NITROGEN REDUCTION IN
RECIRCULATING BIOFILTER TREATMENT CONCEPTS

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Since the recirculation concept was first proposed by Hines and Favreau in the 1970's, recirculating biofilters—utilizing sand, gravel and newer synthetic filtration media—have proliferated and become recognized as one of the most consistent and reliable treatment concepts for small-scale wastewater systems. Further work on the concept in the 1980's—most notably by Roland Mote at Tennessee, Dee Mitchell at Arkansas, Rich Piluk at Maryland, and A. T. Sandy at West Virginia—illuminated how this concept could be harnessed to achieve considerable nitrogen reduction by clever manipulation of the nitrogen cycle within the process. Recirculation is the key, introducing effluent that was nitrified in the filter bed to the anaerobic environment of a septic tank, which serves as the preclarification treatment stage in front of the biofiltration process. Because recirculation is practiced in any case, this modification provides essentially "free" nitrogen removal. This paper reviews this concept and the potential nitrogen removal rate attainable from it. Detailed data from the Washington Island project—the most extensive field trial of this treatment concept—are examined to elucidate the impact of design decisions and operating conditions on the level of reduction attainable.

DESCRIPTION OF THE PROCESS

Formulation of an "enhanced" version of the recirculating biofilter process was guided by the experiences of the Washington Island project. The author has termed this process the "high performance biofiltration concept". This process is illustrated in Figure 1. The heart of the treatment process is of course the biofilter bed. The balance of the system is designed to allow the biofiltration process in the filter bed to be as stable—thus as consistent and reliable—as practical, and to enhance the ease of system operations and maintenance. This process is reviewed in detail in another paper in these proceedings.

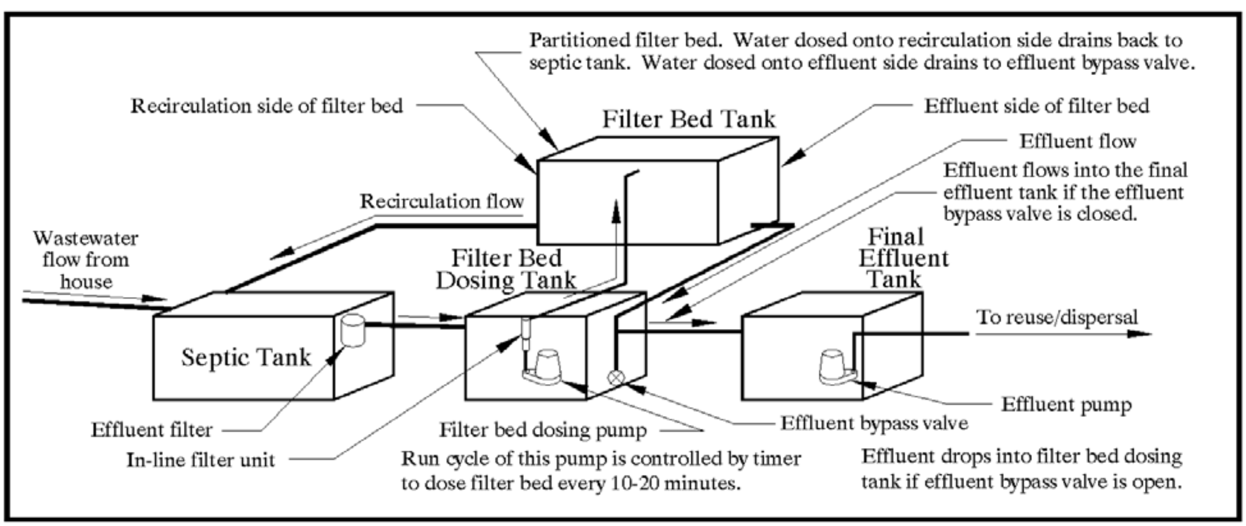

Fig. 1. High Performance Biofiltration Treatment System Concept

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Here we consider the nitrogen removal capability of this process. As Figure 1 illustrates, in the high performance biofiltration concept, the flow out of the filter bed is split into a recirculation flow and an effluent flow. The nitrogen cycle in this process is illustrated in Figure 2. As shown, nitrification occurs in the filter bed, and then nitrate in the recirculation flow is denitrified during the passage of the recirculation flow through the septic/recirculation tank. With this being the case, the theoretical "limit" on nitrogen removal rate would be the ratio of the recirculation side flow to the effluent side flow.

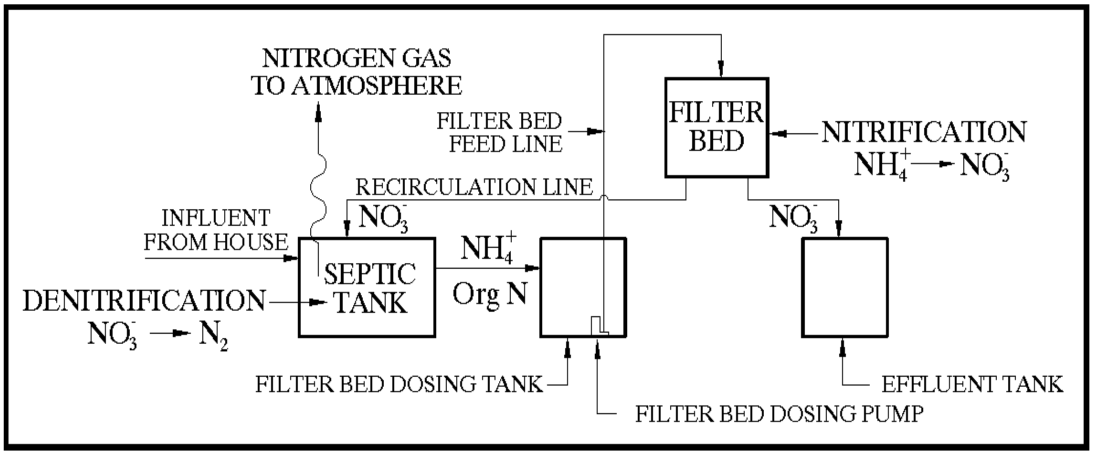

Fig. 2. Nitrogen Cycle in the High Performance Biofiltration Concept

For example, if the flow split were 2:1 – that is, two gallons flows onto the recirculation side of the filter bed for every one gallon that flows onto the effluent side – then the removal rate "limit" would be 2/3, or 67%, since 2/3 of the total flow onto the filter bed would flow through the recirculation loop, where the nitrate it carries could be denitrified. Likewise, if the flow ratio were 3:1, then 3/4, or 75% removal, would be the "limit". This capability could be further limited due to incomplete nitrification in the filter bed and/or incomplete denitrification in the septic/recirculation tank. The overall nitrogen removal rate might be increased above this "limit", however, due to denitrification occurring within the filter bed.

Recognizing that gravity recirculation schemes employed at the time—which did not include an effluent bypass valve, so when there was low, or no, forward flow, there would be "gaps" in the filter bed loading cycle—represented a major compromise of the uniform dosing regime demanded by coarse media filters receiving high hydraulic loading rates, the Washington Island project employed pumped recirculation systems. That system concept is illustrated in Figure 3. This, however, proved to impart its own hazards when one of the recirculation pumps failed—and was not noticed, thus not repaired, for over a month—and critically compromised one of the systems. There is no straightforward way to trigger an alarm when the recirculation pump fails, so it was determined to "correct" the gravity recirculation scheme, which was accomplished with the effluent bypass valve. While the operation of the effluent bypass is not belabored here—see again the paper in these proceedings detailing the high performance biofiltration concept—it can be seen from Figure 1 that, when it opens, flow from the effluent side drops into the filter bed dosing tank instead of flowing to the final effluent holding tank. When this occurs, further denitrification of nitrates in this flow may occur in the filter bed dosing tank, if sufficient anoxia prevails in it. This could provide some additional nitrogen removal that was not attainable in the system concept used in the Washington Island systems.

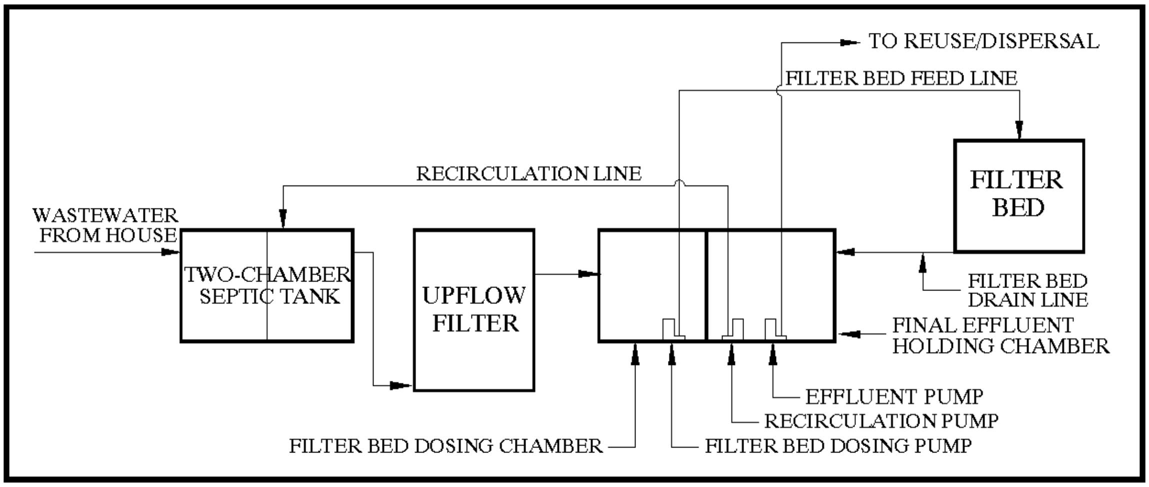

Fig. 3. Washington Island Treatment System Concept

This difference in the treatment concept may call to question the validity of accepting the results of the Washington Island project as an indication of the nitrogen removal capability of the high performance biofiltration concept. However, other than the factor just noted, the two concepts are essentially equivalent in regard to nitrogen removal capability. In the pumped recirculation concept—shown on the left side of Figure 4—the total recirculation flow remained the same regardless of the amount of flow into the system, since it was provided by a pump that was run by a timer. The actual recirculation rate would vary over any given time period, depending on the actual amount of forward flow into the system. In the high performance biofiltration concept—shown on the right side of Figure 4—the total recirculation flow also remains the same regardless of the amount of forward flow since the filter bed dosing pump is run by a timer and the split between the recirculation side and the effluent side is always the same. Thus, in either concept, the amount of flow back through the septic/recirculation tank is constant, based on the timer setup, so that the actual recirculation rate over any time period would vary with the actual amount of forward flow in exactly the same way.

