BEFORE THE FEDERAL ENERGY REGULATORY COMMISSION
APPLICATION FOR LICENSE FOR MAJOR PROJECT – EXISTING DAM

Cannonsville Hydroelectric Project

FERC Project No. 13287

VOLUME 11
Appendix E-9: Flow Management Plan during Construction

City of New York

NYC Environmental Protection

February 2012

1.0 Introduction

The City of New York (the "City"), acting through the New York City Department of Environmental Protection ("DEP"), filed the following draft applications with the Federal Energy Regulatory Commission ("FERC") on September 20, 2011 with respect to its West of Hudson Hydroelectric Project (FERC Project No. 13287):

- Cannonsville Hydroelectric Development- Application for License for Major Project- Existing Dam
- Pepacton Hydroelectric Development- Application for Exemption of Small Hydroelectric Project from Licensing- Existing Dam
- Neversink Hydroelectric Development- Application for Exemption of Small Hydroelectric Project from Licensing- Existing Dam

Comments in response to the City's draft applications were provided by the following entities:

- FERC Staff
- New York State Department of Environmental Conservation ("NYSDEC")
- United States Fish and Wildlife Service ("USFWS")
- Delaware County Board of Supervisors

The purpose of this Flow Management Plan is to address specific comments raised by NYSDEC in its comment letter dated December 19, 2011 in response to the City's draft applications. Specifically, this Flow Management Plan is intended to address the following comments from NYSDEC relative to the use of siphons for maintaining downstream flows during the construction period:

Siphon Use during Construction:

The operation of siphons for a three month period during construction is a concern for the reservoirs at Pepacton, Cannonsville, and Neversink. The siphons will draw warm water from the surface; however, the normal release regime must sustain a coldwater ecosystem in the stream below the reservoir. The time of year in which the siphons may be used will be limited in the 401 Water Quality Certificate to October 1st through May 15th. This window of siphon use will not adversely impact the coldwater fisheries downstream of the reservoirs because the ambient surface water temperature during this period is typically 60F or cooler.

Siphon Operational Ability:

Current release protocols must be outlined in the 401 Water Quality Certificate and approved by NYSDEC. When releases of water are compromised by events including, but not limited to, the plugging of siphons with woody debris and lower reservoir levels below the operation of the siphons, the operation of the siphon is negatively impacted. The protocols shall include: 1) measures that the NYCDEP will employ to maintain protocol requirements; 2) alternative measures (i.e., pumps) and an evaluation of additional impacts such as noise and exhaust; and 3) quantification of the capacity of the siphons and their ability to maintain the release requirements.

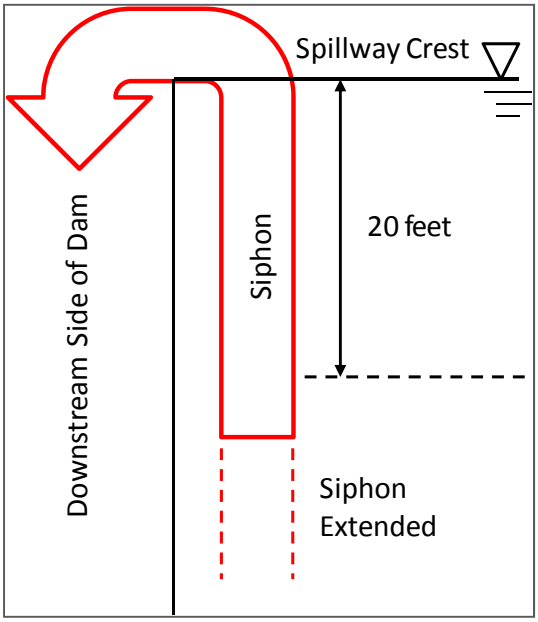
2.0 Background

As noted in the draft applications, the City initially proposed using a single siphon with a capacity of 200 cfs at each development to maintain conservation releases for approximately three months during construction in order to facilitate interconnection of the generating equipment at each development. At each development, the temporary siphon would be draped over the spillway crest in order to maintain conservation releases through discharges over the existing spillway at each development. Siphons have a lift of approximately 20 feet, thus the reservoir elevation at each development must be maintained within 20 feet of the spillway crest. The spillway crest elevation and the elevation 20 feet below the spillway crest are shown Table 2.0-1 for each development.

Table 2.0-1: Spillway Crest Elevations and 20 feet below Spillway Crest Elevation

Development	Spillway Crest Elevation (feet, mean sea level)	20 feet below Spillway Crest Elevation (feet, mean sea level)
Cannonsville	1150	1130
Pepacton	1280	1260
Neversink	1440	1420

The inset is a rendering of a siphon, showing the spillway crest and the direction of flow. The reservoir elevation must be within 20 feet of the spillway crest for siphon operation; however, the siphon intake can be placed lower than 20 feet. There is, however, a limit as to how deep the siphon intake pipe can be located as headlosses from the intake to the siphon's apex can become too high, thereby rendering the siphon inoperable.



Also note that the bathymetry immediately in front of the spillway directly impacts the length of pipe. If the reservoir bottom is mildly sloped, it may require a very long pipe to access deeper coldwater.

Further analyses were conducted to address the questions raised in the NYSDEC's December 19, 2011 comment letter. The sections of this Flow Management Plan are briefly described below and a summary of the proposed management plan follows.

Section 3: An analysis of historic reservoir elevations and releases.

Section 4: The operating protocols under the Flexible Flow Management Program with the Operations Support Tool ("FFMP-OST"), the currently applicable operating protocol agreed to by the parties to the 1954 U.S. Supreme Court decree,[1] are briefly summarized. Specifically, reservoir elevation management and conservation release requirements under the FFMP-OST are provided.

Section 5: An analysis of the reservoir elevations and releases, as modeled utilizing the FFMP-OST requirements.

[1] *New Jersey v. New York*, 347 U.S. 995 (1954). The parties to the decree are the City of New York, the States of Delaware, New Jersey and New York, and the Commonwealth of Pennsylvania (hereinafter, the "Decree Parties").

Section 6: The findings in Sections 2-6 are summarized and a proposed Flow Management Plan is provided.

Summary of Proposed Flow Management Plan

The flow management plan includes the following assumptions:

- The siphon(s) at each development would operate during a three month period from approximately October 1 to December 31, which is within the permitted period of October 1 to May 15 specified by NYSDEC in its December 19, 2011 comment letter.
- From a construction scheduling perspective, the City intends to sequence construction activities such that siphon operation at Neversink and Pepacton would occur simultaneously, with siphon(s) operation at Cannonsville occurring at a different time. Thus, if directed releases are required, such releases would be primarily maintained by Cannonsville Reservoir, which would be operating normally (i.e., without siphons). Likewise, when the siphon(s) are utilized at Cannonsville, directed releases would be primarily maintained by Neversink and Pepacton Reservoirs, which would be operating normally (i.e., without siphons).
- Conservation releases required by the applicable operating protocol agreed to by the Decree Parties will be maintained during the period the siphon(s) operate.
- Coldwater releases will be maintained during the period the siphon(s) operate.
- Reservoir elevation will be maintained within 20 feet of the spillway crest during the period the siphon(s) operate.
- During the period the siphons operate, spill over the spillway should be avoided to the maximum extent possible. Accordingly, construction sequencing and siphon operation should be planned to retain sufficient reservoir storage prior to the spring freshet so as to avoid spill over the spillway crest in the spring.

Period of Siphon Operation

The City proposes to sequence construction activities such that the siphon(s) operate for approximately three months from October 1st to December 31st. Moreover, construction activities will be sequenced such that the siphons operate at Neversink and Pepacton Reservoirs simultaneously, while construction activities at Cannonsville Reservoir will be sequenced such that the siphons operate during a different October 1st to December 31st period. Reservoir temperatures during this period are generally cold, thus the siphon(s) would release coldwater downstream. Furthermore, this period of operation is within the October 1st to May 15th period specified by NYSDEC in its December 19, 2011 comment letter.

Siphon Sizing

Two factors were evaluated to size the siphon(s). First, the siphon capacity must be sufficient to maintain conservation releases from October 1st to December 31st. Second, in cases of high inflows during such period, the siphon(s) must be sized so as to limit spill over the spillway.

As further described in the analysis contained in this Flow Management Plan, relative to meeting conservation releases for protecting downstream aquatic resources, the City has determined that a single siphon with a capacity of 200 cfs will be sufficient at Pepacton and Neversink. With respect to Cannonsville, based on the analysis contained herein, the City has determined that two siphons, each with

a capacity of 200 cfs, will be required.[2] With respect to Pepacton and Cannonsville, when the reservoir elevations are very high, there are periods when "discharge mitigation releases" may exceed the siphon capacity proposed herein.[3] However, it is important to note that such releases are discharge mitigation releases; they are not based on the protection of aquatic resources.

As further described herein, an analysis was conducted to determine the siphon capacity needed between October 1st and December 31st so as to limit spill over the spillway. A water balance was conducted whereby the water supply withdrawals were subtracted from the estimated reservoir inflow to compute the net inflow to each reservoir. In addition, the available storage capacity within the 20 foot zone was factored into the water balance. Based on the assumption that on October 1st the reservoir elevation was 20 feet below the spillway crest and if net inflow exceeded the siphon capacity, excess inflow could be stored up to the spillway crest. The number of siphons required at each development was determined based on the objective of limiting spill over the spillway crest. Based on such analysis, it was concluded that the proposed siphon designed described above would be sufficient (i.e., a single siphon with a capacity of 200 cfs at Neversink and Pepacton, and two siphons each with a capacity of 200 cfs at Cannonsville).

Reservoir Elevations

The operation of the siphons is intended to result in the reservoir elevation being close to 20 feet below the spillway crest by December 31st. After the interconnection of the generating equipment is completed, discharges through the existing release works (or turbines if operational) and water supply withdrawals would be increased, as necessary, to lower the reservoir elevation based on snowpack and anticipated precipitation with the goal of limiting spill over the spillway crest in March or April. Typically, the reservoirs are near their lowest elevations in February or March. An additional reason for limiting the operation of the siphons to the October 1st through December 31st period is to provide sufficient time throughout January and February to increase downstream releases and water supply withdrawals, as needed, to attain the desired reservoir elevation to limit spill over the spillway crest as a result of the spring freshet.

Temporary Waiver of Operating Protocols

The proposed operation of the reservoir elevations and downstream releases may require a temporary waiver from the requirements of applicable operating protocol agreed to by the Decree Parties. The current agreement, effective June 1, 2011, includes a temporary suspension or modification of requirements of the operating protocol.[4] Specifically, Section 17 of the current agreement between the Decree Parties provides the right to seek such a temporary suspension or modification under certain circumstances. The City will consult with the Decree Parties, NYSDEC and USFWS well in advance of operating the siphons, and, if required, seek a temporary suspension or modification of the requirements of the applicable operating protocol agreed to by the Decree Parties.

The specific temporary waivers sought include:

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[2] This represents a change from the draft license application filed by the City with respect to the Cannonsville Hydroelectric Development, which indicated that the City anticipated utilizing only a single siphon with a capacity of 200 cfs at Cannonsville. The City will modify any final license application filed with respect to the Cannonsville Hydroelectric Development accordingly to reflect the determinations contained in this Flow Management Plan.

[3] As further described herein, this may require the City to seek a temporary waiver from the requirements of the applicable operating protocol agreed to by the Decree Parties.

[4] The current agreement between the Decree Parties is available at: http://water.usgs.gov/osw/odrm/documents/ffmp_ost_052511_final.pdf.

- Allowing for the release of up to 400 cfs at Cannonsville, when the reservoir is in storage zone L1-a, where the discharge mitigation release exceeds 400 cfs.
- Allowing for the release of up to 200 cfs at Pepacton, when the reservoir is in storage zones L1-a and L1-b, where the discharge mitigation release exceeds 200 cfs.

Siphon Plugging

Based on historical conditions observed at the affected reservoirs and dams, it is not expected that debris plugging of the siphons would occur. First, the intake locations for the siphons will be structurally supported; the intakes will not sit on the reservoir bottom where debris could collect, rather it will be elevated. Second, the orientation relative to prevailing winds at Cannonsville and Pepacton tends to keep debris away from the southwest end of each reservoir, where the siphons would be located. At Neversink Reservoir, however, the City proposes to install a debris boom. At Gilboa Dam, where siphons are currently being utilized in connection with construction related activities associated with the dam, a debris boom was placed roughly 0.5 miles upstream of the siphons and the City has experienced no debris plugging.

