Stony Brook University

New York State
Center for Clean Water Technology

Engineering Report:
Woodchip Box Polishing Units

NYS Center for Clean Water Technology (NYS CCWT)

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ACCEPTED BY THE SUFFOLK COUNTY DEPARTMENT OF HEALTH SERVICES (DEPARTMENT) BASED ON INFORMATION PROVIDED BY VENDOR.

The Department has reviewed this submittal for completeness and is hereby approved for use in Suffolk County. This approval is solely for the model(s), units(s) and/or structure(s) included in the engineering report provided by the technology Vendor. Any changes or modifications to the approved design must be submitted for review and approval by the Department prior to its use in Suffolk County. The Department is not responsible for any errors, omissions, failures, construction defects or installation errors that may occur due to design professional, manufacturer, distributor or installer oversight or negligence.

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This report is intended for use by Professional Engineers to design woodchip box polishing units to remove residual nitrate/nitrate (NO_x^-) from the final effluent of certain Innovative and Alternative Onsite Wastewater Treatment Systems (I/A OWTS) technologies permitted under provisionally accepted or general use by Suffolk County (SC) Article 19. The design specifications and installation and maintenance advice described here was developed by the NYS Center for Clean Water Technology ('NYS CCWT') based on reviews of published engineering and scholarly articles, New York State (NYS) and SC standards, its own research experiments and discussions with professionals involved with septic designs and installations. The document is subject to further revision based on ongoing research and the results of NYS CCWT experiments.

Coupled with I/A OWTS approved by SC Department of Health Services (SC DHS) which generate effluent with residual NO_x^-, single-pass woodchip box polishing units can achieve incremental NO_x^- reduction thereby effectively lowering total nitrogen (TN) introduced by I/A OWTS into groundwater. Testing of demonstration models of coupled systems at two sites in East Hampton has shown substantial removal of residual NO_x^- and consequently of TN in I/A OWTS effluent (Fig. 1). Results from a larger dataset of woodchip boxes (n= 8) coupled to nitrifying sand beds installed in Suffolk County show woodchip boxes capable of removing > 80% of woodchip box influent nitrate (NYS CCWT) over multi-year periods.

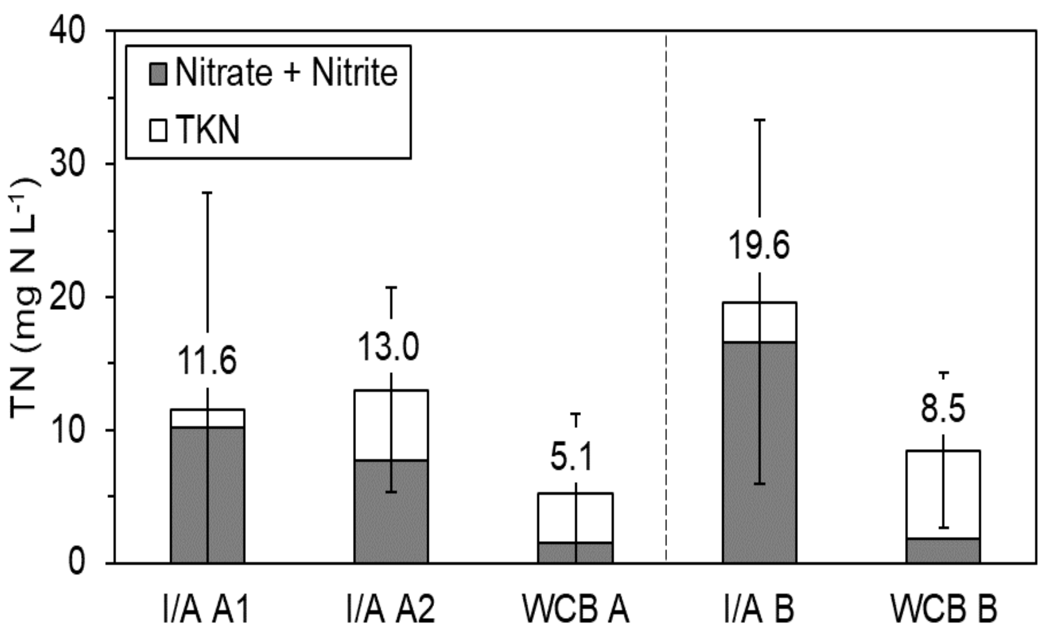


Fig. 1. Results of testing of demonstration project coupling woodchip box polishing units to I/A OWTS at two sites located in the Georgica Pond watershed in East Hampton.

