Comments

To: Regulated Flow Advisory Committee (RFAC)
From: Thomas L. Brand, PE, NJDEP
RE: Alternate FFMP Extension Proposals, Recent Storm, NYC Use Record & Other Issues

Date: March 21, 2011

Introduction

RFAC Meetings; Comments; General: Several participants at the March 8th RFAC meeting expressed a desire for more in-depth discussion of several issues. Therefore, it was agreed that the recent alternate FFMP proposals would be posted on the DRBC website and written responses would be provided by the Parties on those proposal or any others past issues raised, prior to the next RFAC meeting for possible future discussion. The following is offered.

1. Alternate FFMP Extension Proposals At the March 8, 2011, RFAC meeting, several proposals for conditions on a 1-year extension of the Flexible Flow Management Program (FFMP) were made in lieu of the possibility of D-77-20-CP and D-77-20-CP, Revised, (together referred to herein as REV 1) being reapplied. (It should be noted that reapplying REV 1, would require as much negotiating over safe yield , ERQ, demand and fishery releases as the FFMP and the Work Group has not prepared any alternative "fall back" version of what REV 1 conditions would look like.)

1.a Baseline Problem of all FFMP Alternative Over-draft Programs: The current FFMP and all proposals to modify and extend the FFMP avoid resolving several major issues raised in the NJDEP White Paper (downloadable at: http://www.nj.gov/dep/watersupply/doc/analysisnycreservoir.pdf). A critical issue is: The baseline simulations generated by the OASIS model incorporate the presumption that NYC *has needed* or *will need* 800 mgd (or 765 mgd, it makes no significant difference) from its Delaware reservoirs at a linear, daily rate, and therefore modeling creates an unrealistic base-line range of Montague releases, fisheries maintenance releases, water supply drafts and "drought days." An operating plan based on the imperative of a 765 or 800 mgd linear daily need ultimately also hinders constructive modeling for development of alternate, sustainable, operating programs that may achieve useful flood mitigation.

1. b. Flood Mitigation, General: The FFMP alternatives proposed up to march 8th have no significant flood mitigation; even if there is perhaps some statistically measurable increase in the occurrence of "void space" due to increased fishery releases, there is no indication that it results in any significant, responsive, flood mitigation. Because the over-draft plan is designed to respond to a *constant* need of 800 mgd instead of a *peak* need of 800 mgd for about 3 months, it results in excess storage and leads to frequently full or surcharged reservoirs which exacerbate flood, unnecessarily. A safe yield based program would allow for realistic flood mitigation assessment alternatives. The imperative to preserve a constant demand of 800 mgd in the model results in much water available to fisheries being unnecessarily withheld. Perhaps *the* primary unfulfilled objective of the USGS/ACE/DRBC Flood Study of 2010, was to identify ways to improve flood mitigation. Although the Study clearly demonstrated the impact of full reservoirs on flooding as far down as Trenton, it has not been further developed in coordination with an appropriate, conjunctive use, safe yield reassessment of NYC's reservoirs, a necessity for any useful, reliable flood mitigation. While the Study appeared to successfully reconstruct the flows for three flood events, it failed to

provide a useful tool or any major impetus for the logical resolution of the evident cause and effect relationship between the over-draft operating program and the resultant increased flood risk. Re-tasking reservoir use is a growing international problem (Google: Andreas Schumann, Ruhr Valley flooding, 2002) due to the changes in water use, conservation and energy efficiency. Similar surcharged reservoir conditions during floods have been occurring in several other large systems throughout this country and the world similar institutional hurdles to adapting have arisen elsewhere. Overcoming a reluctance to adapt is not a problem, it is an opportunity.

1. c. FFMP and Flood of March 11, 2011. Also at the Tuesday, March 8th, RFAC meeting some attendees expressed concern that they were expecting another flood as severe rains were predicted over the next few days and NYC's reservoirs were already exceeding 92 % full. Void space needed for snow pack had been about 20 %, so some expressed concern that the storms might exacerbate flooding by the week-end. However, significant flood mitigation *was* facilitated by the NYC reservoirs due to what remained of the snow pack void space, although not enough to prevent the reservoirs from spilling again. The storm was also not as severe as predicted. By March 8th, Cannonsville Reservoir (see Figs 1-3) had a modest void space, about 5 %, and was continuing to fill ahead of the expected storm despite spill mitigation releases of about 1,400 cfs (+-). Although Cannonsville quickly filled, it never the less provided useful flood mitigation. Had it already been full, Cannonsville may have spilled earlier and at a high enough rate to raise Hale Eddy flows to nearly a foot above its 11 foot flood stage. Because of the 5 % void space, the actual stage reached was 9.35 feet or 1.65 feet *below* flood stage. While the March 11th storm showed the advantage of a more accurate accounting for snow pack run-off, it also substantiated the need for void space. The continued spilling of the NYC reservoirs, now surcharged, indicates that a flood mitigation void should be added to the snow pack void. None of the FFMP extension proposals, with or without OST, seem to give any priority to the need for effectively managed flood mitigation.

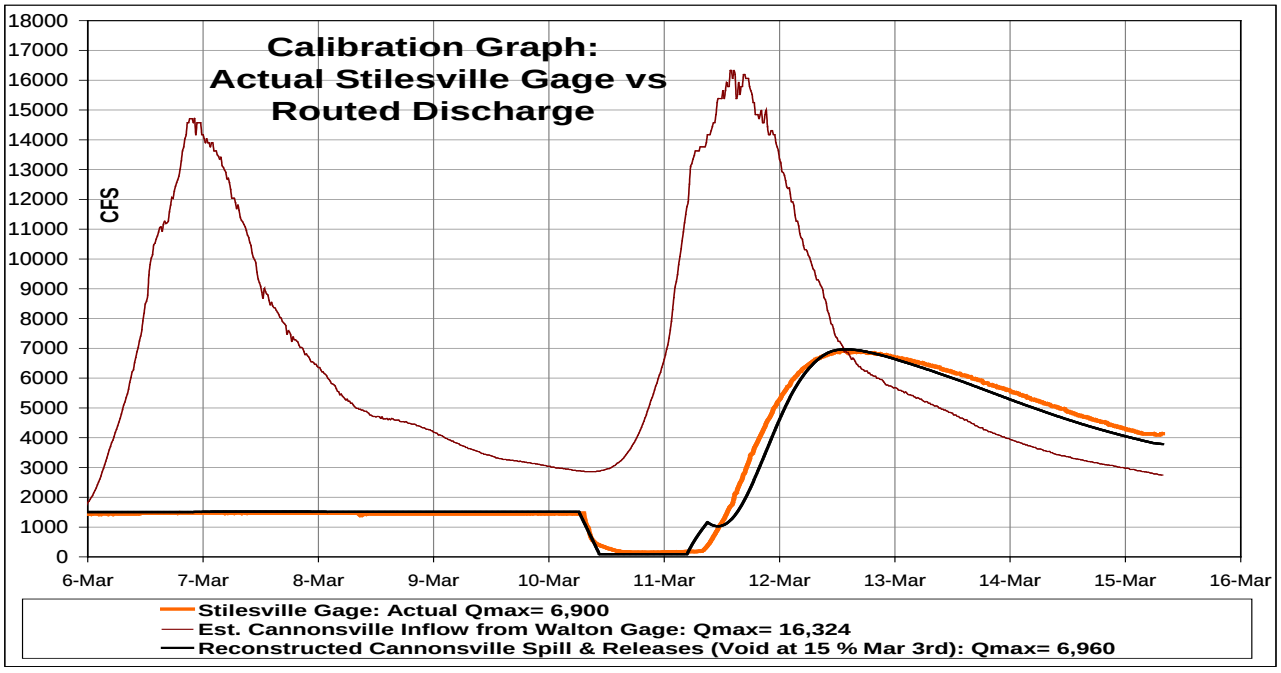

Figure 1. Reconstruction of Cannonsville inflow/outflow for March 6 to 15, 2011 storm events, assuming a 15 % void on March 3rd. The actual flow at Stilesville Gage is assumed equivalent to reservoir discharge and spill is compared to the reconstructed flow to calibrate routing model and assumptions.