3.0 Historic Reservoir Elevations, Inflow and Downstream Releases

3.1 Reservoir Elevations

In developing the Pre-Application Document ("PAD") for the West of Hudson Hydroelectric Project,[5] 25 years (1982-2007) of daily measured reservoir elevations and downstream releases were obtained. Using these data, an analysis was conducted to determine the percentage of time each month the reservoir elevation was maintained within 20 feet of the spillway crest. Figures 3.1-1, 3.1-2 and 3.1-3 include monthly and annual reservoir elevation duration curves at Cannonsville, Pepacton and Neversink Reservoirs, respectively. Table 3.1-1 shows the percentage of time the reservoir elevation is maintained within 20 feet of the spillway crest.

Table 3.1-1: Percent of Time Reservoir Elevation is maintained within 20 feet of the Spillway Crest (Observed Conditions)

Development	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Cannonsville	61	67	75	86	94	96	88	56	34	33	41	59	66
Pepacton	42	44	60	85	92	96	96	76	45	32	31	43	62
Neversink	40	50	54	84	93	96	87	53	19	21	31	41	56

Based on the historic data, the reservoirs are maintained within 20 feet of the spillway crest primarily from April through July (80% or higher). During the period prescribed by NYSDEC for siphon operation, (i.e., October 1-May 15) the reservoirs are maintained below the applicable operating limits of the siphons a higher percentage of the time. Thus, changes to reservoir elevation management are necessary for the siphons to operate during the October 1st to May 15th period specified by NYSDEC.

3.2 Historic Reservoir Inflow, Water Supply Withdrawals and Downstream Releases

Historic inflows and releases from the dams were quantified using United States Geological Survey ("USGS") gage flow data. Table 3.2-1 list the USGS gages used to quantify inflow and discharge from each dam.

Table 3.2-1: USGS Located Upstream and Downstream of Dams

Gage No.	Gage Name	Period of Record	Drainage Area	Comments
Cannonsville, Drainage Area at Dam= 456 mi^2				
01350000	West Br. Delaware River at Walton, NY	Oct 1950-Sep 2007	332 mi^2	Measures 73% of the inflow to Cannonsville Reservoir. Accordingly, measured flows were multiplied by 456/332 to estimate total inflow at the dam.
01350101	West Br. Delaware River at Stilesville, NY	Jan 1964-Sep 2007	456 mi^2	Measures discharge directly below Cannonsville Dam.
Pepacton, Drainage Area at Dam= 372 mi^2				
01413500	East Br. Delaware River at Margaretville, NY	Feb 1937-Sep 2007	163 mi^2	Measures 44% of the inflow to Pepacton Reservoir. Accordingly, measured flows were multiplied by 372/163 to estimate total inflow at the dam.
01417000	East Br. Delaware River at Downsville, NY	Jan 1955-Sep 2007	372 mi^2	Measures discharge directly below Downsville Dam.

[5] The PAD was filed with FERC on August 13, 2009 in FERC Docket No. P-13287.

Gage No.	Gage Name	Period of Record	Drainage Area	Comments
Neversink, Drainage Area at Dam= 161 mi^2				
01435000	Neversink River near Claryville, NY	Nov 1937-May 1949, Jul 1951-Sep 2007	66.6 mi^2	Measures 71% of the inflow to Neversink Reservoir. Accordingly, measured flows were multiplied by 92.6/66.6 to estimate total inflow at dam.
01436000	Neversink River at Neversink, NY	Oct 1941-Sep 2007	92.6 mi^2	Measures discharge directly below Neversink Dam.

In the PAD, the mean flow was computed at each of the USGS gages listed in Table 3.2-1. To estimate the natural inflow to each dam, the USGS gages on the West Branch, East Branch and Neversink Rivers, located upstream of each dam, were multiplied by the ratio of drainage areas (see comments in Table 3.2-1). The estimated inflows do not account for water supply withdrawals from each reservoir. Accordingly, DEP records were used to compute the mean water supply withdrawal. Shown in Table 3.2-2 is the following:

- estimated mean inflow based on prorating of upstream USGS gage flow data;
- observed mean discharge based on USGS gage flow data;
- observed mean water supply withdrawal;
- mean net inflow (computed as the estimated mean inflow less observed mean water supply withdrawal).

Shown in Figures 3.2-1, 3.2-2, and 3.2-3 are graphs showing the estimated mean inflow, observed mean discharge, relative to the capability of a single 200 cfs siphon.

Table 3.2-2: Estimated Mean Inflow, Water Supply Withdrawals, Net Inflow and Discharge for each Dam. All flows in cfs.

Inflow or Discharge	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Cannonsville													
Mean Inflow	919	913	1,534	1,759	919	544	293	223	317	503	883	1,015	817
Mean Water Supply Withdrawal	244	290	316	229	300	288	269	251	164	169	135	167	235
Mean Net Inflow	675	623	1,218	1,530	619	256	24	-28	153	334	748	848	582
Mean Discharge	382	411	821	1,260	701	573	619	628	600	550	355	412	640
Pepacton													
Mean Inflow	778	717	1,246	1,655	924	513	283	194	269	436	728	849	714
Mean Water Supply Withdrawal	454	451	403	332	460	490	630	640	644	588	561	500	513
Mean Net Inflow	324	266	843	1,323	464	23	-347	-446	-375	-152	167	349	201
Mean Discharge	145	116	37	554	402	237	121	123	186	167	189	179	213
Neversink													
Mean Inflow	249	220	395	585	352	213	146	113	145	218	293	300	270
Mean Water Supply Withdrawal	135	126	136	180	183	183	223	255	238	204	212	182	188
Mean Net Inflow	114	94	259	405	169	30	-77	-142	-93	14	81	118	82
Mean Discharge	16	13	9	23	43	44	51	49	46	28	22	15	24

Note: Mean net inflows shown in red represent months where no spill would occur assuming (a) one 200 cfs siphon, (b) water supply withdrawal rates remain similar and (c) inflows are similar to historic conditions.

A volumetric water accounting balance was conducted to determine the months the reservoir could be maintained within 20 foot of the spillway crest without spilling water over the spillway crest. To conduct this analysis the following was assumed:

- The maximum hydraulic capacity of a siphon at each development is 200 cfs.
- On Day 1 of siphon operation, the reservoir elevation would be 20 feet below the spillway crest to leave a buffer to account for high inflows.
- During periods of high inflow, excess net mean inflow (net mean inflow less 200 cfs for the siphon) could be stored.
- The storage volume within 20 feet of the spillway crest was computed for each reservoir, converted to cfs-days and then divided by 90 days (the approximate duration the siphon would operate) to estimate the storage volume in cfs. The storage volumes at Cannonsville, Pepacton and Neversink Reservoirs are 487 cfs, 595 cfs, and 157 cfs, respectively.
- If mean net inflow exceeded the available storage volume plus 200 cfs, it would result in spill over the spillway. Thus, if mean net inflow to Cannonsville, Pepacton and Neversink Reservoirs exceeded 687 cfs, 795 cfs and 357 cfs, respectively, spillage would occur.
- Siphon operation would be limited from October 1st to December 31st.

Based on this analysis, from October 1st through December 31st, a single siphon with a capacity of 200 cfs was determined to be sufficient at Pepacton and Neversink such that no spill over the spillway crest occurs.

At Cannonsville, spill of the spillway crest would occur (based on mean inflow and water withdrawals) during November and December. If the Cannonsville water supply withdrawal was increased to 300 cfs in November and December, the net inflow would drop to 583 cfs and 715 cfs, respectively. Again, however, even under such circumstances (i.e., increased water supply withdrawals) inflows would still cause spill during December.

Based on this analysis, it was determined that two siphons, each with a capacity of 200 cfs, are needed at Cannonsville. The addition of a second 200 cfs siphon (total discharge capacity of 400 cfs) at Cannonsville results in limited spill over the spillway in December as shown in Table 3.2-3. In October, all net inflows can be passed using the siphons, thus no inflow would be placed into 20 feet of buffer storage. In November, the net inflow is 748 cfs, thus 348 cfs (748 cfs-400 cfs in siphon capacity) of the net inflow must be contained in storage. The analysis assumes that the reservoir is maintained 20 feet below the spillway crest on November 1. Thus, at the end of November, 28% of the storage capacity is available. In December, the net inflow is 848 cfs less 400 cfs for the siphon release leaving 448 cfs to be placed in storage. Because the available storage capacity at the end of November is 139 cfs, a spill of approximately 309 cfs (448 cfs-139 cfs) would occur. However, as noted above, the mean water supply withdrawal could be increased accordingly such that no spill occurs.

Table 3.2-3: Cannonsville- : Estimated Mean Inflow, Water Supply Withdrawals, Net Inflow and Storage Volume Used. All flows in cfs.

Statistic	Oct	Nov	Dec
Mean Inflow	503	883	1,015
Mean Water Supply Withdrawal	169	135	167
Mean Net Inflow	334	748	848
Siphon Capacity	400	400	400
Mean Net Inflow-Siphon Capacity	-66	+348	+448
Available Storage Capacity expressed in cfs	487	487	487
Available Storage Capacity Remaining	487	139 cfs of storage remains (487-348) or 28% of storage capacity remains	309 cfs of spill (448-139), no storage capacity remains

4.0 Operating Protocols for FFMP-OST

The draft applications contain a detailed description of the current operating protocol agreed to by the Decree Parties (i.e., FFMP-OST). For purposes of the analysis conducted in relation to this Flow Management Plan, particular emphasis was placed on the applicable requirements of the FFMP-OST governing reservoir elevations and conservation releases.

Under the FFMP-OST, the City makes conservation releases from its Delaware River basin reservoirs[6] in accordance with Figure 4.0-1 and Figure 4.0-2. These figures depict the percentage of combined useable storage capacity of all three reservoirs (y-axis) relative to the time of the year (x-axis). However, translating the combined useable storage capacity of the three reservoirs to a specific reservoir elevation at each of the Cannonsville, Pepacton and Neversink Reservoirs is difficult as the magnitude and timing of water supply withdrawals from each reservoir varies based on numerous factors (e.g., water quality, inflow, downstream flow needs, etc).

Conservation releases from Cannonsville, Pepacton and Neversink Reservoirs are shown in Tables 4.0-1, 4.0-2, and 4.0-3, respectively, assuming 0 cfs of Forecast-based Available Water ("FAW"). The FFMP-OST includes different tables of conservations releases at each development based on 0, 10, 20, 35, 50, 75 and 100 MGD FAW. In general, the higher the FAW, the higher the discharge mitigation release. Conservation releases highlighted in red are equal to or less than the flow capability of the applicable siphon design for each reservoir as discussed in Section 3.2 (i.e., a single 200 cfs siphon each at Neversink and Pepacton; and two siphons each with a capacity of 200 cfs at Cannonsville for a total capability of 400 cfs).

The conservation releases do not account for directed releases as may be required to meet the flow objective of 1,750 cfs (during normal operations, L1, L2) at the USGS gage on the Delaware River at Montague, New Jersey ("NJ"). The Delaware River Master orders directed releases on a daily basis for the purpose of meeting the applicable flow objective at Montague, NJ. The City must comply with these directives but may use any of the three Delaware River basin reservoirs to meet the flow target. Having the flexibility to use any of the three reservoirs to provide the directed flow will allow the City the ability to maintain such directed flows because the City intends to sequence construction such that siphons are not operating at all three reservoirs simultaneously. Instead, the City proposes to sequence construction such that the siphons would operate at Neversink and Pepacton simultaneously, while the operation of the siphons at Cannonsville would be scheduled to occur during a different October 1st through December 31st period. Accordingly, the City would be able to utilize the reservoir(s) where siphons are not operable to meet any directed releases necessary to maintain the Montague, NJ flow objective.

As shown in the tables below, conservation releases from the dams various based on the time of year and available storage capacity of all three reservoirs (see storage zones defined in Figure 4.0-1 and Figure 4.0-2). Generally, as the reservoir storage declines, conservation releases also decline to preserve the drinking water supply. Likewise as the reservoir storage reaches level L1-b, and L1-c, discharge mitigation releases generally increase.

[6] The City's Delaware River basin reservoirs include: Cannonsville, Pepacton and Neversink.

