LITTLE SENECA RESERVOIR

"NATURAL" DAILY INFLOW DEVELOPMENT

Prepared by

Erik R. Hagen
Roland C. Steiner

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Interstate Commission on the Potomac River Basin
6110 Executive Boulevard, Suite 300
Rockville, Maryland 20852

The Interstate Commission on the Potomac River Basin

Section for Cooperative Water Supply Operations on the Potomac

This report was prepared by the Interstate Commission on the Potomac River Basin, Section for Cooperative Water Supply Operations on the Potomac. Funds were provided for this report by the Washington Suburban Sanitary Commission, the Washington Aqueduct Division of the U.S. Army Corps of Engineers, and the Fairfax County Water Authority. The opinions expressed are those of the authors and should not be construed as representing the opinions or policies of the United States or any of its agencies, the several states, the Commissioners of the Interstate Commission on the Potomac River Basin, or the water utilities.

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1. Introduction

Little Seneca Reservoir is located on Little Seneca Creek in Montgomery County, Maryland. It has a usable capacity of 4.02 billion gallons (bg) out of a total capacity of 4.25 bg (Black and Veatch, 1980). The reservoir is about 20 miles north of the District of Columbia and just north of Gaithersburg, MD (Figure 1). The construction, operation and maintenance costs of this reservoir are jointly shared by the Washington metropolitan area (WMA) utilities including Fairfax County Water Authority (FCWA), Washington Aqueduct Division (WAD) of the US Army Corps of Engineers, and Washington Suburban Sanitary Commission (WSSC). Little Seneca Reservoir is operated in conjunction with Jennings Randolph Reservoir on the North Branch of the Potomac to assist in meeting the water supply requirements of the WMA utilities. The CO-OP Section of the Interstate Commission on the Potomac River Basin (ICPRB) maintains inflow records for the reservoir as part of its mission for efficient utilization of all available water supply facilities for the Washington Metropolitan Area, particularly during drought periods.

The drainage area to the reservoir is 20.8 square miles (Black and Veatch, 1980). The reservoir filling time under average conditions is approximately 12 to 13 months. During a severe drought period, the filling time could be as long as 35 months. The minimum filling time during an exceptionally wet season could be as little as 2 to 3 months (Black and Veatch, 1980). These filling times include consideration of a minimum streamflow release below the dam of 1.73 cubic feet per second (cfs) which is equal to 1.12 mgd.

Throughout the historical gage-record there were no gages directly measuring the inflow to the site of the Little Seneca Reservoir. However, a record of daily inflows was constructed for the period from March 19, 1925 through September 30, 1997 using the area-adjustment method. Area-adjustment factors were applied to flow measurements from gages located near or within the reservoir watershed. Measured flow from the gaged drainage area was adjusted by an amount equal to the area of the reservoir watershed divided by the area of the gage station watershed:

$$\text{Reservoir inflow} = \frac{(Gaged\ \ flow) * (Area\ of\ \ reservoir\ \ watershed)}{(Area\ of\ \ gage\ station\ \ watershed)}$$

Although the area-adjustment method is appropriate for predicting the total volume of inflow to the reservoir over time, this technique is not appropriate for estimating the timing and magnitude of *peak* flows into the reservoir. Therefore, the inflow record created using this method should not be used to analyze the magnitude or frequency of peak daily flow events (e.g., as for flood risk analysis). This inflow sequence was instead developed and validated for use in simulation models that perform volumetric accounting of reservoir contents, for water supply planning purposes.

