181	190	4.5
P2 (ft3/s)	2,560	2,170	-15
P100 (ft3/s)	7,250	4,880	-33
Qavg (ft3/s)	567	565	0
Baseflow((ft3/s)	413	445	7.7
Avg Annual Precipitation (in.)	29.8	31.2	4.7
Milwaukee River at Milwaukee			
Q7,2 (ft3/s)	52.0	102	96
Q7,10 (ft3/s)	23.2	62.2	168
P2 (ft3/s)	4540	4840	6.6
P100 (ft3/s)	15,000	15,600	4.0
Qavg (ft3/s)	382	525	37
Baseflow((ft3/s)	163	277	70
Avg Annual Precipitation (in.)	29.9	32.8	9.7
Sugar River at Brodhead			
Q7,2 (ft3/s)	128	200	56
Q7,10 (ft3/s)	92.4	141	53
P2 (ft3/s)	3,730	2,550	-32
P100 (ft3/s)	16,800	9,880	-41
Qavg (ft3/s)	334	409	22
Baseflow((ft3/s)	197	291	48
Avg Annual Precipitation (in.)	31.3	34.4	9.9

ANNUAL PRECIPITATION

- Annual precipitation increased 6.6 percent
- Increase was 3.3 percent for forested streams and 8.8 percent for agricultural streams
- Increase caused some of the increase in low flows
- Increase probably primary reason for increased annual average flow
- Increase appears to have not increased flood peaks which actually decreased

SUMMARY

- Streamflow characteristics were determined for fifteen gaging stations for three periods.
- Significant trends were found at many stations
- More trends occurred where the dominant land use was agriculture compared to forest



PURPOSE

- To determine trends in streamflow characteristics for streams in Wisconsin.
- Select a period of record for future low flow studies that best represents current conditions.

Gaging Stations Used in Study and Change in Annual 7-Day Low Flow, Annual Average Flow and Annual Flood Peaks between 1915-1968 and 1969-2008

Number	Streamflow Gaging Stations Name and Location	Years of Record	Drainage Area sq. mi	Forest Cover %	Soil Permeability in/hr	Annual 7-Day	Annual	Annual Flood Peak Percent Change	Precipitation Percent Change
						Low Flow Percent Change	Average Flow Percent Change		
						1915-68 to 1969-2008	1915-68 to 1969-2008	1915-68 to 1969-2008	1915-68 to 1969-2008
	Forested Streams								
04071000	Oconto River near Gillett	99	678	80.5	7.42	6.0	0.0	-18	5.0
05333500	St. Croix River near Danbury	92	1558	75.9	6.99	-2.8	4.6	2.6	6.4
04027000	Bad River near Odanah	61	597	88.3	1.66	15	0.8	-9.9	1.6
05394500	Prairie River near Merrill	87	184	82.1	5.36	3.4	1.3	-9.1	2.3
05362000	Jump River at Sheldon	94	574	81.4	2.70	49	2.1	-7.7	1.2
	Average for five stations					14	1.8	-8.42	3.3
	Agricultural Streams								
05410490	Kickapoo River - Steuben	76	690	45.9	1.70	34	16	-18	7.6
05379500	Trempealeau River - Dodge	81	643	43.3	4.01	61	33	-26	9.7
05414000	Platte River - Rockville	74	142	15.2	1.28	58	9	-51	7.1
04073500	Fox River at Berlin	111	1430	32.2	6.21	8.3	17	-11	6.6
05399500	Big Eau Pleine River - Stratford	83	224	21.1	1.21	48	3.5	-10.5	1.1
04087000	Milwaukee River at Milwaukee	95	696	26.1	4.13	76	37	6.2	9.5
05436500	Sugar River - Brodhead	95	523	15.2	3.05	51	22	-37	10.0
05545750	Fox River - New Munster	69	868	22.6	3.63	82	34	12.5	10.6
05426000	Crawfish River - Milford	78	762	8.2	2.66	117	41	4.6	10.0
05430500	Rock River at Afton	93	6,363	12.9	3.86	44	34	0.9	10.0
	Average for ten stations					58	25	-12.93	8.2
	Average for all fifteen stations					43.3	17.0	-11.4	6.58

Kendall Tau Rank Correlation and p Values for Three Flow Characteristics for Period 1915-2008.