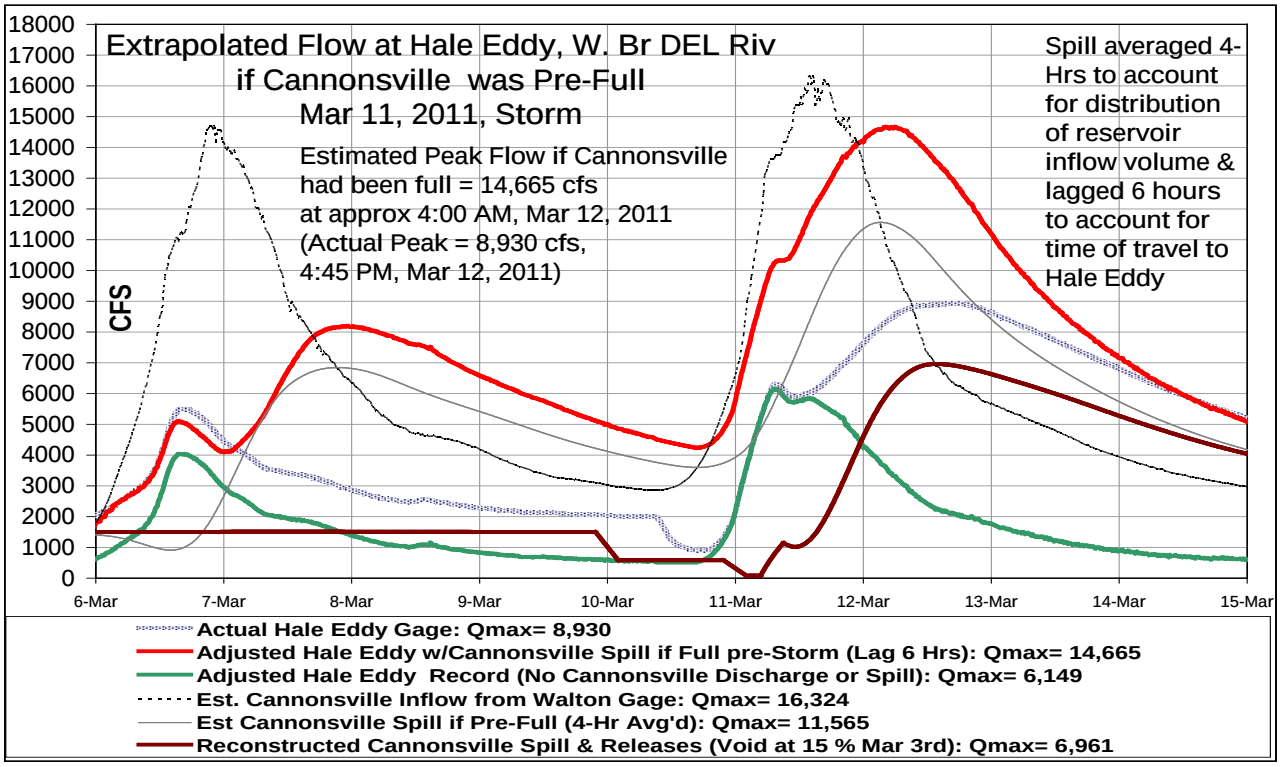

Figure 2. Reconstruction of Cannonsville inflow/outflow had it been full on March 6 to 15, 2011 storm event. The actual flow at Hale Eddy, when the March 11th pre-storm void was at about 5 %, is compared to other reconstructed flows, including inflow and outflow if full.

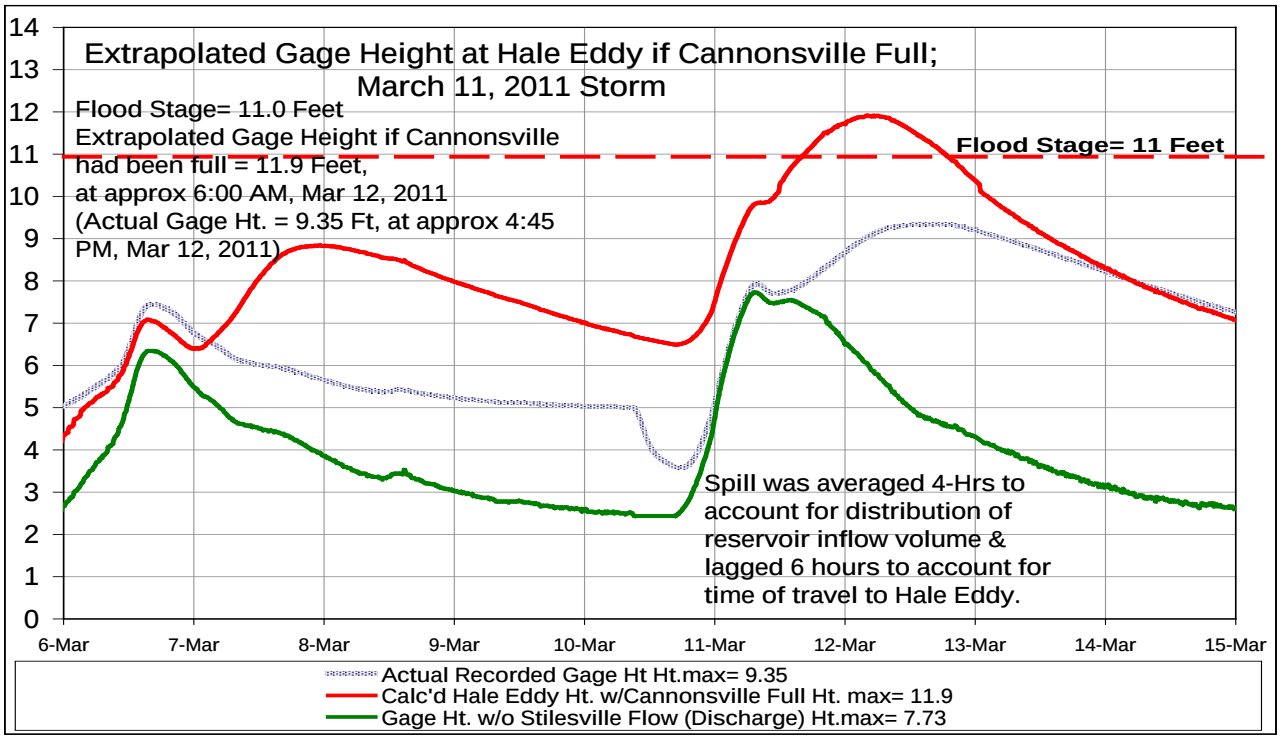

Figure 3. Reconstruction of Hale Eddy gage height, March 6 to15, 2011, extrapolated as if Cannonsville Reservoir had been full.