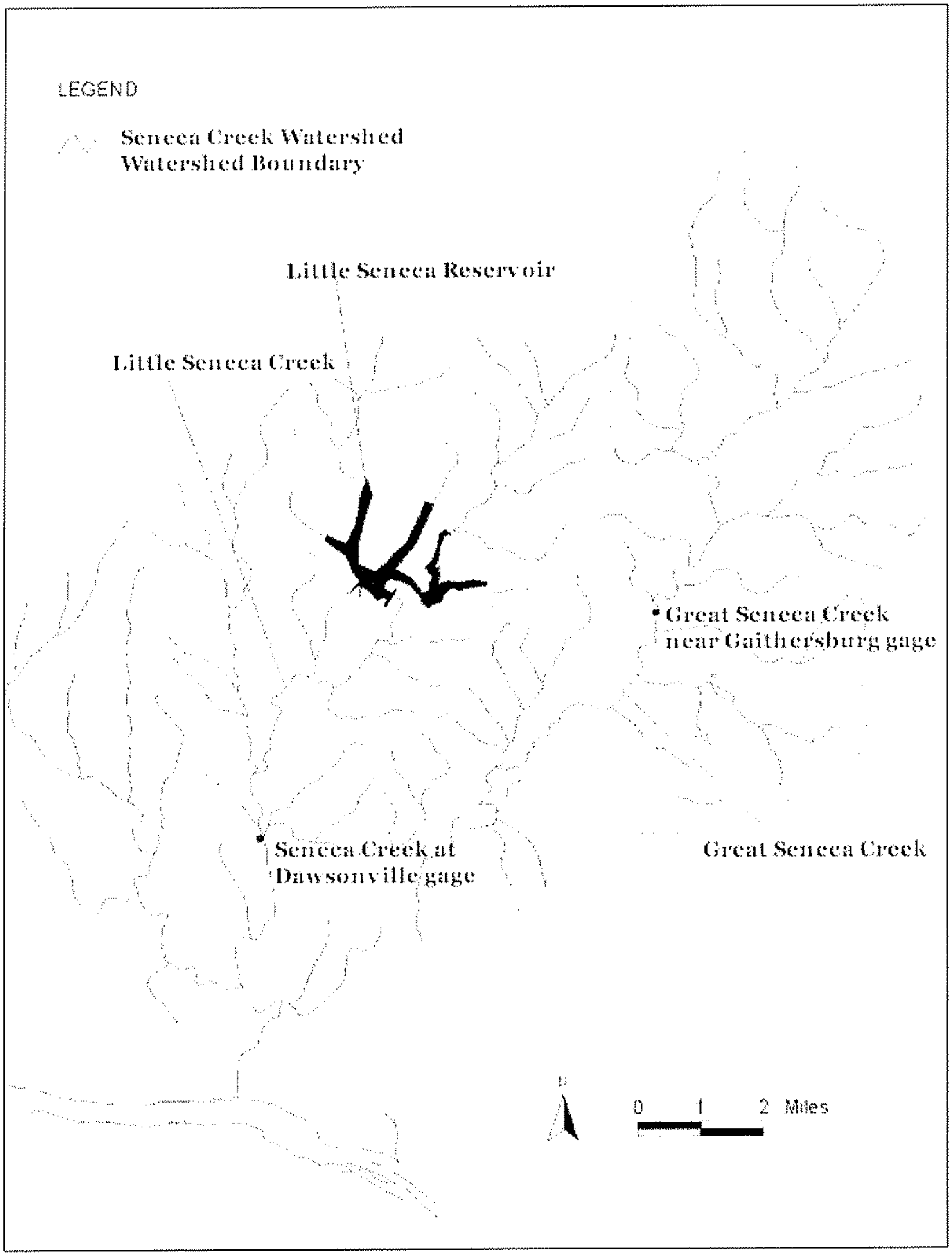


Figure 1: Little Seneca Reservoir watershed and neighboring tributaries, USGS gaging stations, and sub-watersheds

2. Development of inflow data set

The ICPRB inflow data set for Little Seneca was developed in three sections for water years 1925-1930, 1930-1976, and 1977-1997 using the area-adjustment method. The inflow sequence represents those inflows to the reservoir that would have occurred without upstream withdrawals, return flows, or reservoir regulation—i.e., "natural" inflows. Upstream reservoir regulation and wastewater return flows are documented in this section. When necessary, alternative gages are used that are not corrupted by upstream diversions or return flows.

1925-1930

The 1925-1930 inflow was based on area-adjustment applied to a gage on a tributary to Little Seneca Creek, the Great Seneca Creek near Gaithersburg gage (Great Seneca gage) for the period 3/19/1925 through 9/25/1930. This gage has a drainage area of 41 square miles as compared to the reservoir watershed area of 20.8 square miles, so the area adjustment factor is 0.507 (equals 20.8 divided by 41).