Station	Stream name and location	Years of Record	Drainage Area (sq. mi.)	Forest Cover (percent)	7-day low flow		Average flow		Annual peak flow	
					Tau	P value	Tau	P value	Tau	P value
	Forested streams									
04071000	Oconto River near Gillett	99	678	88	-0.017	0.804	-0.115	0.102	-0.166	0.019
05333500	St. Croix River near Danbury	92	1,558	83	0.078	0.278	0.091	0.206	0.13	0.069
04027000	Bad River near Odanah	61	597	80	0.135	0.056	0.099	0.160	-0.064	0.445*
05394500	Prairie River near Merrill	87	184	74.6	-0.047	0.524	-0.143	0.055	-0.052	0.478
05362000	Jump River at Sheldon	94	574	62	0.311	<0.001	-0.009	0.897	-0.021	0.765
	Agricultural streams									
05410490	Kickapoo River at Steuben	76	690	37.2	0.338	<0.001	0.145	0.041	-0.191	0.015*
05379500	Trempealeau River - Dodge	81	643	25.8	0.5	<0.001	0.265	<0.001	-0.113	0.140*
05414000	Platte River near Rockville	74	142	22.3	0.355	<0.001	0.023	0.746	-0.36	0.000*
04073500	Fox River at Berlin	111	1,430	22	-0.0016	0.984	0.058	0.412	-0.178	0.011
05399500	Big Eau Pleine River at Stratford	83	224	21.2	0.147	0.038	-0.048	0.496	0.009	0.906*
04087000	Milwaukee River at Milwaukee	95	696	12	0.378	<0.001	0.167	0.018	-0.013	0.860
05436500	Sugar River at Brodhead	95	523	12	0.375	<0.001	0.145	0.038	-0.191	0.007
05545750	Fox River - New Munster	69	868	10	0.316	<0.001	0.155	0.030	0.103	0.214*
05426000	Crawfish River - Milford	78	762	7.4	0.31	<0.001	0.142	0.045	-0.01	0.898*
05430500	Rock River at Afton	95	6,363	7.9	0.145	0.04	0.188	0.008	-0.057	0.418
* for actual period of record, no estimated periods										

