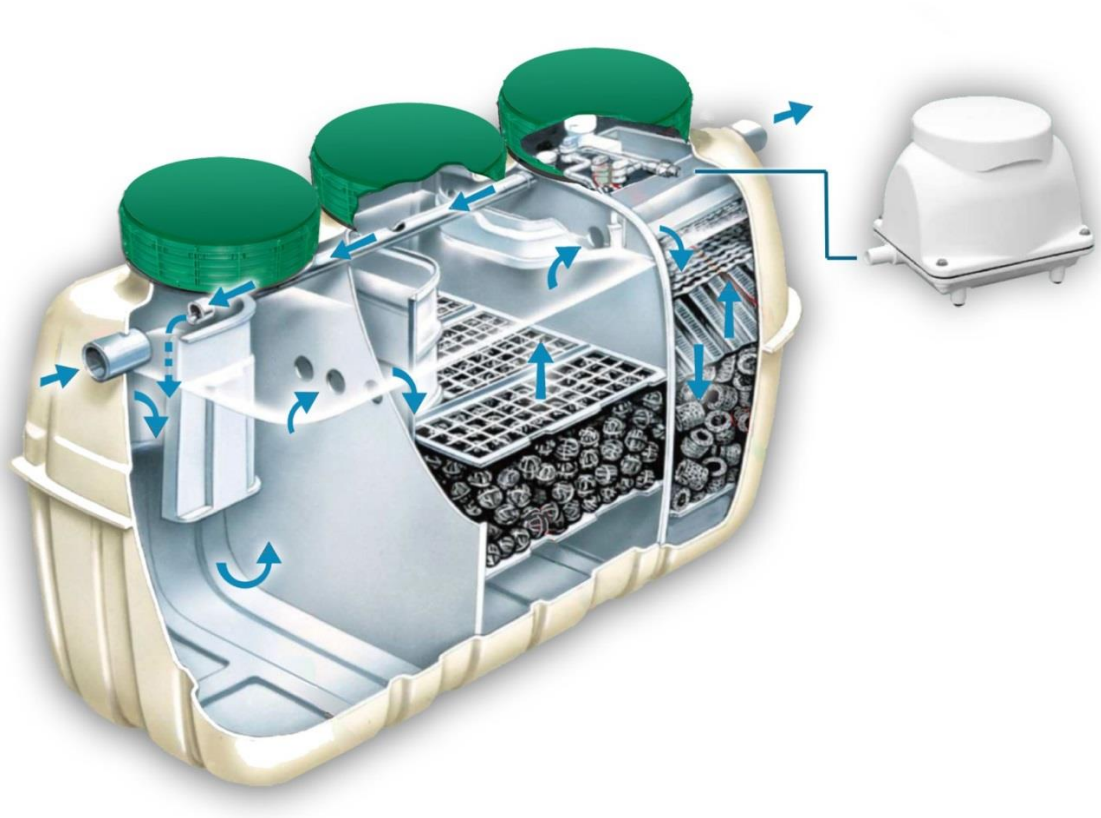
FujiClean USA™ LLC
Toward Clean Water…



RHODE ISLAND DESIGN MANUAL
FUJI CLEAN CEN5, CEN7, CEN10 AND CEN14

Rev: 11-28-23

NSF®
Certified to
NSF/ANSI Standards 40 & 245

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Contents

INTRODUCTION

This manual provides information to design a Fuji Clean CEN-Series wastewater treatment unit. This manual is specific to the State of Rhode Island though it incorporates contemporary design practices applicable to decentralized wastewater treatment systems. Please follow Rhode Island Department of Environmental Management (RIDEM) requirements should you observe a discrepancy.

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DEFINITIONS

The following definitions are used in this manual.

NSF/ANSI Standard 40: A performance certification standard intended for onsite wastewater treatment systems having a flow between 400 and 1500 gpd (gallons per day) and a single point of discharge.

NSF/ANSI Standard 40/245: A performance certification standard intended for nitrogen-reducing onsite wastewater treatment systems having a flow between 400 and 1500 gpd (gallons per day) and a single point of discharge.

$CBOD_5$: The concentration of oxygen (expressed as mg/L) utilized by microorganisms in the non-nitrogenous oxidation of organic matter during a five-day period at a temperature of 20^{o}C.

Clarify: A process of separating from wastewater fats, oils, grease, and floatable materials, which float to the surface; and solids, which sink to the bottom.

Commercial Occupancy: A building used for commerce or industry.

Commercial Wastewater: Wastewater generated by non-residential occupancies and/or having constituent characteristics different and usually in higher concentrations than typical domestic wastewater.

Dispersal: A process for recycling treated wastewater back into the environment.

Dosing: A process for periodic discharge of wastewater to a Fuji Clean CEN-Series unit.

Effluent: The discharge from a treatment component or system.

Flow Equalization: A process for mitigating variations in flow by holding wastewater in a tank and dosing the wastewater into the Fuji Clean CEN-Series unit.

Flow Equalization Tank: A watertight, airtight tank, timer, and pumping system having a detention time of 16-to-24 hours used to capture and retain solids, grit, and scum, and then meter the water into the Fuji Clean CEN-Series unit through periodic dosing.

FOG: Fats, oils, and grease in wastewater.

Frequenter: A visitor to and/or customer of a commercial occupancy.

Grease Trap: A tank for capturing and retaining fats, oil, and grease.

Maintenance: Periodic activities intended to maintain the efficiency and effectiveness of the system.

Mixed Liquor. The contents of the Fuji Clean CEN-Series aeration chamber consisting of, but not limited to, partially treated wastewater and microbial colonies that oxidize the organic material in the wastewater.

Onsite Wastewater Treatment System. A device or combination of devices, which may include tanks, vessels, pumps, aerators, and other mechanical equipment, intended to treat and disperse wastewater at or near the point of generation.

Pre-aeration: Aeration of wastewater to reduce the $CBOD_5$ prior to discharge to the Fuji Clean CEN-Series unit.

Pre-Aeration Tank: A tank used to partially reduce the $CBOD_5$ of the wastewater before it enters the Fuji Clean CEN-Series unit.

Pretreatment Tank: A watertight, airtight tank having a detention time from 12-to-24 hours used to capture and retain solids, grit, and scum before the wastewater enters the Fuji Clean CEN-Series unit.

Residential Occupancy: A building used to house individuals and families.