1930-1976

The Great Seneca gage was discontinued in the early 1930s. The 1930-1976 inflow was based on area-adjustment applied to the Little Seneca Creek near Dawsonville gage for the period 9/26/1930 through 12/31/1976. There may have been small diversions above this gage for irrigation purposes (USGS, 1998), but no record of diversions exists (Personal communication, Bob James, USGS, April 2, 1999). Conservatively, no adjustment was made to the inflow record to account for diversions. The Dawsonville gage has a drainage area of 101 square miles as compared to the reservoir watershed area of 20.8 square miles, so the area adjustment factor is 0.206 (equals 20.8 divided by 101).

1977-1997

Starting in 1977, WSSC began discharging from a small wastewater treatment plant (WWTP) into Great Seneca Creek near Riffle Ford Road and Route 28. The discharge is above the Dawsonville gage. The plant discharged about 2 mgd in 1977, increasing to approximately 7.5 mgd in 1999. The plant is slated for replacement and will soon have a capacity of 10 mgd (Personal communication, Karen Wright, WSSC, April 6, 1999). This plant increases the flow at Dawsonville gage above natural flow rates so a different gage was selected for inflow development to Little Seneca Reservoir.

Note that natural flows at Dawsonville gage were also corrupted by the influence of the newly constructed Little Seneca Reservoir upstream. On April 24 1985, the valve at the bottom of Little Seneca Dam was closed and flow was reduced as water from Little Seneca Creek began filling the reservoir. On December 25 1986, water filled Little Seneca to the top of the reservoir spillway, marking the end of major diversions from Little Seneca Creek to the reservoir. The total volume of flow diverted was approximately 4 bg. The total volume of flow measured at Dawsonville in the April 24, 1985 through December 25, 1986 period was 24.6 bg, so the 4 bg diversion represents approximately 16% of the total gaged flow. Since December 25, 1986, Little Seneca Reservoir has been kept near full and the reservoir since that time has had a negligible effect on flow at Dawsonville gage (personal communication, Karen Wright, WSSC, January 20, 1999).

Nearby gage sites were examined to see if any were good substitutes for the Dawsonville gage for this time period. The area-adjustment method assumes equal area-unit runoff from watersheds, so the gage with the closest values of annual runoff to Dawsonville gage should be selected as the best substitute for the Dawsonville gage. Two gage sites were selected that measured flow from small tributaries similar in size to that measured by the Dawsonville gage and that were located in adjacent watersheds. These gage sites are given in Table 1.

Table 1 compares the annual runoff in cubic feet per second per square mile (CFSM) for these gages for time periods before and after the WWTP came online. Neither Bennet Creek at Park Mills (Bennet gage) nor Patuxent River near Unity gage (Unity gage) was significantly closer in annual runoff to the Dawsonville gage as based on the comparison provided in Table 1, for the period before the WWTP was active. For the 1977 through 1997 period, both the Bennet and Unity gages registered similar values of average runoff. By this analysis, either gage was equally valid to develop an inflow record for Little Seneca.

Note that as expected, the average runoff was relatively higher in the Dawsonville gage subwatershed after the WWTP became active.

Table 1: Comparison of average runoff (cubic feet per second per square mile, CFSM) for Little Seneca Creek at Dawsonville gage and nearby gages.

Station name	**Drainage Area** (square miles)	**Average Runoff (CFSM)**	
		8/1/1966-12/31/1976 No WWTP return flow	**1/1/1977- 9/30/1997 Dawsonville gage includes WWTP return flow**
Seneca Creek at Dawsonville	101	1.26	1.28
Bennet Creek at Park Mills	62.8	1.18	1.16
Patuxent River near Unity	34.8	1.33	1.20

Source: USGS Water Resources Data

The Bennet gage is unaffected by upstream regulations or diversions (USGS, 1997). The record of estimated inflow to Little Seneca Reservoir was obtained by multiplying Bennet gage flows by an area adjustment factor of 0.3312 = (20.8 ÷ 62.8) for the period January 1, 1977 through September 30, 1997. Bennet gage overlaps with Dawsonville gage in the period before the WWTP became active. Figure 2 compares inflows to Little Seneca as based on Bennet and Dawsonville gage for this time period. The comparison shows that Bennet gage is a good surrogate for Dawsonville gage.