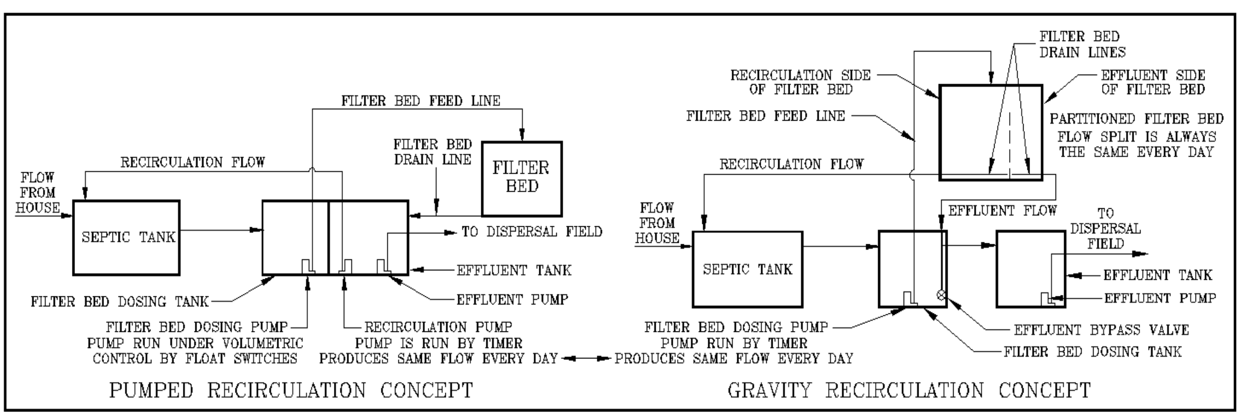

Fig. 4. Pumped Recirculation Concept vs. High Performance Biofiltration Concept

When using the pumped recirculation concept, however, flow rate onto the filter bed would vary with the actual forward flow, and the timing of the filter bed doses would also be affected. This is because the filter bed dosing pump was started and stopped by float switches—that is, run under volumetric control. With no forward flow, a maximum dosing interval would be determined by the recirculation flows. When forward flow entered the system, this would add to the flow entering the filter bed dosing tank, so the dose volume would build up more quickly and a shorter dosing interval would result. In the high performance biofiltration concept, those variations are eliminated so that true steady-state hydraulic loading of the filter bed is obtained. This being the case, performance of the high performance biofiltration concept may be superior to that obtained using the pumped recirculation concept.

The other major difference between the two concepts is the presence of the upflow filter in the Washington Island systems. Based on the work of the previously noted researchers, it was expected at that time that this sort of attached-growth bed would be required to obtain a high denitrification rate. It was observed, however, that when recirculation flow was routed through even a small secondary chamber of a two-chamber septic tank prior to entering the attached-growth filter, as in the Washington Island systems, most of the nitrate entering this tank was denitrified there, leaving little for the upflow filter to do. For the five systems, the observations showed the following average nitrate concentrations over the approximately 5-month period this data was collected in both second chamber septic tank effluent and upflow filter effluent:

- System No. 1 (36 samples):
  - Second chamber septic tank effluent – 0.5 mg/L NO_3
  - Upflow filter effluent – 0.1 mg/L NO_3
- System No. 2 (20 samples):
  - Second chamber septic tank effluent – 1.5 mg/L NO_3
  - Upflow filter effluent – 0.5 mg/L NO_3
- System No. 3 (19 samples):
  - Second chamber septic tank effluent – 7.1 mg/L NO_3
  - Upflow filter effluent – 6.3 mg/L NO_3
- System No. 4 (22 samples):
  - Second chamber septic tank effluent – 2.2 mg/L NO_3
  - Upflow filter effluent – 0.6 mg/L NO_3
- System No. 5 (12 samples):
  - Second chamber septic tank effluent – 4.5 mg/L NO_3
  - Upflow filter effluent – 2.3 mg/L NO_3

Other projects—most notably the work of Rich Piluk in Anne Arundel County, Maryland—also demonstrated that eliminating the attached-growth filter would not significantly degrade system performance, provided that the enhanced clarification provided by the upflow filter was imparted by other means. In the high performance biofiltration concept, this is accomplished with an effluent filter in the septic tank and an in-line filter on the filter bed dosing pump discharge. Therefore, the Washington Island project data can be used as a valid indication of the performance to be expected from the high performance biofiltration treatment concept.

NITROGEN REMOVAL PERFORMANCE

Observations of treatment system performance for the five systems that were operated year-round in the Washington Island project are displayed in Tables 1-5. The important physical characteristics of these systems are outlined below:

System	S.T. 1st Chamber	S.T. 2nd Chamber	Filter Bed Area
No. 1	500 gal.	500 gal.	30.25 sq. ft.
No. 2	425 gal.	343 gal.	25.0 sq. ft.
No. 3	584 gal.	559 gal.	30.0 sq. ft.
No. 4	584 gal.	559 gal.	30.0 sq. ft.
No. 5	unknown	464 gal.	36.0 sq. ft.

Filter Bed Design:

System No. 1 – startup through December 1993, stratified bed design
- Top layer – 12” fine gravel (~1/4”-3/8”, 6-9.5 mm)
- Bottom layer – 12” coarse sand (~1.5 mm E.S.)

System No. 1 – December 1993 and after, single media layer
- 24” fine gravel (~1/4”, 6 mm)

System No. 2 – 24” coarse sand (~1.5 mm E.S.)

System No. 3 – 28” fine gravel (~1/4”-3/8”, 6-9.5 mm)

System No. 4 – stratified bed design
- Top layer – 12” fine gravel (~1/4”-3/8”, 6-9.5 mm)
- Bottom layer – 12” coarse sand (~1.5 mm E.S.)

System No. 5 – 24” coarse sand (~1.5 mm E.S.)

Paired observations of influent and effluent quality were obtained about once per week. The nitrogen data in Tables 1-5 include influent Total N—almost always entirely TKN—and effluent TKN, nitrate, and Total N. Also shown are influent and effluent BOD_5, effluent temperature, and forward flow and recirculation flow meter readings, allowing calculations of interval average daily flows for each. From the interval average daily forward flow rate, the forward flow hydraulic loading rate (HLR) onto the filter bed and the organic loading rate (OLR) on the system were calculated.

Note that “influent” values were taken at the discharge from the first chamber of the septic tank, since it was not practical to obtain a representative influent sample from the building drain. This is not expected to have any impact on systemic nitrogen removal data, as it is not expected that nitrogen removal would occur in the first chambers of the septic tanks (unless there were nitrates in the raw wastewater—this was not evaluated, but is typically not to be expected). They did not typically accomplish complete mineralization—typically 1/4–1/3 of TKN was in the organic form, indicating perhaps that considerable TKN was passing through the tank with solids. The actual influent BOD’s, however, may have been higher than indicated in the tables, so the organic loading rates may be understated. These chambers were rather small and not very optimally configured, so considerable solids indeed passed through. In any case, the tables show that influent BOD’s were generally higher than typically expected in first chamber septic tank effluent. The result is that even though the hydraulic loading rates onto the filter beds were often modest, the organic loading rate remained fairly high in most cases, and was extremely high—>0.02 lb/s.f./day—through some intervals, in particular through "peak periods" in System No. 4.

As in any such investigation, the Washington Island project experienced some "glitches", so the data was selected to represent "well behaved" periods. The conditions limiting each system are:

- In System No. 1 (a residence), the recirculation pump failure mentioned previously was a prominent "glitch". It was one in a series of events that rendered the data from this system of questionable value from when that pump failed until nitrification was established in the filter bed after the media was changed, a gap of over a year, as Table 1 indicates.
- System No. 2 (a residence) was operated as a single-pass system for about 8 months, for which very poor performance was observed. It was then converted into a recirculating system, which is the point at which the data in Table 2 begins. Thereafter, problems with meters and with operation of the recirculation system caused a data gap of several months.
- System No. 3 (a residence) was operated with recirculation flow directly into the upflow filter for about 8 months before it was modified to route it through the second chamber of the septic tank. The data reported in Table 3 is only for the period that this system operated in that mode.
- In System No. 4 (the island's grocery store, with meat cutting, vegetable washing and toilet flushing being the main wastewater generators), the effluent line froze up for a short period each winter, and there appeared to be a prolonged period after startup during which denitrification was "incomplete". Data from the full 2-year evaluation period is shown in Table 4, but that prolonged startup period is neglected when calculating overall averages.
- For System No. 5 (a residence and guest house), it was determined that recirculation flow was causing "dilution" of the first chamber septic tank effluent samples, so the removal rates were not valid. Data for that system is reported in Table 5 only for the period after a new port was installed to obtain "undiluted" first chamber septic tank effluent samples.

The results show that a high degree of total nitrogen reduction can be delivered consistently and reliably by this treatment system concept. For the data periods shown in Tables 1-5, total N removal rate ranged from 63.9% to 91.7%. The overall averages for each of the five systems over their respective periods of observation are listed below. The anomalous startup period for System No. 4 is not included in these averages.

System No. 1 – Influent = 54.4 mg/L, effluent = 14.1 mg/L, 74% removal
System No. 2 – Influent = 43.2 mg/L, effluent = 15.3 mg/L, 65% removal
System No. 3 – Influent = 85.8 mg/L, effluent = 16.8 mg/L, 80% removal
System No. 4 – Influent = 128.4 mg/L, effluent = 13.8 mg/L, 89% removal
System No. 5 – Influent = 42.4 mg/L, effluent = 11.6 mg/L, 73% removal

Performance was maintained at these high levels without regard to influent strength, flow fluctuations, organic loading rate, and all the vagaries of operation in the field environment. An effluent total N concentration of about 15 mg/L or less appears typically attainable.

In the spirit of full disclosure, more data points for effluent quality were obtained than are reported in Tables 1-5. Reported there are only the samples for which paired influent-effluent data was taken, as this allowed calculation of removal rates. For part of the observation period, sampling alternated between first chamber septic tank effluent samples and upflow filter effluent samples, so paired observations were not available for the latter sampling events. Reviewed below are the means, medians, and standard deviations for the full data set of effluent samples, compared to those measures for the data sets shown in Tables 1-5. From these comparisons, it is concluded that the data in Tables 1-5 is a fair representation of the overall performance of each system. Note that for System No. 3 and System No. 5 the data sets were identical, and for System No. 4, the anomalous startup period is again eliminated in both data sets.

System No. 1 effluent	Mean Total N	Median Total N	Std. Dev. Total N
Table 1 data set	14.0	14.1	4.7
Full data set	14.9	15.4	5.4

System No. 2 effluent	Mean Total N	Median Total N	Std. Dev. Total N
Table 2 data set	15.3	14.6	5.1
Full data set	15.1	13.9	5.3

System No. 3 effluent	Mean Total N	Median Total N	Std. Dev. Total N
Table 3 data set	16.8	16.1	4.3
Full data set	16.8	16.1	4.3

System No. 4 effluent	Mean Total N	Median Total N	Std. Dev. Total N
Table 4 data set	13.8	13.0	5.8
Full data set	14.0	12.8	6.1

System No. 5 effluent	Mean Total N	Median Total N	Std. Dev. Total N
Table 5 data set	11.6	11.3	3.6
Full data set	11.6	11.3	3.6

From the data in Tables 1-5, it appears as if the N removal rate increases with increasing influent total N concentration. However, this may be an artifact of the recirculation rates having been higher in systems where influent total N is higher. Recall that the theoretical "limit" of removal rate is the recirculation rate, expressed as a percent of total flow onto the filter bed that recirculates. Examination of Tables 1-5 show how well the total N removal rate matches with the percent of total flow that is recirculated. The comparisons for each of the 15 data periods (omitting the System No. 4 startup period, prior to Jan. 25, 1993) are shown below. Overall averages would not be very meaningful due to the varying conditions among the data periods.

