

Commercial Treatment Systems

Design Considerations for AdvanTex® Treatment Systems

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Equations and Parameters Frequently Used In This Design Criteria

For recommendations regarding minimum hydraulic retention times, primary tankage, and configurations, see Table A, page 22.

Determining mass load in AdvanTex® systems

(For complete information on how to use these equations, see page 23.)

Mass Load (lbs/day)

$$\text{Concentration (mg/L)} \times (8.34 \times 10^{-6}) \times \text{Flow (gpd)}$$

Mass Load (kg/day)

$$\text{Concentration (mg/L)} \times (0.001) \times \text{Flow (m}^3/\text{day)}$$

Determining standard AdvanTex® stage sizing

(For complete information on how to use these equations, see pages 15-16.)

	Design Avg (US Units)	Design Max. (US Units)	Design Avg (SI Units)	Design Max. (SI Units)
Based on Organic Loading Rate (OLR)	0.04 lbs BOD ₅ /ft ² •d	0.08 lbs BOD ₅ /ft ² •d	0.2 kg BOD ₅ /m ² •d	0.4 kg BOD ₅ /m ² •d
Based on Hydraulic Loading Rate (HLR)	25 gpd/ft ²	50 gpd/ft ²	1 m ³ /m ² •d	2 m ³ /m ² •d
Based on Total Nitrogen Loading Rate (TNLR)	0.014 lbs TN/ft ² •d	0.028 lbs TN/ft ² •d	0.07 kg TN/m ² •d	0.14 kg TN/m ² •d
Based on Ammonia Loading Rate (ALR)	0.01 lbs NH ₃ -N/ft ² •d	0.02 lbs NH ₃ -N/ft ² •d	0.05 kg NH ₃ -N/m ² •d	0.1 kg NH ₃ -N/m ² •d

Determining second stage AdvanTex sizing in two-stage systems

(For complete information on how to use these equations, see pages 16-17.)

	Design Avg (US Units)	Design Max. (US Units)	Design Avg (SI Units)	Design Max. (SI Units)
Based on Organic Loading Rate (OLR)	0.02 lbs BOD ₅ /ft ² •d	0.04 lbs BOD ₅ /ft ² •d	0.1 kg BOD ₅ /m ² •d	0.2 kg BOD ₅ /m ² •d
Based on Hydraulic Loading Rate (HLR)	75 gpd/ft ²	125 gpd/ft ²	3 m ³ /m ² •d	5 m ³ /m ² •d
Based on Total Nitrogen Loading Rate (TNLR)	0.007 lbs TN/ft ² •d	0.014 lbs TN/ft ² •d	0.035 kg TN/m ² •d	0.07 kg TN/m ² •d
Based on Ammonia Loading Rate (ALR)	0.005 lbs NH ₃ -N/ft ² •d	0.01 lbs NH ₃ -N/ft ² •d	0.025 kg NH ₃ -N/m ² •d	0.05 kg NH ₃ -N/m ² •d

Determining anticipated treatment performance from standard AdvanTex systems

(For complete information on how to use these equations, see pages 25-25.)

Based on BOD₅

$$\text{BOD}_{5e} = \text{BOD}_{5i} \times (1 - C_{BR})$$

where: BOD_{5e} = BOD₅ effluent from standard AdvanTex stage
 BOD_{5i} = BOD₅ primary treated effluent value
 C_{BR} = 0.90 coefficient

Based on TKN or NH₃-N

$$\text{TKN}_e = \text{TKN}_i \times (1 - C_{NR})$$

where: TKN_e = TKN effluent from standard AdvanTex stage
 TKN_i = TKN primary treated effluent value
 C_{NR} = 0.95 coefficient

Based on NO₃

$$\text{NO}_{3e} = (\text{TKN}_i - \text{TKN}_e) \times (1 - C_{DNR})$$

where: NO_{3e} = NO₃ effluent from standard AdvanTex stage
 TKN_i = TKN primary treated effluent value
 TKN_e = TKN effluent
 C_{DNR} = 0.70 coefficient

Based on TN

$$\text{TN}_e = \text{TKN}_e + \text{NO}_{3e}$$

where: TN_e = TN effluent from standard AdvanTex stage
 TKN_e = TKN effluent from standard AdvanTex stage
 NO_{3e} = NO₃ effluent from standard AdvanTex stage

Determining anticipated treatment performance for total nitrogen from post-anoxic AdvanTex treatment stages

(For complete information on how to use these equations, see page 26.)

$$\text{TN}_{PAe} = \text{TKN}_e + \text{NO}_{3e} \times (1 - C_{DNR})$$

where: TN_{PAe} = TN effluent from post-anoxic stage
 TKN_e = TKN effluent from standard Advantex stage
 NO_{3e} = NO₃ effluent from standard AdvanTex stage
 C_{DNR} = 0.70 coefficient

Introduction

Orenco's AdvanTex® Treatment Systems were developed for the long-term processing of domestic- and commercial-strength wastewater to advanced treatment levels. The heart of all AdvanTex systems is a multiple-pass, packed-bed, fixed-film media filter that reliably provides high-quality effluent in a wide range of applications. These systems have undergone numerous national and international testing protocols, as well as multiple third-party field verification programs. This manual provides design information and guidance for commercial applications using an AdvanTex Treatment System. For other applications, contact Orenco or your local Orenco Dealer for more information.

AdvanTex® Model Descriptions

Three AdvanTex models are typically used in commercial applications. Your choice of model depends on system sizing requirements and site characteristics. All three operate in the manner described in the Treatment Process Description, and all perform similarly. For exact dimensions and specific treatment configurations, see AdvanTex Treatment System drawings.

AdvanTex AX20

AX20 Specifications

Length	91 inches (2311 mm)
Width	40 inches (1016 mm)
Height	31 inches (787 mm)
Dry weight	400 lbs (181 kg)
Treatment surface area	20 ft ² (1.9 m ²), nominal
Installation footprint	25 ft ² (1.9 m ²), actual
Installation methods	Partial burial or bermed installation; 6 inches (150 mm) above grade, minimum; antifloatation flanges available for areas with high groundwater
Recirculation-blend tankage	External
Recirculation method	Recirculating splitter valve

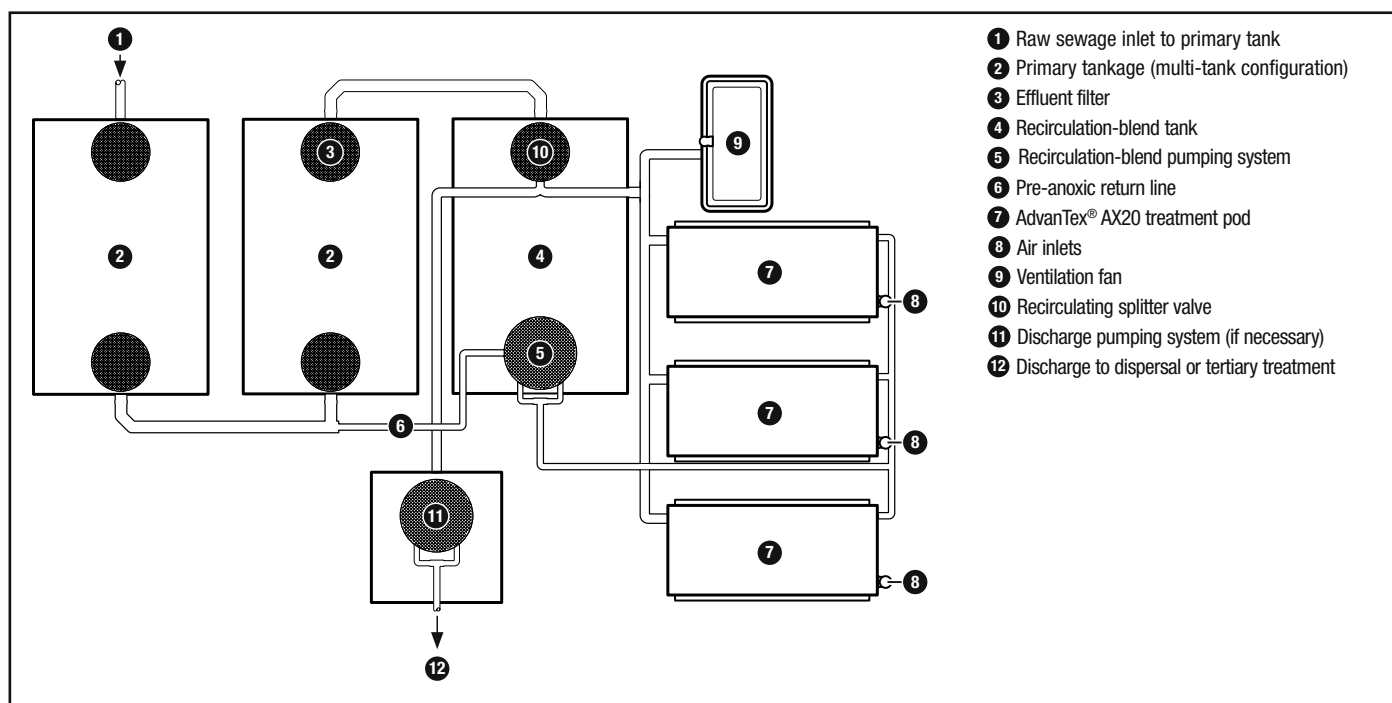


Figure 1. Example of an AdvanTex AX20 Commercial Treatment System

AdvanTex AX100

AX100 Specifications:

Length	191 inches (4851 mm)
Width	94 inches (2388 mm)
Height	42 inches (1067 mm)
Dry weight	1760 lbs (798 kg)
Treatment surface area	100 ft ² (9.3 m ²), nominal
Installation footprint	128 ft ² (11.9 m ²), actual
Installation methods	Partial burial or bermed installation; 6 inches (150 mm) above berm, minimum; 9 inches (230 mm) below natural grade, maximum
Recirculation-blend tankage	External
Recirculation method	Recirculating splitter valve

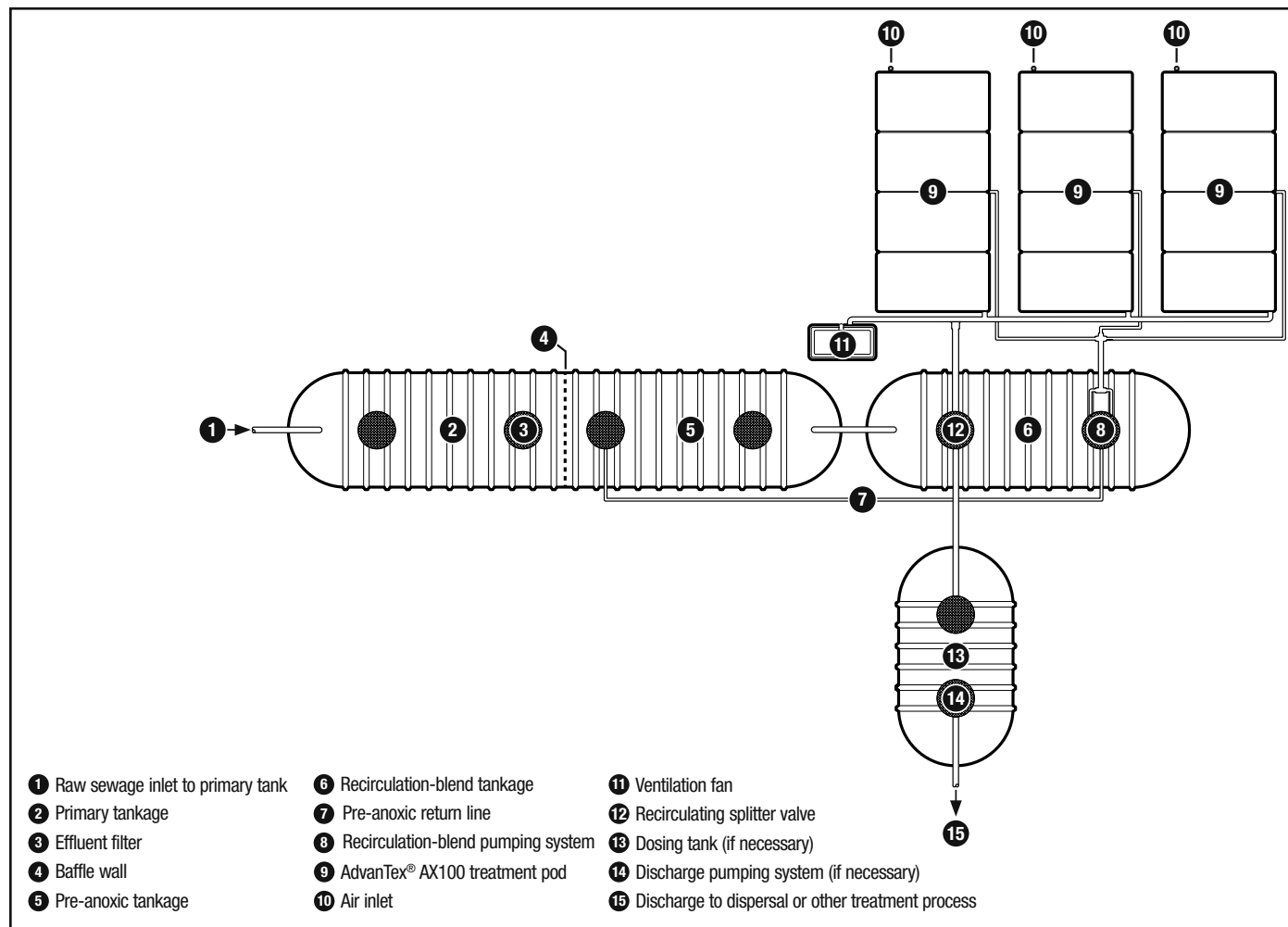


Figure 2. Example of an AdvanTex AX100 Commercial Treatment System

AdvanTex AX-Max™

AX-Max Specifications:

Length	14-42 ft (4.2-12.8 m)
Width	90 inches (2286 mm)
Height	97 inches (2464 mm)
Dry weight	Variable, up to 12,000 lbs (5440 kg)
Treatment surface area	25-300 ft ² (2.3-27.9 m ²), nominal
Installation footprint	112-336 ft ² (10.4-31.2 m ²), actual
Installation methods	Partial burial or bermed installation, or free-standing installation; 24-36 inches (610-910 mm) above grade or berm for ease of maintenance; antifloatation available for areas with high groundwater
Recirculation-blend tankage	Included
Recirculation method	Tank baffle wall, recirc-return valve

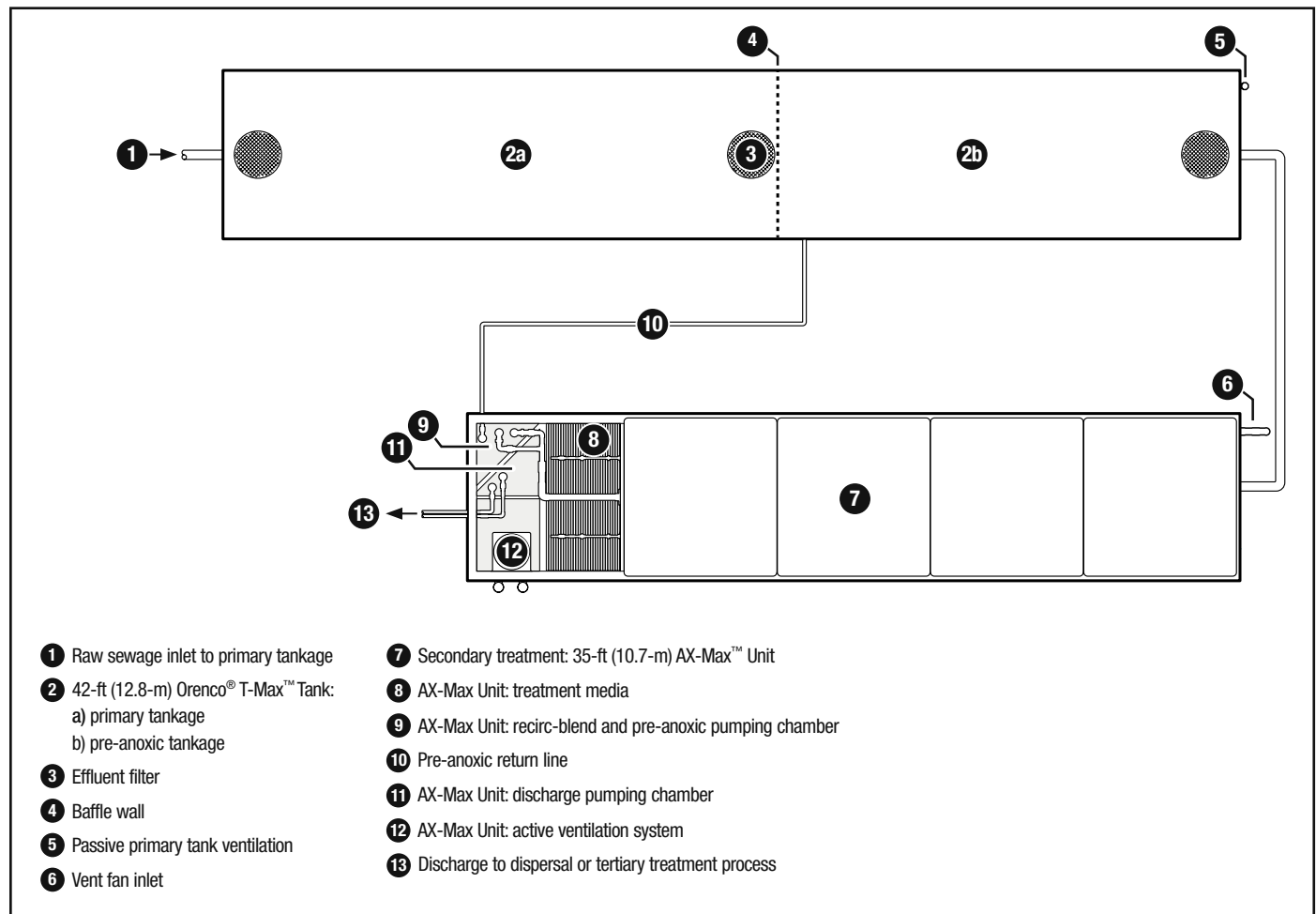


Figure 3. Example of an AdvanTex AX-Max Commercial Treatment System

Design Basis

To ensure that the system is designed properly for a given application, it is critical to first determine the design basis. The design basis for any treatment system consists of careful evaluation of several parameters that control the system's design and subsequent performance. Orenco's "Engineered Project Questionnaire," NFO-ATX-ADM-2, is available to assist in identifying and characterizing these parameters. It can be downloaded from Orenco's Document Library at www.orenco.com, or you may contact Orenco or your local Orenco Dealer for a copy. This document provides a list of the typical design parameters necessary to determine the suitability of Orenco products to a given project and for forming the system's design basis.