1. d. Drought: While nearly 6,000 "drought days" are generated, in actuality, NYC's reservoirs tend to be near-full, full or surcharged much more frequently and for longer durations than they need to be under an appropriate, safe yield based operating program; preferably an inter-basin plan that re-tasks NYC's reservoir operations to offset their own negative impacts and sustains multiple uses. Any FFMP modifications that are derived from use of the existing OASIS model and the current over-draft policy will result in no significant sustainable operating improvements. All results are severely limited between a reduction of NYC's over-draft of 800 mgd (or 765 mgd) or an increase of fishery releases to fill the difference in *actual* demand and an *unrealistic 800 mgd (or 765 mgd) "need*." Modeling at greater fishery releases and lower demand to meet the same drought days as lower fishery releases and the high over-draft results in the same unrealistic results. In the first case, the increased fishery releases may actually bring NYC closer to triggering droughts and in the second much water is wasted, spilled or sitting in storage, unusable, which results in increased flood risk by remaining too long and too often in storage, unnecessarily. As had been predicted over 60 years ago, since NYC has completed its universal metering program, it does not now need, nor should it ever need, 765 to 800 mgd from the Delaware reservoirs, *if any kind of reasonable, equitable, safe yield based operating program is applied in compliance with the intents and purposes of the 1954 Decree.* The change in NYC's use characteristics, post metering, has had a large impact, changing it from a predictable, nearly linear draft to a seasonal, non-linear draft. The over-draft program now *intensifies* the probability of "storage droughts," that is, drought conditions prematurely triggered by storage levels rather than hydrologic conditions, since it is designed to respond to a *constant* need of 800 mgd instead of a *peak* need of 800 mgd for 3 months. A linear, daily 800 mgd demand (or 765 mgd) is not only unneeded, it is unavailable *hydrologically* during the drought of record since it would, by definition of what the over-draft policy is, *exceed the safe yield of the Delaware reservoirs*. In other words, 765 or 800 mgd is *unsustainable*, except in non-drought years when over-drafting can be carried by replenishing rainfall. Further the over-draft program intensifies the severity of true droughts.

1. e. Inter-basin Effects. The over-draft program promotes NYC's imperative to keep the Delaware reservoirs full beyond any current probabilistic need in order to prepare the City for peak demand periods. The City is thus poised to extend the over-draft as long as possible while conserving use of its Catskill and Croton systems. If drought conditions ensue, Montague flow and fishery release reductions are triggered, NYC's diversion reduced and Delaware reservoirs' storage is conserved. Peak season transfers and needs have already been served. This results in less use of the Hudson Basin reservoirs, which tends to cause a "topped off" condition for them; their already ample 25 % reserve storage (or 65 BG) is "topped off" or augmented by water held by under-utilization of Hudson Basin storage as NYC opts to over-draft the Delaware System. Under-utilization also promotes sedimentation, eutrophication and wasted spill. The wasted spill is a sign of inefficient use of storage and mainly due to the over-draft program, which incorporates no realistic operating and demand conditions. Recently however, NYC has provided ad-hoc flood mitigation in *both basins*, but not due to any deliberate, inter-basin flood mitigation program or by design of the FFMP but, according to the City, due to public pressure in the *Hudson Basin* to develop some void space in the *Catskill System* due to the frequent flooding problems there. Hudson Basin public pressure also motivated NYC to add flood gates to Gilboa Dam several years ago. The March storm was mitigated in the Hudson by NYC's having discharged Ashokan Reservoir water, via a diversion channel to Esopus River, up to 580 mgd for about 3.5 months (Oct 15 +- to Jan 31 +-). Because the City used none of the Croton System for water supply, it also was able to spill more than the entire safe yield of the Croton System from New Croton Reservoir. During this time, nearly all the City's water was supplied by the Delaware System, which, under the FFMP, (by NJDEP modeling) has a

combined total safe yield of about 740 mgd, including Rondout and West Branch (in the Croton River watershed) reservoirs. The discharge of water from the Ashokan reservoir also enabled NYC to purge some of the settled fines in Ashokan reservoir. The resultant 3.5 months of excessive turbidity in the Esopus River was most likely caused more by a turbulent, scouring *discharge* rather than 3.5 months of turbid *inflow*. The City was finally directed to stop the Ashokan discharge by the NYSDEC after public protests of the turbidity impacts to the Esopus. This purging project increased the City's average use of the Delaware reservoirs from a recent average of about 500 mgd to 540 mgd. All these disjointed operations result directly or indirectly from the over-draft program and have led to multiple, inter-basin problems including impacts to fisheries, water supply, unnecessary drought declarations, and increased flood risk. None of the alternate FFMP proposals address these issues, all of which are about 45 years over-due to be addressed; the reassessment NJDEP called for in the FFMP is the first step needed. The NJDEP's original intent in calling for the reassessment was to induce a collaborative and cooperative approach to develop an appropriate inter-basin, safe yield based program.

2. Alternate Fishery Release Proposals

2. a. Temporary FFMP; Dr. Peter Kolesar: Dr. Kolesar's proposal modeled improved fishery releases with NYC 's demand set at a conservatively reasonable rate (that is on the high side) of 550 mgd for the coming year, while increasing the fishery releases sustainable with the water available from the difference in demand between 765 mgd and 550 mgd. The result was a fishery program that is closer to the PA/NY Fisheries' White Paper recommendations and comes to virtually the same number of "drought days" as those obtained when using a demand 765 mgd under the current FFMP. It is assumed that NYC's water supply would have a very high probability of being met in the short term at 550 mgd, or less.

Dr. Kolesar's proposal, counter-intuitively, may *increase* the likelihood NYC will trigger drought conditions causing reduced Montague flows and fishery releases because the increased fishery releases, together with NYC's reduced demand, are probably closer to an *actual* demand of 765 mgd. Since NYC is not using its Croton System and it is not possible to induce it to do so under the existing IERQ and FFMP over-draft policy, the proposal may therefore be more marginal than it appears. There is nothing in the FFMP, the OST or any recent proposals that are clear improvements and may actually be counter-productive given that NYC has indicated the OST will be used to optimize water supply quality by over-drafting Delaware Basin. However, it is about a 70 % probability that NYC *can* meet the fishery and Montague flow objectives if its demand is kept to 550 mgd and under. This is not a function of the FFMP model, it is simply because 70 % of the time annual rainfall exceeds 41 inches and the model is mostly irrelevant during such rainfall years. At 550 mgd and under, it is a greater than 70 % likelihood that no severe reduction of Montague would be necessary. However, the effects of unbalanced use will continue, especially in the West Branch Delaware River.