ANNUAL PRECIPITATION CHARACTERISTICS

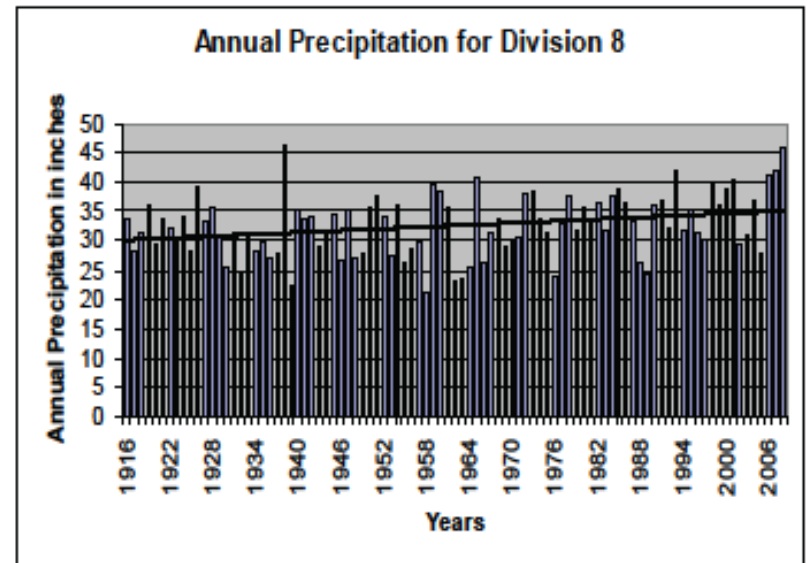
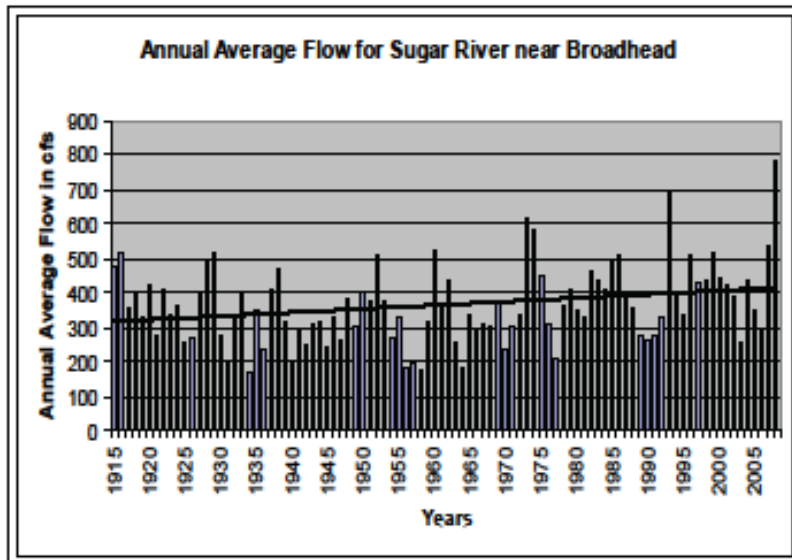
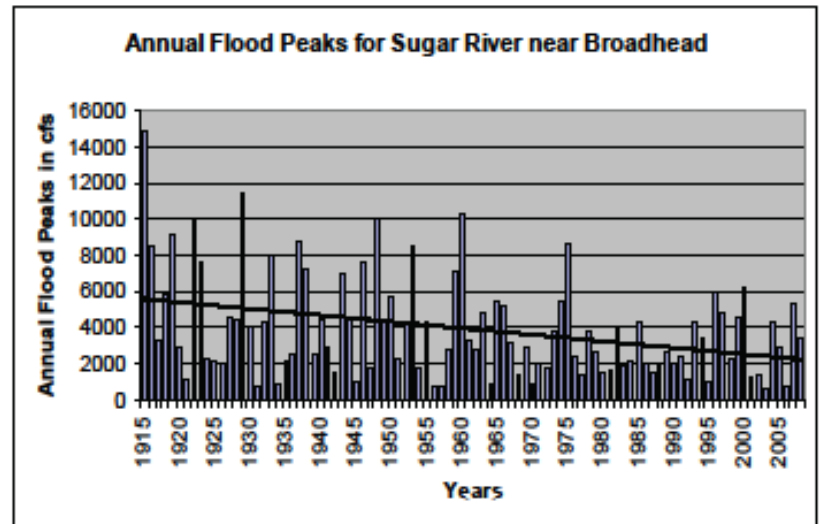
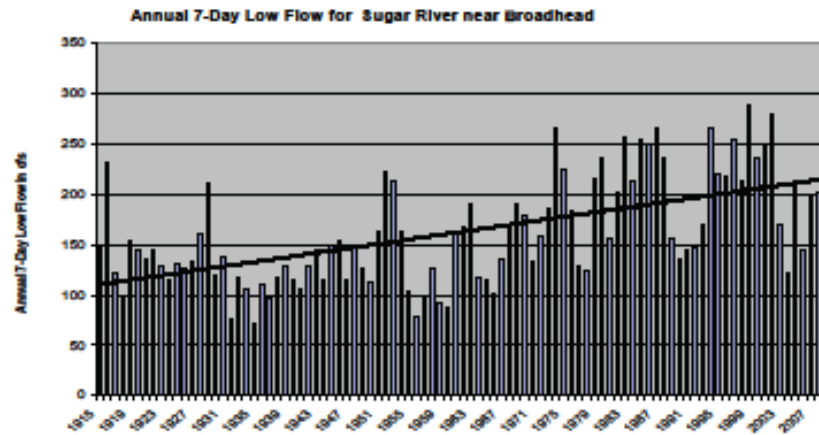
	Climatic Divisions	1915 - 1968	1969 - 2008	Percentage Increase	
		(inches)	(inches)		
Forested Streams					
Oconto River	3	29.81	31.29	4.96	
St. Croix River	1	29.78	31.68	6.38	
Bad River	1, 2	31.55	32.07	1.64	
Prairie River	2, 3	31.11	31.84	2.33	
Jump River	1, 2	31.72	32.11	1.21	
Average for 5 streams				3.30	
Agricultural Streams					
Kickapoo River	4, 7	31.69	34.10	7.63	
Trempealeau River	4	30.30	33.24	9.68	
Platte River	7	32.09	34.35	7.07	
Fox River at Berlin	5, 6, 8	30.73	32.77	6.63	
Big Eau Pleine River	2	31.77	32.12	1.10	
Milwaukee River	6, 8, 9	29.94	32.80	9.54	
Sugar River	8	31.30	34.43	10.00	
Fox River at New Munster	9	30.78	34.03	10.56	
Rock River	5, 6, 8, 9	30.95	34.06	10.05	
Crawfish River	5, 6, 8	31.30	34.42	9.98	
Average for 10 streams				8.22	
Average for 15 streams				6.58	