Average Day and Maximum Day Flows

Flows may be defined or calculated differently by application and local regulation; however, as used in this document:

Design Average Flow (Q_A) is the average of the daily volume to be received for a continuous 12-month period expressed as a volume per day. For facilities having critical seasonal high hydraulic loading periods (e.g., recreational areas, campgrounds) the design average is based on the daily average flow during the seasonal period.

Design Maximum Day Flow (Q_M) is the largest volume of flow to be received during a continuous 24-hour period expressed as a volume per day. The Design Maximum Day Flow is highly dependent on the application and collection technology used. For Effluent Sewer (STEP), Grinder Sewer, and Vacuum Sewer, a typical value is two times the Design Average Flow ($2Q_A$).

For Conventional Gravity Sewer applications, a typical value for Q_M is four times the Design Average Flow ($4Q_A$) for new construction and can range to over ten times ($10Q_A \pm$) for existing systems. Make sure to carefully evaluate any existing flow information and regulatory requirements when establishing this design parameter.

Primary-Treated Effluent Wastewater Strength

Organic Constituents in Wastewater

The two primary organic constituents in wastewater used in determining applicability and sizing of AdvanTex Treatment Systems are biochemical oxygen demand (**BOD₅**) and total suspended solids (**TSS**). These constituents are typically quantified either in raw wastewater or after the primary treatment stage. In order to determine the waste load to the AdvanTex Treatment System, it is necessary to determine the constituent concentrations after primary treatment. These constituent concentrations are referred to as primary-treated effluent throughout this document, and all percent reduction estimates are calculated relative to these concentrations. If these constituents are provided as raw wastewater values, it is the responsibility of the designer to determine the appropriate primary treatment requirements to achieve the primary-treated effluent values used in the design. Industry experts typically estimate that appropriate primary treatment (see Appendix A for primary tank sizing recommendations) will provide 50% reduction of BOD₅ (down to a minimum of 150 mg/L) and 90% reduction of TSS (down to a minimum of 50 mg/L).

Nitrogen Constituents in Wastewater

The principal forms of nitrogen found in wastewater are Organic Nitrogen (**Organic-N**), Ammonia Nitrogen (**NH₃-N**), Ammonium Nitrogen (**NH₄-N**), Nitrite Nitrogen (**NO₂-N**), and Nitrate Nitrogen (**NO₃-N**). These are expressed either individually or as components of the following:

- **Total Kjeldahl Nitrogen (TKN)**, which is the sum of Organic-N + NH₃-N
- **Total Inorganic Nitrogen (TIN)**, which is the sum of NH₃-N + NO₂-N + NO₃-N
- **Total Nitrogen (TN)**, which is the sum of TKN + NO₂-N + NO₃-N

As with the organic constituent concentrations, the nitrogen constituent concentrations must be quantified after the primary treatment stage to determine waste load to the AdvanTex Treatment System and are listed as primary-treated effluent throughout this document. A thorough understanding of the nitrogen cycle and how it works within the wastewater system is important when designing a system to treat for these parameters. A brief description of the processes follows:

Ammonification

Nitrogen is usually introduced into the wastewater system as Organic-N and NH₄-N. Organic-N (including feces, urea, and other animal and vegetable matter) in wastewater is converted into NH₄-N by the process of ammonification. In ammonification, proteins, amino acids, and other nitrogen-containing compounds are biochemically degraded by heterotrophic bacteria. Ammonification typically occurs in primary tankage and transport lines, as well as in the secondary treatment process. Because of this, a raw wastewater ammonia measurement may be significantly lower than the true value. In these instances, TKN is a better measure of overall nitrogen content and should be used when determining waste load to the AdvanTex Treatment System.

Nitrification and Denitrification

Once primary treated effluent is introduced into the secondary treatment process, nitrogen removal occurs first by nitrification and then by denitrification. In the first step of nitrification, an ammonium-oxidizing autotrophic bacteria, (*Nitrosomonas*), converts ammonium to nitrite. In the second step of nitrification, a nitrite-oxidizing bacteria, (*Nitrobacter*), converts nitrite to nitrate. Both of these processes occur under aerobic conditions. Lastly, denitrification occurs when nitrate is converted to nitrogen gas by heterotrophic bacteria under anoxic conditions ($DO < 0.5$ mg/L).

Therefore, treatment for NH_3 -N and TKN occurs through an aerobic process while treatment for NO_3 -N, TIN, and TN occurs through a combination of aerobic and anoxic processes.

For more information about the nitrogen process in wastewater, see Metcalf & Eddy's "*Small and Decentralized Wastewater Management Systems*," 4th Edition (1999). For information on pH and temperature effects on Nitrification and Denitrification, see *pH Effect on Nitrification* and *Temperature Effect on Nitrification and Denitrification* in the Design Considerations section on page 19.

Discharge Treatment Levels and Sampling Requirements

Discharge treatment levels and sampling requirements play a significant role in treatment facility design. Secondary treatment (effluent concentrations of BOD_5 and TSS of ≤ 30 mg/L based on a 30-day average) is a simple process typically requiring only a single-stage AdvanTex Treatment System. Additionally, advanced secondary treatment (BOD_5 and TSS of ≤ 10 mg/L based on a 30-day average) can typically be accomplished in the same manner. However many permits are now requiring some higher level of nitrogen treatment as well as providing values of "not to exceed" in place of "30-day average" or "30-day arithmetic mean." In these instances a safety factor of some kind is typically applied (or additional processes added) so that the discharge parameters are not exceeded even under maximum day flow conditions or maximum day primary-treated effluent concentrations.

Likelihood of System Expansion and Potential Permit Changes

Permits are typically limited in duration, and over the past two decades treated effluent discharge requirements have become stricter. In fact, many permit renewals are now asking for measurement of various constituents that were not part of the original treatment facility design. When designers are planning for future expansion, or for future modifications to permits, Orenco recommends using incremental engineering to plan for and provide space for potential future treatment upgrades. By understanding the various stages used in AdvanTex Treatment Systems, designers can lay out the treatment facility in a manner that allows for additional stages in the event that a planned build-out or future permit modification requires it. Please see sections titled *Treatment System Configurations* and *Process Stages* for more information.

Highly Variable or Seasonal Flow Considerations

Hundreds of AdvanTex systems are installed in parks, campgrounds, resorts, and lodges that experience highly variable flows (or complete shutdowns for long periods) due to seasonal use and they are ideally suited for these applications. Shortly after the system is placed in service, a thin bacterial film develops in the upper portion of the textile media; removal of BOD_5 /TSS occurs the first day after being in service. Independent tests show AdvanTex systems are capable of removing $> 85\%$ $cBOD_5$ and $> 97\%$ TSS within the first few days of operation. Many other technologies (especially suspended growth technologies) require weeks to treat to this level and struggle during periods of low loading.

The Operations & Maintenance (O&M) manual provided with each AdvanTex system can help guide the operator on appropriate O&M for systems with highly variable or seasonal flows, including the use of trending to automatically adjust recirculation ratios. For more information on determining which O&M method is best for a particular highly variable or seasonal flow application, contact Orenco.

Water Softener Backwash

Water softener regenerate (backwash) must not be plumbed into any Orenco AdvanTex treatment system. The concentration of sodium and chlorides in water softener backwash alters the settling and general solids segregating characteristics through the system and chlorides are elevated above the 180 mg/L toxicity or inhibitory threshold established by EPA for nitrogen removal.

This backwash is bacteria-free and not an organic-based wastewater. Essentially it is a "salt/mineral-laden water, free of contaminants," suitable for ground discharge as recognized by many states. In fact, many jurisdictions prohibit salt water regenerate from being discharged to septic systems, advanced treatment systems, and/or sanitary sewer. Instead, there is a provision for constructing a separate small dispersal area for backwash.

Application Types

Applications can typically be classified into one of seven application types, each characterized by waste streams and usage characteristics. Table 1 lists each application type, examples, the criteria used to establish each type, and associated design notes.

It is important to note that the flow and constituent concentration ranges associated with each application type represent Orenco's observations from similarly classified applications. However, they do not represent actual flows and constituent concentrations of the applications at hand. The engineer is responsible for ensuring that wastewater in each project is properly characterized and, whenever possible, waste streams should be sampled and actual values used in the design.

Table 1. Application Types

Application Types	Examples	Characterization Criteria	Design Notes
Type 1: <i>Domestic Primary-Treated Effluent Quality (Blend of Black and Grey Water Waste)</i>	<ul style="list-style-type: none"> • Apartments • Condominiums • Mobile Home Parks • Municipal Systems • Planned Communities • Residential Subdivisions • Work Camps 	<ul style="list-style-type: none"> • Waste streams are residential in nature • Contributions come from both black and grey water sources 	<ul style="list-style-type: none"> • Some "Type 1" applications have flow contributions that bias them toward another application type (e.g., communities serving primarily commercial core areas with minimal residential connections, or work camps with commercial kitchens serving meals for workers from other camps). • With appropriate primary treatment, primary-treated effluent typically ranges from: <ul style="list-style-type: none"> – BOD₅ 140-250 mg/L – TSS 40-140 mg/L – TKN 50-80 mg/L
Type 2: <i>Primarily Black Water Waste</i>	<ul style="list-style-type: none"> • Airport Facilities • Campgrounds • Fire Departments • Golf Courses • Manufacturing Facilities • Offices • Parks • Public Toilets/Rest Areas • RV Parks • Ski Resorts • Visitor Centers 	<ul style="list-style-type: none"> • Waste streams are commercial in nature • Contributions come from primarily black water sources 	<ul style="list-style-type: none"> • Some "Type 2" applications have flow contributions that bias them toward another application type (e.g., facilities with restaurants or RV parks or campgrounds with flow contributions from dump stations exceeding 20% of the daily flow). • With appropriate primary treatment, primary-treated effluent typically ranges from: <ul style="list-style-type: none"> – BOD₅ 300-500 mg/L – TSS 80-250 mg/L – TKN 90-200 mg/L
Type 3: <i>Primarily Black Water Waste with Surge Flows</i>	<ul style="list-style-type: none"> • Churches • Schools 	<ul style="list-style-type: none"> • Waste streams are commercial in nature and primarily from black water sources • Flows and primary treated effluent quality are heavily dependent on the facilities (e.g., schools with cafeterias and shower facilities vary significantly from those without) 	<ul style="list-style-type: none"> • Due to variations in daily waste volumes, flow equalization tankage should be strongly considered in order to optimize the treatment process. • With appropriate primary treatment, primary-treated effluent typically ranges from: <ul style="list-style-type: none"> – BOD₅ 300-500 mg/L – TSS 80-250 mg/L – TKN 90-150 mg/L
Type 4: <i>Primarily Black Water Waste with Pharmaceuticals or Toxic Inhibitors</i>	<ul style="list-style-type: none"> • Hospitals • Retirement Facilities • Veterinary Clinics 	<ul style="list-style-type: none"> • Waste streams are commercial in nature and primarily from black water sources 	<ul style="list-style-type: none"> • Antibiotics and other pharmaceutical products in the waste stream may impair microorganism health in the primary tank and the AdvanTex unit. • The designer should note on the plan set that the wastewater treatment system can be negatively affected by the introduction of these substances and care should be taken to limit their discharge. • With appropriate primary treatment, primary-treated effluent typically ranges from: <ul style="list-style-type: none"> – BOD₅ 300-700 mg/L – TSS 100-350 mg/L – TKN 70-120 mg/L

Application Types	Examples	Characterization Criteria	Design Notes
Type 5: <i>Black Water with Restaurant Waste</i>	<ul style="list-style-type: none"> • Bars/Taverns • Casinos • Delis • Gas Stations • Hotels/Motels • Restaurants • Resorts • Shopping Centers • Strip Malls 	<ul style="list-style-type: none"> • Waste streams are commercial in nature • Contributions range from primarily black water with some kitchen sources to primarily kitchen sources with some black water • Raw wastewater has significant grease and oil (G&O) contributions 	<ul style="list-style-type: none"> • Careful evaluation is required to properly size AdvanTex systems for "Type 5" applications. Waste strength varies significantly depending on the hours of business, menu, take-out vs. dine-in eating, dining seat turnover rate, catering and event hosting activities, etc. • Restaurant applications require a pre-anoxic return loop (see Process Stages section on page 12). • Restaurants and applications with greater than a 50% flow contribution from restaurants and BOD₅ values greater than 800 mg/L will require the use of pre-aeration and clarification (see Process Stages section on page 13). • Grease tanks must be sized to ensure that the maximum G&O contribution to the secondary treatment system does not exceed 25 mg/L. Recommended grease tank sizes are provided in Appendix A. • Kitchen dishwashing appliances used in conjunction with AdvanTex treatment must be high-temperature appliances. • For existing systems with low-temperature, chemical-type appliances, pre-aeration will be necessary. • With appropriate primary treatment, primary-treated effluent typically ranges from: <ul style="list-style-type: none"> – BOD₅ 300-1000+ mg/L – TSS 80-300 mg/L – TKN 90-200+ mg/L
Type 6: <i>Polishing Bioreactors & Greywater Waste</i>	<ul style="list-style-type: none"> • Organic Removal • Ammonia Removal • Showers • Sinks 	<ul style="list-style-type: none"> • Waste streams have typically been treated to secondary levels prior to polishing unit • These are sized based upon the organic and or ammonia removal loading rates provided in this document. 	<ul style="list-style-type: none"> • Polishing of lagoon or holding pond effluent requires removal of algae prior to introduction to the polishing bioreactor system. • Contact Orenco for support on all high-strength waste projects. • See Appendix 4A: Special Considerations for Greywater Treatment Systems (Application Type 6) in this Design Criteria for details on hydraulic loading and wastewater constituent characteristics for greywater systems.
Type 7: <i>High Strength Process Waste</i>	<ul style="list-style-type: none"> • Wineries • Breweries • Dairies • Food Processing Facilities • Slaughterhouses 	<ul style="list-style-type: none"> • These are complex waste streams requiring careful evaluation 	<ul style="list-style-type: none"> • Chemical cleaning processes used in facilities that produce high-strength process waste must be addressed to ensure they are compatible with AdvanTex biological treatment processes. • All Type 7 applications require the use of a pre-anoxic return loop (see Process Stages). • All Type 7 applications will require the use of pre-aeration and clarification (see Process Stages). • Additional treatment processes, such as bioaugmentation (the addition of necessary nutrients required to speed up the rate of degradation of a contaminant), are often necessary in addition to the secondary treatment system. • Contact Orenco for support on all high-strength waste projects.

