3. DETAILED ANALYSIS OF PLANT PERFORMANCE & STATUS OF NITROGEN CONTROL ACTIONS

This section of the document provides a detailed analysis of nitrogen removal performance and status of nitrogen control actions by plant, following an aggregate overview. All nitrogen loads presented in this section are based on total flow.

3.1. Upper East River WPCPs

The four Upper East River WPCPs (Wards Island, Hunts Point, Tallman Island, and Bowery Bay WPCPs) have undergone, or are currently undergoing, retrofits for BNR implementation.

There have been no significant changes in the influent TN loading to the Upper East River WPCPs, as shown in **Figure 5**. The centrate TN loadings did exceed the Upper Control Limits twice during Calendar Year 1997, because of uncharacteristically high centrate TN concentrations at Hunts Point WPCP; see **Figure 6**. There was no apparent cause for the increase in centrate TN loadings at Hunts Point WPCP; the increase in centrate TN loadings at Hunts Point WPCP is most likely due to the high variability associated with importing digested sludge from other plants and from the variability of the data as a result of sampling only twice per month.

The Upper East River WPCPs exceeded the maximum monthly TN discharge limit of 88,600 lbs/day fourteen times since January 1997. The Upper East River WPCPs had achieved a 12-month rolling average TN discharge of 78,170 lbs/day in August 1998 and the current 12-month rolling average TN limit for the Upper East River WPCPs is 73,900 lbs/day. The decrease in the effluent TN discharges throughout 1998 as shown in **Figure 7** and **Figure 8** were due to improvements in separate centrate treatment, Basic Step Feed BNR being implemented at Hunts Point & Bowery Bay WPCPs, and increasing the sludge age in the “A” Battery at Wards Island WPCP.

The TN discharges from the Upper East River WPCPs are expected to continue decreasing as the following nitrogen control actions remain in effect and the following proposed nitrogen control actions are implemented in the near future:

1. Wards Island WPCP has implemented Basic Step Feed BNR in the newly constructed Aerator #13 as of December 1997. The tank was chosen for Basic Step Feed BNR because it was designed with baffles and mixers along with a surface wasting system to control frothing problems. Wards Island WPCP has also increased the sludge age in Battery “A” and the data obtained from this study will help NYCDEP obtain full-scale operating data, verify or refute results projected by modeling programs, and identify process limitations at the plant. The sludge age throughout the plant has not been increased because of potential operational upsets and potential frothing problems. The sludge age throughout the plant will be increased when the froth control system is completed, provided additional plant limitations are not identified. The plant personnel has also modified Aerator #9 for separate centrate treatment without chemical addition which was implemented in October of 1996.

2. Hunts Point WPCP has implemented Basic Step Feed BNR as of January 1998 and as a result has been removing a significant amount of nitrogen from the wastewater. However, the plant had to discontinue Basic Step Feed BNR in October 1998 due to frothing problems and subsequent process upsets. The plant will reimplement Basic Step Feed BNR when process parameters are restored and the froth control system becomes operational. The plant is also treating the centrate stream separately in Aerator #5 without chemical addition.

3. Tallman Island WPCP has been operating half the plant in the Basic Step Feed BNR mode since April 1997. However, Basic Step Feed BNR had to be occasionally discontinued due to process upsets, operational limitations, and to perform studies which were mandated by the SPDES Phase 1 Pilot Work Requirements.

4. Bowery Bay WPCP has been retrofitted for Basic Step Feed BNR and implemented Basic Step Feed BNR in July 1998. The plant had to discontinue Basic Step Feed BNR due to severe frothing problems but should reimplement the process when the froth control system is operational. The plant also implemented separate centrate treatment in Aerator #8 in August of 1997 without chemical addition.

The expected nitrogen discharges from the Upper East River WPCPs, after implementation of all nitrogen control actions, based on the BioWin model were presented in **Table 1**. According to the model TN projections, the Upper East River WPCPs will meet the current SPDES permit nitrogen discharge limits, when the proposed nitrogen control actions are implemented at these plants. All TN projections are calculated based on total flow.