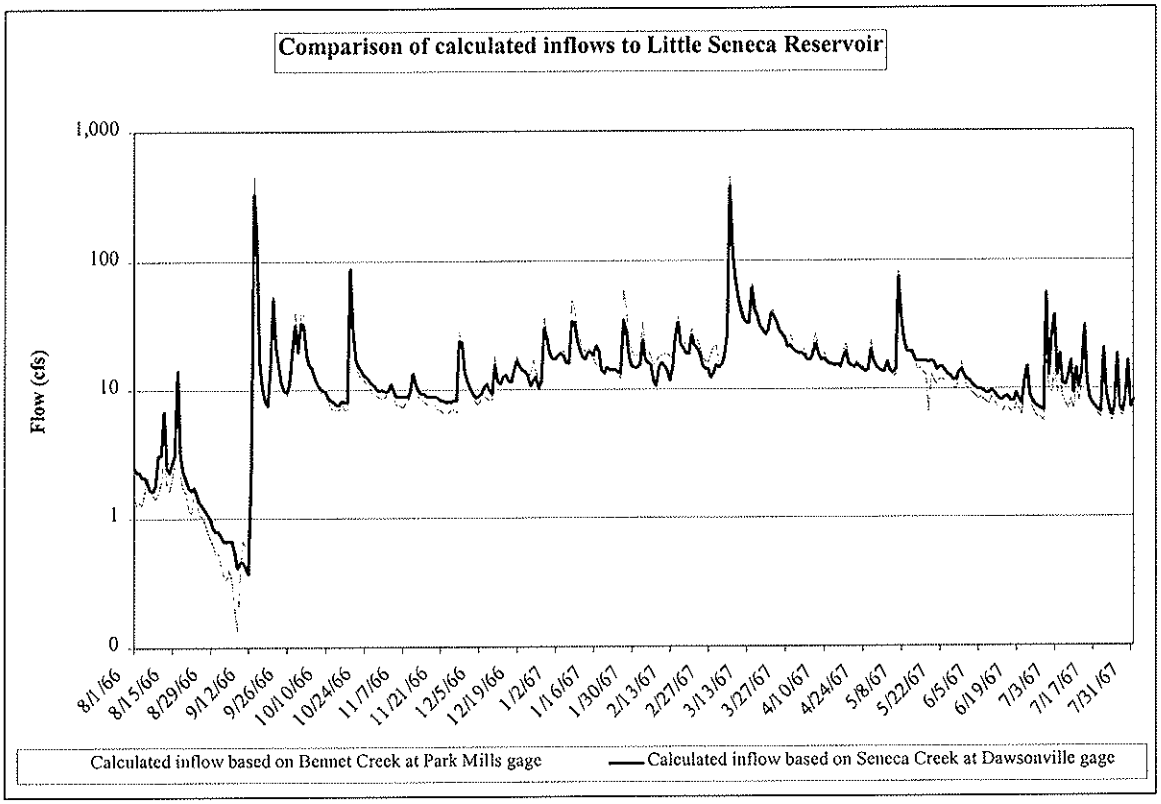


Figure 2: Comparison of calculated inflows to Little Seneca, example hydrograph

Table 2 summarizes the different stream gages and time periods used in the development of each segment of the Little Seneca Reservoir inflow record.

Table 2: Stream gages used to develop the Little Seneca Reservoir inflow record

Inflow period of record	Gage period of record	USGS stream gages used for record generation	Gage number	Drainage Area (Sq. miles)
3/19/1925 through 9/25/1930	March 1925 through 1931	Great Seneca Creek near Gaithersburg gage	01644500	41
9/26/1930 through 12/31/1976	September 1930 through current year	Little Seneca Creek near Dawsonville gage	01645000	101
1/1/1977 through 9/30/1997	August 1966 through current year	Bennet Creek at Park Mills gage	01643500	62.8

3. Storage loss due to sedimentation

A June of 1996 bathymetric survey shows that the original capacity of 12,315 acre feet (4.01 bg) has been reduced to 11,852 acre feet (3.86 bg) by sedimentation (Personal Communication, Karen Wright, WSSC, April 7, 1999). This represents a loss of 463 acre feet (0.15 bg or 3.7%) in the first ten years that the reservoir has been operational.

4. Evaporation

Evaporation could account for up to 0.04 bg of water loss per month (Black and Veatch, 1980).

5. Travel time of a release

Trial releases from Little Seneca Dam were made in April of 1989 to determine the travel time of the release from the Dam to the Potomac River. Flow time from the Dam to the intakes is critical information for management of raw water releases during drought situations. The trial release showed that a release of 200 mgd or more takes about six hours to reach the Potomac River and that at a lower release rate, flow time to the Potomac is approximately 10 hours (Appndix A.)