Septic System: An onsite wastewater treatment system comprised of a septic tank and soil absorption system.

Sanitary Wastewater. Sanitary wastewater is wastewater generate from human activities including toilet use, handwashing, and clothes washing. The term generally excludes kitchen wastewater when a kitchen is used for commercial or institutional activities.

Septic Tank: A watertight, airtight tank having a detention time of 24-to-48 hours, or more, used to clarify wastewater and capture fats, oil, greases, and inert solids.

Soil Absorption System: A system consisting of trenches and pipes—or equivalent "gravel-less" devices—used to disperse water into the soil where additional treatment may occur and the water is dispersed from the site.

Trash Trap: A watertight, airtight tank for capturing and retaining solids.

Seeding: A process for facilitating bacterial growth by providing mixed liquor from another Fuji Clean CEN-Series unit.

TKN (Total Kjeldahl Nitrogen): The quantity of organic nitrogen and ammonia (expressed in mg/L) found in wastewater.

TN: The total quantity of nitrogen (expressed in mg/L-N) that exists in the wastewater. Nitrogen may be in the form of ammonia, TKN, nitrate or nitrite.

TSS: The quantity of solids (expressed in mg/L) that can be readily removed from a well-mixed sample with standard laboratory filtering procedures.

Typical Domestic Wastewater: Wastewater generated by residential occupancies and having the characteristics as shown in Table 1:

Table 1—Typical Domestic Wastewater	
Constituent	**Value**
$CBOD_5$	100-300 mg/L
TSS	100-350 mg/L
FOG	30 mg/L
TKN	60 mg/L

Wastewater: Water generated as a result of human activities and containing feces, urine, blood, food byproducts, rinse water, laundry water, process water, and the like.

Brief Description of the Treatment Process

The Fuji Clean CEN-Series is a combined-process wastewater treatment system. "Combined process" [i] refers to the use elements generally described as "fixed media" and "suspended growth" wastewater treatment. Another term is an Integrated Fixed-Film Activated Sludge (IFAS) process. Fixed media designs typically apply wastewater to a medium, on which the microbes attach themselves. Suspended growth refers to a technique of suspending microbes in a tank of water using aeration. Models consist of a single tank divided into three main chambers, two of which contain proprietary media, to treat the wastewater. The design is a variation of the Modified Ludzak-Ettinger (MLE) process. [ii] The design incorporates a diaphragm compressor to supply oxygen and energize an air lift pump to recirculate treated wastewater back to the influent chamber. A separate air lift pump regulates effluent discharge. The integrated nature or the design precludes the need for additional upstream tankage, which is common for many onsite wastewater treatment products.

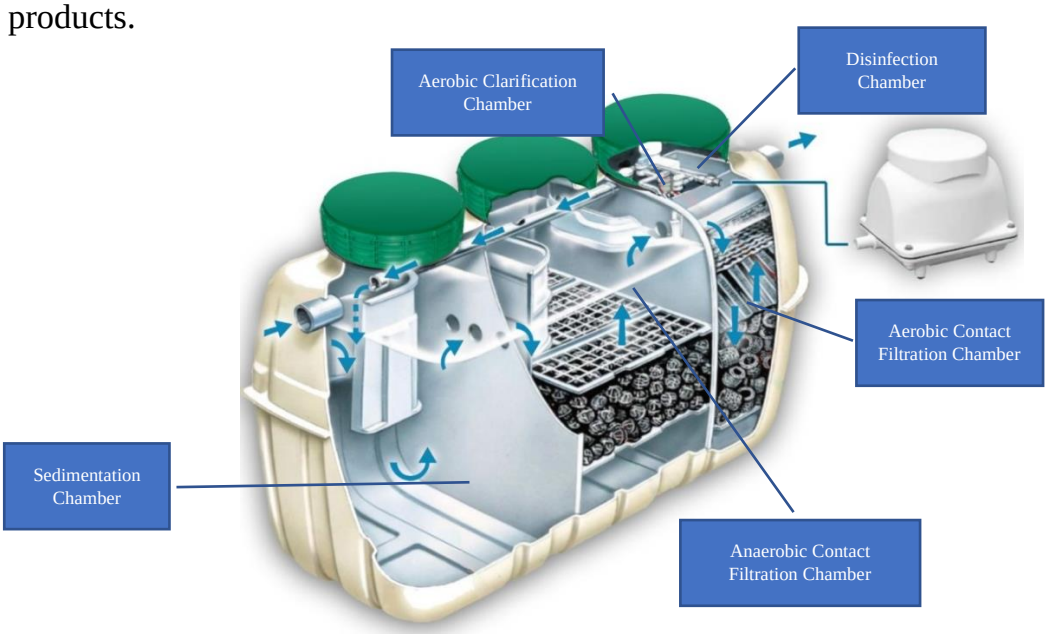


Figure 1—Fuji Clean CEN-Series Schematic

The system operates between a minimum and maximum elevation, known as the Low Water Level (LWL) and High Water Level (HWL). The effluent air lift pump will not operate unless the water elevation exceeds the LWL.

TABLE 2—FUJI CLEAN USA RESIDENTIAL SYSTEM SPECIFICATION TABLE				
ITEM	MODEL			
Model	**CEN5**	**CEN7**	**CEN10**	**CEN14**
Flow (GPD)	500	700	1,000	1,350
EFFLUENT ASSUMES TYPICAL DOMESTIC WASTEWATER				
BOD (mg/L)	10	10	10	10
TSS (mg/L)	10	10	10	10
TN (mg/L)	10	10	10	10
Blower Model / CFM (Standard)	FujiMAC 80RII 2.8 CFM	FujiMAC 100RII 3.5 CFM	FujiMAC 150RII 5.3 CFM	FujiMAC 200RII 7.0 CFM
Power Use (kWh/day)	1.2	1.7	2.7	3.7
Tank Detail:				
Material	Fiber-Reinforced Plastic			
Height (inches)	65.7	73.6	77.4	81.3
Length (inches)	95.7	98.8	118.9	152.8
Width (inches)	49.2	56.7	68.9	72.4
Weight (lbs.)	463	705	926	1,168
Inlet Invert (inches, to 1/8")	53	61	62	65
Outlet Invert (inches to 1/8")	51	59	59.5	63
Access Ports (number)	3	3	3	3
Access Port Diameter (inches)	2@20" 1@24"	2@20" 1@24"	2@20" 1@24"	2@20" 1@24"
Volume Total (gallons)	749	1,069	1,498	2,252

All models are proportionally sized such that critical process parameters are identical.