Treatment System Configurations

This section shows the three most common treatment system configurations using an AdvanTex Treatment System. Determination of the appropriate configuration is based upon flow, primary treated effluent constituent concentrations, and discharge permit requirements.

Each configuration shows the applicable treatment stages utilized and where to find the information to properly size the systems.

For systems with restaurant waste contributions, adequate grease tankage or similar means are necessary to ensure that the maximum grease contribution to the secondary treatment system does not exceed 25 mg/L greases and oils. Levels above 25 mg/L will tend to clog the textile sheets prematurely, preventing adequate aeration and uniform delivery of wastewater constituents for effective biological breakdown.

The appropriate sizing equations are referenced in each figure. When multiple equations are referenced, each calculation should be performed and the largest resulting textile surface area must be used in the design. Please contact Orenco or the nearest Orenco Dealer for support regarding the appropriate configuration or sizing criteria.

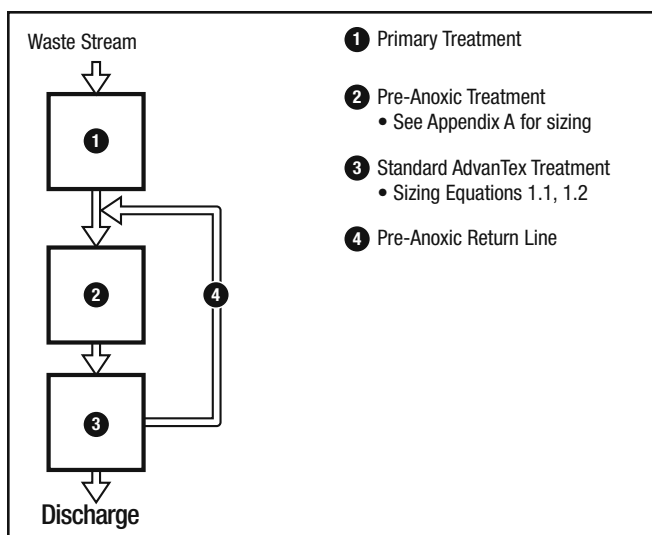


Figure 4. Treatment Diagram for Removal of Organics

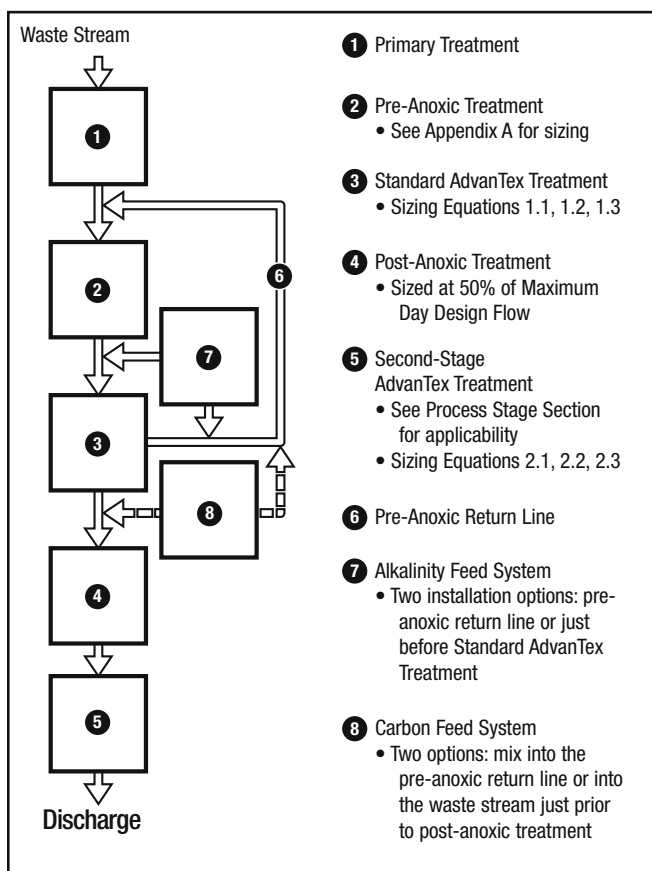


Figure 5. Treatment Diagram for Advanced Removal of Nitrogen

Standard AdvanTex Systems

Use for BOD₅/cBOD₅, TSS, and Nitrogen Discharge Limits

Organic removal is the simplest form of advanced treatment, typically requiring only primary and secondary treatment. When loaded at or below the applicable loading rates, standard AdvanTex Treatment Systems typically achieve treatment levels of < 10 mg/L BOD₅/cBOD₅ and TSS (based on 30-day average or 30-day arithmetic mean), and they typically provide reduction of total nitrogen (TN) > 60% and removal of ammonia (NH₃-N) of 95% (range 90-99%).

Figure 4 shows the typical configuration for discharge limits associated with these constituents. See the AdvanTex Unit Sizing section of this document for the sizing equation listed.

A pre-anoxic stage is recommended for all organic-only removal applications and it is required for systems with high-strength primary treated effluent (Application Types 5 & 7).

A two-stage AdvanTex system will be necessary for systems with discharge limits of NOT TO EXCEED 10 mg/L BOD₅/cBOD₅ or for discharge limits of ≤ 5 mg/L BOD₅/cBOD₅ based on a 30-day average or 30-day arithmetic mean.

AdvanTex Systems for the Advanced Removal of Nitrogen

Use for Systems with Permits Requiring Discharge Limits of 60-90% Removal of Total Nitrogen, Total Inorganic Nitrogen, or Nitrate Nitrogen

For wastewater systems with permit limits for TN, TIN, or NO₃-N requiring greater than 60% nitrogen reduction, pre-anoxic and post-anoxic treatment stages are needed, as well as the possible addition of both supplemental carbon and alkalinity. Figure 5 shows one of the typical configurations for systems with discharge limits requiring this level of treatment.

The nitrification occurring in the AdvanTex treatment stage is heavily influenced by the alkalinity required to buffer the process (7.14 mg/L alkalinity per 1 mg/L of ammonia-N). pH levels of 7.5 to 8.5 are ideal for complete nitrification and should be buffered to remain above a pH of 7 for all applications. The use of the pre-anoxic stage benefits overall operation of the system, since denitrification in this stage will return as much as 50% of the alkalinity consumed during nitrification. A supplemental alkalinity feeder immediately preceding the AdvanTex treatment stage may still be necessary to ensure sufficient alkalinity for nitrification.

Carbon addition should be balanced to the wastewater flows to ensure carbon-to-nitrogen (C:N) ratios are appropriate. C:N ratios greater than 4:1 are necessary and around 6:1 are preferable, to ensure that denitrification occurs. Carbon is added in the post-anoxic stage to maintain the proper carbon-to-nitrogen ratio. A post-anoxic tank with carbon addition is generally adequate for applications requiring up to 80% removal of

nitrogen. For applications requiring greater than 80% removal of nitrogen, a moving bed bioreactor (MBBR) is typically necessary. See *Post Anoxic Treatment Stage* in the *Process Stages – AdvanTex Treatment Systems* section for more information.

Depending on permit requirements, either a one-, two- or three-stage configuration is used. When there are stringent organic removal requirements (effluent BOD₅/cBOD₅ < 20 mg/L), a two-stage configuration (second stage as polishing) is often used to remove excess carbon (cBOD₅) prior to discharge.

For TN, TIN, and $\text{NO}_3\text{-N}$ discharge requirements of <10 mg/L, or for applications with primary treated effluent TN values of >150 mg/L and $>80\%$ nitrogen removal requirements, it will be necessary to integrate a two-stage AdvanTex system, followed by a denitrifying moving bed bioreactor (MBBRd), denitrification upflow filter, or other denitrification technology into the treatment process. Contact Orenco prior to designing a system to meet these requirements. See *pH Effect on Nitrification* and *Temperature Effect on Nitrification and Denitrification* in the *Design Considerations* section on page 19.

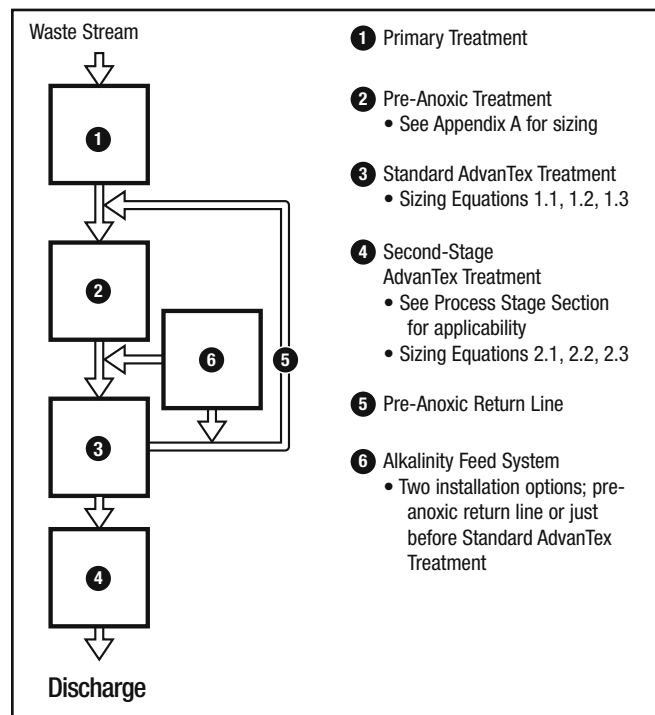


Figure 6. Treatment Diagram for Advanced Removal of Ammonia

out relying on this occurrence. As operational data becomes available for the specific treatment system – demonstrating the return of alkalinity through denitrification – alkalinity feed rates can be adjusted downward. See *pH Effect on Nitrification* and *Temperature Effect on Nitrification and Denitrification* in the *Design Considerations* section on page 19.

Process Stages – AdvanTex Treatment Systems

Primary Treatment Stage

Purpose and Description:

The primary treatment stage is designed to collect wastewater; segregate settleable and floatable solids (sludge and scum); accumulate, consolidate and store solids; digest organic matter; and discharge primary-treated effluent. Passive, energy-free primary tankage provides the most cost-efficient method of primary treatment available for nonindustrial sewage; BOD removal of $>50\%$ and TSS removal of $>90\%$ (when using an effluent filter) are typically accomplished with passive primary treatment.

The primary treatment stage can be configured in several ways, including single- or multiple-compartment tanks, single tanks with meandering baffles (partitions), or multiple tanks in series. Some systems may utilize solids separation devices. Primary treatment includes effluent screening, and effluent may be discharged to the secondary treatment stage via gravity or pump.

Design Notes and Special Considerations:

The volume and configuration of primary tankage or inclusion of other primary treatment devices (e.g. solids separation) is dependent on the system, the application type, and the expected waste strength. When using tankage for primary treatment, proper sizing ensures adequate volume for the development of the necessary microbial environments, appropriate sludge and scum storage, and surge volume. For recommendations on sizing of primary tankage, see Appendix A. The tank's structural soundness and watertightness are vital to the system's performance, and all tanks should be reviewed by the engineer and water-tested in the field after installation.

AdvanTex Systems for the Advanced Removal of Ammonia

Use for Systems with Permits Requiring Discharge Limits $>95\%$ Removal of Ammonia or TKN

For wastewater systems requiring ammonia removal due to restrictive ammonia nitrogen ($\text{NH}_3\text{-N}$) or TKN discharge limits ($>95\%$ removal), a Second Stage AdvanTex system will be necessary following standard AdvanTex treatment. Figure 6 shows the typical configuration for discharge limits associated with this level of treatment.

The nitrification occurring in the AdvanTex system is heavily influenced by the alkalinity required to buffer the process (7.14 mg/L alkalinity per 1 mg/L of ammonia-N). pH levels of 7.5 to 8.5 are ideal for complete nitrification and should be buffered to remain above a pH of 7 for all applications. Immediately preceding the AdvanTex treatment stage, a supplemental alkalinity feeder may be necessary to ensure sufficient alkalinity for nitrification to break down ammonia.

Using a pre-anoxic stage helps buffer pH, as denitrification in this stage will return as much as 50% of the alkalinity consumed during nitrification. In addition, readily available BOD is consumed in the pre-anoxic denitrification stage, reducing the BOD load to the secondary treatment unit. Most application types provide adequate carbon in the incoming stream to achieve denitrification and subsequent alkalinity return, but in the design it is best to ensure that there is enough alkalinity added with-

Pre-Anoxic Treatment Stage

Purpose and Description:

This process consists of recirculating a portion of the recirc-blend (or filtrate) from the AdvanTex secondary treatment system to an anoxic zone within the initial primary solids settling/collection chamber or, preferably, in a separate pre-anoxic tank. A pre-anoxic treatment stage tends to balance and lower concentrations. By blending primary treated effluent with AX filtrate, it also provides an environment for denitrifying a portion of the nitrified filtrate.

The use of a pre-anoxic stage benefits all applications and is essential for those applications with high-strength waste (organic or nitrogen concentrations), and restrictive permit limits, as well as applications desiring higher-quality effluent and enhanced overall removal performance.

Design Notes and Special Considerations:

Orenco recommends the use of a pre-anoxic stage for all projects. For recommendations on sizing of pre-anoxic tankage (typically 1 day Q_M), see Appendix A. Pre-anoxic tankage volume is a component of the overall primary tankage. For an effluent sewer collection system (i.e. STEP) the pre-anoxic tank is sized at 50% of the values provided in Appendix A for gravity or onsite tankage options.

The pre-anoxic return ratio (R_{NOX}) is the ratio of flow of the pre-anoxic return loop in relation to the average day design flow.

For most applications, the R_{NOX} value is equal to $1 \pm$ and therefore the return flow to the pre-anoxic stage (Q_{RNOX}) is equal to the Average Day Design Flow (Q_A).

Alkalinity is often added in this stage, because the pre-anoxic return line is a convenient place to add alkalinity while simplifying the overall system layout. The pre-anoxic return line can also be used to introduce supplemental carbon while maintaining a simple design. The establishment of denitrification in this stage reduces organic and nitrogen levels while returning about 50% of the alkalinity consumed during the first stage of secondary treatment (3.57 mg/L alkalinity per 1 mg/L NO_3 -N denitrified).

Consider supplemental carbon addition in the pre-anoxic stage for...

- Systems requiring significant total nitrogen reduction ($> 85\%$)
- Systems with high nitrogen values in primary treated effluent (Application Types 2, 3, & 5), resulting in low C:N ratios ($< 4:1$)

Orenco offers liquid and dry chemical feed units for adding alkalinity and liquid chemical feed units for supplemental carbon. There are advantages and disadvantages to various alkalinity sources and supplemental carbon products, so consider specific project conditions when making a selection.

Flow Equalization Stage

Purpose and Description:

Flow equalization (EQ) provides stability by leveling out peaks in flow and allowing consistent loading of the treatment system. EQ is strongly recommended for systems with variable flow patterns and restrictive discharge limits. EQ is especially important for systems that have highly variable flow patterns due to usage (e.g., resorts and churches) or collection method (e.g., conventional gravity collection).

The EQ stage consists of a tank or tanks fitted with a timed-dose-controlled pumping system. It follows the primary tank and pre-anoxic tank (if used) and is typically located before pre-aeration/clarification tankage (if used) or a recirculation-blend chamber.

Design Notes and Special Considerations:

EQ tank sizing recommendations vary for systems with significant fluctuations in flow. For support with EQ tank sizing, contact Orenco.

For schools and churches, Orenco typically recommends dividing the system's total weekly flow by six and using this value as the Design Average Flow, with one day allowed for recovery. Using this technique, an EQ tank equal to the Design Maximum Day Flow is generally adequate, but calculations should be performed to verify the tank sizing requirement.

By their nature, effluent sewer collection systems inherently provide a significant amount of flow equalization. When using this collection method, the addition of EQ tanks at the treatment site is only necessary for systems with extreme flow fluctuations (e.g., fairgrounds, racing venues, etc.) or highly restrictive permit requirements.

Pre-Aeration Treatment Stage

Purpose and Description:

Pre-aeration reduces organic waste strength prior to secondary treatment, with a typical target reduction of BOD_5 to less than 400 mg/L.

It is used for applications with high strength waste streams (such as Type 7 applications and any application with a significant volume of restaurant waste, such as Type 5) to condition the waste stream prior to secondary treatment by raising dissolved oxygen levels.