As Dr. Kolesar pointed out during the March, 8th, 2011, RFAC meeting, Cannonsville Reservoir, under REV 8, was very low in a short-term, 2005, low flow period affecting fishery releases to West Branch Delaware River. However, it is a fallacy to think that this low storage was *caused* by REV 8 or that an appropriately conducted REV 1 re-formulation would result in similar dire consequences. In 2005, for example, since the combined storage of the Delaware reservoirs never fell below the "normal" range (that is not to imply the rule curves are appropriately set), no drought was declared. The reason Cannonsville was so low in 2005 is that NYC did not use Cannonsville

reservoir in a balanced way between the other Delaware Basin reservoirs and Hudson Basin reservoirs as NYC would have been *compelled to do under the original ERQ and Decree conditions*. REV 1 would require that the ERQ be calculated by the difference between a 1,665 mgd safe yield and a demand of 1,200 mgd or, alternatively, the *actual* REV 1 safe yield of between 1,430 and 1,470 mgd and a demand of 1,200 mgd; each of these ERQs would provide a significant bank of water for fisheries to be used at the lower basin Parties discretion and each would tend to induce balanced use by NYC. Inspection of the 2005 Delaware River Master Reports shows Cannonsville was used almost exclusively to maintain Montague flows and by October 10th, was at about 26 % full while Pepacton was about 56 % full and Neversink at about 62 % full for a total combined fill percentage of 46 %. Normal for October 10th is about 61 % and drought watch about 40 %. Most telling, however, is that had NYC used *any* of its Croton System's 240 mgd safe yield in 2005, the City could have easily prevented any significant drawdown of Cannonsville at all; by October, the combined total Delaware reservoirs would have been at about 58% of capacity, near normal (whatever "normal" is in an over-draft program). Extreme impacts from the April, 2005 flood to the October, 2005 "drought" are an effect of *in-basin and inter-basin unbalanced use*.

2. b. Alternate Fishery Release Proposal; FFMP-OST; Hazen & Sawyer/NYC: The Hazen and Sawyer proposal, sponsored by NYC, increases fishery releases, presumably due to the water gained from the predictive efficiency the OST brings to the FFMP. The OST would be used to "look ahead" (say, 2-weeks ahead), comparing NYC's existing and immediate future water supply needs to the expected storage level and inflow in comparison to fishery releases for the 800 mgd (or 765 mgd demand tables. Assuming the demand will be much less than 800 mgd, the FFMP release tables can be used as a palette to select a greater release, week by week, adapting to changes in inflow and the effects of releases and demand on storage levels. In other words, the leeway in storage between a demand of 800 mgd and NYC's actual expected demand, is used to judge which release schedule in the FFMP can be used to safely augment fishery releases by choosing a higher fishery release schedule applied while above the L-3 Zone. The L-3 to L-5 Zone releases would remain the same. The Hazen and Sawyer table shows the range of L-1 and L-2 fishery releases for a NYC demand of 800 mgd (Base) to 700 mgd (Row F). Therefore, at no time would the fishery releases ever exceed those developed to support an over-draft of, at best, 700 mgd, still far greater than NYC's annual average need, greater than sustainable and greater than should be currently diverted under any reasonable definition of equitable and balanced use.

The extra releases will be an essentially subjective decision and most likely result in sporadic rate increases, needed or not, distributed throughout the seasons most likely during higher reservoir levels; such additional releases are represented graphically in H&S Slide 16 for May to October. Hazen and Sawyer's modeling, using the OASIS model with its in-built exclusion of the effects of NYC's conjunctive use, (one wonders how the OASIS-W2 might compare) indicates that over the period of record, on a year-round basis, weekly average PCN (Pepacton, Cannonsville and Neversink) releases would be *greater* than those of the current FFMP *over 60 % of the time* and that May through October weekly average PCN releases *match or exceed the FFMP's over 70 % of the time*. These are fuzzy, unhelpful statistics illustrated by the following: *(For simplicity's sake, the example is not an exact replication of any schedule, but the rates are comparable to Neversink releases)* Say, over a summer's 100 day period, the FFMP provides a 100 mgd release, *every day* at L-2 Levels for the current FFMP base line, i.e., 765 mgd of demand. Now, say the proposed FFMP-OST program might increase the releases to 150 mgd for about 30 days at the beginning of the same period. Then consider that, for 20 days, these extra fishery releases induce storage to drop more quickly in the L-2 zone so that the normal 100 mgd releases is reestablished. Then let us say

storage drops into the L-3 for 30 days in the middle of the 100 day period (say equivalent to a mid-summer period), and the releases are reduced to 50 mgd because the previous higher releases have helped pre-maturely draw down the reservoirs through the L-2 Zone and into the L-3 Zone. Say, without the releases, that storage would have never fallen below the L-2 Zone. Say, after 30 days at L-3 and releases reduced to 50 mgd, the reservoirs start to recover and storage levels return to the L-2 Zone and remain there with 100 mgd releases again for the final 20 days of the 100 day period. This is equivalent to 30 days at 150 mgd, 20 days at 100 mgd, 30 days at 50 mgd and 20 days at 100 mgd again. This is the same average of 100 days at 100 mgd (30*150+30*50+40*100)/100, distributed differently with a drop to 50 mgd during a critical, 30-day mid-summer period. Does it satisfy the statement, *'70 % of the time the May through October releases match or exceed the FFMP ?* Clearly for 30 days the releases are 150 % greater and for 40 days the releases are the same; therefore for 70 days, or 70 % of the time, the FFMP-OST releases would match or exceed the FFMP releases even though there is a serious, undesirably low release period in the middle of the low flow period. For example, a schedule of 30 days at 200, 30 days at *0*, and 40 days at 100 satisfies the statistic also.

The FFMP-OST plan continues the program of *designing* premature large draw downs by subjectively allowing to increase releases, needed or not, in late spring and early summer so that, if a drought develops, the City is poised to trigger reductions of Montague and fishery releases that ultimately increase NYC's water supply. The Hazen and Sawyer/NYC proposal shows a statistical scattershot (H&S Slide 16) of improved release days that would likely occur at the least needed times and ultimately wastes storage similar to the ineffective 1,850 cfs Montague release that was dropped from the FFMP. The Hazen and Sawyer/NYC proposal provides no known additional benefit for maintenance of temperatures and low flows during critical low flow periods, a frequent issue especially given the vastly under-estimated IERQ. The releases are set without realistic operating criteria, demand characteristics or performance standards for fishery needs, such as temperature or low flow targets in the tributaries. This is why storage banks are created, to reliably meet such performance standards. To develop such a bank, the actual, realistic, safe yield considering the impact of conjunctive use, *needs to* be known and applied

Consider further that *70 % of the time*, rainfall averages *41 inches per year, or greater*. This means about 70 % of the time that NYC releases are being made, they are essentially replenished by natural inflow; further, that many of these releases needn't or shouldn't be made at all if flow and temperature in the downstream tributaries are already adequate. At such times, any unneeded releases *should* be" banked" for a needy day, perhaps a low flow day *caused* by NYC's over-drafting triggering another unnecessary drought condition. To add a fuzzy set of potential fisheries releases to an existing set of fuzzy fishery releases that can only be sustained during average-and-above years relative to a difference in demand between 700 mgd, minimum and 800 mgd is far too broad and vague; it is no "metric" at all. It is an unknown, a "black box." It would be far more effective to apply an appropriate ERQ to develop a reliable bank for the lower basin to use at it sees fit. The IERQ should be based on a safe yield of about 1,470 mgd and a demand of 1,200 mgd, from which a significant bank can be developed.