6. Summary

Table 3 summarizes the calculated daily inflows to Little Seneca Reservoir by month from April 1925 through September 1997. Figure 3 summarizes annual inflow to the reservoir. Data are available in electronic format from ICPRB for both daily and monthly inflows.

Table 3: Monthly inflow to Little Seneca

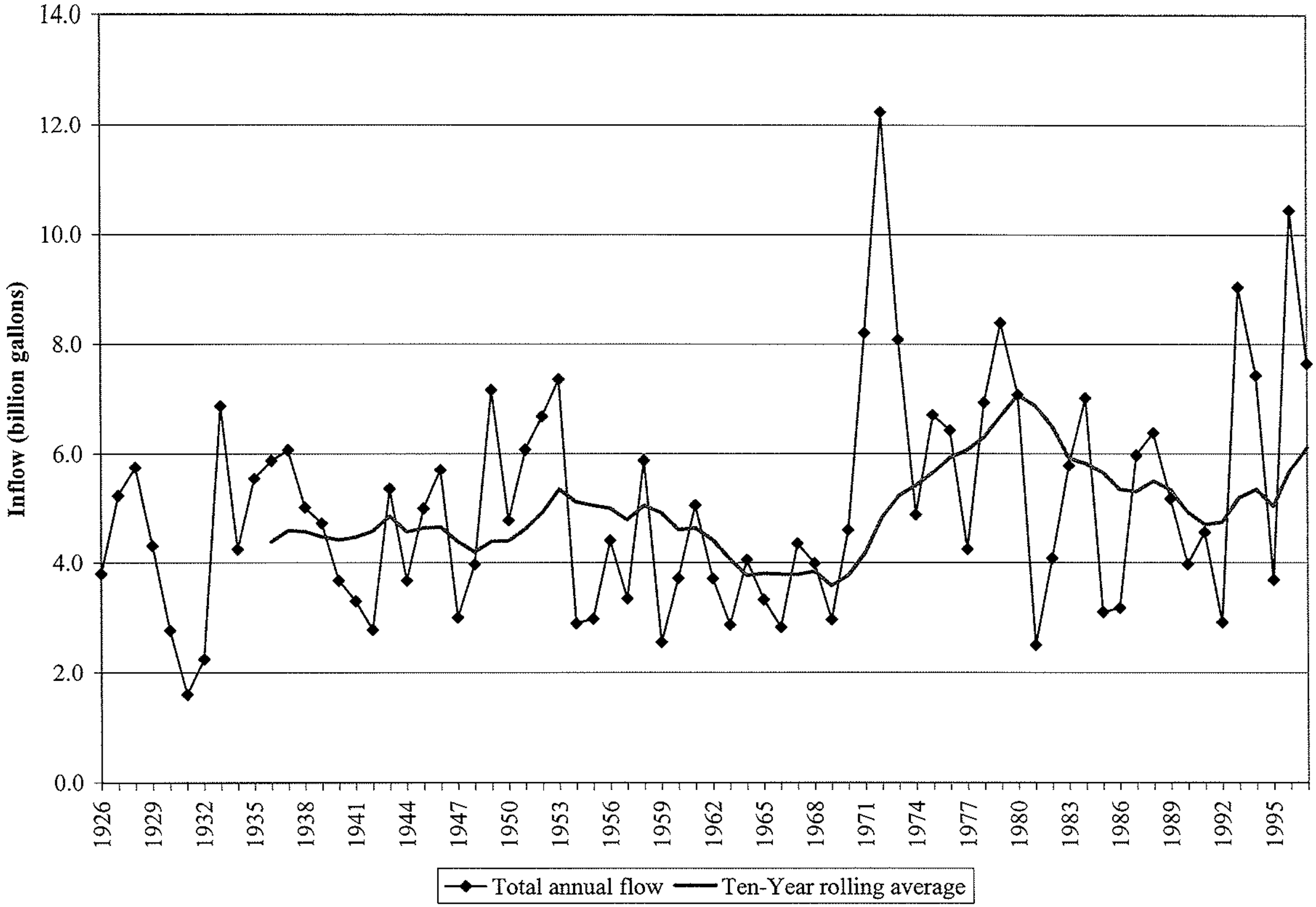
	1925	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939	1940	1941	1942
January		451	446	326	346	217	143	243	448	364	500	928	802	430	496	238	385	145
February		605	605	579	469	389	99	238	476	211	763	1,184	753	449	972	399	324	193
March		351	502	499	678	353	183	451	569	815	733	955	514	456	724	490	412	288
April	311	273	641	533	649	452	230	401	795	488	814	585	763	401	629	775	495	412
May	247	199	514	447	493	243	125	402	889	441	655	350	528	302	397	444	200	338
June	154	139	371	796	324	131	177	161	420	299	341	283	628	215	338	241	245	177
July	228	188	227	400	247	52	231	87	639	159	194	203	280	239	178	225	186	236
August	148	224	240	594	141	28	146	34	897	134	115	311	697	278	136	157	107	486
September	140	452	171	390	103	19	40	49	325	641	382	128	298	235	126	143	55	231
October	268	343	366	301	386	29	40	388	265	304	227	172	884	153	184	146	46	950
November	366	622	313	281	271	63	50	631	201	246	385	136	699	193	202	418	73	397
December	284	544	513	278	228	126	85	394	223	493	337	493	423	378	175	326	154	614
Total	2,146	4,390	4,908	5,424	4,336	2,102	1,550	3,479	6,148	4,596	5,447	5,729	7,270	3,730	4,557	4,003	2,681	4,466