An aeration tank, followed by a clarification tank, is situated between the primary treatment system (or pre-anoxic tank if used) and the secondary treatment system.

Design Notes and Special Considerations:

Pre-aeration units should be sized to provide the appropriate amount of oxygen to reduce organic waste strength or to reduce BOD₅ to less than 400 mg/L. For systems with high BOD₅ influent values from restaurant waste, pre-aeration can be sized to accomplish approximately 50% reduction in BOD₅ values. For systems with extreme BOD₅ influent values from food or wine processing, pre-aeration can be sized to accomplish approximately 75% reduction in BOD₅ values. For recommendations on sizing pre-aeration and clarification tanks, see Appendix A.

Pre-aeration is required for all Application Type 7 systems, and highly recommended for systems that have greater than a 50% contribution of flow from restaurants (primarily Application Type 5 systems). Orenco provides a number of standard pre-aeration packages for lower flow ranges and can assist in sizing and recommendations for higher flow or extreme BOD₅ influent values. Contact Orenco for configurations and sizing.

Standard AdvanTex Treatment Stage

Purpose and Description:

After primary or pre-anoxic treatment, effluent is transported to the recirculation-blend tank or chamber, where it is blended with AdvanTex filtrate. The blended wastewater is distributed over the AdvanTex textile media and percolates down through the media, where it is filtered, cleaned, and nitrified by the naturally occurring microorganisms populating the media. After treatment, a portion of the filtrate is returned to the recirculation-blend chamber while a portion is transported to the next treatment stage or to dispersal. Note that a portion of the recirc-blend (or filtrate) is often returned directly to the pre-anoxic treatment stage.

In the secondary treatment process, AdvanTex units filter and clean effluent from the primary treatment system. When loaded at or below the applicable loading rate, they typically achieve treatment levels of < 10 mg/L BOD₅/cBOD₅ and TSS (30-day average or 30-day arithmetic mean), with total nitrogen (TN) reduction typically > 60% and nitrification averages of 95% (range 90-99%).

For nitrogen loading rates and sizing requirements, refer to the *AdvanTex Unit Sizing* section of this document.

Post-Anoxic Treatment Stage

Purpose and Description:

The post-anoxic treatment stage provides additional denitrification after secondary treatment in wastewater systems that require significant reductions in TN, TIN, or NO₃-N. Nitrified AdvanTex filtrate from the secondary treatment stage is transported to an anoxic zone inside of the post-anoxic tank. During post-anoxic denitrification, BOD is consumed during the conversion of NO₃ to N₂ gas by facultative heterotrophic bacteria. The N₂ gas is then returned to the atmosphere. There are two options for post-anoxic treatment — standard post-anoxic treatment without media or an anaerobic moving bed bioreactor (MBBRd) with media. A supplemental carbon feed unit is required for both options to provide the post-anoxic stage with the necessary carbon-to-nitrogen ratio for effective denitrification.

Design Notes and Special Considerations:

Post-anoxic tanks are typically sized at 100% of the Average Day Design Flow. For denitrification to take place, oxygen levels must be depleted to the level that nitrate becomes the primary oxygen source for microorganisms. Requirements for effective denitrification include ...

- Dissolved oxygen levels < 0.5 mg/L (preferably < 0.2 mg/L)
- Carbon-to-nitrogen ratio of 4:1 to 8:1
- Sufficient residual alkalinity (100 mg/L ±) in the secondary treatment stage to ensure optimum pH in the post-anoxic stage
- Temperature of the waste stream shall remain above 50° F (10° C) at all times and should typically be above 59° F (15° C)

For standard post-anoxic treatment meeting the above conditions, reduction of nitrate (NO₃) through conversion to nitrogen gas (N₂) should exceed 70%. For additional nitrogen reduction, Orenco recommends a denitrifying Moving Bed Bioreactor. MBBRd units are built in insulated fiberglass vessels. They can achieve up to 90% reduction of nitrate (NO₃) through conversion to nitrogen gas (N₂) and are typically configured as follows ...

- Fiberglass vessel, sized at 50% Average Day Design Flow, with media retention screens and filters as needed
- Media fill is typically 20% of the vessel volume
- One pneumatic ejector provided per 4 lineal ft (1.22 m) of vessel to ensure optimal mixing and food delivery to the media
- Blowers, housed in a control building, to power ejectors

AdvanTex Treatment – Second Stage of Two-Stage and Three-Stage Treatment

Purpose and Description:

A second stage of AdvanTex treatment can be used cost-effectively for enhanced nitrification or polishing:

- Nitrifying the waste stream for systems with very low ammonia ($\text{NH}_3\text{-N}$) or TKN discharge requirements – typically > 95% removal (nitrification)
- Removing any excess BOD_5 that is not consumed in the denitrification process following the post-anoxic stage on projects with restrictive $\text{BOD}_5/\text{cBOD}_5$ permit limits, typically 20 mg/L or less (polishing)
- Removing BOD_5 for systems with NOT TO EXCEED permit limits of < 10 mg/L $\text{BOD}_5/\text{cBOD}_5$ or 30-day average permit limits of ≤ 5 mg/L $\text{BOD}_5/\text{cBOD}_5$ (polishing)

The treatment mechanisms are the same as described under *Standard AdvanTex Treatment Stage* on page 13. For sizing requirements, refer to the AdvanTex Unit Sizing section of this document.

For information on the importance of pH and temperature on the nitrification process, see *pH Effect on Nitrification* and *Temperature Effect on Nitrification and Denitrification* in the Design Considerations section on page 19.

Final Polishing Treatment Stage – Third Stage of Three-Stage Treatment

Purpose and Description:

An AdvanTex Final Polishing Stage unit is typically used for final polishing of $\text{BOD}_5/\text{cBOD}_5$ for projects with high influent organic and/or nutrient loads and strict organic and nutrient limits:

- Nitrifying the waste stream for systems with very low ammonia ($\text{NH}_3\text{-N}$) or TKN discharge requirements – typically > 90% removal (nitrification)
- Removing any excess BOD_5 that is not consumed in the denitrification process following the post-anoxic stage on projects with restrictive $\text{BOD}_5/\text{cBOD}_5$ permit limits, typically 20 mg/L or less (polishing)

The treatment mechanisms are the same as described under *Standard AdvanTex Treatment Stage* on page 13. For sizing requirements, refer to the AdvanTex Unit Sizing section of this document.

For information on the importance of pH and temperature on the nitrification process see *pH Effect on Nitrification* and *Temperature Effect on Nitrification and Denitrification* in the *Design Considerations* section on page 19.

Disinfection Stage

Purpose and Description:

Secondary-treated effluent is usually clear and odorless, but it still contains pathogens at levels that can cause illness if ingested or released to the environment. Disinfection is required in many surface discharge or reuse systems. Disinfection can be achieved by any method that destroys pathogens; ultraviolet (UV) rays, chlorine (tablet or gas), and ozonation are the most common methods.

Due to the low turbidity of AdvanTex effluent and the fact that UV disinfection requires no chemicals and leaves no toxic residue, UV disinfection is the most common method used following AdvanTex systems.

Chlorination is also a common disinfection method that is utilized; however, handling issues and concerns about chemical residue make it less desirable than UV. Ozonation, another common method, is extremely effective and popular for re-use applications within facilities (e.g. toilet flushing), due to its ability to remove any residual color in the effluent stream. Ozonation is typically the least economical of the three methods in the lower flow applications common with decentralized systems.

Design Notes and Special Considerations:

UV disinfection lamps require cleaning and servicing on a regular basis (once a month to once a year, depending on effluent quality and UV system design).

Disinfection devices can be integrated into the treatment system and connected to the TCOM™ control system for monitoring and control.

Reuse applications, such as for toilet flushing and industrial processes, require a high level of effluent purity. Chlorination or ozonation are often used in these applications. In some circumstances, tertiary treatment may be required. This can include (in addition to chemical or ultraviolet disinfection) the use of fine mesh filter processes such as polishing filters; multi-media filtration; micro-, ultra-, or nano-filtration through membranes; reverse osmosis; or cloth/disc filters. Contact Orenco for more information.

Performance Requirements and Unit Sizing

Performance of Typical AdvanTex Systems

When loaded at or below the applicable loading rates, AdvanTex systems typically achieve <10 mg/L BOD₅ and TSS (30-day average or 30-day arithmetic mean). Total Nitrogen (TN) reduction typically exceeds 60%, with nitrification exceeding 95%, given liquid temperature levels greater than 50°F (10°C) and pH values between 7-9. The loading rates provided in AdvanTex Stage Sizing are based upon these minimum values for liquid temperature and pH. With additional components and configurations (see Treatment System Configurations), AdvanTex Treatment Systems can meet more stringent treatment levels.

Standard AdvanTex Stage Sizing

The primary criteria used to determine the amount of textile surface area necessary to meet treatment requirements are the daily flow volume (Average and Maximum Day), primary-treated effluent Organic Load, Organic Loading Rate (**OLR**), and Hydraulic Loading Rate (**HLR**). For facilities that require advanced nitrogen discharge levels (> 60% TN or > 95% NH₃-N), the Ammonia Loading Rate (**ALR**) or Total Nitrogen Loading Rate (**TNLR**) should be used in conjunction with the organic and hydraulic loading rates to size the system. **The loading rate that corresponds to the largest textile surface area will control the design.** AdvanTex Treatment Systems must be sized so that the designed treatment area meets or exceeds that required by the controlling loading rate.

Standard AdvanTex Treatment Loading Rates – All Systems:

Organic Loading Rates (OLR)

- Design Average: 0.04 lbs BOD₅/ft² • d (0.2 kg BOD₅/m² • d)
- Design Maximum Day: 0.08 lbs BOD₅/ft² • d (0.4 kg BOD₅/m² • d)

The equation for determining OLR-based treatment area is as follows:

$$A_{OLR} = BOD_{5i} / OLR$$

Equation 1.1

where: A_{OLR} = Treatment area based on Organic Loading, ft² (m²)

BOD_{5i} = Primary treated effluent BOD₅ (organic) load, lbs/d (kg/d)

OLR = Organic loading rate, lbs/ft² • d (kg/m² • d)

Hydraulic Loading Rates (HLR)

- Design Average: 25 gpd/ft² (1 m³/m² • d)
- Design Maximum Day: 50 gpd/ft² (2 m³/m² • d)

The equation for determining the HLR-based treatment area is as follows:

$$A_{HLR} = Q / HLR$$

Equation 1.2

where: A_{HLR} = Surface area based on Design Average Hydraulic Loading, ft² (m²)

Q = Influent hydraulic load, gpd (m³/d)

HLR = Hydraulic loading rate, gpd/ft² • d (m³/m² • d)

Systems with Total Nitrogen-Based Discharge Limits:

For systems requiring a greater than 60% removal rate for TN, TIN, or NO₃-N, the required textile area is determined by using the Total Nitrogen Loading Rate (TNLR) and the TN value (if available) or TKN value (if the TN value isn't available) in the primary treated effluent. (The value for TN and TKN should be the same after anaerobic primary treatment, but it will vary significantly if pre-aeration is used.)

Total Nitrogen Loading Rates (TNLR)

- Design average TNLR is 0.014 lbs TN/ft² • d (0.07 kg TN/m² • d).

The equation for determining TNLR-based treatment size is as follows:

$$A_{\text{TNLR}} = (\text{TKN}_i \text{ or } \text{TN}_i) / \text{TNLR} \quad \text{Equation 1.3}$$

where: A_{TNLR} = Treatment area based on Total Nitrogen Loading, ft² (m²)
 TKN_i = Primary treated effluent Total Kjeldahl Nitrogen load, lbs/d (kg/d)
 TN_i = Primary treated effluent Total Nitrogen load, lbs/d (kg/d)
 TNLR = Total nitrogen loading rate, lbs/ft² • d (kg/m² • d)

Systems with Ammonia-Based Discharge Limits:

For applications requiring ammonia or TKN removal greater than 95%, use both the ALR (see below) and the TNLR (Equation 1.3) and choose the greater of the two values. ALR for primary-treated effluent ammonia and TNLR accounts for any organic nitrogen that may be converted to ammonia through the primary or secondary treatment processes (see Ammonification).

Ammonia Loading Rates (ALR)

- Design average ALR is 0.01 lbs NH₃-N/ft² • d (0.05 kg NH₃-N/m² • d)

The equation for determining ALR-based treatment area is as follows:

$$A_{\text{ALR}} = \text{NH}_3\text{-N}_i / \text{ALR} \quad \text{Equation 1.4}$$

where: A_{ALR} = Surface area based on NH₃-N loading, ft² (m²)
 $\text{NH}_3\text{-N}_i$ = Primary treated effluent Ammonia load, lbs/d (kg/d)
 ALR = Stage 1 Ammonia loading rate, lbs/ft² • d (kg/m² • d)

Second Stage or Third Stage AdvanTex Sizing in Two-Stage and Three-Stage Systems

For the calculation of second stage or third stage AdvanTex treatment area, use BOD_{5e} and TKN_e — the treated effluent values from the Standard AdvanTex Treatment system. Standard AdvanTex Stage treated effluent values for BOD₅ and TKN are typically based upon 95% nitrification and 70% denitrification through the Pre-Anoxic Stage and Standard AdvanTex Treatment Stage. See Appendix B for example calculation.

Second Stage or Third Stage Organic Loading Rates (OLR)

- Design Average: 0.02 lbs BOD₅/ft² • d (0.1 kg BOD₅/m² • d)
- Design Maximum Day: 0.04 lbs BOD₅/ft² • d (0.2 kg BOD₅/m² • d)

The equation for determining OLR-based treatment area is as follows:

$$A_{\text{OLR}} = \text{BOD}_{5e} / \text{OLR} \quad \text{Equation 2.1}$$

where: A_{OLR} = Treatment area based on Organic Loading, ft² (m²)
 BOD_{5e} = Secondary treated effluent BOD₅ (organic) load, lbs/d (kg/d)
 OLR = Organic loading rate, lbs/ft² • d (kg/m² • d)

Second Stage or Third Stage Hydraulic Loading Rates (HLR)

- Design Average: 75 gpd/ft² (3 m³/m² • d)
- Design Maximum Day: 125 gpd/ft² (5 m³/m² • d)

The equation for determining HLR-based treatment area is as follows:

$$A_{\text{HLR}} = Q / \text{HLR} \quad \text{Equation 2.2}$$

where: A_{HLR} = Surface area based on Design Average Hydraulic Loading, ft² (m²)
 Q = Influent hydraulic load, gpd (m³/d)
 HLR = Hydraulic loading rate, gpd/ft² • d (m³/m² • d)

Second Stage or Third Stage Total Nitrogen Loading Rates (TNLR)

- Design average TNLR is 0.007 lbs TN/ft² • d (0.035 kg TN/m² • d).

The equation for determining TNLR-based treatment size is as follows:

$$A_{\text{TNLR}} = \text{TKN}_e / \text{TNLR}$$

Equation 2.3

where: A_{TNLR} = Treatment area based on Total Nitrogen Loading, ft² (m²)

TKN_e = Secondary treated effluent Total Kjeldahl Nitrogen, lbs/d (kg/d)

TNLR = Total nitrogen loading rate, lbs/ft² • d (kg/m² • d)

Second Stage or Third Stage Ammonia Loading Rates (ALR)

- Design average ALR is 0.005 lbs NH₃-N/ft² • d (0.025 kg NH₃-N/m² • d)

The equation for determining ALR-based treatment area is as follows:

$$A_{\text{ALR}} = \text{TKN}_e / \text{ALR}$$

Equation 2.4

where: A_{ALR} = Surface area based on NH₃-N loading, ft² (m²)

TKN_e = Secondary treated effluent Total Kjeldahl Nitrogen, lbs/d (kg/d)

ALR = Ammonia loading rate, lbs/ft² • d (kg/m² • d)

Design Considerations

Recirculation-Blend Tank Sizing

AdvanTex AX20 and AX100 Treatment Systems require external recirculation-blend tankage. The following design considerations apply to recirculation-blend tankage for AX20 and AX100 systems:

- For standard AdvanTex Treatment Systems, recirculation-blend tankage should be sized to at least 75% of the design maximum day flow, or 100% average day design flow, whichever is greater.
- For Stage 2 AdvanTex Treatment Systems, recirculation-blend tankage should be sized to at least 25% of the design maximum day flow.

AdvanTex AX-Max units are configured with integral recirculation-blend capacity and do not require an external recirculation-blend tank.