Treated wastewater recirculation is continuous and adjustable to maximize treatment performance. Typically, the recirculation ratio is set between four and six times the influent flow.

Table 3—CEN-Series Model Details

	CEN5	CEN7	CEN10	CEN14
HYDRAULIC RATING (GPD)	500	700	1,000	1,350
SEDIMENTATION CHAMBER (GAL)	277	397	558	837
% OF TOTAL VOLUME	37%	37%	37%	37%
DETENTION TIME (HRS)	13.30	13.61	13.39	14.88
ANAEROBIC FILTRATION CHAMBER (GAL)	278	396	558	839
% OF TOTAL VOLUME	37%	37%	37%	37%
DETENTION TIME (HRS)	13.34	13.58	13.39	14.92
SPECIFIC SURFACE (M2/M3)	41	41	41	41
PACKING RATIO (%)	46%	46%	46%	46%
AEROBIC CONTACT FILTRATION CHAMBER (GAL)	127	181	248	378
PERCENT OF TOTAL VOLUME	17%	17%	17%	17%
DETENTION TIME (HRS)	6.10	6.21	5.95	6.72
SPECIFIC SURFACE (M2/M3)	71	71	71	71
PACKING RATIO (%)	16%	17%	17%	17%
SPECIFIC SURFACE (M2/M3)	107	107	107	107
PACKING RATIO (%)	57%	55%	55%	55%
AEROBIC CLARIFICAITON CHAMBER (GAL)	63	90	124	186
% OF TOTAL VOLUME	8%	8%	8%	8%
DETENTION TIME (HRS)	3.02	3.09	2.98	3.31
DISINFECTION CHAMBER (GAL)	4	6	12	12
% OF TOTAL VOLUME	1%	1%	1%	1%
DETENTION TIME (HRS)	0.19	0.21	0.29	0.21
TOTAL VOLUME INCLUDING SURGE FLOW (GAL)	749	1,070	1,498	2,252
TOTAL TREATMENT TIME (HRS)	35.95	36.69	35.95	40.04

Treatment Chambers

The three main chambers of each CEN-model are the Sedimentation Chamber, Anaerobic Contact Chamber, and Aerobic Contact Filtration Chamber, which includes two sub-chambers; the Aerobic Clarification Chamber, and the Disinfection Chamber. Each is described below and shown in Figure 1.

Sedimentation Chamber

The Sedimentation Chamber receives and conditions influent wastewater. Wastewater discharged directly from the dwelling enters the chamber where it is diverted downward by an influent baffle. The influent mixes with recirculated treated wastewater, which is also discharged in front of the influent baffle. This mixing conditions the influent such that

concentrations are attenuated. The mixed water passes beneath the baffle into the chamber, where heavier solids settle (sedimentation) and lighter solids float (flotation). Clarified wastewater moves from the chamber through two 3.0625-inch holes centered 12 inches below the low water elevation.

The Sedimentation Chamber has a flow through detention time of 8.9 hours, which is associated with an approximate BOD removal of 45 percent and a TSS removal of 65 percent. Taking a 4.5 recirculation ratio into account, the instantaneous detention time will be approximately 2.0 hours, which is associated with BOD and TSS removals in the range of 35 and 55 percent, respectively. [iii] Both values are in keeping with typical wastewater engineering practice.

Anaerobic Contact Filtration Chamber

The Anaerobic Contact Chamber receives conditioned wastewater directed to it through a baffle to the chamber floor for flow up through the tapered column skeleton media. Technically, this tank may be considered anoxic and not anaerobic. Fuji Clean uses the term in a general sense to distinguish the chamber from the aerated chamber.

Upflow contact filtration is a well-documented process. Microbes floating in or attached to the skeletal media use recirculated nitrate as the terminal electron and hydrogen acceptor. The electron donor is BOD in the wastewater. Nitrate is the terminal electron and hydrogen acceptor when free oxygen is not available and when facultative heterotrophs are present. The pass through and instantaneous detention times in the chamber is identical to the Sedimentation chamber, 8.9 and 2 hours, respectively. Generally, a three-hour detention time is required to achieve denitrification; the time spent in both chambers will be approximately four hours under instantaneous flow conditions, sufficient to facilitate denitrification.

Aerobic Contact Filtration Chamber

Wastewater passes to the Aerobic Contact Filtration Chamber by passing through one of two 3.0635-inch holes located on each side of the chamber wall into the Aerobic Contact Filtration Chamber, which is divided by the Aerobic Clarification Chamber, and moves downward through two different media types located in each side. The first media is a sheet-type while the second media is hollow cylindrical. The downward flowing wastewater passes through upward-flowing air bubbles supplied by a diaphragm compressor attached to supply piping. The pass through and instantaneous detention times are 4 hours and 53 minutes, respectively.

Aerobic Clarification Chamber

Aerobic Contact Filtration effluent passes to an aerobic clarification chamber located in the middle. Clarification uses gravity separation to clarify the effluent. Fuji Clean engineers called this area the "Storage Chamber." An effluent airlift pump, with an intake located at Low Water Level (LWL), lifts and spills treated effluent into the Disinfection Chamber. When influent flow ceases, the tank volume will eventually drop to the LWL. All treated wastewater will be recycled at that point and continue until influent flow resumes.

Disinfection Chamber

The disinfection chamber is the last chamber in each unit. Disinfection is provided by a removable chlorine tablet feeder if disinfection is permitted and desired. Disinfection is optional. The chamber also serves as a convenient effluent sampling location. The chamber has an approximate 8-minute detention time.