3. Analysis of NY City Use Record (Distributed by USGS). At the January, 2011, RFAC meeting the public expressed its desire to obtain a fully transparent accounting of New York City's (NYC) annual use record from the Delaware River Master. The USGS, Delaware River Master has since compiled a spreadsheet of NYC's use (referred to as "consumption" in the Decree) between 1954 and 2010 in a PDF file and forwarded it to the Work Group. It is also available on the DRBC

website. The NJDEP has conducted an analysis of NYC's use record for comparison to other historical records, use reports and safe yield analyses.

3. a. General: Previous safe yield analyses and all operating models derived from them are fatally flawed since none assess NYC's actual safe yield derived from the effect of the conjunctive use of the City's combined total systems; this is ***the*** pivotal criteria and has been for 45 years, ever since the drought of the 60's enabled NYC the option to move water through Rondout Reservoir via the Delaware Aqueduct at rates that exceed the safe yields of the combined Rondout, Pepacton, Neversink, Cannonsville reservoirs' safe yields. An appropriate analysis of NYC's entire system as well as the Delaware System (which includes Rondout and West Branch reservoirs) remains an unfulfilled task of D-77-20-CP and REV 1. Moving more than the safe yield through the Delaware System was a diversion characteristic not assumed possible under the 1954 Decree's safe yield based conditions, all based on the less severe1930's drought. The implications of NYC's past operations, demand characteristics, relationship to safe yield, Montague flow maintainable, and the effect of the over-draft policy applied since the 1983 Good Faith Agreement are all discussed in the following analysis, which is unaffected by whether the D-77-20-CP, REV 1 over-draft or the FFMP over-draft program is applied. There is no new information in the following analysis; the existing records have simply been carefully examined and applied in the context of assessing actual operating impacts and options under a more equitable, inter-basin operating approach, in accordance with the Decree and reconstructed.

3. b. Two Critical Issues: Over-drafting and Sustainability: From time to time, definitions of a few terms that have had a long history still periodically tend to confuse people, so it is important to clarify at least two basic concepts before the main body of the analysis of NYC 's use record; the terms "over-drafting" and "sustainability."

> **3. b. i. Over-drafting:** The concept "over-drafting," is a term often defined and used in the negotiations of the Decree at least since 1952 and all alternate Delaware River Basin operating programs negotiated since 1977. (It is likely to be contained in the 1931 Decree testimony, also.) It simply means to take more water from a reservoir than will allow it to *sustain* its design purposes during a repeat of the design drought, in the case of the Delaware River basin, the most severe drought of record. The design purposes for the Delaware reservoirs were originally only Montague flow maintenance and public water supply. Periodic use greater than the average safe yield is not over-drafting and can always be done as long as an appropriate, probability analysis shows that, at times, such over-drafting will not compromise the design uses. This is not the over-draft program of the FFMP. In the FFMP, over-drafting means taking water in a way *designed* to exceed the safe yield. The 1954 Decree provided protection from NYC's over-drafting the Delaware reservoirs' safe yield, as well as to prevent unbalanced use between the basins, with the Excess Release Quantity (ERQ). The ERQ established a formula that required NYC to return a substantial volume of its combined total unused safe yield to the Delaware Basin each year, thus deterring the inequitable use of Delaware Basin reservoirs while under-utilizing Hudson basin reservoirs. A more severe drought necessitates a change in calculating an ERQ, but not the principles of sustainability and safe yield that it was based upon. This became crucial after the 60's drought when NYC' ability to divert water from the Delaware Basin reservoirs exceeded these reservoirs' safe yields. For the 30's drought, the safe yields of the reservoirs, when factoring in that the Delaware Aqueduct from Rondout is limited to a peak capacity of 890 mgd, *exceeded* NYC's ability to obtain. That is, the Rondout Reservoir's safe yield of about 125 mgd for the 30's drought, coupled with the

Delaware reservoirs (Pepacton, Neversink and Cannonsville) original combined safe yield of 800 mgd (or 850 as per USGS 1968 Study) equals between 925 and 975 mgd, which clearly exceeds the Delaware Aqueduct's carrying capacity from Rondout Reservoir. (The 890 mgd capacity is documented by several NYC and NYS consultant engineer's reports.) The original difference between the actual 1930's drought safe yield and the Delaware Aqueduct capacity is the most likely reason that, soon after the 1954 Decree, NY State was able to add the equivalent of about 40 mgd of minimum conservation releases to the Delaware reservoirs; at the time there was between 85 mgd and 35 mgd of safe yield available, quite literally as 'water over the dam,' for conservation releases, depending on which safe yield, 850 or 800 mgd, is applied. This all changed after the 60's drought and, since that drought, it has been necessary to perform an appropriate conjunctive use safe yield reassessment of NYC's systems. No agency, no contractor of the lower Delaware Basin Parties, has ever been tasked properly to perform such an analysis. Instead several "parsed" analyses have been done, confined to separate basins, which result in an under-estimation of the actual conjunctive use safe yield. The effects of conjunctive use between storage reservoirs is especially important under the over-draft policy, since NYC obtains a greater safe yield then is apparent under the parsed analyses. It is highly likely that such an analysis already exists between NYS, NYC, Hazen & Sawyer or HydroLogics, completed and updated since 1967 and could be provided to the Parties and Delaware River Master. The OASIS model can not assess the actual safe yield derived by the over-draft program because it does not include the Rondout and West Branch reservoirs.

3. b. ii. Sustainability: The second concept causing some unnecessary confusion is, "sustainability." The difference of opinion over the meaning of sustainability is not an arbitrary semantics issue. Sustainability is the essence of safe yield. Sound practices and principles of water supply engineering and management require an equitable, sustainable, safe yield based operating program derived from a realistic analysis of the water available. This will enable the reliable maintenance of multiple uses and goals; that is the uses will be sustainable. NYC and NYS have framed sustainability in the context of maintaining the continued over-drafting of the Delaware Basin reservoirs at 800 mgd: *This is not sustainability, but its opposite: Depletion*. Sustainability is also an important goal of environmental protection, which is currently a fundamental deficiency of the EPA's FAD with NYC. The EPA does not consider how the FAD produces inter-basin impacts of flood, drought and fisheries from NYC's increased usage of Delaware Basin waters for water quality.

3. c. Analysis of NYC Use Records: This analysis expands on the NJDEP White Paper via forensic examination of the effects of NYC's historic demand record, as well as the historic flow records, NYCDEP's Water Department reports and the effects of the EPA/NYC Filtration Avoidance Decision (FAD). This analysis identifies and explains the primary causes of water shortages in the City's system and its impacts, past and present, on the Delaware reservoirs and Montague flow.

