Appendix E

Deficit Analysis Data

Souhegan River Water Management Plan

August 2013

APPENDIX E - DEFICIT ANALYSIS DATA

Table 1 - Upper Souhegan Annual Deficits (1946-1975, 2002-2012)

Year	Annual deficit (cfs)	Annual deficit (cfsm)*	Annual deficit (ac-ft)
1957	7.3	0.0707	28.9
1963	10.9	0.1054	43.1
1964	41.6	0.4043	165.2
1965	65.3	0.6344	259.2
1966	28.5	0.2762	112.9
1967	9.3	0.0905	37.0
1968	18.4	0.1782	72.8
2002	11.9	0.1158	47.3
2010	12.3	0.1197	48.9
2012	12.3	0.1197	48.9

* Relative to USGS gage Souhegan R. Near Milford

	= drought years of 1963-1966
	= assessment results of 2002-2012

Maximum all years		259.2	ac-ft
Non drought years		72.8	ac-ft
90th percentile all years		202.8	ac-ft
Non drought years		65.6	ac-ft
plus 20% all years		243.3	ac-ft
Non drought years		78.8	ac-ft

Table 2 - Upper Souhegan individual deficit events by Bioperiod (BP)

Bioperiod	year	deficit (cfs)	deficit+20% (cfs)	deficit (ac-ft)	deficit (ac-ft) + 20%
BP 1	1965	18.6	22.3	73.6	88.3
BP 1	1965	13.1	15.8	52.1	62.5
BP 1	1965	9.5	11.4	37.8	45.3
BP 1	1965	11.3	13.6	44.9	53.9
BP 1	1966	14.3	17.1	56.6	67.9
BP 1	2002	11.9	14.3	47.3	56.8
BP 2	1967	9.3	11.2	37.0	44.4
BP 2	1968	18.4	22.0	72.8	87.4
BP 2	2012	12.3	14.8	48.9	58.7
BP 3	1964	31.7	38.0	125.7	150.8
BP4	--	--	--	--	--
BP5	1957	7.3	8.7	28.9	34.7
BP5	1963	7.9	9.5	31.3	37.5
BP5	1963	2.4	2.8	9.4	11.3
BP5	1964	3.7	4.4	14.6	17.5
BP5	1964	3.0	3.6	11.8	14.1
BP5	1965	6.5	7.8	25.9	31.1
BP5	1965	6.3	7.5	24.9	29.9
BP5	1966	6.9	8.3	27.6	33.1
BP5	1966	7.2	8.7	28.8	34.5
BP5	2010	12.3	14.8	48.9	58.7
BP6	--	--	--	--	--
	= drought years of 1963-1966				
	= assessment results of 2002-2012				

Table 3 - Upper Souhegan bioperiod release values

Upper Souhegan						
Bioperiod	**Bioperiod name**	**Start**	**End**	**Volume of 90 percentile of historical deficits* (ac-ft)**	**Release volume needed to meet 90% of historical deficits with 20% buffer (ac-ft)**	**Two-day flow release (cfs)**
1	Overwintering	15-Nov	28-Feb	47.3	56.8	14.3
2	Spring Flood	1-Mar	30-Apr	48.9	58.7	14.8
3	Clupeid Spawning	1-May	14-Jun	--	--	--
4	GRAF Spawning	15-Jun	14-Jul	--	--	--
5	Rearing & Growth	15-Jul	30-Sep	28.9	34.7	8.7
6	Salmon Spawning	1-Oct	14-Nov	--	--	--

-- Release flow management currently too rare to define release flows.

* Based on maximum value or second to maximum value when available of individual deficit values from 1946-1975, 2002-2012.