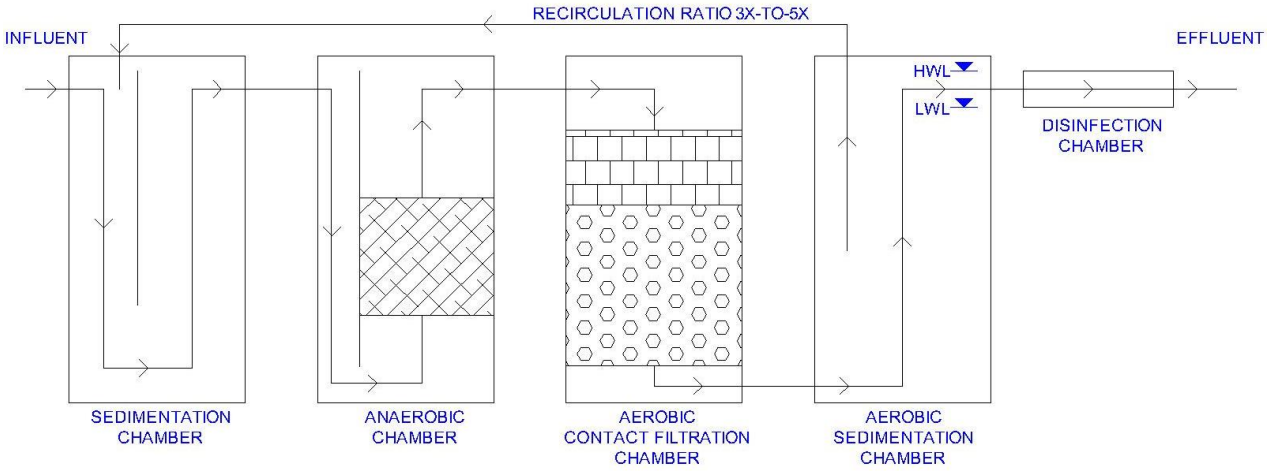


Figure 2—Fuji Clean CEN-Process Schematic

	CHAMBER	Volume (gal)
①	Sedimentation Chamber	277
②	Anaerobic Filtration Chamber	278
③	Aerobic Contact Filtration Chamber	127
④	Storage Chamber	63
⑤	Disinfection Chamber	4
	Total Volume	749

SPECIFICATIONS			
Anaerobic Media	PP / PE	Filling Rate	32%
Board Type Aerobic Media	PVC / PP / PE	Filling Rate	16%
Aerobic Media	PP / PE	Filling Rate	57%
Blower	2.8 cfm		
Tank	FRP		
Piping	PVC / PP / PE		
Access Covers	Plastic / Cast Iron		
Disinfectant (Optional)	Chlorine Tablets		

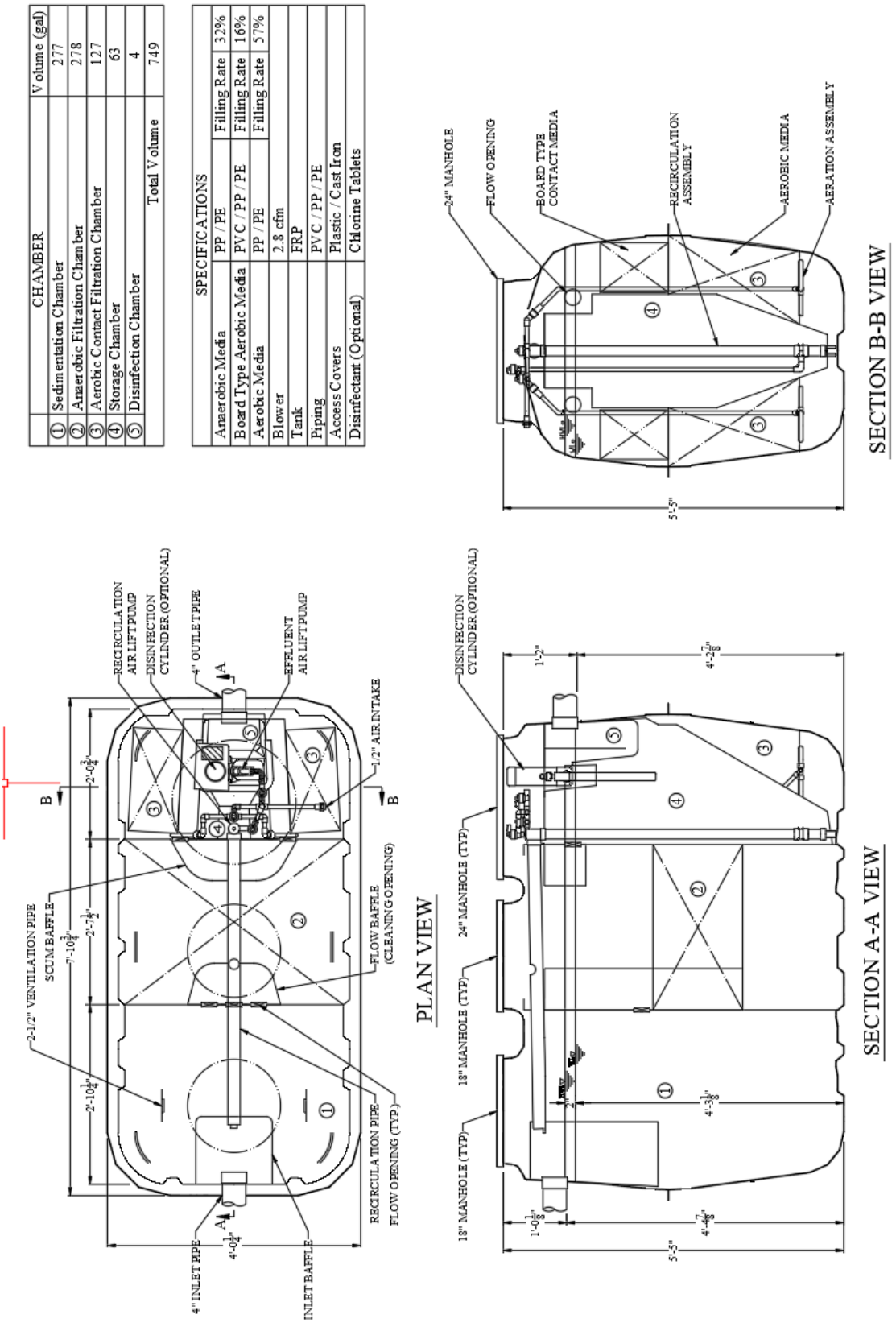


Figure 3—CEN5

CHAMBER		Volume (gal)
①	Sedimentation Chamber	397
②	Anaerobic Filtration Chamber	396
③	Aerobic Contact Filtration Chamber	181
④	Storage Chamber	90
⑤	Disinfection Chamber	6
	Total Volume	1069

