Case Study on VSEP Treatment of Hog Manure in TRS

Written by John Lau 2020-10-08

Hog Farm in China

Tang Ren Shen (TRS) has a joint venture farm with Whiteshire Hamrock USA raising genetic pigs located at the outskirts of Zhuzhou city, Hunan Province, China. The barn is modern, environmental controlled, and biosecure for raising prized genetic pigs. Slats in the floors allow manure from pigs to be washed down to a collection basin where it stays for a period of time of up to three years depending on population. Hog manure is partially digested in this collection basin. As water level rises, excess liquid manure is discharged down the hillside to a biogas and facultative wastewater treatment plant (WWTP). Heavier solids drop to the bottom of the basin. After a couple of years sludge is dredged from basin bottom and disposed.

The original WWTP is anaerobic and aerobic processes consisting of several stages of collection, addition of lime, addition of chemicals, use of anaerobic digestion (generating biogas), and ponds with aerators. Sludge from pond bottoms are put through a press filter to separate out solids. Treated wastewater is discharged from the final pond to a stream further down the hill side. Process flow chart and site plan in Appendix A.

The WWTP did not always work to meet national livestock discharge criteria. Things became more serious after discharge limits were tightened years into the operation of the barn. There were incessant complaints from villagers living downstream about smell and colour of the stream. Villages downstream depend on stream water for their livelihoods. Water tests exposed discharges above limits. Conventional WWTP have difficulties in treating hog manure and POME because of the high contents of protein. It should be noted that barn effluent is not manure in original state. Effluent from collection basin is sent from top half of water body avoiding collection of heavy solids. This effluent is very liquid, brownish black in colour (see picture) with 2.2% total solids.

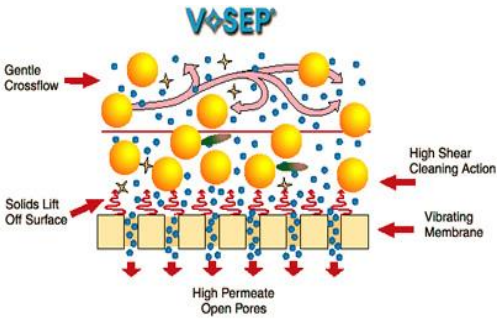
Some factors affect operations of conventional WWTP using bacteria or other biological methods. In winter farm surroundings drop to freezing temperatures. As temperatures drop to low tens, biological activity is much curtailed and completely drops near freezing. Evidence of halt in bacteria digestion is seen from frothing foam in the WWTP. Observers describe seeing the whole WWTP and surrounding areas covered with thick continuous blanket of foam. Summer has other problems. Rain swells the amount of water body causing early discharge before digestion is complete. Overflowing carries large volume of untreated wastewater all over the place.

TRS barn has a very high biosecurity to minimize infection of their prize pigs. Medication is used only when necessary. The same cannot be said of porker farms that raise pigs for food where excessive medication is applied to reduce losses due to death or health implications. Medication can impact the biology in a conventional WWTP. Over 50% of medication discharged with manure cannot be destroyed with conventional means. Although there is no limits imposed on pharmaceutical discharge from livestock farms it has consequential impacts on aquatic life and should be a point worth looking into.

VSEP introduced to TRS

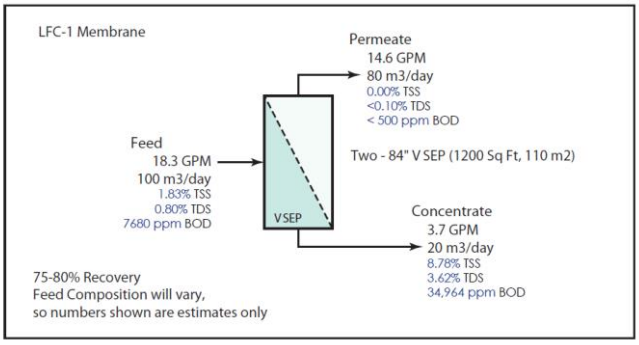
TRS is keen to improve on the situation and after considering various technologies decided on a VSEP system to not only meet but exceed environmental standards. Reverse osmosis membrane is used to remove contaminants of below nanometer sizes including bacteria, minerals, phosphates, sulfur compounds, and also applicable in removing discharged medications. Conventional RO membrane filters are not applicable as it would rapidly foul due to nature of hog manure. Frequent stopping to clean is high in cost and blinding of pores will reduce membrane life significantly. Membrane replacement is a significant cost element.