Recirculation Pump Sizing

AX20 pods have five laterals and sixty-eight 1/8-inch (3-mm) diameter orifices in each pod. A residual pressure of 5 ft (1.5 m) is used to determine initial timed-dosing settings. Typically, residual pressure ranges from 3 to 6 ft (0.9 to 1.8 m). This may vary depending on system hydraulics or special treatment requirements. Table 3 provides sizing information for Orenco 4-inch (100-mm) submersible effluent pumps used in AdvanTex AX20 recirculation pumping assemblies with typical design configurations.

Table 3. Recirculation Pump Sizing, AX20

Number of Pods	Number and Operation of Pumps	Nominal Flow Rate	60 Hz Pump Selections	50 Hz Pump Selections
1	2 pumps, alternate dosing	30 gpm (1.9 L/sec)	½ hp (0.37 kW); PF3005	¾ hp (0.56 kW); PF3005
2	2 pumps, alternate dosing	50 gpm (3.2 L/sec)	½ hp (0.37 kW); PF5005	¾ hp (0.56 kW); PF5007
3	2 pumps, alternate dosing	75 gpm (4.7 L/sec)	1 hp (0.7 kW); PF7510	1 hp (0.7 kW); PF7510
4	2 pumps, 1 pump to 2 pods, alternate dosing	50 gpm (3.2 L/sec)	½ hp (0.37 kW); PF5005	¾ hp (0.56 kW); PF5007

AX100 pods have four laterals with two spin nozzles per lateral, for a total of eight spin nozzles. The pumping rate is about 50 gpm± per AX100 pod (minimum 6 gpm ± per nozzle at 3.0 psi, or 0.38 L/sec at 20.7 kPa). Adjusting pressure at the pod inlet can vary flow. Sufficient pump redundancy is required to ensure operational integrity with one or more inoperable pumps. Table 4 provides sizing information for Orenco 4-inch (100-mm) submersible effluent pumps used in AdvanTex AX100 recirculation pumping assemblies for typical design configurations.

Table 4. Recirculation Pump Sizing, AX100

Number of Pods	Number and Operation of Pumps	Nominal Flow Rate	60 Hz Pump Selections	50 Hz Pump Selections
1	2 pumps, alternate dosing	50 gpm (3.2 L/sec)	¾ hp (0.56 kW); PF5007	¾ hp (0.7 kW); PF5007
2	2 pumps, 1 pump per pod, alternate dosing	50 gpm (3.2 L/sec)	¾ hp (0.56 kW); PF5007	1 hp (0.7 kW); PF5010
3	2 pumps, simultaneous dosing	75 gpm (4.7 L/sec)	1 hp (0.7 kW); PF7510	1 hp (0.7 kW); PF7510
4	4 pumps, 1 pump per pod, alternate dosing	50 gpm (3.2 L/sec)	¾ hp (0.56 kW); PF5007	1 hp (0.7 kW); PF5010
5-6	4 pumps, 2 pumps per 2-3 pods, simultaneous or alternating dosing	75 gpm (4.7 L/sec)	1 hp (0.7 kW); PF7510	1 hp (0.7 kW); PF7510
7-9	6 pumps, 2 pumps per 2-3 pods, simultaneous or alternating dosing	75 gpm (4.7 L/sec)	1 hp (0.7 kW); PF7510	1 hp (0.7 kW); PF7510

AX-Max units are typically designed to accommodate a specific application, based on Design Average and Design Maximum Day flows, the application type's targeted treatment levels, and other factors. Because of this, AX-Max configurations vary and recirculation pumps for these units are determined on a project-by-project basis. Contact Orenco for more information.

AdvanTex TCOM™ Control System

The TCOM™ Control Panel is a telemetry-based panel — which can be connected to a landline, cellular service, Internet, or satellite service — that controls all sensors and pumping equipment. TCOM panels are an integral part of all commercial AdvanTex Treatment System equipment packages. Telemetry provides real-time operator monitoring and control of system components, as well as remote data collection of key operational parameters and events. Its communication function provides notice to system operators in the event of an alarm. Operators can call into the control unit, determine the cause of the alarm, and — often — address the situation without having to be physically present at the treatment facility.

The TCOM unit can be programmed to use trend data for adjusting timer settings automatically, based on established recirculation ratios, so frequent operator adjustment is not necessary for systems with flow variations. If additional equipment for pretreatment, tertiary treatment, or disinfection is required, the controls for each component can easily be incorporated into the TCOM control panel. This allows Orenco to contact the panel directly to assist the operator in system evaluation and troubleshooting or to manually override operations. TCOM control panels can also integrate into existing SCADA systems. Consult with Orenco early in the design process to discuss any integration needs.

Orenco's TCOM control panels are available with multiple enclosure types; however, for ease of operation, they should be protected from direct sunlight to protect the electronics and allow the operator access without direct exposure to the elements (rain, snow, etc.). This should be taken into account when determining location of the control unit. Shelters are recommended for panels whenever possible. Contact Orenco for a quote.

AdvanTex System Ventilation

Proper ventilation, achieved by active or passive ventilation, is critical for maintaining aerobic treatment processes in AdvanTex Treatment Systems.

Active Ventilation

Active ventilation is the preferred means of ventilating AdvanTex Systems and is required for the following systems:

- All systems with design maximum day flows > 10,000 gpd (37,854 L/day)
- All systems with average primary treated effluent waste strength > 200 mg/L BOD₅ and 100 mg/L TSS
- All systems with nitrogen discharge limits
- All AX-Max systems; *at least one* ventilation assembly is required per two connected units (AX-Max units are typically designed with a built-in active vent system and one vent system per unit is preferred)

Passive Ventilation

Passive ventilation can be considered in AX20 or AX100 systems receiving primary-treated effluent of residential strength, with constituent concentrations of < 200 mg/L BOD₅ and < 100 mg/L TSS and with design maximum day flows < 10,000 gpd (37,854 L/day) for AX100 systems and 4,000 gpd (15,140 L/day) for AX20 systems. For proper function, it is critical for air movement to be greater than 5 cubic feet per minute (cfm) for every 100 ft² of treatment area (0.002 m³/minute for every 9.3 m²). It is also critical to ensure that there is a clear path for airflow through the system if the system relies on passive ventilation. If these conditions cannot be met, active ventilation should be used.

Although activated carbon media is included to adsorb and mitigate odors in AdvanTex passive ventilation systems, slight odors may occur during dosing events. Passively ventilated systems should be located in areas where this will not be perceived as a nuisance.

Anti-Buoyancy Features

AdvanTex AX20 pods come standard with anti-flotation flanges to help prevent the pod from floating out of the ground under saturated soil conditions. Always keep the top of the pod at least 6 inches (150 mm) above grade at all times. When buried to this level, pod spacing is 5 feet (1.5 m) between AX20 units. Contact Orenco for details.

AdvanTex AX100 Pods are designed for installation in areas that are free of water. AX100 pods can be bermed and free draining, but the bottom of each pod should be no more than 9 inches (230 mm) below the natural grade to protect it from floating in saturated conditions.

AX-Max units should be ordered with anti-buoyancy provisions if the unit will be partially buried. Spacing of the units varies, but at maximum bury of 6 feet (1.82 m) with high groundwater conditions, this spacing would be approximately 10 feet (3.04 m) between units. When the unit is set at natural grade and the material used for berming is free flowing, anti-buoyancy will not be necessary. Contact Orenco for details.

pH Effect on Nitrification

pH is extremely important for nitrification. (See Figure 7.) The effective reaction rate (RN) is 0.95 at a pH of 8±, dropping to 0.47 at a pH of 7, and dropping precipitously to 0.15 at a pH of 6. Nitrification effectively ceases at a pH of 5. The use of additional alkalinity to buffer the process is critical for all nitrogen removal configurations and the feed system should be sized to provide a minimum targeted residual of 80 mg/L, with a preferred residual target of 100 mg/L.

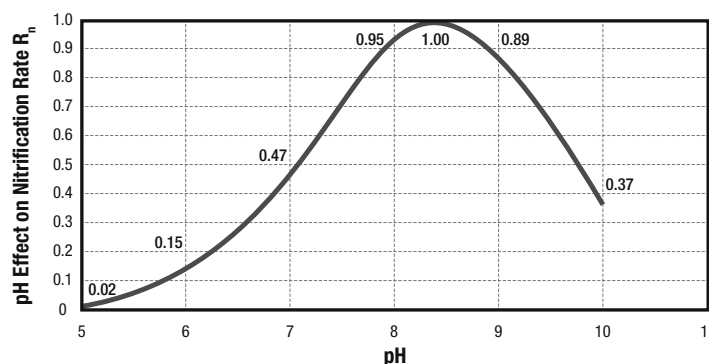


Figure 7. pH Effects on Nitrification

Cold Weather Considerations

The naturally occurring bacteria that populate the AdvanTex treatment media are active at temperatures above 44° F (6.7° C), with an optimal temperature range above 68° F (20° C). To ensure treatment in cold climates or areas with seasonal cold weather, it is recommended that the liquid temperature remain above 50° F (10° C). Temperature is especially important in the nitrification and denitrification process. If temperature values are expected to be below this threshold, contact Orenco for heating options and/or safety factors for design purposes.

Temperature Effect on Nitrification and Denitrification

Temperatures in the liquid stream and treatment media have an impact on both the nitrification and denitrification processes. The effect of temperature on nitrification and denitrification rates can be used to predict efficiency of the overall treatment process, as shown in Figure 8. Orenco bases performance on minimum temperature values of 50° F (10° C) during winter operation and 59° F (15° C) during summer operation. For actual liquid temperatures below these values, systems should be upsized to achieve treatment expectations described in this document. Following are cold weather considerations for AX20 pods, AX100 pods, and AX-Max units, as well as general cold weather considerations for all systems to prevent freezing and avoid damage due to frost heave:

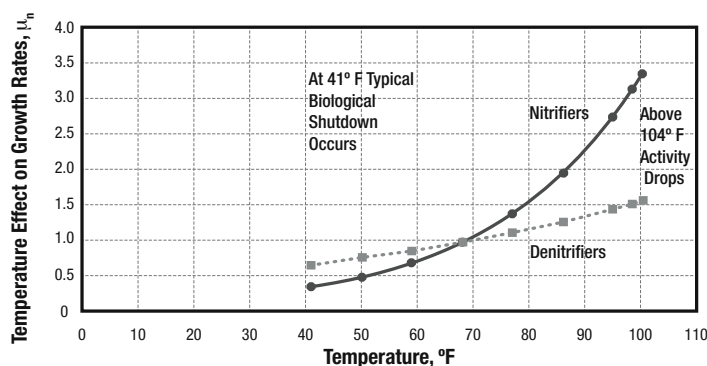


Figure 8. Temperature Effect on Nitrification and Denitrification

AX20 and AX100 Pods

- Insulated foam-core lids with a minimum R-value of R-6 (RSI-1) are standard equipment to prevent heat loss through the top of AX20 and AX100 pods. If necessary, insulation board or spray-on insulation foam can be added during installation.
- The depth of the recirculation-blend tank can be increased — but the tank must still be accessible to operators for maintenance activities.
- Warm air ventilation is critical. High flows of cold air through the treatment unit can cause significant temperature drops.
- Orenco Fiberglass Shelters provide a climate-controlled environment — providing a temperature controlled air source for the treatment system, access to the control system, and equipment and storage for chemical feed equipment.

AX-Max Units

- Units are configurable for use in climates with extreme temperatures ranging from -60° F to 125° F (-51°C to 52° C).
- Units are constructed with 4-inch (100-mm) foam cells that provide an estimated insulation value of R-26 (RSI-5).
- Orenco Fiberglass Shelters provide a climate-controlled environment — providing a temperature controlled air source for the treatment system, access to the control system, and equipment and storage for chemical feed equipment.

General Cold Weather Considerations for All Systems

- Standard cold weather practices for AdvanTex systems include allowing all lines to drain back to tankage and insulating access lids on primary and recirculation-blend tankage.
- In extreme climates with long periods of subfreezing weather, a warm air source into the treatment pods or units or immersion heaters may be necessary to keep treatment temperatures above 50° F (10° C).
- In areas where snow typically accumulates each winter, air vents must be extended to ensure they are above peak snow levels.
- In areas where frost heave is a concern, backfilling access riser excavations with pea gravel is recommended.

Several times per year Orenco provides training on general wastewater concepts, design, and operation and maintenance at our facility in Sutherlin, Oregon, as well as throughout the United States and abroad. If you are interested in attending a training session, contact Orenco or your local Orenco Dealer.

Orenco staff is prepared to support the designer throughout the project cycle, from the initial evaluation of technologies, to the preliminary design, to a thorough and timely design review — all without cost. Orenco can also assist with the approval process and the evaluation of operational and life cycle costs.

Appendix A. Sizing for Primary and Pre-Anoxic Tankage

All secondary treatment systems are limited in their ability to break down and treat organic material. The purpose of primary tankage in AdvanTex Treatment Systems is to reduce and maintain organic material at a level that can be efficiently and economically treated by the AdvanTex treatment unit(s). Primary tankage can anaerobically digest organic material, remove solids, modulate flow, and provide emergency storage volume. To operate effectively, primary tankage must be properly designed and sized, structurally sound, watertight, and well-maintained.

For the application types defined in this Design Criteria, Table A provides recommended minimum tank volumes. To calculate recommended minimum tank volumes, multiply the Design Maximum Day Flow specified for the system by the necessary hydraulic retention time (HRT) in days. For example, if local regulations require a 10,000 gpd system design (based on Design Maximum Day Flow) for an office facility, Orenco recommends a minimum total tank volume of 30,000 gallons. (See Table A, Application Type 2.) To determine preferred tank volumes, add approximately 50% to the minimum values.

The minimums in Table A exceed those set by the United States Environmental Protection Agency (USEPA) and the regulatory requirements for nearly every state in the United States. With regard to tank sizing, larger hydraulic retention times result in improved primary treatment.* Research strongly indicates that the smaller volumes calculated by using the USEPA formula (based on 1940's information), as well as the listed volumes for most state and local health agencies, consistently produce poor quality effluent. They are also associated with increased pumpout frequencies and costs, increased need for secondary treatment capacity, and an increased need for maintenance activities, with their associated costs.

Orenco recommends the use of pre-anoxic tankage prior to the recirculation-blend tank for all systems. Recommended total primary tankage is provided in Table A, followed in parentheses by the recommended configuration of the primary tankage for specific treatment needs, if any, such as a pre-anoxic stage, aeration unit, clarification chamber, or flow equalization.

Table A is intended as a general guideline for decentralized wastewater treatment designs. The system designer is responsible for ensuring adequate primary treatment prior to the secondary treatment system. Check local regulations to ensure that the recommended minimum volumes meet applicable regulatory requirements. For questions about special cases where larger tankage or other measures may be necessary, or for general questions about flow equalization, please call Orenco at (800) 348-9843 or +1-541-459-4449.

*Metcalf & Eddy, "Wastewater Engineering Collection, Treatment, Disposal," 1972 (New York, McGraw Hill).

Winneberger, John H. Timothy, "Septic Tank Systems, A Consultant's Toolkit, Volume II The Septic Tank," 1984 (Butterworth Publishers, Ann Arbor Science).

Laak, Rein, "Wastewater Engineering Design for Un-Sewered Areas," 1980 (Butterworth Publishers, Ann Arbor Science).

Philip, H. et. al., "Septic Tank Sludges: Accumulation Rate and Biochemical Characteristics," 1993 Water Science & Technology.