SPECIFICATIONS			
Anaerobic Media	PP / PE	Filling Rate	32%
Board Type Aerobic Media	PVC / PP / PE	Filling Rate	17%
Aerobic Media	PP / PE	Filling Rate	55%
Blower	2.8 cfm		
Tank	FRP		
Piping	PVC / PP / PE		
Access Covers	Plastic / Cast Iron		
Disinfectant (Optional)	Chlorine Tablets		

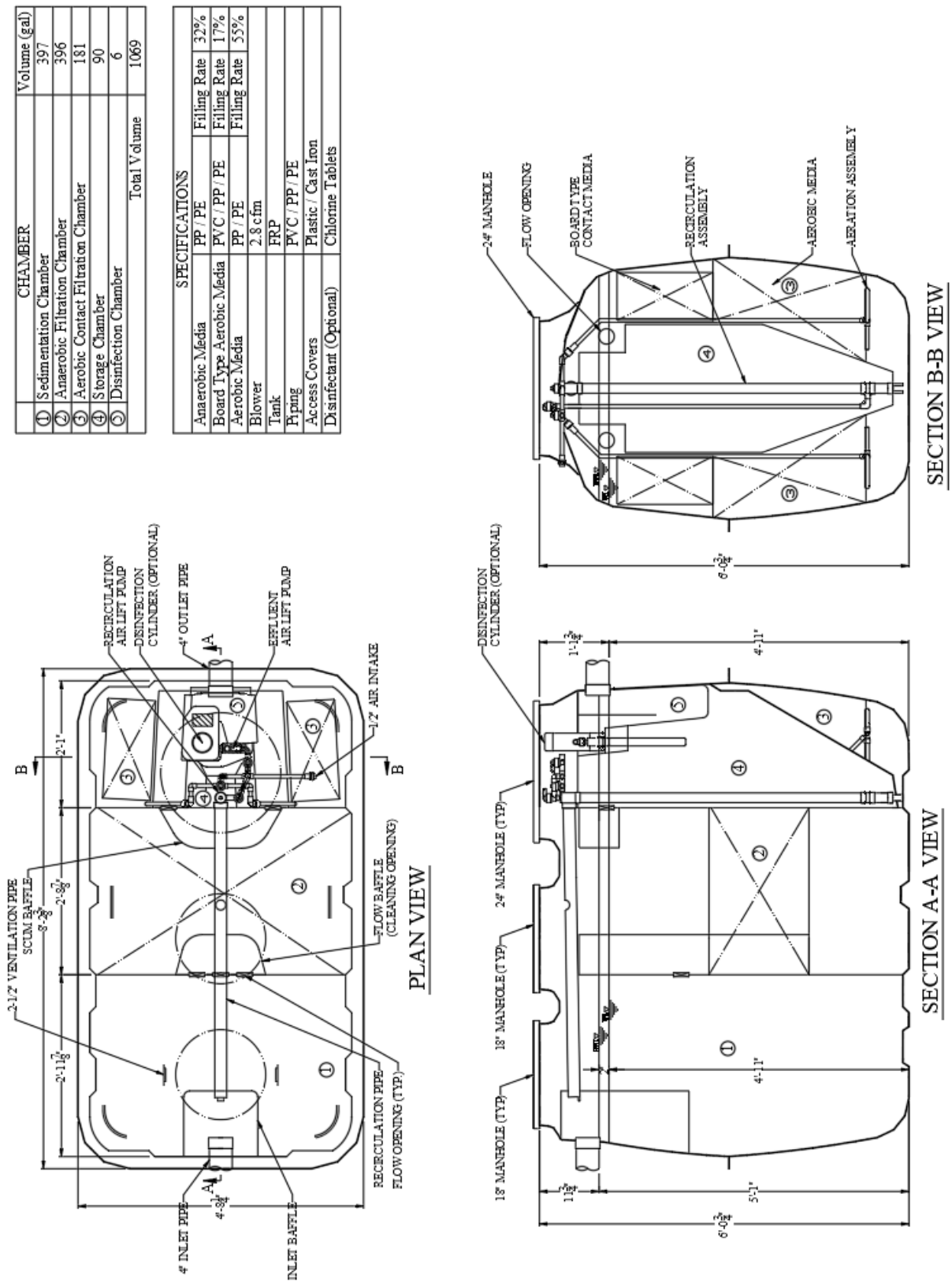
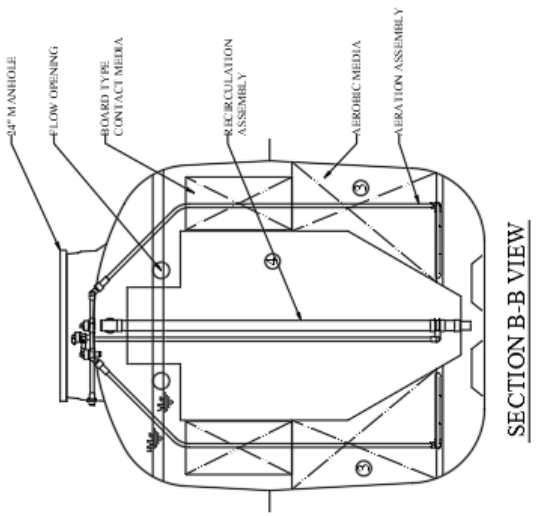