Based on data obtained from SC DHS by NYS CCWT, I/A OWTS systems which generate residual nitrate in final effluent and are approved for provisional acceptance or general use in SC include Fuji CEN and Hydro-Action AN series, Orenco AX-20, SeptiTech STAAR and Norweco Hydro-Kinetic. Together with other I/A OWTS previously approved and installed (but not currently permitted) under Article 19 which produce effluent containing NO_x^-, these systems may be coupled with woodchip box polishing units to lower TN loading to the environment.

1) A brief description of the technology proposed

The polishing units described herein are single pass woodchip biofilters housed in either precast concrete or off-the-shelf plastic tanks typically installed below grade and coupled to various I/A OWTS technologies which produce residual NO_x^- in final effluent. Tanks should be filled with woodchips from local sources of oak, pine or cherry/maple. Microbial respiration in the tank provides anoxic conditions which together with carbon from the woodchips promotes denitrification of residual NO_x^-.

2) Design drawings depicting the size of the unit(s) at the rated design flow rate(s) and process flow diagram (where applicable).

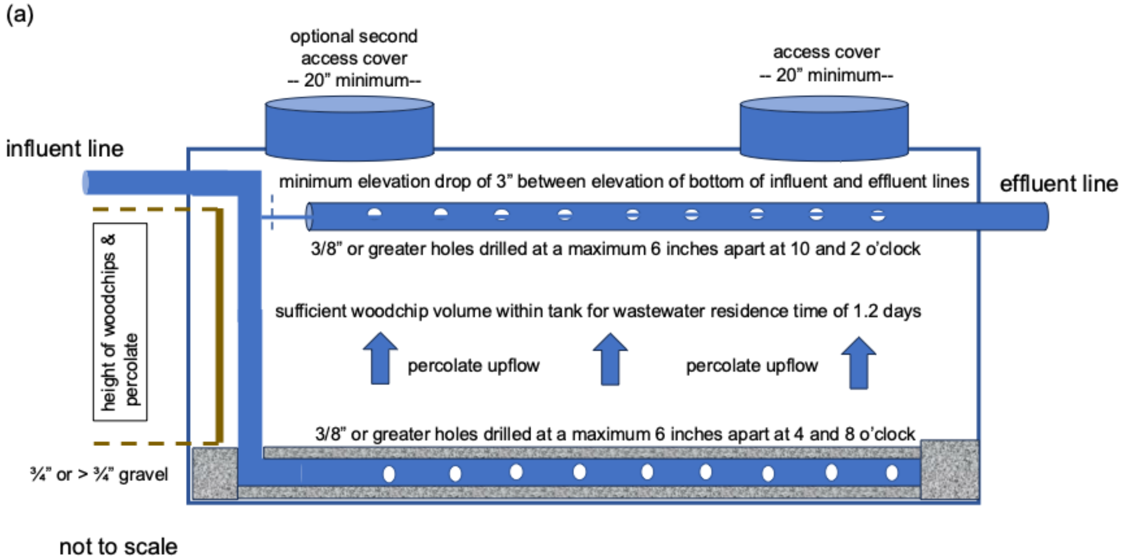
While tank size, volume of woodchips, configuration and materials are site specific, Figure 1 (a) & (b) below illustrates relevant design features common to all tanks housing woodchip biofilters referred to as a woodchip box polishing units. All flow in woodchip boxes must percolate upwards from an influent pipe at the bottom of the tank. The drop in elevation between the influent and effluent lines should be a minimum of 3”. The box should be accessible by at least one covered entrance at least 20” in diameter.