	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960
January	463	571	451	544	391	430	1,082	315	414	612	897	302	150	251	337	734	279	308
February	689	217	592	553	207	617	924	675	848	499	578	240	405	622	505	440	268	522
March	692	698	446	508	390	466	776	742	552	540	1,221	376	508	607	460	962	290	430
April	519	596	322	325	228	409	611	385	510	1,146	747	404	246	395	521	741	345	566
May	425	329	276	714	398	487	692	482	427	1,001	839	283	150	235	277	581	230	481
June	261	176	386	772	237	420	288	384	1,121	550	397	182	176	163	200	474	174	259
July	161	86	838	305	255	276	576	439	445	417	242	112	55	1,128	84	519	74	190
August	67	65	573	259	198	218	294	182	200	569	460	137	691	195	48	288	209	216
September	117	95	396	231	110	137	188	350	140	619	164	62	182	190	90	174	141	234
October	143	193	261	195	80	256	235	285	117	231	148	88	255	237	93	176	112	141
November	446	158	451	184	256	465	223	403	244	863	190	114	210	242	132	188	153	168
December	253	367	783	209	173	1,011	363	728	369	722	459	215	157	344	741	179	249	148
Total	4,235	3,551	5,776	4,799	2,923	5,193	6,253	5,370	5,387	7,768	6,341	2,515	3,184	4,610	3,488	5,457	2,525	3,660

	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
January	341	307	309	837	395	124	382	545	228	412	421	685	679	703	461	1,381	223	1,574
February	952	412	281	457	418	442	321	275	281	529	1,114	1,090	796	376	411	565	312	426
March	742	840	727	698	682	327	897	585	280	425	551	1,002	616	550	714	491	578	917
April	770	540	241	546	402	332	322	295	223	773	412	1,166	1,322	603	462	701	739	401
May	539	391	154	341	280	436	359	347	163	481	718	920	838	413	564	488	262	1,179
June	606	325	349	188	169	211	208	465	199	391	490	2,981	538	393	405	325	235	367
July	322	187	88	127	128	83	258	199	206	604	350	990	415	174	537	314	134	400
August	175	97	156	90	207	50	642	109	245	238	1,022	444	271	165	193	232	101	241
September	149	78	90	63	100	480	184	184	451	95	2,260	250	450	215	1,973	191	53	141
October	126	93	70	93	140	313	175	137	124	112	960	256	225	126	645	875	120	107
November	166	216	343	122	92	200	178	299	156	401	950	718	191	160	560	358	272	145
December	247	167	288	329	108	261	633	255	372	351	808	1,185	874	703	536	376	900	444
Total	5,136	3,651	3,096	3,891	3,119	3,260	4,561	3,695	2,927	4,812	10,056	11,689	7,215	4,581	7,459	6,295	3,929	6,342