<u>System No. 1</u>

1st period: Influent TKN = 65.2 % Recirc. = 67.8 % Denit. = 71.7 Diff. = -3.9%
2nd period: Influent TKN = 54.4 % Recirc. = 78.0 % Denit. = 76.8 Diff. = +1.2%
3rd period: Influent TKN = 38.6 % Recirc. = 90.3 % Denit. = 73.1 Diff. = +17.1%

System No. 2

1st period:	Influent TKN = 42.8	% Recirc. = 63.5	% Denit. = 63.9	Diff. = -0.4%
2nd period:	Influent TKN = 46.7	% Recirc. = 77.8	% Denit. = 70.3	Diff. = +7.4%

System No. 3

1st period:	Influent TKN = 122.7	% Recirc. = 87.0	% Denit. = 87.3	Diff. = -0.2%
2nd period:	Influent TKN = 56.7	% Recirc. = 87.7	% Denit. = 68.8	Diff. = +18.9%
3rd period:	Influent TKN = 52.5	% Recirc. = 87.0	% Denit. = 65.7	Diff. = +21.3%

System No. 4

1st period:	Influent TKN = 123.1	% Recirc. = 93.1	% Denit. = 87.4	Diff. = +5.7%
2nd period:	Influent TKN = 137.7	% Recirc. = 86.9	% Denit. = 87.8	Diff. = -1.0%
3rd period:	Influent TKN = 117.8	% Recirc. = 92.1	% Denit. = 90.7	Diff. = +1.4%
4th period:	Influent TKN = 128.0	% Recirc. = 91.0	% Denit. = 91.7	Diff. = -0.7%

System No. 5

1st period:	Influent TKN = 50.2	% Recirc. = 79.5	% Denit. = 75.9	Diff. = +3.7%
2nd period:	Influent TKN = 36.8	% Recirc. = 83.1	% Denit. = 71.4	Diff. = +11.7%
3rd period:	Influent TKN = 46.9	% Recirc. = 81.1	% Denit. = 72.3	Diff. = +8.9%

The individual interval removal rates shown in the tables vary widely—not surprising given that this is all based on grab samples—but the above averages do indicate that the total N removal rate in this treatment process can be roughly predicted relative to the recirculation rate employed in the system, with some caveats:

- In System No. 1, it was seen that when average recirculation rate was greatly increased while average influent total N decreased significantly, the removal rate did not elevate above what it had been in previous periods with lower average recirculation rates.
- In System No. 2, where fairly low influent total N concentrations prevailed throughout the data periods, a jump in the recirculation rate induced an increase in the removal rate that was smaller than the increase in average recirculation rate.
- In System No. 3, while the average recirculation rate remained stable across all the observation periods, the average influent total N concentration drastically decreased in the last two observation periods (there is no explanation for why this happened—it may have been a drastic change in diet, as one of the occupants had been diagnosed with cancer), and this resulted in significantly lower removal rates.
- In System No. 4, where average conditions remained stable from period to period, the difference scores were fairly low and consistent over all periods (noting that for the first period, with a higher difference score, the period over which recirculation rate was calculated is different than the period over which removal rate was calculated). Both influent total N and recirculation rate were high and fairly uniform over all the periods, however, so the influence of changing recirculation rate on removal rate when total N is high could not be determined.

- In System No. 5, where the average recirculation rate remained fairly stable throughout, the difference score rose and fell in inverse relationship with average influent total N concentration. This may indicate this relationship is not linear, rather is a “second order” relationship.

Understanding that the observations are all based on grab samples and that the averages are not flow-weighted, no doubt imparting some errors, the results seem to suggest:

- With a recirculation rate of about 2:1 (67%) or more, a minimum removal rate of 60% appears fairly well assured when influent total N concentration is in the “typical” range for normal domestic wastewater of 40-60 mg/L.
- At recirculation rates in the range of 2:1 (67%) to 3:1 (75%) and influent total N concentration in the “typical” range, removal rate rises with increasing recirculation rate.
- At recirculation rates in the range of 2:1 (67%) to 3:1 (75%) and influent total N concentration in the “typical” range, an effluent total N concentration of less than 20 mg/L would be assured, consistently and reliably. An average of <15 mg/L is quite likely.
- When influent total N concentration increases, recirculation rate should also increase in order to achieve an effluent total N concentration in the 15 mg/L range. When influent total N concentration is very high—e.g., above 100 mg/L—then average removal rate may rather closely track average recirculation rate even at rather high recirculation rates, on the order of 9:1 (90%).
- There is a point of diminishing returns, where increasing the recirculation rate further appears not to provide a commensurate increase in removal rate, and may even be counterproductive. This appears to be more so the lower influent total N concentration is.
- All this depends as well on the hydraulic loading rate on the filter bed. When influent strength is high, the forward flow HLR should be “de-rated” in concert with the increase in recirculation rate so that total HLR onto the filter bed remains “moderate”.
- Though that data is not reviewed here, it was observed that there appeared to be some nitrogen loss within the filter bed. It is presumed that this is due to in-bed denitrification, imparted in anaerobic microsites within the filter bed. In-bed losses occurred even in the very coarse gravel media (6–9.5 mm) filter beds. This may be the reason that negative average difference scores—that is, removal rates above the expected “limit”—were observed.
- A confounding factor is the degree of nitrification attained, as only the nitrate portion of total N in filter bed effluent could be denitrified. System No. 1 and System No. 2 in particular experienced periods of inconsistent nitrification, and System No. 4 had a lower nitrification rate during the summer peak period, when organic loading rates were extremely high. There is quite likely some correlation to organic loading rate, as this would tend to inhibit nitrification due to competition from the heterotrophic microbes that digest BOD.

The treatment concept, the Washington Island experiences, the data, and these observations will be presented to and discussed with the participants in the NOWRA Pre-Conference Symposium on “Nitrogen and Decentralized Systems”.

TABLE 1

SYSTEM No. 1 FLOW AND NITROGEN REMOVAL DATA

										Organic Loading				Effluent Nitrogen				
Date	F.F. Meter Reading	Interval F.F. rate (gpd)	Recirc. Meter Reading	Interval Recirc. Flow (gpd)	Interval Total Flow rate (gpd)	Interval Recirc. Rate	Percent Flow to Recirc.	Effluent Temp. Deg. C	Interval F.F. Filter HLR (gal/s.f./day)	Influent BOD (mg/L)	OLR (lb/s.f./day)	Effluent BOD (mg/L)	Influent Total N (mg/L)	TKN (mg/L)	Nitrate (mg/L)	Total N (mg/L)	Total N Removal Rate (%)	% Recirc. minus % Denit.
2-Jul-92	astewater flow into system starte																	
25-Aug-92	60011		160484	recirculation started														
27-Aug-92	60530	260	161670	593	853	3.29	69.6%	19.0	8.6	221	0.0158	3.9	37.3	2.8	13.2	16.0	57.1%	12.5%
8-Sep-92	64558	336	168683	584	920	2.74	63.5%	17.0	11.1	289	0.0268	3.5	73.3	1.1	15.6	16.7	77.2%	-13.7%
14-Sep-92	65983	238	172083	567	804	3.39	70.5%	16.0	7.9	315	0.0206	5.5	94.6	1.5	11.4	12.9	86.4%	-15.9%
21-Sep-92	67594	230	176153	581	812	3.53	71.6%	16.0	7.6	213	0.0135	3.2	53.3	2.8	14.7	17.5	67.2%	4.5%
28-Sep-92	69098	215	180081	561	776	3.61	72.3%	14.0	7.1	422	0.0250	3.8	80.2	2.5	16.5	19.0	76.3%	-4.0%
5-Oct-92	71003	272	184231	593	865	3.18	68.5%	14.0	9.0	267	0.0200	5.6	36.6	7.1	18.1	25.2	31.1%	37.4%
12-Oct-92	72896	270	188151	560	830	3.07	67.4%	13.0	8.9	311	0.0232	14.5	58.7	8.7	9.2	17.9	69.5%	-2.1%
19-Oct-92	75651	394	192122	567	961	2.44	59.0%	10.0	13.0	162	0.0176	3.7	28.0	5.5	12.2	17.7	36.8%	22.3%
2-Nov-92	79074	245	199809	549	794	3.25	69.2%	10.0	8.1	386	0.0260	4.2	63.5	5.2	12.2	17.4	72.6%	-3.4%
9-Nov-92	80901	261	203509	529	790	3.03	66.9%	9.0	8.6	386	0.0278	11.5	70.0	8.1	8.6	16.7	76.1%	-9.2%
16-Nov-92	82622	246	207153	521	766	3.12	67.9%	7.0	8.1	466	0.0316	8.0	89.0	9.4	13.4	22.8	74.4%	-6.5%
23-Nov-92	83930	187	210792	520	707	3.78	73.6%	8.0	6.2	653	0.0337	1.5	98.2	8.5	13.2	22.7	76.9%	-3.3%
Average over data period		266		559	825	3.10	67.8%	12.8	8.8	341	0.0250	5.7	65.2	5.3	13.2	18.5	71.6%	-3.8%
28-Feb-94	166510		397520															
7-Mar-94	167320	116	399980	351	467	4.04	75.2%	8.0	3.8	299	0.0095	19.2	38.3	7.2	10.3	17.5	54.3%	20.9%
10-Mar-94	167620	100	401810	610	710	7.10	85.9%	7.0	3.3	343	0.0095	5.0	50.2	4.5	9.6	14.1	71.9%	14.0%
14-Mar-94	168150	133	404270	615	748	5.64	82.3%	7.0	4.4	346	0.0126	12.7	29.5	1.9	7.0	8.9	69.8%	12.4%
17-Mar-94	168590	147	406090	607	753	5.14	80.5%	7.0	4.8	565	0.0229	13.7	96.2	12.6	5.5	18.1	81.2%	-0.7%
21-Mar-94	169030	110	408400	578	688	6.25	84.0%	7.0	3.6	408	0.0124	11.2	34.9	3.1	5.5	8.6	75.4%	8.6%
24-Mar-94	169510	160	410260	620	780	4.88	79.5%	7.0	5.3	251	0.0111	13.3	52.2	4.8	6.2	11.0	78.9%	0.6%
28-Mar-94	170170	165	412630	593	758	4.59	78.2%	7.0	5.5	402	0.0183	11.0	46.8	5.3	7.6	12.9	72.4%	5.8%
31-Mar-94	170510	113	414370	580	693	6.12	83.7%	7.0	3.7	266	0.0083	11.5	45.5	4.9	7.5	12.4	72.7%	10.9%
4-Apr-94	171200	173	416570	550	723	4.19	76.1%	7.0	5.7	466	0.0222	15.1	104.6	5.0	7.3	12.3	88.2%	-12.1%
11-Apr-94	172380	169	420380	544	713	4.23	76.4%	8.0	5.6	402	0.0187	9.0	48.0	3.8	6.0	9.8	79.6%	-3.2%
14-Apr-94	172860	160	422020	547	707	4.42	77.4%	9.0	5.3	358	0.0158	8.1	48.6	3.1	6.2	9.3	80.9%	-3.5%
18-Apr-94	173620	190	424240	555	745	3.92	74.5%	9.1	6.3	249	0.0131	12.5	33.1	5.6	4.7	10.3	68.9%	5.6%
21-Apr-94	174140	173	425870	543	717	4.13	75.8%	9.3	5.7	334	0.0160	7.9	57.9	4.3	5.4	9.7	83.2%	-7.4%
25-Apr-94	174860	180	427980	528	708	3.93	74.6%	9.9	6.0	337	0.0167	10.1	54.5	5.8	9.0	14.8	72.8%	1.7%
28-Apr-94	175520	220	429490	503	723	3.29	69.6%	8.8	7.3	257	0.0156	11.4	69.9	9.0	8.6	17.6	74.8%	-5.2%
2-May-94	176070	138	431460	493	630	4.58	78.2%	9.5	4.5	373	0.0141	13.0	59.5	7.6	7.1	14.7	75.3%	2.9%
Average over data period		152		539	690	4.55	78.0%	8.0	5.0	354	0.0148	11.5	54.4	5.5	7.1	12.6	76.8%	1.2%
	New recirculation meter		146440															
5-May-94	176330	87	149610	1057	1143	13.19	92.4%	10.2	2.9	486	0.0116	28.4	106.5	7.7	3.1	10.8	89.9%	2.6%
9-May-94	176870	135	154510	1225	1360	10.07	90.1%	10.7	4.5	157	0.0058	14.1	37.7	14.8	2.8	17.6	53.3%	36.8%
12-May-94	177210	113	158210	1233	1347	11.88	91.6%	11.5	3.7	167	0.0052	14.8	33.4	12.0	4.0	16.0	52.1%	39.5%
16-May-94	177850	160	163120	1228	1388	8.67	88.5%	11.5	5.3	597	0.0264	12.3	20.7	5.0	3.2	8.2	60.4%	28.1%
19-May-94	178180	110	166820	1233	1343	12.21	91.8%	12.3	3.6	167	0.0051	7.0	28.8	6.5	3.8	10.3	64.2%	27.6%
23-May-94	178740	140	171700	1220	1360	9.71	89.7%	13.5	4.6	233	0.0090	8.1	22.1	5.4	2.9	8.3	62.4%	27.3%
31-May-94	179790	131	181290	1199	1330	10.13	90.1%	14.1	4.3	232	0.0084	10.9	18.1	5.8	0.9	6.7	63.0%	27.1%
6-Jun-94	180580	132	188540	1208	1340	10.18	90.2%	14.6	4.4	413	0.0150	8.4	42.2	8.2	0.8	9.0	78.7%	11.5%
13-Jun-94	181582	143	197124	1226	1369	9.57	89.5%	15.6	4.7	196	0.0077	6.2	38.2	5.4	1.1	6.5	83.0%	6.6%
Average over data period		131		1218	1350	10.28	90.3%	12.7	4.3	294	0.0107	12.2	38.6	7.9	2.5	10.4	73.1%	17.1%