COMPARISON OF ANNUAL PRECIPITATION BETWEEN 1915-1968 AND 1969-2008 PERIODS

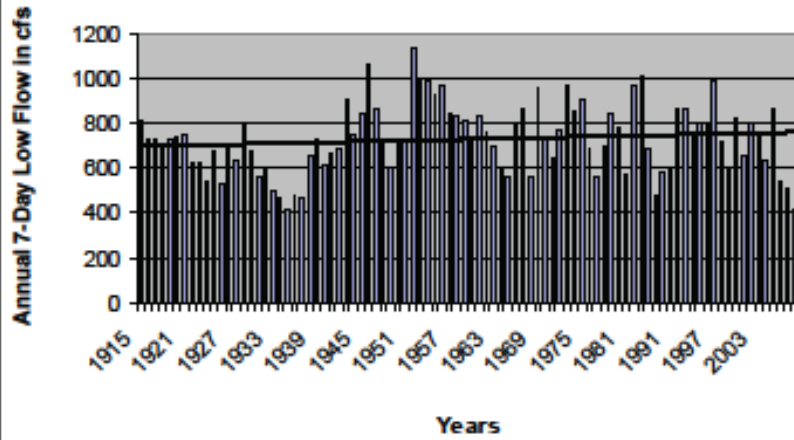
	Climatic DivisionS	1915 - 1968 (inches)	1969 - 2008 (inches)	Percent increase
Forested Streams				
Oconto River	3	29.81	31.29	4.96
St. Croix River	1	29.78	31.68	6.38
Bad River	1, 2	31.55	32.07	1.64
Prairie River	2, 3	31.11	31.84	2.33
Jump River	1, 2	31.72	32.11	1.21
Average for 5 streams				3.30
Agricultural Streams				
Kickapoo River	4, 7	31.69	34.10	7.63
Trempealeau River	4	30.30	33.24	9.68
Platte River	7	32.09	34.35	7.07
Fox River at Berlin	5, 6, 8	30.73	32.77	6.63
Big Eau Pleine River	2	31.77	32.12	1.10
Milwaukee River	6, 8, 9	29.94	32.80	9.54
Sugar River	8	31.30	34.43	10.00
Fox River at New Munster	9	30.78	34.03	10.56
Rock River	5, 6, 8, 9	30.95	34.06	10.05
Crawfish River	5, 6, 8	31.30	34.42	9.98
Average for 10 streams				8.22
Average for 15 streams				6.58

SUMMARY

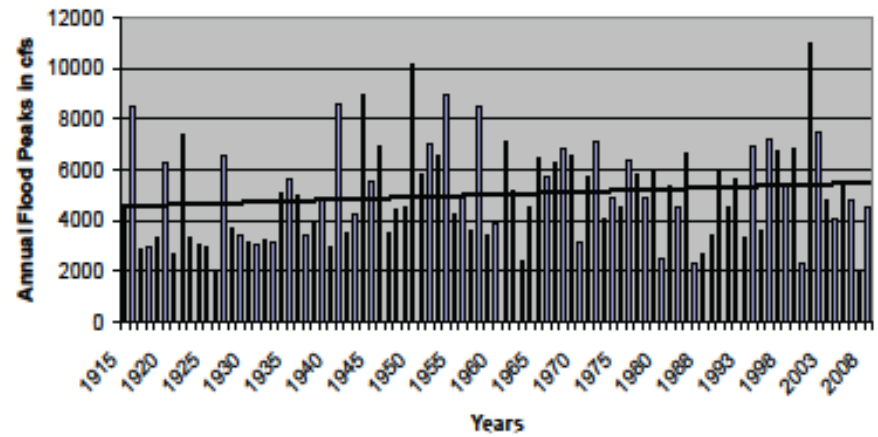
- For the annual 7- day low flow statistically increasing trends were found for 10 of 15 streams for the period 1915-2008.
 - increases occurred in agricultural areas vs forested area
 - increases for the 10 streams averaged 58 percent ranging from 8.3 to 117 percent
 - increases are probably result of change in ag practices and increased precipitation