Table 4 - Lower Souhegan annual deficits (1946-1975, 2002-2012)

Year	Annual deficit (cfs)	Annual deficit (cfsm)*	Annual deficit (ac-ft)
1947	22.7	0.1325	89.9
1948	22.3	0.1306	88.6
1949	12.3	0.0721	48.9
1950	11.8	0.0688	46.7
1952	68.8	0.4021	272.8
1953	24.7	0.1442	97.8
1956	55.8	0.3261	221.2
1957	49.7	0.2904	197.0
1958	14.3	0.0838	56.8
1962	10.0	0.0585	39.7
1963	91.7	0.5360	363.6
1964	144.4	0.8444	572.8
1965	166.0	0.9705	658.4
1966	112.0	0.6549	444.3
1968	55.8	0.3261	221.2
1969	11.3	0.0663	44.9
1970	17.3	0.1013	68.7
2002	28.3	0.1657	112.4
2010	21.8	0.1275	86.5
2012	37.0	0.2164	146.8

* Relative to USGS gage Souhegan R at Merrimack		
	= drought years of 1963-1966	
	= assessment results of 2002-2012	
Maximum all years	658.4	ac-ft
Non drought years	272.8	ac-ft
90th percentile all years	457.1	ac-ft
Non drought years	221.2	ac-ft
plus 20% all years	548.5	ac-ft
Non drought years	265.4	ac-ft

Table 5 - Lower Souhegan individual events by Bioperiod (BP)

Bioperiod	year	deficit (cfs)	deficit+20% (cfs)	deficit (ac-ft)	deficit (ac-ft) + 20%
BP 1	1965	31.0	37.2	123.0	147.6
BP 1	1965	22.0	26.4	87.3	104.7
BP 1	1965	16.0	19.2	63.5	76.2
BP 1	1965	19.0	22.8	75.4	90.4
BP 1	1966	25.0	30	99.2	119.0
BP 1	2002	8.0	9.6	31.7	38.1
BP 2*	2012	37.0	44.4	146.8	176.1
BP3	1963	29.0	34.8	115.0	138.0
BP3	1964	38.0	45.6	150.7	180.9
BP4	--	--	--	--	--
BP5	1957	8.0	9.6	31.7	38.1
BP5	1957	10.0	12	39.7	47.6
BP5	1962	10.0	12	39.7	47.6
BP5	1948	6.0	7.2	23.8	28.6
BP5	1963	9.0	10.8	35.7	42.8
BP5	1963	5.0	6	19.8	23.8
BP5	1963	6.0	7.2	23.8	28.6
BP5	1964	12.0	14.4	47.6	57.1
BP5	1964	12.0	14.4	47.6	57.1
BP5	1964	8.4	10.08	33.3	40.0
BP5	1964	5.0	6	19.8	23.8
BP5	1965	12.3	14.76	48.8	58.6
BP5	1965	12.0	14.4	47.6	57.1
BP5	1965	12.5	15	49.6	59.5
BP5	1965	12.5	15	49.6	59.5
BP5	1966	15.0	18	59.5	71.4
BP5	1966	11.6	13.92	46.0	55.2
BP5	1966	10.4	12.48	41.3	49.5
BP5	2010	16.8	20.16	66.6	80.0
BP5	2010	5.0	6	19.8	23.8
BP6 rev	1947	11.3	13.596	44.9	53.9
BP6 rev	1947	11.3	13.596	44.9	53.9
BP6 rev	1948	16.3	19.596	64.8	77.7
BP6 rev	1949	12.3	14.796	48.9	58.7
BP6 rev	1950	11.8	14.112	46.7	56.0
BP6 rev	1952	68.8	82.512	272.8	327.3
BP6 rev	1953	7.3	8.796	29.1	34.9
BP6 rev	1953	17.3	20.796	68.7	82.5

BP6 rev	1956	55.8	66.912	221.2	265.4
BP6 rev	1957	17.3	20.796	68.7	82.5
BP6 rev	1957	14.3	17.196	56.8	68.2
BP6 rev	1958	14.3	17.196	56.8	68.2
BP6 rev	1963	21.3	25.596	84.6	101.5
BP6 rev	1963	21.3	25.596	84.6	101.5
BP6 rev	1964	26.3	31.596	104.4	125.3
BP6 rev	1964	15.3	18.396	60.8	73.0
BP6 rev	1964	27.3	32.796	108.4	130.1
BP6 rev	1965	18.3	21.996	72.7	87.3
BP6 rev	1965	10.3	12.396	41.0	49.2
BP6 rev	1966	21.3	25.596	84.6	101.5
BP6 rev	1968	55.8	66.912	221.2	265.4
BP6 rev	1969	11.3	13.596	44.9	53.9
BP6 rev	1970	17.3	20.796	68.7	82.5
	= drought years of 1963-1966				
	= assessment results of 2002-2012				

*Spring (BP2) 2012 was an unprecedented drought year with new daily minimums occurring over several days to weeks.