Table A. Recommended Minimum HRTs, Primary Tankage and Configurations

Application Type	Hydraulic Retention Time (HRT) in Days		Minimum Volumes & Configurations for Primary Tankage	
	Grease Tankage ¹	Primary Tankage ²	Without Aeration	With Aeration
Type 1 , Residential quality waste ³ (includes apartments, condos, mobile home parks, municipal, planned communities, subdivisions, work camps)	n/a	2	2× design max. day flow (1P + 1A)	n/a
Type 2 , Primarily black water waste ^{4,5} (includes airport facilities, campgrounds, fire departments, golf courses, marinas, offices, parks, public toilets, rest areas, RV parks ⁵ , ski resorts, visitor centers)	3	3	3× design max. day flow (2P + 1A)	n/a
Type 3 , Primarily black water waste with surge flows ^{6, 7} (includes churches and schools)	3	3	3× design max. day flow (2P + 1A with no flow equalization)	n/a
		4	4× equalized design day flow (2P + 1A + 1Q _M with flow equalization)	
Type 4 , Primarily black waster waste with pharmaceutical concerns ⁸ (includes hospitals, retirement facilities, veterinary clinics)	3 ⁴	4	4× design max. day flow (3P + 1A)	3× design max. day flow (1P + 1A + 0.5 AE + 0.5 C)
Type 5 , Black water waste and restaurant waste ^{9, 10} (includes bars/taverns, casinos, delis, gas stations, hotels/motels, restaurants, resorts, shopping centers/strip malls)	3	n/a	4× design max. day flow (3P + 1A)	4× design max. day flow (2P + 1A + 0.5 AE + 0.5 C)
Type 6 , Polishing bioreactors (includes polishing bioreactors for organic or ammonia removal, e.g. lagoon compliance)	n/a	n/a	n/a	n/a
Type 7 , High-strength process waste ¹⁰ (includes wineries, breweries, dairy or food processing facilities, slaughterhouses)	n/a	n/a	n/a	4.5× design max. day flow (2P + 1A + 1AE + 0.5C)
All other applications	Contact Orenco for support with application types having characteristics not listed in this chart.			
Key:	P = Primary Tankage	A = Pre-Anoxic	AE = Aeration Tankage	C = Clarification Tankage
				EQ = Equalization Tankage

¹ HRT is based on a separate kitchen design maximum day flow, integrated into the main flow prior to the primary septic tanks. Orenco recommends a grease tank for any facility with a commercial kitchen. Additional grease tankage provides increased reduction of organics, as well as separation of grease and oil (G&O) prior to secondary treatment. G&O concentrations entering secondary treatment should be limited to 25 mg/L. Chemical disinfection dishwashers can cause significant downstream problems due to the high volumes of sanitizing compounds and emulsifiers and should not be used in onsite treatment and soil dispersal applications.

² HRT is based on the sum of the Design Maximum Day Flows from all sources. This assumes each waste source has a separate primary tank and a watertight collection system. For systems using gravity collection to a single primary tank, add 1 day HRT (based on Design Maximum Day Flow). For grinder or vacuum collection systems feeding into primary tankage, the recommended volume for pre-anoxic tankage is 1.5 days HRT; the recommended volume for primary tankage is 2.5 days HRT for a total HRT of 4 days (based on Design Maximum Day Flow).

³ Communities with gravity sewers should review 12+ months of documented wastewater flows to determine Design Maximum Day Flow.

⁴ For systems with cafeteria or restaurant facilities, use the grease tankage listed.

⁵ RV dump stations should have a minimum 7 days of storage; flow should be blended into the balance of the waste stream throughout the course of the day by timer-controlled pumps. Dump station flow contributions should not exceed 20% of the design maximum day flow.

⁶ Flow equalization is strongly recommended for this application type to reduce the total treatment area required. If flow equalization is not used, base the total primary tankage volume and treatment area on Design Maximum Day Flow.

⁷ If using flow equalization for this application type, base the total primary tankage on Equalized Design Day Flow (EDDF) to secondary treatment. EDDF = total weekly flow divided by 6, allowing 1 day for recovery.

⁸ To reduce seepage pumping in these and other specialized applications, we recommend using multiple tanks: The first should be small (0.5 to 0.75 day HRT); subsequent tanks should provide the remaining HRT requirements.

⁹ For facilities with restrooms and kitchen, the primary tank volume is determined by summing the design maximum day flows of the restrooms and kitchen — and then multiplying by the HRT value in the primary tankage column. Kitchen dishwashing appliances should be high-temperature disinfection models only; low-temperature chemical disinfection dishwashers are not recommended.

¹⁰ Pre-treatment (e.g., aeration) is necessary for this application type to reduce overall influent organic waste strength.

Appendix B. Basic Equations

Converting Waste Constituent Concentrations and Flow to Mass

To convert constituent concentrations of the primary treated effluent (PTE, mg/L) and flow (gallons, imperial gallons, liters, or cubic meters) to mass/day (lbs/day or kg/day), use the following equation:

Equation B1

$$\text{Load} = \text{PTE Value (mg/L)} \times \text{Conversion Factor} \times \text{Flow (Q)}$$

A) Using flow in gallons to calculate pounds/day:

$$\text{Conversion Factor, CF}_G = \frac{1 \text{ lb}}{453,592 \text{ mg}} \times \frac{3.785 \text{ L}}{1 \text{ gal}} = 8.34 \times 10^{-6} \frac{\text{lbs} \cdot \text{L}}{\text{mg} \cdot \text{gal}}$$

B) Using flow in imperial gallons to calculate pounds/day:

$$\text{Conversion Factor, CF}_{IG} = \frac{1 \text{ lb}}{453,592 \text{ mg}} \times \frac{4.546 \text{ L}}{1 \text{ gal}} = 1.002 \times 10^{-5} \frac{\text{lbs} \cdot \text{L}}{\text{mg} \cdot \text{gal}}$$

C) Using flow in liters to calculate kilograms/day:

$$\text{Conversion Factor, CF}_L = \frac{1 \text{ kg}}{1,000,000 \text{ mg}} \times \frac{1 \text{ L}}{1 \text{ L}} = 1 \times 10^{-6} \frac{\text{kg}}{\text{mg}}$$

D) Using flow in cubic meters to calculate kilograms/day:

$$\text{Conversion Factor, CF}_{CM} = \frac{1 \text{ kg}}{1,000,000 \text{ mg}} \times \frac{1000 \text{ L}}{1 \text{ m}^3} = 0.001 \frac{\text{kg} \cdot \text{L}}{\text{mg} \cdot \text{m}^3}$$

Example 1

PTE value of 150 mg/L BOD₅; Flow of 1000 gallons per day

Determine BOD₅ mass load in pounds per day using Equation B1A:

$$\text{BOD}_5 \text{ Mass Load} = (150 \text{ mg/L}) \times (8.34 \times 10^{-6} \text{ lbs} \cdot \text{L} / \text{mg} \cdot \text{gal}) \times 1000 \text{ gpd} = 1.25 \text{ lbs/d}$$

Example 2

PTE value of 150 mg/L BOD₅; Flow of 5 cubic meters per day

Determine BOD₅ mass load in kilograms per day using Equation B1D:

$$\text{BOD}_5 \text{ Mass Load} = (150 \text{ mg/L}) \times (0.001 \text{ kg} \cdot \text{L} / \text{mg} \cdot \text{m}^3) \times 5 \text{ m}^3 / \text{d} = 0.75 \text{ kg/d}$$

Performing a Mass Balance Calculation for a Blended Waste Stream

Some applications are configured so that the waste stream to the treatment plant is made up from several contributing sources with varying flows and constituent concentrations. To determine the waste strength of a blended waste stream, a mass balance calculation must be performed.

The easiest way to perform the mass balance calculation is to prepare a table listing each source, the flow contribution from the source, and the constituent concentrations being treated.

- List contributing sources, anticipated flows and corresponding waste strengths
- Waste strengths are provided after primary tankage and are listed as primary-treated effluent (PTE)

Table B1: Sample Mass Balance Calculation Table

Source ¹	Design Flow ² , Q (gal or imp. gal or L or m ³)	Constituent 1: BOD ₅ (mg/L)	Constituent 2: TSS (mg/L)	Constituent 3: TKN (mg/L)
Source 1	Q _{S1}	BOD _{5S1}	TSS _{S1}	TKN _{S1}
Source 2	Q _{S2}	BOD _{5S2}	TSS _{S2}	TKN _{S2}
Source 3	Q _{S3}	BOD _{5S3}	TSS _{S3}	TKN _{S3}
Source 4	Q _{S4}	BOD _{5S4}	TSS _{S4}	TKN _{S4}
Total Flow³, Q_T		BOD_{5B}	TSS_B	TKN_B

¹The table can be built with as many contributing sources and constituents as needed; four sources and three constituents shown for simplicity.

²The actual unit of measure doesn't matter as long as the same unit of measure is used for all sources as they fall out in the equation.

³The total flow, Q_T is the sum of flow from all contributing sources.

For Constituent 1 (BOD₅) the mass balance equation for blended waste strength concentration (BOD_{5B}) is:

Equation B2

$$\text{Blended BOD}_{5B}, \text{ mg/L} = \frac{(Q_{S1} * \text{BOD}_{5S1}) + (Q_{S2} * \text{BOD}_{5S2}) + (Q_{S3} * \text{BOD}_{5S3}) + (Q_{S4} * \text{BOD}_{5S4})}{Q_T}$$

Example

Determine the blended BOD_{5B} given the following for a camp application and using Equation B2.

Table B2: Sample Equation Table

Source	Design Flow (gpd)	PTE BOD ₅ (mg/L)
RV Dump Station	250	1800
Shower House w/ Restrooms	4500	225
Restrooms	1800	300
Camp Host Living Quarters	150	150
Total Flow (Q _T)	6700	BOD _{5B}

$$\text{Blended BOD}_{5B} = \frac{(250 \text{ gpd} * 1800 \text{ mg/L}) + (4500 \text{ gpd} * 225 \text{ mg/L}) + (1800 \text{ gpd} * 300 \text{ mg/L}) + (150 \text{ gpd} * 150 \text{ mg/L})}{6700 \text{ gpd}} = 302 \text{ mg/L}$$

Determining Alkalinity Demand and Need for Supplemental Alkalinity Addition

Ensuring that the pH remains above 7 (and preferably above 7.5) at all times is critical for ammonia sensitive applications. Supplemental alkalinity should be included if influent alkalinity is insufficient to buffer the process. During nitrification, 7.14 mg/L alkalinity is used per mg/L TKN; during denitrification with a pre-anoxic return loop (at 100% denitrification), half of that — or 3.57 mg/L — is returned. Without a denitrification component, there is no return. To be conservative in our calculation of alkalinity need, we assume a 60% denitrification efficiency and a return of 2.14 mg/L during denitrification. To determine alkalinity need, multiply the primary treated effluent value for TKN_i (in mg/L) by 5 (7.14 mg/L – 2.14 mg/L). Alkalinity demand can be calculated using the following equations and assuming complete nitrification of the denitrified effluent:

Equation B3

$$\text{Alkalinity Demand} = \text{TKN}_i \text{ mg/L} \times \frac{5 \text{ mg/L Alkalinity}}{1 \text{ mg/L TKN}}$$

Equation B4

$$\text{Alkalinity Need} = \text{Alk Demand} + \text{Target Residual Alk} - \text{Influent Alk}$$

As described in *pH Effect on Nitrogen* on page 19 of the Design Criteria, the target residual for alkalinity is 100 mg/L. If the result of Equation B4 is a positive number, the system will require supplemental alkalinity addition. If the result is a negative number, there is a likely surplus of alkalinity in the source water and the system should function without alkalinity addition.

Example

PTE values of 80 mg/L TKN and 160 mg/L alkalinity in waste stream

Target residual of 100 mg/L alkalinity

Determine the amount of alkalinity required to buffer the treatment process

Solving for Equation B3:

$$\text{Alkalinity Demand} = 80 \text{ mg/L} \times \frac{5 \text{ mg/L Alkalinity}}{1 \text{ mg/L TKN}} = 400 \text{ mg/L Alkalinity}$$

Now solving for Equation B4:

$$\text{Alkalinity Need} = 400 \text{ mg/L} + 100 \text{ mg/L} - 160 \text{ mg/L} = 340 \text{ mg/L}$$

Therefore the system will require supplemental alkalinity addition to buffer the treatment process.

Anticipating Treatment Performance for Standard AdvanTex Stage

Standard AdvanTex Stage treated effluent values for BOD₅, TKN, and NH₃-N are typically based upon conservative estimates of 90% BOD₅ removal (Coefficient of BOD Removal, CBR), 95% nitrification (Coefficient of Nitrification, CNR) and 70% denitrification (Coefficient of Denitrification, CDNR). **The calculations below assume pH values are maintained between 7 and 8.4 and the temperature of the liquid stream is maintained above 50° F (10° C) at all times.**

Equation B5

$$\text{BOD}_{5e} = \text{BOD}_{5i} \times (1 - C_{BR})$$

Equation B6

$$\text{TKN}_e = \text{TKN}_i \times (1 - C_{NR})$$

Equation B7

$$\text{NH}_{3e} = \text{NH}_{3i} \times (1 - C_{NR})$$

Equation B8

$$\text{NO}_{3e} = (\text{TKN}_i - \text{TKN}_e) \times (1 - C_{DNR})$$

Example

PTE values of 225 mg/L BOD_{5i}, 120 mg/L TKN_i, and 100 mg/L NH₃-N in waste stream

Determine the value of BOD_{5e} and TKN_e after the Standard AdvanTex Stage

Solving for Equation B5:

$$\text{BOD}_{5e} = 225 \text{ mg/L} \times (1 - 0.90) = 22.5 \text{ mg/L}$$

Solving for Equation B6:

$$\text{TKN}_e = 120 \times (1 - 0.95) = 6 \text{ mg/L}$$

Solving for Equation B7:

$$\text{NH}_{3e} = 100 \text{ mg/L} \times (1 - 0.95) = 5 \text{ mg/L}$$

Solving for Equation B8:

$$\text{NO}_{3e} = (120 - 6) \times (1 - 0.70) = 34.2 \text{ mg/L}$$

Therefore the estimated Total Nitrogen (TN_e) value after the Standard AdvanTex Stage is:

$$\text{TN}_e = \text{TKN}_e + \text{NO}_{3e} = 6 \text{ mg/L} + 34.2 \text{ mg/L} = 40.2 \text{ mg/L}$$

In a two-stage AdvanTex system, the treated effluent values from the Standard AdvanTex Stage (BOD_{5e} , TKN_e , and/or NH_{3e}) are used to calculate the treatment area of the second stage AdvanTex unit.

Anticipating Total Nitrogen Treatment Performance for Post Anoxic Stage

For projects requiring 60-80% TN, TIN, or NO_3 -N reduction, the use of a post-anoxic stage for conversion of NO_3 -N to nitrogen gas (N_2) is often the most cost-effective means. A C_{DNR} of 0.7 (70%) is used to anticipate the performance of the post-anoxic stage. **These calculations assume pH values are maintained between 7 and 8.4 and the temperature of the liquid stream is maintained above 50° F (10° C) at all times.**

Equation B9

$$TN_{PAe} = TKN_e + NO_{3e} \times (1 - C_{DNR})$$

Example

Using the example above, determine the value of TN_e after the Post Anoxic Stage

Solving for Equation B9:

$$TN_{PAe} = 6 \text{ mg/L} + 34.2 \text{ mg/L} \times (1 - 0.70) = 16.3 \text{ mg/L}$$

Appendix 1A: Example Design for an Apartment Complex (Application Type 1)

AdvanTex Treatment for Removal of Organics and Ammonia With cBOD_5 , TSS, and $\text{NH}_3\text{-N}$ Discharge Limits

Example: Forty-unit apartment complex consisting of twelve one-bedroom units and twenty-eight two-bedroom units. The system is to be discharged to a creek and permit requirements include organic and ammonia discharge limits.

Establishing a Design Basis

Flows

List contributing sources, anticipated flows, and corresponding waste strengths

Table 1A-1: Flows

Source	Max. Day Design Flow Per Unit (gpd)	Max. Day Design Flow (gpd)	Ave. Day Design Flow (gpd)
12 one-bedroom units	200	2,400	1,200
28 two-bedroom units	300	8,400	4,200
Total		10,800¹	5,400

¹ For Average Day Design Flow use 50% of Maximum Day Design Flow

Discharge Type

Stream discharge

Influent (Primary Treated Effluent) and Permit Parameters

Table 1A-2: Influent and Permit Parameters

	BOD_5 (mg/L)	TSS (mg/L)	TKN (mg/L)	$\text{NH}_3\text{-N}$ (mg/L)	Alkalinity (mg/L)
Primary Treated Effluent (Ave/Max)	140/250	40/140	50/80	40/70	60
Discharge Permit Requirement (30-day Average)	20	20	N/A	1 summer/3 winter	N/A

Other Design Considerations

Temperature effects

Temperature impacts the performance of a treatment system. For systems with stringent nitrogen limits, it is important to ensure liquid and treatment system temperatures are maintained above minimum levels. AX-Max systems are constructed within insulated vessels and are preferred for cold environments, though AX100 with external insulation added in the field can also be utilized.