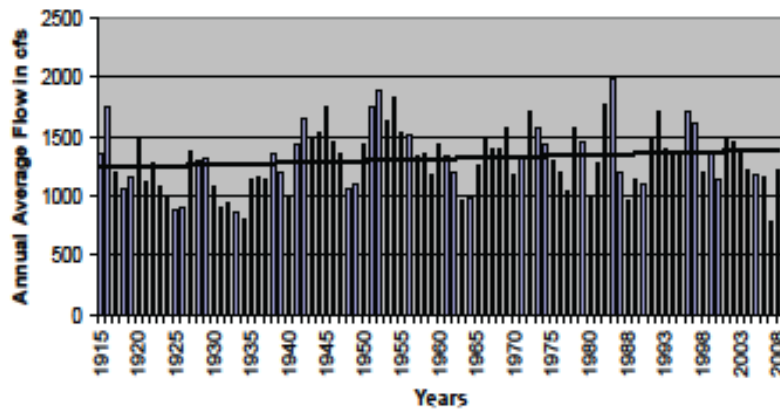
Annual 7- Day Low Flow for St Croix River nr Danbury



Annual Flood Peaks for St Croix River nr Danbury



Annual Average Flow for St Croix River nr Danbury



Annual Precipitation for Division 1

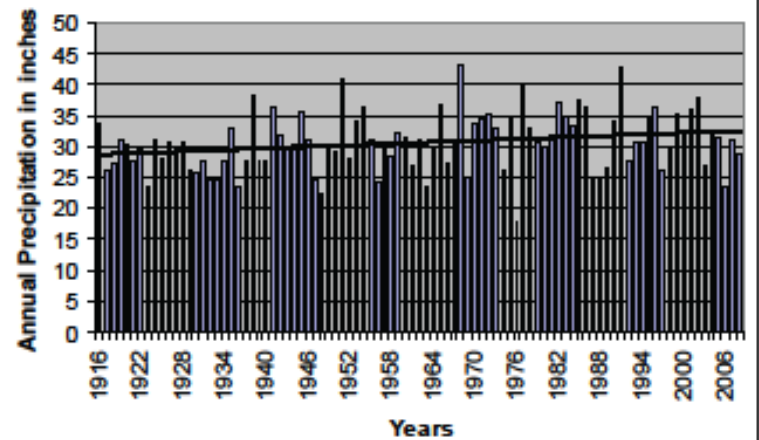


Table 1 - Gaging stations used in study and percent change in annual 7-day low flow, annual average flow and annual flood peaks between 1915-1968 and 1969-2008.										
						Annual 7-Day	Annual			
	Streamflow Gaging Stations	Years of	Drainage	Forest	Soil	Low Flow	Average Flow	Annual Flood Peak	Precipitation	
Number	Name and Location	Record	Area	Cover	Permeability	Percent Change	Percent Change	Percent Change	Percent	
			sq. mi	%	in/hr				Change	
						1915-68 to	1915-68 to	1915-68 to	1915-68 to	
	Forested Streams					1969-2008	1969-2008	1969-2008	1969-2008	
04071000	Oconto River near Gillett	99	678	88	7.42	6.0	0.0	-18	5.0	
05333500	St. Croix River near Danbury	92	1558	83	6.99	-2.8	4.6	2.6	6.4	
04027000	Bad River near Odanah	61	597	80	1.66	15	0.8	-9.9	1.6	
05394500	Prairie River near Merrill	87	184	74.6	5.36	3.4	1.3	-9.1	2.3	
05362000	Jump River at Sheldon	94	574	62	2.70	49	2.1	-7.7	1.2	
	Average for five stations					14	1.8	-8.42	3.3	
	Agricultural Streams									
05410490	Kickapoo River - Steuben	76	690	37.2	1.70	34	16	-18	7.6	
05379500	Trempealeau River - Dodge	81	643	25.8	4.01	61	33	-26	9.7	
05414000	Platte River - Rockville	74	142	22.3	1.28	58	9	-51	7.1	
04073500	Fox River at Berlin	111	1430	22	6.21	8.3	17	-11	6.6	
05399500	Big Eau Pleine River - Stratford	83	224	21.2	1.21	48	3.5	-10.5	1.1	
04087000	Milwaukee River at Milwaukee	95	696	12	4.13	76	37	6.2	9.5	
05436500	Sugar River - Brodhead	95	523	12	3.05	51	22	-37	10.0	
05545750	Fox River - New Munster	69	868	10	3.63	82	34	12.5	10.6	
05426000	Crawfish River - Milford	78	762	7.4	2.66	117	41	4.6	10.0	
05430500	Rock River at Afton	93	6,363	7.9	3.86	44	34	0.9	10.0	
	Average for ten stations					58	25	-12.93	8.2	
	Average for all fifteen stations					43.3	17.0	-11.4	6.58	