TABLE 2

SYSTEM No. 2 FLOW AND NITROGEN REMOVAL DATA

Date	F.F. Meter Reading	Interval F.F. rate (gpd)	Recirc. Meter Reading	Interval Recirc. Flow (gpd)	Interval Total Flow rate (gpd)	Interval Recirc. Rate	Percent Flow to Recirc.	Effluent Temp. Deg. C	Interval F.F. Filter HLR (gal/s.f./day)	Organic Loading			Influent Total N (mg/L)	Effluent Nitrogen			Total N Removal Rate (%)	% Recirc. minus % Denit.
										Influent BOD (mg/L)	OLR (lb/s.f./day)	Effluent BOD (mg/L)		TKN (mg/L)	Nitrate (mg/L)	Total N (mg/L)		
20-May-93	recirculation started																	
24-May-93	809		5060															
27-May-93	1382	191	6280	407	598	3.13	68.0%	8.0	7.6	299	0.0191	10.8	56.6	3.1	10.6	13.7	75.8%	-7.8%
3-Jun-93	2467	155	9221	420	575	3.71	73.1%	9.0	6.2	181	0.0094	34.9	62.2	10.4	7.8	18.2	70.7%	2.3%
7-Jun-93	2997	133	10882	415	548	4.13	75.8%	9.0	5.3	159	0.0070	8.1	44.5	9.1	10.5	19.6	56.0%	19.9%
10-Jun-93	3412	138	12038	385	524	3.79	73.6%	10.0	5.5	186	0.0086	21.3	42.6	7.3	7.4	14.7	65.5%	8.1%
17-Jun-93	4474	152	15130	442	593	3.91	74.4%	11.2	6.1	196	0.0099	12.8	34.8	4.6	9.3	13.9	60.1%	14.4%
21-Jun-93	5078	151	16647	379	530	3.51	71.5%	11.0	6.0	253	0.0128	6.6	54.6	3.5	9.6	13.1	76.0%	-4.5%
24-Jun-93	6240	387	17892	415	802	2.07	51.7%	11.0	15.5	940	0.1215	12.0	87.1	8.3	12.6	20.9	76.0%	-24.3%
28-Jun-93	7508	317	19553	415	732	2.31	56.7%	12.0	12.7	291	0.0308	15.3	32.1	9.3	11.0	20.3	36.8%	19.9%
1-Jul-93	8300	264	20799	415	679	2.57	61.1%	12.0	10.6	143	0.0126	49.5	11.8	17.6	1.8	19.4	-64.4%	125.5%
6-Jul-93	9952	330	22883	417	747	2.26	55.8%	14.0	13.2	178	0.0196	15.5	48.0	2.0	6.5	8.5	82.3%	-26.5%
8-Jul-93	10394	221	23712	415	636	2.88	65.2%	14.0	8.8	383	0.0283	15.7	40.2	3.6	7.4	11.0	72.6%	-7.4%
12-Jul-93	10953	140	25362	413	552	3.95	74.7%	14.0	5.6	229	0.0107	10.0	32.1	2.2	6.2	8.4	73.8%	0.9%
15-Jul-93	12333	460	26604	414	874	1.90	47.4%	13.0	18.4	129	0.0198	23.0	54.1	26.1	2.9	29.0	46.4%	1.0%
19-Jul-93	14265	483	28247	411	894	1.85	46.0%	14.0	19.3	146	0.0235	16.4	42.3	26.8	2.3	29.1	31.2%	14.8%
22-Jul-93	15279	338	29479	411	749	2.21	54.9%	14.0	13.5	134	0.0151	8.7	25.1	8.0	9.5	17.5	30.3%	24.6%
26-Jul-93	16329	263	31108	407	670	2.55	60.8%	15.0	10.5	170	0.0149	11.7	42.0	7.3	8.2	15.5	63.1%	-2.3%
29-Jul-93	17552	408	32352	415	822	2.02	50.4%	15.0	16.3	119	0.0162	10.0	45.4	8.5	7.1	15.6	65.6%	-15.2%
2-Aug-93	19103	388	34016	416	804	2.07	51.8%	15.0	15.5	195	0.0252	6.4	25.9	6.2	6.6	12.8	50.6%	1.2%
5-Aug-93	20106	334	35252	412	746	2.23	55.2%	15.0	13.4	632	0.0705	6.6	81.5	9.2	8.1	17.3	78.8%	-23.6%
9-Aug-93	21690	396	36880	407	803	2.03	50.7%	15.0	15.8	211	0.0279	10.0	55.8	16.4	2.2	18.6	66.7%	-16.0%
12-Aug-93	22761	357	38100	407	764	2.14	53.3%	15.0	14.3	181	0.0216	4.7	45.2	20.1	3.7	23.8	47.3%	5.9%
16-Aug-93	23995	309	39771	418	726	2.35	57.5%	16.0	12.3	166	0.0171	4.9	23.2	10.4	2.7	13.1	43.5%	14.0%
19-Aug-93	24522	176	40951	393	569	3.24	69.1%	16.0	7.0	140	0.0082	2.8	61.4	5.1	5.4	10.5	82.9%	-13.8%
26-Aug-93	26121	228	43767	402	631	2.76	63.8%	N/A	9.1	271	0.0207	12.2	54.2	6.5	5.4	11.9	78.0%	-14.3%
30-Aug-93	27268	287	45286	380	667	2.32	57.0%	N/A	11.5	287	0.0275	3.4	43.8	4.4	3.1	7.5	82.9%	-25.9%
2-Sep-93	27919	217	46444	386	603	2.78	64.0%	N/A	8.7	219	0.0159	18.3	37.4	7.5	1.9	9.4	74.9%	-10.9%
9-Sep-93	29144	175	49170	389	564	3.23	69.0%	N/A	7.0	166	0.0097	2.2	35.4	3.3	9.0	12.3	65.3%	3.7%
13-Sep-93	29789	161	50664	374	535	3.32	69.8%	N/A	6.5	138	0.0074	7.9	23.7	2.0	13.7	15.7	33.8%	36.1%
16-Sep-93	29930	47	51740	359	406	8.63	88.4%	15.0	1.9	381	0.0060	32.4	29.5	0.5	8.3	8.8	70.2%	18.2%
20-Sep-93	30219	72	53307	392	464	6.42	84.4%	N/A	2.9	297	0.0072	3.4	50.8	0.8	9.5	10.3	79.7%	4.7%
23-Sep-93	30546	109	54485	393	502	4.60	78.3%	N/A	4.4	172	0.0063	15.7	40.2	1.9	12.6	14.5	63.9%	14.3%
27-Sep-93	31052	127	56049	391	518	4.09	75.6%	N/A	5.1	124	0.0052	3.3	27.2	3.2	11.7	14.9	45.2%	30.3%
30-Sep-93	31412	120	57158	370	490	4.08	75.5%	N/A	4.8	173	0.0069	5.8	32.1	3.1	9.3	12.4	61.4%	14.1%
4-Oct-93	31713	75	58472	329	404	5.37	81.4%	N/A	3.0	198	0.0050	2.5	44.9	1.1	8.0	9.1	79.7%	1.6%
7-Oct-93	32049	112	59314	281	393	3.51	71.5%	N/A	4.5	210	0.0079	8.0	32.0	3.3	8.7	12.0	62.5%	9.0%
11-Oct-93	32310	65	60366	263	328	5.03	80.1%	N/A	2.6	181	0.0039	5.2	44.8	3.3	8.3	11.6	74.1%	6.0%
14-Oct-93	32612	101	61202	279	379	3.77	73.5%	N/A	4.0	133	0.0045	8.2	50.9	5.7	13.2	18.9	62.9%	10.6%
18-Oct-93	33603	248	62043	210	458	1.85	45.9%	N/A	9.9	217	0.0179	15.0	41.1	7.9	16.8	24.7	39.9%	6.0%
21-Oct-93	34301	233	62748	235	468	2.01	50.2%	N/A	9.3	252	0.0196	11.8	52.2	5.9	12.7	18.6	64.4%	-14.1%