VSEP uses membrane filtration with addition of a vibration enhancement of liquid. High shear force on surface of the membrane causes dissolved solids, minerals, and bacteria or virus being kept away from the pores (see drawing). Water and smaller dissolved solids is allowed to pass through freely. Crystal and biofilm formation is kept away from the membrane surface too. This made operation time last ten times longer than conventional RO before backwash cleaning. Membrane pack in case of TRS is expected to last 3 years or more in TRS operation.



VSEP design and installation

After reviewing the contents of barn effluent from which years of data are available, New Logic Research proposed a VSEP system with a membrane selected for this purpose for a zero liquid discharge system. On the right is a schematic of the process through a VSEP filter unit. Clean drinkable water is returned to the barn.



The system involves a small mesh grit and solids screen before entering VSEP. Batch operation 20 hours per day to handle around 100 cu.m. effluent. A single unit model i84 VSEP with reverse osmosis (RO) membrane is used for separation of dissolved solids and filtering out 80% water. This filtrate is further filtered with a spiral RO (Fig.1) to polish water to drinkable standards. A UV-C disinfection system was suggested for TRS to disinfect the water should it be necessary. Proposed layout and schematic of VSEP plant is in Appendix B. It is noteworthy about the compact footprint of a VSEP plant sited inside original WWTP (figure 2 blue rectangle). The plant space requires 180 square metres with a ceiling clearance of at least 8 metres as VSEP i84 stands 6 metres tall.

Figure 1 Second stage spiral RO.

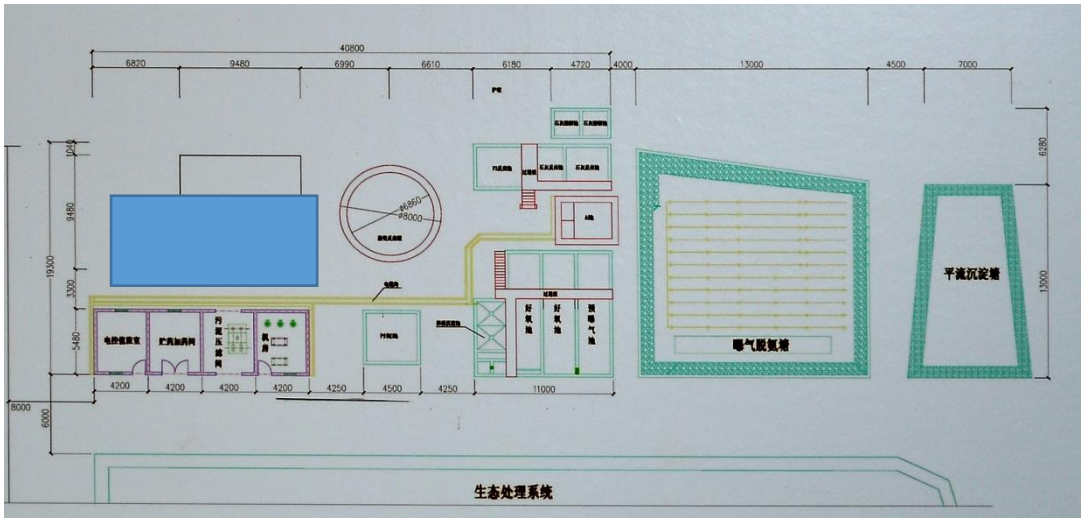


Figure 2VSEP plant (blue area) within original WWTP

Results

Due to its unique design VSEP need not go through multiple membrane filters that conventional RO filtration must have. VSEP accepts wastewater directly from a day tank with only a screen for removing large particles such as grit or sand. VSEP has much lower pressure drop than normal RO systems which resulted in a lower energy bill. Contents from TRS barn data consists of 2.2% solids (22,000 mg/L) of which total suspended solids is 7% and 10% are dissolved solids.