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	Grand Tota
January	1,496	551	103	203	216	423	240	204	600	599	378	495	968	207	661	707	711	1,919	678	36,807
February	1,371	334	575	849	450	1,104	739	648	479	526	379	396	383	254	491	885	318	756	592	39,096
March	1,239	871	250	463	998	1,202	326	557	735	497	777	338	636	585	2,446	1,697	462	832	1,021	47,190
April	638	822	299	522	1,762	1,253	286	443	762	483	456	630	462	425	1,838	971	307	872	517	42,662
May	552	926	257	341	1,002	738	229	201	371	2,001	1,667	710	251	324	576	515	338	764	326	36,488
June	504	364	317	860	463	283	218	98	325	467	445	335	153	205	303	223	259	1,565	222	28,513
July	292	228	173	256	202	218	187	64	1,179	278	279	186	82	193	170	257	270	791	97	21,322
August	370	148	84	158	140	244	88	80	126	162	162	191	58	125	182	475	119	634	92	18,059
September	1,234	84	63	109	67	165	68	47	547	168	108	104	59	167	144	209	70	918	79	19,362
October	1,624	101	101	111	120	167	140	54	254	121	217	487	71	246	139	192	286	1,031		18,856
November	685	163	80	168	330	258	365	214	498	221	211	406	108	475	620	257	600	1,029		22,849
December	445	115	136	205	937	294	329	578	440	180	162	609	252	1,511	731	382	506	1,960		32,144
Total	10,450	4,706	2,438	4,243	6,686	6,349	3,216	3,189	6,318	5,702	5,241	4,888	3,483	4,715	8,301	6,771	4,246	13,071		363,349

Figure 3: Annual inflow to Little Seneca by water year and ten-year rolling average inflow



9. References

Black and Veatch. 1980. Project Development Report on Little Seneca Lake for the Washington Suburban Sanitary Commission. Black and Veatch. ICPRB library number Mdse-8. Bethesda, MD.

U.S. Geological Survey. 1998. *Water Resources Data: Maryland and Delaware, Water Year 1997.* USGS-WDR-MD-DE-97-1. Towson, MD.

Appendix A: Test Release from Little Seneca Dam on April 25, 1989

RECEIVED APR 2 8 1989

Washington Suburban Sanitary Commission

INTEROFFICE MEMORANDUM

TO: John Corless
Water Operations Division

FROM: Steve Gerwin SCG
Systems Control Unit

DATE: April 26, 1989

SUBJECT: Test Release from Little Seneca Dam on April 25, 1989

On April 25, 1989, in coordination with the Interstate Commission on the Potomac River Basin, this office oversaw a trial release of water from Little Seneca Dam. The intent of this release was to attempt to measure river flow times to various points along the Little Seneca and Seneca Creek. As you know, flow time from Little Seneca Dam to various raw water intakes is critical to managing raw water flow allotments during drought situations.

To attempt to possibly measure flow time from the dam to WSSC's intake and WAD's intake, steady Potomac River flows were necessary. This criterion had delayed this exercise to the late April date.

Flow release started at 6:00 AM on the 25th and finished at 5:00 AM on the 26th. Discharge released after 2:00 PM on the 25th was necessary due to a DNR request to "ramp down" discharge slowly upon completion of the test. A total of 95 million gallons of water was discharged during the trial with a maximum rate of discharge of 310 MGD from 6:00 AM - 7:45 AM on the 26th. The discharge schedule was as follows:

TIME	RATE (MGD)
6:00 AM - 7:45 AM	310
7:45 AM - 1:00 PM	150
From 1:00 PM 4/25	↓
Through 5:00 AM 4/26	↓
	0

(See attached flow chart)

Flow times to various points are as follows:

LOCATION	FLOW TIME FROM DAM
Hoyles Mill Road	1 hour, 15 minutes
Schaefer Road	1 hour, 55 minutes
Darnestown Road	2 hours, 45 minutes
Berryville Road	4 hours, 15 minutes
River Road	4 hours, 40 minutes

No direct river elevation change could be observed at Riley's Lock, but secondary signs such as turbid water and surface trash would indicate arrival at 5 hours and 15 minutes after release. (See attached map for locations.)

