Pennsylvania Onlot Technology Verification Program

Final Evaluation Report

Orenco Systems, Inc.
AdvanTex® AX20N Treatment Unit

Commonwealth of Pennsylvania

Department of Environmental Protection

NSF International

Report Prepared by:

NSF International
Ann Arbor, Michigan

Final Evaluation Report
Pennsylvania Onlot Technology Verification Program

Orenco Systems, Inc.
AdvanTex® AX20N

Prepared for:

The Pennsylvania Department of Environmental Protection
Harrisburg, Pennsylvania

Prepared by:

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Ann Arbor, Michigan

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Acronyms and Abbreviations

ANSI	American National Standards Institute
BOD_5	Five-day biochemical oxygen demand
$CBOD_5$	Five-day carbonaceous biochemical oxygen demand
°C	Celsius degrees
CFU	Colony forming units
gal	Gallons
gpd	Gallon(s) per day
L	Liters
NA	Not applicable
ND	Non-detect
NH_3	Ammonia nitrogen – expressed as mg/L as N
NO_2	Nitrite – expressed as mg/L as N
NO_3	Nitrate – expressed as mg/L as N
NO_x	Sum of nitrate and nitrite nitrogen
mg/L	Milligram(s) per liter
mL	Milliliter(s)
NSF	NSF International
NTU	Nephelometric Turbidity Units
O&M	Operation and maintenance
PADEP	Pennsylvania Department of Environmental Protection
QA	Quality assurance
QAPP	Quality assurance project plan
QC	Quality control
RPD	Relative Percent Difference
SOP	Standard operating procedure
S.U.	Standard units
TKN	Total Kjeldahl nitrogen – expressed as mg/L as N
TN	Total nitrogen – sum of TKN, NO_2 and NO_3 – expressed as mg/L as N
TSS	Total suspended solids
UV	Ultra-violet

Executive Summary

The purpose of this project was to field verify the performance of the AdvanTex® AX20N residential wastewater treatment system manufactured by Orenco Systems, Incorporated. The Pennsylvania Onlot Technology Verification Program addresses verification of all proprietary and non-proprietary components of an experimental onlot sewage system, as defined and regulated under Pennsylvania regulations (Chapter 73; Standards For Onlot Sewage Treatment Facilities), that are reproducible from one location to another. The program consists of an application, test center certification and field verification phases.

The AdvanTex System has been evaluated by NSF International at a qualified testing center under NSF/ANSI Standard 40, and is currently classified as a Class I unit. The overall mean performance from the system during the NSF/ANSI Standard 40 test was 5 mg/L $CBOD_5$, 4 mg/L TSS, and 4 NTU turbidity. Orenco elected to collect influent and effluent nitrogen samples during a portion of the NSF/ANSI Standard 40 test and for several months following completion of the test. A total of seven months of data was collected. Over that time frame, the AdvanTex System (Mode 1 configuration) reduced total nitrogen by 64%.

The Orenco AdvanTex AX20N was installed and tested at eleven sites across the State of Pennsylvania. Field sites were selected based on the intended use of the technology. Each site was tested for a minimum of twelve months (with nine of the eleven sites being tested for two to three years) to evaluate the variations in the effluent quality that are likely to occur based on the influent sewage strength, flow rate and temperature. Effluent samples were collected monthly and analyzed for specific parameters outlined in the quality assurance project plan (QAPP), including the typical wastewater measurements ($CBOD_5$, TSS, turbidity, alkalinity, nitrogen species, fecal coliform, pH and temperature).

Influent samples were collected weekly for four weeks prior to effluent sampling to establish a baseline influent waste strength concentration. Following the effluent sampling, influent waste strength was also monitored for four weeks to establish a baseline. It was also useful to document the rate at which the primary compartment reverted back to its anaerobic state.

Over the course of the field evaluation the mean effluent $CBOD_5$ was 6 mg/L and the mean effluent total suspended solids was 10 mg/L. The mean influent total nitrogen was 44 mg/L and the mean effluent total nitrogen was 17 mg/L, representing a 61% reduction. The median effluent $CBOD_5$ was 4 mg/L and the median effluent total suspended solids was 5 mg/L. The median effluent total nitrogen was 16 mg/L.

Chapter 1 Introduction

It is the policy of the Pennsylvania Department of Environmental Protection (PADEP) to evaluate concepts or technologies new to Pennsylvania that are applicable to onlot wastewater disposal. It is necessary that such evaluations be consistently applied and impartially conducted by a nationally recognized, independent third party organization, following nationally recognized protocols. This testing will assist PADEP staff and local Sewage Enforcement Officers (SEOs) in determining the expected performance of new onlot wastewater technologies for the purpose of design, permitting and operation.

Field verification testing of the Orenco AdvanTex AX20N treatment system was conducted across the state of Pennsylvania at residential sites, where the technology would typically be used. The selection of representative sites and a minimum year-long test period served to capture variations in the effluent quality that may have occurred based on the residential sewage strength, flow rate and seasonal temperature fluctuations. Each site was chosen based on a collaborative effort between PADEP and Orenco.

The AdvanTex system was installed and tested at a total of eleven representative sites across the State of Pennsylvania.

1.1 Project Objectives

The Pennsylvania verification program consists of test center certification and field verification phases. The Orenco AdvanTex AX20N treatment system was evaluated by NSF International at a qualified testing center under NSF/ANSI Standard 40, and is currently certified by NSF as a Class I unit. The purpose of this project was to *field verify* the performance of the AdvanTex AX20N onlot wastewater treatment unit at representative sites across the State of Pennsylvania.

1.2 Testing Process, Test Site and Technology Description

1.2.1 Selection of Test Sites

The selection of each site was based on the intended use of the technology, and the extremes of flow and waste strength that may be expected at the residences. Considerations given during site selection included, but were not limited to: two sites per DEP region, garbage disposal within homes, homes with and without water conservation devices, both public and on-lot water supplies, and number and age of family members. Both new and repaired systems were considered as possible representative sites. Nitrogen sensitive sites and those with shallow soils provided optimal opportunity for demonstration of the performance of the Orenco AdvanTex AX20N.

Table 1-1. Selected Sites

Site #	Site ID	County	Disposal Method
1	SMI4540	York	At-Grade Bed
2	KEN6320	Berks	Stream Discharge
3	LEC6350	Berks	Stream Discharge
4	END6334	Berks	Stream Discharge
5	KRI6360	Berks	Stream Discharge
6	WEI887	Butler	Stream Discharge
7	BRO1000	Westmoreland	Stream Discharge
8	ZAK628	Bucks	Stream Discharge
9	JAC2375	York	At-Grade Bed
10	BRU4380	York	At-Grade Bed
11	HEN40	York	Standard Trench

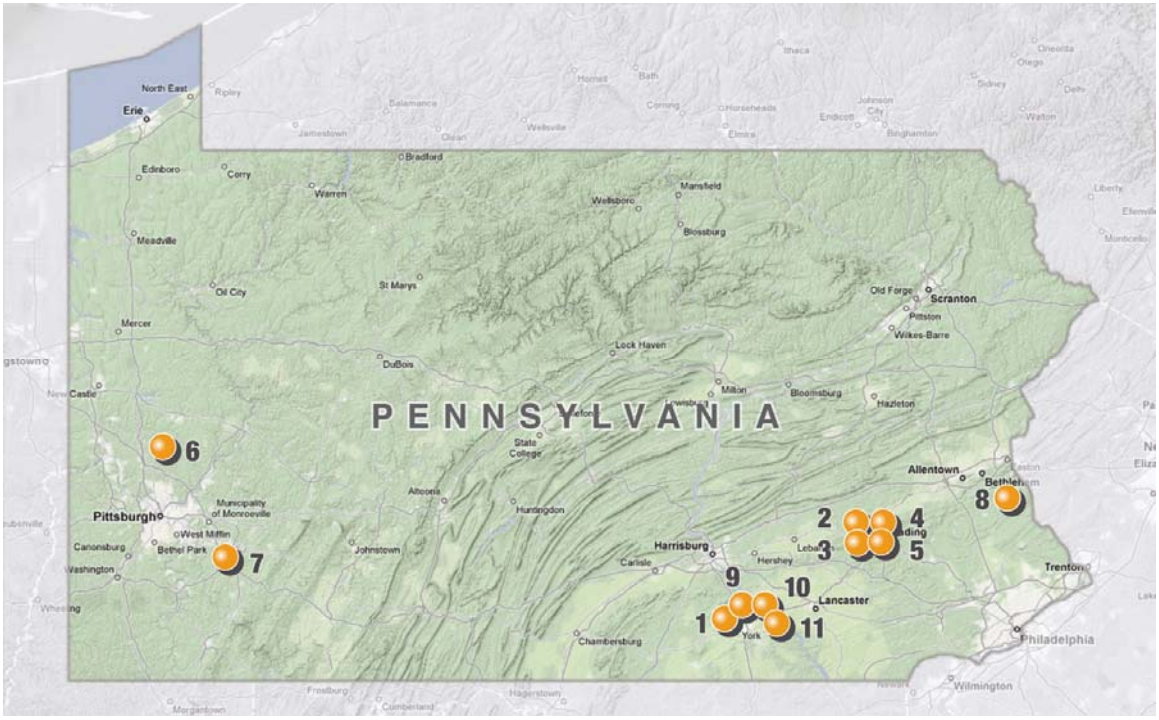

Figure 1-1. Location of Orenco evaluation sites in Pennsylvania.

1.2.2 Test System Construction

Orenco installed the AdvanTex AX20N treatment system at the selected test sites in accordance with their installation instructions. Refer to Figures 1-2 and 1-3 for a process flow and a typical installation of the treatment system.

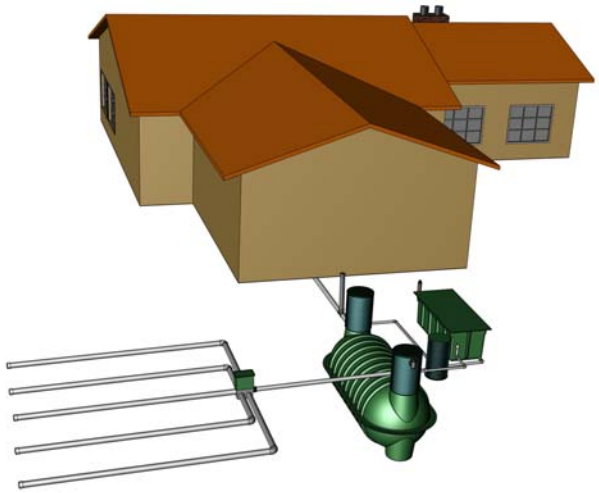

Figure 1-2. AdvanTex process flow diagram.

Figure 1-3. Typical AdvanTex AX20N installation.

1.2.3 Orenco AdvanTex AX20N Treatment System Process Description

The Orenco AdvanTex AX20N is an attached growth multiple pass packed bed reactor. In the packed bed reactor, microorganisms remove soluble contaminants from the wastewater, utilizing them as a source of energy for growth and reproduction. The organic matter is solubilized by various specific extracellular enzymes that break down complex organic molecules (solids) into a soluble state that is readily available to the microorganisms as a food source. The microorganisms primarily responsible for the degradation of the organic and some inorganic matter are aerobic bacteria. As such, the transfer of oxygen into the wastewater is critical to the treatment process. A passive ventilation system is used to provide fresh air to the interior of the packed bed reactor pod.

The layout of the treatment system is shown in Figures 1-4 and 1-5. Raw sewage enters the primary compartment of a 1,500 gallon (gal), two-compartment fiberglass tank, also known as the processing tank. The primary compartment (1,000 gal working volume) provides about 48 hours (hr) retention at the rated capacity. This compartment provides primary treatment; settleable solids accumulate on the bottom and floatable solids accumulate on the surface. Effluent from the clear layer flows into the second compartment of the tank (500 gal volume), which provides about 24 hr retention at the rated capacity. A pump located in a screened pump vault within the second compartment transfers effluent at a predetermined frequency to a manifold. The manifold then distributes the liquid over textile media inside a filter pod in small frequent doses of about 10 gal each. Effluent percolates down through the media and is collected at the bottom of the filter pod. The treated effluent flows by gravity through a pipe to a splitter basin. The splitter basin splits the flow to be recirculated back through the primary compartment or to the secondary compartment of the 1,500 gallon processing tank. When 100% of the filtrate is returned to the primary compartment it is designated as "Mode 3". When configured to return 100% of the filtrate returning to the secondary compartment the system is designated as "Mode 1." The splitter basin can be configured to adjust the percentage of this split between the two compartments from anywhere between 0-100% which is designated as a "Combo Mode." To facilitate influent sampling the system was in the Mode 1 configuration during this sampling period. During periods of effluent sampling the system was in the Combo Mode configuration. The Combo Mode was set so that about 50% of the treated effluent goes back to the primary compartment and 50% goes through the splitter valve to the secondary compartment. During periods of no flow to the system, all of the treated effluent is returned back into the processing tank to be recirculated. Otherwise, approximately 50% of one or more of the treated effluent doses may be discharged, and 50% is recirculated. The target system recirculation ratio is 4:1 with a range of 3:1 to 7:1 based upon actual forward flow. The timer settings are adjusted by the system operator, as needed, depending upon actual forward flow to achieve the correct recirculation ratio. See figures 1-4 and 1-5 below for layout of the treatment system.

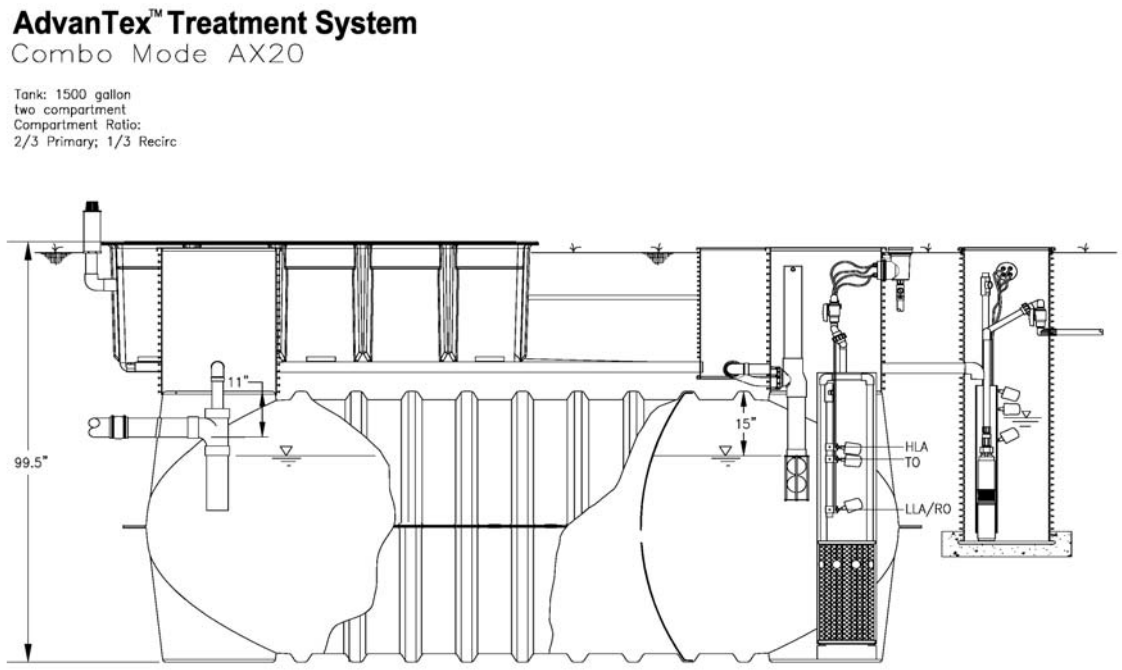

Figure 1-4. Profile of treatment system layout.

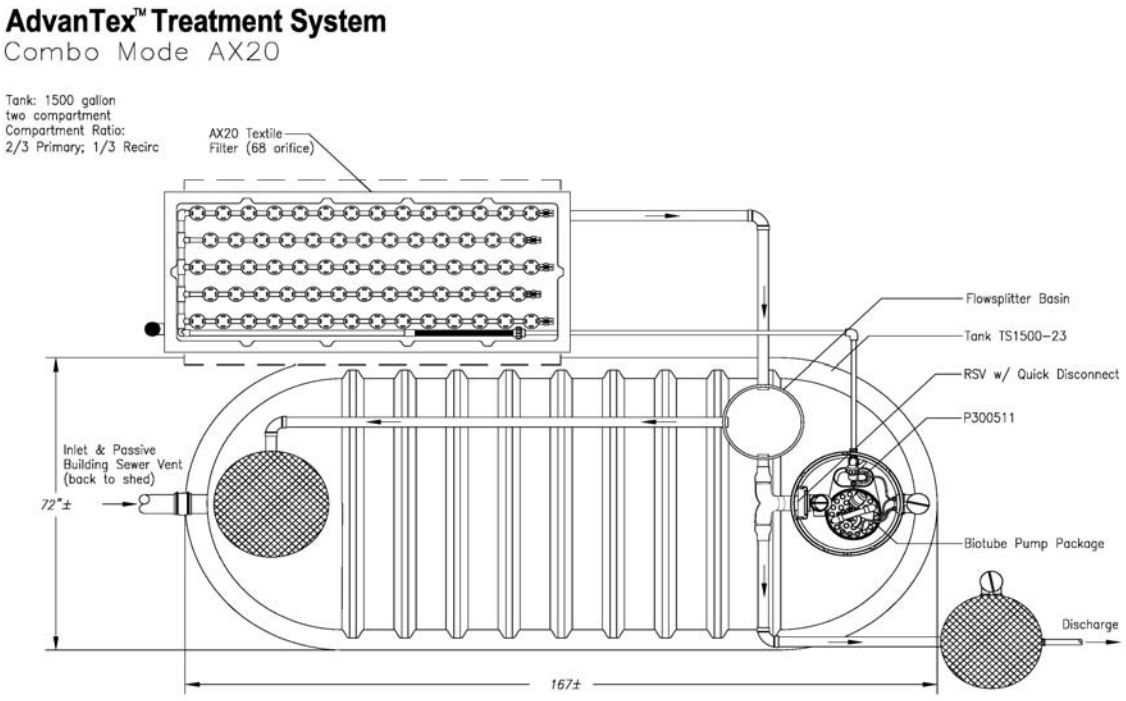

Figure 1-5. Plan view of treatment system layout.