TABLE 2

SYSTEM No. 2 FLOW AND NITROGEN REMOVAL DATA

Date	F.F. Meter Reading	Interval F.F. rate (gpd)	Recirc. Meter Reading	Interval Recirc. Flow (gpd)	Interval Total Flow rate (gpd)	Interval Recirc. Rate	Percent Flow to Recirc.	Effluent Temp. Deg. C	Interval F.F. Filter HLR (gal/s.f./day)	Organic Loading: Influent BOD (mg/L)	Organic Loading: OLR (lb/s.f./day)	Organic Loading: Effluent BOD (mg/L)	Influent Total N (mg/L)	Effluent Nitrogen: TKN (mg/L)	Effluent Nitrogen: Nitrate (mg/L)	Effluent Nitrogen: Total N (mg/L)	Total N Removal Rate (%)	% Recirc. minus % Denit.
25-Oct-93	34754	113	63819	268	381	3.36	70.3%	N/A	4.5	53	0.0020	7.2	28.9	3.1	14.6	17.7	38.8%	31.5%
28-Oct-93	35039	129	64589	275	404	3.14	68.2%	N/A	5.1	198	0.0085	9.3	37.6	5.2	14.3	19.5	48.1%	20.0%
Average over data period		218		379	597	2.74	63.5%	13.1	8.7	228	0.0166	11.9	42.8	7.2	8.3	15.5	63.9%	-0.4%
New meters installed																		
26-May-94	431290		105350															
2-Jun-94	432400	159	108060	387	546	3.44	70.9%	12.5	6.3	345	0.0183	2.2	62.2	1.9	17.3	19.2	69.1%	1.8%
9-Jun-94	432890	70	111230	453	523	7.47	86.6%	12.5	2.8	137	0.0032	3.0	53.1	0.8	10.2	11.0	79.3%	7.3%
16-Jun-94	433870	140	114420	456	596	4.26	76.5%	13.4	5.6	181	0.0085	13.1	49.9	2.9	10.7	13.6	72.7%	3.8%
23-Jun-94	435004	162	117562	449	611	3.77	73.5%	N/A	6.5	205	0.0111	7.6	42.8	4.0	11.4	15.4	64.0%	9.5%
30-Jun-94	435550	78	120250	384	462	5.92	83.1%	14.4	3.1	178	0.0046	10.5	25.7	3.1	7.0	10.1	60.7%	22.4%
Average over data period		122		426	547	4.50	77.8%	13.2	4.9	209	0.0085	7.3	46.7	2.5	11.3	13.9	70.3%	7.4%

TABLE 3

SYSTEM No. 3 FLOW AND NITROGEN REMOVAL DATA

Date	F.F. Meter Reading	Interval F.F. rate (gpd)	Recirc. Meter Reading	Interval Recirc. Flow (gpd)	Interval Total Flow rate (gpd)	Interval Recirc. Rate	Percent Flow to Recirc.	Effluent Temp. Deg. C	Interval F.F. Filter HLR (gal/s.f./day)	Organic Loading: Influent BOD (mg/L)	Organic Loading: OLR (lb/s.f./day)	Organic Loading: Effluent BOD (mg/L)	Influent Total N (mg/L)	Effluent Nitrogen: TKN (mg/L)	Effluent Nitrogen: Nitrate (mg/L)	Effluent Nitrogen: Total N (mg/L)	Total N Removal Rate (%)	% Recirc minus % Denit.
6-May-93	24086		172466															
13-May-93	24620	76	177740	753	830	10.88	90.8%	N/A	2.5	405	0.0086	2.7	140.5	6.4	9.9	16.3	88.4%	2.4%
20-May-93	25509	127	183231	784	911	7.18	86.1%	8.0	4.2	293	0.0104	4.8	94.5	5.1	12.9	18.0	81.0%	5.1%
27-May-93	26233	103	188623	770	874	8.45	88.2%	8.0	3.4	183	0.0053	6.3	79.6	5.4	11.9	17.3	78.3%	9.9%
3-Jun-93	26927	99	193794	739	838	8.45	88.2%	9.0	3.3	578	0.0159	3.9	133.4	5.1	9.3	14.4	89.2%	-1.0%
10-Jun-93	27279	50	198895	729	779	15.49	93.5%	11.0	1.7	172	0.0024	8.6	56.2	8.5	10.7	19.2	65.8%	27.7%
17-Jun-93	28179	129	204166	753	882	6.86	85.4%	10.7	4.3	472	0.0169	4.2	104.5	4.1	7.8	11.9	88.6%	-3.2%
24-Jun-93	29100	132	208606	634	766	5.82	82.8%	12.0	4.4	1067	0.0391	6.4	87.5	7.7	11.2	18.9	78.4%	4.4%
1-Jul-93	29830	104	213405	686	790	7.57	86.8%	13.0	3.5	1173	0.0340	3.3	211.7	6.1	8.0	14.1	93.3%	-6.5%
8-Jul-93	30539	101	218105	671	773	7.63	86.9%	14.0	3.4	776	0.0219	7.0	155.6	7.3	13.2	20.5	86.8%	0.1%
15-Jul-93	31248	101	222803	671	772	7.63	86.9%	14.0	3.4	636	0.0179	2.9	165.9	6.0	10.1	16.1	90.3%	-3.4%
22-Jul-93	32517	181	227425	660	842	4.64	78.5%	15.0	6.0	507	0.0256	5.0	126.4	7.4	15.4	22.8	82.0%	-3.5%
29-Jul-93	33063	78	232117	670	748	9.59	89.6%	15.0	2.6	359	0.0078	3.7	99.7	5.1	8.9	14.0	86.0%	3.6%
5-Aug-93	33773	101	236797	669	770	7.59	86.8%	15.0	3.4	652	0.0184	4.6	130.7	4.3	9.4	13.7	89.5%	-2.7%
12-Aug-93	34311	77	241501	672	749	9.74	89.7%	15.0	2.6	406	0.0087	3.2	96.4	3.6	9.1	12.7	86.8%	2.9%
19-Aug-93	34866	79	246148	664	743	9.37	89.3%	16.0	2.6	406	0.0090	2.1	116.5	3.9	10.1	14.0	88.0%	1.3%
26-Aug-93	35585	103	250771	660	763	7.43	86.5%	N/A	3.4	499	0.0143	2.2	119.9	4.0	9.9	13.9	88.4%	-1.9%
2-Sep-93	36409	118	254999	604	722	6.13	83.7%	N/A	3.9	402	0.0132	1.4	159.6	3.8	11.7	15.5	90.3%	-6.6%
9-Sep-93	37327	131	259391	627	759	5.78	82.7%	N/A	4.4	410	0.0150	2.4	140.0	2.3	13.2	15.5	88.9%	-6.2%
16-Sep-93	37777	64	264335	706	771	11.99	91.7%	17.0	2.1	305	0.0055	3.2	125.2	3.0	14.9	17.9	85.7%	6.0%
23-Sep-93	38498	103	268830	642	745	7.23	86.2%	N/A	3.4	197	0.0056	0.0	116.5	2.3	10.5	12.8	89.0%	-2.8%
30-Sep-93	39021	75	273372	649	724	9.68	89.7%	N/A	2.5	400	0.0083	4.5	104.0	5.7	12.8	18.5	82.2%	7.5%
7-Oct-93	39554	76	277859	641	717	9.42	89.4%	N/A	2.5	386	0.0082	2.2	111.5	2.5	9.6	12.1	89.1%	0.2%
14-Oct-93	40259	101	282366	644	745	7.39	86.5%	N/A	3.4	334	0.0094	4.1	87.9	2.2	11.4	13.6	84.5%	1.9%
21-Oct-93	41126	124	286844	640	764	6.16	83.8%	N/A	4.1	684	0.0236	9.7	126.1	1.9	12.2	14.1	88.8%	-5.0%
28-Oct-93	41834	101	291334	641	743	7.34	86.4%	N/A	3.4	447	0.0126	3.6	177.7	2.5	10.7	13.2	92.6%	-6.2%
Average over data period spring/summer/fall		101		679	781	7.70	87.0%	12.8	3.4	486	0.0137	4.1	122.7	4.6	11.0	15.6	87.3%	-0.2%
4-Nov-93	42594	109	295822	641	750	6.91	85.5%	N/A	3.6	440	0.0133	2.4	116.4	1.7	11.4	13.1	88.7%	-3.2%
11-Nov-93	43435	120	300245	632	752	6.26	84.0%	N/A	4.0	292	0.0098	1.8	93.1	1.8	10.2	12.0	87.1%	-3.1%
18-Nov-93	43967	76	304657	630	706	9.29	89.2%	11.0	2.5	213	0.0045	6.2	50.3	2.3	13.9	16.2	67.8%	21.4%
2-Dec-93	45739	127	313316	619	745	5.89	83.0%	9.0	4.2	N/A	N/A	N/A	102.7	1.7	13.0	14.7	85.7%	-2.7%
9-Dec-93	47170	204	323550	1462	1666	8.15	87.7%	9.0	6.8	129	0.0073	3.8	53.3	2.2	14.5	16.7	68.7%	19.1%
16-Dec-93	N/A	N/A	N/A	N/A	N/A	N/A	N/A	7.0	N/A	106	N/A	4.6	46.0	1.8	12.5	14.3	68.9%	N/A
23-Dec-93	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	110	N/A	8.5	31.5	0.8	11.8	12.6	60.0%	N/A
30-Dec-93	48233	51	334237	509	560	11.05	91.0%	N/A	1.7	88	0.0012	1.8	31.4	0.9	10.1	11.0	65.0%	26.0%
13-Jan-94	49500	91	344980	767	858	9.48	89.5%	7.0	3.0	175	0.0044	1.6	62.2	1.3	18.3	19.6	68.5%	21.0%
27-Jan-94	51105	115	355641	762	876	7.64	86.9%	7.0	3.8	172	0.0055	4.7	53.3	3.0	13.3	16.3	69.4%	17.5%
10-Feb-94	52388	92	366200	754	846	9.23	89.2%	N/A	3.1	140	0.0036	2.5	59.5	1.7	N/A	N/A	N/A	N/A
17-Feb-94	53100	102	371450	750	852	8.37	88.1%	7.0	3.4	90	0.0025	0.5	51.4	2.1	11.2	13.3	74.1%	13.9%
24-Feb-94	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	124	N/A	9.4	28.1	2.4	26.9	29.3	-4.3%	N/A
3-Mar-94	54540	103	381990	753	856	8.32	88.0%	N/A	3.4	91	0.0026	2.1	53.9	1.9	26.4	28.3	47.5%	40.5%