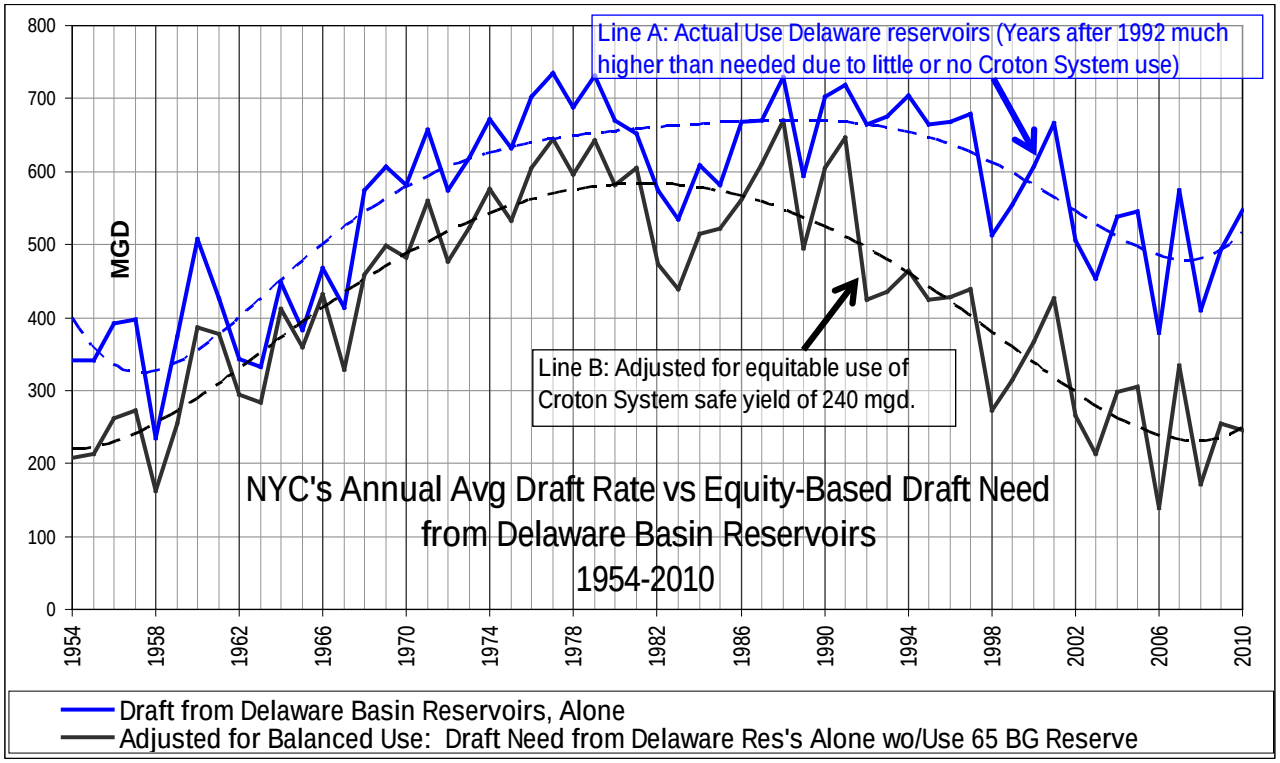

Figure 4. Delaware Reservoirs. NYC's average annual draft from Delaware reservoirs alone, Line A. Line B is annual average Delaware reservoirs' drafts after adjusted for equitable use of Croton System, only.

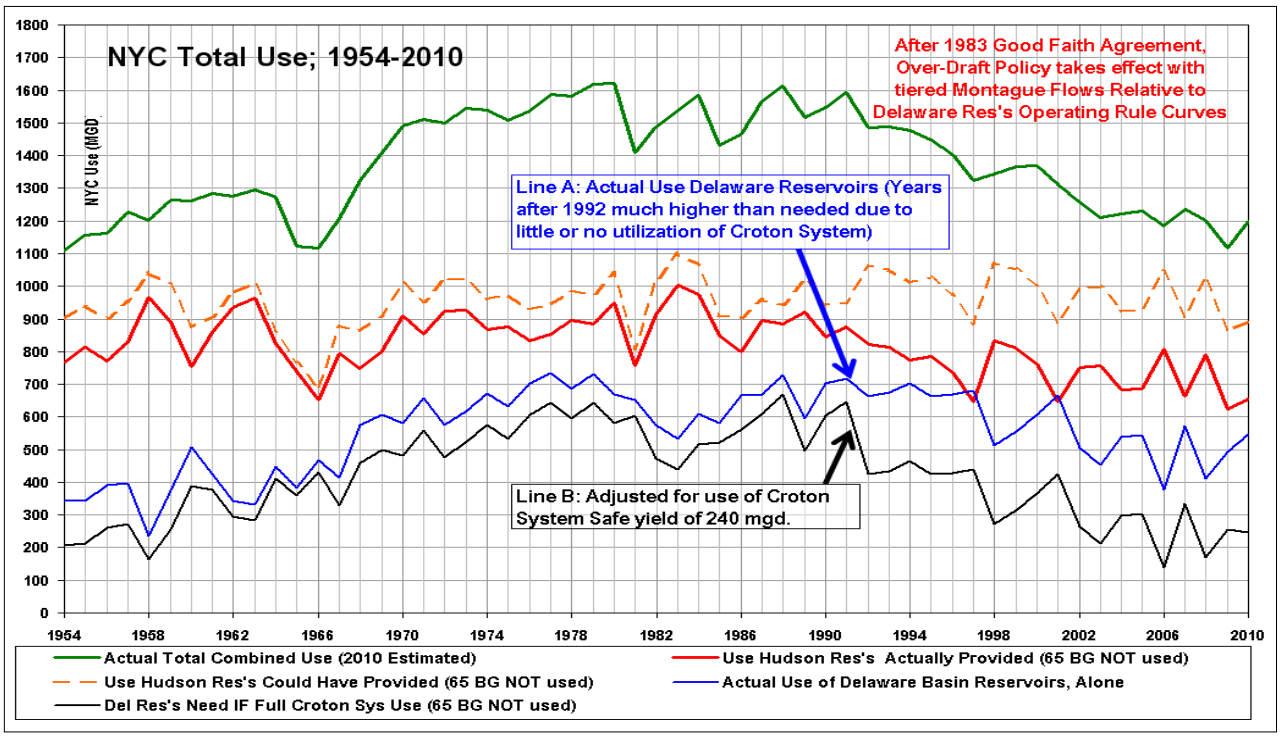

Figure 5. Delaware and Hudson & Total. Total average annual drafts of NYC from combined Delaware-Hudson Basin Systems as well as drafts from only Delaware reservoirs. Clearly shown is declining overall need, declining use of Hudson reservoirs and escalating Delaware Basin use. (Lines A & B are same as for Figure1.)