Table 4.0-1: Schedule of Cannonsville Releases (cfs) with 0 MGD FAW

Cannonsville Storage Zone	Winter		Spring		Summer			Fall		
	Dec 1-Mar 31	*Apr 1-Apr 30*	*May 1-May 20*	*May 21-May 31*	*Jun 1-Jun 15*	*Jun 16-Jun 30*	*Jul 1-Aug 31*	*Sep 1-Sep 15*	*Sep 16-Sep 30*	*Oct 1-Nov 30*
L1-a	1500	1500	*	*	*	1500	1500	1500	1500	1500
L1-b	400	400	*	*	*	*	400	400	400	400
L1-c	110	110	200	250	275	275	275	275	175	110
L2-a	75	75	150	200	225	225	225	225	150	75
L2-b	60	60	135	175	190	190	190	190	135	60
L3	55	55	85	85	135	135	135	85	85	85
L4	50	50	60	60	100	100	100	50	50	50
L5	40	40	40	40	90	90	90	40	40	40

** Indicates storage zone not present at this time period; release is entry in cell below*
Values in red are equal to or less than two 200 cfs siphons or 400 cfs.

Table 4.0-2: Schedule of Pepacton Releases (cfs) with 0 MGD FAW

Pepacton Storage Zone	Winter		Spring		Summer			Fall		
	Dec 1-Mar 31	*Apr 1-Apr 30*	*May 1-May 20*	*May 21-May 31*	*Jun 1-Jun 15*	*Jun 16-Jun 30*	*Jul 1-Aug 31*	*Sep 1-Sep 15*	*Sep 16-Sep 30*	*Oct 1-Nov 30*
L1-a	700	700	*	*	*	700	700	700	700	700
L1-b	300	300	*	*	*	*	300	300	300	300
L1-c	85	85	110	130	150	150	150	150	100	85
L2	50	50	75	90	100	100	100	100	60	50
L3	45	45	60	60	75	75	75	45	45	45
L4	40	40	50	50	65	65	65	40	40	40
L5	35	35	35	35	60	60	60	35	35	35

** Indicates storage zone not present at this time period; release is entry in cell below*
Values in red are equal to or less than one 200 cfs siphon.

Table 4.0-3: Schedule of Neversink Releases (cfs) with 0 MGD FAW

Neversink Storage Zone	Winter		Spring		Summer			Fall		
	Dec 1-Mar 31	*Apr 1-Apr 30*	*May 1-May 20*	*May 21-May 31*	*Jun 1-Jun 15*	*Jun 16-Jun 30*	*Jul 1-Aug 31*	*Sep 1-Sep 15*	*Sep 16-Sep 30*	*Oct 1-Nov 30*
L1-a	190	190	*	*	*	190	190	190	190	190
L1-b	125	110	*	*	*	*	150	150	150	125
L1-c	65	65	85	100	110	110	110	100	75	65
L2	35	35	55	65	75	75	75	65	50	35
L3	30	30	40	40	55	55	55	30	30	30
L4	25	25	30	30	45	45	45	25	25	25
L5	20	20	20	20	40	40	40	20	20	20

** Indicates storage zone not present at this time period; release is entry in cell below*
Values in red are equal to or less than one 200 cfs siphon.

Based on this analysis, two 200 cfs siphons at Cannonsville are sufficient to meet the applicable conservation release requirements during the October 1st through December 31st period in all circumstances except when the reservoir is in storage zone L1-a.

Based on this analysis, one 200 cfs siphon at Pepacton is sufficient to meet the applicable conservation release requirements during the October 1st through December 31st period in all circumstances except when the reservoir is in storage zones L1-a or L1-b.

Based on this analysis, one 200 cfs siphon at Neversink is sufficient to meet the applicable conservation release requirements during the October 1st through December 31st under all potential conditions.

5.0 OASIS Modeling of FFMP-OST: Reservoir Elevations, Inflow and Downstream Releases

As noted in the City's draft applications, DEP developed a simulation model of the City's water supply system (*i.e.*, all 19 impoundments). The model, called the New York City Water Supply Operational Analysis Simulation of Integrated Systems ("OASIS"), which is a proprietary version of the publicly available OASIS model, simulated the water supply demands, conservation releases, directed releases, water level drawdowns, discharge mitigation releases, and other requirements set forth in the FFMP-OST. Output from the OASIS model includes daily reservoir elevation, total discharge, conservation releases, water supply withdrawals, and spillage. The rules of the FFMP-OST were incorporated into the model to simulate the estimated discharges from each reservoir using the historic inflow hydrology. Note that for modeling purposes the City's full 800 million gallons per day ("MGD") allocation, as authorized by the 1954 U.S. Supreme Court decree, is included in the analysis.

The model includes a set of rules dictating how each of the City's Delaware River basin reservoirs will operate. For example, if flow on the Delaware River drops below the prescribed flow objective for Montague, NJ, the OASIS model will require directed releases from the City's Delaware River basin reservoirs, as needed, to maintain the applicable Montague, NJ prescribed flow. The model's period of record extends from 1948 to 2008. Although some of the Delaware River basin reservoirs were constructed after 1948, for modeling purposes it was assumed that all of the reservoirs were in place in 1948. The purpose of the modeling effort was to determine how the reservoirs would operate under conditions in the FFMP-OST based on using long-term historic inflow information. The general premise is that the previous 61 years of inflow will be representative of future inflows.

5.1 OASIS Modeling of FFMP-OST: Reservoir Elevations

Using OASIS modeling output, an analysis was conducted to determine the percentage of time each month the reservoir elevation was maintained within 20 feet below the spillway crest. Figures 5.1-1, 5.1-2 and 5.1-3 include monthly and annual reservoir elevation duration curves at Cannonsville, Pepacton and Neversink Reservoirs, respectively. Table 5.1-1 shows the percentage of time the reservoir elevation is maintained within 20 feet of the spillway crest.

Table 5.1-1: Percent of Time Reservoir Elevation is maintained within 20 feet of the Spillway Crest (OASIS Model)

Development	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Cannonsville	64	66	79	94	97	96	93	64	39	26	34	52	67
Pepacton	46	49	64	85	90	93	90	65	32	23	26	38	59
Neversink	66	68	79	90	95	95	94	78	52	32	35	52	70

Similar to the historic observed data presented in Table 3.1-1, the OASIS modeling results indicated that the reservoirs are maintained within 20 feet of the spillway crest primarily during the period from April through July. During the period prescribed by NYSDEC for siphon operation (i.e., October 1-May 15), the modeling results indicate that the reservoir elevations are not always maintained within the siphon operating limits. Therefore, consistent with the conclusion of Section 3.1, changes to reservoir elevation management would be necessary for the siphons to operate from October 1st to May 15th.

5.2 OASIS Modeling of FFMP-OST: Reservoir Inflow, Water Supply Withdrawals and Downstream Releases

Shown in Table 5.2-1 is the model produced mean inflow, mean water supply withdrawal, mean net inflow (mean inflow less water supply withdrawal) and mean discharge for each dam on a monthly basis.

Shown in Figures 5.2-1, 5.2-2, and 5.2-3 are graphs showing the estimated mean inflow, observed mean discharge, relative to the capability of a single siphon with a capacity of 200 cfs.

Table 5.2-1: OASIS Modeling of FFMP-OST: Mean Inflow, Water Supply Withdrawal, Net Inflow and Discharge for each Dam. All flows in cfs.

Inflow or Discharge	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Cannonsville													
Mean Inflow	947	951	1559	1750	915	535	302	260	322	493	865	1027	826
Mean Water Supply Withdrawal	319	299	258	149	259	250	232	146	91	122	204	277	17
Mean Net Inflow	628	652	1301	1601	656	285	70	114	231	371	661	750	609
Mean Discharge	808	821	966	1416	835	794	902	805	685	654	541	686	827
Pepacton													
Mean Inflow	831	787	1282	1543	868	319	172	118	115	220	549	618	435
Mean Water Supply Withdrawal	441	445	450	359	379	393	443	444	424	438	419	389	419
Mean Net Inflow	390	342	832	1184	489	-74	-271	-326	-309	-218	130	229	16
Mean Discharge	639	654	617	826	751	787	869	847	809	729	641	614	732
Neversink													
Mean Inflow	252	231	385	561	308	194	125	99	124	201	278	301	255
Mean Water Supply Withdrawal	90	82	68	134	129	103	88	171	212	195	11	99	124
Mean Net Inflow	16	149	317	427	179	91	37	-72	-88	6	157	202	131
Mean Discharge	196	188	228	457	278	246	214	282	301	269	201	198	255
Mean Discharge	16	13	9	23	43	44	51	49	46	28	22	15	24

Notes: Mean net inflows shown in red represent months where no spill would occur assuming (a) one 200 cfs siphon, (b) water supply withdrawal rates remain similar and (c) inflows are similar to historic conditions.

The same analysis conducted above in Section 3.2 using observed data was repeated here. Essentially, the findings in Table 5.2-1 are similar to the observed conditions (Table 3.2-2), indicating that use of a single siphon with a capacity of 200 cfs at Neversink and Pepacton would be sufficient.

At Cannonsville, spill over the spillway crest would occur (based on mean inflow and water withdrawals) during December assuming two 200 cfs siphons (400 cfs capacity as shown in Table 5.2-2. In October, net inflow can be passed using the siphons, thus no inflow would be placed into 20 feet of buffer storage. In November, the net inflow is 661 cfs, thus 261 cfs (661 cfs-400 cfs in siphon capacity) of the net inflow must be contained in storage. The analysis assumes that the reservoir is maintained 20 feet below the spillway crest on November 1. Thus, at the end of November, 46% of the storage capacity is available. In December, the net inflow is 750 cfs less 400 cfs for the siphon release leaving 350 cfs to be placed in storage. Because the available storage capacity at the end of November is 226 cfs, a spill of approximately 124 cfs (350 cfs-226 cfs) would occur. However, as noted above, the mean water supply withdrawal could be increased accordingly such that no spill occurs.

Table 5.2-2: Cannonsville- : Estimated Mean Inflow, Water Supply Withdrawals, Net Inflow and Storage Volume Used. All flows in cfs.

Statistic	Oct	Nov	Dec
Mean Inflow	493	865	1027
Mean Water Supply Withdrawal	122	204	277
Mean Net Inflow	371	661	750
Siphon Capacity	400	400	400
Mean Net Inflow-Siphon Capacity	-29	+261	+350
Available Storage Capacity expressed in cfs	487	487	487
Available Storage Capacity Remaining	487	226 cfs of storage remains (487-261) or 46% of storage capacity remains	124 cfs of spill (350-226), no storage capacity remains

6.0 Flow Management Plan

6.1 Findings

Based on the above analyses, the following general conclusions can be drawn.

Siphon Capacity

Inflow Capacity: A single siphon with a capacity of 200 cfs at each development was initially proposed in the City's draft applications. Based on the historic and modeled conditions analysis conducted in connection with this Flow Management Plan, use of a single 200 cfs siphon at Pepacton and Neversink appears sufficient to prevent spillage during all months except March and April (based on average flow conditions). However, based on such analysis, it has been determined that two siphons each with a capacity of 200 cfs (i.e., total capability of 400 cfs) would be sufficient at Cannonsville to reduce spillage, again assuming mean inflow and water supply withdrawals.

Discharge Capacity: In terms of maintaining conservation flows, use of a single 200 cfs siphon would be sufficient to maintain required conservation releases at Pepacton, unless storage levels are in L1-a or L1-b zones. The proposed use of two siphons each with a capacity of 200 cfs at Cannonsville would be sufficient to maintain required conservation releases, unless storage levels are in the L1-a zone. With respect to Neversink, the proposed use of a single 200 cfs siphon would be sufficient to meet the required conservation releases and discharge mitigation releases.

Reservoir Elevations: Based on historic and modeled conditions, the reservoirs are generally maintained within 20 feet of the spillway crest the majority of the time from April through July. If the siphons operate outside of this period, modifications to current water level management protocols will be required to ensure the operability of the siphons.

6.2 Proposed Flow Management Plan

The flow management plan includes the following assumptions:

- The siphon(s) at each development would operate during a three month period from approximately October 1 to December 31, which is within the permitted period of October 1 to May 15 specified by NYSDEC in its December 19, 2011 comment letter.
- From a construction scheduling perspective, the City intends to sequence construction activities such that siphon operation at Neversink and Pepacton would occur simultaneously, with siphon(s) operation at Cannonsville occurring at a different time. Thus, if directed releases are required, such releases would be primarily maintained by Cannonsville Reservoir, which would be operating normally (i.e., without siphons). Likewise, when the siphon(s) are utilized at Cannonsville, directed releases would be primarily maintained by Neversink and Pepacton Reservoirs, which would be operating normally (i.e., without siphons).
- Conservation releases required by the applicable operating protocol agreed to by the Decree Parties will be maintained during the period the siphon(s) operate.
- Coldwater releases will be maintained during the period the siphon(s) operate.
- Reservoir elevation will be maintained within 20 feet of the spillway crest during the period the siphon(s) operate.
- During the period the siphons operate, spill over the spillway should be avoided to the maximum extent possible. Accordingly, construction sequencing and siphon operation should be planned to

retain sufficient reservoir storage prior to the spring freshet so as to avoid spill over the spillway crest in the spring.