1.3 Key Project Participants

1.3.1 Pennsylvania DEP (PADEP)

The entire technology verification process was coordinated with PADEP. It is the responsibility of PADEP to determine how technologies that complete field verification may be used in Pennsylvania.

The key Pennsylvania DEP contact for this program is:

Mr. John Diehl, Project Officer, PADEP
(717) 783-1820 Email: jdiehl@state.pa.us

Pennsylvania Department of Environmental Protection
10th Floor, Rachel Carson State Office Building
P.O. Box 8466
Harrisburg, PA 17105-8466

1.3.2 Vendor

Orenco Systems, Inc. provided the AdvanTex® AX20N technology and assisted with installation at the selected test sites.

The key contact for Orenco is:

Mr. Sam Carter
1-800-536-4192 Email: scarter@orenco.com

Orenco Systems, Inc.
814 Airway Avenue
Sutherlin, OR 97479

1.3.3 NSF International (NSF)

NSF was responsible for providing oversight during all stages of the project, collecting data, ensuring QA/QC was being met, taking field notes, and preparing this final report.

The key contacts at NSF for this program are:

Mr. Tom Bruursema, General Manager
(734) 769-5575 Email: bruursema@nsf.org

Mr. Tom Stevens, Federal Programs Manager
(734) 769-5347 Email: stevenst@nsf.org

Ms. Adriana Greco-Mastronardi, Certification Project Manager
(734) 913-5754 Email: amastronardi@nsf.org

NSF International
789 N. Dixboro Rd.
Ann Arbor, MI 48105

1.3.4 Laboratory

Benchmark Analytics was the responsible for the sampling and analysis of all field data. The key contact for Benchmark for this project was:

Ms. Stephanie Olexa, Ph.D.
(610) 974-8100

Benchmark Analytics
4777 Saucon Creek Road
Center Valley, PA 18034

1.3.5 Homeowner

The homeowners participating in this project granted permission for involvement in this PADEP program. They agreed to allow their systems to be tested and to participate in operation training provided by Orenco regarding disposal of septic system safe chemicals/products and how to record any unusual events that may affect septic system operation.

Chapter 2 Sampling and Analysis

2.1 Influent Wastewater Collection

The AdvanTex Treatment System is a recirculating packed bed (media) filter that returns a portion of the treated effluent back to the primary compartment to facilitate further denitrification. Because of this, the influent wastewater entering the primary tank is immediately mixed and diluted with processed wastewater making it difficult to collect a representative influent sample to determine influent waste strength. However, to satisfy the State of Pennsylvania's Field Verification Testing requirements a method for verifying influent waste strength was required. To facilitate influent sample collection, the system configuration was operated in Mode 1 during periods of influent sampling. In this mode, the treated effluent was recirculated through the secondary compartment, preventing it from mixing with the incoming raw wastewater.

Raw influent wastewater grab samples were collected during the first and last month of field verification for each site. Samples were taken once a week for four weeks at the start up and at the end of the 12-month testing period. A subsurface grab sampler, as shown in Figure 2-1, was used to pull samples from the clear zone in the primary compartment at the "influent sample" point indicated in Figure 2-2. The sampler is made of high strength aluminum tubing with a polypropylene head and telescopic pole. A 1,000 mL borosilicate glass bottle with a Teflon-lined cap was attached to the end of the pole.

Figure 2-1. Subsurface grab sampler.

The subsurface grab sampler was inserted into the clear zone of the tank, to a depth of 34" as measured from the outside top of the tank. The sampler was manually opened to fill the sample bottle with liquid from this depth. The sampler was then manually closed and withdrawn from the tank. If a scum mat had developed on the surface of the water an opening was made in the scum mat in order to extend the sampler into the clear zone. This method of influent sampling had not been previously tried, so it was unknown how representative the results would be, but was agreed to by all parties as the only efficient way of trying to obtain an influent sample. More discussion about the sampling method and results is detailed later in the report.

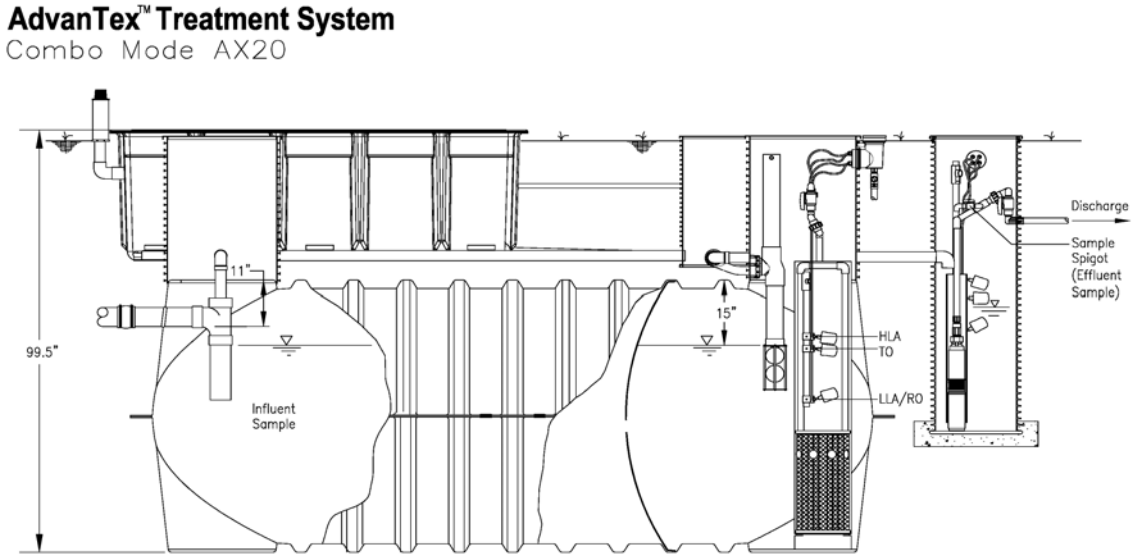

Figure 2-2. Sampling arrangement.

2.2 Final Effluent Collection

Final effluent grab samples were collected once a month for at least a 12-month time period (with nine of the eleven sites being tested for two to three years). Samples were collected from a discharge assembly sample spigot located in the final discharge pump basin following the AdvanTex Treatment System at the point indicated in Figure 2-2. The sample spigot was opened and the discharge pump manually engaged. The sample was collected following approximately 20 seconds of discharge pump operation

2.3 Sampling Frequency and Types

Table 2-1 shows the analyses that were completed during the evaluation, including sample type and location. The frequency of sample collection is shown in Table 2-2. Grab samples for all parameters listed in Table 2-1 were obtained from the influent and effluent wastewater streams at the location shown in Figure 2-2 above. QC samples were taken in the field by drawing a separate sample from the grab sample per sampling event for the monthly samples.

2.4 Sampling Duration

All sites were sampled in accordance with Table 2-1 and 2-2. During the evaluation it was agreed upon by all parties that extended effluent sampling should take place until the last site installed was done with its minimum sampling. For these sites, monthly effluent sampling was continued beyond the second round of weekly influent sampling. Table 2-3 below indicates the total number of months that each site was evaluated and the start up dates for all sites.

Table 2-1. Sampling Type and Location

Parameter	Type	Influent	Effluent
BOD_5	Grab	√	
$CBOD_5$	Grab		√
TSS	Grab	√	√
Alkalinity	Grab	√	√
TKN	Grab	√	√
Ammonia-N	Grab	√	√
NO_3-N	Grab		√
NO_2-N	Grab		√
Fecal Coliform	Grab	√	√
pH	Grab	√	√
Temperature	Grab	√	√
Total Dissolved Oxygen	Grab		√
Turbidity	Grab	√	√

Table 2-2. Sampling Schedule[1]

Sample Number	Sample Source[2]	Elapsed Time	Influent	Effluent
1	I – Week 1	1 week	√	
2	I – Week 2	2 weeks	√	
3	I – Week 3	3 weeks	√	
4	I – Week 4	4 weeks	√	
5	E – Month 1	8 weeks		√
6	E – Month 2	12 weeks		√
7	E – Month 3	16 weeks		√
8	E – Month 4	20 weeks		√
9	E – Month 5	24 weeks		√
10	E – Month 6	28 weeks		√
11	E – Month 7	32 weeks		√
12	E – Month 8	36 weeks		√
13	E – Month 9	40 weeks		√
14	E – Month 10	44 weeks		√
15	E – Month 11	48 weeks		√
16	E – Month 12	52 weeks		√
17	I – Week 1	53 weeks	√	
18	I – Week 2	54 weeks	√	
19	I – Week 3	55 weeks	√	
20	I – Week 4	56 weeks	√	

[1] *Some of the sites were sampled monthly beyond the initial 56-week period as explained in section 2.4.*
[2] *Influent samples designated as "I", effluent samples designated as "E".*

Table 2-3. Sampling Duration

Site ID	Site Number	Start Up Date	Duration (months)
SMI4540	1	9/5/2005	36
KEN6320	2	9/19/2005	35
LEC6350	3	9/25/2005	35
END6334	4	9/25/2005	35
KRI6360	5	9/25/2005	35
WEI887	6	10/27/2005	35
BRO1000	7	5/26/2006	27
ZAK628	8	8/29/2006	24
JAC2375	9	1/19/2007	19
BRU4380	10	9/22/2006	23
HEN40	11	7/26/2007	14

Chapter 3 Testing and Measurement Protocols

The laboratory methods used in analyzing samples during this evaluation are described in Table 3-1. The relevant SOP reference and typical reporting limit for each analysis are also included in the table.

Table 3-1. Analytical Methods, Relevant SOP's and Reporting Limits

Analysis	Reference Method[1]	SOP[2]	Typical Reporting Limit
BOD_5	SM 5210B	MB 015 (C)	2.0 mg/L
$CBOD_5$	SM 5210B		2.0 mg/L
TSS	EPA 160.2	IN 057 (D)	5 mg/L @ 100 mL
Alkalinity	SM 2320B	IN 002	10 mg/L
TKN	EPA 351.2	IN 069	0.1 mg/L
Ammonia-N	EPA 350.1	IN 064 (E)	0.04 mg/L
NO_3-N	EPA 353.2	IN 051	0.02 mg/L
NO_2-N	EPA 353.2	IN 051	0.02 mg/L
Fecal Coliform	SM 9222D	MB 020 (F)	1 CFU/100 mL
pH	SM 4500 H^+-B	MB 040	N/A
Temperature	SM 2550B	IN 091	N/A
Total Dissolved Oxygen	SM 4500 O-G	MB 026	0.1 mg/L
Turbidity	EPA 180.1	IN 042	0.5 NTU

[1] *Methods are detailed in the following documents: (1) APHA, AWWA, and WEF. 1998. Standard Methods for the Examination of Water and Wastewater, 20th Edition. Washington, DC; (2) United States Environmental Protection Agency. Revised 1983. Methods for Chemical Analysis of Water and Wastes, EPA 600/4-79-020; and (3) United States Environmental Protection Agency. 1993. Methods for the Determination of Inorganic Substances in Environmental Samples, EPA/600/R-93-100.*

[2] *Benchmark Analytics SOPs; appendix containing SOP indicated in parentheses.*

Chapter 4 Quality Assurance/Quality Control

4.1 Quality Control Objectives

The primary QA/QC objectives for this test were to ensure that (1) strict methods and procedures were followed during the testing process so the resulting data are valid for use by the Pennsylvania Onlot Technology Verification Program, and (2) the conditions under which data were obtained were properly recorded so as to be directly linked to the data, should a question arise as to their validity.

Treatment results generated by the equipment must be verifiable for the purposes of this program to be fulfilled. High-quality, well-documented analytical laboratory results are essential for meeting the purpose and objectives of this field verification testing. Therefore, the following indicators of data quality shall be closely evaluated to determine the performance of the equipment when measured against data generated by the analytical laboratory. The lab test quality assurance objectives for this evaluation are described in Table 4-1.

Table 4-1. QA Objectives for Precision, Completeness, and Accuracy

Parameter	Analytical Method	Units	Precision (Relative % Difference)	Accuracy (%)
BOD_5	SM 5210B	mg/L	0-20	±25
$CBOD_5$	SM 5210B	mg/L	0-20	±25
TSS	EPA 160.2	mg/L	0-10	N/A
Alkalinity	SM 2320	mg/L as $CaCO_3$	0-10	N/A
TKN	EPA 351.2	mg/L as N	0-10	±20
Ammonia-N	EPA 350.1	mg/L as N	0-10	±20
NO_3	EPA 353.2	mg/L as N	0-10	±40
NO_2	EPA 353.2	mg/L as N	0-10	±40
Fecal Coliform	SM 9222D	CFU/100 mL	N/A	N/A
pH	SM 4500 H^+B	S.U.	0-10	N/A
Temperature	SM 2550B	˚C	0-10	N/A
Total Dissolved Oxygen	SM 4500	mg/L	0-10	N/A
Turbidity	EPA 180.1	NTU	0-10	N/A

4.2 Laboratory Analysis

NSF contracted with Benchmark Analytics, a laboratory in Eastern Pennsylvania, to conduct all the laboratory analysis and to collect samples from nine of the eleven sites. Kevco Labs collected samples for the two sites located in Western Pennsylvania and shipped them to Benchmark Analytics for analysis. Due to the need for shipment, microbiological samples for the WEI887 and BRO1000 sites were out of hold time.

Chapter 5 Analytical Results

Chemical analyses of samples collected during the evaluation were completed using the procedures outlined in the Quality Assurance Product Plan (QAPP). Results of the chemical analyses and on-site observations and measurements are summarized below.

5.1 Influent Results

There were two rounds of weekly influent samples taken, one prior to and one following the monthly effluent sampling regime. Influent samples were collected weekly for four weeks during both rounds of influent sampling. For both rounds, the system was configured so that it did not recirculate through the primary compartment. The first round of influent sampling was completed to establish a baseline influent strength prior to the monthly effluent sampling.

Following completion of the effluent sampling the system configuration was adjusted to the way it was during the first round of influent sampling. The second round of influent sampling was also monitored for four weeks to try to establish a baseline and to document the rate at which the primary compartment reverted back to its anaerobic state. This data includes all influent analytical results from all sites through the duration of testing except for the BRU4380 site, which exhibited an extremely high influent strength (mean >900 mg/L BOD_5) throughout the testing. This site has been set aside and classified as a special case site for purposes of data analysis. Detailed analysis and discussion is provided in Appendix K. Table 5-1 shows the mean of influent sampling results.

Table 5-1. Influent Water Quality for All Sites[3]

	BOD_5 (mg/L)	TSS (mg/L)	Turbidity (NTU)	Nitrogen[1] (mg/L as N)				Temp (°C)	Alkalinity (mg/L)	Fecal Coliform (CFU/100mL)[2]
				TKN	NH_3	NO_3[1]	TN			
Mean	130	180	140	41	33	3.2	44	18	300	3.7×10^4
Median	110	50	45	32	27	2.1	44	18	320	8.2×10^4
Std. Dev.	72	300	190	20	19	3.8	22	5	110	3.7×10^4
Min	53	32	32	15	10	2.1	15	6.5	80	9.7×10^3
Max	260	960	660	90	80	9.5	97	30	480	1.4×10^5

[1] *Source water nitrate-n concentration used to calculate total nitrogen where available.*
[2] *Fecal Coliform is a geometric mean.*
[3] *BRU4380 site not included*

Table 5-2 shows the mean influent sampling results for the parameters indicated below for each of the 11 sites.