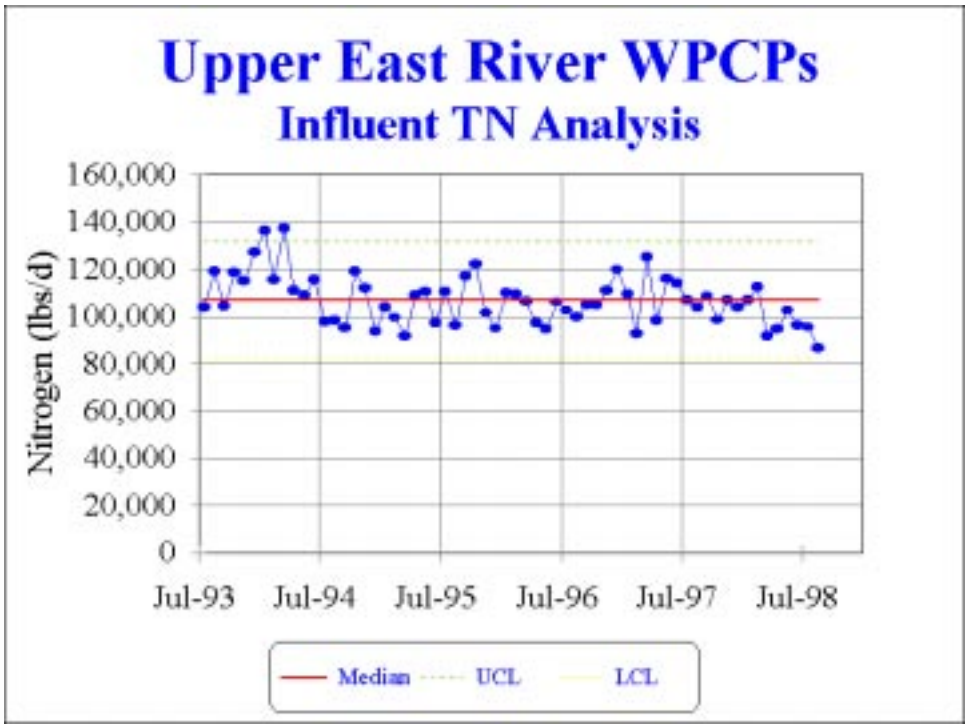

Figure 5

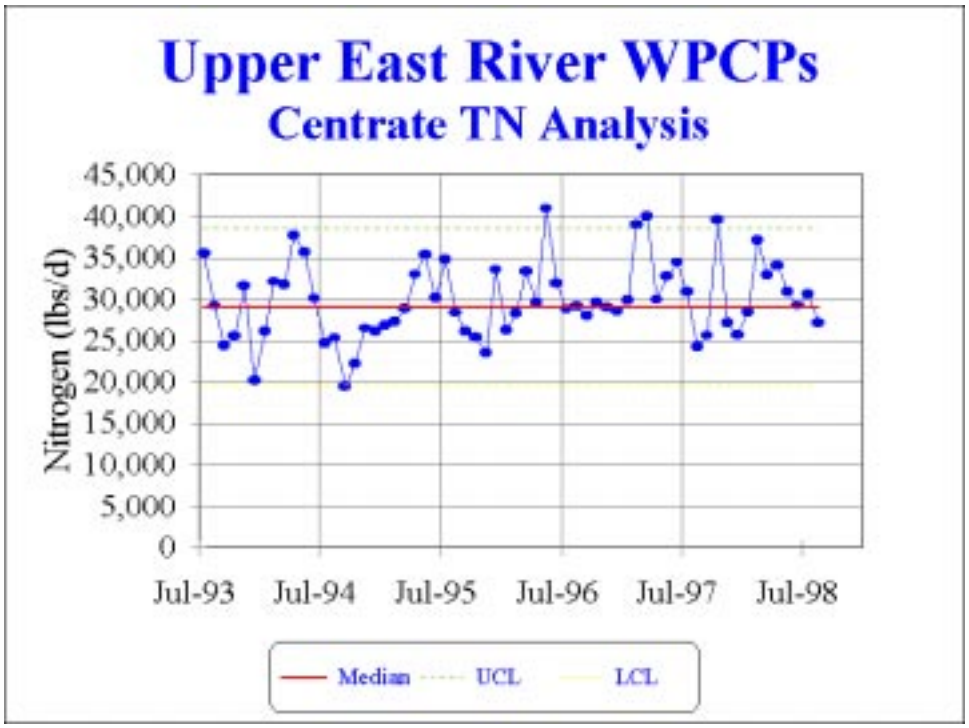

Figure 6

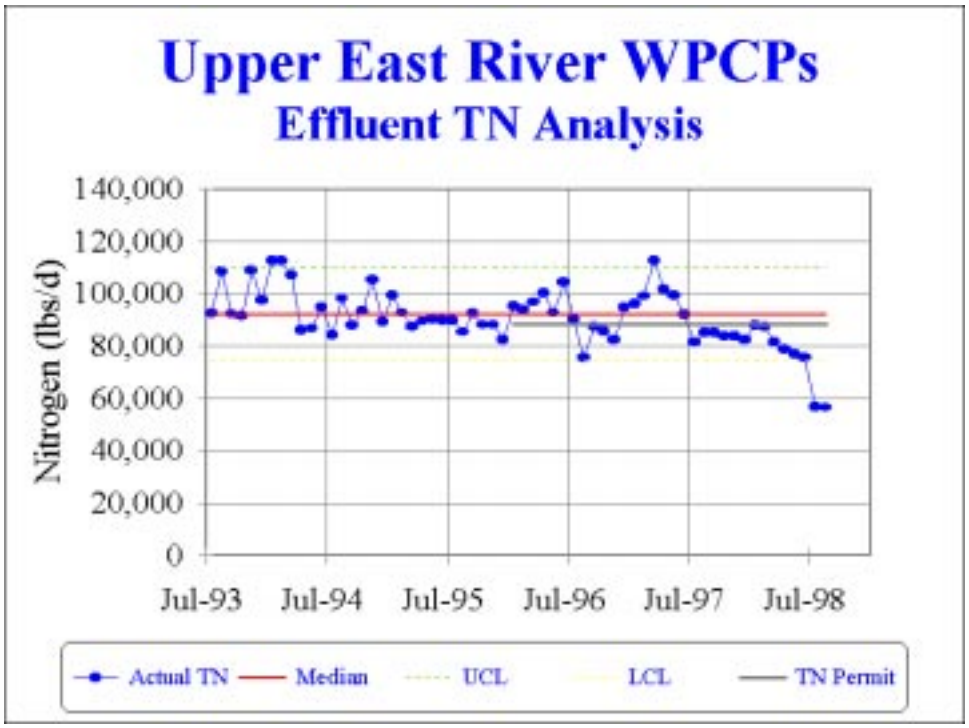

Figure 7

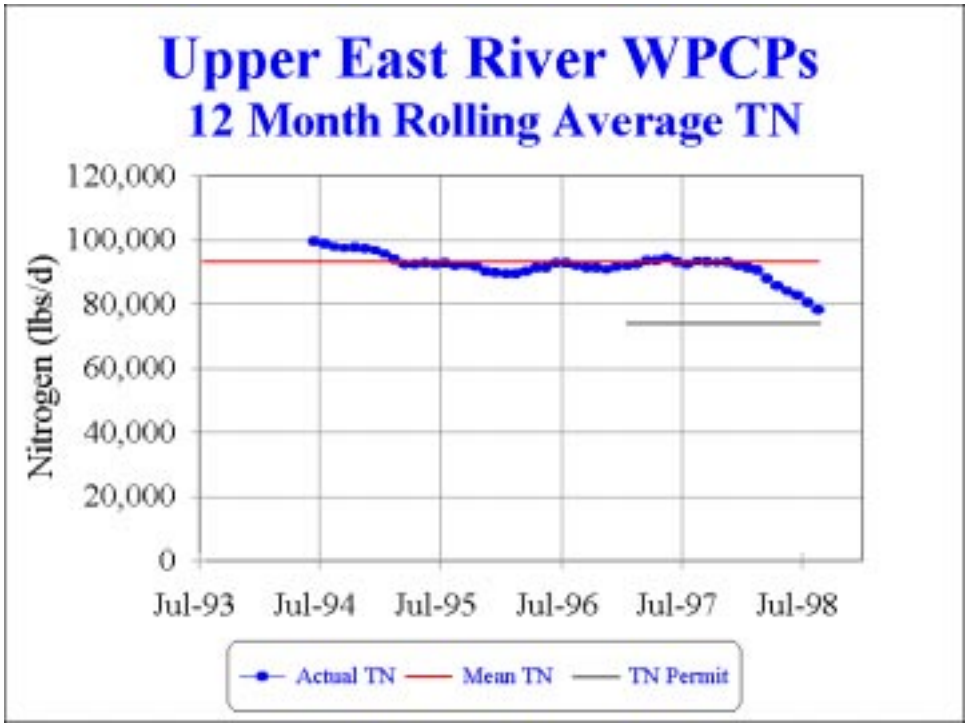

Figure 8

3.1.1. Wards Island WPCP

Nitrogen Control Actions and Status

Basic Step Feed BNR has been implemented at Wards Island in the newly constructed Battery E (Aerator #13) as of January 1998. The data obtained from this study will help NYCDEP obtain full-scale operating data, verify or refute results from modeling programs, and identify process limitations at the plant. Aerator No. 13 was chosen because it was designed with baffles and mixers along with a surface wasting system to eliminate frothing problems. However, the surface wasting system is not successfully suppressing the froth, and as a result a chlorine spray hood will also be installed in Aerator No. 13. The chlorine spray hoods are currently being installed throughout Wards Island WPCPs, and will enable the plant to increase its sludge age upon completion. As mentioned in previous reports, the installation of the froth control system was delayed due to conflicts with an existing contract and as a result the contractor submitted a change order proposal to the NYCDEP. The change order addressed all necessary piping modifications and the froth control system is expected to be operational by March 1999.

The sludge age was increased in Battery "A" at Wards Island in January 1998 without a froth control system being installed. The plant has had some froth but was able to maintain the high sludge age up until the present time. The operating data from these aeration tanks will be used to determine the nitrogen removal capabilities of the existing plant and identify operational limitations that may be encountered. The sludge age throughout the plant will be increased when the froth control system is completed, provided additional plant limitations are not identified. The froth control system was bid out at $561,780 and there is currently a $12,974 change order pending.

The plant has also been treating the centrate stream separately in Aeration Tank #9 since October 1996. The nitrified centrate was previously discharged directly to the final tanks but submersible pumps have recently been installed and the plant now returns the nitrified centrate stream to the aeration tanks for further treatment.

Performance

There have been no significant changes in either the influent TN loadings or the centrate TN loading as shown in **Figure 9** and **Figure 10**. The effluent TN discharges have steadily decreased throughout 1998 as shown on **Figure 11**. The decrease in effluent TN values can be attributed to Basic Step Feed BNR being implemented in the new Battery "E" and the increased sludge age in Battery "A", both of which enabled some degree of biological nitrification and denitrification. Improvements to the separate centrate treatment also resulted in additional nitrogen removals. The nitrified centrate stream was previously discharged from Aeration Tank #9 to the final tanks and as a result the nitrified centrate stream had no chance to denitrify. The nitrified centrate stream is now being sent to the aeration tanks where the nitrates can be denitrified in biological zones where the dissolved oxygen levels are low enough. The plant was unable to increase the sludge age in July 1993 **(Figure 12)** because inoperative bell weirs prevented the plant from increasing its return sludge flow. The bell weirs were repaired

in-house and the plant can now increase its sludge age provided frothing problems don't arise.

According to the BioWin TN projections, Wards Island WPCP is expected to achieve an average TN discharge of approximately 29,260 lbs/day when all the recommended nitrogen control actions have been implemented. The Wards Island WPCP has been achieving an average TN discharge of 28,800 lbs/d since implementing all the above nitrogen control actions and these removals will improve when Wards Island WPCP increases the sludge age throughout the plant. **Table 9** provides the wastewater characteristics and operating assumptions for which the above nitrogen model projections are based, along with the data used in the Original Nitrogen Control Action Plan. These TN projections may differ from the actual TN discharges if for any reason the assumptions used in the model vary from the actual field conditions.