Two of the more difficult dissolved solids to remove in the case of hog manure are ammonia and phosphorus. The pair are also heavy pollutants. Ammonia is toxic and gives off strong malodour. Phosphorus spawns algal blooms then a collapse that devoid water body of oxygen strangling aquatic life. Successful removal offers a safe discharge into natural water bodies. The objective for TRS VSEP project is set higher with zero liquid discharge. This is accomplished with a second RO filter of standard spiral format to polish off remaining dissolved solids. Suspended solids are 100% filtered off in VSEP.

After commissioning, first test results were obtained on barn effluent and two stages of filtration. The results are shown in Appendix C. Below table is a summary. All units in mg/litre.

Dissolved solids	Influent	Clean water	NLR design	EPA Limit
Ammonia	886	0	43	80
Phosphorus	60.56	3.27	5.6	8
BOD	No data	No data	65	50
COD	1,250	0	116	400

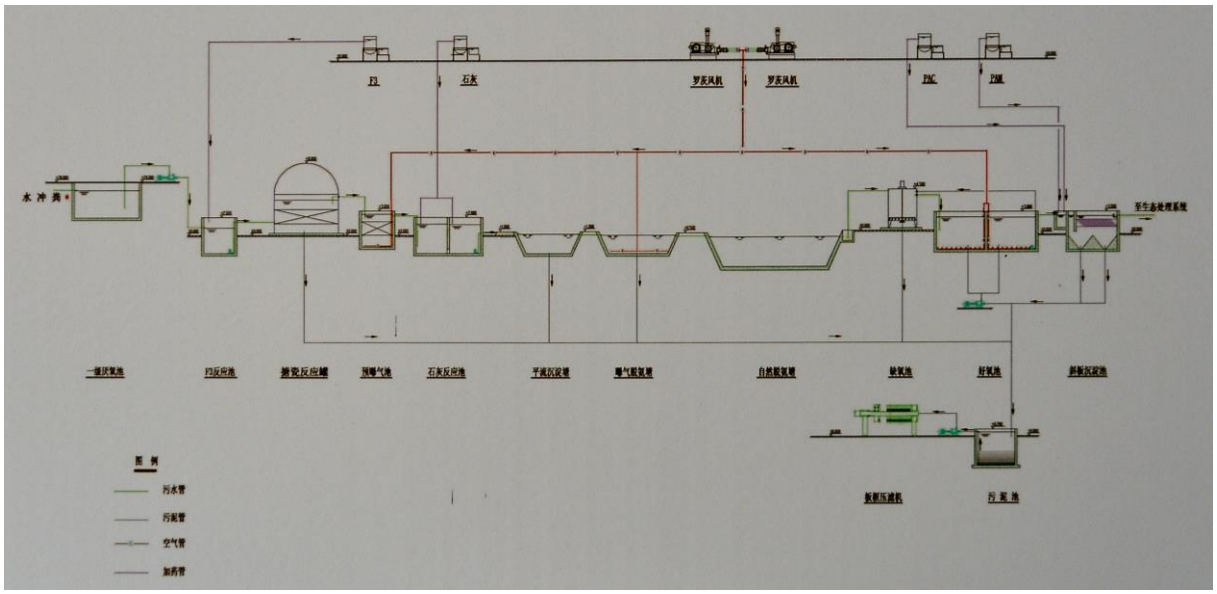
Total dry mass is removed from 0.29% (2,900 mg/L) down to 0.00 which means below detectable by laboratory. Brownish black wastewater becoming pure clean water in front of their eyes convince TRS staff that they drank the water after the trial run. Larger picture of dirty and clean water collected in bottles in Appendix C.