Table 6 - Lower Souhegan bioperiod release values

Lower Souhegan						
Bioperiod	**Bioperiod name**	**Start**	**End**	**Volume of 90 percentile of historical deficits * (ac-ft)**	**Release volume needed to meet 90% of historical deficits with 20% buffer (ac-ft)**	**Two-day flow release (cfs)**
1	Overwintering	15-Nov	28-Feb	31.7	38.1	9.6
2	Spring Flood	1-Mar	30-Apr	--	--	--
3	Clupeid Spawning	1-May	14-Jun	--	--	--
4	GRAF Spawning	15-Jun	14-Jul	--	--	--
5	Rearing & Growth	15-Jul	30-Sep	27.0	32.4	8.2
6 revised	Salmon Spawning	1-Oct	14-Nov	73.5	88.2	22.2

-- Release flow management currently too rare to define release flows.

*Based on 90th percentile of individual deficit values from 1946-1975, 2002-2012, except BP1 where maximum deficit value was applied.

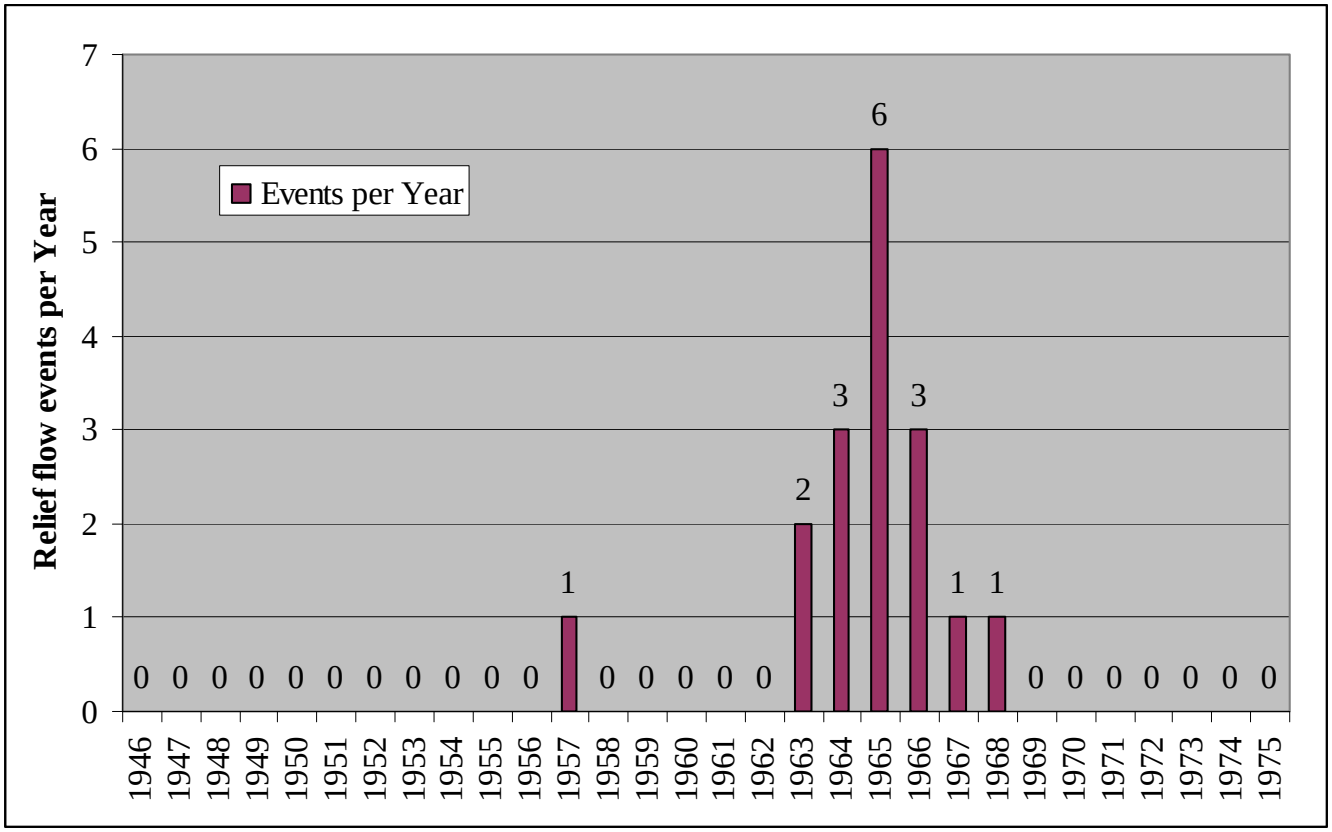

Figure 1 – Upper Souhegan River - Catastrophic events per year (1946-1975)