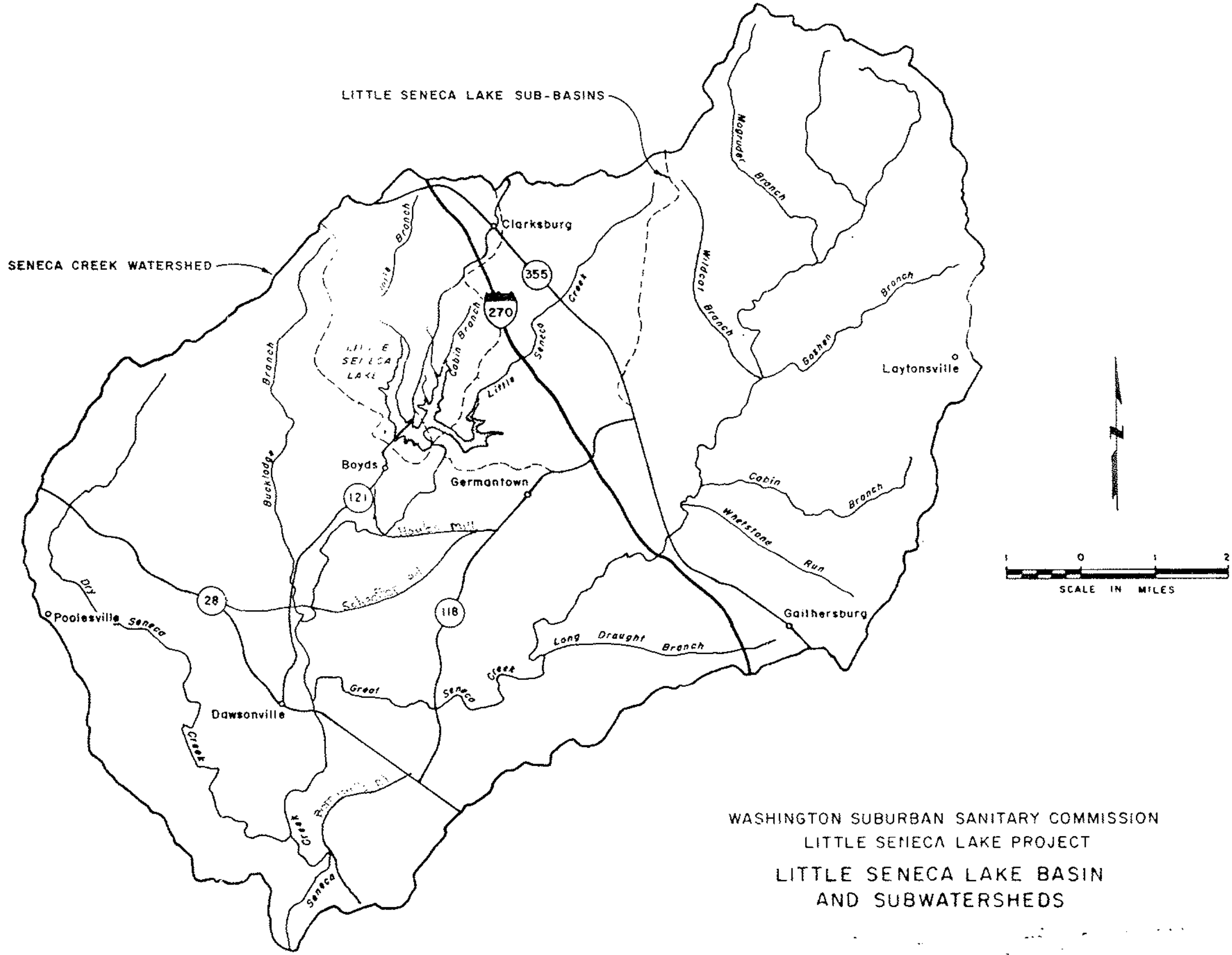
With respect to the 1986 test, flow times measured were much shorter, showing higher velocities. This test also sustained a higher initial flow rate (310 MGD) for a longer period of time. Also, the creek flow was several times higher due to weather conditions this year as opposed to 1986.

In conclusion, it appears that flow times from Little Seneca Dam to the Potomac River are dependent on rate of flow. With high rates of flow ~ +200 MGD range flow time is about six hours. With less flow, flow time to the Potomac River could stretch to 10 hours.

SCG:jb

Attachments: 2

cc: T. Stumm
J. Asner
R. Steiner, ICPRB



WASHINGTON SUBURBAN SANITARY COMMISSION
LITTLE SENECA LAKE PROJECT

LITTLE SENECA LAKE BASIN
AND SUBWATERSHEDS