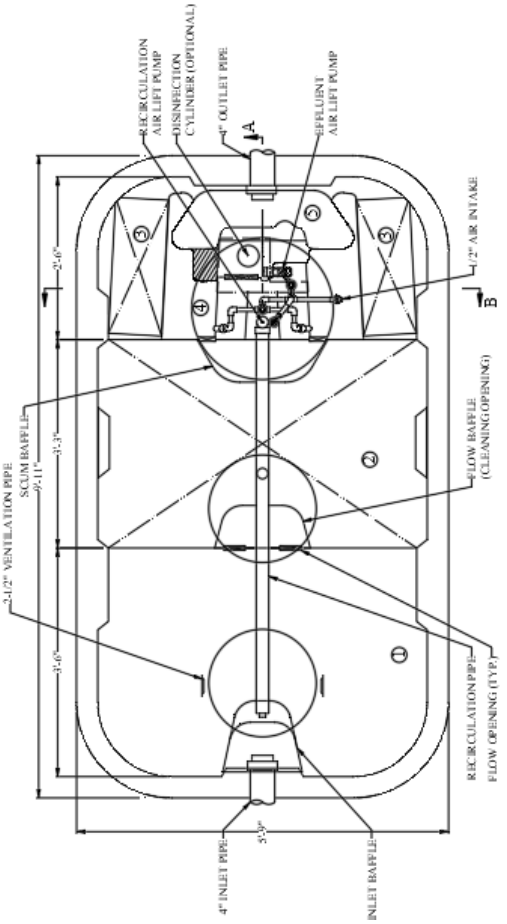
Figure 4—CEN7

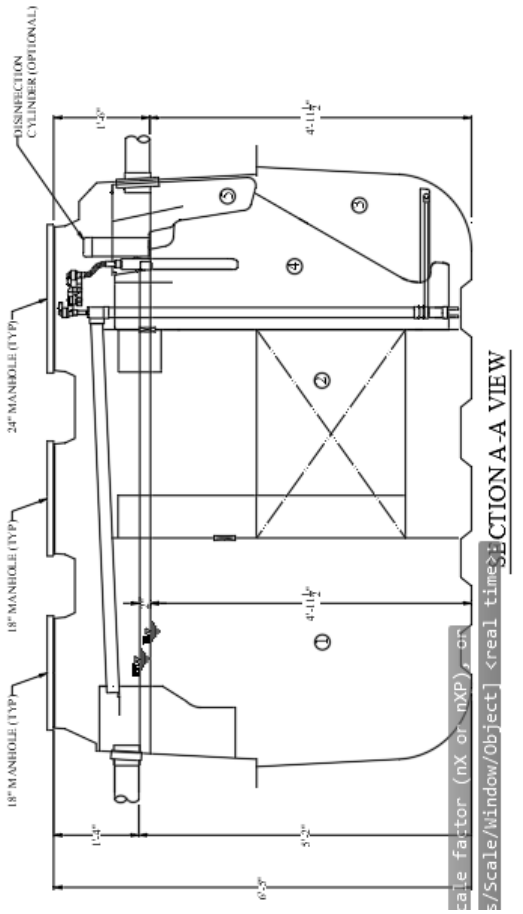
	CHAMBER	Volume (gal)
①	Sedimentation Chamber	558
②	Anaerobic Filtration Chamber	556
③	Aerobic Contact Filtration Chamber	248
④	Storage Chamber	125
⑤	Disinfection Chamber	11
	Total Volume	1,498

SPECIFICATIONS			
Anaerobic Media	PP / PE	Filling Rate	46%
Board Type Aerobic Media	PVC / PP / PE	Filling Rate	17%
Aerobic Media	PP / PE	Filling Rate	54%
Blower	3.0 cfm		
Tank	FRP		
Piping	PVC / PP / PE		
Access Covers	Plastic / Cast Iron		
Disinfectant (Optional)	Chlorine Tablets		



SECTION B-B VIEW





SECTION A-A VIEW

Figure 5 — CEN10

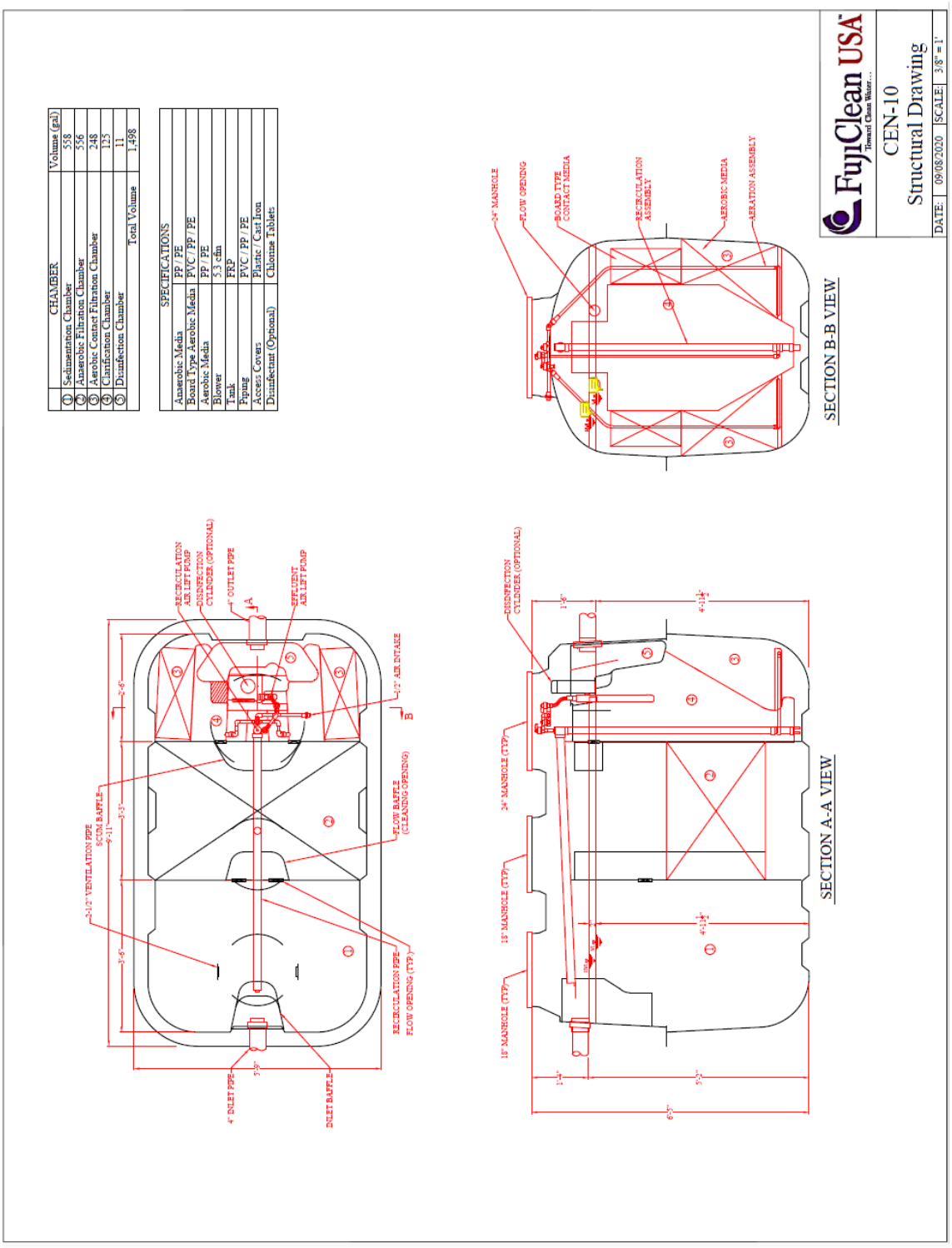


Figure 6 — CEN14

Process Considerations

This section discusses process considerations. Fuji Clean treats design elements, particularly as they relate to the selection and use of synthetic media, as trade secrets. A complete analysis is not possible though sufficient information is available to confirm that the designs conform to general design practice for synthetic media.