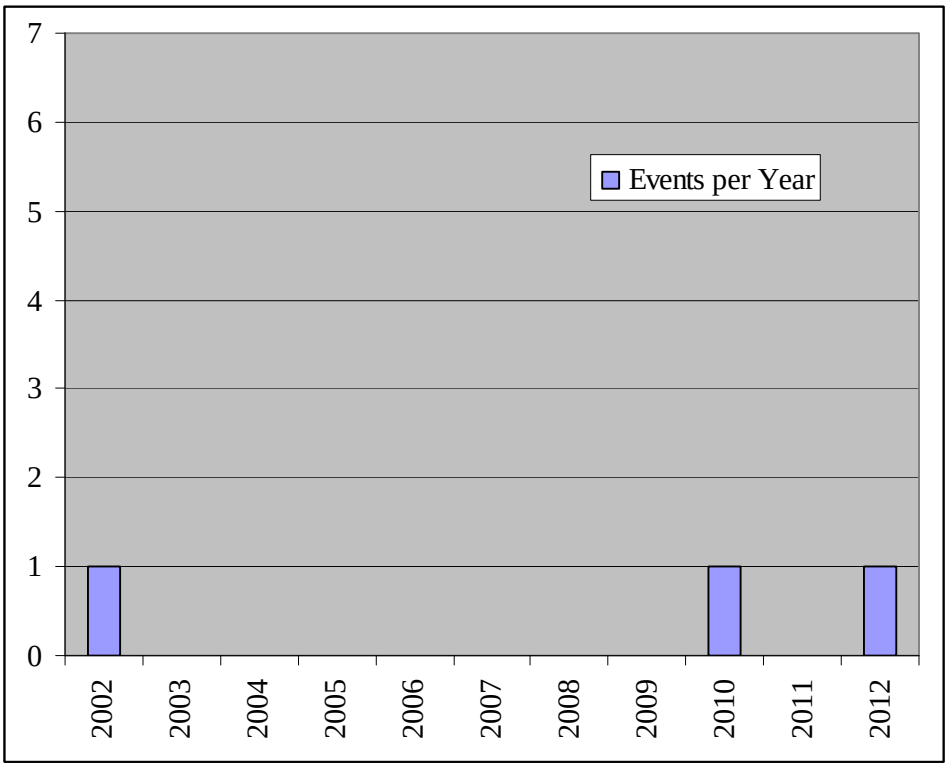

Figure 2 - Upper Souhegan River - Catastrophic events per year (2002-2012)