To monitor conditions during the period the siphons operate the following would be recorded on a real-time basis:

- Estimated reservoir inflow based on prorating USGS gage flow data
- Dam releases as recorded at the USGS gage immediately downstream of each dam
- Water supply withdrawals

Period of Siphon Operation

During the City's proposed October 1st through December 31st period for operating the siphons, the reservoir elevation at the reservoir(s) at which the siphons are operating would be maintained within 20 feet of the spillway crest elevation.

Siphon Sizing to pass Conservation Releases and to Reduce Spill over Spillway Crests

For Pepacton and Neversink, use of a single 200 cfs siphon is sufficient for maintaining conservation releases needed to protect downstream aquatic resources. For Cannonsville, two siphons each with a capacity of 200 cfs siphons will be required. In the case of Pepacton and Cannonsville, when the reservoir elevations are high (storage zone L1-a at Cannonsville; and L1-a and L1-b at Pepacton), conservation releases under the FFMP-OST exceed the siphon capacity. It is important to note, however, that these conservation releases are actually discharge mitigation releases; they are not based on the protection of aquatic resources.

The siphons were also sized so as to reduce spill over the spillway crest from October 1st to December 31st. The analysis conducted in connection with this Flow Management Plan indicate that under mean inflow and water supply withdrawal conditions, spill over the spillway crest would not result from the proposed siphon operations Pepacton and Neversink (i.e., a single 200 cfs siphon each at Neversink and Pepacton). At Cannonsville, some spill would occur in December; however, if water supply withdrawals were increased, no spill would occur based on mean inflow conditions.

Reservoir Elevations

As demonstrated above, having the reservoir elevation within 20 feet of the spillway crest from October 1 to December 31 is not standard operating practice. During this period, real time inflows, releases, water supply withdrawals and reservoir elevations will be monitored. To maintain the water elevations within the 20 foot band, adjustments could be made to the magnitude of water supply withdrawals and siphon discharges.

The goal is by December 31 the reservoir elevation is close to 20 feet below the spillway crest. Based on the above analysis this can be accomplished at Pepacton and Neversink, but by December 31 Cannonsville would be at the spillway crest. After the interconnection is complete, discharges through the existing release works (or turbines if operational) and water supply withdrawals could be increased to purposely lower the reservoir elevation, as needed, based on snowpack and anticipated precipitation with the goal of not spilling over the spillway crest in March or April as a result of the spring freshet. Typically, the reservoirs are near their lowest elevations in February or March. Accordingly, limiting operation of the siphons from October 1 through December 31 is intended to provide the opportunity throughout January and February to increase downstream releases and/or water supply withdrawals, as needed, to attain historic reservoir elevation levels.

Under the premise that the reservoir elevations would be lowered further after December 31st to create storage for the spring freshet, an analysis was conducted to determine if discharges during January and February could be increased sufficiently to achieve the average February reservoir elevation and the lowest recorded February reservoir elevation. To conduct the analysis for Pepacton and Neversink, it was assumed that on December 31 the reservoir elevations were 20 feet below the spillway crest. To conduct the analysis for Cannonsville, it was assumed that on December 31, the reservoir elevation was at the spillway crest due to spill.

The storage between the December 31 reservoir elevation and the February mean reservoir elevation (and February lowest elevation) was computed in units of cfs-days. This volume was then divided by 59 days (January and February) to estimate the continuous release (either in dam releases or water supply withdrawals) to reach the mean or lowest February reservoir elevation. The results of this analysis are set forth in Table 6.2-1.

Table 6.2-1: Releases in January/February needed to meet the Mean February Reservoir Elevation and Lowest February Reservoir Elevation.

Statistic	Cannonsville	Pepacton	Neversink
Reservoir Elevation on December 31 (20 feet below spillway crest at Pepacton and Neversink, at the spillway crest at Cannonsville)	296,841 ac-ft (1150 ft, msl)	335,598 ac-ft (1260 ft, msl)	80,902 ac-ft (1420 ft, msl)
Storage based on mean February reservoir elevation	218,280 ac-ft (1132 ft, msl)	316,414 ac-ft (1256 ft, msl)	84,680 ac-ft (1423 ft, msl)
Net storage volume between December 31 reservoir elevation and mean February reservoir elevation (ac-ft) and discharge (cfs) needed to reach lowest elevation in 59 days	78,561ac-ft 671 cfs	19,184 ac-ft 164 cfs	Already within 20 feet
Worst Case Scenario: Storage based on lowest February reservoir elevation	33,460 ac-ft (1068 ft, msl)	55,486 ac-ft (1178 ft, msl)	38,791 ac-ft (1381 ft, msl)
Worst Case Scenario: Net storage volume between 20 feet below the spillway crest elevation and lowest February reservoir elevation (ac-ft) and discharge (cfs) needed to reach lowest elevation in 59 days	263,381 ac-ft 2,250 cfs (exceeds FFMP-OST maximum flows)	280,112 ac-ft 2,393 cfs (exceeds FFMP-OST maximum flows)	42,111 ac-ft 360 cfs (exceeds FFMP-OST maximum flows)

As Table 6.2-1 shows, limiting siphon operation from October 1st through December 31st will provide sufficient time to achieve the mean February reservoir elevation. However, the City would not be able to be able achieve the lowest historical February elevation within the maximum flow requirements of the FFMP-OST.

Temporary Waiver of Operating Protocols

As indicated in Section 4.0, the proposed operation of the reservoir elevations and downstream releases may require a temporary waiver from the requirements of applicable operating protocol agreed to by the Decree Parties. The current agreement, effective June 1, 2011, includes a provision authorizing the City to seek a temporary suspension or modification of requirements of the operating protocol. Specifically, Section 17 of the current agreement between the Decree Parties provides the right to seek such a temporary suspension or modification under certain circumstances. The City will consult with the Decree Parties, NYSDEC and USFWS well in advance of operating the siphons, and, if required, seek a temporary suspension or modification of the requirements of the applicable operating protocol agreed to by the Decree Parties.

The specific temporary waivers sought include:

- Allowing for the release of up to 400 cfs at Cannonsville, when the reservoir is in storage zone L1-a, where the discharge mitigation release exceeds 400 cfs.
- Allowing for the release of up to 200 cfs at Pepacton, when the reservoir is in storage zones L1-a and L1-b, where the discharge mitigation release exceeds 200 cfs.

Siphon Plugging

Based on historical conditions observed at the affected reservoirs and dams, it is not expected that debris plugging of the siphons would occur. First, the intake locations for the siphons will be structurally supported; the intakes will not sit on the reservoir bottom where debris could collect, rather it will be elevated. Second, the orientation relative to prevailing winds at Cannonsville and Pepacton generally keeps debris away from the southwest end of each reservoir where the siphons would be located. At Neversink Reservoir, however, the City proposes to install a debris boom. At Gilboa Dam, where siphons are currently being utilized in connection with construction related activities associated with the dam, a debris boom was placed roughly 0.5 miles upstream of the siphons and the City has experienced no debris plugging.

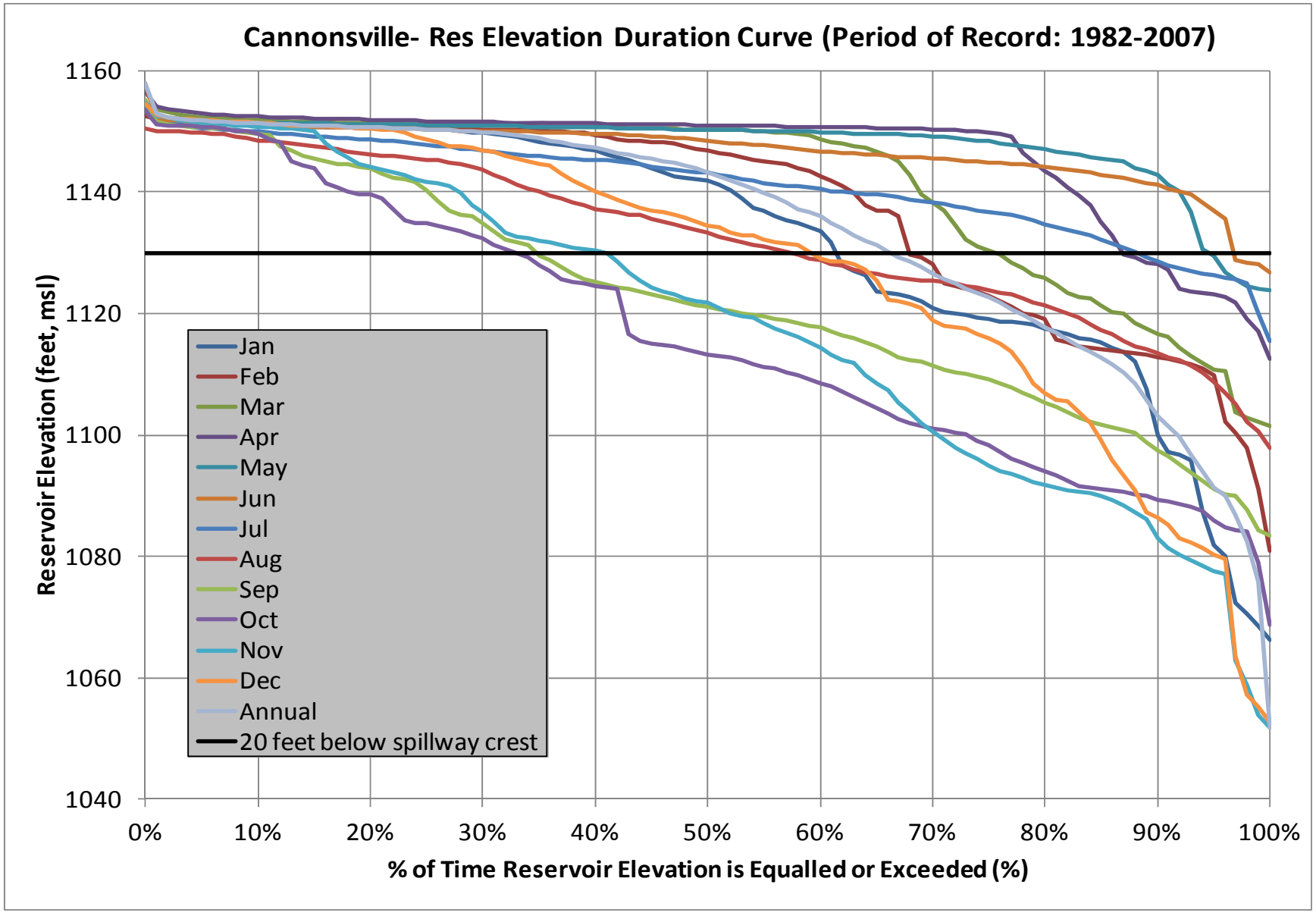

Figure 3.1-1: Cannonsville Reservoir- Observed Reservoir Elevation Duration Curve (Period of Record: 1982-2007)