TABLE 3

SYSTEM No. 3 FLOW AND NITROGEN REMOVAL DATA

										Organic Loading				Effluent Nitrogen				
Date	F.F. Meter Reading	Interval F.F. rate (gpd)	Recirc. Meter Reading	Interval Recirc. Flow (gpd)	Interval Total Flow rate (gpd)	Interval Recirc. Rate	Percent Flow to Recirc.	Effluent Temp. Deg. C	Interval F.F. Filter HLR (gal/s.f./day)	Influent BOD (mg/L)	OLR (lb/s.f./day)	Effluent BOD (mg/L)	Influent Total N (mg/L)	TKN (mg/L)	Nitrate (mg/L)	Total N (mg/L)	Total N Removal Rate (%)	% Recirc minus % Denit.
10-Mar-94	55220	97	387070	726	823	8.47	88.2%	11.0	3.2	322	0.0087	4.0	58.5	0.6	30.7	31.3	46.5%	41.7%
17-Mar-94	56050	119	392250	740	859	7.24	86.2%	6.0	4.0	83	0.0027	2.9	28.4	3.1	13.4	16.5	41.9%	44.3%
24-Mar-94	56530	69	397260	716	784	11.44	91.3%	7.0	2.3	180	0.0034	5.0	53.8	2.1	15.9	18.0	66.5%	24.7%
31-Mar-94	57560	147	402180	703	850	5.78	82.7%	6.0	4.9	285	0.0117	3.2	46.4	2.4	15.5	17.9	61.4%	21.3%
Average over data period winter		102		724	825	8.11	87.7%	7.9	4.1	178.8	0.0051	3.8	56.7	1.9	15.8	17.7	68.8%	18.9%
14-Apr-94	59180	116	411230	646	762	6.59	84.8%	8.0	3.9	353	0.0114	3.4	67.0	2.7	13.4	16.1	76.0%	8.8%
21-Apr-94	59860	97	415620	627	724	7.46	86.6%	7.5	3.2	31	0.0008	1.7	27.5	2.8	17.5	20.3	26.2%	60.4%
28-Apr-94	60730	124	420040	631	756	6.08	83.6%	8.2	4.1	261	0.0090	4.3	69.0	2.0	18.2	20.2	70.7%	12.8%
5-May-94	61280	79	424500	637	716	9.11	89.0%	8.6	2.6	55	0.0012	1.0	54.5	1.8	21.3	23.1	57.6%	31.4%
12-May-94	61980	100	429010	644	744	7.44	86.6%	9.1	3.3	181	0.0050	3.3	68.2	2.6	19.8	22.4	67.2%	19.4%
19-May-94	62480	71	433530	646	717	10.04	90.0%	10.0	2.4	118	0.0023	1.3	51.1	1.6	19.1	20.7	59.5%	30.5%
26-May-94	63200	103	438020	641	744	7.24	86.2%	11.2	3.4	123	0.0035	4.7	46.0	2.0	15.7	17.7	61.5%	24.7%
2-Jun-94	63720	74	442520	643	717	9.65	89.6%	11.8	2.5	112	0.0023	4.1	63.1	3.0	13.2	16.2	74.3%	15.3%
9-Jun-94	64390	96	447020	643	739	7.72	87.0%	12.8	3.2	219	0.0058	3.0	54.6	2.0	13.2	15.2	72.2%	14.9%
16-Jun-94	65030	91	451420	629	720	7.88	87.3%	13.8	3.0	64	0.0016	2.9	21.8	2.5	11.3	13.8	36.7%	50.6%
23-Jun-94	65686	94	455743	618	711	7.59	86.8%	N/A	3.1	160	0.0042	2.9	47.7	2.7	13.0	15.7	67.1%	19.7%
30-Jun-94	66230	78	459980	605	683	8.79	88.6%	15.3	2.6	288	0.0062	4.0	59.2	2.6	12.3	14.9	74.8%	13.8%
Average over data period spring/summer		95		635	730	7.67	87.0%	10.6	3.2	164	0.0043	3.1	52.5	2.4	15.7	18.0	65.7%	21.3%

TABLE 4

SYSTEM No. 4 FLOW AND NITROGEN REMOVAL DATA

Date	F.F. Meter Reading	Interval F.F. rate (gpd)	Recirc. Meter Reading	Interval Recirc. Flow (gpd)	Interval Total Flow rate (gpd)	Interval Recirc. Rate	Percent Flow to Recirc.	Effluent Temp. Deg. C	Interval F.F. Filter HLR (gal/s.f./day)	Organic Loading: Influent BOD (mg/L)	Organic Loading: OLR (lb/s.f./day)	Organic Loading: Effluent BOD (mg/L)	Influent Total N (mg/L)	Effluent Nitrogen: TKN (mg/L)	Effluent Nitrogen: Nitrate (mg/L)	Effluent Nitrogen: Total N (mg/L)	Total N Removal Rate (%)	% Recirc. minus % Denit.
20-Aug-92	wastewater flow into system started																	
25-Aug-92	705		831	recirculation started				16.0		221		30.7	115.5	114.7	0.0	114.7	N/A	
3-Sep-92	1284	64	5810	553	618	9.60	89.6%	N/A	2.1	87	0.0016	18.6	126.1	124.8	1.7	126.5	-0.3%	89.9%
8-Sep-92	1575	58	10244	887	945	16.24	93.8%	15.0	1.9	235	0.0038	2.6	128.0	57.7	11.1	68.8	46.3%	47.6%
14-Sep-92	2045	78	14111	645	723	9.23	89.2%	15.0	2.6	420	0.0092	12.9	129.2	65.1	50.4	115.5	10.6%	78.6%
21-Sep-92	2416	53	18815	672	725	13.68	92.7%	15.0	1.8	437	0.0064	10.9	118.7	21.9	96.0	117.9	0.7%	92.0%
28-Sep-92	2804	55	23442	661	716	12.93	92.3%	13.0	1.8	463	0.0071	7.7	100.3	4.1	65.0	69.1	31.1%	61.2%
5-Oct-92	2994	27	28176	676	703	25.92	96.1%	13.0	0.9	352	0.0027	3.5	133.3	3.1	66.7	69.8	47.6%	48.5%
12-Oct-92	3373	54	32875	671	725	13.40	92.5%	12.0	1.8	1097	0.0165	4.2	116.3	4.3	38.9	43.2	62.9%	29.7%
19-Oct-92	3761	55	37550	668	723	13.05	92.3%	10.0	1.8	411	0.0063	12.2	144.4	3.3	40.0	43.3	70.0%	22.3%
Average over data period summer/fall since recirc. startup		56		668	723	13.02	92.3%	13.3	1.9	438	0.0068	9.1	124.5	35.5	46.2	81.8	34.3%	58.0%
2-Nov-92	4340	41	46925	3351	3392	82.02	98.8%	8.0	1.4	271	0.0031	2.4	137.0	2.5	60.3	62.8	54.2%	44.6%
9-Nov-92	4604	38	51614	670	708	18.76	94.7%	9.0	1.3	253	0.0027	1.2	145.4	2.7	59.1	61.8	57.5%	37.2%
16-Nov-92	4770	24	56283	667	691	29.13	96.6%	7.0	0.8	329	0.0022	3.6	117.0	3.0	69.7	72.7	37.9%	58.7%
23-Nov-92	5162	56	60925	663	719	12.84	92.2%	7.0	1.9	275	0.0043	2.1	144.7	4.5	71.9	76.4	47.2%	45.0%
3-Dec-92	5558	40	67535	661	701	17.69	94.3%	4.0	1.3	241	0.0027	11.1	133.9	4.6	68.8	73.4	45.2%	49.2%
7-Dec-92	5756	50	70189	664	713	14.40	93.1%	5.0	1.7	406	0.0056	4.3	135.7	3.6	66.2	69.8	48.6%	44.5%
14-Dec-92	5954	28	74794	658	686	24.26	95.9%	4.2	0.9	226	0.0018	10.1	145.1	2.6	70.0	72.6	50.0%	45.9%
4-Jan-93	N/A	N/A	88568	656	N/A	N/A	N/A	3.0	N/A	242	N/A	4.1	170.8	3.4	68.3	71.7	58.0%	N/A
11-Jan-93	N/A	N/A	93118	650	N/A	N/A	N/A	2.0	N/A	501	N/A	2.2	175.1	3.0	76.4	79.4	54.7%	N/A
18-Jan-93	7002	30	97622	643	673	22.49	95.6%	2.0	1.0	961	0.0080	2.8	178.5	3.7	68.0	71.7	59.8%	35.7%
25-Jan-93	7529	75	102130	644	719	9.55	89.5%	2.4	2.5	502	0.0105	28.8	120.9	12.8	14.9	27.7	77.1%	12.4%
1-Feb-93	7757	33	106533	629	662	20.31	95.1%	2.0	1.1	264	0.0024	6.3	125.6	5.7	18.9	24.6	80.4%	14.7%
8-Feb-93	N/A	N/A	109970	491	N/A	N/A	N/A	2.0	N/A	416	N/A	4.2	154.7	6.0	23.1	29.1	81.2%	N/A
15-Feb-93	9421	119	115352	769	888	7.47	86.6%	2.0	4.0	165	0.0055	6.5	84.9	4.6	4.3	8.9	89.5%	-2.9%
25-Feb-93	effluent line frozen		121641	629	N/A	N/A	N/A	N/A	N/A	901	N/A	10.9	146.1	2.4	11.4	13.8	90.6%	N/A
1-Mar-93	N/A	N/A	124158	629	N/A	N/A	N/A	2.0	N/A	1186	N/A	12.8	116.5	4.6	1.3	5.9	94.9%	N/A
8-Mar-93	N/A	N/A	128660	643	N/A	N/A	N/A	2.0	N/A	1517	N/A	0.1	132.6	8.6	6.5	15.1	88.6%	N/A
15-Mar-93	N/A	N/A	132356	528	N/A	N/A	N/A	1.0	N/A	133	N/A	11.9	92.1	3.5	5.6	9.1	90.1%	N/A
22-Mar-93	N/A	N/A	136760	629	N/A	N/A	N/A	0.1	N/A	541	N/A	7.3	146.9	3.7	6.3	10.0	93.2%	N/A
29-Mar-93	10738	N/A	141272	645	N/A	N/A	N/A	2.0	N/A	778	N/A	8.8	110.8	3.6	6.7	10.3	90.7%	N/A
Average over data period winter		48		644	692	14.54	93.1%	3.5	1.6	505	0.0067	7.1	135.7	4.5	38.9	43.3	68.1%	25.1%
5-Apr-93	11531	113	145687	631	744	6.57	84.8%	2.0	3.8	695	0.0219	15.0	127.1	4.1	6.9	11.0	91.3%	-6.6%
12-Apr-93	11737	29	150040	622	651	22.13	95.5%	2.0	1.0	573	0.0047	10.2	186.5	3.1	7.1	10.2	94.5%	1.0%
19-Apr-93	12167	61	154327	612	674	10.97	90.9%	2.0	2.0	653	0.0112	10.0	154.7	4.0	8.4	12.4	92.0%	-1.1%
26-Apr-93	12366	28	158592	609	638	22.43	95.5%	3.0	0.9	473	0.0037	7.8	136.9	3.1	7.1	10.2	92.5%	3.0%
3-May-93	12679	45	162860	610	654	14.64	93.2%	N/A	1.5	522	0.0065	5.9	228.0	3.5	9.3	12.8	94.4%	-1.2%
10-May-93	12883	29	167001	592	621	21.30	95.3%	N/A	1.0	709	0.0057	6.7	172.2	3.7	5.8	9.5	94.5%	0.8%
17-May-93	13088	29	171100	586	615	21.00	95.2%	N/A	1.0	1486	0.0121	10.4	150.5	3.9	8.9	12.8	91.5%	3.7%