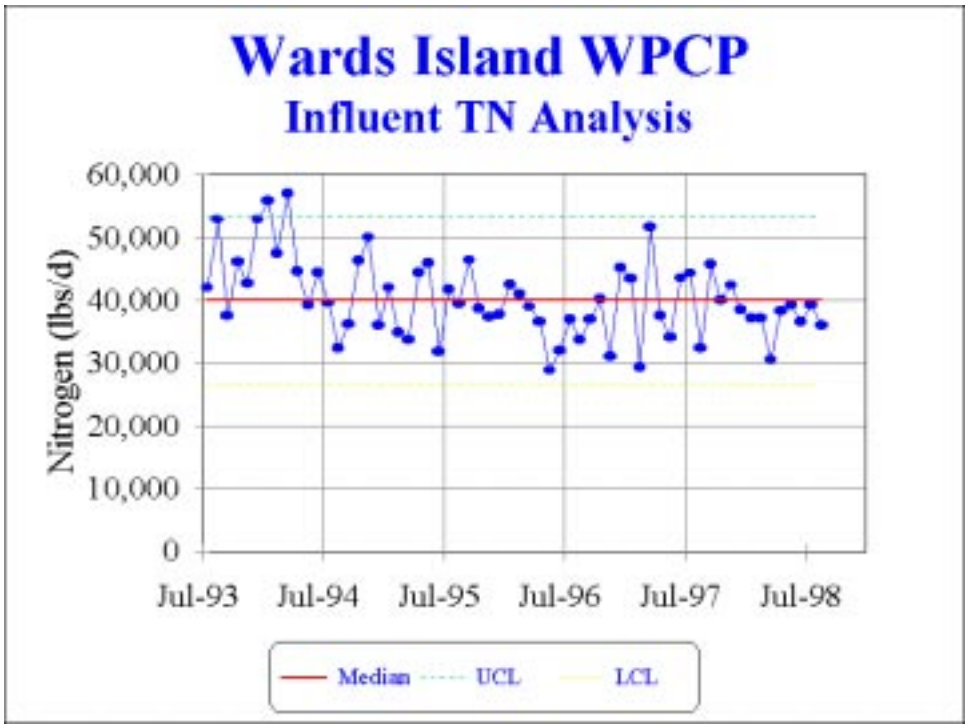

Figure 9

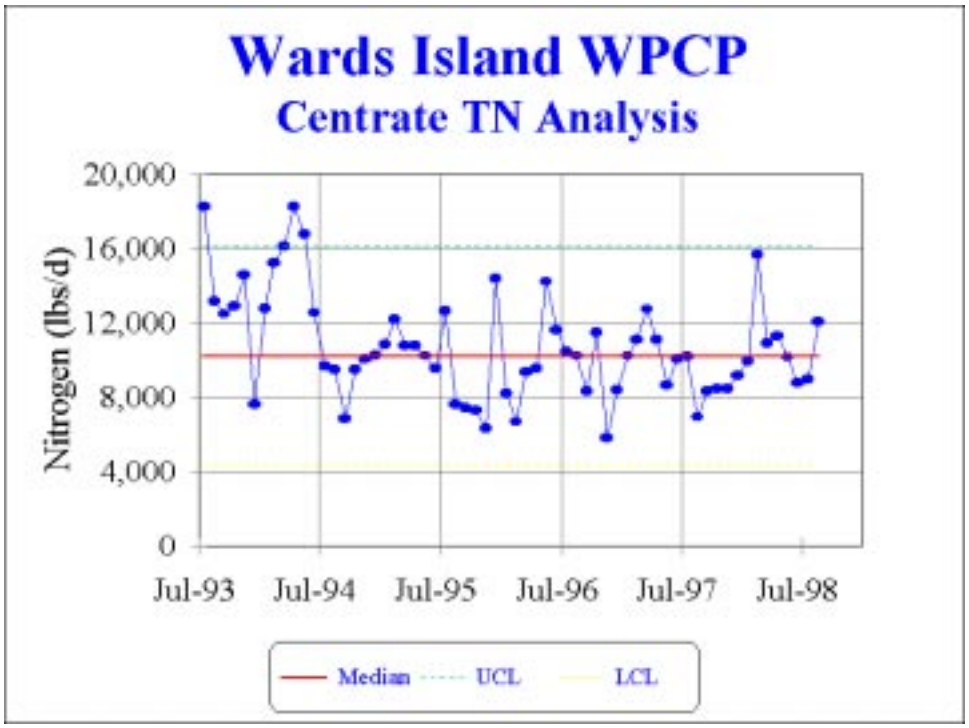

Figure 10

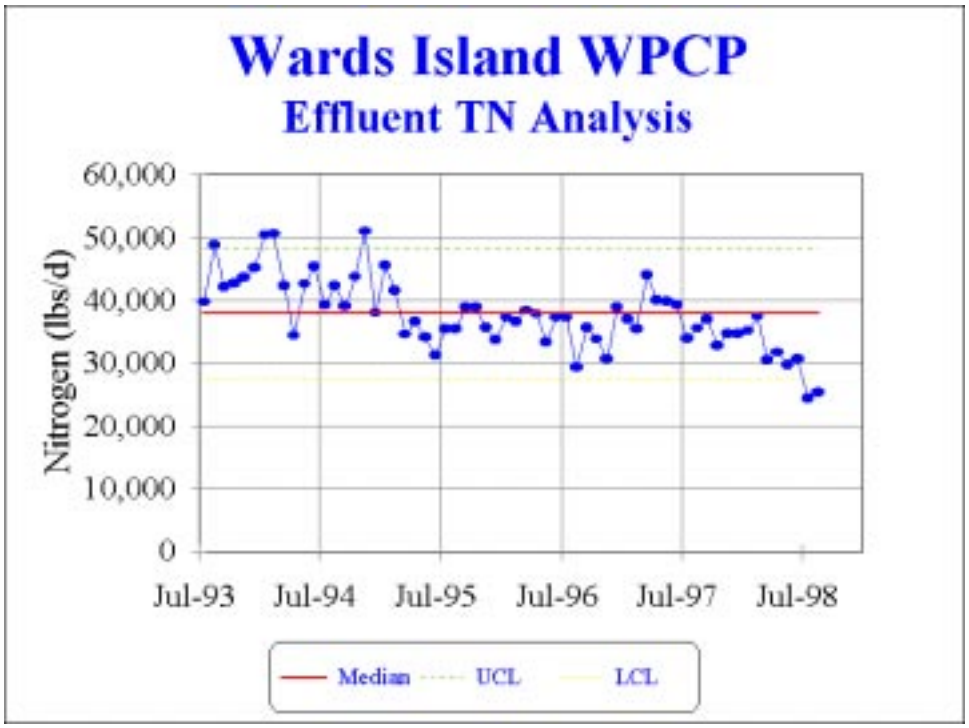

Figure 11

Figure 12

Wards Island WPCP (Table 9)

Original Nitrogen Control Action Plan (FY94):
- Increased Sludge Age (A-E Batteries)
- Separate Centrate Treatment in Aeration Tank #9

Revised Nitrogen Control Action (CY 97):
- Step BNR (E Battery)
- Increased Sludge Age (A-D Batteries)
- Separate Centrate Treatment in Aeration Tank #9

Operating Conditions

Item	Equipment Summary	Original NCAP (FY94)	Revised NCAP#6 (CY97)	Comments
Process Air	4-42,500 cfm 2-28,500 cfm	180,000 cfm	102,000 cfm	Original NCAP air flow was based on maintaining a DO of 2 mg/L.
% Return Flow	8-17.3 MGD 4-8.0 MGD	50%	30% A-D Batteries 70% E Battery	A-D Batteries treat 91% of the Total Flow and the new E battery treats 9% of the Total Flow
Aerator Eff Conc.	NA	2,000 mg/L	1,600 mg/L in A-D 2,000 mg/L in E	Plant should determine the maximum aerator effluent concentration achievable.
RAS Conc.	NA	6,000 mg/L	6,900 mg/L in A-D 4,800 mg/L in E	RAS concentrations were calculated using the following formula: %R = AE / (RAS-AE)
Flow Distribution	NA	33% to B, C, & D passes		Plant must make an attempt to distribute flow evenly to B, C, & D passes

Wastewater Characteristics

Parameter	Original NCAP (FY94)	Revised NCAP #6 (CY97)	Comments
Average Flow	274 MGD	224 MGD	Average flow was used for TN projections in both the original NCAP and the revised NCAP #6.
Dry Flow	------	213 MGD	
Raw TKN	19.8 mg/L	21.4 mg/L	Original NCAP used raw influent loadings for TN projections
Raw BOD	81 mg/L	104 mg/L	Original NCAP used raw influent loadings for TN projections
PE TKN	22.3 mg/L	22.9 mg/L	Revised NCAP #6 used primary effluent loadings for TN projections
PE BOD	59 mg/L	45 mg/L	Revised NCAP #6 used primary effluent loadings for TN projections
Centrate TN	15,400 lbs/d	9,640 lbs/d	
Eff TKN	9.9 mg/L	9.37 mg/L	
Eff NOx	4.0 mg/L	6.29 mg/L	
Eff TN Discharges	31,760 lbs/d	29,260 lbs/d	Effluent TN discharge were calculated using the total flow.