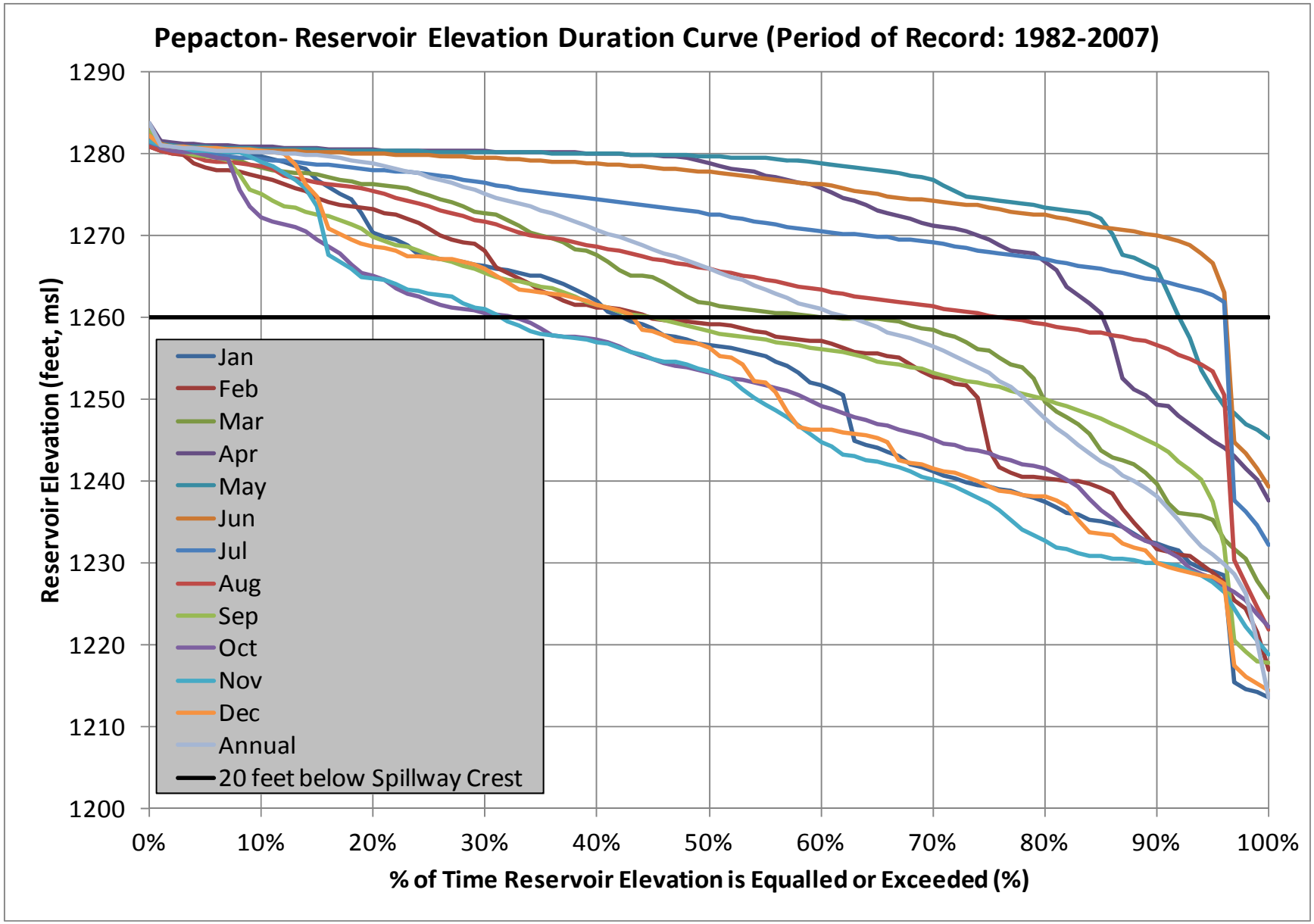

Figure 3.1-2: Pepacton Reservoir- Observed Reservoir Elevation Duration Curve (Period of Record: 1982-2007)

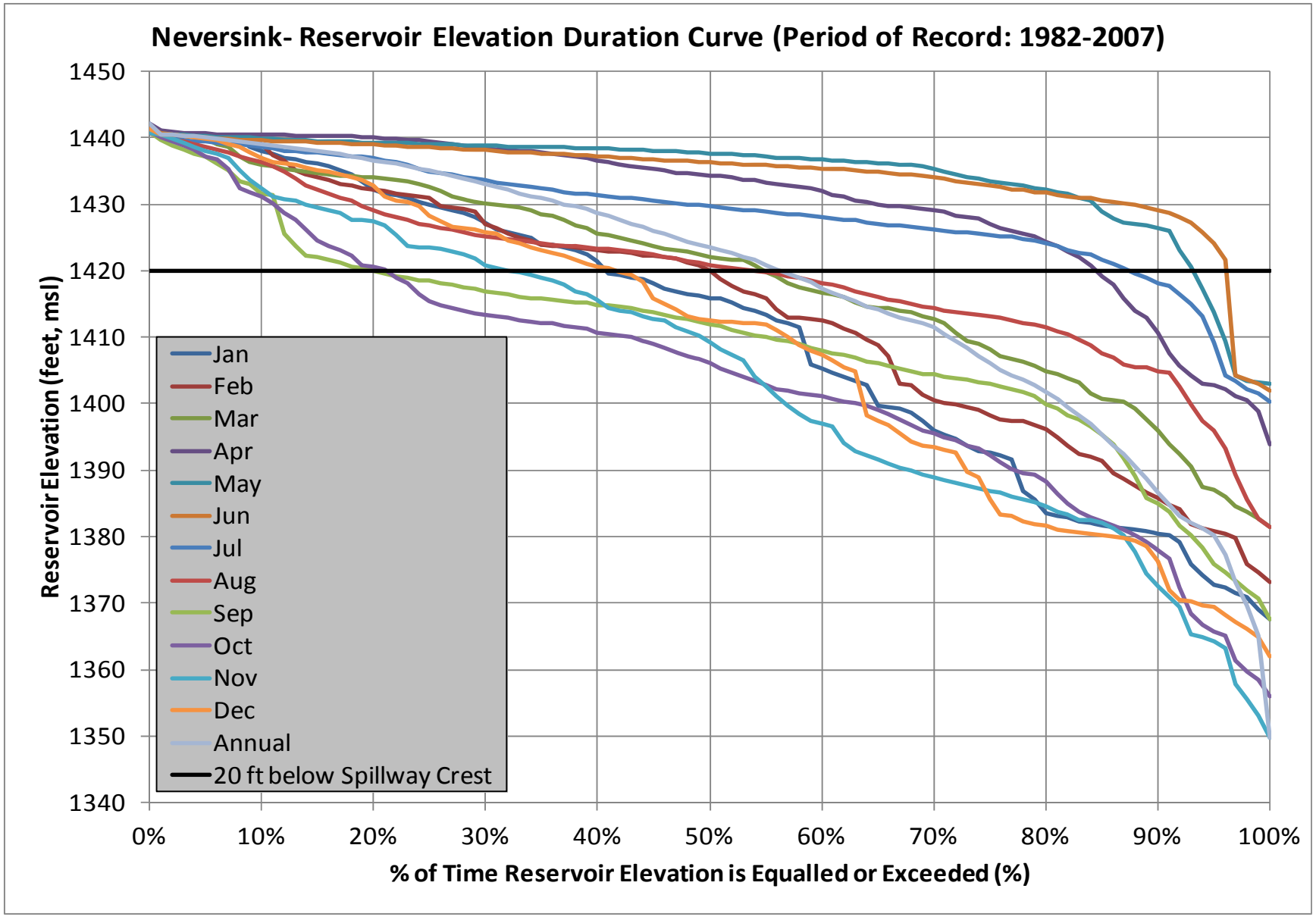

Figure 3.1-3: Neversink Reservoir - Observed Reservoir Elevation Duration Curve (Period of Record: 1982-2007)

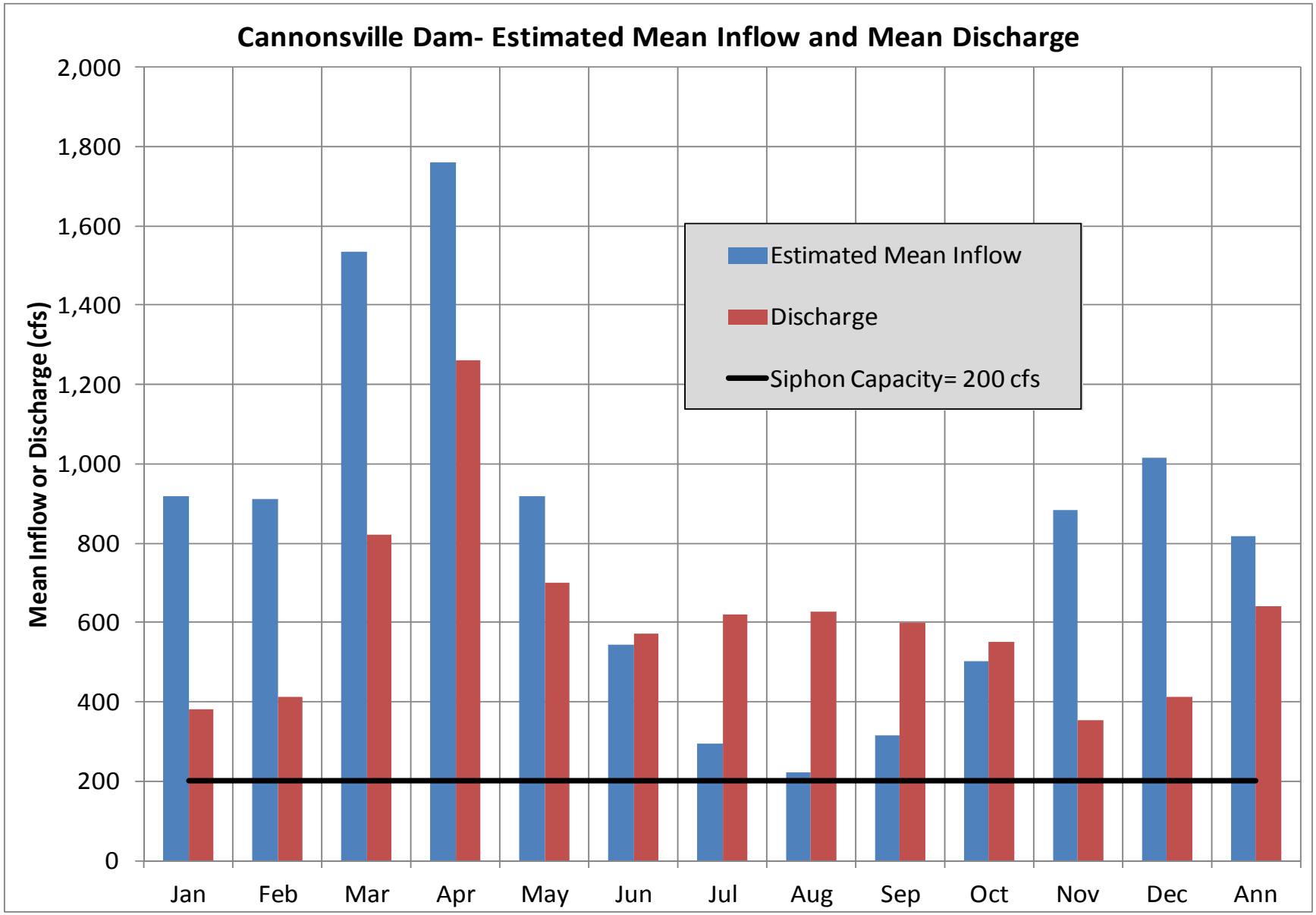

Figure 3.2-1: Cannonsville Reservoir - Estimated Mean Inflow and Mean Discharge relative to 200 cfs Siphon Capacity