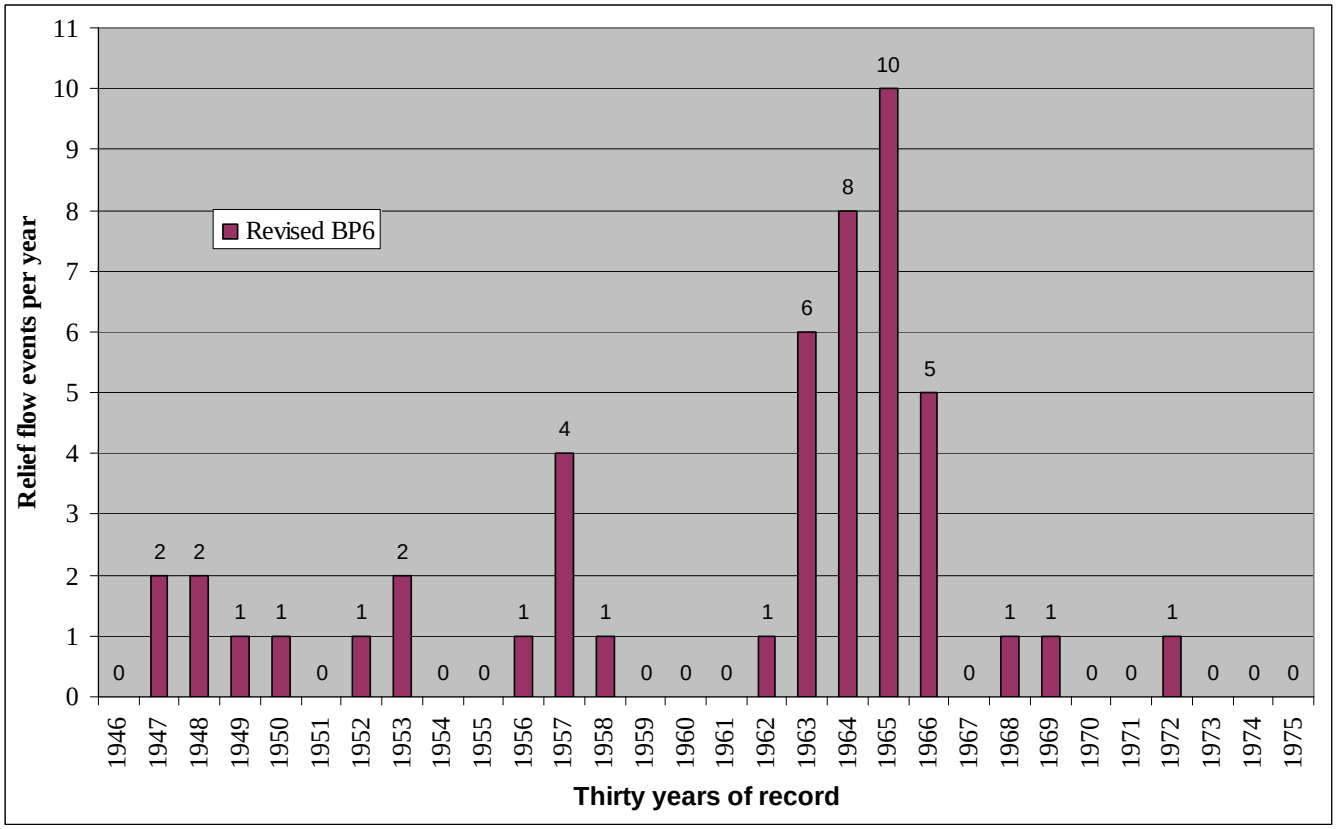

Figure 3 - Lower Souhegan River - Catastrophic events per year (1946-1975)

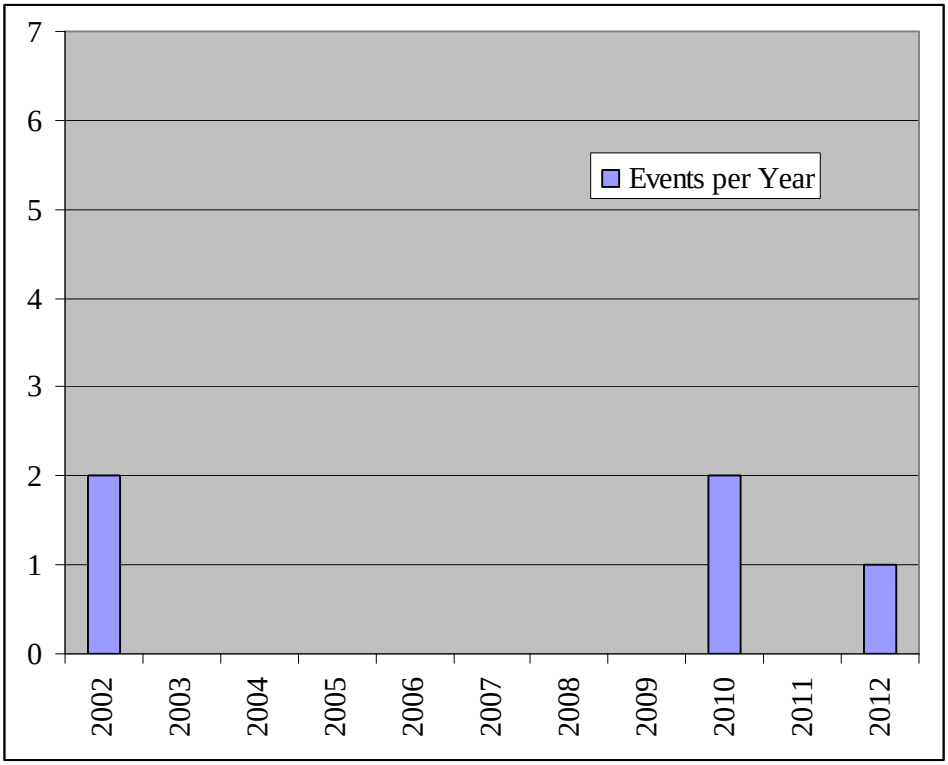

Figure 4 - Lower Souhegan River - Catastrophic events per year (2002-2012)