3.1.2. Hunts Point WPCP

Nitrogen Control Actions and Status

Baffles and mixers were installed in the aeration tanks at Hunts Point in July 1996 at a cost of $1,300,000. The plant has attempted to implement Basic Step Feed BNR without a froth control system as of December 1997, in order to comply with TN permit limits in an expedient manner. However, the plant had to discontinue Basic Step Feed BNR as of October 1998 because of frothing problems in both the aeration tanks and the anaerobic digesters. The plant will not be able to operate in the Basic Step Feed BNR mode until the froth control system is operational.

The froth control system was expected to be completed by November 1997 at a cost of $482,000, but the contractor has been deemed in default. The remaining work will be completed through the Bonding Company and is expected to be completed prior to December 1999. The centrate stream is still being sent to Aeration Tank #5 for separate centrate treatment and the nitrified centrate stream is then sent to the head of the plant.

Performance

There have been no significant changes in the influent TN loading in Calendar Year 1997, as compared to recent previous years, as shown in **Figure 13**. However, the centrate stream had exceeded the Upper Control Limit several times since January 1997, as shown in **Figure 14**. A portion of this increase in the centrate nitrogen loading can be attributed to poor solids capture in the dewatering facility during the first half of Calendar Year 1997, when Hunts Point was using a new polymer for sludge dewatering. The variability in the centrate loading can also be attributed to Hunts Point WPCP's random importing of sludge from different WPCPs and sampling the centrate stream only twice per month. There has been a significant decrease in the effluent TN discharges since December 1997 when Basic Step Feed BNR was implemented as shown on **Figure 15.** The plant had to discontinue Basic Step Feed BNR in October 1998 due to frothing problems and will not reimplement Basic Step Feed BNR until the froth control system is operational. The plant initially attempted to increase its sludge age in July 1993 but was unable to build up the biomass. The plant later discovered that the aeration tank dump valves weren't operating properly. The dump valves were fixed in-house and the plant was able to implement Basic Step Feed BNR as mentioned above.

According to the BioWin TN projections, Hunts Point WPCP is expected to achieve an average TN discharge of approximately 17,270 lbs/day with Basic Step Feed BNR and separate centrate treatment. The actual effluent TN discharge has been averaging about 18,500 lbs/d since Basic Step Feed BNR was implemented in December 1997. The slight discrepancies between the actual and projected TN values could be due to the variability in sludge ages as shown on **Figure 16**. These TN projections are based on wastewater characteristics and operating assumptions presented in **Table 10**, which also presents the wastewater characteristics and operating assumptions used in the original Nitrogen Control Action Plan. These TN projections may differ from the actual TN discharges if for any reason the assumptions used in the model vary from the actual field conditions.