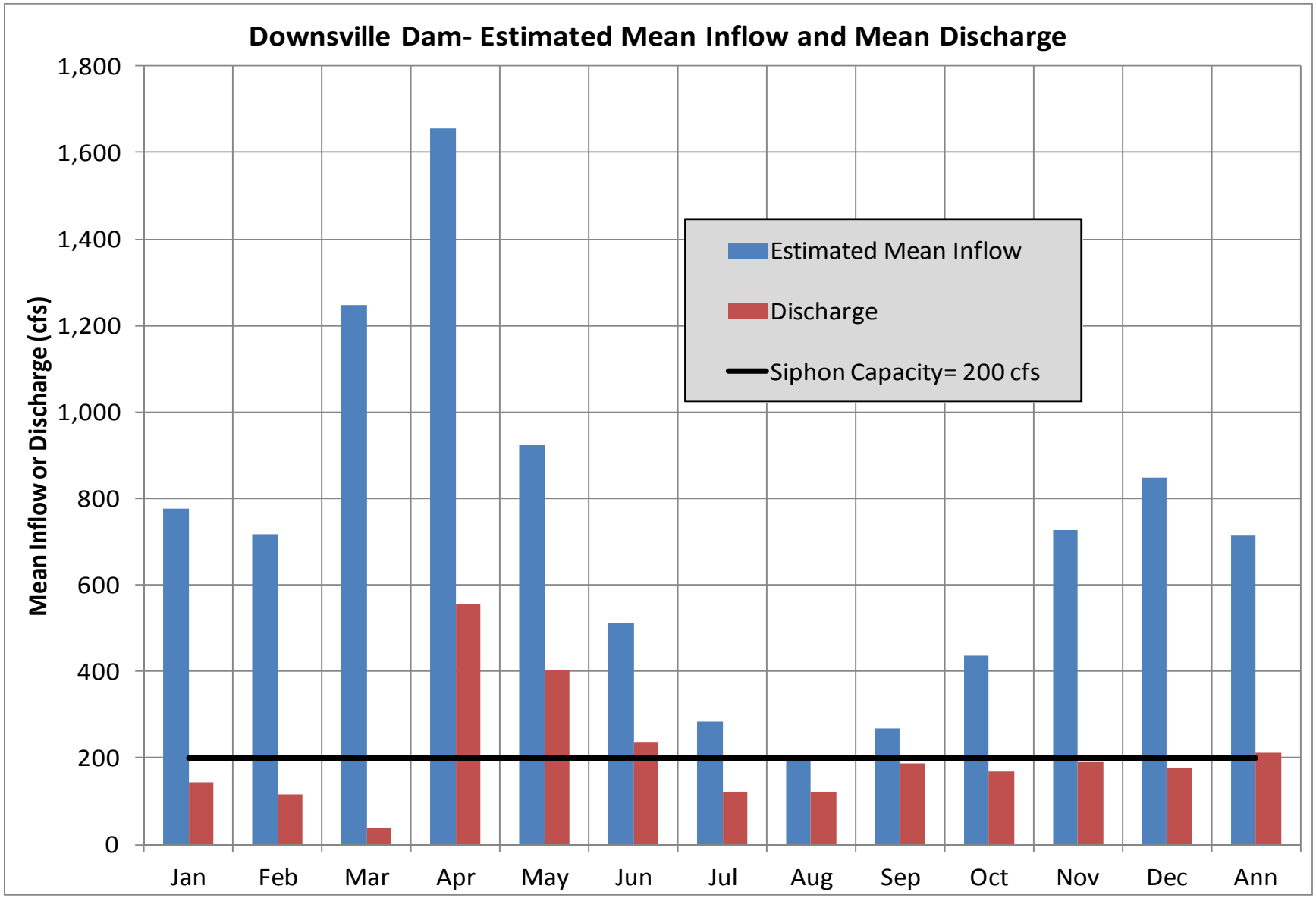

Figure 3.2-2: Pepacton Reservoir - Estimated Mean Inflow and Mean Discharge relative to 200 cfs Siphon Capacity

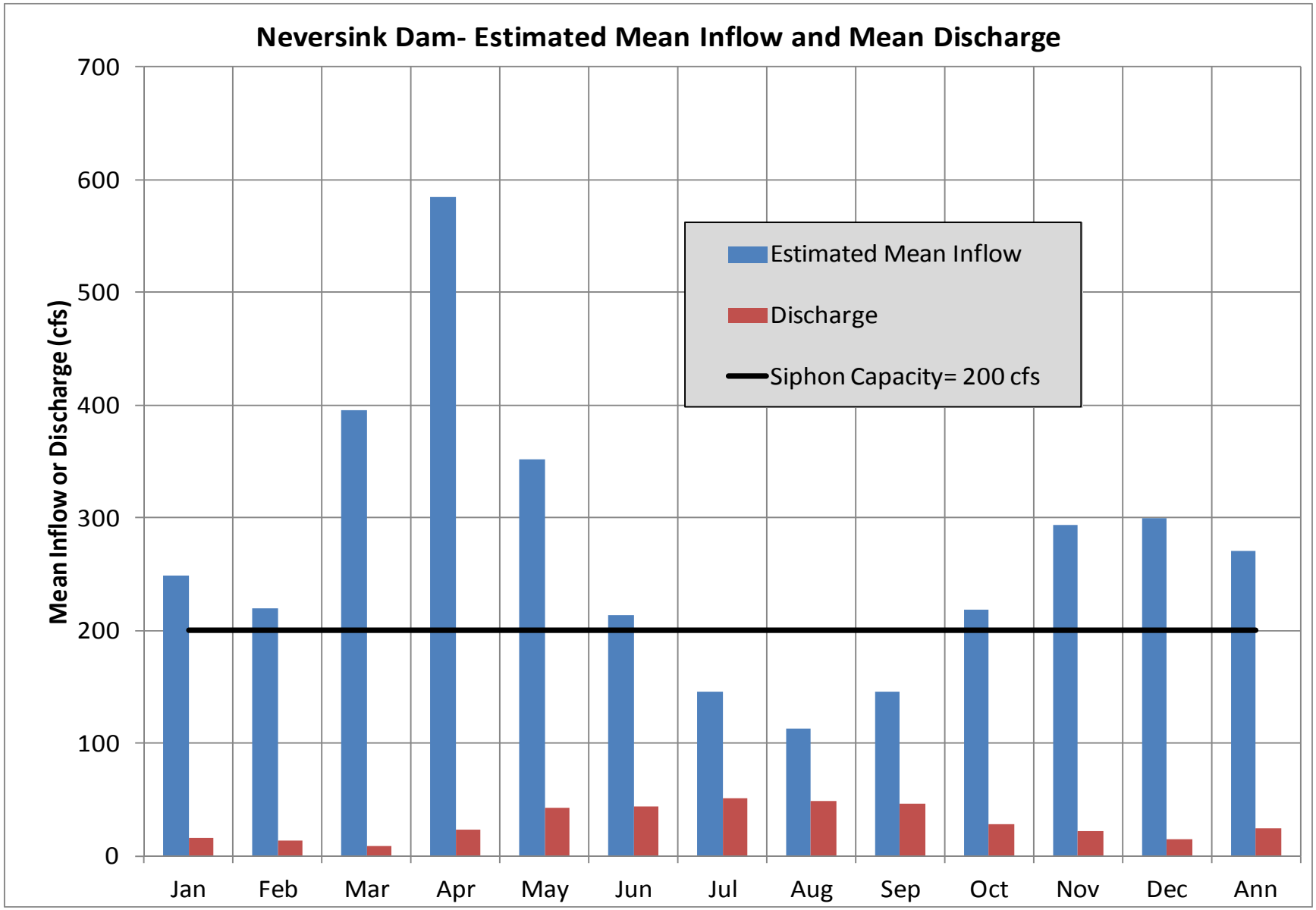

Figure 3.2-3: Neversink Reservoir - Estimated Mean Inflow and Mean Discharge relative to 200 cfs Siphon Capacity