All tanks used for woodchip box polishing units shall have previous SC DHS approval and shall be rated for the applicable structural load; manhole covers must meet minimum SC DHS requirements. Any plans including alternate tanks would need to be accompanied by structural calculations. All tanks should be either precast concrete or plastic monolithic tanks either in a cylindrical or rectangular form. All piping used in plumbing the box should be a minimum of 4” Ø SCH 40 PVC. Following the vertical pipe, perforated pipe (influent line) should run the entire length (or diameter) of the bottom of the tank (Fig. 1(a)). It should be drilled with minimum of two 3/8th inch holes every 6 inches at the 4 and 8 o’clock positions. Alternately, the bottom influent pipe may have ~ 1/8” slits on alternating sides every three inches or less from roughly 7 to 11 o’clock and from 1 – 5 o’ clock. This influent line should be laid on and then covered with 3/4 inch or larger gravel. The effluent line in Fig. 1 (a) below shows a perforated pipe which extends across the length or diameter of the tank on the top of the woodchips and drilled across its length w/ minimum 3/8th inch holes every 6 inches at the 10 and 2 o’clock positions. Alternately, the vertical influent pipe may connect to a perforated pipe (influent line) running across the width at the bottom of the tank (Fig. 1 (b)). In this configuration a vertical ‘drop-T’ with a plastic 1/8th inch mesh screen which extends several inches into the woodchip volume could be used as the effluent line. The bulkhead fitting at the outlet end of effluent pipe must be watertight. Effluent from woodchip box polishing units should be directed to a final leaching structure.

A checklist of design specifications is appended (Appendix A).

Woodchip box design schematic

(a)



(b)

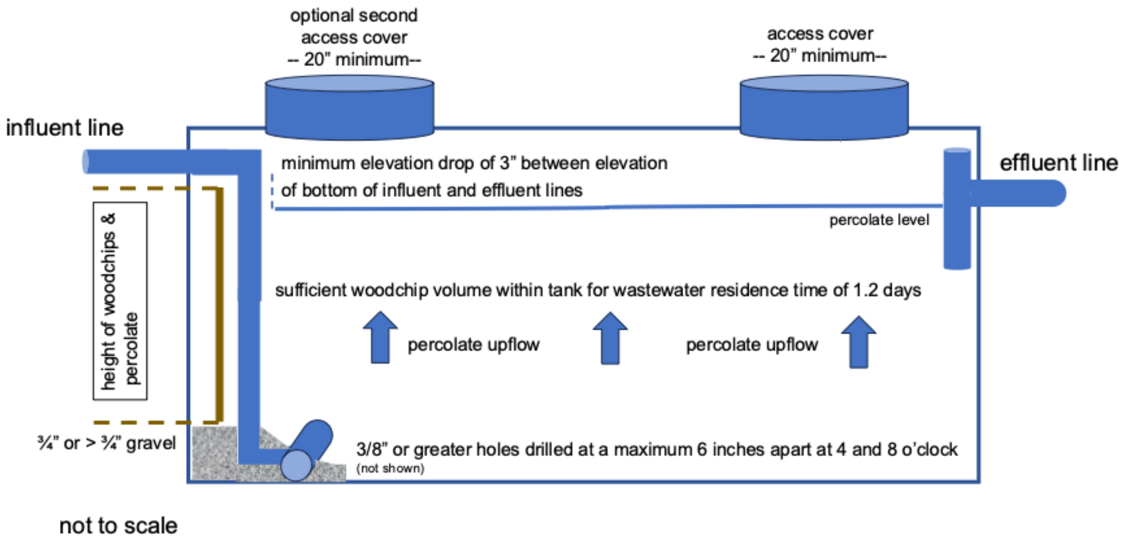


Fig. 2. Woodchip box design schematics. (Woodchips not indicated for clarity of illustration). (a) Box w/ influent pipe crossing length of tank; (b) box w/ influent pipe crossing width of tank.

3) Treatment specific design calculations such as hydraulic loading rate, residence time, and treatment kinetics. The expected influent waste strength and effluent goal should also be included.