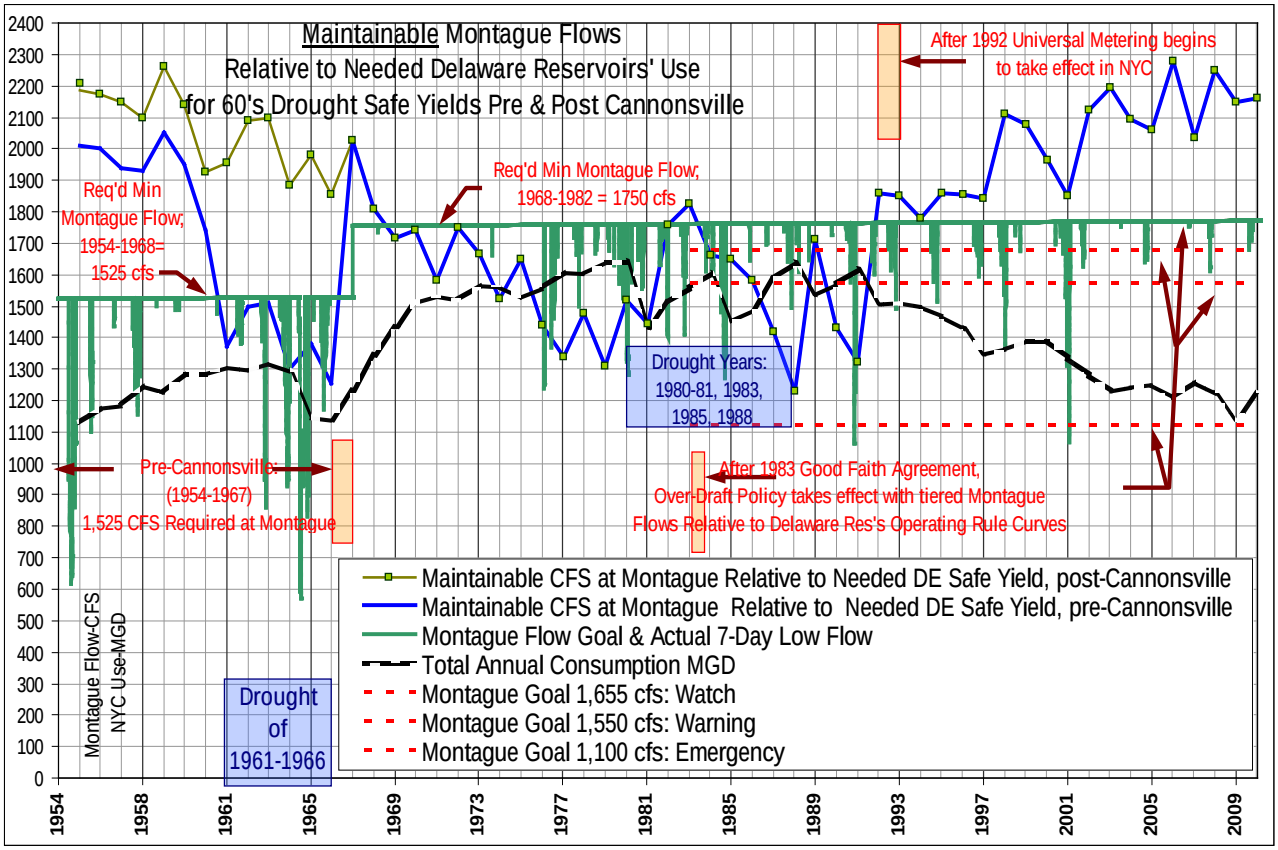

Figure 6. Comparison of the historically maintainable Montague flow with historical demand and actual 7-day average flow at Montague. Between 1954 and 1968, the minimum flow required at Montague was 1,525 cfs.

3. c. ii. Figure 4 and 5: Figures 4 and 5 show (blue line or Line A in both graphs) NYC's annual use of the combined three Delaware Basin reservoirs. Figure 4 shows only the Delaware basin reservoirs for clarity along with average trend lines. Figure 4 and 5 each also show, in heavy black lines, NYC's total actual *needed* Delaware reservoir use, after adjusting for a more balanced use by NYC of *only* the Croton System. In other words, the adjusted Delaware reservoirs' *need* is derived by adjusting for equitable use of only NYC's Croton System, even though the Catskill System is also under-utilized. This tends to make the need estimate more conservative. NYC's normal demand should have been only about 1,250 mgd (+- 50 mgd) between 1961 and 1966, indicated by use records and a 1965 statement by Edward Clark, NYC Chief Engineer. After the 60's drought, between 1968, when NYC's annual use was about 1,324 mgd, and 1970, the City's demand sharply increased. The 1,250 mgd projected average demand during the 60's drought period was reduced by emergency use restrictions to 1,123 mgd in the worst year of the drought, 1965. After the introduction of an effective universal metering program in the late 1989, from about 1992 on, Figure 5 shows the declining total demand and the effect of metering on both the Delaware and Hudson basin use. In Figure 5, the heavy red line represents the total Hudson systems' use, including outside communities, and was obtained simply by subtracting the Delaware reservoirs' use from the total use. This is shown by. The dashed red line of Figure 5 shows total Hudson systems' reservoirs use when adjusted for use of the Croton System's 240 mgd safe yield, a source rarely used (because of poor water quality) since 1992 and not used at all since 2004, but soon to be available with the completion of a filtration plant. Shown in Figure 5 is the effect of NYC's s reduced use of the Croton System, since the advent of the EPA's more stringent water

quality regulations in the early 1990's. NYC's subsequent lack of use of the Croton System is offset by the successful universal metering program and NYC's increasing proportion of use of the Delaware Basin reservoirs, a "hidden" increase of about 200 mgd. In other words, over a nearly 20-year period when Delaware Basin reservoir use *should* have declined by 200 mgd, it stayed nearly the same while Hudson Basin use declined by 200 mgd. This difference is a significant volume of water, which would make a significant fishery bank if NYC were induced by an appropriate ERQ to use its Croton and Catskill System equitably. Since 1992, the EPA and other agencies, such as the DRBC and Delaware River Master's Office, have not considered the cause and effect relationships of water quality regulations and reservoir operations under NYC's Filtration Avoidance Decision. The environmental impact to the Delaware Basin has already been huge, in water quality, fisheries, flood and drought.

3. c. iii. Figure 6: Figure 6 shows that, had Cannonsville been built, NYC could have maintained 1,750 cfs at Montague under the average demand of about 1,250 mgd expected at that time. However, since Cannonsville had not filled and was not making a substantial contribution to NYC's safe yield, NYC could not meet the 1,525 cfs Montague obligation at that time, even with only a 1,250 mgd demand. However, the graph shows that neither did NYC need to reduce Montague flow to the lows it did.

Figure 6 indicates NYC also failed to meet its Decree obligation of 1,525 cfs at Montague during several years previous to the 60's drought, 1954, to 58, probably because of the City's inability to anticipate and control run-away demand and its practice to first use the Delaware storage and conserve Hudson Basin water above all else. NYC, with Hazen and Sawyer's OST and HydroLogics' OASIS-W2 model mayo continue over-drafting the Delaware reservoirs' safe yield and perhaps *increase* the over-draft to the point of using the Delaware System nearly exclusively. This is possible because, since the 1983 Good Faith Agreement, an appropriate ERQ to prevent such over-drafting has never been developed. Instead, all ERQ's have been based on a total combined safe yield of only 1,290 mgd. NJDEP modeling shows the total safe yield is *at least* 1,410 mgd under the D-77-20-CP Revised Docket and 1,460 to 1,470 mgd under the FFMP. Continuing to use the 83 % reduction factor to provide some room for error and applying a total demand of 1,200 mgd, the ERQ should be between 63.6 and 78.8 BG and no cap should be applied since the 70 BG cap was a figure relative only to 1953 demand and 1954's safe yield; the cap is irrelevant now and the 83 % reduction factor allows enough room for growth, especially since NYC's growth has declined.

Figure 6 also shows that, after 1992, NYC's metering and fire hydrant lock program began to take effect and overall demand trended downward even though droughts in 1998, 1999 and 2002 occurred. In fact, after 1992, there is not a single year when NYC could not have met 1,750 cfs at Montague. Yet many times NYC did not maintain Montague; this is an artifact of the over-draft rules. The fact that NYC has not provided filtration to its Croton and Catskill systems and prefers to use Delaware Basin water even if it induces droughts, also triggers Delaware basin "storage droughts." Since 1992, during such droughts, drafts to NYC, despite being curtailed, have had no effect on its ability to meet full demand due to its ability to conjunctively use and shift storage between the basins. Such operations shift the Delaware reservoir low volumes to winter time, triggering winter drought conditions and draft curtailments that have no impact on NYC. That is, under the over-draft program, use restrictions would only be applied during the late summer, fall or winter periods and have little or no impact on NYC's supply via conjunctive use of the Delaware System. Because of the

EPA's mandate for filtering open water sources, NYC could no longer rely on the Croton System and since about 1992, NYC has increased over-drafting of the Delaware reservoirs disproportionately to equitable use.