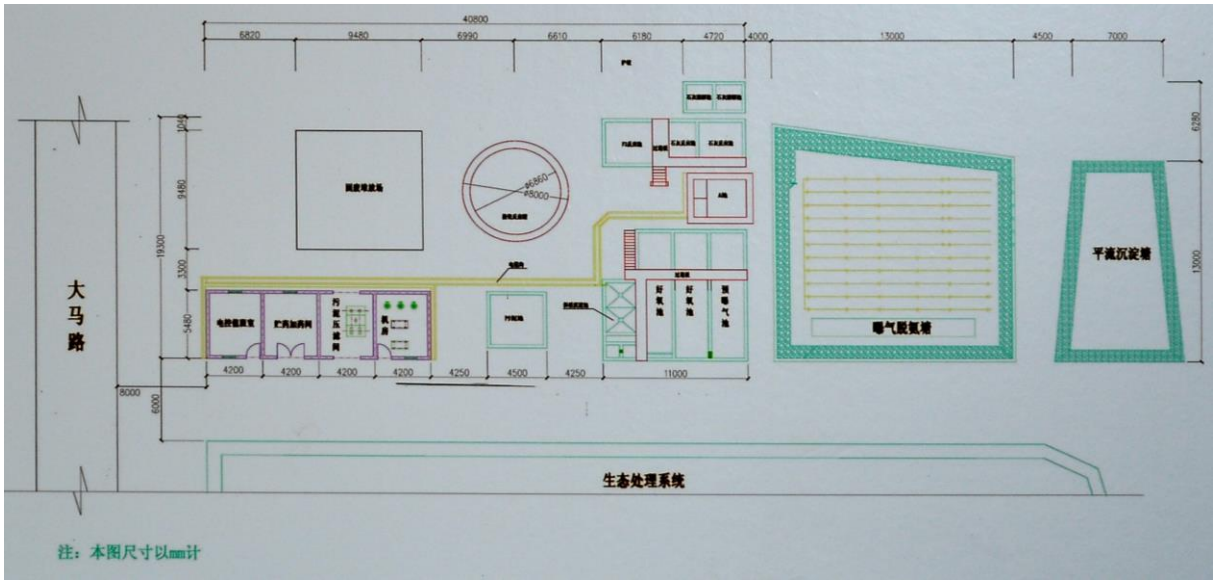
Energy bill was observed for the operation data came back as expected. A clean-in-place (CIP) system is put in place with NLR chemicals for cleaning VSEP membrane. A summary of operation cost is shown in Appendix D. Operation costs were in line with design estimations. It was reported to be around RMB16 per metric ton of wastewater. This includes electricity, cleaning chemicals consumed, and membrane amortization cost (breakdown in Appendix D).

NLR approach to wastewater treatment starts with analysis of contents, especially dissolved solids the most difficult to separate out from water or liquid. From hundreds of membranes available a suitable one is suggested for a particular treatment to realize objectives given. Filter efficiency on each type of dissolved solid dictates quantities that come out together with clean water. In order to meet discharge limits or drinkable water level, there may be need for one or several polishing membrane.