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Design Calculations. Tank size is determined by the volume of woodchips required to denitrify influent nitrate. Required woodchip volume depends on targeted design flow and residence time of IA effluent in the woodchip tank as well as woodchip porosity.

woodchip volume required =
*Design Flow (G/d) * Residence Time (d) ÷ woodchip porosity*

Longer residence time of IA effluent in woodchip boxes enhances removal of residual NO_x^-. In testing at its Wastewater Research and Innovation Facility, NYS CCWT found woodchip biofilters consisting of local oak or pine with residence times of greater than or equal to 1.2 days denitrifed > 95% of nitrate in a 20 mg-N L^{-1} nitrate solution compared to similar biofilters with residence times of less than 1 day which denitrify < 80% of nitrate in the solution. Tanks used for woodchip box polishing units should consequently have a minimum residence time of 1.2 days or greater. Porosity of fully saturated woodchips from local Long Island species including oak, cherry and pine measured by the NYS CCWT have porosities ~ 0.5 (± 0.08). Based on these values, a four bedroom house would require a minimum woodchip volume of over 1,056 G using woodchips with a porosity of 0.5 as illustrated by the calculation below:

*woodchip volume required = 440 (G/d) * 1.2 d ÷ 0.5 = 1,056* G

Consequently, a 1,100 gallon or standard size 1,250 gallon tank would be an appropriate sized tank for woodchips. If alternate parameter values are used to calculate the size of the woodchip tank, the reasons for the choice of these values should be explained on the design drawings.

The woodchip box polishing unit is intended only to treat NO_x^- and not other forms of nitrogen or other wastewater constituents.

4) Hydraulic design calculations which identify minimum pressure head required to ensure there is no adverse impact on the hydraulic performance of the I/A OWTS system (i.e. invert differential between I/A OWTS outlet and polishing unit inlet, pump curve/requirements, etc.). Any min/max conditions identified through the calculations should be represented in the design detail drawing.

Hydraulic design calculations (minimum head pressure). Hydraulic loading rates are determined by the rate of IA effluent generated by the IA OWTS. Flow is by gravity unless otherwise specified on design drawings by design professional with relevant pump curve requirements. If the IA OWTS has a discharge pump (e.g., Septitech STAAR), then an intermediate reservoir (d-box) should be inserted between the IA and the woodchip box so effluent pumped from the IA will flow by gravity from the reservoir to the woodchip box. Alternately, a pressured effluent pipe from an IA (1 ¼” diameter) could be coupled to a length of 4” gravity pipe sufficient to prevent back-pressure from the woodchip box to the discharge pump (specifications must be indicated on design plans).

To identify a minimum head pressures required to ensure continuous hydraulic performance in a worst case, high flow scenario, Darcy’s Law calculations are illustrated below for two different tank configurations: (a) one based on plastic, cuboid tank with a greater surface area and shorter depth than (b) a second based on a precast cylindrical tank with narrow diameter and substantial height. Each tank is sized for a 4 bedroom house and each has roughly equivalent volume for a woodchip biofilter. In each case, the minimum head is calculated at a high flow volume of 0.0068 $f^3 s^{-1}$ or 183 G hr^{-1} representing 42% of daily design flow for a 4 bedroom house in a single dose. Minimum head pressure to maintain flow through the woodchip biofilter is- in part- a function of saturated woodchip hydraulic conductivity (K*sat*). There are no national standards recommended for woodchip design values but a review article by Johnson et al. 2022 *Ecol. Eng.* reports K*sat* values from 1- 10 cm s^{-1}. To illustrate minimum pressure head required in worst case scenarios, Table 1 below assumes minimum hydraulic conductivity (requiring maximum hydraulic head) of an equivalent value of 1 cm s^{-1}. For perspective, a model by the Illinois Natural Resource Conservation Service uses a K*sat* value of 2.94 cm s^{-1}.

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h= (Q * L)/(k * A)

where
h = minimum head required to facilitate flow (f)
L = length of tank (f)
Q = ($f^3 s^{-1}$)
A = surface area of tank (f^2)
k = hydraulic conductivity of saturated, settled woodchips (cm s^{-1})/ 30.48 (f cm^{-1}).

Even though minimum head calculations in Table 1 reflect conservative assumptions about hydraulic conductivity of woodchips and hydraulic loading, required hydraulic head is low. Allowing for 1.5 safety multiple, required hydraulic head is less than 1.25 inches. Hydraulic head within the woodchip box itself reflects a required difference of 3 inches between the inlet and effluent outlet.