Figure 2 is a process diagram of the CEN-Series. This diagram is generally representative of IFAS systems incorporating attached-growth denitrification. [iv] The distinguishing characteristics include the use of submerged media, aerobic and anoxic zones, and recirculation. [v] Some design parameters have been previously discussed; others are noted below.

Synthetic Media

Synthetic media specific surface, packing ratio, and chamber detention times are provided in Table 3. All values are within the range of values documented as successful for other synthetic media. Synthetic media recommendations are typically provided as a range. Manufacturers and engineers anticipate adjustment of application and recirculation ratios based on actual flow and loading regimes. Fuji Clean units are similarly designed, so recirculation rates and aeration can be set based on the actual performance of the system.

Sedimentation and Recirculation

The detention time for Sedimentation and Aerobic Sedimentation chambers are reasonable. Fuji Clean engineers have indicated but do not generally publicize that their design allows for sludge digestion, which eliminates solids, including TSS (total suspended solids). Moreover, flow paths through synthetic media facilitate capture and retention of TSS. The result is that CEN-unit effluent has fewer TSS than other systems relying on gravity sedimentation.

The Aerobic Sedimentation Gravity Chamber also controls dissolved oxygen (DO) concentrations to facilitate influent denitrification. It has been observed that the DO level within the Aerobic Contact Filtration Chamber will be near saturation but falls within the range of 2 mg/L in the Disinfection Chamber. This drop is a result of residual BOD removal that occurs within the Aerobic Sedimentation Chamber. This phenomenon has two effects. First, BOD is reduced further before treated wastewater is discharged.

Second, recirculated wastewater will lack sufficient oxygen to maintain aerobic conditions within the Sedimentation chamber. Aerobic conditions would inhibit denitrification, so low DO in recirculated wastewater is essential to denitrification.

Recirculated wastewater also mitigates the effects of slug doses of cleaning products, medicines, or other substances that inhibit wastewater treatment unless the substances are diluted. Influent is constantly mixed with recirculated wastewater to dilute, to the extent possible, any potentially harmful concentrations of substances.

NSF Results

The Fuji Clean CEN-Series is certified under NSF/ANSI Standard 40/245. The technology report confirms the general design theory presented here. A Fuji Clean CEN5 was documented to produce effluent having a 30-day mean effluent of 9, 10, and 10 mg/L, respectively, for CBOD, TSS, and TN. The effluent TN average represents a 74 percent reduction from the influent TN. A second report confirms that the CEN5, when coupled with a Salcor 3G ultraviolet light disinfection device, can produce a fecal coliform effluent having a geometric mean of 70 cfu/100 mL.

DESIGN INFORMAITON

Residential and Commercial Use

The Fuji Clean CEN-Series is designed without additional tankage for typical residential installations. Table 4 specifies the appropriate model based on the number of bedrooms. Figure 6 illustrates a typical residential installation.

TABLE 4—CEN-SERIES SELECTION FOR RESIDENTIAL OCCUPANCY @ 115 GPD/BR		
CEN-SERIES UNIT	**BEDROOMS**	**DESIGN FLOW (GPD)**
CEN5	1	115
CEN5	2	230
CEN5	3	345
CEN5	4	460
CEN7	5	575
CEN7	6	690
CEN10	7	805
CEN10	8	920
CEN 14	9	1,035
CEN14	10	1,150
CEN14	11	1,265

In a typical residential installation, wastewater flows directly to the Fuji Clean unit. Upstream tankage is not allowed per RIDEM. Designers anticipating unusual flow regimes and/or wastewater characteristics should contact FujiClean for assistance with the design. RIDEM will allow upsized FujiClean models for increased sludge storage capacity.

Maximum cover over tank is 24-inches riser height. Air line may be either ¾" or 1" conduit or flexible pipe. Air line should be less than 100-ft and have fewer than 5 "elbows." If site conditions will not allow, please contact manufacturer for blower upsize calculation. Please refer to Fuji Clean Installation Manual.

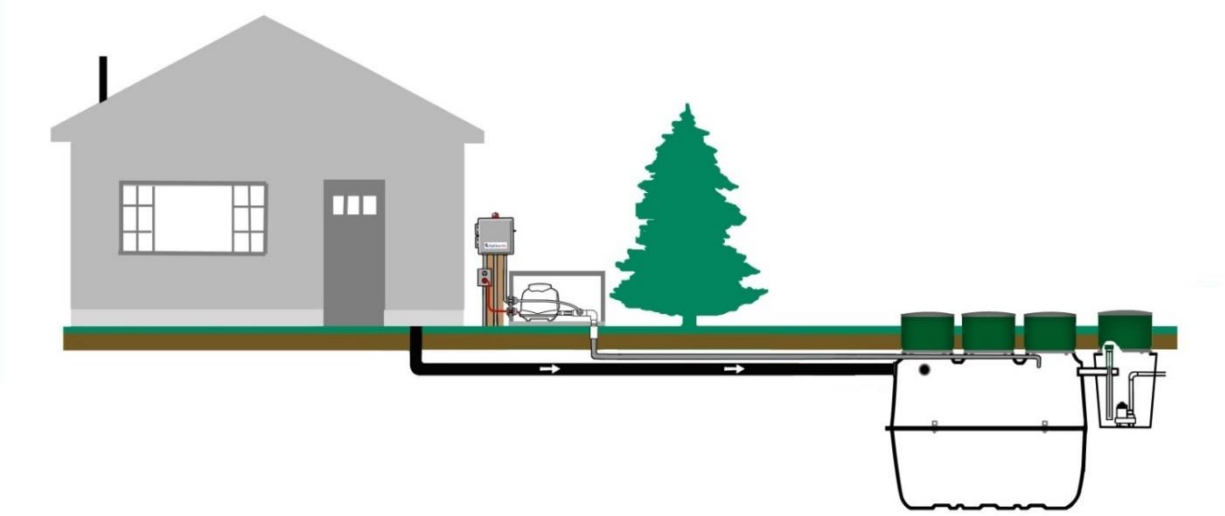


Figure 7—Typical Residential Installation

Commercial Use

FujiClean technology is RIDEM permitted for some commercial applications if the proposed sources of wastewater are equivalent to residential strength. FujiClean USA must review and approve all commercial designs.