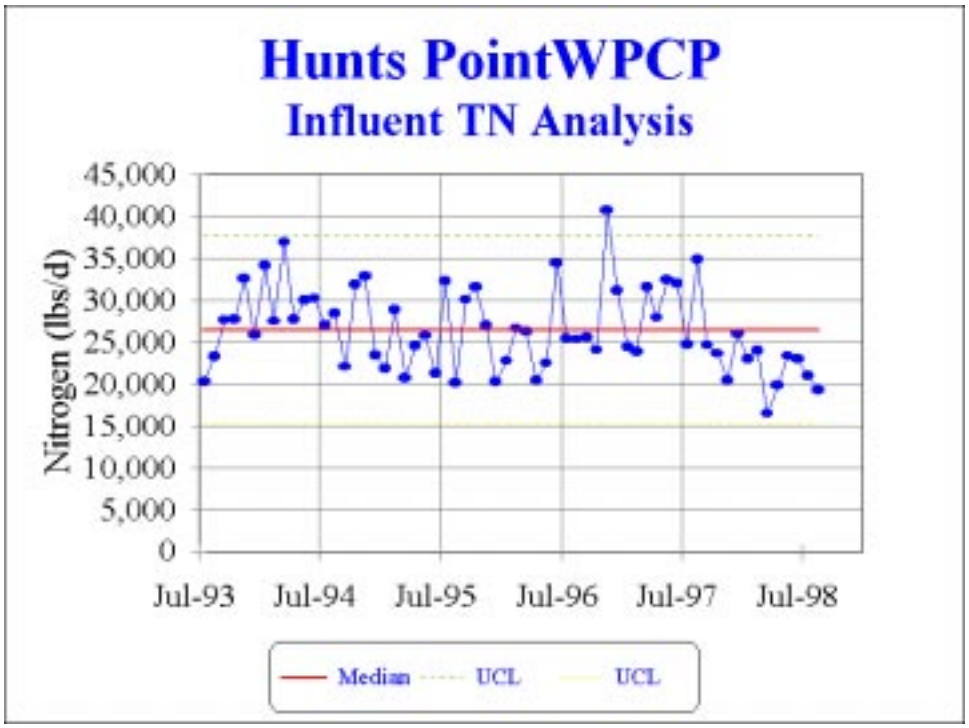

Figure 13

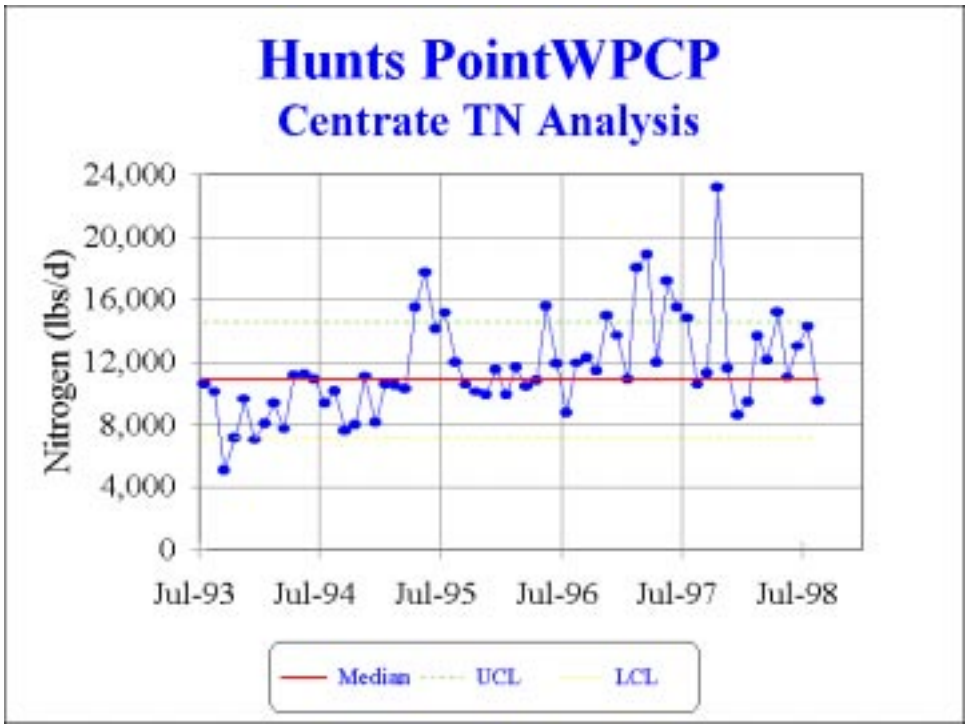

Figure 14

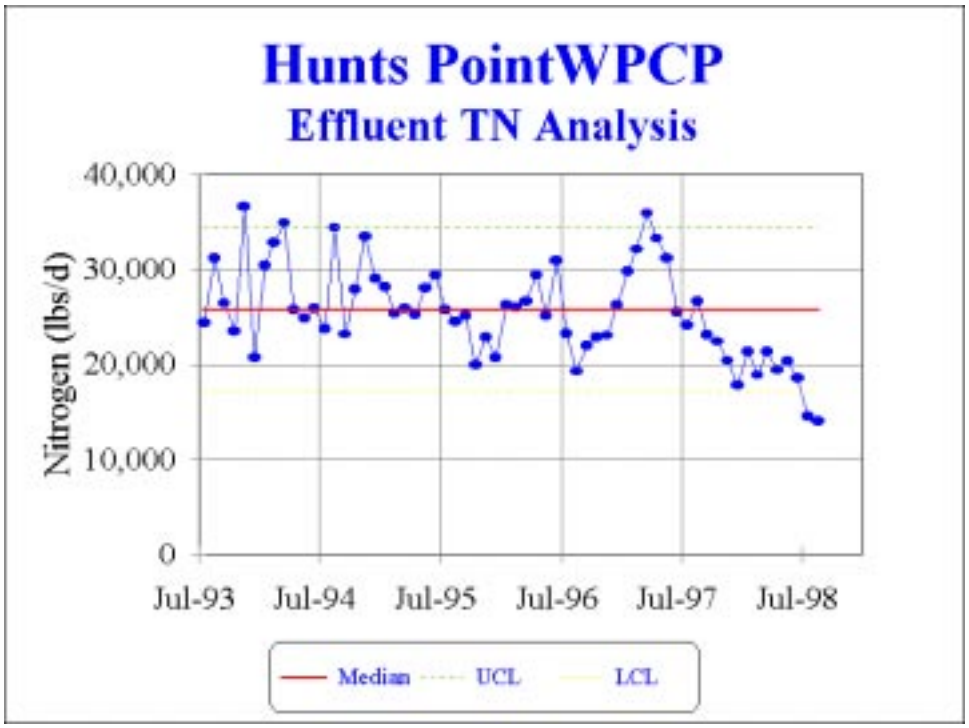

Figure 15

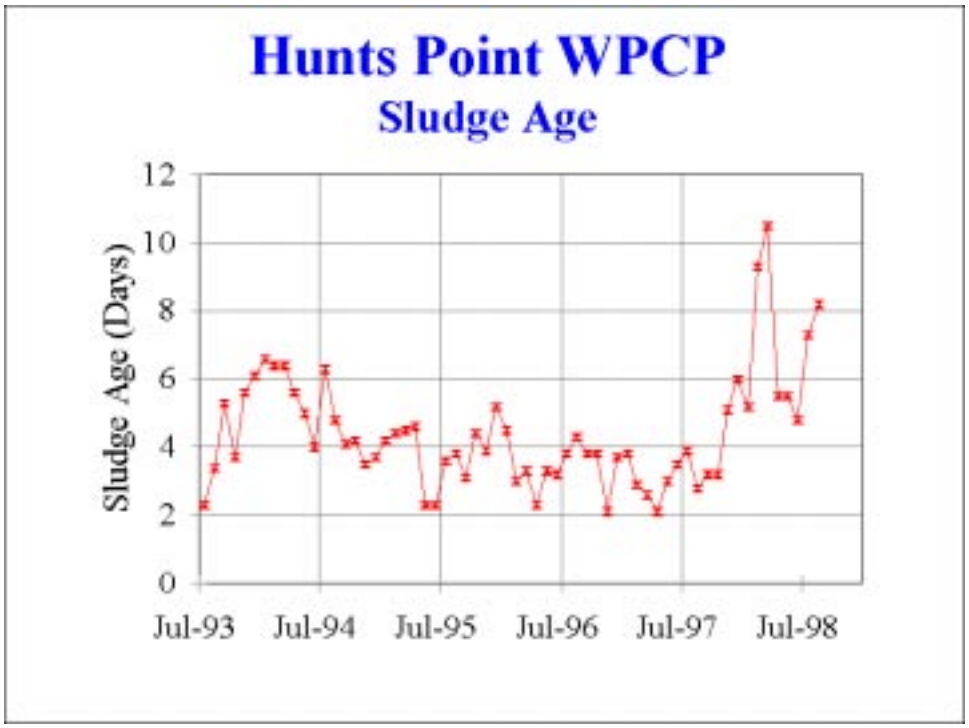

Figure 16

Hunts Point WPCP (Table 10)

Original Nitrogen Control Action Plan (FY94):
- Step BNR
- Separate Centrate Treatment in Aeration Tank #5

Revised Nitrogen Control Action (CY 97):
- Step BNR
- Separate Centrate Treatment in Aeration Tank #5

Operating Conditions

Item	Equipment Summary	Original NCAP (FY94)	Revised NCAP#6 (CY97)	Comments
Process Air	5-42,000 cfm	117,000 cfm	100,800 cfm	Original NCAP air flow was based on maintaining a DO of 2 mg/L.
% Return Flow	3/6/6 15/18/12 MGD	50%	34%	
Aerator Eff Conc.	NA	2,000 mg/L	2,000 mg/L	Plant should determine the maximum aerator effluent concentration achievable.
RAS Conc.	NA	6,000 mg/L	7,800 mg/L	RAS concentrations were calculated using the following formula: %R = AE / (RAS-AE)
Flow Distribution	NA	33% to B, C, & D passes		Plant must make an attempt to distribute flow evenly to B, C, & D passes

Wastewater Characteristics

Parameter	Original NCAP (FY94)	Revised NCAP #6 (CY97)	Comments
Average Flow	133 MGD	128 MGD	Average flow was used for TN projections in both the original NCAP and the revised NCAP #6.
Dry Flow	-----	120 MGD	
Raw TKN	25.7 mg/L	22.8 mg/L	Original NCAP used raw influent loadings for TN projections
Raw BOD	100 mg/L	86 mg/L	Original NCAP used raw influent loadings for TN projections
PE TKN	29.5 mg/L	31.3 mg/L	Revised NCAP #6 used primary effluent loadings for TN projections
PE BOD	76 mg/L	71 mg/L	Revised NCAP #6 used primary effluent loadings for TN projections
Centrate TN	11,180 lbs/d	13,010 lbs/d	
Eff TKN	12.8 mg/L	11.49 mg/L	
Eff NOx	2.7 mg/L	4.69 mg/L	
Eff TN Discharges	17,192 lbs/d	17,270 lbs/d	Effluent TN discharge were calculated using the total flow.

3.1.3. Tallman Island WPCP

Nitrogen Control Actions and Status

Tallman Island was retrofitted for Basic Step Feed BNR in August 1996, which included the installation of baffles, mixers, three different types of fixed media, and internal recycle pumps in Aeration Tank #3. The Basic Step Feed BNR implementation was intended for November 1996, when a froth control system was installed. However, the froth control system was inoperable due to problems with pumps. The problems were corrected and the froth control system was operable by April 1997, at which time Basic Step Feed BNR was implemented at the plant. The total cost for the Basic Step Feed BNR retrofit including the froth control system was $4,700,000. The fixed media and internal recycle were installed as part of a SPDES permit required study to evaluate the effects of fixed media and internal recycle on the BNR process. The City College of New York (CCNY) has been evaluating the effects of both fixed media and internal recycle on Basic Step Feed BNR, and have encountered several operational problems and limitations such as:

1. Aeration Tank No. 4 had to be taken out of service occasionally due to severe air leaks in the diffuser manifolds, resulting in a loss of the autotrophs needed for nitrification which would require one to three months to repopulate the biomass with these autotrophs due to their low growth rate.

2. The benefits of using attached/suspended growth, as compared with purely suspended growth, in the BNR system was not apparent by CCNY in the early part of the study. CCNY theorized based on literature searches and findings at the Tallman Island WPCP that higher dissolved oxygen levels were necessary to diffuse into the larger biological floc which were attached to the fixed media. However, there was not sufficient process air at Tallman Island to increase the dissolved oxygen levels in all aeration tanks. Therefore, CCNY discontinued Basic Step Feed BNR in the West Side of the plant and sent the additional process air to the East Side of the plant.

3. NYCDEP has also been experiencing difficulties with the internal recycle pumps at Tallman Island WPCP because the internal recycle pumps didn't have sufficient lift to start-up the recycle. NYCDEP then tried using separate pumps to overcome the initial lift and then let the existing pumps continue with the recycle. However, additional problems with balancing and measuring the flow to Aerator #3 were encountered when the internal recycle pumps were started due to the increased hydraulic profile in the aeration tank. Preliminary findings show no benefit of recycling flow from the "D" pass to the "A" pass.

Performance

There had been no significant changes in the influent TN loadings to Tallman Island WPCP as shown in **Figure 17.** The centrate TN loading slightly exceeded the Upper Control Limit twice since January 1997 as shown on **Figure 18**. The reason for the slightly higher centrate loading has not been identified and based on recent plant performance will not be an issue in meeting TN permit limits in the Upper East River. The plant has been removing nitrogen over the last twelve

months as shown on **Figure 19** and TN removals should increase when Basic Step Feed BNR is implemented throughout the plant. The plant was achieving excellent TN removals in the summers of 1993 and 1994 with only one out of four tanks retrofitted for Basic Step Feed BNR, when the sludge age was higher as shown on **Figure 20.** As a result, the NYCDEP expects significantly higher TN removals when the sludge age is increased throughout the plant with the Basic Step Feed BNR retrofit completed in all four aeration tanks.