Table 5-2. Mean Influent Analytical Results per Testing Site

Site #	BOD_5 (mg/L)	TSS (mg/L)	Turbidity (NTU)	Nitrogen [2] (mg/L as N)				Temp (°C)	Alkalinity (mg/L)	Fecal Coliform (CFU/100mL)[1]
				TKN	NH_3	NO_3[2]	TN			
SMI4540	160	100	66	90	80	7.2	97	17	480	2.6×10^4
KEN6320	260	960	660	35	22	3.5	38	19	350	9.7×10^3
LEC6350	240	400	230	50	38	NA	50	18	390	2.5×10^4
END6334	91	33	32	24	20	2.1	26	18	260	2.8×10^4
KRI6360	53	36	34	43	37	NA	43	18	360	3.7×10^4
WEI887	88	45	51	15	10	NA	15	14	82	1.4×10^5
BRO1000	130	53	160	38	30	NA	38	20	210	2.6×10^4
ZAK628	170	55	50	40	31	NA	40	18	360	6.9×10^4
JAC2375	62	40	38	46	36	9.3	55	10	280	5.0×10^4
BRU4380	920	110	110	69	50	3.8	73	22	340	4.4×10^5
HEN40	87	80	110	30	24	9.5	39	21	230	5.4×10^4

[1] *Fecal Coliform is a geometric mean*
[2] *Source water nitrate-n concentration used to calculate total nitrogen where available.*
[3] *Unless otherwise stated below, under specific sites, Total Nitrogen values are a result of adding effluent TKN, Nitrate and Nitrite values.*

5.1.1 Influent Results First Round vs. Second Round

Influent samples were collected from the clear zone of the primary tank through the inlet riser. As mentioned previously, this sampling method had never been tried previously and it was relatively unknown as to how representative the results would be in comparison to typical residential strength raw wastewater. There are several factors that could have impacted the results of this sampling method, some of which include: maturity of the primary tank following start-up and after switching system configuration; solids contamination of sampling bottle; and, depth of sample point in relation to sludge and scum layers and relative flow conditions during the sampling event. The second round of influent sampling was monitored to try to document the rate at which the primary compartment reverted back to its anaerobic state. The mean BOD_5 concentration increased slightly between the first and second round of sampling while the mean TSS concentration increased significantly. The main reason for the increase in the TSS concentration was a result of very high results from the second round of sampling on the KEN6320 site, which had influent TSS in the 1000 mg/L range. By removing the effects of the KEN6320 site results, the mean TSS between the first and second round of sampling is almost exactly the same. The results are more indicative of septic tank effluent than raw wastewater and are probably a result of the samples being collected from the clear zone of the primary tank. The mean total nitrogen results decreased significantly between the first and second round of influent sampling. It is suspected that there was not sufficient time given between the switch in system

configuration and the start of the second round of sampling for the primary tank to return to anaerobic conditions. The results from the influent sampling rounds are summarized in Table 5-3.

Table 5-3. Mean Influent Sampling Results

	BOD_5 (mg/L)	TSS (mg/L)	Total Nitrogen (mg/L as N)
First Round	130	100	54
Second Round	130	260	36

5.2 Effluent Results

Table 5-4 summarizes the effluent data from all sites through the duration of testing except for the BRU4380 site, which exhibited extremely high influent strengths (mean >900 mg/L TSS and BOD_5) as previously described.

Table 5-4. Effluent Water Quality (Including Outliers)

	$CBOD_5$ (mg/L)	TSS (mg/L)	Turbidity (NTU)	Nitrogen (mg/L as N)			Temp (°C)	Alkalinity (mg/L)	Fecal Coliform (CFU/100mL)[1]
				TKN	NH_3	TN			
Mean	9.1	13	9.5	4.9	2.7	18	17	145	1.8×10^3
Median	3.7	5.0	3.0	2.5	0.7	16	18	140	6.6×10^2

[1] *Fecal Coliform is a geometric mean of all systems without the use of UV. This excludes the BRO1000, WEI887 and ZAK628 sites.*

As indicated in Table 1-1, seven of the eleven sites discharged the treated wastewater to a stream. In these installations an ultra-violet (UV) disinfection system was incorporated into the treatment train following the AdvanTex System to disinfect the wastewater prior to discharge. Only results from non-disinfected wastewater were included in the summary analysis in order to properly characterize fecal coliform concentrations in AdvanTex Treatment System effluent. Four of the seven sites with UV disinfection operated for a period of time without the system in operation. These include the KEN6320, LEC6350, END6334 and KRI6360 sites. The results from that initial period of time without disinfection are recorded below.

5.3 Effluent Results per Evaluation Site

Table 5-5 shows the mean sampling results for the parameters indicated below for each of the 11 sites, including all outliers described further in Chapter 6.

Table 5-5. Mean Effluent Analytical Results per Testing Site (Including Outliers)

Site #	$CBOD_5$ (mg/L)	TSS (mg/L)	Turbidity (NTU)	Nitrogen (mg/L as N)				Temp (°C)	Alkalinity (mg/L)	Fecal Coliform[1,2] (CFU/100mL)
				TKN	NOx	NH_3	TN			
SMI4540	4.2	8.4	7.0	1.9	26	0.4	28	16	100	3.1×10^2
KEN6320 [3]	8.4	19	13	5.1	7.1	1.9	12	18	180	5.6×10^2
LEC6350 [3]	9.0	14	6.3	9.5	16	6.5	24	18	280	1.2×10^4
END6334 [3]	3.1	6.3	2.9	2.2	9.0	0.8	11	17	160	3.5×10^3
KRI6360 [3]	7.1	7.9	5.2	4.3	13	1.9	17	17	170	4.4×10^4
WEI887	7.0	7.2	4.4	2.3	7.2	1.1	9.5	20	49	----
BRO1000	23	9.4	7.2	4.2	11	2.6	15	19	66	----
ZAK628	18	36	41	12	13	7.8	25	17	230	----
JAC2375	7.5	5.8	2.0	2.9	20	1.8	23	16	110	8.3×10^2
BRU4380	73	49	75	40	2.6	30	43	14	310	1.0×10^4
HEN40	4.4	12	5.3	4.3	12	2.1	16	17	91	2.3×10^2

[1] *Fecal Coliform is a geometric mean.*
[2] *Sites with no value had UV disinfection systems, which prevented analysis of AdvanTex effluent for fecal coliform.*
[3] *Sites that included only a portion of their testing without UV disinfection.*

Chapter 6 Data Analysis and Outlier Evaluation

Any set of data that is collected will have the presence of outliers. It is standard statistical practice to systematically identify and remove extreme outliers in a performance evaluation, because outliers can skew the apparent mean and standard deviation and give a false impression of actual performance capabilities. Outliers that actually represent irregularities in the influent waste stream, or in the sampling procedure, can be mistaken for operational malfunctions or misinterpreted as long-term trends. Even a properly functioning treatment system is subject to periodic swings in effluent concentration, due to variable factors such as influent waste strength, household water usage, temperature, household chemical use, etc. Sample non-homogeneity can also be a source of sampling error where suspended solids collected with the sample (for example, sloughed pieces of microbial mat, or material that may be dislodged from surfaces during sample collection) and are disproportionately included in subsamples used for analysis.

For purposes of this study, the data set was evaluated to identify outliers that could be attributed to documented events, such as acts of nature, human error, mechanical malfunction, etc., or could be attributable to inconsistent data results. The following is a summary of the data excluded from the statistical analysis with a description of the basis for the exclusion:

Site 1 – SMI4540

- 01/02/2006 – Nitrate and nitrite values were inconsistent with previous results; this data, along with the resulting TN value was not included in the means.

- 04/24/2006 - TSS of 44 mg/L was not consistent with low $CBOD_5$ (5.6 mg/L), turbidity (3.2 NTU), and ammonia (0.43 mg/L) for this sample.

Site 2 – KEN6320

- All data collected was analyzed; no outliers were identified.

Site 3 – LEC6350

- 01/21/2008 – All data collected on this day was omitted from the means due to system overload; homeowners reported a prolonged visit of houseguests. Orenco was not informed of the change in occupancy and could not adjust their timer settings to accommodate for this. This was confirmed by the higher flows in January compared to other flows from the previous two years.

- 05/13/2008 – TSS value of 44 mg/L was inconsistent with the previous and subsequent results; it was also not consistent with a turbidity result of 5.6 NTU that was taken on the same day.

Site 4 – END6334

- All data collected was analyzed; no outliers were identified.

Site 5 – KRI6360

- 04/17/2006 – $CBOD_5$ value of 38 mg/L was inconsistent with previous and subsequent results. The value was nearly three times any other value recorded for this parameter at this location. The corresponding TSS, turbidity and ammonia effluent concentrations all appear to be within range of previous and subsequent samples indicating the system was operating properly.

Site 6 – WEI887

- 09/12/2006 – All data collected on this day was omitted due to an electrical failure in the control panel at the site. The system was pumped out on 8/28/2006 and restarted on 9/12/2006 the same day the sampling event was scheduled. The system did not have adequate time to re-circulate and thus properly treat the wastewater. This is validated when looking at all the previous and subsequent data points for this site.

Site 7 – BRO1000

- 02/07/2007 – $CBOD_5$ value of 420 mg/L was omitted as the sample was received past holding time by the laboratory; when compared to other $CBOD_5$ values, this data point was inconsistent with previous and subsequent samples.

- 07/23/2008 - Two of the owner's sons had moved back from college; the service provider was not notified of this and the timer settings had not been adjusted for the increase in flow experienced during this period.

Site 8 – ZAK628

- 06/18/2007 and 07/19/2007 – Data omitted on both of these days due to a lightening strike hitting the house and disabling the electronics in the control panel; the system was not operating properly for the months of June and July 2007.

- 03/28/2008 – Data omitted because it did not correlate with previous or subsequent analysis.

Site 9 – JAC2375

- 03/12/2007 – TN value omitted because of lack of proper start up conditions. Microbes responsible for nitrification and denitrification are sensitive to environmental conditions including temperature; it is common for a system to take up to three months to establish robust colonies of nitrifiers; this system was started in January and the first effluent sample was in March.

- 07/09/2007 – $CBOD_5$ was omitted as it was nearly three times any other value recorded for this parameter at this location and is not consistent with previous or subsequent samples; it is also not consistent with low TSS, Turbidity, and ammonia results for the same sample.

Site 10 – BRU4380

- Data for this site was not included in calculations because of extremely concentrated wastewater.

Site 11 – HEN40

- 07/22/2008 – All results for this sampling event were omitted as the owner had several houseguests for a week during the sampling event; the results of this sampling event are not consistent when compared to previous and subsequent results.

Table 6-1 represents the median results for the effluent with outliers removed. The median was included to better characterize the data because it removes the impact of very large and small values. Table 6-2 represents the mean results for the influent and effluent with outliers removed.

Table 6-1. Median Effluent Water Quality – Excluding Outliers

$CBOD_5$ (mg/L)	TSS (mg/L)	Turbidity (NTU)	Nitrogen (mg/L as N)				Temp (°C)	Alkalinity (mg/L)	Fecal Coliform (CFU/100mL)
			TKN	NH_3	NO_3	TN			
3.5	5.0	2.9	2.4	0.6	12	16	18	140	6.1×10^2

Table 6-2. Mean Effluent Water Quality – Excluding Outliers

$CBOD_5$ (mg/L)	TSS (mg/L)	Turbidity (NTU)	Nitrogen (mg/L as N)				Temp (°C)	Alkalinity (mg/L)	Fecal Coliform (CFU/100mL)[1]
			TKN	NH_3	NO_3	TN			
5.8	10	7.4	3.6	1.7	14	17	17	140	9.5×10^2

[1] *Fecal Coliform is a geometric mean of all systems without UV disinfection.*

Table 6-3 shows the mean sampling results for the parameters indicated below for each of the 11 sites excluding all outliers. As indicated in Section 5-2, only results from non-disinfected wastewater were included in the summary analysis in order to properly characterize fecal coliform concentrations in AdvanTex Treatment System effluent. Four of the seven sites with UV disinfection operated for a period of time without the system in operation. These include the

KEN6320, LEC6350, END6334 and KRI6360 sites. The results from that initial period of time without disinfection are recorded below.

Table 6-3. Mean Effluent Analytical Results per Testing Site – Excluding Outliers

Site	$CBOD_5$ (mg/L)	TSS (mg/L)	Turbidity (NTU)	Nitrogen (mg/L as N)				Temp (°C)	Alkalinity (mg/L)	Fecal Coliform[1,2] (CFU/100mL)
				TKN	NOx	NH_3	TN			
SMI4540	4.2	8.4	7.0	1.9	27	0.4	29	16	100	3.1×10^2
KEN6320[3]	8.4	19	13	5.1	7.1	1.9	12	18	180	5.6×10^2
LEC6350[3]	7.5	11	5.1	6.6	16	3.6	22	18	290	1.2×10^4
END6334[3]	3.1	6.3	2.9	2.2	9.0	0.8	11	17	160	3.5×10^3
KRI6360[3]	23	18	5.1	4.3	23	1.9	17	17	170	4.7×10^4
WEI887	5.0	6.6	3.2	1.7	7.3	0.6	9.0	20	46	----
BRO1000	4.9	9.4	7.2	4.2	11	2.6	15	19	66	----
ZAK628	10	22	25	5.8	14	2.8	20	17	210	----
JAC2375	5.1	5.8	2.0	1.6	19	1.8	21	16	110	8.3×10^2
BRU4380	66	23	73	40	2.6	30	42	14	300	1.0×10^4
HEN40	3.5	6.5	2.6	2.3	11	0.7	13	17	90	1.9×10^2

[1] *Fecal coliform is a geometric mean.*
[2] *Sites with no value had UV disinfection systems which prevented analysis of AdvanTex effluent for fecal coliform.*
[3] *Sites that included only a portion of their testing without UV disinfection.*

Chapter 7 Total Nitrogen Performance

Total nitrogen is calculated by adding the measurements of total Kjeldahl nitrogen (TKN), nitrite, and nitrite. Because there is very little nitrate and nitrite (typically less than 1 mg/L) in raw wastewater, TKN was utilized as the parameter to establish the concentration of total nitrogen (TN) in the raw wastewater. All of the sites used private wells as their water source and it was determined that some of the sites had higher than typical concentrations of nitrate in their water as many of the sites were located in heavy agricultural areas, which is thought to be the primary contributor of nitrate in the groundwater. A sample of the water was collected from some of the sites and analyzed to determine the nitrate concentration. Table 7-1 summarizes the results from this testing.

Table 7-1. Background Nitrate-N Concentration

Site ID	Nitrate-N (mg/L as N)
SMI4540	7.2
KEN6320	3.5
LEC6350	NA
END6334	2.1
KRI6360	NA
WEI887	NA
BRO1000	NA
ZAK628	NA
JAC2375	9.3
BRU4380	3.8
HEN40	9.5

The nitrate in the water supply represented an additional nitrogen load upon the system that was not taken into account by considering TKN only as the raw wastewater TN. For sites with a known concentration of nitrate in their water, the sum of TKN and nitrate was used as the influent TN load to more accurately reflect system performance. Table 7-2 is a mean of the influent and effluent TN with the background nitrate-n results included.

Table 7-2. Mean Effluent Water Quality - Percent Nitrogen Removal

	Total Nitrogen (mg/L as N)
Influent	44
Effluent	17
Percent Reduction	61%

The mean influent concentration from all sites, excluding all outliers and the BRU4380 site, was 44 mg/L and the mean effluent was 17 mg/L resulting in a TN removal of 61%.

7.1 Flow Monitoring

Each AdvanTex® system was controlled and monitored via a remote VeriComm® Telemetry control panel. The control panel has a built in data logger which monitors many different aspects of the system operation, including monitoring of the discharge pumping events by time and date stamping each one. The daily discharge pump run time was downloaded periodically from the control panel and used to calculate the daily flow being loaded into the system. The AdvanTex System was tested under a wide range of uses during the study. Sites ranged anywhere from one to six occupants and a range of continuous flows from 56gpd to 234gpd and peaks into the thousands of gallons per day. There were also two residences that had occupants that would reside there intermittently. The peak flows are most likely attributed to leaky fixtures or stuck toilets. One site (KEN6320) experienced a considerable amount of infiltration into the system, which was determined to be due to a leaky building sewer, not a leak into the treatment system. Table 7-3 summarizes the mean, median, minimum and maximum daily flow for each site during the period of testing.

Table 7-3. Daily Flow (gpd)

Site ID	Number of Occupants	Mean	Median	Minimum	Maximum
SMI4540	2	117	216	0	439
KEN6320[1]	4	1,843	272	0	33,812
LEC6350	3[2]	62	61	0	15,385
END6334	2	268	56	0	15,835
KRI6360	2	102	70	0	2,113
WEI887	2	207	141	0	2,080
BRO1000	1[3]	233	203	3	1,383
ZAK628	4	190	188	0	984
JAC2375	2	83	131	0	1,569
BRU4380	6	240	234	0	1,984
HEN40	2	92	82	0	346

[1] *Site had problems with rainwater infiltration; the median is more representative of how the system was loaded during normal use.*
[2] *Three fulltime residents and two additional intermittent residents.*
[3] *One fulltime resident with two additional intermittent residents.*

Chapter 8 Summary of Performance

Evaluation of the Orenco AdvanTex® AX20N under the Pennsylvania Experimental Onlot Wastewater Technology Verification Program was conducted with NSF International providing third party oversight, data analysis, and reporting. Field-testing of the AdvanTex AX20N system was conducted at eleven representative sites across the State, which were chosen in a collaborative effort between the Pennsylvania DEP and Orenco. The site selection and year-long test period served to capture variations in the effluent quality that may occur based on sewage strength, flow rate and seasonal temperature fluctuations.

Influent and effluent samples were collected at each of the sites. Summaries of the data collected at each site are included in Tables 5-2 (influent) and 5-4 (effluent). As explained in Chapter 6, some of the data was omitted from statistical analysis of the performance of the AdvanTex AX20N for reasons summarized in that Chapter. In particular, Site BRU4380 was excluded from the system performance analysis because of unusually high wastewater strength. A summary of the effluent results for each site, excluding the omitted data points, is provided in Table 6-2.

The mean overall system performance is shown in Table 8-1 and the median overall system performance is shown in Table 8-2.