Uplift Restraint

Uplift restraint—often called "anti-floatation"—is required for installations where high groundwater is a consideration. Fuji Clean has developed alternative uplift restraint methods, including collars, blocks, and pads. Shown in Figure 7 is one alternative that Fuji Clean recommends.

Uplift restraint should be considered on a case-by-case basis. Please feel free to contact Fuji Clean to discuss unique uplift restraint methods to address site specific issues. Also, please note that the values provided in Table 5 do not include factors of safety. The designer should calculate and specify the specific uplift restraint required to address a specific site.

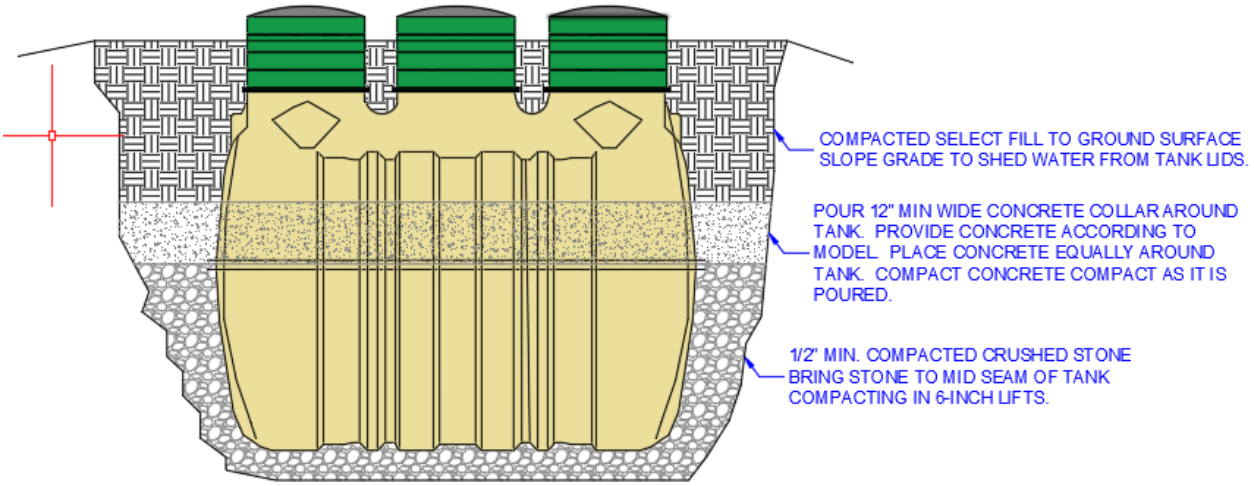


Figure 8—Uplift Restraint Using Concrete Collar Above Mid-Seam

TABLE 5--UPLIFT RESTRAINT FOR CEN-SERIES MODELS							
MODEL	**TOTAL VOLUME (GAL)**	**TANK WEIGHT (LBS)**	**WATER WEIGHT (LB/GAL)**	**EMPTY WEIGHT BUOUNCY (LBS)**	**25% SAFETY FACTOR (LBS)**	**TOTAL UPLIFT RESTRAINT (LBS)**	**CONCRETE REQ'D @ 3,800 LB/CY (CY)**
CEN5	749	463	8.34	5,784	1,446	7,230	2
CEN7	1,069	705	8.34	8,210	2,053	10,263	3
CEN10	1,498	926	8.34	11,567	2,892	14,459	4
CEN14	2,252	1,168	8.34	20,128	5,032	25,160	7

H-20

For Rhode Island sites that require a H-20 loading design, FujiClean USA offers options. Please contact FujiClean USA for details. All Rhode Island designs that incorporate H-20 loading require review and certification from a Rhode Island licensed Professional Engineer.

Surge Capacity

As noted previously, the CEN-Series models operate between two conditions: a Low Water Level (LWL) and a High Water Level (HWL). Should the water level fall below the LWL, effluent will not flow because the water level will be too low for the effluent air-lift pump to operate. During normal operation, the air lift pump operates at an approximate flow of 4.5 gpm. Thus, each CEN-Series model has a surge capacity to process high flow events.

The surge volume varies with each model. Table 6 provides the surge volume for each model.

TABLE 6 — SURGE VOLUME BY MODEL	
MODEL	**SURGE VOLUME (GAL)**
CEN5	28
CEN7	33
CEN10	49
CEN14	85

Cold Weather Installation

Fuji Clean CEN-Series units will benefit from insulation. Fuji Clean recommends insulated risers and covers as well as foam board or insulating material (minimum R-8 value) over the upper half of the treatment tank. The Fuji Clean Operation and Maintenance Manual provides details on how to insulate tanks.

Seasonal Use

Fuji Clean CEN-Series units are designed to accommodate seasonal site and "vacation home" applications. For short-term no-flow applications (i.e. no flow for < 30 days), the blower should not be shut off. For long-term no-flow applications (i.e. no flow for ≥30 days), Fuji Clean recommends the blower be turned off. Ideally, the blower should be re-started approximately 1-week before flow commences. Assuming subsurface installation per the Fuji Clean Installation Manual, the system should remain full of process water during shut down. There is no need to pump out the contents due to inactivity.

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[i] Tchobanoglous, G. *Wastewater Engineering: Treatment and Reuse*, Fourth Edition. New York: McGraw Hill. See Chapter 9, for a further discussion of combined process design.

[ii] Tchobanoglous, Page 616-623.

[iii] Tchobanoglous, Page 405.

[iv] Tchobanoglous, Page 952-971 discuss various IFAS considerations and process variations.

[v] The words "anoxic" and "anaerobic" are used interchangeably though they mean different conditions. "Anoxic" is the correct term to describe conditions facilitating denitrification. "Anaerobic" is the term used in this document because it is the term the Japanese use to describe the compartments. Laypersons and non-native speakers often use the term "anaerobic" to distinguish when air is supplied to the treatment tank—"aerobic."