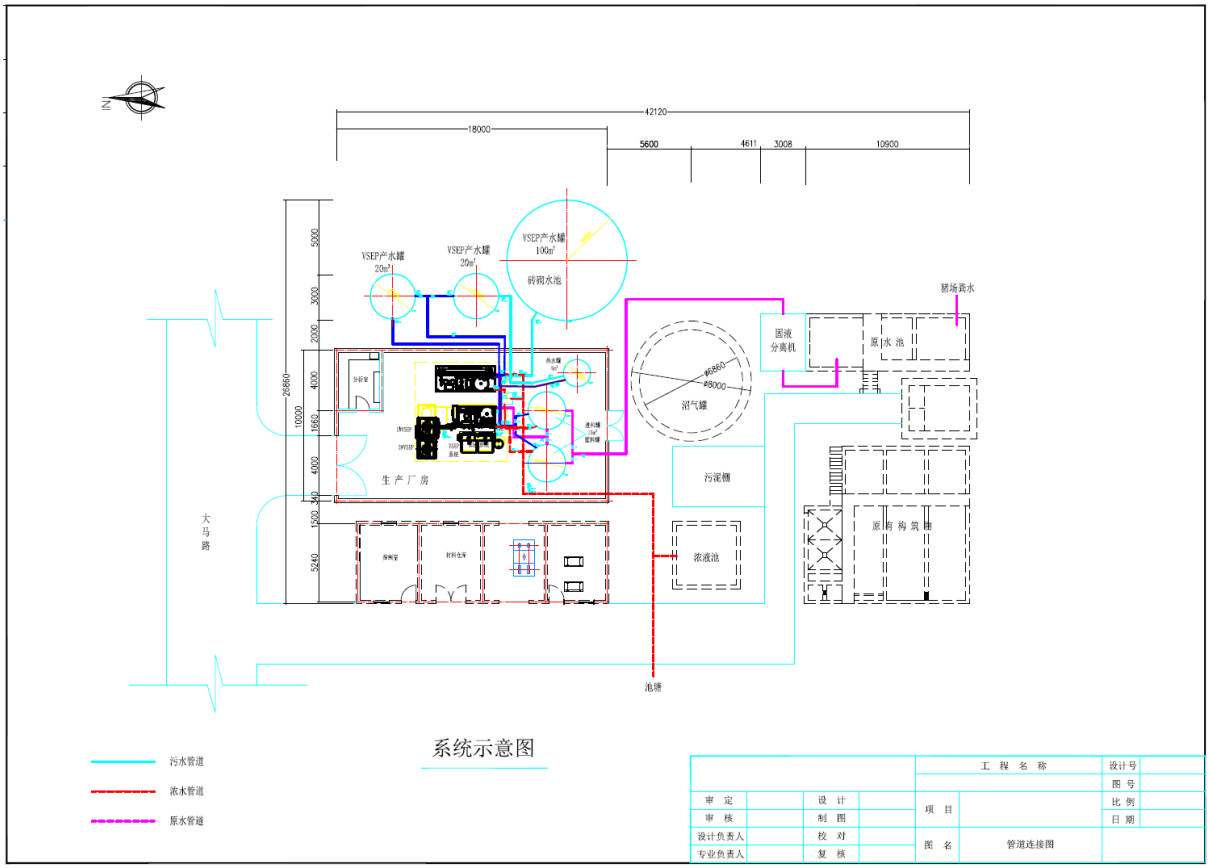
The TRS experience testify to the experience and scientific knowhow of NLR design engineers. The technology of high shear with vibration is not matched by other methods, especially in difficult to treat wastewater like hog manure. TRS staff attest to the results achieved something they had never witnessed before. For TRS barn no discharge, no complaints received.