According to the BioWin TN projections, Tallman Island is expected to achieve a TN discharge of approximately 8,580 lbs/day when Basic Step Feed BNR is implemented throughout the plant. The plant has been achieving a TN discharge of about 7,800 lbs/d over the last 12 months with only half of the plant operating in the Basic Step Feed BNR mode and these TN removals will improve when Basic Step Feed BNR is implemented throughout the plant. The above BioWin TN projections are based on wastewater characteristics and operating assumptions provided in **Table 11**. These TN projections may differ from the actual TN discharges if for any reason the assumptions used in the model vary from the actual field conditions.

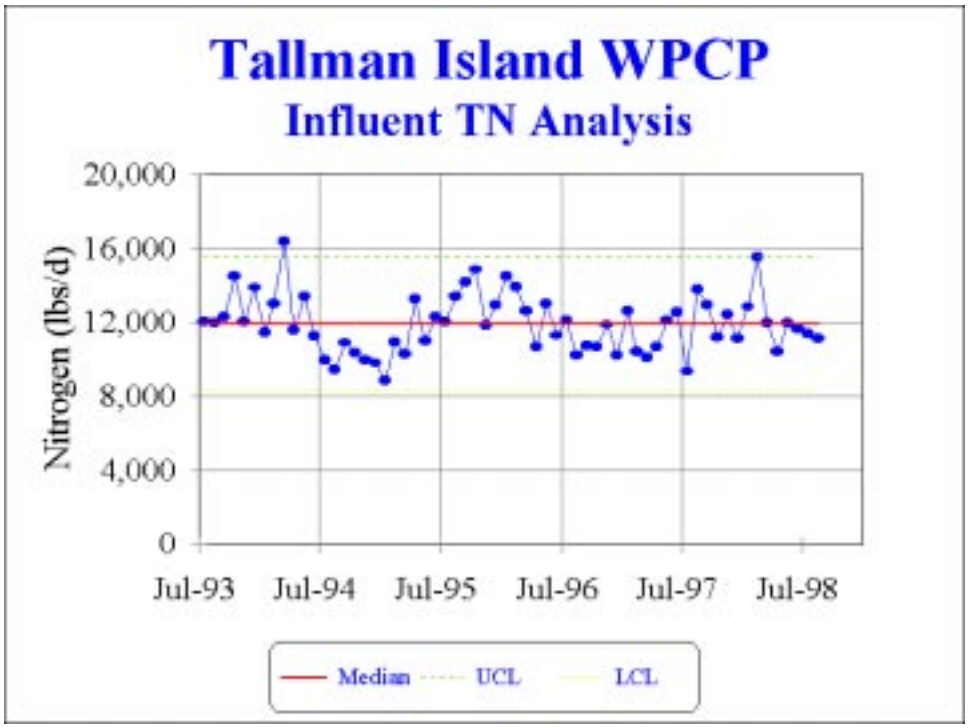

Figure 17

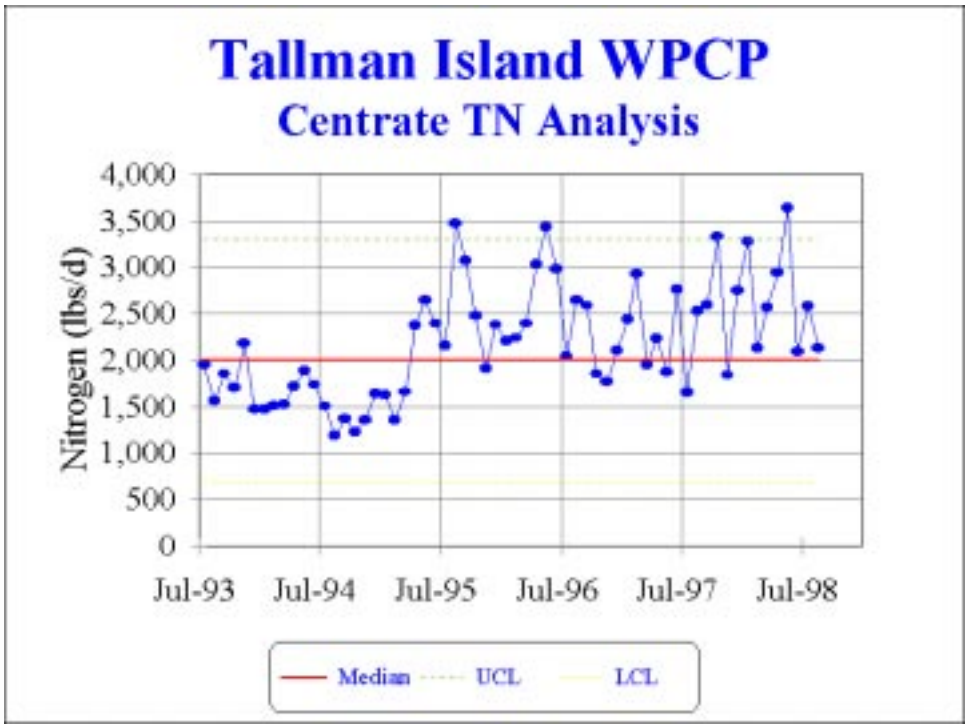

Figure 18

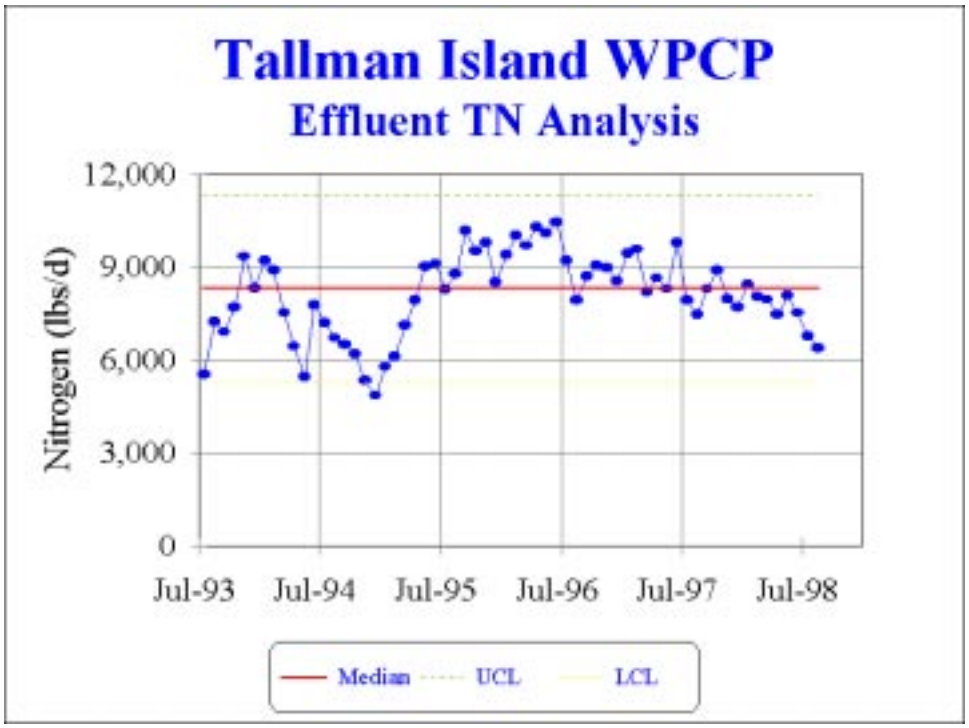

Figure 19

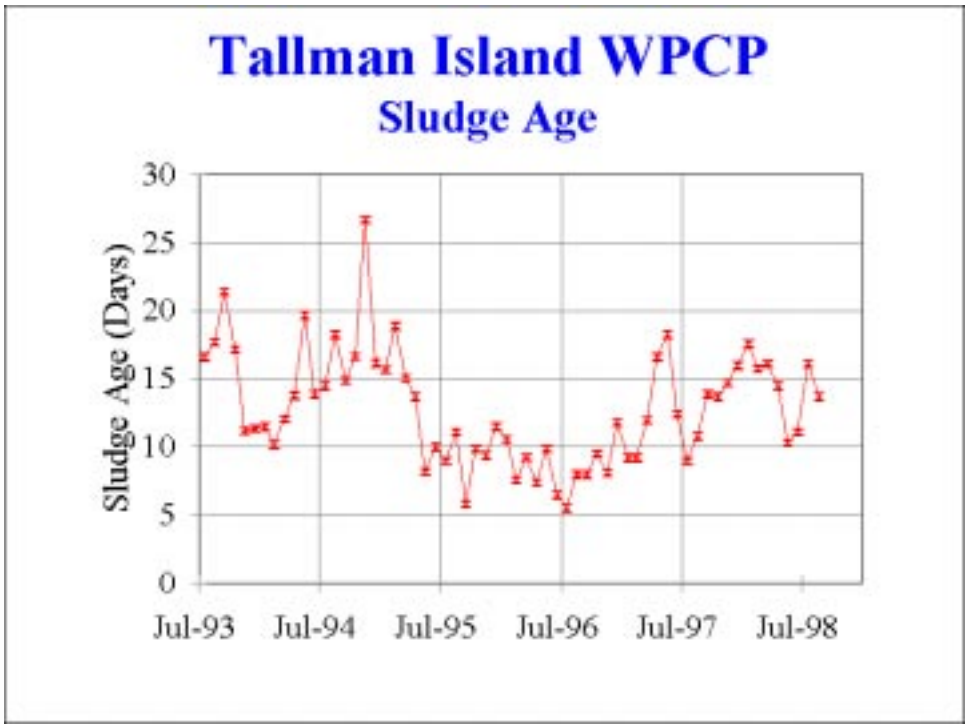

Figure 20

Tallman Island WPCP (Table 11)