Alkalinity needs

Because ensuring that the pH remains above 7 (and preferably greater than 7.5) at all times is critical for ammonia-sensitive applications, alkalinity addition should be included if influent alkalinity is insufficient to buffer the process. Using Equation 3B from Appendix B, the alkalinity demand for this project is:

$$\text{Alkalinity Demand} = 80 \text{ mg/L TKN} \times \frac{5 \text{ mg/L alkalinity}}{1 \text{ mg/L TKN}} = 400 \text{ mg/L}$$

Equation B4 from Appendix B:

$$\text{Alkalinity Need} = 400 \text{ mg/L} + 100 \text{ mg/L} - 60 \text{ mg/L} = 440 \text{ mg/L}$$

Equation B1A from Appendix B:

$$\text{Alkalinity Mass Load} = (440 \text{ mg/L}) \times (8.34 \times 10^{-6} \text{ lbs} \cdot \text{L/mg} \cdot \text{gal}) \times 5400 \text{ gpd} = 19.8 \text{ lbs/d}$$

The equation shows that a minimum addition of 19.8 pounds of alkalinity per day is required for this system to accomplish 100% removal of TKN (assuming complete ammonification occurs).

Design Specifics

Tankage Requirements

Primary tankage for apartment complexes is usually provided as either a single primary tank or through the use of several distributed primary tanks (locating smaller tanks next to each apartment block). If distributed primary tanks are used, pumps may be required if the treatment facility is located at an elevation higher than the primary tanks.

Apartment complexes fall within Application Type 1 in Appendix A; therefore total primary tank recommendations call for a minimum of 2 days' retention at maximum day design flow. Since a pre-anoxic tank is required and will be situated at the treatment site, provide a minimum of 1 day retention in primary and 1 day retention in pre-anoxic.

Table 1A-3: Sample Tank Sizing Recommendations

Tank Sizing	Max. Day Design Flow (gpd)	Recommended Minimum Primary Tank Size (Gallons)
Primary Tank	10,800	10,800 – use 12,000
Pre-Anoxic Tank	10,800	10,800 – use 12,000

A two-stage AdvanTex is required for ammonia removal. The configuration is as follows (see page 11):

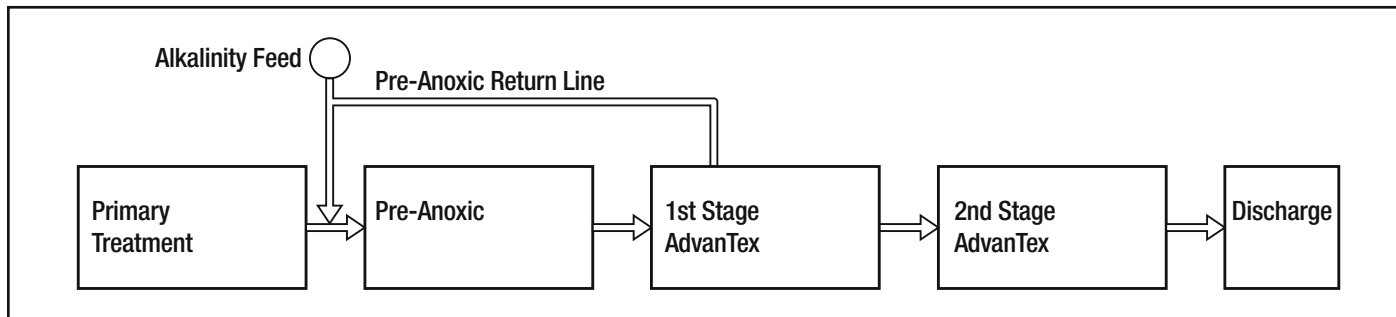


Figure 1A-1. Configuration for Ammonia Removal

Loading Calculations — First Stage

For all first stage calculations, the design maximum day loading rates are double the average day design loading rates. Since the design maximum day flow is not greater than two times the average day design flow, the calculation for maximum day design load is unnecessary.

Organic Loading

Since BOD_5 is greater than TSS, the calculation for the most restrictive parameter (BOD_5) is necessary. Design Average OLR_A is 0.04 lbs $BOD_5/ft^2 \cdot d$. (See *Standard AdvanTex Stage Sizing*, Design Criteria page 15). Use Equation B1A from Appendix B to determine the pounds per

$$OL_A = (140 \text{ mg/L}) * (8.34 \times 10^{-6} \text{ lbs} \cdot \text{L/mg} \cdot \text{gal}) * (5,400 \text{ gpd}) = 6.31 \text{ lbs/d}$$

day of Average Day Organic Load, OL_A :

$$A_{OLRA} = \frac{(6.31 \text{ lbs/d})}{0.04 \text{ lbs/ft}^2 \text{d}} = 158 \text{ ft}^2$$

Determine the textile area required based on Average Day Organic Load, A_{OLRA} using Equation 1.1:

Hydraulic Loading

Design average HLR_A is 25 gpd/ft². (See *Standard AdvanTex Stage Sizing*, Design Criteria page 15). Use Equation 1.2 to determine the textile area required based on Average Day Hydraulic Load:

$$A_{HLRA} = \frac{(5400 \text{ gpd})}{25 \text{ gal/ft}^2 \text{d}} = 216 \text{ ft}^2$$

Total Nitrogen Loading

Design average $TNLR_A$ is 0.014 lbs TKN/ft² (from page 15). Use Equation B1 from Appendix B to determine the pounds per day of Average Day Nitrogen Load, TNL_A :

Determine the textile area required based on Average Day Nitrogen Load, A_{TNLRA} using Equation 1.3:

$$TNL_A, \text{lbs/d} = (50 \text{ mg/L}) * (8.34 \times 10^{-6} \text{ lbs} \cdot \text{L/mg} \cdot \text{gal}) * (5,400 \text{ gpd}) = 2.25 \text{ lbs/d}$$

Ammonia Loading

$$A_{TNLRA} = \frac{(2.25 \text{ lbs/d})}{0.014 \text{ lbs/ft}^2 \text{d}} = 161 \text{ ft}^2$$

Design average $ALRA$ is 0.01 lbs NH_3 -N/ft². Use Equation B1 from Appendix B to determine the pounds per day of Average Day Ammonia Load, AL_A :

$$AL_A, \text{lbs/d} = (40 \text{ mg/L}) * (8.34 \times 10^{-6} \text{ lbs} \cdot \text{L/mg} \cdot \text{gal}) * (5,400 \text{ gpd}) = 1.8 \text{ lbs/d}$$

Determine the textile area required based on Average Day Ammonia Load, A_{ALRA} using Equation 1.4:

$$A_{ALRA} = \frac{(1.8 \text{ lbs/d})}{0.01 \text{ lbs/ft}^2 \text{d}} = 180 \text{ ft}^2$$

The treatment area associated with the Hydraulic Loading Rate is the most restrictive; therefore, the first stage AdvanTex area should be a minimum of 216 ft².

Treatment Unit Options — First Stage

Option 1: Using AX-Max units – 216 ft² area

AX-MAX225-35 (Max unit includes recirc-blend tankage and discharge tankage)

Option 2: Using AX pod units – 216 ft² area

(3) AX100, 8100-gallon recirc tank (recirculation-blend tank sized at minimum of 75% of Q_M per page 17 of Design Criteria)

Loading Calculations — Second Stage

For all second stage calculations, the values used are based on the predicted performance of the first stage system. Per page 25 of the design criteria, the Standard AdvanTex Stage treated effluent values for BOD_5 and TKN are typically based upon 90% BOD_5 removal, 95% nitrification, and 70% denitrification through Pre-Anoxic Stage and First-Stage AdvanTex Treatment.

Organic Loading

Design Average OLR_A is 0.02 lbs BOD_5 /ft²•d (from page 15). Use Equation B5 in Appendix B to determine the value of First-Stage AdvanTex effluent BOD_{5e} :

$$BOD_{5e} = 140 \text{ mg/L} * (1 - 0.9) = 14 \text{ mg/L}$$

Determine the pounds per day of Average Day Organic Load, OL_A using Equation B1 from Appendix B:

$$OL_{A2} = (14 \text{ mg/L}) * (8.34 \times 10^{-6}) * (5,400 \text{ gpd}) = 0.32 \text{ lbs/d}$$

Determine the textile area required based on Average Day Organic Load, A_{OLRA} using Equation 1.1:

$$A_{OLRA} = \frac{(0.32 \text{ lbs/d})}{0.02 \text{ lbs/ft}^2 \text{d}} = 16 \text{ ft}^2$$

Hydraulic Loading

Design average HLR_A is 75 gpd/ft²; Design Maximum HLR_A is 125 gpd/ft² (from page 15). Determine the textile area required based on Average Day Hydraulic Load, A_{HLRA} using Equation 1.2:

$$A_{HLRA} = \frac{(5400 \text{ gpd})}{75 \text{ gal/ft}^2 \text{d}} = 72 \text{ ft}^2$$

Determine the textile area required based on Maximum Day Hydraulic Load, A_{HLRA} , using Equation 1.2:

$$A_{HLRM} = \frac{(10800 \text{ gpd})}{125 \text{ gal/ft}^2 \text{d}} = 86.4 \text{ ft}^2$$

Ammonia Loading

Design average ALR_A is 0.005 lbs NH_3 -N/ft². Determine the value of First-Stage AdvanTex effluent TKN_e using Equation B6 in Appendix B:

$$TKN_e = 50 \text{ mg/L} \times (1 - 0.95) = 2.5 \text{ mg/L}$$

Determine the pounds per day of Average Day TKN Load, TKN_e using Equation B1 from Appendix B:

$$TKN_e = (2.5 \text{ mg/L}) \times (8.34 \times 10^{-6}) \times (5,400 \text{ gpd}) = 0.113 \text{ lbs/d}$$

Determine the textile area required based on Average Day Ammonia Load, ALR_A using Equation 1.4:

$$A_{ALRA} = \frac{(0.113 \text{ lbs/d})}{0.005 \text{ lbs/ft}^2 \text{d}} = 23 \text{ ft}^2$$

The treatment area associated with the Design Maximum Day Hydraulic Loading Rate is the most restrictive; therefore, the second stage AdvanTex area should be a minimum of 86 ft².

Treatment Unit Options — Second Stage

Option 1: Using AX-Max units – 86 ft² area

AX-MAX100-21 (Max unit includes recirc-blend tankage and discharge tankage)

Option 2: Using AX pod units – 86 ft² area

(1) AX100, 2700-gallon recirc tank or 2160-gallon discharge tank (2700-gallon recirculation-blend tank sized at minimum of 25% of Q_M per page 17 of the Design Criteria; 2160-gallon discharge tank size based on local regulation, but typically sized at minimum of 20% of Q_M)

Other Design Notes

- Ensure access to treatment site for maintenance activities
- Ensure availability of water at treatment site for maintenance activities
- Adequate alkalinity control
- Adequate temperature control

Appendix 2A: Example Design for a Campground (Application Type 2)

Standard AdvanTex Treatment for Removal of Organics With $cBOD_5$ and TSS Discharge Limits

Example: Campground with 5 RV spaces and dump station, 40 camping spaces, a shower house with restroom facility, a separate restroom only building, and living quarters for a camp host. System is to be discharged to a pressurized drainfield and permit requirements include organic ($cBOD_5$ and TSS) discharge limits.

Establishing a Design Basis

Flows

- List Contributing Sources, Anticipated Flows and Corresponding Waste Strengths
- Waste strengths are provided after primary tankage and are listed as primary-treated effluent (PTE)

Table 2A-1: Flows

Source	Design Maximum Day Flow ¹ (gpd)	BOD_5 (mg/L)	TSS (mg/L)	TKN (mg/L)
RV Dump Station ²	250	1,800	800	160
Shower House w/ Restrooms ³	4,500	225	75	80
Restrooms ⁴	1,800	300	100	120
Camp Host Living Quarters	150	150	60	60
Total Flow (Q_M)	6,700	302⁵	108⁵	93⁵

¹ For Average Day Design Flow (Q_A), assume 50% of Maximum Day Design Flow (Q_M); $Q_A = 3350$ gpd

² Dump station flow calculated using 50 gallons/RV per day

³ Typically equals Number of Sites \times Usage per Site or Number of Visitors \times Usage per Visitor (45 sites \times 4 users per site \times 25 gpcd)

⁴ Typically equals Number of Sites \times Usage/Site or Number of Visitors \times Usage per Visitor (45 sites \times 4 users per site \times 10 gpcd)

⁵ Total Waste Strength is determined by mass balance calculation using the volume and strength of each contributing source; see Equation B2 in Appendix B and example below

Determine the mass balance for the blended concentration of BOD_{5B} using Equation B2 from Appendix B:

$$= \frac{(250 \text{ gal} \times 1800 \text{ mg/L}) + (4500 \text{ gal} \times 225 \text{ mg/L}) + (1800 \text{ gal} \times 300 \text{ mg/L}) + (150 \text{ gal} \times 150 \text{ mg/L})}{6700 \text{ gal}}$$

Using the calculations, the blended concentration of $BOD_{5B} = 302$ mg/L (approximately 300 mg/L).

Discharge Type

Pressurized drainfield.

Influent (Primary Treated Effluent) and Permit Parameters

Table 2A-2: Influent and Permit Parameters

	BOD_5 (mg/L)	TSS (mg/L)
Primary Treated Effluent (Ave/Max)	302	108
Discharge Permit Requirement (30-day Average)	20	20

Other Design Considerations

Seasonal use

Some camps are only used seasonally and flows may vary wildly during this period. For those with highly variable flow fluctuations with limited full occupancy, flow equalization and a corresponding downsizing of the treatment facility may be in order.

Temperature effects

Seasonally low temperatures may impact performance of a treatment system. For camps that are to be used during the winter months, there may be a need to address waste stream temperature effects. AX-Max systems are constructed within insulated vessels and are preferred for cold environments, though AX100 with external insulation added in the field can also be utilized.

Design Specifics

Tankage Requirements

Distributed primary tankage (locating tanks next to the flow sources) is the most common method of primary tankage due to the configuration of most campground facilities. The primary tanks may require the use of a pump if the treatment facility is located at an elevation higher than the primary tanks. Using a primary tank at the treatment area would likely require either a small STEP collection system or a gravity sewer (which increases the risk for I&I).

Campgrounds fall within Application Type 2 in Appendix A; therefore total primary tank recommendations call for a minimum of 3 days' retention at maximum day design flow. Since a pre-anoxic tank is recommended and will be situated at the treatment site, provide a minimum of 2 days retention at each distributed site, except for the RV dump station.

Table 2A-3: Sample Tank Sizing Recommendations

Tank Sizing	Max. Day Design Flow (gpd)	Recommended Minimum Primary Tank Size (Gallons)
RV Dump Station ⁶	250	1,750; use 2,000
Shower House w/ Restrooms	4,500	9,000
Restrooms	1,800	3,600; use 4000
Camp Host Living Quarters	150	300; use 1,000 gallon minimum

⁶ Per note 5 in Appendix A, Primary tankage for RV dump station should be a minimum of 7 days

Size for the Pre-Anoxic Tank at the Treatment Site: 6700 gallons, use 6,000 or 8,000 gallons. Since the system is only required to treat for organic constituents, it would be configured as shown below (see page 10):

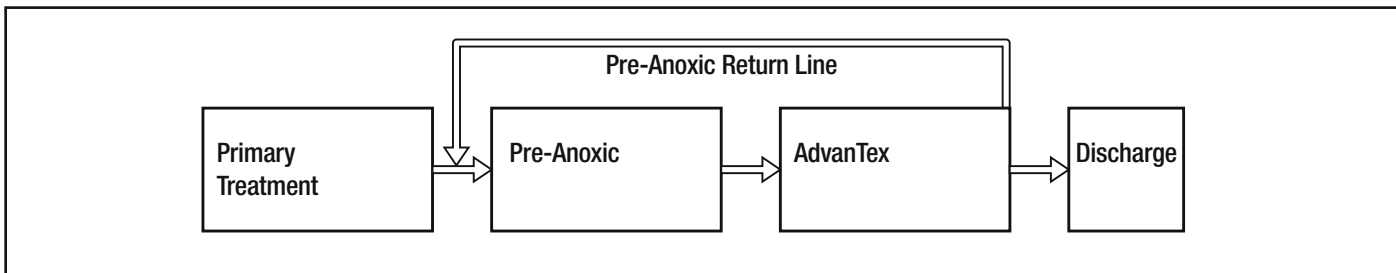


Figure 2A-1. Treatment Configuration for Organic Constituents

Loading Calculations

For all loading calculations, the design maximum day loading rates are double the design loading rates for average day. Since the design maximum day flow is not greater than two times the average day design flow, the calculation for maximum day design load is unnecessary.

Organic Loading

Since BOD_5 is greater than TSS, calculating for the most restrictive parameter (BOD_5) is necessary. Design Average OLR_A is 0.04 lbs $BOD_5/ft^2 \cdot d$.