Appendix A – Original WWTP at TRS

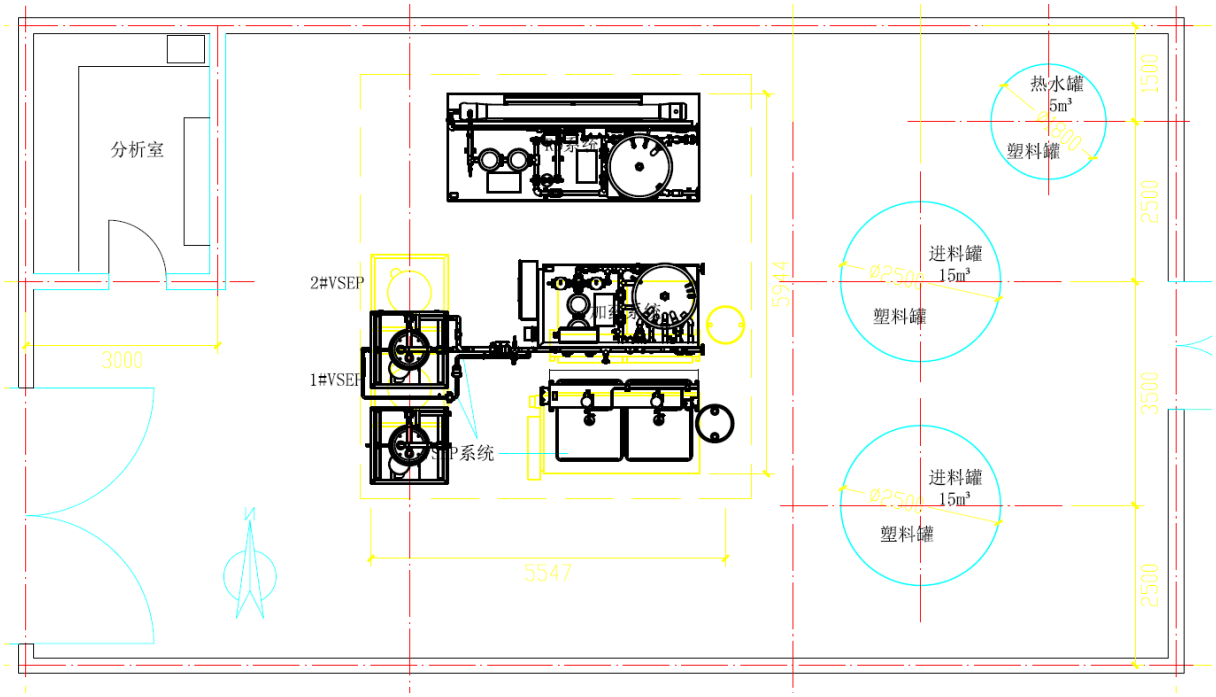




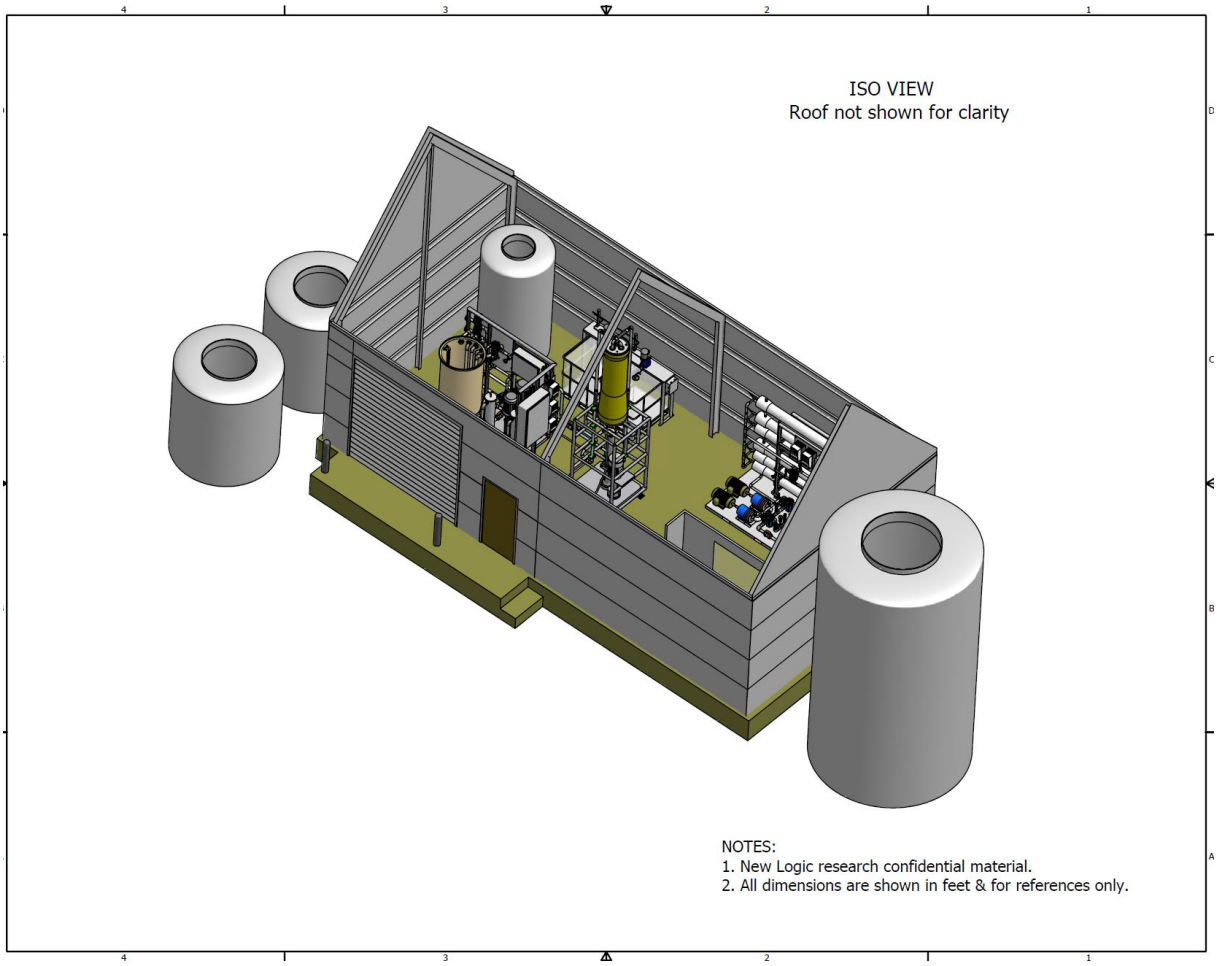