Original Nitrogen Control Action Plan (FY94):
- Step BNR with Fixed Media

Revised Nitrogen Control Action (CY 97):
- Step BNR

Operating Conditions

Item	Equipment Summary	Original NCAP (FY94)	Revised NCAP#6 (CY97)	Comments
Process Air	5-20,100 cfm	39,000 cfm	47,200 cfm	Original NCAP air flow was based on maintaining a DO of 2 mg/L.
% Return Flow	4-4 MGD 4-1.5 MGD	50%	55% West Side 21% East Side	
Aerator Eff Conc.	NA	2,000 mg/L 800 mg/L FM	1,600 mg/L West Side 2,500 mg/L in E	Plant should determine the maximum aerator effluent concentration achievable.
RAS Conc.	NA	6,000 mg/L	6,500 mg/L 9,100 mg/L	RAS concentrations were calculated using the following formula: %R = AE / (RAS-AE)
Flow Distribution	NA	33% to B, C, & D passes		Plant must make an attempt to distribute flow evenly to B, C, & D passes

Wastewater Characteristics

Parameter	Original NCAP (FY94)	Revised NCAP #6 (CY97)	Comments
Average Flow	59 MGD	59 MGD	Average flow was used for TN projections in both the original NCAP and the revised NCAP #6.
Dry Flow	-----	56 MGD	
Raw TKN	25.8 mg/L	23.3 mg/L	Original NCAP used raw influent loadings for TN projections
Raw BOD	113 mg/L	115 mg/L	Original NCAP used raw influent loadings for TN projections
PE TKN	27.3 mg/L	30.1 mg/L	Revised NCAP #6 used primary effluent loadings for TN projections
PE BOD	88 mg/L	63 mg/L	Revised NCAP #6 used primary effluent loadings for TN projections
Centrate TN	2,000 lbs/d	1,600 lbs/d	
Eff TKN	2.7 mg/L	13.61 mg/L	
Eff NOx	8.5 mg/L	3.82 mg/l	
Eff TN Discharges	5,510 lbs/d	8,580 lbs/d	Effluent TN discharge were calculated using the total flow.

3.1.4. Bowery Bay WPCP

Nitrogen Control Actions and Status

The installation of mixers, baffles, and a new fine bubble membrane diffuser system was completed in October 1996 at a cost of $4,360,000. There were problems encountered balancing air through the new diffusers, but these problems were alleviated by installing pressure gages in the pipe gallery and throttling the air to the main headers to equalize the pressure losses throughout the system. The plant attempted to implement Basic Step Feed BNR in July 1998 without a froth control system and had to discontinue the Basic Step Feed BNR process in September 1998 due to severe frothing problems. The froth control system has been installed but is not yet operational because of some leaks. The froth control system is expected to be operational in 1999, at which time Basic Step Feed BNR will be reimplemented. The froth control system was bid out at a cost of $482,000.

Bowery Bay WPCP initiated separate centrate treatment in August 1997, in which the centrate stream was sent to Aerator #8 and then discharged to the final tanks. The plant modified its separate centrate treatment process during the summer of 1998 and now returns the nitrified centrate stream to the head of the plant.

Performance

The influent total nitrogen loading exceeded the Upper Control Limit twice since January 1997 as shown in **Figure 21.** The slightly higher than expected influent TN loading was probably due to a non-representative influent TN sample which is taken only twice per month and shouldn't affect the TN projections. There were no significant changes in the centrate TN loading throughout Calendar Year 1997 as shown in **Figure 22**. The effluent TN discharges were significantly lower than the Lower Control Limit during the summer of 1998 as shown on **Figure 23**. These TN reductions were due mainly to the plant implementing Basic Step Feed BNR along with improvements made to the separate centrate treatment. The centrate stream was initially being sent to Aerator #8 then to the final tank which didn't give the nitrified centrate stream an opportunity to denitrify. However, the plant has recently begun returning the nitrified centrate stream to the head of the plant which gave the nitrified centrate stream an opportunity to be denitrified. The plant also attempted to increase its sludge age in the beginning of 1994 as shown on **Figure 24**, but had to lower the sludge age due to froth problems.

According to the model projection, Bowery Bay is expected to achieve an average TN discharge of approximately 12,490 lbs/day with Basic Step Feed BNR. The plant has averaged an effluent TN discharge of 11,000 lbs/d during the summer of 1998. However, the BNR process is highly sensitive to temperature and better TN removals are expected in the summer time due to increased kinetic rates. The NYCDEP needs to verify that Bowery Bay can meet the projected TN values in the winter months to ensure that the Upper East River WPCPs can comply with the SPDES TN limits. The above TN projections are based on wastewater characteristics and operating conditions presented in **Table 12**. These TN projections may differ from the actual TN discharges if for any reason the assumptions used in the model vary from actual field conditions.