Table 1. Parameters for minimum hydraulic head requirements

	symbol	units	Roth 1,000 G RMT	Precast cylinder
Flow	Q	$f^3 s^{-1}$	0.0068	0.0068
Effective tank height	L	f	3.5	7**
Surface area of tank	A	f^2	50.8	21
Hydraulic conductivity*	K(*sat)*	f s^{-1}	0.033	0.033
Capacity for woodchip biofilter		G	1,147	1,100
Minimum head	h	f	0.01	0.07
Minimum head	h	inches	0.2	0.8

*for saturated, settled woodchips
** use 2 4’ precast rings

Woodchips may settle as they age lowering permeability and published estimates of hydraulic conductivity from lab-based experiments are generally lower for aged, compacted woodchips than for fresh woodchips (e.g., Johnson et al. 2022 *Ecol. Eng.*). The hydraulic conductivity coefficient used in the above table allows for compression as woodchips age.

5) Materials of construction and source of any imported material proposed (e.g., woodchips, etc.). A safety data sheet ("SDS") must be provided for any material of construction that has not been previously approved by the Office of Wastewater Management (e.g., precast concrete, fiberglass, polyethylene, etc.).

Materials of construction. Tank materials consist of precast concrete structures (e.g., modified septic tanks; grease traps, manholes, etc.) previously approved by SCDHS or plastic tanks. All tanks, manholes (including chimneys, and sewage pipe shall conform to the STANDARDS FOR APPROVAL OF PLANS AND CONSTRUCTION FOR SEWAGE DISPOSAL SYSTEMS FOR OTHER THAN SINGLE-FAMILY RESIDENCES or the STANDARDS FOR APPROVAL OF PLANS AND CONSTRUCTION FOR SEWAGE DISPOSAL SYSTEMS FOR SINGLE-FAMILY RESIDENCES, depending on the site use.

Woodchips shall be primarily 3/8th to 2 1/2" oak, cherry/maple or pine and shall be free from leaves, small particles or debris. While it is not required to screen woodchips, cleaner woodchips can be produced if they are produced from large logs cut from the base of the tree or large limbs rather than from small branches. Woodchip available from local landscaping companies should be used in preference to commercial woodchips shipped from outside Suffolk County. Photos of both woodchips appropriate for woodchip box polishing units and mulch-like woodchips not appropriate for woodchip box polishing units are shown in Appendix II.

The design professional shall certify that the wood chips used are virgin material which has not been treated with creosote, chromated copper arsenate (CCA) or pentachlorophenol. The certification statement shall read "*To the best of the design professional's knowledge and belief, the woodchips material being used is Certified Clean and not contaminated pursuant to any applicable standards*." The Certification of Constructed Works shall identify the steps taken to validate conformance with this requirement. If the woodchips are obtained from a larger processing facility, the name and location of the processing facility shall be provided.

6) A description of maintenance activities needed to sustain the treatment performance of the system and prevent clogging/hydraulic failure shall be provided along with a maintenance schedule/frequency.

Maintenance. O&M for woodchip boxes should be carried out according to SC Article 19 and at the same time as the I/A OWTS is serviced. Maintenance involves removing tank cover and inspecting the tank to ensure the percolate height is at the elevation of the effluent line. If the percolate level is above or below the elevation of the effluent line further inspection will be necessary to determine whether the effluent line is blocked, or a leak has occurred and whether a repair is required. Maintenance of the woodchip box must be clearly identified on the O&M contract for the I/A OWTS, on file with the Department.

Tanks should be filled with woodchips to the same elevation as the effluent line from the woodchip box. Saturated woodchips settle as they age. Over multiple years, consolidation of woodchips could y lead to 'short-circuiting' of upward percolation evenly through-out the woodchip volume into preferential channels or along sidewalls and pooling on the top of the biofilter. Such flow if it occurred would reduce residence time nitrified I/A effluent would be exposed to woodchip carbon and lead to suboptimal denitrification. Maintenance providers should monitor pooling over the woodchips and report levels > 3". If subsidence is associated w/ declining rates of nitrate removal, consider adding woodchips to the tank or remove and replace the old material using a vacuum truck and then refill the tank with fresh woodchips. NYS

CCWT has not found any evidence ‘short-circuiting’ occurs in either precast or plastic woodchip tanks even in its oldest installations which have been in use from 5- 8 years.