Table 8-1. Mean Influent/Effluent Results [1]

	BOD_5/ $CBOD_5$	TSS	Alkalinity	TKN	NH_3	NO_3	TN	Fecal Coliform
Influent	130	180	300	41	33	3.2	44	3.7×10^4
Effluent	5.6	10	140	3.6	1.7	14	17	9.5×10^2
% Reduction	93	94	-	91	95	-	61	2 log

[1] *Excluding outliers omitted from raw data set; does not include any data from the BRU4380 site.*

Table 8-2. Median Influent/Effluent Results [1]

	BOD_5/ $CBOD_5$	TSS	Alkalinity	TKN	NH_3	NO_3	TN	Fecal Coliform
Influent	110	50	320	32	27	5.4	44	8.3×10^4
Effluent	3.5	5.0	140	2.4	0.6	12	16	6.1×10^2
% Reduction	97	90	-	93	98	-	64	2 log

[1] *Excluding outliers omitted from raw data set; does not include any data from BRU4380 site.*

Appendix A - System Specifications

PLANT SPECIFICATIONS

Orenco Systems, Inc.
AdvanTex® AX20N

Plant Capacity

Design Flow	500 gpd
Plant Hydraulic Capacity (at Design Flow)	1,500 gallons
First compartment (pre-treatment)	1,000 gallons
Second compartment	500 gallons
Hydraulic Retention Time (at Design Flow)	
First compartment (pre-treatment)	48 hours
Second compartment	24 hours

Pump

Effluent Pump	Orenco Systems Inc. P300511, ½ HP, 115 V, 60 Hz,
Filter	AdvanTex AX20 Textile Filter

Technical Data Sheet

AdvanTex® – AX20 Filter

Applications

Orenco's AdvanTex® Treatment System* is an innovative technology for onsite treatment of residential wastewater. The heart of the System is the AdvanTex® Filter, a sturdy, watertight fiberglass basin filled with an engineered textile material. This lightweight, highly absorbent textile material treats a tremendous amount of wastewater in a small space. The AdvanTex® Treatment System is ideal for:

- Small sites
- System upgrades and repairs
- New construction
- Poor soils
- Nitrogen reduction
- Price-sensitive markets
- Pretreatment

For sizing, see "AdvanTex® Design Criteria," NDA-ATX-2.

The heart of the AdvanTex® Treatment System is this sturdy, watertight fiberglass basin filled with an engineered textile material.

**Covered by U.S. patent numbers 5,980,748; 5,531,894; 5,480,561; 5,360,555; 5,492,635; and 4,439,323. Additional patents pending.*

Features/Specifications

To specify this product, require the following:

- Wastewater treatment to better than secondary treatment standards
- Consistent treatment, even during peak flows
- Timer operation for flow monitoring, flow modulation, and surge control
- Fixed film textile media (a polyester plastic), operated in an unsaturated condition
- Consistent media quality
- Low maintenance beyond annual servicing
- Low energy consumption (under $1.25-2.50/month power cost at national average electric rate of $.08 kWh)
- Complete pre-manufactured package, ready-to-install
- Watertight construction, corrosion-proof materials, tamper-proof lid bolts
- Anti-flotation flanges
- Quiet operation

Standard Models

AX20, AX20N

(AX20 units carrying the NSF logomark are labeled AX20N, per NSF protocol.)

Physical Specifications

*Approximate Dimensions***	
Filter Basin Length in. (mm)	91 (2311)
Width in. (mm)	40 (1016)
Height in. (mm)	31 (787)
Area (footprint) in. (m^2)	20 ft^2 (1.86)
Filter Dry Weight lb (kg)	400 (181)

*** See AdvanTex® Treatment System drawings for exact dimensions*

AdvanTex® Treatment System AXN Models meet the requirements of NSF-ANSI Standard 40 for Class I Systems.

Appendix B - SMI4540

Influent Total Nitrogen Results

Twelve influent samples were collected at this site over the course of the testing. The TN concentrations were calculated by adding the influent TKN value with 7.2 mg/L nitrate-N in the site's water supply. Influent TN concentrations ranged from 24 to 180 mg/L, with a mean concentration of 96.7 mg/L and median concentration of 88.7 mg/L. Table B-1 provides a summary of the influent data collected and analyzed at the SMI4540 site during the evaluation. Figure B-1 presents a graphical presentation of the influent TN data collected at the site.

Table B-1. Summary of Influent Analytical Results (SMI4540)

Parameter	Statistical Analyses				
	Mean	Median	Standard Deviation	Minimum	Maximum
BOD_5	160	120	140	7.7	550
TSS	100	86	86	17	330
Alkalinity	480	460	190	210	790
pH	NA	7.0	NA	6.8	8.1
Turbidity	66	64	31	17	120
TKN	90	82	53	17	170
TN	97	89	53	24	180
NH_3	80	69	54	14	160
Fecal Coliform[1]	2.2×10^4	2.6×10^4	1.3×10^5	82	3.9×10^5

[1] *Fecal coliform is calculated as a geometric mean.*

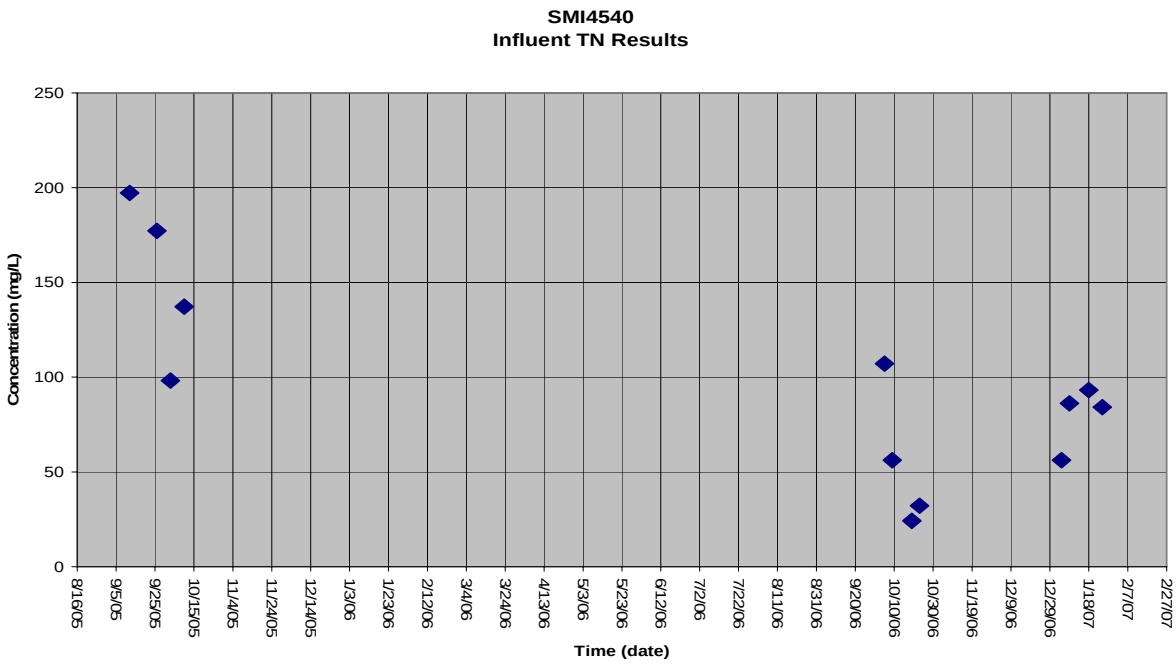

Figure B-1. Influent TN results for SMI4540.

Effluent Total Nitrogen Results

There were a total of 25 samples taken over the course of the testing and in the analysis. The data that follows includes all identified outliers. The effluent TN concentrations ranged from 2 to 46 mg/L, with a mean concentration of 28 mg/L and a median concentration of 26 mg/L. The overall percent reduction in TN was 71%. Table B-2 provides a summary of the effluent data collected and analyzed at site SMI4540 during the evaluation, which is shown graphically for TN in Figure B-2.

Table B-2. Summary of Effluent Analytical Results for SMI4540

Parameter	Statistical Analysis				
	Mean	Median	Standard Deviation	Minimum	Maximum
$CBOD_5$	4	2	4.6	2	21
TSS	8	5	9.4	5	44
Alkalinity	100	110	42	39	170
pH	NA	7	NA	6.7	8.0
Turbidity	7	3	13	0.7	56
TKN	2	2	1.4	0.5	7.3
NH_3	0.42	0.16	0.80	0.05	4
NO_3	26	22	11	0.02	44
NO_2	0.05	0.03	0.04	0.001	0.13
NOx	26	22	10	0.02	44
TN	28	26	12	2	46
DO	8	8	1.4	5.8	10.8
Fecal Coliform[1]	3.1×10^2	2.3×10^2	1.6×10^3	25	4.9×10^3

[1] *Fecal coliform is calculated as a geometric mean.*

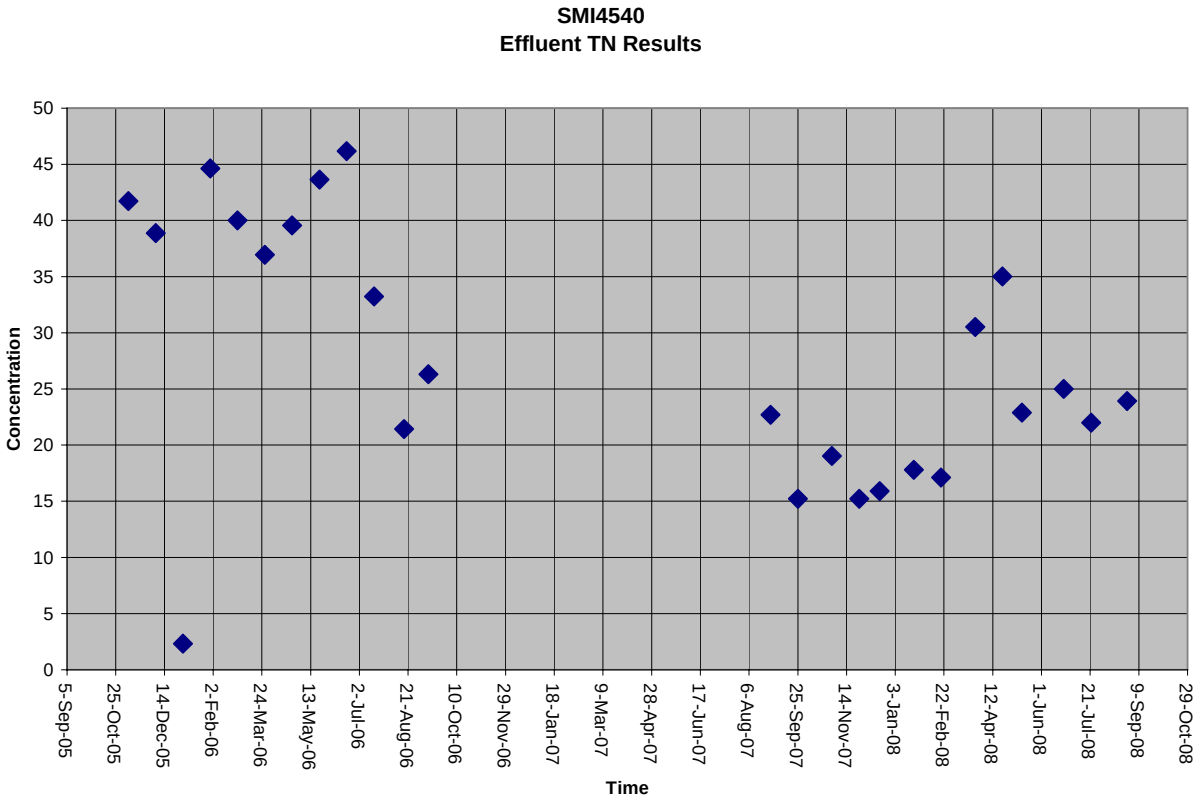

Figure B-2. Effluent TN results for SMI4540.

Appendix C - KEN6320

Influent Total Nitrogen Results

Eight influent samples were collected at this site over the course of the testing. The TN concentrations were calculated by adding the influent TKN value with 3.5 mg/L nitrate-N in the site's water supply. Influent TN concentrations ranged from 14 to 104 mg/L, with a mean concentration of 38 mg/L and median concentration of 29 mg/L. Table C-1 provides a summary of the influent data collected and analyzed at the KEN6320 site during the evaluation. Figure C-1 presents a graphical presentation of the influent TN data collected at the site.

Table C-1. Summary of Influent Analytical Results for KEN6320

Parameter	Statistical Analysis				
	Mean	Median	Standard Deviation	Minimum	Maximum
BOD_5	260	230	180	100	680
TSS	960	55	1,300	20	3,400
Alkalinity	350	340	69	240	450
pH	NA	7.0	NA	6.7	7.4
Turbidity	660	43	1,200	32	3,000
TKN	35	26	28	11	100
TN	38	29	28	14	104
NH_3	22	18	14	5.9	52
Fecal Coliform[1]	9.7×10^4	1.4×10^5	8.8×10^5	1	2.0×10^6

[1] *Fecal coliform is calculated as a geometric mean.*

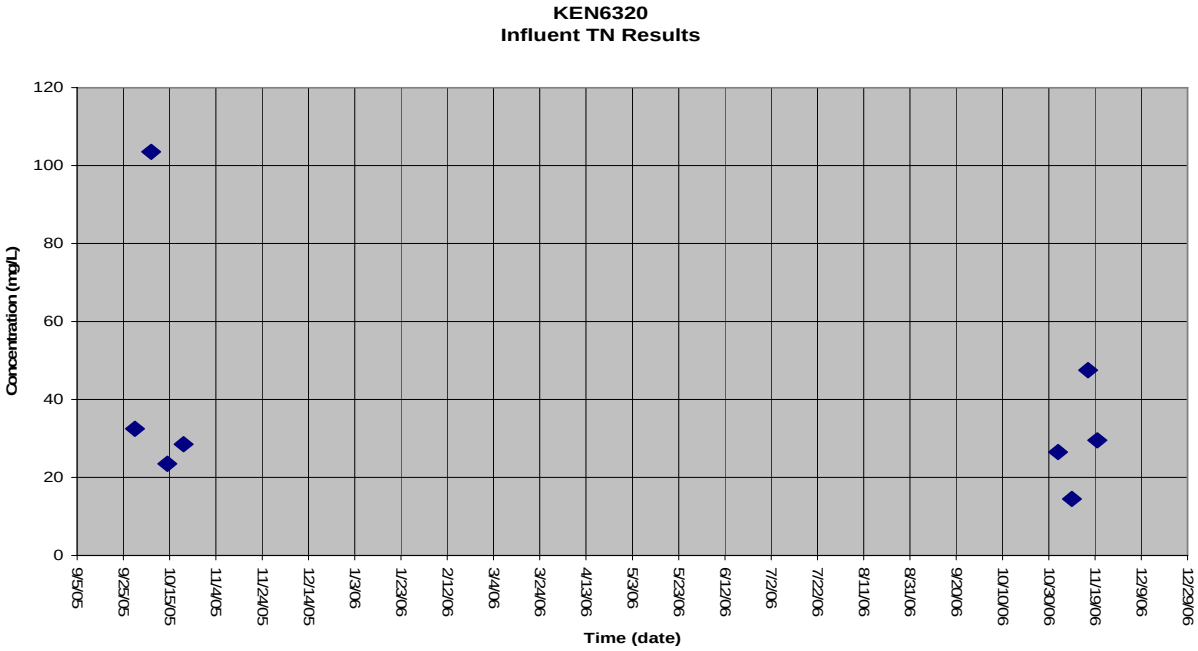

Figure C-1. Influent TN results for KEN6320.

Effluent Total Nitrogen Results

There were a total of 24 samples taken over the course of the testing and in the analysis. The data that follows includes all identified outliers. The effluent TN concentrations ranged from 6.6 to 27 mg/L, with a mean concentration of 12 mg/L and a median concentration of 11 mg/L. The overall percent reduction in TN was 68%. Table C-2 provides a summary of the effluent data collected and analyzed at site KEN6320 during the evaluation, which is shown graphically for TN in Figure C-2.