TABLE 4

SYSTEM No. 4 FLOW AND NITROGEN REMOVAL DATA

Date	F.F. Meter Reading	Interval F.F. rate (gpd)	Recirc. Meter Reading	Interval Recirc. Flow (gpd)	Interval Total Flow rate (gpd)	Interval Recirc. Rate	Percent Flow to Recirc.	Effluent Temp. Deg. C	Interval F.F. Filter HLR (gal/s.f./day)	Organic Loading: Influent BOD (mg/L)	Organic Loading: OLR (lb/s.f./day)	Organic Loading: Effluent BOD (mg/L)	Influent Total N (mg/L)	Effluent Nitrogen: TKN (mg/L)	Effluent Nitrogen: Nitrate (mg/L)	Effluent Nitrogen: Total N (mg/L)	Total N Removal Rate (%)	% Recirc. minus % Denit.
24-May-93	13490	57	175160	580	637	11.10	91.0%	7.0	1.9	151	0.0024	7.4	149.5	3.7	8.5	12.2	91.8%	-0.8%
7-Jun-93	14360	62	182979	559	621	9.99	90.0%	9.0	2.1	274	0.0047	4.6	128.2	3.5	11.6	15.1	88.2%	1.8%
14-Jun-93	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	758	N/A	7.6	151.6	5.4	14.3	19.7	87.0%	N/A
21-Jun-93	15576	87	190846	562	649	7.47	86.6%	10.0	2.9	414	0.0100	8.8	98.9	2.3	17.3	19.6	80.2%	6.4%
28-Jun-93	16409	119	194700	551	670	5.63	82.2%	11.0	4.0	931	0.0308	31.0	102.0	11.9	11.8	23.7	76.8%	5.5%
6-Jul-93	17214	101	198886	523	624	6.20	83.9%	13.0	3.4	871	0.0244	12.6	126.8	7.1	13.4	20.5	83.8%	0.0%
12-Jul-93	17955	124	201936	508	632	5.12	80.5%	13.0	4.1	818	0.0281	78.4	126.7	10.2	4.3	14.5	88.6%	-8.1%
19-Jul-93	18615	94	205339	486	580	6.16	83.8%	14.0	3.1	2671	0.0701	23.9	127.8	9.3	15.8	25.1	80.4%	3.4%
26-Jul-93	19432	117	208742	486	603	5.17	80.6%	15.0	3.9	904	0.0294	20.1	123.1	8.4	10.9	19.3	84.3%	-3.7%
2-Aug-93	20044	87	212058	474	561	6.42	84.4%	15.0	2.9	1195	0.0291	31.4	108.5	10.0	1.0	11.0	89.9%	-5.4%
9-Aug-93	20865	117	215259	457	575	4.90	79.6%	15.0	3.9	1127	0.0368	31.4	104.8	13.7	0.7	14.4	86.3%	-6.7%
16-Aug-93	21711	121	218340	440	561	4.64	78.5%	16.0	4.0	1381	0.0464	43.6	24.3	16.9	0.5	17.4	28.4%	50.1%
23-Aug-93	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1434	N/A	65.1	118.0	14.1	0.5	14.6	87.6%	N/A
30-Aug-93	22994	92	224396	433	524	5.72	82.5%	N/A	3.1	1231	0.0314	14.0	161.6	9.0	5.7	14.7	90.9%	-8.4%
7-Sep-93	23607	77	227855	432	509	6.64	84.9%	N/A	2.6	926	0.0197	10.3	181.5	8.7	11.2	19.9	89.0%	-4.1%
13-Sep-93	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1300	N/A	6.2	180.8	5.7	17.2	22.9	87.3%	N/A
20-Sep-93	24415	62	233071	401	463	7.46	86.6%	N/A	2.1	1106	0.0191	7.0	176.0	4.8	17.0	21.8	87.6%	-1.0%
27-Sep-93	24826	59	235849	397	456	7.76	87.1%	N/A	2.0	1006	0.0164	2.9	168.1	4.7	16.4	21.1	87.4%	-0.3%
4-Oct-93	25240	59	238533	383	443	7.48	86.6%	N/A	2.0	814	0.0134	5.2	146.3	4.8	17.3	22.1	84.9%	1.7%
11-Oct-93	25655	59	241158	375	434	7.33	86.3%	N/A	2.0	703	0.0116	9.0	122.2	6.4	16.3	22.7	81.4%	4.9%
18-Oct-93	26063	58	243742	369	427	7.33	86.4%	N/A	1.9	454	0.0074	5.3	116.1	3.6	14.2	17.8	84.7%	1.7%
25-Oct-93	26471	58	246386	378	436	7.48	86.6%	N/A	1.9	548	0.0089	5.2	95.1	4.0	12.7	16.7	82.4%	4.2%
Average over data period spring/summer/fall		75		496	571	7.62	86.9%	9.8	2.5	901	0.0188	17.1	137.7	6.7	10.1	16.7	87.8%	-1.0%
1-Nov-93	26890	60	248937	364	424	7.09	85.9%	N/A	2.0	423	0.0070	4.7	92.8	5.1	12.5	17.6	81.0%	4.9%
8-Nov-93	27309	60	251538	372	431	7.21	86.1%	N/A	2.0	436	0.0073	4.0	115.4	4.1	11.5	15.6	86.5%	-0.4%
15-Nov-93	27503	28	254171	376	404	14.57	93.1%	N/A	0.9	458	0.0035	4.6	103.2	3.8	10.9	14.7	85.8%	7.4%
22-Nov-93	N/A	N/A	N/A	N/A	N/A	N/A	N/A	8.0	N/A	372	N/A	2.3	109.9	3.5	9.9	13.4	87.8%	N/A
29-Nov-93	28554	75	259645	391	466	6.21	83.9%	8.0	2.5	390	0.0081	6.3	68.1	4.8	10.8	15.6	77.1%	6.8%
6-Dec-93	28968	59	262622	425	484	8.19	87.8%	8.0	2.0	312	0.0051	3.4	76.6	2.8	9.3	12.1	84.2%	3.6%
13-Dec-93	29410	63	267500	697	760	12.04	91.7%	N/A	2.1	1021	0.0179	10.3	62.7	3.8	6.1	9.9	84.2%	7.5%
20-Dec-93	30020	87	272662	737	825	9.46	89.4%	8.0	2.9	455	0.0110	4.3	68.7	1.8	7.0	8.8	87.2%	2.2%
27-Dec-93	30443	60	277738	725	786	13.00	92.3%	N/A	2.0	360	0.0061	4.3	91.7	0.6	4.8	5.4	94.1%	-1.8%
3-Jan-94	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	277	N/A	5.5	81.1	1.2	4.2	5.4	93.3%	N/A
10-Jan-94	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	546	N/A	11.0	146.7	0.9	4.5	5.4	96.3%	N/A
24-Jan-94	31650	43	298862	754	798	18.50	94.6%	6.0	1.4	676	0.0081	2.8	137.1	2.1	2.7	4.8	96.5%	-1.9%
7-Feb-94	32270	44	309710	775	819	18.50	94.6%	4.0	1.5	947	0.0117	5.0	171.0	2.9	7.8	10.7	93.7%	0.9%
14-Feb-94	32680	59	315080	767	826	14.10	92.9%	N/A	2.0	901	0.0147	5.1	162.6	3.2	8.2	11.4	93.0%	-0.1%
21-Feb-94	33110	61	321210	876	937	15.26	93.4%	5.0	2.0	886	0.0151	5.0	132.0	3.2	9.9	13.1	90.1%	3.4%
28-Feb-94	effluent line frozen		N/A	N/A	N/A	N/A	N/A	6.0	N/A	107	N/A	1.2	106.5	2.5	16.0	18.5	82.6%	N/A
7-Mar-94	N/A	N/A	N/A	N/A	N/A	N/A	N/A	11.0	N/A	916	N/A	8.1	178.2	2.5	7.7	10.2	94.3%	N/A
14-Mar-94	N/A	N/A	336420	724	N/A	N/A	N/A	7.0	N/A	534	N/A	18.4	114.9	6.8	1.2	8.0	93.0%	N/A