Determine the pounds per day of Average Day Organic Load, OL_A using Equation B1A from Appendix B:

$$OL_A = (300 \text{ mg/L}) * (8.34 \times 10^{-6} \text{ lbs} \cdot \text{L/mg} \cdot \text{gal}) * (3350 \text{ gpd}) = 8.4 \text{ lbs/d}$$

Determine the textile area required based on Average Day Organic Load, A_{OLRA} using Equation 1.1:

$$A_{OLRA} = \frac{(8.4 \text{ lbs/d})}{0.04 \text{ lbs/ft}^2 \cdot \text{d}} = 210 \text{ ft}^2$$

Hydraulic Loading

Design average HLR_A is 25 gpd/ft² (from page 15). Determine the textile area required based on Average Day Hydraulic Load, A_{HLRA} using Equation 1.2:

$$A_{HLRA} = \frac{(3350 \text{ gal/d})}{25 \text{ gal/ft}^2\text{d}} = 134 \text{ ft}^2$$

The area associated with organic loading rate is the most restrictive and therefore the AdvanTex area should be a minimum of 210 ft².

Treatment Unit Options

Option 1: Using AX-Max units – 210 ft² area

AX-MAX225-35 (Max unit includes recirc-blend tankage and discharge tankage)

Option 2: Using AX pod units – 210 ft² area

(3) AX100, 5025-gallon recirc tank, 1500-gallon discharge tank. (Recirculation-blend tank sized at minimum of 75% of Q_M , equates to 5,025 gallon minimum, per page 17 of Design Criteria; discharge tank size based on local regulation, but typically sized at minimum of 20% of Q_M , equates to 1340 gallon minimum)

Other Design Notes

- RV dump waste should be limited to no more than 20% of the design flow (average or maximum day) and metered into the system using small doses, preferably with a timed dose system.
- Ensure access to the treatment site for maintenance activities.
- Ensure availability of water at the treatment site for maintenance activities.

Appendix 3A: Example Design for a School (Application Type 3)

AdvanTex Treatment for Removal of Organics and Nitrogen with $cBOD_5$, TSS, and TN Discharge Limits

Example: High School with cafeteria, gymnasium, and sports fields. System is to be discharged to a pressurized drainfield and permit requirements include organic ($cBOD_5$ and TSS) and total nitrogen (TN) discharge limits.

Establishing a Design Basis

Flows

School facilities include cafeteria and gym with seating for 800. Due to their weekly flow characteristics, schools are a perfect application for the use of equalization tankage to evenly distribute the flows over the week. Flow equalization provides a consistent, stable loading of the treatment system, as well as slightly reduces the system size.

Table 3A-1: Flows

Source	Max. Day Design Flow Per Unit (gpd)	Max. Day Design Flow (gpd)
400 students	25	10,000
60 Employees	15	900
School event seating, 800	5	4,000
Total		14,900¹ or 10,500²

¹ For Average Day Design Flow, use the five-day average flow of 10,900 gpd

² If using Flow Equalization, see below

Determine the Design Average Day Flow using Flow Equalization to reduce treatment capacity requirement:

$$\text{Equalized Design Day Flow, } Q_E = \frac{(10,900 \text{ gpd} \times 4 \text{ days}) + (14,900 \text{ gpd} \times 1 \text{ day}) + (4,000 \text{ gpd} \times 1 \text{ day}) + (0 \text{ gpd} \times 1 \text{ day})}{6 \text{ days}^3} = 10,416 \text{ gpd, use 10,500 gpd}$$

³ Allowing for one day for recovery (see pages 12-13)

Discharge Type

Pressurized drainfield.

Influent (Primary Treated Effluent) and Permit Parameters

Table 3A-2: Influent and Permit Parameters

	BOD_5 (mg/L)	TSS (mg/L)	TKN (mg/L)	TN (mg/L)	Alkalinity (mg/L)
Primary Treated Effluent (Ave/Max)	280/350	50/100	160/200	N/A	120
Discharge Permit Requirement (30-day Average)	20	20	N/A	20	N/A

Other Design Considerations

Seasonal use

Most school applications see regular flows five days per week during the school year. For high schools there may be 1-2 days per week that see significant additional flows associated with sporting events or other activities. Flows during the summer months are typically only a fraction of the usage while school is in session. Flow equalization and a corresponding downsizing of the treatment facility is typically in order.

Temperature effects

Seasonally low temperatures may impact performance of a treatment system. For nitrogen sensitive applications, there may be a need to address waste stream temperature effects. This is especially true for systems with significant nitrogen removal requirements.

Alkalinity needs

Ensuring that the pH remains above 7 at all times is critical for ammonia sensitive applications. Therefore alkalinity addition should be included if influent alkalinity is insufficient to buffer the process.

Using Equation B3 from Appendix B provides the alkalinity demand for this project:

$$\text{Alkalinity Demand} = 160 \text{ mg/L TKN} \times \frac{5 \text{ mg/L alkalinity}}{1 \text{ mg/L TKN}} = 800 \text{ mg/L}$$

Using Equation B4 from Appendix B provides the alkalinity need for the project:

$$\text{Alkalinity Need} = 800 \text{ mg/L} + 100 \text{ mg/L} - 120 \text{ mg/L} = 780 \text{ mg/L}$$

These equations show that alkalinity addition is required for this system.

Design Specifics

Tankage Requirements

Depending on the size of the facility, distributed tankage or a small gravity collection system to primary tankage is typically used. For systems with gravity collection, especially in areas with significant rainfall, an adjustment to the per capita flow may be necessary.

Schools fall within Application Type 3 in Appendix A; therefore total primary tank recommendations call for a minimum of 3 days' retention at maximum day design flow. Since a pre-anoxic tank will be used due to the nitrogen reduction requirement, two days of primary tankage will be recommended with an additional one-day pre-anoxic tank situated at the treatment site.

Table 3A-3: Sample Tank Sizing Recommendations (With Flow Equalization)

Source	Equalized Design Daily Flow (gpd)	Recommended Minimum Tank Size (gallons)
Grease Tankage	2,100 ¹	6,300
Primary Tankage	10,500	21,000
EQ Tank	10,500	10,500
Pre-Anoxic Tank	10,500	10,500
1st Stage Recirculation Tank ²	10,500	7,875
Post-Anoxic Tank	10,500	5,250
2nd Stage Recirculation Tank ^{3,4}	10,500	2,625
Discharge Tank	10,500	2,100

¹ Grease flow estimated at 20% of Design Flow

² Only for AX100 Systems; volume included in AX-Max Systems

³ Sized at 25% of Design Flow (see page 17)

⁴ Only for AX100 Systems; volume included in AX-Max Systems

Since the system is required to treat for organic constituents and provide nutrient reduction, it would be configured as shown in Figure 3A-1.

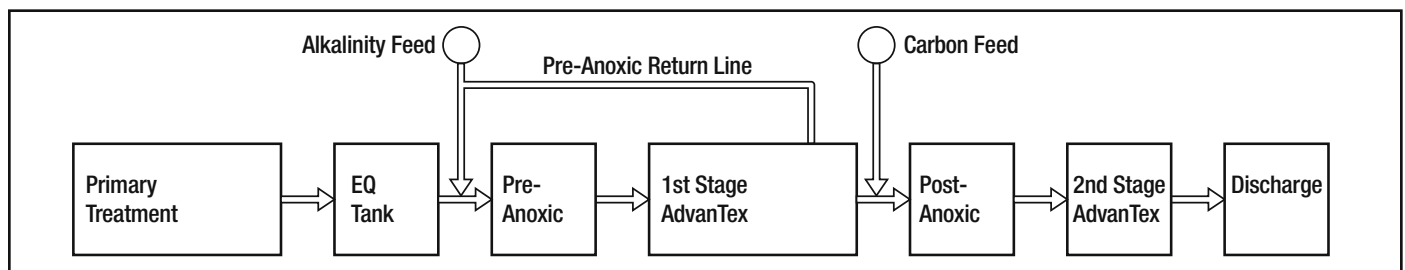


Figure 3A-1. Treatment Configuration for Organic Constituents

When using Flow Equalization, all calculations are performed with the Equalized flow considered as the Design Average Day Flow. Calculations for Maximum Day Design Flow are unnecessary.

Organic Loading – First Stage

Since BOD_5 is greater than TSS, the calculation for the most restrictive parameter (BOD_5) is necessary. Design Average OLR_A is 0.04 lbs $BOD_5/ft^2 \cdot d$ (from page 15).

Determine the pounds per day of Average Day Organic Load, OL_A using Equation B1A from Appendix B:

$$OL_A = (280 \text{ mg/L}) * (8.34 \times 10^{-6} \text{ lbs} \cdot \text{L/mg} \cdot \text{gal}) * (10,500 \text{ gpd}) = 24.5 \text{ lbs/d}$$

Determine the textile area required based on Average Day Organic Load, A_{OLRA} using Equation 1.1:

$$A_{OLRA} = \frac{(24.5 \text{ lbs/d})}{0.04 \text{ lbs/ft}^2 \text{d}} = 613 \text{ ft}^2$$

Hydraulic Loading — First Stage

Design average HLR_A is 25 gpd/ft² (from page 15).

Determine the textile area required based on Average Day Hydraulic Load, A_{HLRA} , using Equation 1.2:

$$A_{HLRA} = \frac{(10500 \text{ gal/d})}{25 \text{ gal/ft}^2 \text{d}} = 420 \text{ ft}^2$$

Total Nitrogen Loading Calculations — First Stage

Design average $TNLR_A$ is 0.014 lbs TKN/ft² (from page 15).

Determine the pounds per day of Average Day Nitrogen Load, $TNLA$, using Equation B1 from Appendix B:

$$TNLA, \text{ lbs/d} = (160 \text{ mg/L}) * (8.34 \times 10^{-6} \text{ lbs} \cdot \text{L/mg} \cdot \text{gal}) * (10,500 \text{ gpd}) = 14 \text{ lbs/d}$$

Determine the textile area required based on Average Day Nitrogen Load, A_{TNLRA} , using Equation 1.3:

$$A_{TNLRA} = \frac{(14 \text{ lbs/d})}{0.014 \text{ lbs/ft}^2 \text{d}} = 1000 \text{ ft}^2$$

The area associated with Total Nitrogen Loading Rate is the most restrictive and therefore the first stage AdvanTex area should be a minimum of 1000 ft².

Treatment Unit Options — First Stage

Option 1: Using AX-Max units – 1000 ft² area

(4) AX-MAX250-35; (1) T-MAX-14 (AX-Max unit includes recirc-blend tankage and discharge tankage)

Option 2: Using AX pod units – 1000 ft² area

(10) AX100, 7875-gallon recirc tank (Recirculation-blend tank sized at minimum of 75% of Q_M per page 17 of Design Criteria)

Loading Calculations — Second Stage

For all second stage calculations, the values used are based on the predicted performance of the first stage system. Per page 25 of the Design Criteria, the Standard AdvanTex Stage treated effluent values for BOD_5 and TKN are typically based upon 90% BOD_5 removal, 95% nitrification and 70% denitrification through the Pre-Anoxic Stage and first stage of AdvanTex Treatment Stage.

Organic Loading – Second Stage

Design Average OLR_A is 0.02 lbs $BOD_5/ft^2 \cdot d$ (from page 15). Use Equation B5 from Appendix B to determine the value of First-Stage AdvanTex effluent BOD_{5e} :

$$BOD_{5e} = 280 \text{ mg/L} \times (1 - 0.9) = 28 \text{ mg/L}$$

Determine the pounds per day of Average Day Organic Load, OL_A using Equation B1 from Appendix B:

$$OL_{A2} = (28 \text{ mg/L}) * (8.34 \times 10^{-6} \text{ lbs} \cdot \text{L/mg} \cdot \text{gal}) * (10,500 \text{ gpd}) = 2.45 \text{ lbs/d}$$

Determine the textile area required based on Average Day Organic Load, A_{OLRA} using Equation 1.1:

$$A_{OLRA} = \frac{(2.45 \text{ lbs/d})}{0.02 \text{ lbs/ft}^2 \text{d}} = 123 \text{ ft}^2$$

Hydraulic Loading — Second Stage

Design average HLR_A is 75 gpd/ft² (from page 15). Use Equation 1.2 to determine the textile area required based on Average Day Hydraulic Load, A_{HLRA} :

$$A_{HLRA} = \frac{(10,500 \text{ gal/d})}{75 \text{ gal/ft}^2 \text{d}} = 140 \text{ ft}^2$$

Total Nitrogen Loading — Second Stage

Design average $TNLR_A$ is 0.007 lbs TN/ft². Use Equation B6 from Appendix B to determine the value of First-Stage AdvanTex effluent TKN_e :

$$TKN_e = 160 \text{ mg/L} * (1 - 0.95) = 8 \text{ mg/L}$$

Determine the pounds per day of Average Day TKN Load, TKN_e , using Equation B1 from Appendix B :

$$TKN_e = (8 \text{ mg/L}) * (8.34 \times 10^{-6} \text{ lbs} \cdot \text{L/mg} \cdot \text{gal}) * (10,500 \text{ gpd}) = 0.70 \text{ lbs/d}$$

Determine the textile area required based on Average Day Nitrogen Load, A_{TNLRA} using Equation 1.3:

$$A_{TNLRA} = \frac{(0.70 \text{ lbs/d})}{0.007 \text{ lbs/ft}^2 \text{d}} = 100 \text{ ft}^2$$

The area associated with the Design Maximum Day Hydraulic Loading Rate is the most restrictive and therefore the second stage AdvanTex area should be a minimum of 140 ft².

Treatment Unit Options — Second Stage

Option 1: Using AX-Max units – 140 ft² area

AX-MAX150-28 (Max unit includes recirc-blend tankage and discharge tankage)

Option 2: Using AX pod units – 140 ft² area

(2) AX100, 2625-gallon recirc tank, 2100-gallon discharge tank (Recirculation-blend tank sized at minimum of 25% of Q_M per page 17 of the Design Criteria; Discharge tank size based on local regulation, but typically sized at minimum of 20% of Q_M)

Other Design Notes

- Ensure access to treatment site for maintenance activities.
- Ensure availability of water at treatment site for maintenance activities.

Appendix 4A: Special Considerations for Greywater Treatment Systems (Application Type 6)

Orenco has increased the permissible hydraulic loading rates when using AdvanTex treatment systems for greywater applications –compared to a standard stage wastewater treatment application– while retaining the organic and nitrogen loading parameters.

Table 4A-1: Standard Advantex Stage Sizing For Greywater

	Design Avg	Design Max.
Hydraulic Loading Rate (HLR)	40 gpd/ft ² *	80 gpd/ft ² *
Organic Loading Rate (OLR)	0.04 lbs BOD ₅ /ft ² /day	0.08 lbs BOD ₅ /ft ² /day
Total Nitrogen Loading Rate (TNLR)	0.014 lbs TN/ft ² /day	0.028 lbs TN/ft ² /day
Ammonia Loading Rate (ALR)	0.01 lbs NH ₃ -N/ft ² /day	0.02 lbs NH ₃ -N/ft ² /day

**This is the maximum rate allowed by Orenco, however local regulation may be more restrictive. Check local regulation.*

Determining Influent Constituent Concentrations:

Orenco prefers sampled data to establish influent waste strengths for greywater applications. When sample data is unavailable, NSF350-1 is typically used to estimate influent constituent concentrations. These concentrations are based upon what is being served and are listed in the tables below.

Table 4A-2: Expected Range of Greywater Constituents, 30-Day Average

Parameter	Application Type 6A, Shower/Bath Only	Application Type 6B, Laundry Only	Application Type 6C, Shower/Bath and Laundry
TSS	50-100 mg/L	50-100 mg/L	80-160 mg/L
BOD₅	100-180 mg/L	220-300 mg/L	130-180 mg/L
Temperature	25-35° C	25-35° C	25-35° C
pH	6.0-7.5	7.0-8.5	6.5-8.0
Turbidity	30-70 NTU	50-90 NTU	50-100 NTU
Sodium	n/a	50-90 mg/L	50-90 mg/L
Total Phosphorous P	1.0-4.0 mg/L	<2.0 mg/L	1.0-3.0 mg/L
Total Kjeldahl nitrogen-N	3.0-5.0 mg/L	4.0-6.0 mg/L	3.0-5.0 mg/L
COD	200-400 mg/L	300-500 mg/L	250-400 mg/L
TOC	30-60 mg/L	50-100 mg/L	50-100 mg/L
E. coli	10 ² -10 ³ cfu/100 mL	10 ² -10 ³ cfu/100 mL	10 ² -10 ³ cfu/100 mL
Total coliforms	10 ³ -10 ⁴ cfu/100 mL	10 ³ -10 ⁴ cfu/100 mL	10 ³ -10 ⁴ cfu/100 mL