Table C-2. Summary of Effluent Analytical Results for KEN6320

Parameter	Statistical Analysis				
	Mean	Median	Standard Deviation	Minimum	Maximum
$CBOD_5$	8	5	7.2	2	27
TSS	19	12	25	5	110
Alkalinity	180	190	37	110	240
pH	NA	7.0	NA	6.8	7.8
Turbidity	13	6	24	1.9	93
TKN	5	4	4.9	1.2	23
NH_3	1.9	1.2	2.3	0.07	11
NO_3	6.9	7.4	2.7	1	11
NO_2	0.21	0.19	0.17	0.01	0.69
NOx	7	8	2.6	1.1	11
TN	12	11	4.7	6.6	27
DO	5	4	2.9	1	11
Fecal Coliform[1]	5.6×10^2	1.6×10^3	1.6×10^3	25	3.8×10^3

[1] *Fecal coliform is calculated as a geometric mean.*

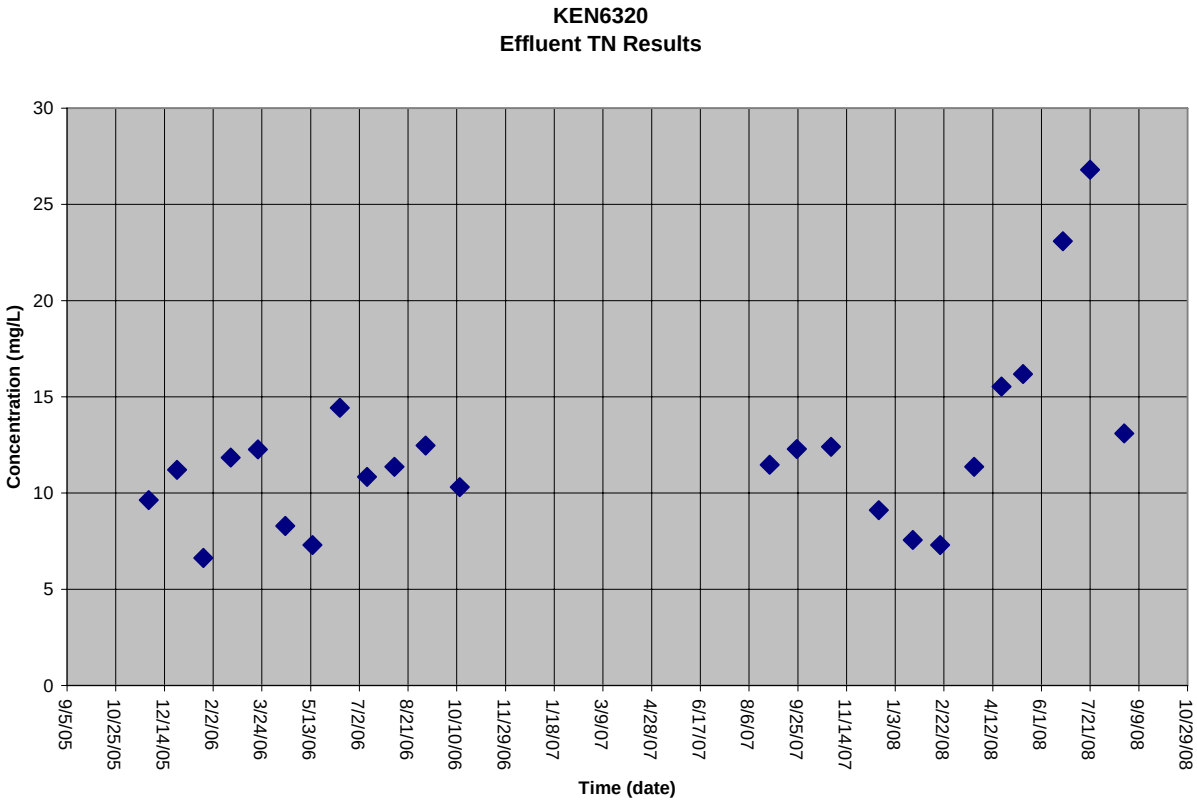

Figure C-2. Effluent TN results for KEN6320.

Appendix D - LEC6350

Influent Total Nitrogen Results

Eight influent samples were collected at this site over the course of the testing. Influent TN concentrations ranged from 26 to 110 mg/L, with a mean concentration of 50 mg/L and median concentration of 47 mg/L. Table D-1 provides a summary of the influent data collected and analyzed at the LEC6350 site during the evaluation. Figure D-1 presents a graphical presentation of the influent TN data collected at the site.

Table D-1. Summary of Influent Analytical Results for LEC6350

Parameter	Statistical Analysis				
	Mean	Median	Standard Deviation	Minimum	Maximum
BOD_5	240	240	150	56	480
TSS	400	190	520	34	1,800
Alkalinity	390	360	99	310	640
pH	NA	6.8	NA	6.2	7
Turbidity	230	73	360	39	1,200
TKN	50	47	23	26	110
NH_3	38	35	20	19	83
Fecal Coliform[1]	2.5×10^4	5.2×10^3	9.0×10^5	9.6×10^2	2.0×10^6

[1] *Fecal coliform is calculated as a geometric mean.*

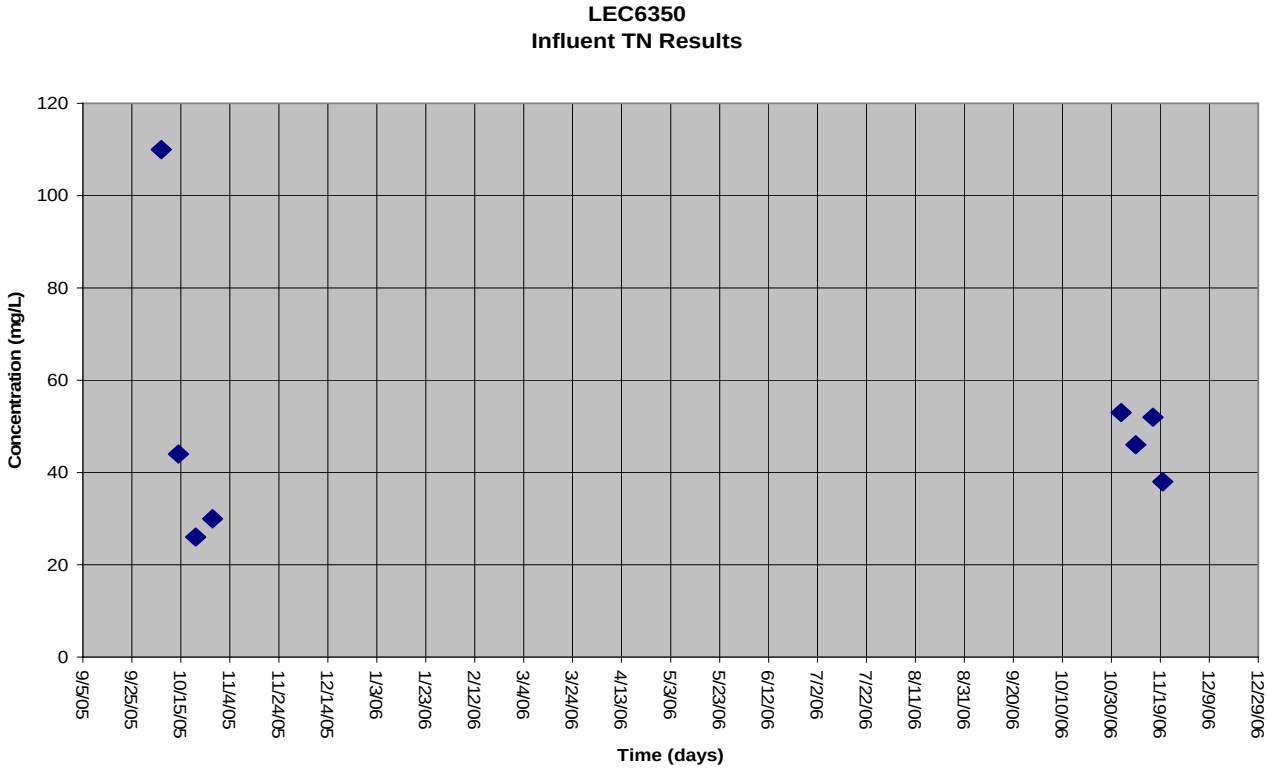

Figure D-1. Influent TN results for LEC6350.

Effluent Total Nitrogen Results

There were a total of 25 samples taken over the course of the testing and in the analysis. The data that follows includes all identified outliers. The effluent TN concentrations ranged from 3 to 81 mg/L, with a mean concentration of 24 mg/L and a median concentration of 23 mg/L. The overall percent reduction in TN was 52%. Table D-2 provides a summary of the effluent data collected and analyzed at site LEC6350 during the evaluation, which is shown graphically for TN in Figure D-2.

Table D-2. Summary of Effluent Analytical Results for LEC6350

Parameter	Statistical Analysis				
	Mean	Median	Standard Deviation	Minimum	Maximum
$CBOD_5$	9.0	4.3	10	2	49
TSS	14	6	17	5	76
Alkalinity	280	220	340	1	1,900
pH	NA	7.1	NA	6.8	7.5
Turbidity	6.3	2.8	11	0.8	50
TKN	9.5	5.6	15	1.7	78
NH_3	6.3	3.1	14	0.25	71
NO_3	16	17	6	1.4	28
NO_2	0.4	0.3	0.4	ND	1.7
NOx	16	17	5.8	2.9	28
TN	24	23	13	3.4	81
DO	5.5	5.1	2.5	1.3	11
Fecal Coliform[1]	1.2×10^4	1.4×10^4	8.3×10^4	3.1×10^2	2.3×10^5

[1] *Fecal coliform is calculated as a geometric mean.*

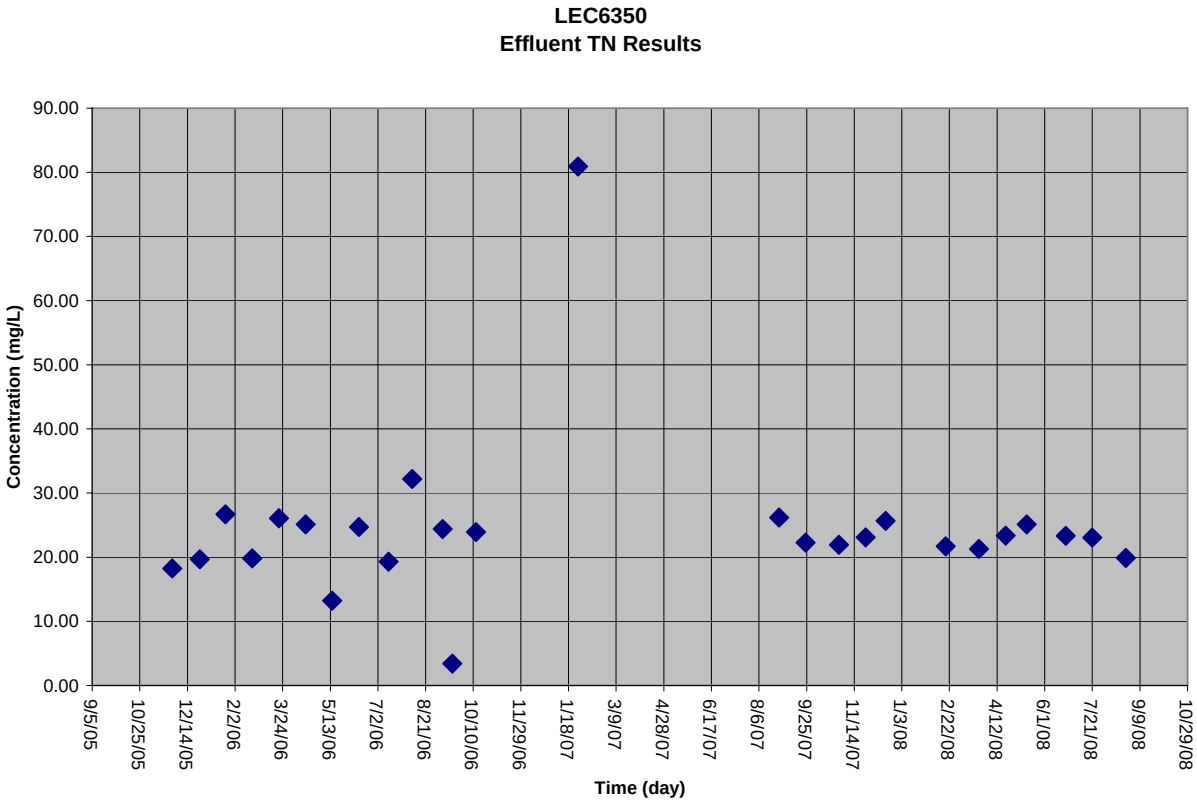

Figure D-2. Effluent TN results for LEC6350.

Appendix E - END6334

Influent Total Nitrogen Results

Eight influent samples were collected at this site over the course of the testing. The TN concentrations were calculated by adding the influent TKN value with 2.1 mg/L nitrate-N in the site's water supply. Influent TN concentrations ranged from 8 to 69 mg/L, with a mean concentration of 26 mg/L and median concentration of 23 mg/L. Table E-1 provides a summary of the influent data collected and analyzed at the END6334 site during the evaluation. Figure E-1 presents a graphical presentation of the influent TN data collected at the site.

Table E-1. Summary of Influent Analytical Results for END6334

Parameter	Statistical Analysis				
	Mean	Median	Standard Deviation	Minimum	Maximum
BOD_5	91	82	53	15	190
TSS	33	26	17	13	58
Alkalinity	260	240	82	140	450
pH	NA	7.1	NA	6.2	7.2
Turbidity	32	32	13	14	52
TKN	24	20	17	5.9	67
TN	26	23	17	8	69
NH_3	20	16	14	3.4	52
Fecal Coliform[1]	2.8×10^4	6.8×10^3	8.4×10^5	2.3×10^2	2.0×10^6

[1] *Fecal coliform is calculated as a geometric mean.*

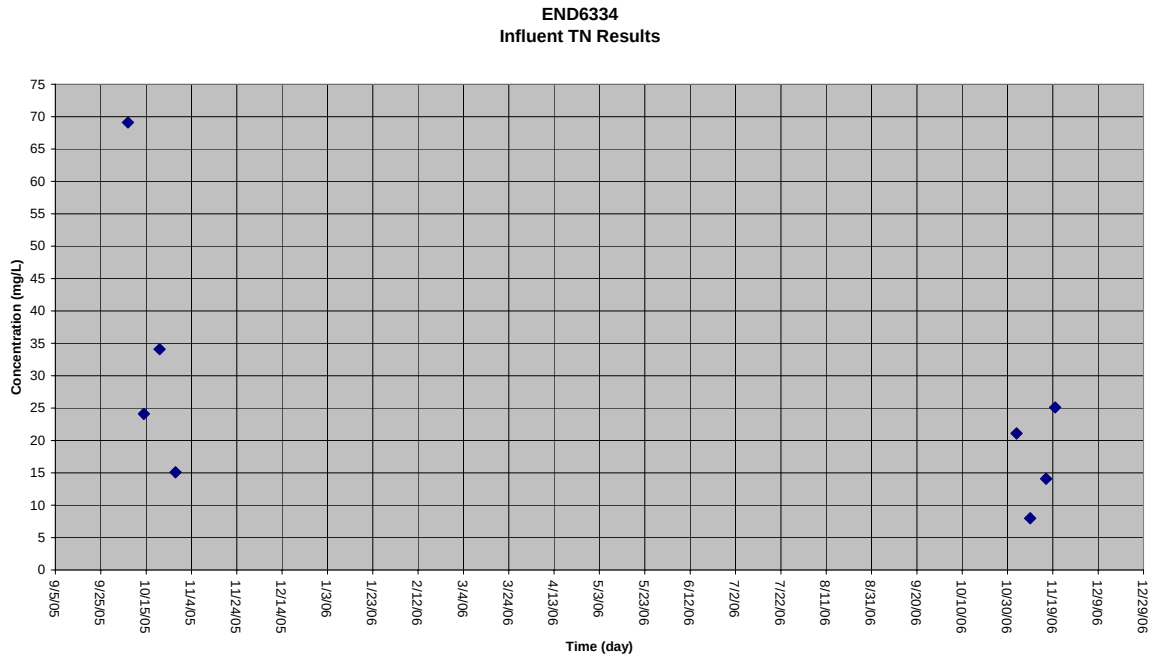

Figure E-1. Influent TN results for END6334.

Effluent Total Nitrogen Results

There were a total of 25 samples taken over the course of the testing and in the analysis. The data that follows includes all identified outliers. The effluent TN concentrations ranged from 5 to 22 mg/L, with a mean concentration of 11 mg/L and a median concentration of 11 mg/L. The overall percent reduction in TN was 58%. Table E-2 provides a summary of the effluent data collected and analyzed at site END6334 during the evaluation, which is shown graphically for TN in Figure E-2.

Table E-2. Summary of Effluent Analytical Results for END6334

Parameter	Statistical Analysis				
	Mean	Median	Standard Deviation	Minimum	Maximum
$CBOD_5$	3.1	2	2.8	2	16
TSS	6.3	5	3.5	2	20
Alkalinity	160	160	35	95	240
pH	NA	7.4	NA	7.1	7.7
Turbidity	2.9	1.6	6.0	0.3	31
TKN	2.2	1.3	3.2	0.6	16
NH_3	0.8	0.08	2.8	0.05	14
NO_3	9.0	9.1	3.3	4.1	17
NO_2	0.05	0.02	0.07	ND	0.36
NOx	9.0	9.1	3.3	4.1	17
TN	11	11	4.3	4.7	22
DO	8.2	8.3	1.4	6.3	11
Fecal Coliform[1]	3.5×10^3	4.8×10^3	1.2×10^5	2.7×10^2	3.4×10^4

[1] *Fecal coliform is calculated as a geometric mean*

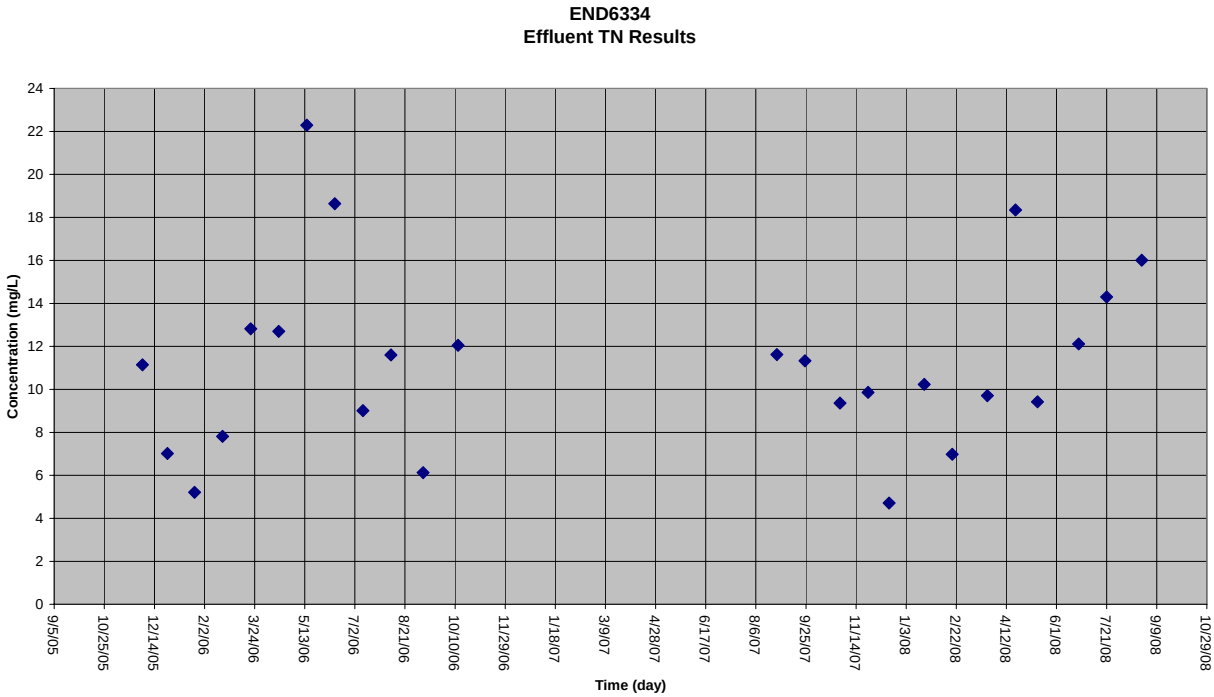

Figure E-2. Effluent TN results for END6334.