3. d. 1961-66 Drought History: In February 7, (+- 1 week) 1965, the lowest storage levels ever experienced by the City were reached. The combined total Delaware reservoirs was 10.5 BG. The percent of NYC's total 476 BG of storage capacity was 24.5 % or 116.6 BG. This means NYC's Hudson Basin Reservoirs were at 116.6-10.5 =106.1 BG, over 10 times the volume of the Delaware reservoirs. In the beginning of August 1965, the City's Chief Engineer, Edward Clark, presented graphs to the public showing the system at 45 % as the City sought to reduce Montague releases. On August 1, 1965, Neversink held 11 BG and Pepacton 41.8 BG for a total Delaware supply of 52.8 BG. Forty-five percent of 476 BG is about 214.2 BG. Therefore, NYC's total Hudson Basin storage was about 214.3-52.8 = 161.4 BG or nearly three times the storage of the Delaware reservoirs. This is a strong indication that NYC had under-used the Catskill/Croton Systems in the 60's.

NJDEP analyses indicate the safe yield of the Delaware reservoirs without Cannonsville when attempting to maintain 1,525 cfs at Montague would be, conservatively, about 276 mgd, The 60's drought safe yield of the Hudson reservoirs is considered 810 mgd, although an independent analysis has never been done by the lower basin Parties. During the 60's drought, then, NYC's safe yield, without use of the 65 BG of reserve storage in the Hudson Basin, would be about 810+276 = 1,086 mgd. This left a safe yield shortage of 1,250 - 1,086 = 164 mgd. Therefore, during the 60's drought, NYC could <u>not</u> maintain Montague at 1,525 cfs. Even though NYC reduced its 1965 and 1966 demand to about 1,123 and 1,118 mgd, respectively, and historic records indicate NYC apparently used none of its 65 BG Hudson Basin reserve storage, it is never the less likely Montague flows would still have had to have been reduced due to the extraordinarily high peak demand during low inflow season, which would have resulted in massive drawdown of the Delaware reservoirs. As Figure 6 shows, with a demand of 1,250 mgd, NYC would have easily been able to maintain 1,750 cfs had Cannonsville been finished and operable.

3.e. Post-60's Drought History: In 1968, NYC's demand soared, likely due mostly to leakage and uncontrolled use, not growth, then leveled off until universal metering was begun in about 1991. The effect of metering reduced NYC's demand to pre-Cannonsville rates and reduced demand on the Delaware reservoirs despite less use of the Croton System. Even so, many unnecessary drought conditions were triggered via the unrealistic over-draft operating rule curves. After 1968, the Delaware System and thus the Delaware Reservoirs, were used more, most likely because the Decree allows NYC to drain the Delaware reservoirs and the size of the Delaware Aqueduct enable's NYC to meet peak demands more efficiently than the rest of NYC's systems. By divorcing the ERQ from an appropriate, safe yield analysis of conjunctive use of NYC's systems, none of the principles of equitable apportionment entailed in the Decree can be applied. However, balanced equitable use *has* been promoted in the past simply by NYC's need to meet high demand. For example, despite NYC's recent years unbalanced over-drafting of the Delaware reservoirs (mainly to offset the Croton System water quality problems), during the droughts of 1980-81, 1985 and 1988-89, the City balanced use of its Hudson and Delaware basin storage as the Croton System was being used more plus the demand was at an all time high and necessitated careful balanced use. The 1980-81 drought, and the perception of dire need it created played a crucial factor in obscuring the actual yield and operating flexibility NYC gained by the Good Faith Agreement during its negotiation. *In fact, several reports (see NJDEP White Paper),found the eighties droughts were more a result of NYC's inability to control <u>peak demand</u> in an unmetered service area during heat*

waves. The failure of NYC's system was due to its failure to control its service area, unmetered and without any means to inhibit opening fire hydrants. During these droughts, NYC also experienced dangerously low pressure in its distribution system which severely reduced its ability to provide fire protection. Today, NYC has corrected these problems via universal metering, fire hydrant locks, and water saving plumbing codes and appurtenances. Similar water conserving methods were proposed as far back as 1919 to control NYC's water use and prevent needless storage projects, but effective universal metering was not begun until the early 1990's, about 1991-92 after a highly critical Comptrollers report was issued in 1989. For a century NYC had consistently over-estimated its average annual needs and under-estimated its peak needs because it lacked a common means of assessing its own use, metering. In 1989, a Hazen and Sawyer report, although recommending metering, still continued a tradition of over-estimating of NYC's build-out need as well as under-estimating the positive effects of metering, by about 300 mgd.

4. Related Decree Issues

4. a. NYC Self-Determination of Safe Yields: It should be noted here that the Decree never gave NYC the right to determine its own safe yield except in the context of carrying out the terms of the 1954 Decree, which pre-determined and set the Delaware reservoirs' safe yields as well as the total combined Delaware and Hudson systems' safe yield, the ERQ methodology, and the Montague flows, all in relationship to the various states of Cannonsville reservoir completion before and after it filled to over 50 BG. Anything between 50 BG and 0 would require a safe yield assessment and within this very specific Decree criteria, NYC was to determine *that* safe yield, not establish any arbitrary safe yield it wished in order to obtain Montague flow reductions. This was the logical result of competent engineers having evaluated the possibility that various stages of completion of Cannonsville relative to NYC's actual expected demand and Montague flow may require adjustment. No purveyor should arbitrarily decide what its own safe yield is, *without substantiation*, when asking to be relinquished from its release obligations. One of the River Master's Decree *duties* is to examine NYC's yields. Further, NYC's actual expected demand is clearly to be determined on a year-by-year projected need basis, *not the highest year's demand ever during a run-away demand period in a failed system.* At least, the FFMP correctly established the expected year's demand; a precedent that should be continued under any alternate plan.

4. b. Croton System Use: Between 1983 and 1992, it is reasonable to extrapolate that NYC's Croton System contribution was approximately 10 % of total use, even greater during droughts. After 1992, one can reasonably extrapolate, without significant error, from NYC's own use reports that it obtained no significant supply from the Croton System, except that obtained through the Delaware System, of which West Branch and Boyd's Corner reservoirs are a part. A brief use of the Croton System occurred during the peak demand months of 2002, but it represented less than 4 % of the total usage. The Delaware Basin reservoirs' use, alone, can then be adjusted for by what should have been drafted had NYC been subject to an appropriate ERQ to prevent over-drafting the Delaware reservoirs. On Figure 4, the heavy black line shows the resultant draft needed when offset by the unused portion of the Croton System's full safe yield of 240 mgd, again without using any of the reserve storage in that system or any part of NYC's Catskill-Delaware Systems. As can be seen, the actual need from the Delaware Basin for the last several years should have been only about 250 mgd. During the same period, the blue line shows NYC actually averaged just at or under 500 mgd. It can estimated that, during these past several years, NYC has been spilling water, unused, from the New Croton Reservoir into the Hudson River at an average rate greater than the safe yield of 240 mgd.