TABLE 4

SYSTEM No. 4 FLOW AND NITROGEN REMOVAL DATA

Date	F.F. Meter Reading	Interval F.F. rate (gpd)	Recirc. Meter Reading	Interval Recirc. Flow (gpd)	Interval Total Flow rate (gpd)	Interval Recirc. Rate	Percent Flow to Recirc.	Effluent Temp. Deg. C	Interval F.F. Filter HLR (gal/s.f./day)	Organic Loading			Influent Total N (mg/L)	Effluent Nitrogen			Total N Removal Rate (%)	% Recirc. minus % Denit.
										Influent BOD (mg/L)	OLR (lb/s.f./day)	Effluent BOD (mg/L)		TKN (mg/L)	Nitrate (mg/L)	Total N (mg/L)		
21-Mar-94	44620	N/A	341770	764	N/A	N/A	N/A	11.0	N/A	878	N/A	3.9	198.3	1.1	6.9	8.0	96.0%	N/A
28-Mar-94	45120	71	346980	744	816	11.42	91.2%	6.0	2.4	541	0.0107	3.4	138.3	1.5	8.2	9.7	93.0%	-1.7%
Average over data period winter		56		653	709	12.71	92.1%	7.3	1.9	572	0.0089	5.7	117.8	2.9	8.0	10.9	90.7%	1.4%
4-Apr-94	45530	59	352160	740	799	13.63	92.7%	6.0	2.0	1951	0.0318	7.9	151.6	2.1	10.7	12.8	91.6%	1.1%
11-Apr-94	45940	59	357150	713	771	13.17	92.4%	6.0	2.0	1733	0.0282	4.9	119.4	1.9	5.4	7.3	93.9%	-1.5%
18-Apr-94	46350	59	361920	681	740	12.63	92.1%	6.5	2.0	1538	0.0251	6.6	130.5	1.2	2.8	4.0	96.9%	-4.8%
25-Apr-94	46550	29	366490	653	681	23.85	95.8%	7.1	1.0	2221	0.0177	5.0	126.4	1.7	4.7	6.4	94.9%	0.9%
2-May-94	46960	59	370980	641	700	11.95	91.6%	7.6	2.0	1321	0.0215	4.0	128.2	0.4	5.9	6.3	95.1%	-3.5%
9-May-94	47370	59	375400	631	690	11.78	91.5%	8.2	2.0	1494	0.0243	3.8	121.7	3.9	7.3	11.2	90.8%	0.7%
16-May-94	47580	30	379740	620	650	21.67	95.4%	8.9	1.0	1005	0.0084	4.6	129.6	1.4	8.9	10.3	92.1%	3.3%
23-May-94	48000	60	383960	603	663	11.05	90.9%	10.2	2.0	484	0.0081	7.1	120.8	1.9	11.4	13.3	89.0%	2.0%
31-May-94	48810	101	388780	603	704	6.95	85.6%	11.3	3.4	634	0.0179	12.9	114.1	5.0	3.2	8.2	92.8%	-7.2%
6-Jun-94	49270	77	392350	595	672	8.76	88.6%	11.8	2.6	1231	0.0263	7.0	104.6	4.7	10.3	15.0	85.7%	2.9%
13-Jun-94	49488	31	396536	598	629	20.20	95.0%	12.4	1.0	691	0.0060	5.2	137.9	4.2	11.1	15.3	88.9%	6.1%
20-Jun-94	50210	103	400690	593	697	6.75	85.2%	13.6	3.4	1486	0.0426	19.4	140.7	9.1	2.3	11.4	91.9%	-6.7%
27-Jun-94	50840	90	404860	596	686	7.62	86.9%	16.0	3.0	981	0.0246	7.9	138.5	9.8	6.4	16.2	88.3%	-1.4%
Average over data period spring		63		636	699	11.12	91.0%	9.7	2.1	1290	0.0226	7.4	128.0	3.6	7.0	10.6	91.7%	-0.7%

TABLE 5

SYSTEM No. 5 FLOW AND NITROGEN REMOVAL DATA

Date	F.F. Meter Reading	Interval F.F. rate (gpd)	Recirc. Meter Reading	Interval Recirc. Flow (gpd)	Interval Total Flow rate (gpd)	Interval Recirc. Rate	Percent Flow to Recirc.	Effluent Temp. Deg. C	Interval F.F. Filter HLR (gal/s.f./day)	Organic Loading: Influent BOD (mg/L)	Organic Loading: OLR (lb/s.f./day)	Organic Loading: Effluent BOD (mg/L)	Influent Total N (mg/L)	Effluent Nitrogen: TKN (mg/L)	Effluent Nitrogen: Nitrate (mg/L)	Effluent Nitrogen: Total N (mg/L)	Total N Removal Rate (%)	% Recirc. minus % Denit.
13-Sep-93	56830		165446															
20-Sep-93	57326	71	168330	412	483	6.81	85.3%	N/A	2.0	169	0.0033	2.4	54.1	1.0	12.6	13.6	74.9%	10.5%
27-Sep-93	58266	134	171278	421	555	4.14	75.8%	N/A	3.7	127	0.0047	1.9	51.0	0.5	10.3	10.8	78.8%	-3.0%
4-Oct-93	59279	145	174212	419	564	3.90	74.3%	N/A	4.0	168	0.0068	3.0	51.1	0.7	13.0	13.7	73.2%	1.1%
11-Oct-93	59777	71	177217	429	500	7.03	85.8%	N/A	2.0	113	0.0022	5.7	45.7	0.8	11.1	11.9	74.0%	11.8%
18-Oct-93	60751	139	180271	436	575	4.14	75.8%	N/A	3.9	134	0.0052	3.2	49.3	0.8	11.3	12.1	75.5%	0.4%
25-Oct-93	61469	103	183480	458	561	5.47	81.7%	N/A	2.8	150	0.0043	3.1	49.9	1.1	9.4	10.5	79.0%	2.8%
Average over data period summer/fall		110		429	540	4.89	79.5%	N/A	3.1	144	0.0044	3.2	50.2	0.8	11.3	12.1	75.9%	3.7%
1-Nov-93	62188	103	186604	446	549	5.34	81.3%	N/A	2.9	147	0.0042	7.0	22.6	1.2	10.0	11.2	50.4%	30.8%
8-Nov-93	63117	133	189818	459	592	4.46	77.6%	N/A	3.7	181	0.0067	4.6	74.0	0.8	11.2	12.0	83.8%	-6.2%
15-Nov-93	64146	147	193049	462	609	4.14	75.8%	N/A	4.1	209	0.0085	4.6	56.3	2.2	13.7	15.9	71.8%	4.1%
22-Nov-93	65340	171	196294	464	634	3.72	73.1%	8.0	4.7	117	0.0056	3.5	44.7	1.2	10.9	12.1	72.9%	0.2%
29-Nov-93	66577	177	199487	456	633	3.58	72.1%	8.0	4.9	177	0.0087	3.5	57.4	1.0	9.3	10.3	82.1%	-10.0%
6-Dec-93	67599	146	202915	490	636	4.35	77.0%	8.0	4.1	218	0.0089	7.2	65.4	4.2	13.0	17.2	73.7%	3.3%
13-Dec-93	68260	94	208030	731	825	8.74	88.6%	N/A	2.6	167	0.0044	6.2	60.9	1.3	9.6	10.9	82.1%	6.5%
20-Dec-93	69710	207	213231	743	950	4.59	78.2%	7.2	5.8	132	0.0076	2.8	49.1	1.0	8.0	9.0	81.7%	-3.5%
27-Dec-93	71122	202	218425	742	944	4.68	78.6%	N/A	5.6	89	0.0050	13.8	64.5	2.0	12.7	14.7	77.2%	1.4%
10-Jan-94	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	263	N/A	7.1	57.0	1.3	8.2	9.5	83.3%	N/A
24-Jan-94	76670	198	238790	727	925	4.67	78.6%	7.0	5.5	197	0.0109	5.2	34.8	1.5	6.7	8.2	76.4%	2.2%
7-Feb-94	77120	32	248900	722	754	23.47	95.7%	6.0	0.9	64	0.0006	3.5	17.5	1.1	3.9	5.0	71.4%	24.3%
14-Feb-94	77121	0	253980	726	726	5081.00	100.0%	N/A	0.0	72	0.0000	4.7	15.1	2.3	5.9	8.2	45.7%	54.3%
21-Feb-94	77330	30	259770	827	857	28.70	96.5%	3.0	0.8	31	0.0003	2.1	12.0	3.0	8.4	11.4	5.0%	91.5%
28-Feb-94	77530	29	264130	623	651	22.80	95.6%	5.0	0.8	24	0.0002	0.5	14.0	0.8	9.8	10.6	24.3%	71.3%
7-Mar-94	77760	33	269200	724	757	23.04	95.7%	5.0	0.9	11	0.0001	3.6	9.1	1.5	4.9	6.4	29.7%	66.0%
14-Mar-94	77761	0	274260	723	723	5061.00	100.0%	5.0	0.0	1	0.0000	2.2	13.1	1.0	6.8	7.8	40.5%	59.5%
21-Mar-94	77762	0	279320	723	723	5061.00	100.0%	5.0	0.0	55	0.0000	1.6	8.7	0.8	7.1	7.9	9.2%	90.8%
28-Mar-94	78450	98	284330	716	814	8.28	87.9%	5.0	2.7	178	0.0049	7.1	22.7	1.8	9.8	11.6	48.9%	39.0%
Average over data period winter		133		655	788	5.91	83.1%	6.0	3.7	123	0.0046	4.8	36.8	1.6	8.9	10.5	71.4%	11.7%
4-Apr-94	79250	114	289240	701	816	7.14	86.0%	5.0	3.2	199	0.0063	2.1	45.5	0.6	13.2	13.8	69.7%	16.3%
11-Apr-94	80830	226	294100	694	920	4.08	75.5%	6.0	6.3	109	0.0068	3.7	59.8	1.7	20.1	21.8	63.5%	11.9%
18-Apr-94	82060	176	298900	686	861	4.90	79.6%	5.4	4.9	102	0.0050	9.8	35.4	1.0	20.5	21.5	39.3%	40.3%
25-Apr-94	83010	136	303700	686	821	6.05	83.5%	5.7	3.8	179	N/A	6.8	48.2	0.7	12.1	12.8	73.4%	10.0%
2-May-94	84030	146	308470	681	827	5.68	82.4%	6.1	4.0	144	0.0058	2.5	51.1	0.6	13.1	13.7	73.2%	9.2%
9-May-94	84950	131	313210	677	809	6.15	83.7%	6.7	3.7	806	0.0295	3.1	68.1	0.6	14.5	15.1	77.8%	5.9%
16-May-94	85340	56	317900	670	726	13.03	92.3%	7.4	1.5	655	0.0102	5.6	60.3	1.8	11.0	12.8	78.8%	13.6%
23-May-94	87000	237	322560	666	903	3.81	73.7%	8.4	6.6	1179	0.0778	5.1	59.1	0.8	10.8	11.6	80.4%	-6.6%
31-May-94	88380	173	327850	661	834	4.83	79.3%	9.4	4.8	161	0.0077	7.3	40.3	1.0	9.7	10.7	73.4%	5.9%
6-Jun-94	89060	113	331800	658	772	6.81	85.3%	9.8	3.1	237	N/A	3.9	43.2	0.8	6.3	7.1	83.6%	1.7%
13-Jun-94	90488	204	336335	648	852	4.18	76.1%	10.6	5.7	219	N/A	12.8	37.4	1.3	7.2	8.5	77.3%	-1.2%

TABLE 5

SYSTEM No. 5 FLOW AND NITROGEN REMOVAL DATA

Date	F.F. Meter Reading	Interval F.F. rate (gpd)	Recirc. Meter Reading	Interval Recirc. Flow (gpd)	Interval Total Flow rate (gpd)	Interval Recirc. Rate	Percent Flow to Recirc.	Effluent Temp. Deg. C	Interval F.F. Filter HLR (gal/s.f./day)	Organic Loading: Influent BOD (mg/L)	Organic Loading: OLR (lb/s.f./day)	Organic Loading: Effluent BOD (mg/L)	Influent Total N (mg/L)	Effluent Nitrogen: TKN (mg/L)	Effluent Nitrogen: Nitrate (mg/L)	Effluent Nitrogen: Total N (mg/L)	Total N Removal Rate (%)	% Recirc. minus % Denit.
20-Jun-94	91420	133	340750	631	764	5.74	82.6%	11.4	3.7	331	0.0123	9.3	42.5	1.2	7.6	8.8	79.3%	3.3%
27-Jun-94	92580	166	345100	621	787	4.75	78.9%	12.2	4.6	91	0.0042	5.1	18.6	0.8	10.0	10.8	41.9%	37.0%
Average over data period spring		155		668	823	5.30	81.1%	8.0	4.3	339	0.0147	5.9	46.9	1.0	12.0	13.0	72.3%	8.9%