Appendix F - KRI6360

Influent Total Nitrogen Results

Eight influent samples were collected at this site over the course of the testing. Influent TN concentrations ranged from 15 to 77 mg/L, with a mean concentration of 43 mg/L and median concentration of 42 mg/L. Table F-1 provides a summary of the influent data collected and analyzed at the KRI6360 site during the evaluation. Figure F-1 presents a graphical presentation of the influent TN data collected at the site

Table F-1. Summary of Influent Analytical Results for KRI6360

Parameter	Statistical Analysis				
	Mean	Median	Standard Deviation	Minimum	Maximum
BOD_5	53	53	16	32	79
TSS	36	43	16	14	52
Alkalinity	360	360	76	240	520
pH	NA	7.1	NA	6.7	7.2
Turbidity	35	30	18	16	62
TKN	43	42	20	15	77
NH_3	37	38	19	12	64
Fecal Coliform[1]	3.7×10^4	2.5×10^5	8.7×10^5	1.5×10^2	2.0×10^6

[1] *Fecal coliform is calculated as a geometric mean.*

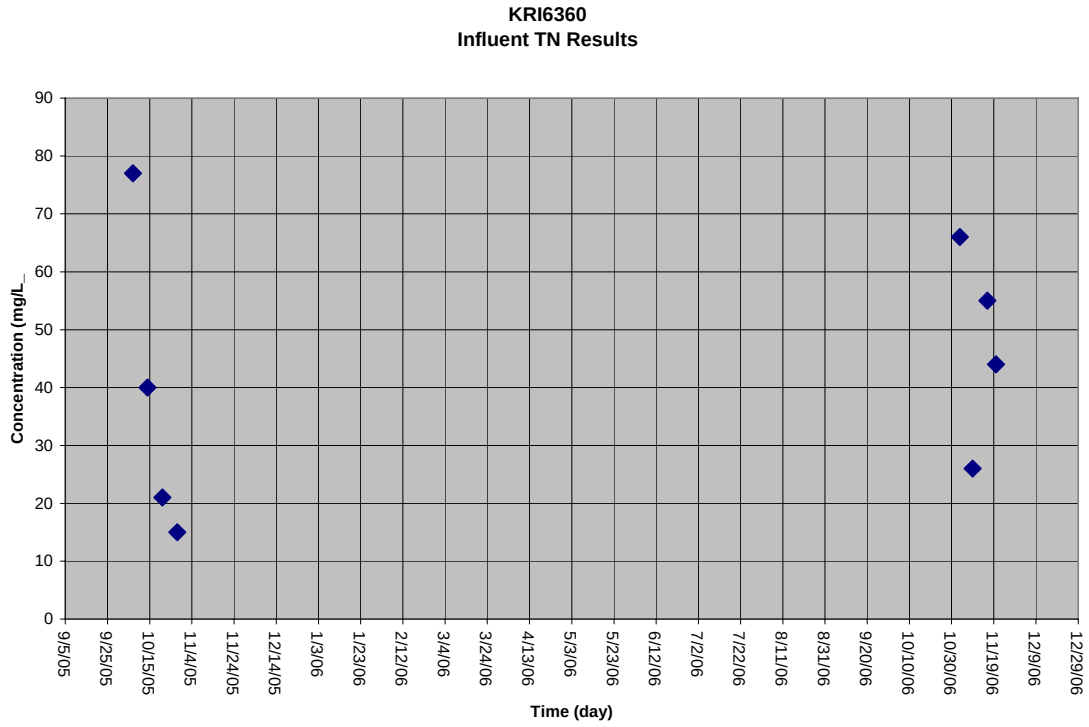

Figure F-1. Influent TN results for KRI6360.

Effluent Total Nitrogen Results

There were a total of 25 samples taken over the course of the testing and in the analysis. The data that follows includes all identified outliers. The effluent TN concentrations ranged from 9 to 27 mg/L, with a mean concentration of 17 mg/L and a median concentration of 18 mg/L. The overall percent reduction in TN was 60%. Table F-2 provides a summary of the effluent data collected and analyzed at site KRI6360 during the evaluation, which is shown graphically for TN in Figure F-2.

Table F-2. Summary of Effluent Analytical Results for KRI6360

Parameter	Statistical Analysis				
	Mean	Median	Standard Deviation	Minimum	Maximum
$CBOD_5$	7.0	4.5	7.8	2	38
TSS	7.9	6.5	3.8	5	18
Alkalinity	170	170	36	110	290
pH	NA	7.1	NA	6.7	7.5
Turbidity	5.2	3.8	4.5	0.8	18
TKN	4.3	3.6	3.5	1.4	19
NH_3	1.9	1.2	2.7	0.16	14
NO_3	13	14	5.1	2.8	23
NO_2	0.17	0.10	0.21	0.01	0.97
NOx	13	14	5.0	3.0	23
TN	17	18	4.3	9.2	27
DO	7.2	7.8	2.3	1.0	11
Fecal Coliform[1]	4.4×10^4	4.1×10^4	6.1×10^4	1.2×10^4	1.7×10^5

[1] *Fecal coliform is calculated as a geometric mean.*

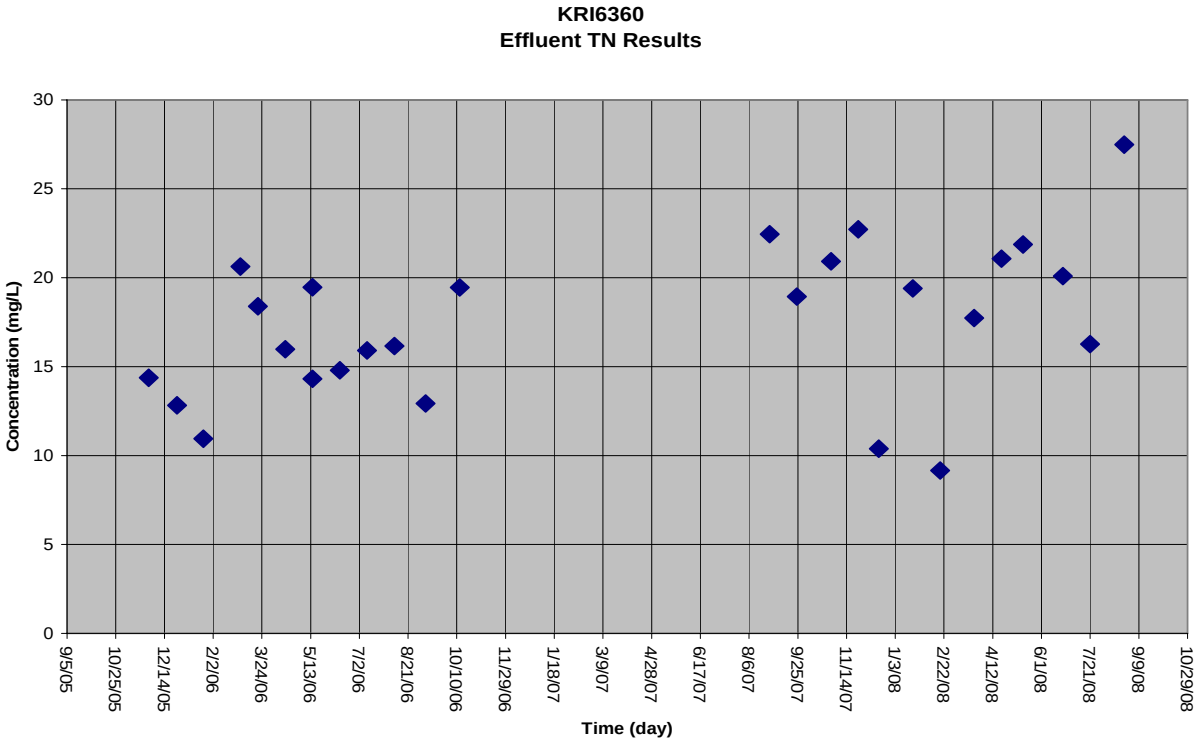

Figure F-2. Effluent TN results for KRI6360.

Appendix G - WEI887

Influent Total Nitrogen Results

Eight influent samples were collected at this site over the course of the testing. Influent TN concentrations ranged from 8 to 28 mg/L, with a mean concentration of 15 mg/L and median concentration of 13 mg/L. Table G-1 provides a summary of the influent data collected and analyzed at the WEI887 site during the evaluation. Figure G-1 presents a graphical presentation of the influent TN data collected at the site.

Table G-1. Summary of Influent Analytical Results for WEI887

Parameter	Statistical Analysis				
	Mean	Median	Standard Deviation	Minimum	Maximum
BOD_5	88	75	56	19	190
TSS	45	42	27	21	110
Alkalinity	82	84	30	15	130
pH	NA	6.8	NA	6.5	7.1
Turbidity	51	45	42	14	150
TKN	15	13	6.5	7.9	28
NH_3	10	7.9	5.0	5.7	20
Fecal Coliform[1]	1.5×10^5	1.0×10^5	2.2×10^5	9.5×10^4	7.2×10^5

[1] *Fecal coliform is calculated as a geometric mean.*

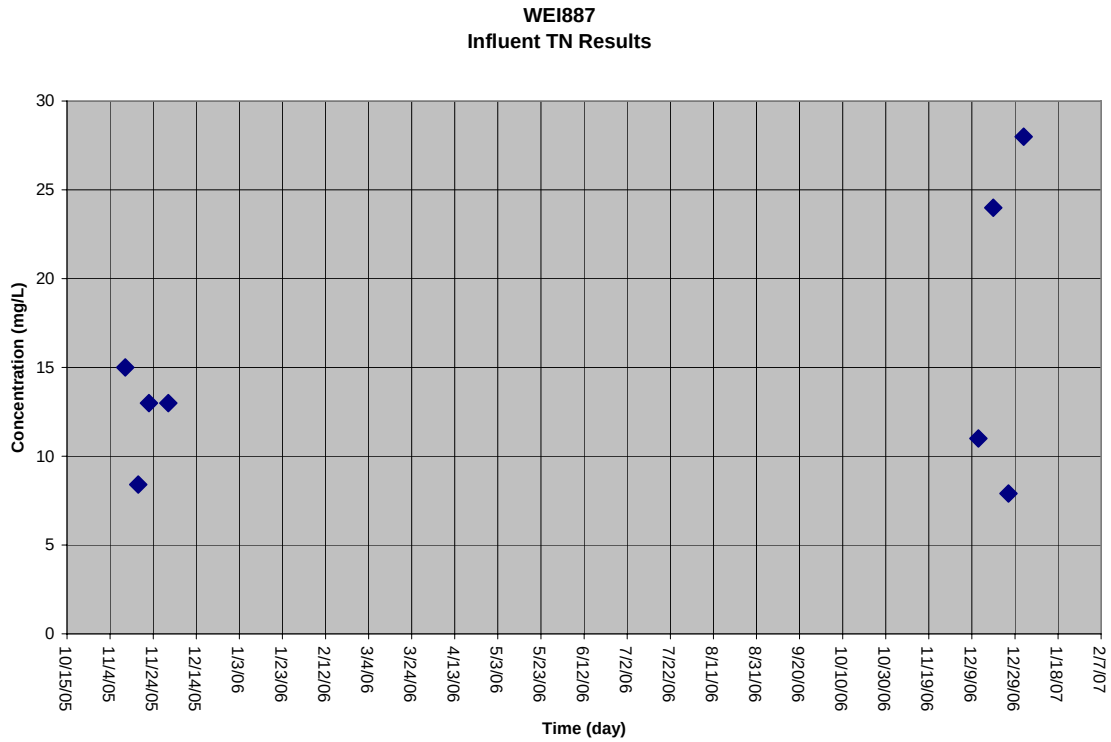

Figure G-1. Influent TN results for WEI887.

Effluent Total Nitrogen Results

There were a total of 25 samples taken over the course of the testing and in the analysis. The data that follows includes all identified outliers. The effluent TN concentrations ranged from 5.0 to 25 mg/L, with a mean concentration of 9.5 mg/L and a median concentration of 9.0 mg/L. The overall percent reduction in TN was 37%. Table G-2 provides a summary of the effluent data collected and analyzed at site WEI1887 during the evaluation, which is shown graphically for TN in Figure G-2.

Table G-2. Summary of Effluent Analytical Results for WEI887

Parameter	Statistical Analysis				
	Mean	Median	Standard Deviation	Minimum	Maximum
$CBOD_5$	7	3.7	11	2	58
TSS	7.2	5	5.4	5	23
Alkalinity	49	46	23	12	120
pH	NA	6.8	NA	6.3	7.4
Turbidity	4.4	2.6	6.9	0.9	36
TKN	2.3	1.5	3.2	0.5	17
NH_3	1.1	0.2	2.8	0.05	14
NO_3	7.2	7.4	5.3	0.02	22
NO_2	0.04	0.02	0.05	ND	0.18
NOx	7.2	7.4	5.3	0.02	22
TN	9.5	9.0	5.0	3.4	23
DO	6.5	7.2	2.3	1	8.8
Fecal Coliform[1]	NA	NA	NA	NA	NA

[1] *Fecal coliform – WEI887 site had a UV disinfection device*

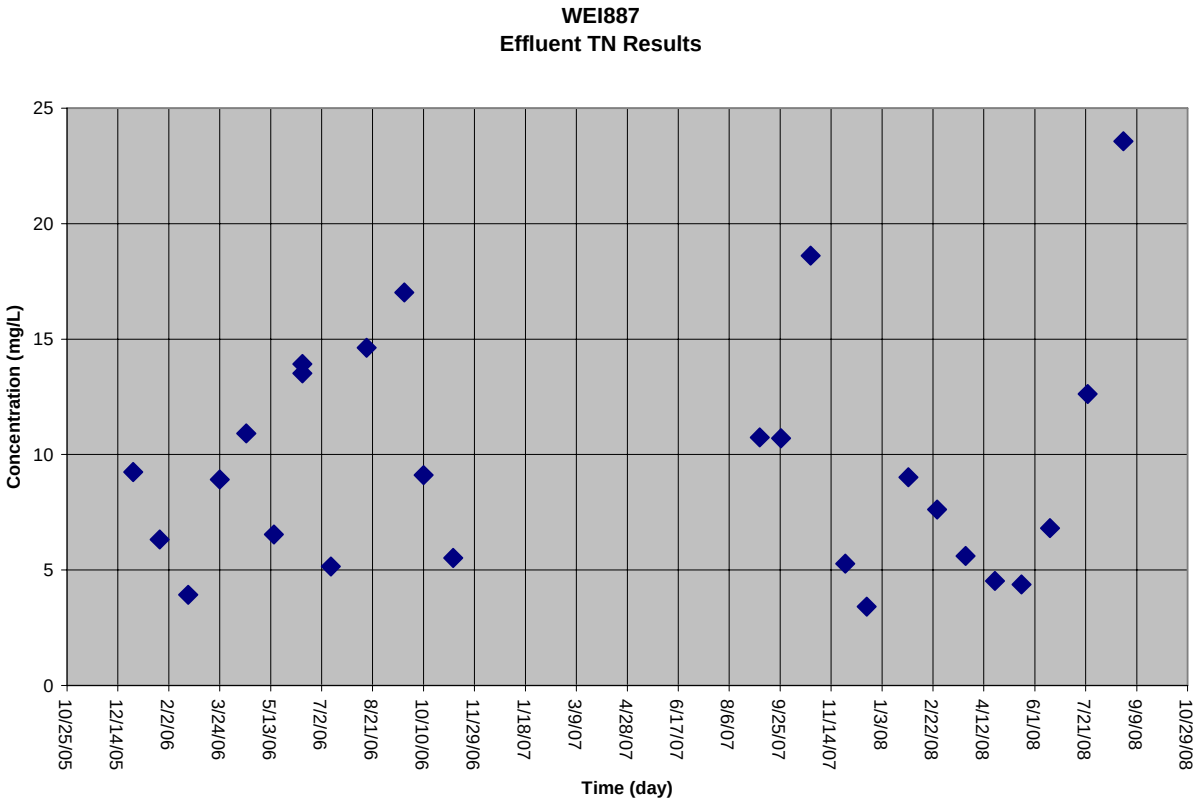

Figure G-2. Effluent TN results for WEI887.

Appendix H - BRO1000

Influent Total Nitrogen Results

Eight influent samples were collected at this site over the course of the testing. Influent TN concentrations ranged from 17 to 58 mg/L, with a mean concentration of 37 mg/L and median concentration of 43 mg/L. Table H-1 provides a summary of the influent data collected and analyzed at the BRO1000 site during the evaluation. Figure H-1 presents a graphical presentation of the influent TN data collected at the site.