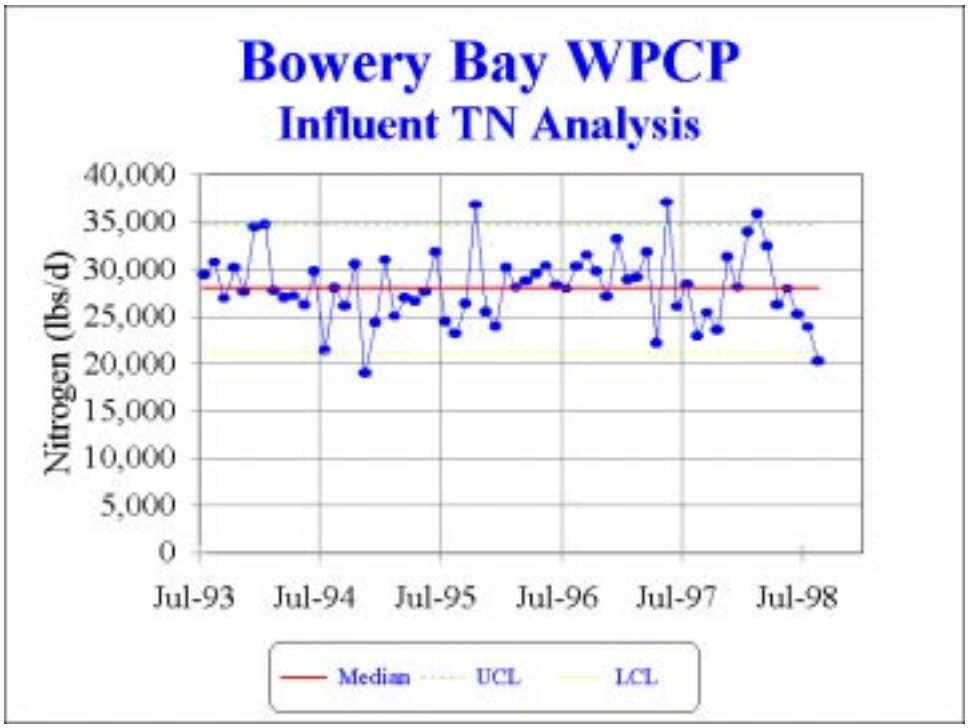

Figure 21

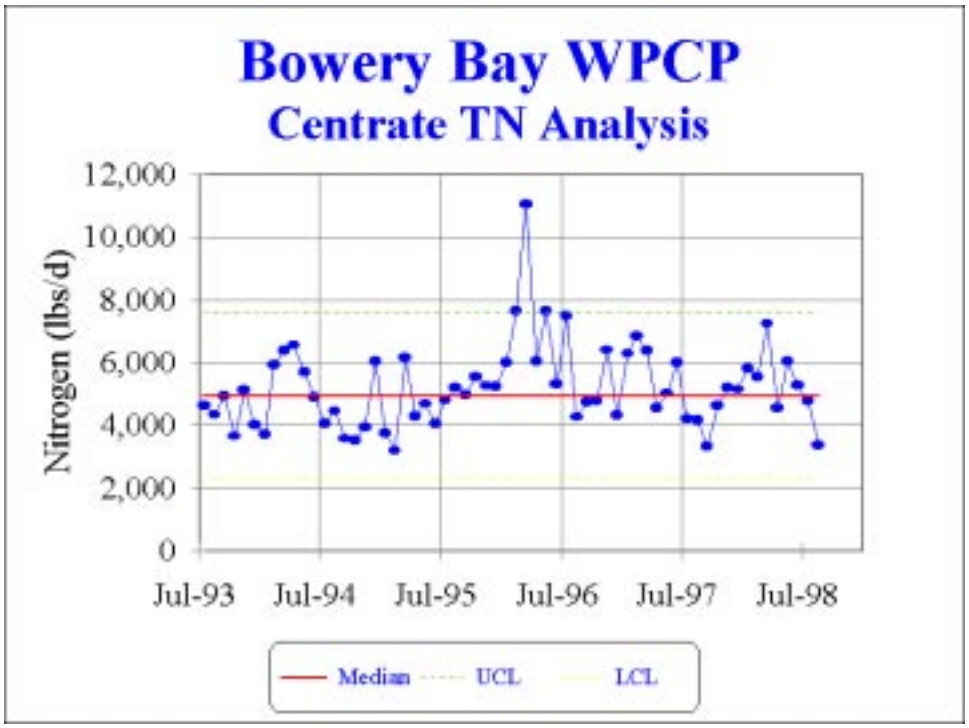

Figure 22

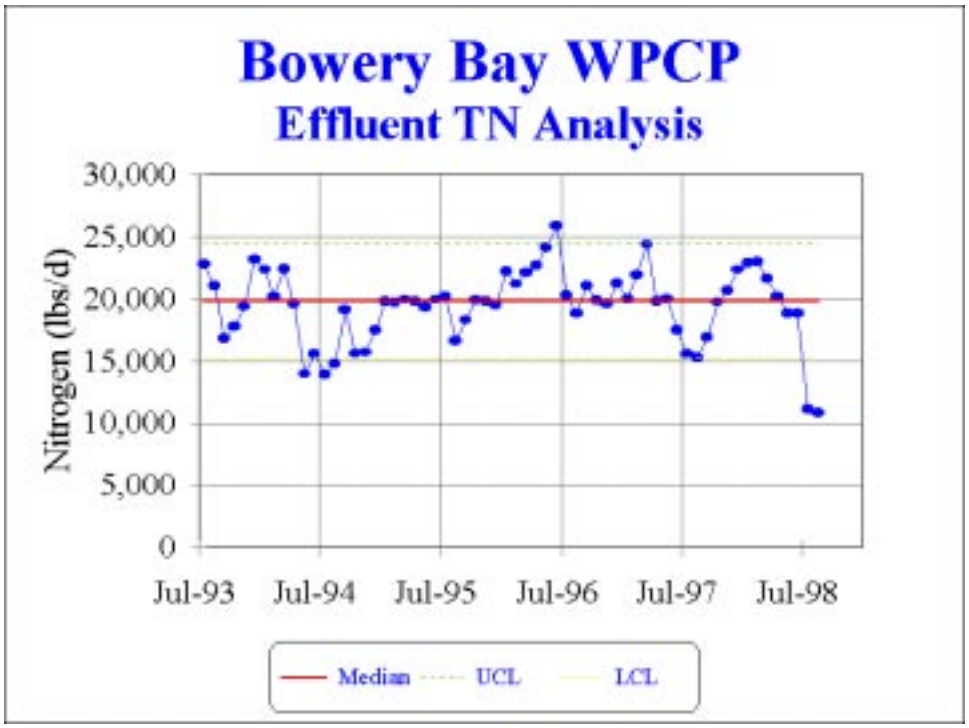

Figure 23

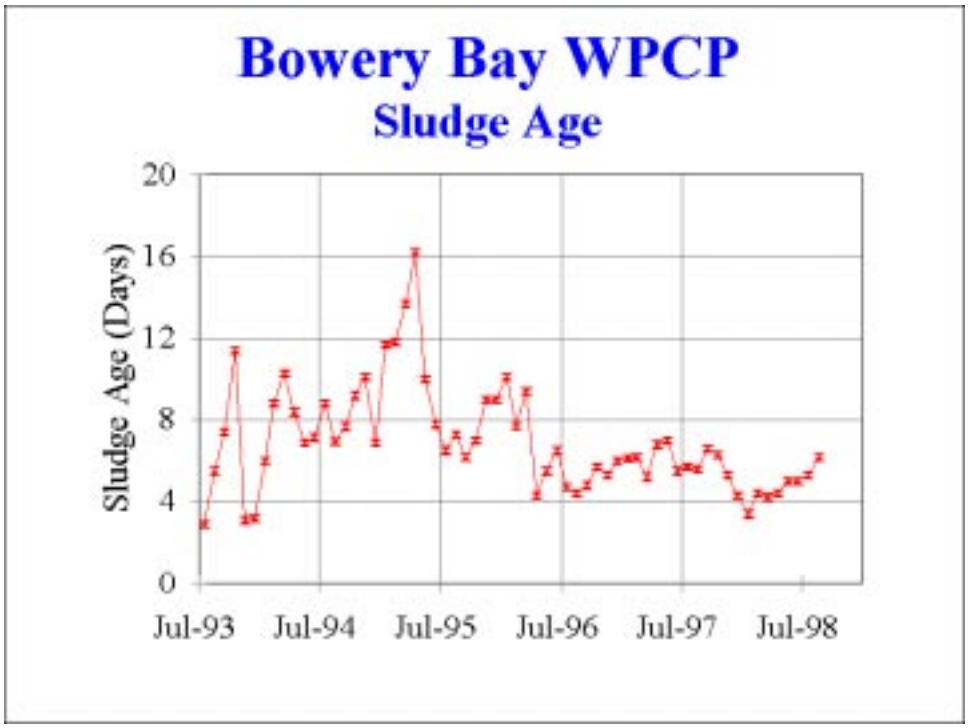

Figure 24

Bowery Bay WPCP (Table 12)

Original Nitrogen Control Action Plan (FY94):
- Step BNR

Revised Nitrogen Control Action (CY 97):
- Step BNR
- Separate Centrate Treatment in Aeration Tank #8

Operating Conditions

Item	Equipment Summary	Original NCAP (FY94)	Revised NCAP#6 (CY97)	Comments
Process Air	8-25,000 cfm	59,000 cfm	60,000 cfm	Original NCAP air flow was based on maintaining a DO of 2 mg/L.
% Return Flow	8-17.3 MGD 4-8.0 MGD	50%	60%	
Aerator Eff Conc.	NA	2,000 mg/L	1,600 mg/L	Plant should determine the maximum aerator effluent concentration achievable.
RAS Conc.	NA	6,000 mg/L	4,200 mg/L	RAS concentrations were calculated using the following formula: %R = AE / (RAS-AE)
Flow Distribution	NA	33% to B, C, & D passes		Plant must make an attempt to distribute flow evenly to B, C, & D passes

Wastewater Characteristics

Parameter	Original NCAP (FY94)	Revised NCAP #6 (CY97)	Comments
Average Flow	125 MGD	124 MGD	Average flow was used for TN projections in both the original NCAP and the revised NCAP #6.
Dry Flow	------	113 MGD	
Raw TKN	28.2 mg/L	26.5 mg/L	Original NCAP used raw influent loadings for TN projections
Raw BOD	100 mg/L	114 mg/L	Original NCAP used raw influent loadings for TN projections
PE TKN	28.5 mg/L	24.9 mg/L	Revised NCAP #6 used primary effluent loadings for TN projections
PE BOD	75 mg/L	57 mg/L	Revised NCAP #6 used primary effluent loadings for TN projections
Centrate TN	3,230 lbs/d	5,210 lbs/d	
Eff TKN	12.9 mg/L	11.45 mg/L	
Eff NOx	2.4 mg/L	1.80 mg/L	
Eff TN Discharges	15,950 lbs/d	13,700 lbs/d	Effluent TN discharge were calculated using the total flow.