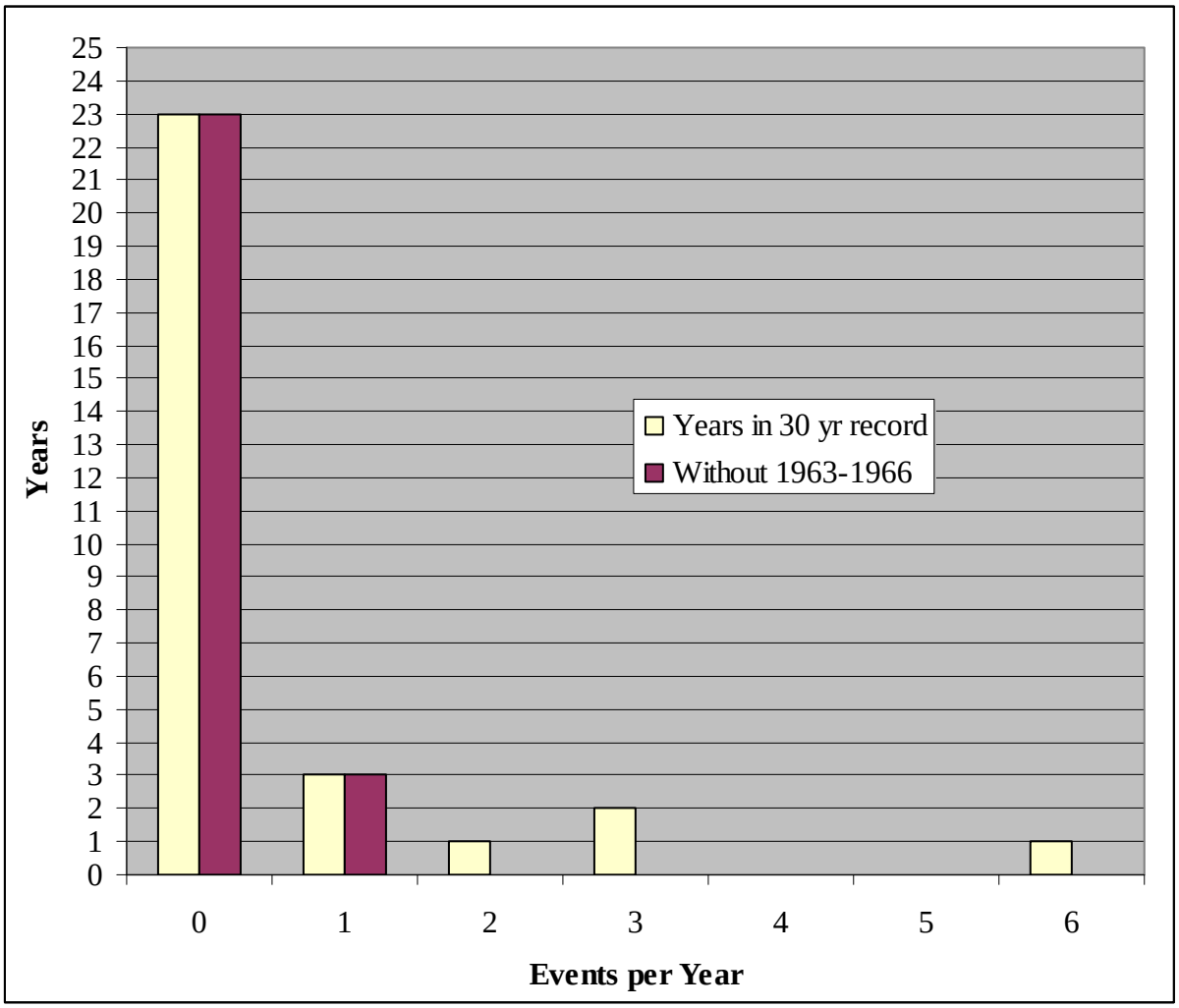

Figure 5 – Frequency of Catastrophic events per year - Upper Souhegan (1946-1975)