Table H-1. Summary of Influent Analytical Results for BRO1000

Parameter	Statistical Analysis				
	Mean	Median	Standard Deviation	Minimum	Maximum
BOD_5	130	150	52	26	190
TSS	53	61	32	10	110
Alkalinity	210	220	56	120	270
pH	NA	7.1	NA	6.8	8.1
Turbidity	160	40	270	1.8	790
TKN	37	43	16	17	58
NH_3	30	30	16	11	51
Fecal Coliform[1]	2.6×10^4	1.9×10^5	2.7×10^5	2.0×10^1	6.7×10^5

[1]*Fecal coliform is calculated as a geometric mean.*

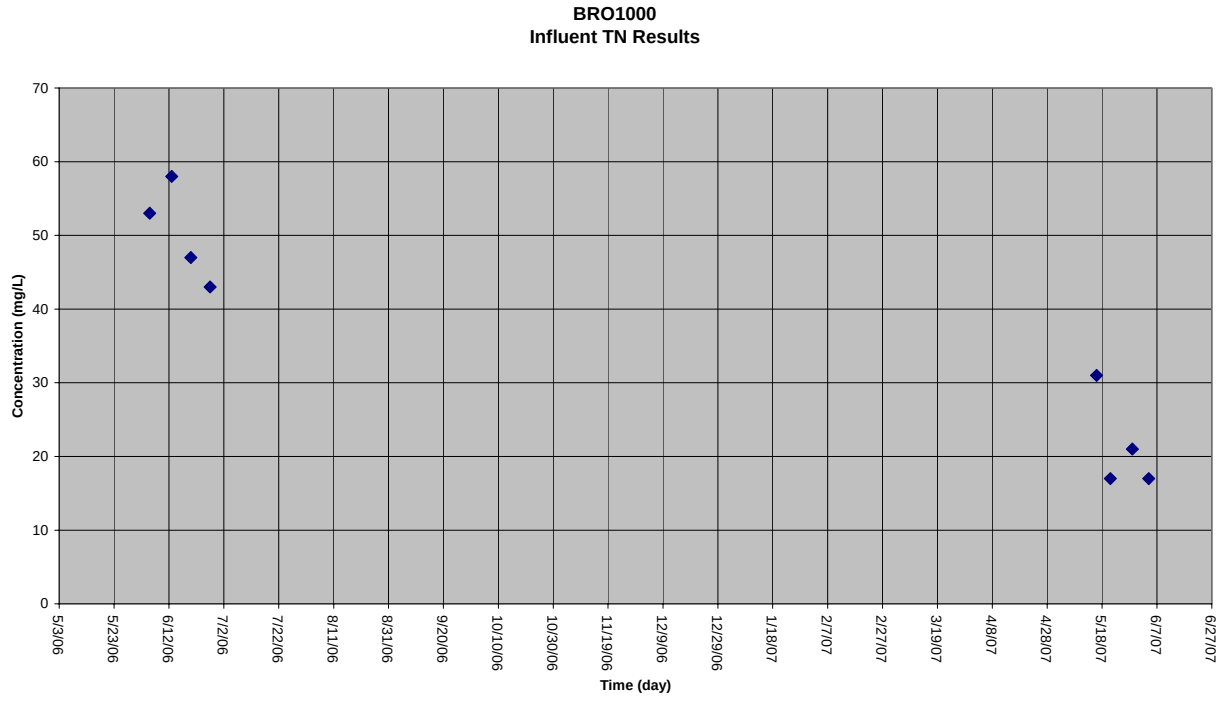

Figure H-1. Influent TN results for BRO1000.

Effluent Total Nitrogen Results

There were a total of 24 samples taken over the course of the testing and in the analysis. The data that follows includes all identified outliers. The effluent TN concentrations ranged from 2.4 to 25 mg/L, with a mean concentration of 15 mg/L and a median concentration of 15 mg/L. The overall percent reduction in TN was 59%. Table H-2 provides a summary of the effluent data collected and analyzed at site BRO1000 during the evaluation, which is shown graphically for TN in Figure H-2.

Table H-2. Summary of Effluent Analytical Results for BRO1000

Parameter	Statistical Analysis				
	Mean	Median	Standard Deviation	Minimum	Maximum
$CBOD_5$	23	3.4	87	2	420
TSS	9.4	5	9.1	5	43
Alkalinity	66	58	44	1	170
pH	NA	7.0	NA	5.6	7.5
Turbidity	7.2	3	11	1.3	49
TKN	4.2	2.4	5.0	0.9	23
NH_3	2.6	0.8	4.0	0.09	17
NO_3	11	10	5.7	1	23
NO_2	0.2	0.1	0.4	ND	1.9
NOx	11	11	5.7	1.0	23
TN	15	15	5.9	2.4	25
DO	5.7	5.8	1.9	1	8.9
Fecal Coliform[1]	NA	NA	NA	NA	NA

[1] *Fecal coliform – BRO1000 site had a UV disinfection device*

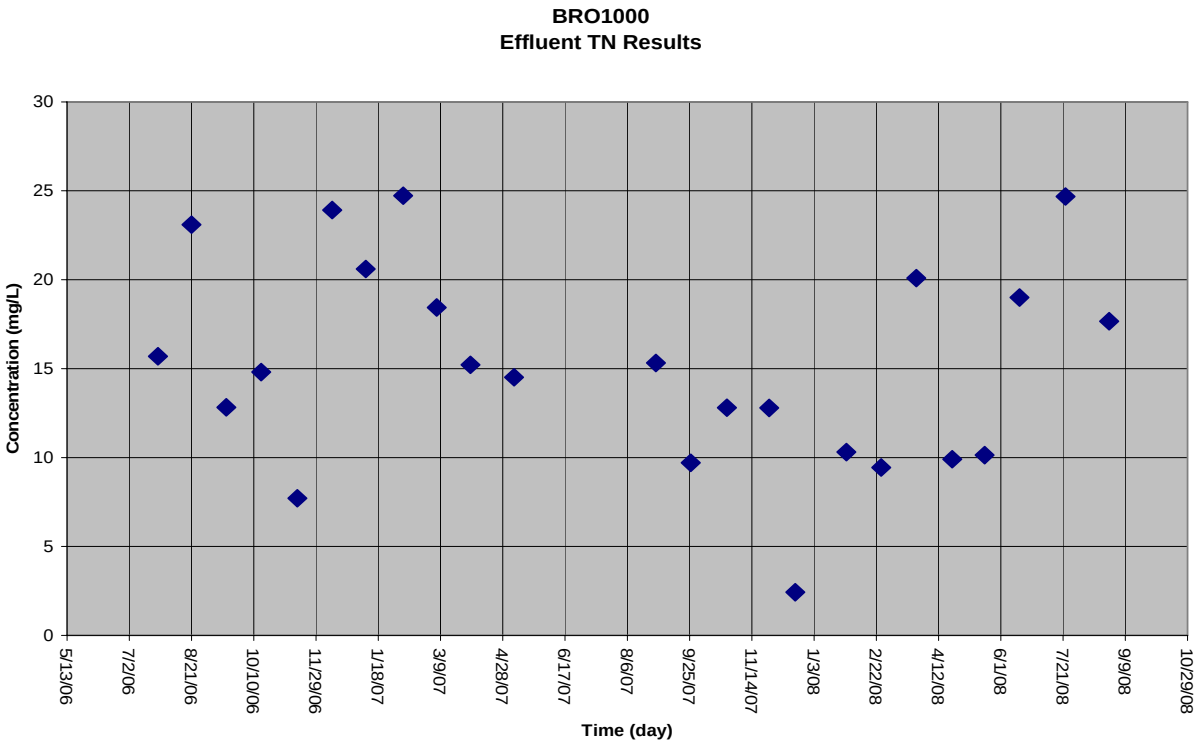

Figure H-2. Effluent TN results for BRO1000.

Appendix I - ZAK628

Influent Total Nitrogen Results

Twelve influent samples were collected at this site over the course of the testing. The TN concentrations were calculated by adding the influent TKN value with 0.69 mg/L nitrate-N in the site's water supply. Influent TN concentrations ranged from 26 to 74 mg/L, with a mean concentration of 41 mg/L and median concentration of 35 mg/L. Table I-1 provides a summary of the influent data collected and analyzed at the ZAK628 site during the evaluation. Figure I-1 presents a graphical presentation of the influent TN data collected at the site.

Table I-1. Summary of Influent Analytical Results for ZAK628

Parameter	Statistical Analysis				
	Mean	Median	Standard Deviation	Minimum	Maximum
BOD_5	170	110	180	16	750
TSS	55	50	30	22	130
Alkalinity	360	360	14	330	380
pH	NA	7.3	NA	6.9	7.6
Turbidity	50	52	18	19	84
TKN	40	34	15	25	73
TN	41	35	15	26	74
NH_3	31	27	14	1.3	51
Fecal Coliform[1]	6.2×10^4	3.4×10^5	1.2×10^6	1	4.6×10^6

[1] *Fecal coliform is calculated as a geometric mean.*

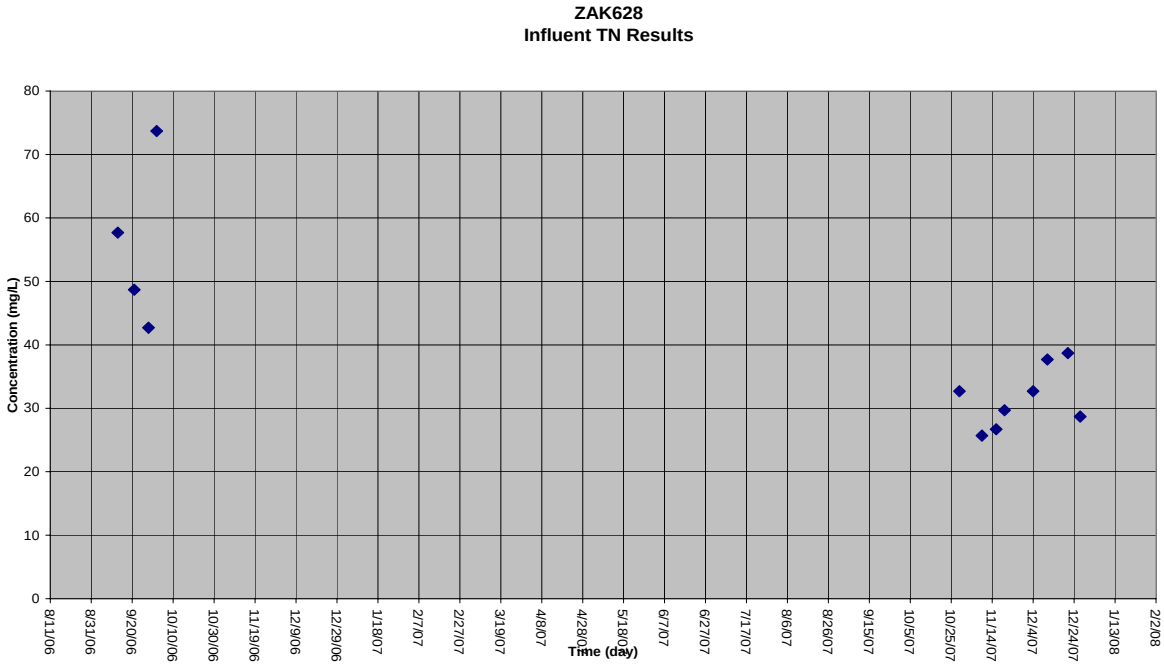

Figure I-1. Influent TN results for ZAK628.

Effluent Total Nitrogen Results

There were a total of 20 samples taken over the course of the testing and in the analysis. The data that follows includes all identified outliers. The effluent TN concentrations ranged from 14 to 70 mg/L, with a mean concentration of 25 mg/L and a median concentration of 20 mg/L. The overall percent reduction in TN was 39%. Table I-2 provides a summary of the effluent data collected and analyzed at site ZAK628 during the evaluation, which is shown graphically for TN in Figure I-2.

Table I-2. Summary of Effluent Analytical Results for ZAK628

Parameter	Statistical Analysis				
	Mean	**Median**	**Standard Deviation**	**Minimum**	**Maximum**
$CBOD_5$	18	8.4	23	3.1	90
TSS	37	20	63	5	300
Alkalinity	230	210	80	170	490
pH	NA	7.5	NA	7.0	7.8
Turbidity	41	16	54	2.2	180
TKN	12	5.9	18	2.4	70
NH_3	7.8	2.8	16	0.51	63
NO_3	12	14	5.2	0.05	19
NO_2	0.4	0.2	0.7	ND	3.4
NOx	13	14	5.0	0.05	19
TN	25	20	14	14	70
DO	6.0	6.4	2.4	1.0	11
Fecal Coliform[1]	NA	NA	NA	NA	NA

[1] *Fecal coliform – ZAK628 site had a UV disinfection device*

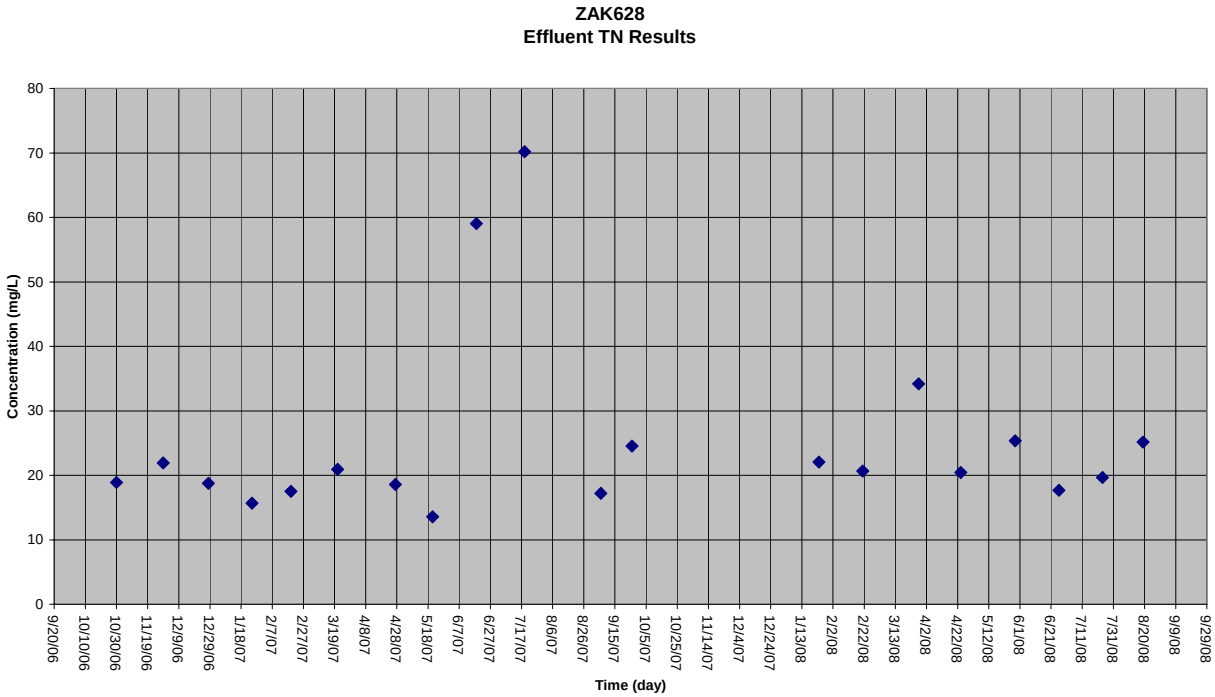

Figure I-2. Effluent TN results for ZAK628.

Appendix J - JAC2375

Influent Total Nitrogen Results

Eight influent samples were collected at this site over the course of the testing. The TN concentrations were calculated by adding the influent TKN value with 9.3 mg/L nitrate-N in the site's water supply. Influent TN concentrations ranged from 32 to 84 mg/L, with a mean concentration of 55 mg/L and median concentration of 59 mg/L. Table J-1 provides a summary of the influent data collected and analyzed at the JAC2375 site during the evaluation. Figure J-1 presents a graphical presentation of the influent TN data collected at the site.