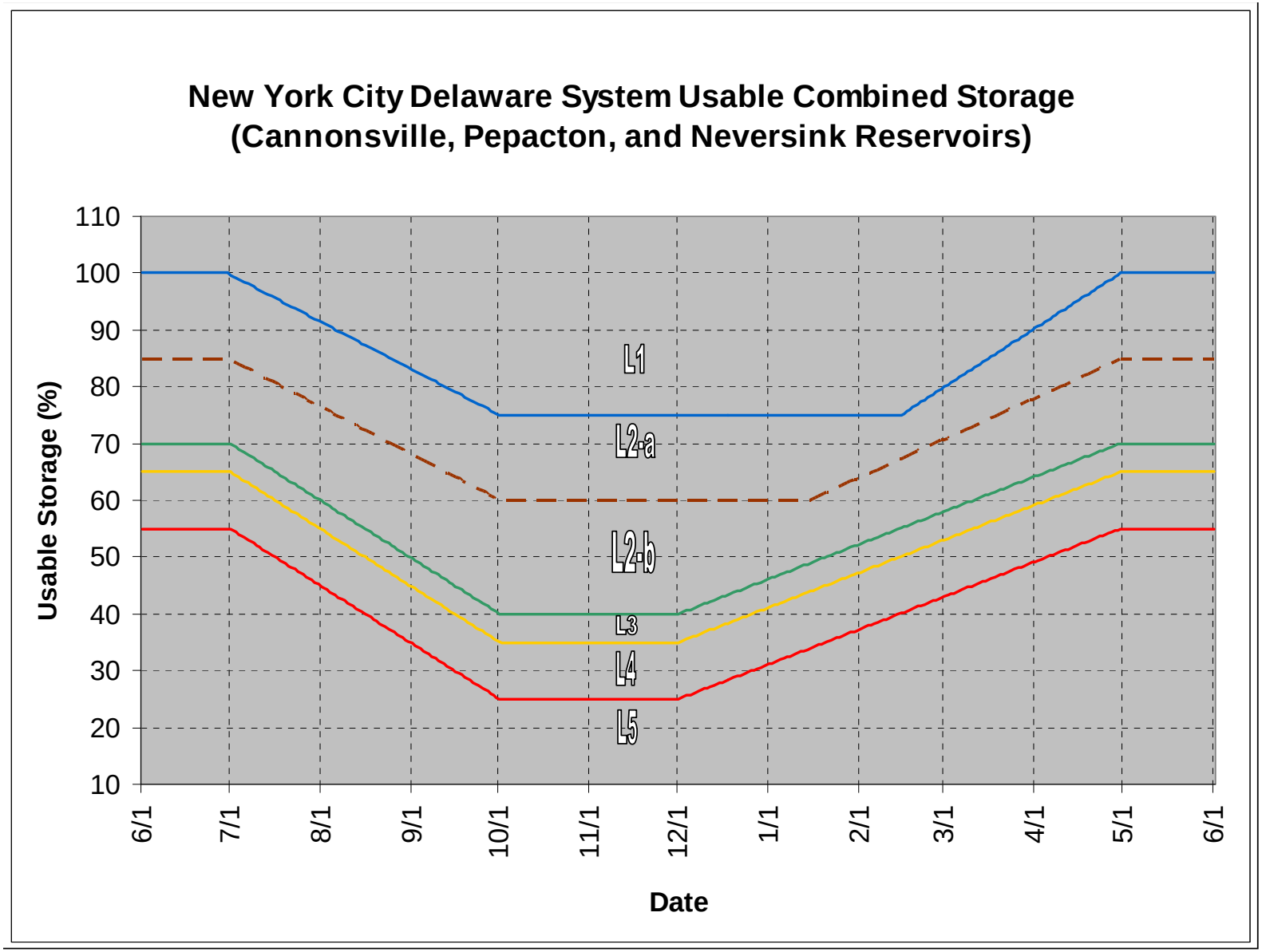

Figure 4.0-1: NYC Delaware River Basin System Usable Combined Storage

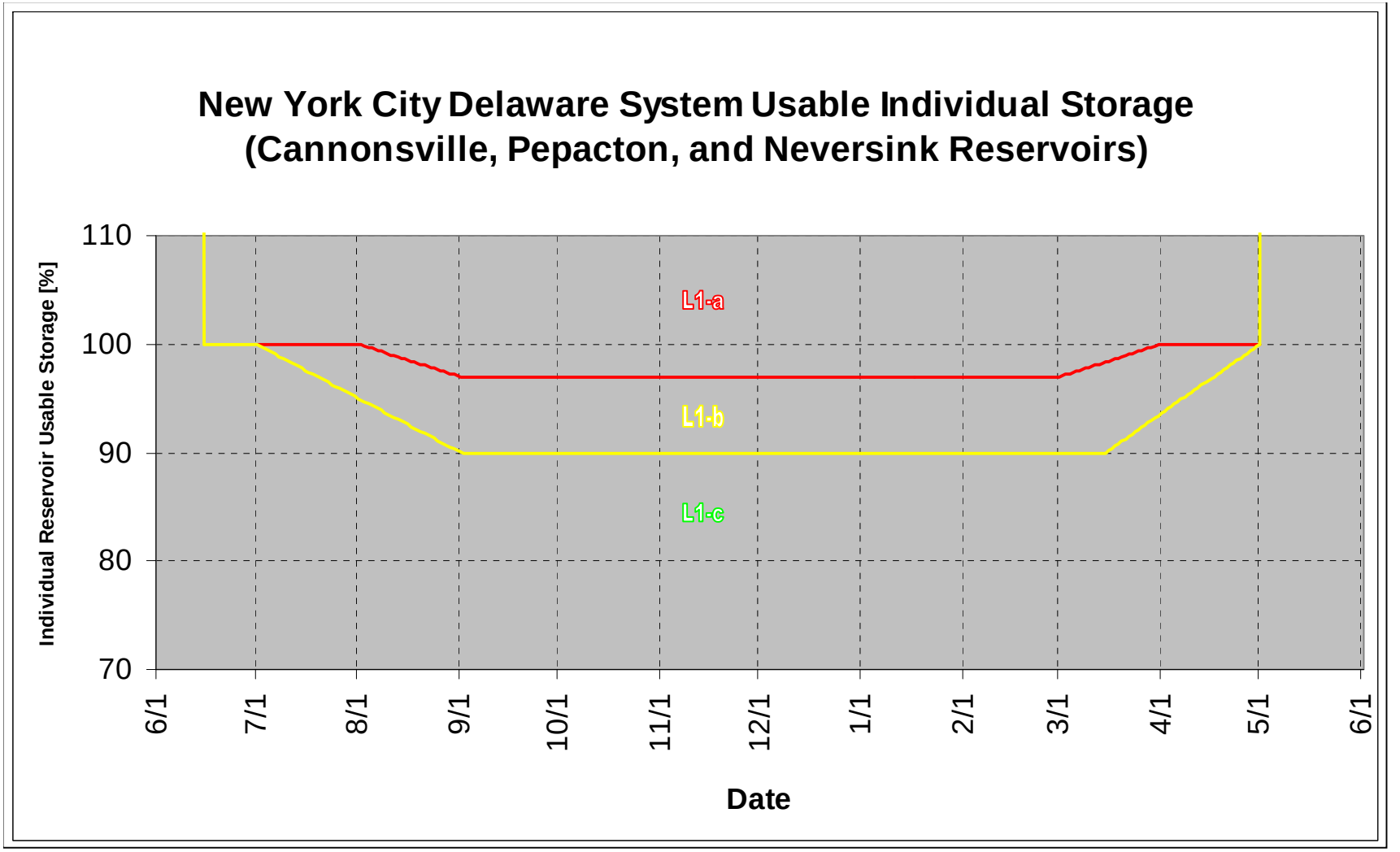

Figure 4.0-2: NYC Delaware River Basin System Usable Individual Storage

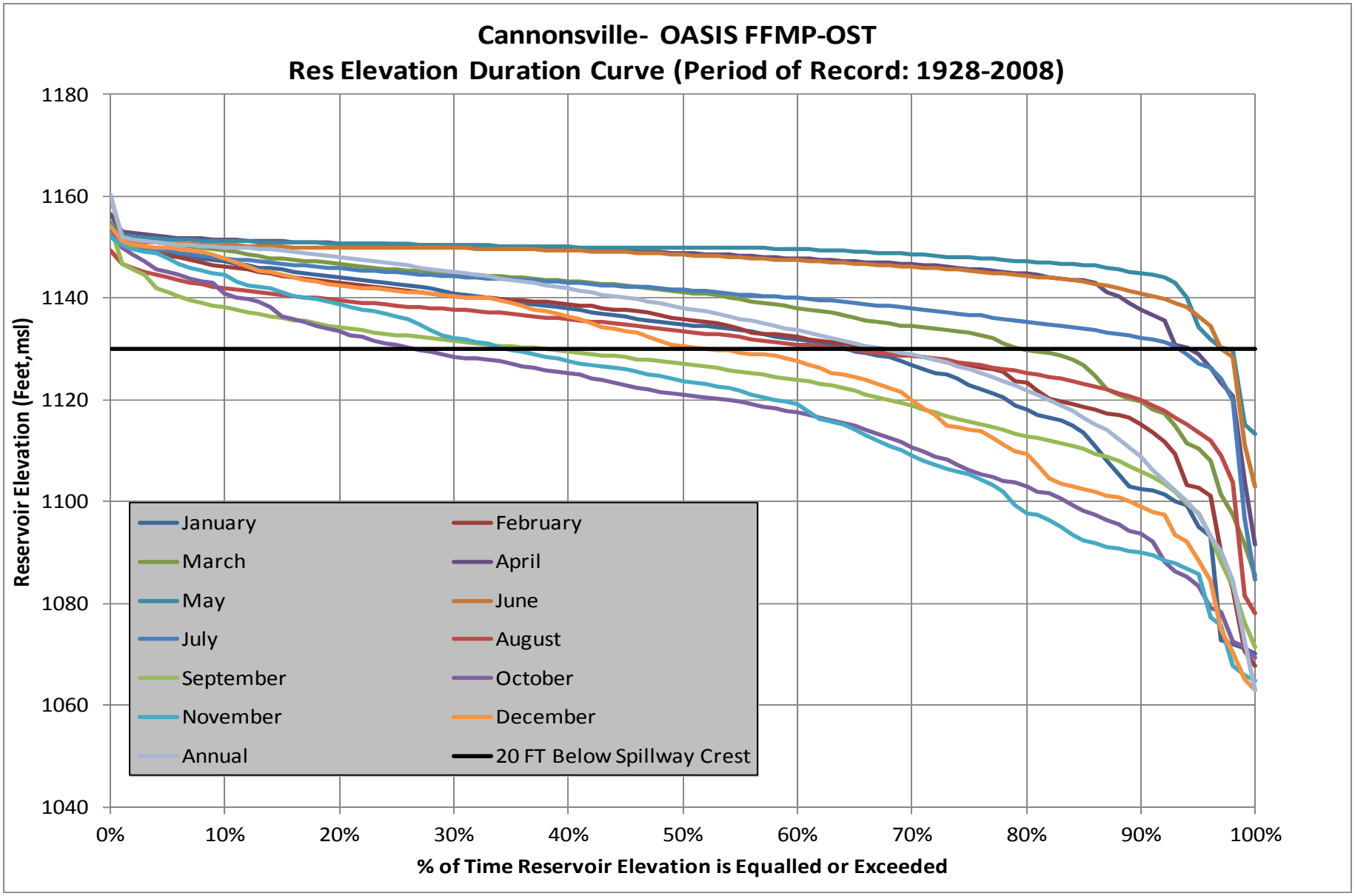

Figure 5.1-1: Cannonsville Reservoir - OASIS FFMP-OST, Reservoir Elevation Duration Curve (Period of Record: 1948-2008)

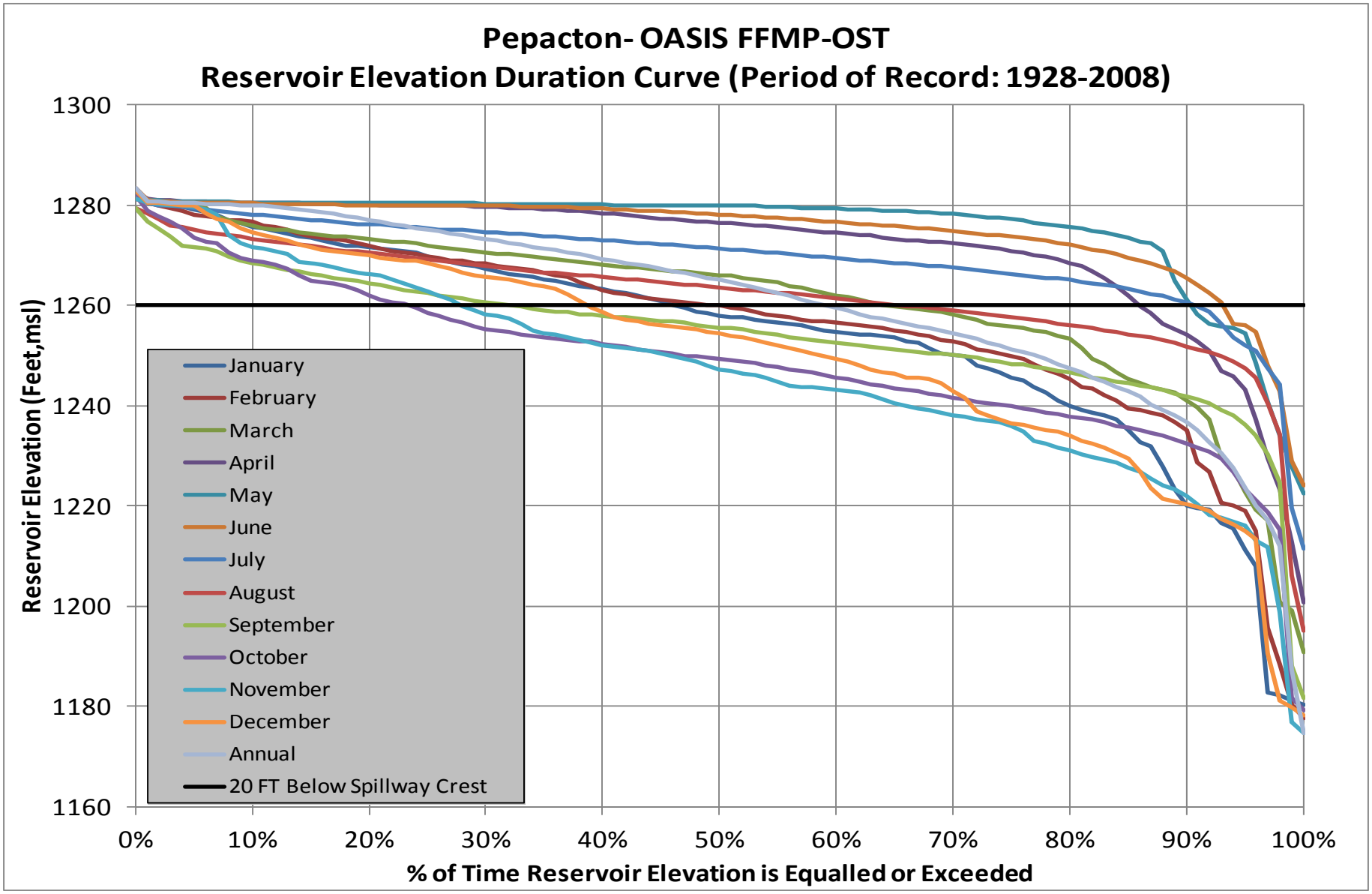

Figure 5.1-2: Pepacton Reservoir - OASIS FFMP-OST, Reservoir Elevation Duration Curve (Period of Record: 1948-2008)

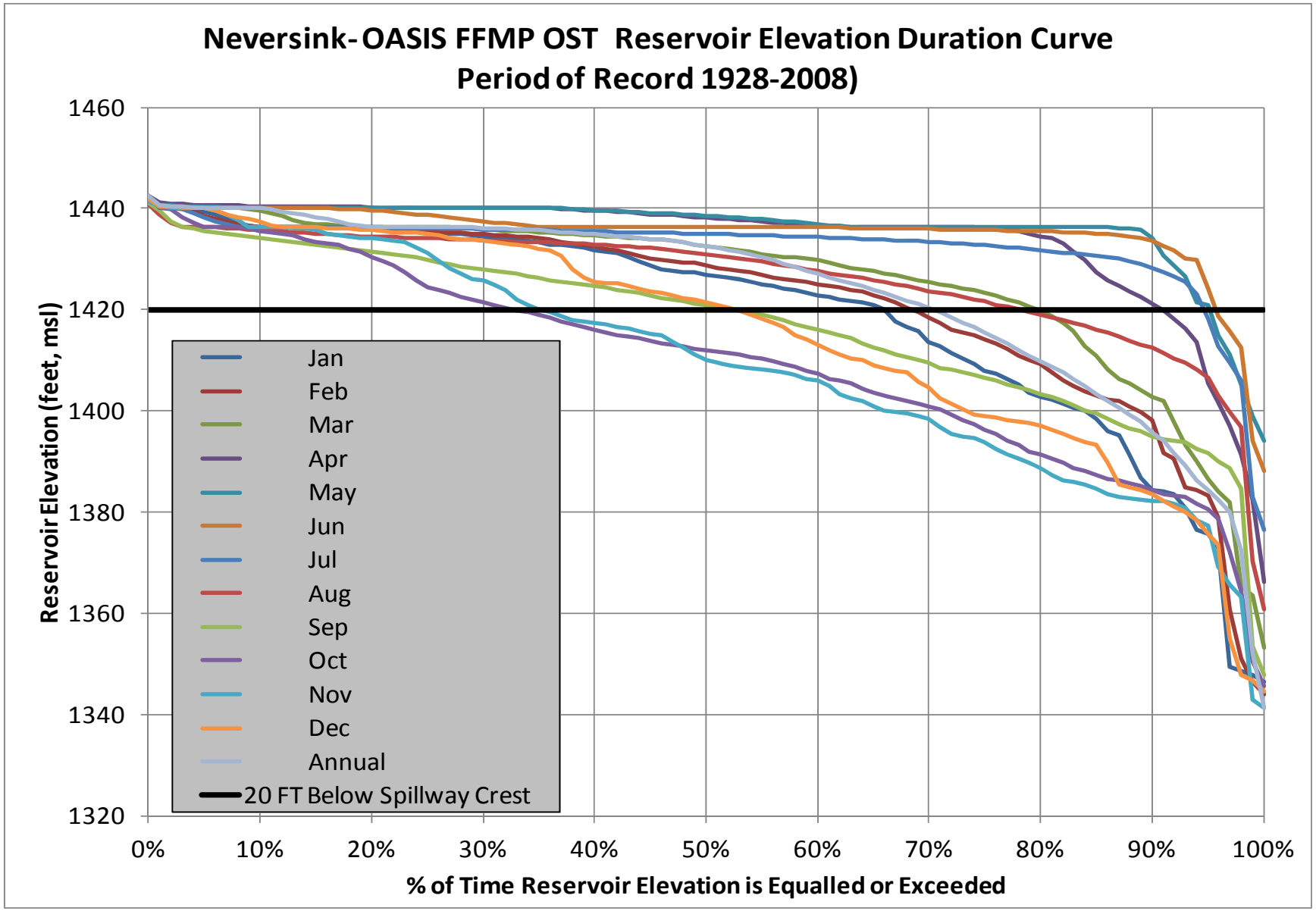

Figure 5.1-3: Neversink Reservoir - OASIS FFMP-OST, Reservoir Elevation Duration Curve (Period of Record: 1948-2008)