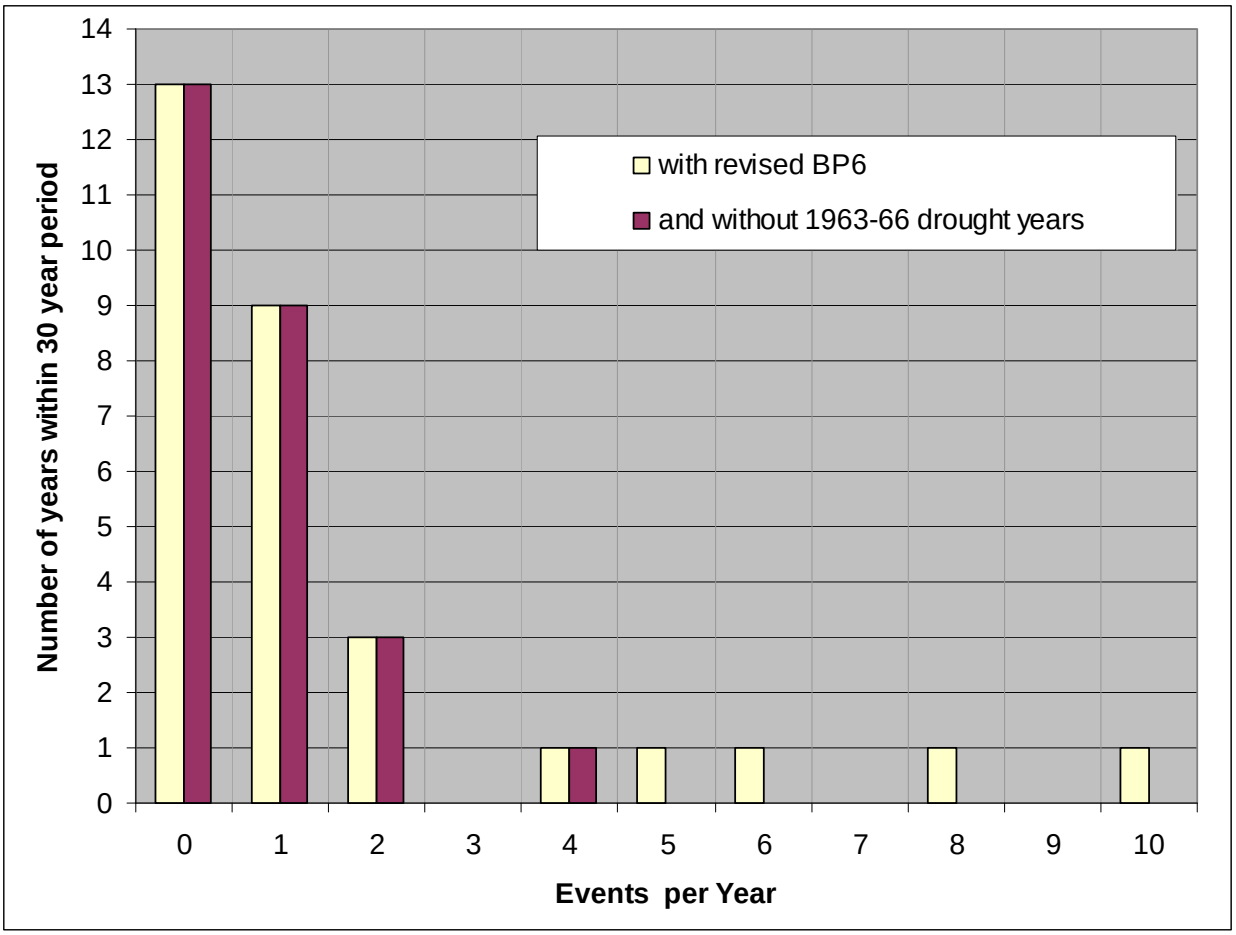

Figure 6 – Frequency of Catastrophic events per year - Lower Souhegan (1946-1975)