Table J-1. Summary of Influent Analytical Results for JAC2375

Parameter	Statistical Analysis				
	Mean	Median	Standard Deviation	Minimum	Maximum
BOD_5	62	48	35	24	120
TSS	40	27	26	13	80
Alkalinity	280	290	82	150	380
pH	NA	7.8	NA	7.2	8.5
Turbidity	38	19	45	6.1	150
TKN	46	50	17	23	75
TN	55	59	17	32	84
NH_3	36	44	18	5.6	59
Fecal Coliform[1]	5.0×10^4	7.0×10^4	3.9×10^5	4.0×10^3	1.0×10^6

[1] *Fecal coliform is calculated as a geometric mean.*

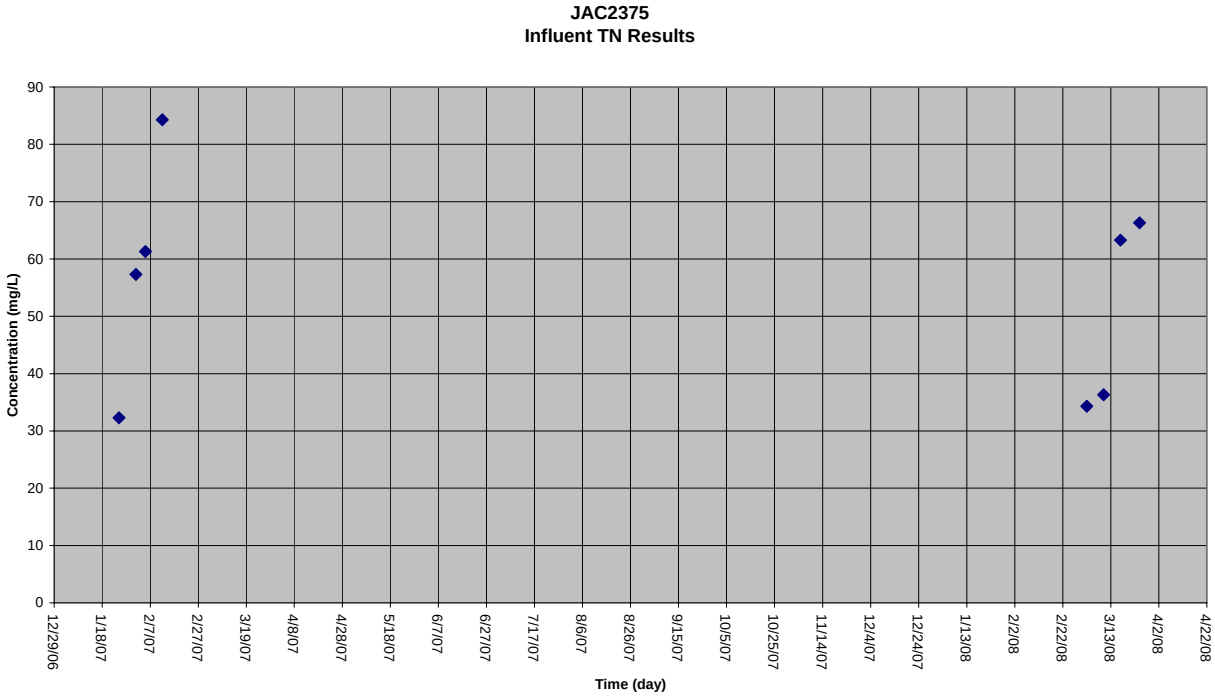

Figure J-1. Influent TN results for JAC2375.

Effluent Total Nitrogen Results

There were a total of 17 samples taken over the course of the testing and in the analysis. The data that follows includes all identified outliers. The effluent TN concentrations ranged from 11 to 50 mg/L, with a mean concentration of 23 mg/L and a median concentration of 18 mg/L. The overall percent reduction in TN was 58%. Table J-2 provides a summary of the effluent data collected and analyzed at site JAC2375 during the evaluation, which is shown graphically for TN in Figure J-2.

Table J-2. Summary of Effluent Analytical Results for JAC2375

Parameter	Statistical Analysis				
	Mean	**Median**	**Standard Deviation**	**Minimum**	**Maximum**
$CBOD_5$	7.5	2.9	11	2	47
TSS	5.8	5	2.2	3	12
Alkalinity	110	120	36	40	160
pH	NA	7.3	0.2	6.9	7.7
Turbidity	2.0	1.9	1.0	0.8	4.4
TKN	2.9	1.3	5.3	0.06	23
NH_3	1.8	0.17	5.2	0.05	22
NO_3	19	16	9.0	9.3	39
NO_2	1.1	0.12	3.8	0.02	16
NOx	20	17	9.0	9.5	39
TN	23	18	11	11	50
DO	7.9	7.7	2.0	4.2	11
Fecal Coliform[1]	8.4×10^2	1.0×10^3	3.4×10^3	4.2×10^1	1.4×10^4

[1] *Fecal coliform is calculated as a geometric mean.*

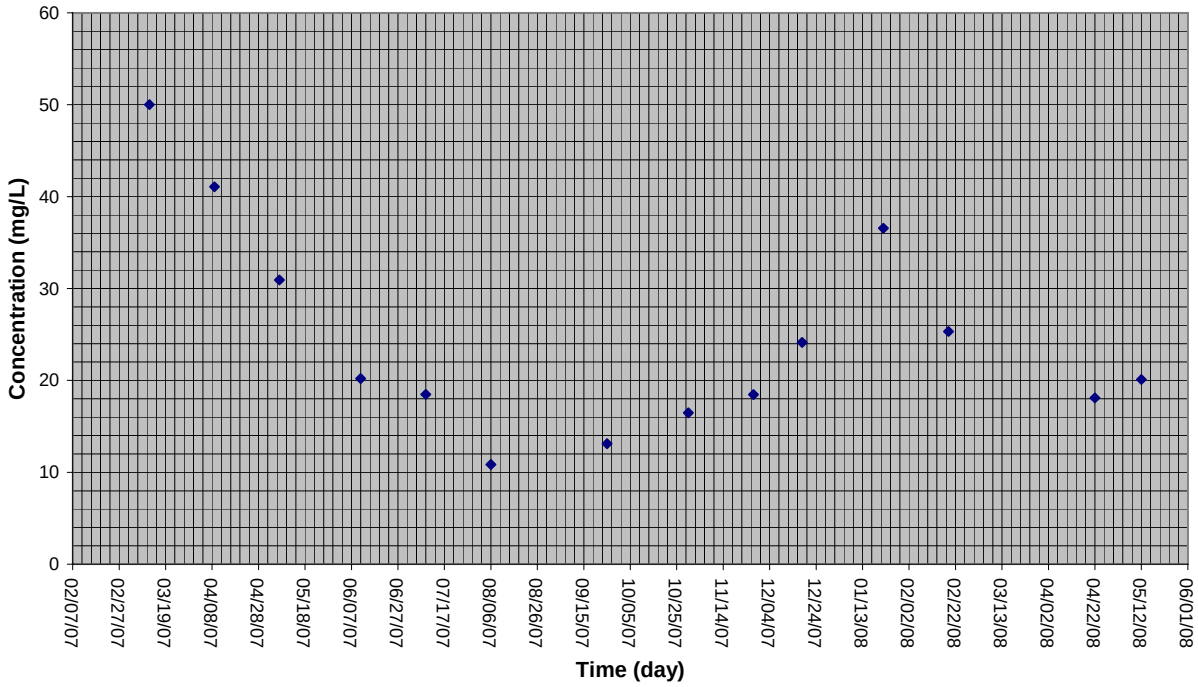

Figure J-2. Effluent TN results for JAC2375.

Appendix K - BRU4380

The influent mean BOD_5 on this site was greater than 900 mg/L, which is significantly higher than typical residential waste strength. The homeowners were interviewed numerous times throughout the evaluation to try and determine what practices of theirs might be resulting in such a high waste strength. Nothing definite was ever identified but they do own a couple of dairy cows and make their own dairy products; it is suspected that the byproducts of this process are being discharged to the onsite wastewater system. A COD analysis was completed on a sample for this location and found to have a COD concentration of 1,700 mg/L, which can be indicative of a very high concentration of organic waste. Even with the high organic loading the system still achieved 92% reduction in BOD, 57% reduction in TSS and 39% reduction in total nitrogen. Because of the extremely high waste strength it was decided to separate data collected from this site from the remainder of the analysis.

Evaluation of Effluent samples was not completed. The data is reported below.

Table K-1. Mean Water Quality Data

	$CBOD_5$ (mg/L)	TSS (mg/L)	Turbidity (NTU)	Nitrogen (mg/L as N)			Temp (°C)	Alkalinity (mg/L)	Fecal Coliform (CFU/100mL)[1]
				TKN	NH_3	TN			
Influent	900	110	110	69	50	69	22	340	4.4×10^5
Effluent	73	49	75	40	30	43	14	310	1.0×10^4

[1] *Fecal coliform is calculated as a geometric mean.*

Appendix L - HEN40

Influent Total Nitrogen Results

Eight influent samples were collected at this site over the course of the testing. The TN concentrations were calculated by adding the influent TKN value with 9.5 mg/L nitrate-N in the site's water supply. Influent TN concentrations ranged from 20 to 48 mg/L, with a mean concentration of 39 mg/L and median concentration of 44 mg/L. Table L-1 provides a summary of the influent data collected and analyzed at the HEN40 site during the evaluation. Figure L-2 presents a graphical presentation of the influent TN data collected at the site.

Table L-1. Summary of Influent Analytical Results for HEN40

Parameter	Statistical Analysis				
	Mean	Median	Standard Deviation	Minimum	Maximum
BOD_5	86	76	51	19	170
TSS	80	72	51	18	150
Alkalinity	230	240	51	150	280
pH	NA	7.0	NA	6.9	7.6
Turbidity	110	110	76	7.3	200
TKN	30	34	10	10	38
TN	39	44	10	20	48
NH_3	24	28	8.2	8.2	32
Fecal Coliform[1]	5.4×10^4	8.5×10^4	3.6×10^5	3.1×10^3	9.8×10^5

[1] *Fecal coliform is calculated as a geometric mean.*

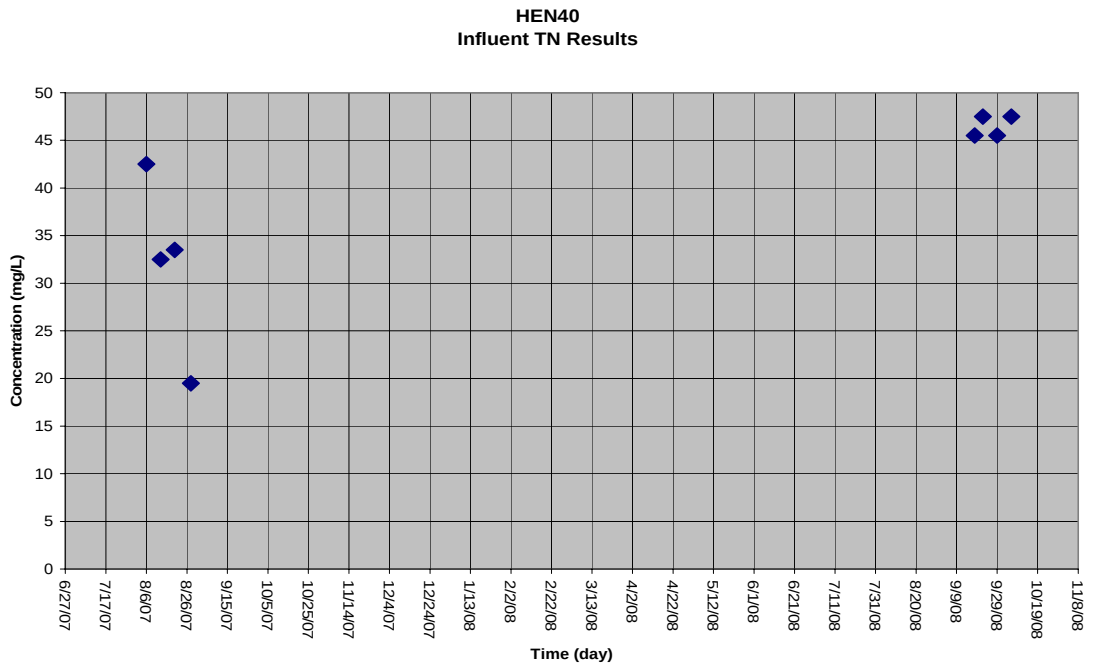

Figure L-1. Influent TN results for HEN40

Effluent Total Nitrogen Results

There were a total of 13 samples taken over the course of the testing and in the analysis. The data that follows includes all identified outliers. The effluent TN concentrations ranged from 10 to 47 mg/L, with a mean concentration of 16 mg/L and a median concentration of 14 mg/L. The overall percent reduction in TN was 64%. Table L-2 provides a summary of the effluent data collected and analyzed at site HEN40 during the evaluation, which is shown graphically for TN in Figure L-2.

Table L-2. Summary of Effluent Analytical Results for HEN40

Parameter	Statistical Analysis				
	Mean	**Median**	**Standard Deviation**	**Minimum**	**Maximum**
$CBOD_5$	4.4	3.1	3.7	2	15
TSS	12	5	21	5	82
Alkalinity	91	86	15	74	120
pH	NA	7.1	NA	5.7	7.4
Turbidity	5.3	2.3	9.9	0.7	38
TKN	4.3	1.6	7.6	1.1	29
NH_3	2.1	0.17	5.2	0.05	19
NO_3	12	11	3.5	3	18
NO_2	0.10	0.03	0.13	ND	0.34
NOx	12	11	3.5	3.3	18
TN	16	14	9.6	10	47
DO	7.40	8.4	2.7	3.3	10
Fecal Coliform	2.3×10^2	2.5×10^2	1.1×10^3	1.3×10^1	4.0×10^3

[1] *Fecal coliform is calculated as a geometric mean.*

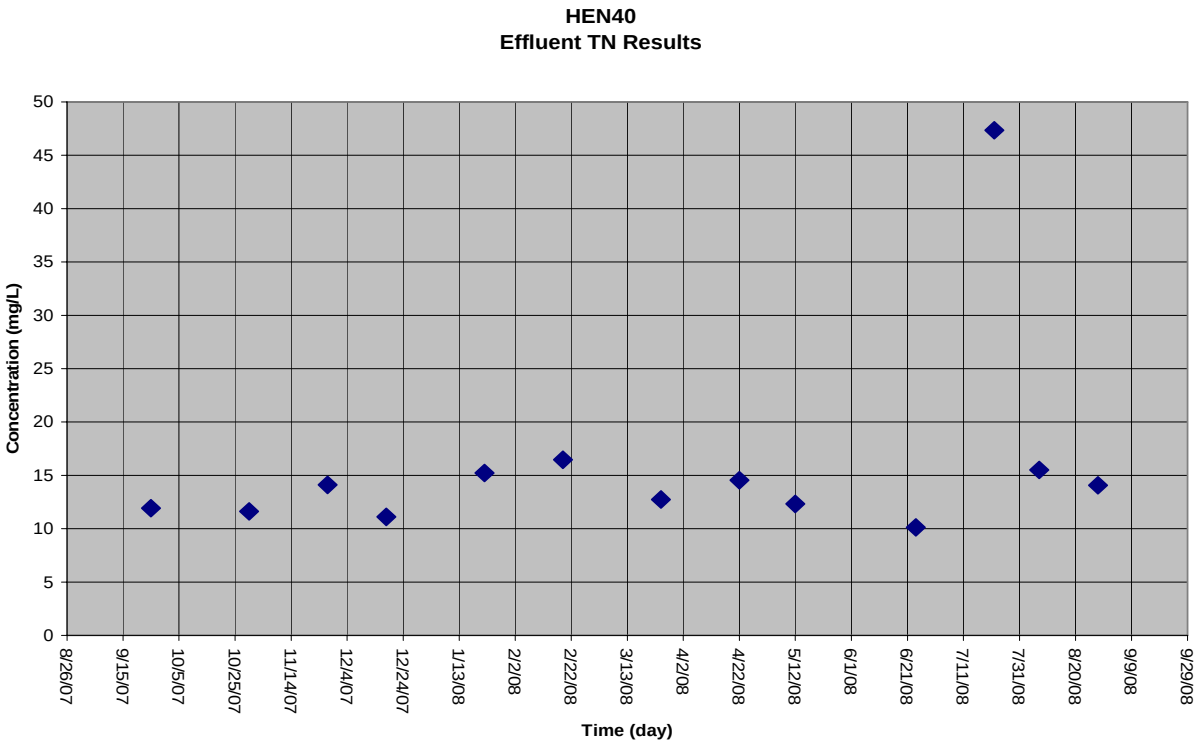

Figure L-2. Effluent TN results for HEN40.

Appendix M – Site Summary

AdvanTex - Pennsylvania Technology Verification Program Sites

Site ID#	Homeowner	Region	County	City	Township	Alkalinity (mg/L)	Water Softener	Water Supply	Water Conservation Devices?	# of Bedrooms	Occupants	Disposal Method	Repair or New Construction	Occupied Year Around?	Garbage Disopsal	Normal Residents?
1	SMI4540	SC	York	Dover	Dover	156	Yes - bypass	Well		2	2	At Grade Bed	Repair	Yes	Yes	Yes
2	KEN6320	SC	Berks	Birdsboro	Exator	186	No	Well	Yes	3	4	Stream	Repair	Yes	No	Yes
3	LEC6350	SC	Berks	Birdsboro	Exator	220	Yes - bypass	Well	Yes	3	3	Stream	Repair	Yes	No	Yes
4	END6334	SC	Berks	Birdsboro	Exator	216	No	Well	No	3	2	Stream	Repair	Yes	No	Yes
5	KRI6360	SC	Berks	Birdsboro	Exator	190	No	Well	Yes	3	2	Stream	Repair	Yes	No	Yes
6	WEI887	NW	Butler	Saxonburg	Clinton	43	Yes - bypass	Well	No	3	2	Stream	Repair	Yes	No	Yes
7	BRO1000	SW	Westmoreland	Jeannette	Penn	29.2	No	Well	?	3	2	Surface	Repair	Yes	Yes	Yes
8	ZAK628	SE	Bucks	Perkasie	Hilltown	230	Yes - bypass	Well	Yes	4	4	Surface	Repair	Yes	No	Yes
9	JAC2375	SC	York	York	West Manchester	To be obtained	No	Well	No	3	2	Sub-Surface, At-Grade Bed	Repair	Yes	No	Yes
10	BRU4380	SC	York	Thomasville	Dover	120	Yes - bypass	Well	No	4	6	Sub-Surface, At-Grade Bed	Repair	Yes	No	Yes
11	HEN40	SC	York	Jacobus	Jacobus	10.2	No	Well	No	4	2	Existing Standard Trench	Alteration?	Yes	No	Yes