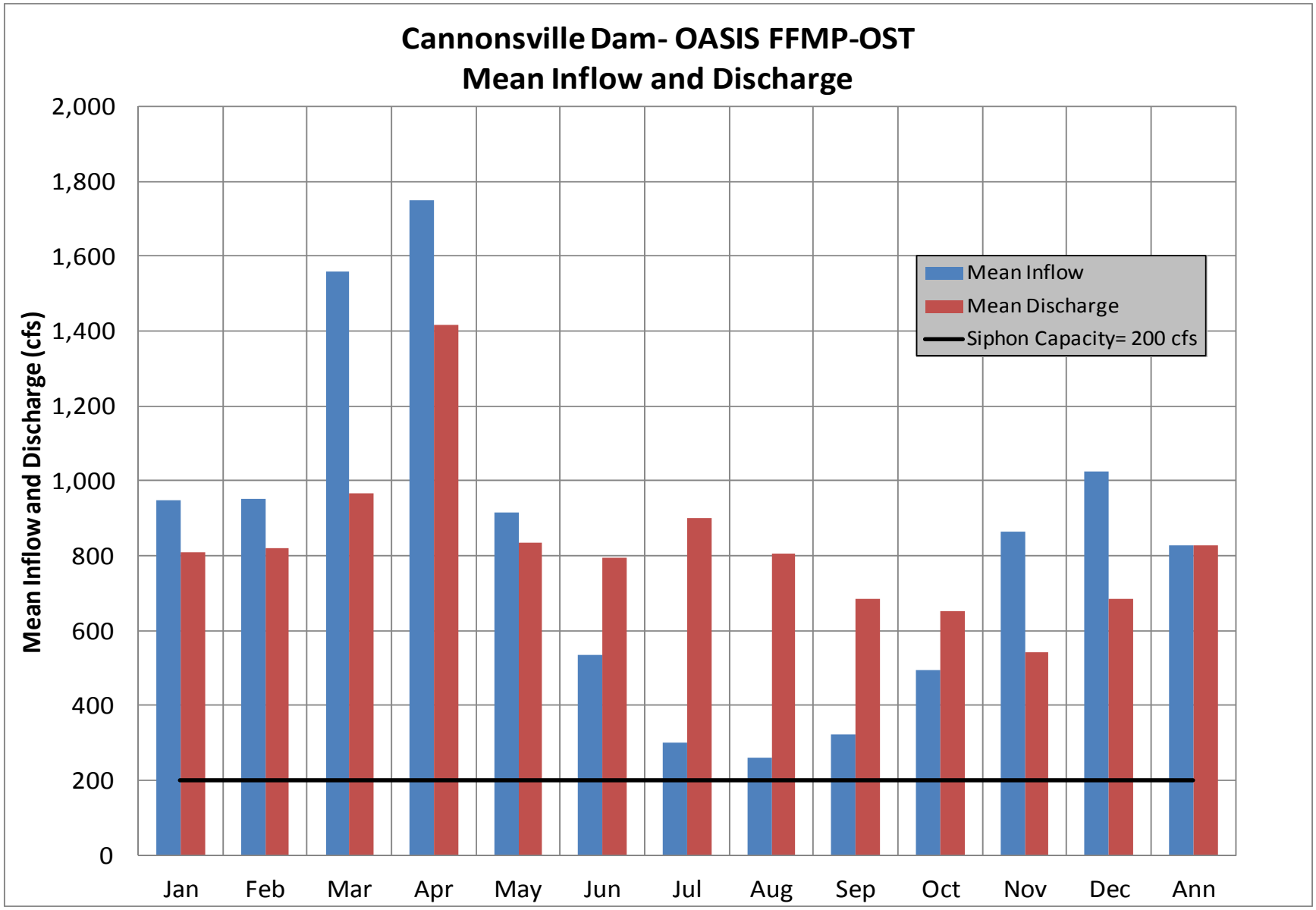

Figure 5.2-1: Cannonsville Reservoir - OASIS FFMP-OST- Mean Inflow and Discharge relative to 200 cfs Siphon Capacity

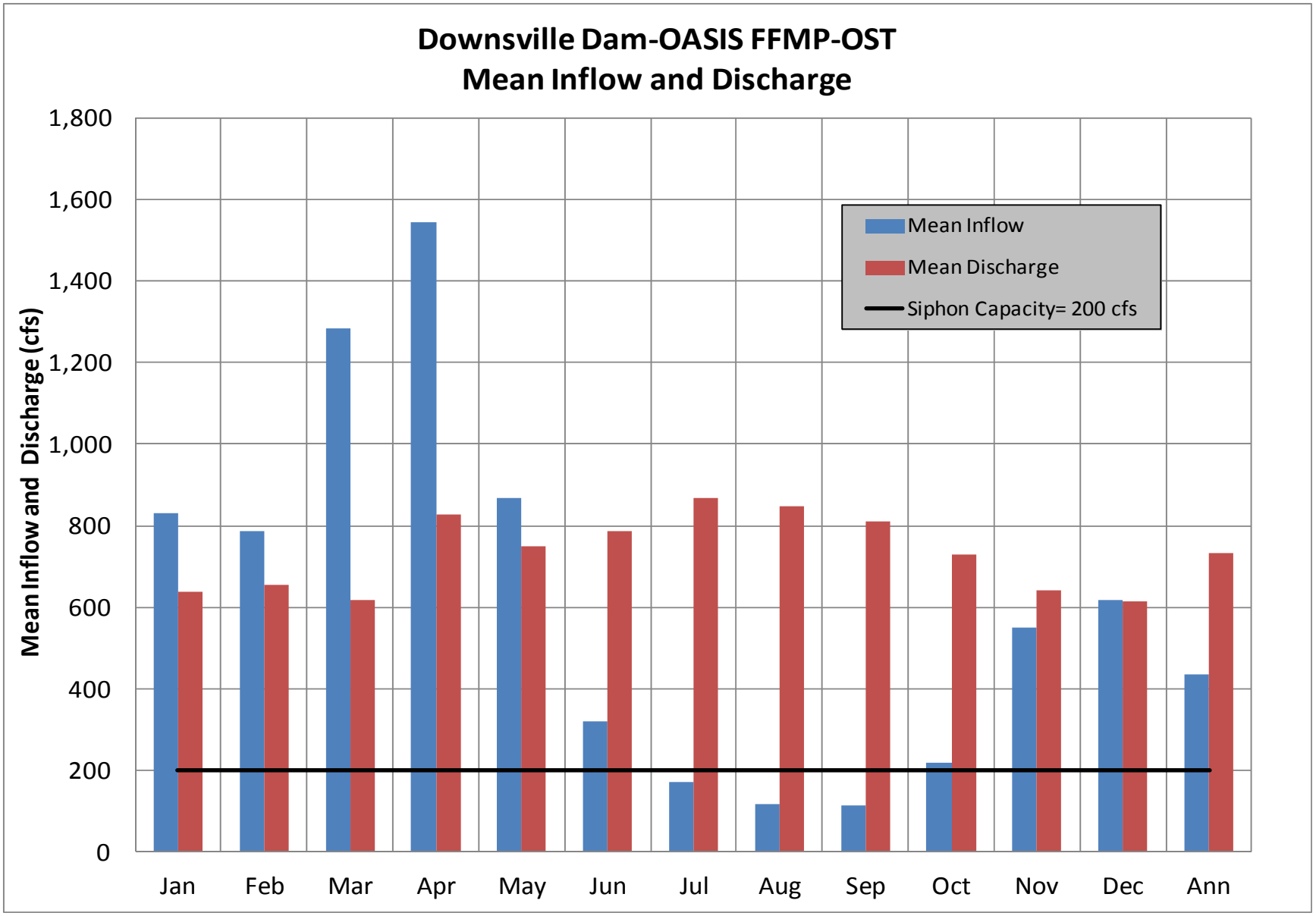

Figure 5.2-2: Pepacton Reservoir - OASIS FFMP-OST- Mean Inflow and Discharge relative to 200 cfs Siphon Capacity

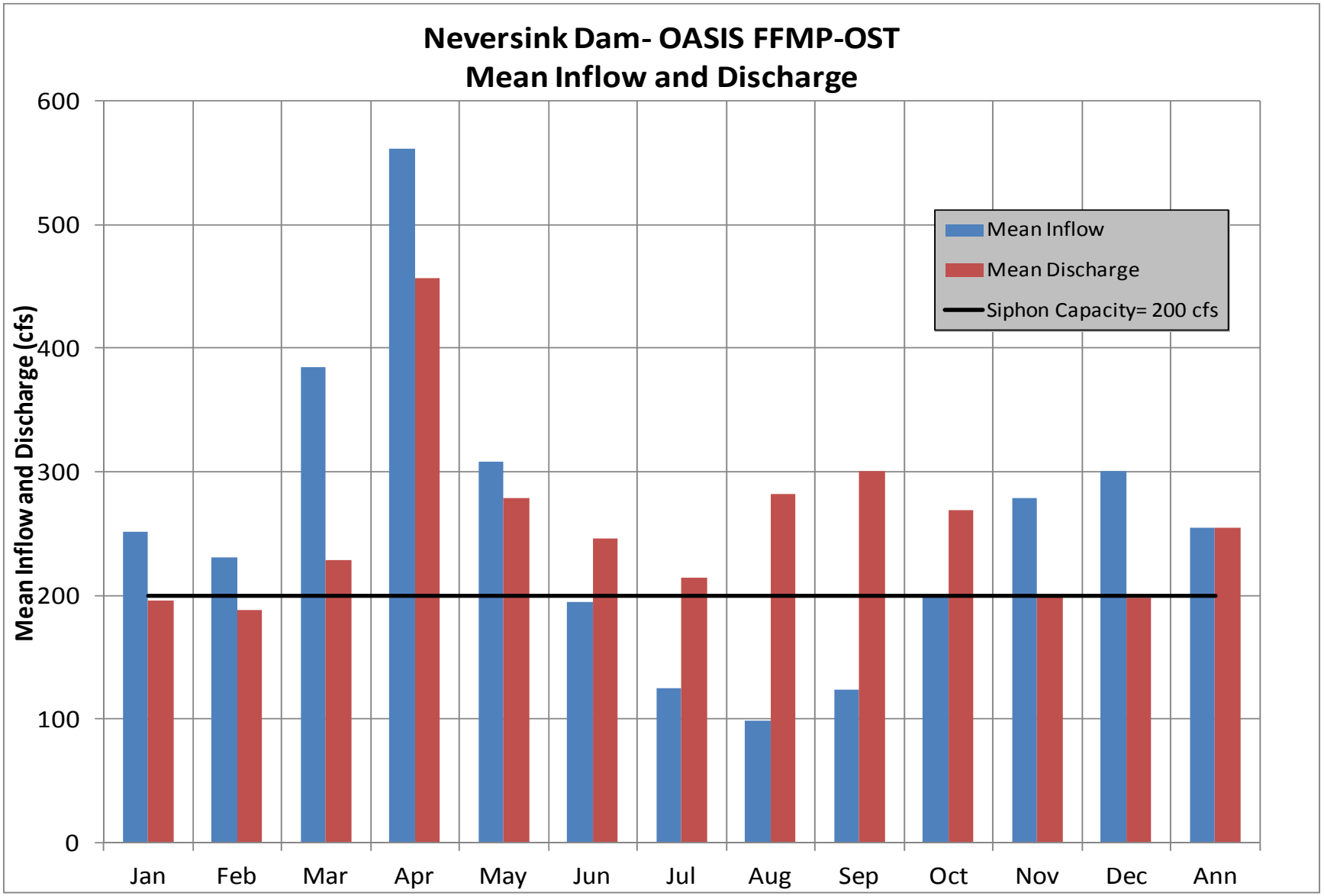

Figure 5.2-3: Neversink Reservoir - OASIS FFMP-OST- Mean Inflow and Discharge relative to 200 cfs Siphon Capacity