7) A description of construction/installation requirements and methodology.

Installation. Installation should conform to the applicable installation standards for tanks in Suffolk County’s STANDARDS FOR APPROVAL OF PLANS AND CONSTRUCTION FOR SEWAGE DISPOSAL SYSTEMS FOR OTHER THAN SINGLE-FAMILY RESIDENCES or in its STANDARDS FOR APPROVAL OF PLANS AND CONSTRUCTION FOR SEWAGE DISPOSAL SYSTEMS FOR SINGLE-FAMILY RESIDENCES depending on the site use.

Tanks can be pre-plumbed off site and connected to the effluent line from the IA OWTS or plumbed onsite. Depending on depth to minimum groundwater at the site, concrete footings may be installed in the tank as necessary. After plumbing and connection to the IA effluent line, the tank may be filled with woodchips. The tank should be leak tested with clean water prior to opening the effluent line to the tank. Once leak tested, the tank cover can be placed and, subject to SC DHS inspection and approval, the excavation backfilled.

All designs should include a two-way valve connected to a by-pass valve to allow flow to be directed to final disposal (e.g., leaching ring, leaching galleys) circumventing the woodchip polishing unit.

8) Provide a description of polishing unit influent pretreatment requirements, if any (e.g., maximum TSS concentration, BOD concentration, etc.).

The woodchip box polishing units shall only be used downstream of IAdvanced OWTS approved under SC Article 19 for provisional and general use thereby producing effluent with total nitrogen < 19 mg- N L^{-1} and meeting NYS Category 1 or 2 standards for BOD5 (biological oxygen demand) and TSS (total suspended solids) of < 20 mg L^{-1} or 30 mg L^{-1} for each constituent.

9) Procedures and locations for collecting effluent wastewater samples from the polishing unit, including sample port design if necessary.

Sampling. Woodchip box effluent should be sampled at the same site visit as I/A effluent is sampled. A sampling port (e.g. PVC connected to a sump or equivalent) must be provided on the design drawings located on the IA OWTS effluent line upstream of the woodchip box. Effluent from the woodchip box can generally be sampled in a d-box upstream of leaching pools or galleys. In the absence of a d-box, woodchip box effluent can be sampled from the top levels of the woodchip box prior to the effluent pipe. Samples should be analyzed for ammonium (NH4+), nitrate/nitrite (NOx) and Total Kjeldahl Nitrogen (TKN) by a laboratory certified by the NYS Department of Health Environmental Laboratory Approval Program (ELAP).

Appendix A. Woodchip box polishing units. Design & installation checklist		check
Minimum drop in elevation between influent inlet and effluent outlet	3”	
Minimum size of access cover to woodchip box	20”	
tanks	monolithic precast concrete or plastic tanks previously approved by SC DHS	
Manhole covers	previously approved by SC DHS	
Influent pipe	Either lengthwise (a) or across the width of the tank(b) , minimum 4” Ø SCH 40 PVC w/ minimum 3/8” holes drilled every 6’ at 4 and 8 o’clock positions. Alternately, pipe may be cut with ~1/8” slits on each side (~ 7- 11 o’clock and 1-5 o’clock) every 3” on alternating sides along its length.	
Effluent pipe	minimum 4” Ø SCH 40 PVC w/ minimum 3/8” holes drilled every 6” at 10 and 2 o’clock positions across lengthwise pipe (a) or a 4” Ø ‘drop-T’ with a metals/plastic 1/8th inch screen (b)	
Effluent pipe	bulkhead fitting water tight	
Minimum Woodchip volume required	1.2 day residence time and 0.5 porosity unless alternate design calculation and parameters justified by design professional on submitted drawings	
Woodchip type & size	primarily 3/8th to 2 1/2” woodchips from oak, cherry/maple or pine; local source preferred	
woodchip source	signed certification woodchips are from virgin wood and free from creosote, chromated copper arsenate or PCPs	
by-pass valve	two way valve capable of redirecting flow from woodchip box to final disposal structures (leaching ring or galleys)	

Appendix B. Photos of (a) suitable and (b) unsuitable mulch-like woodchips which may lead to 'short-circuiting' of flow around woodchips.