Appendix B – VSEP Design Plant Layout



Layout of VSEP plant within existing facilities.

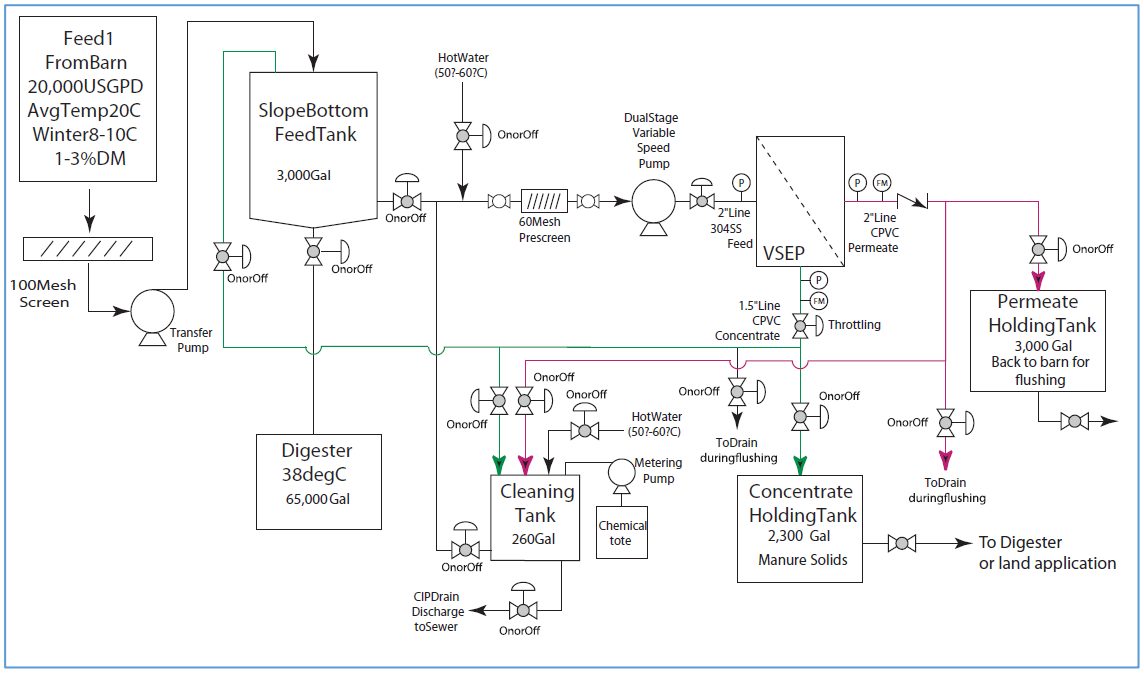


Blown up of VSEP plant.



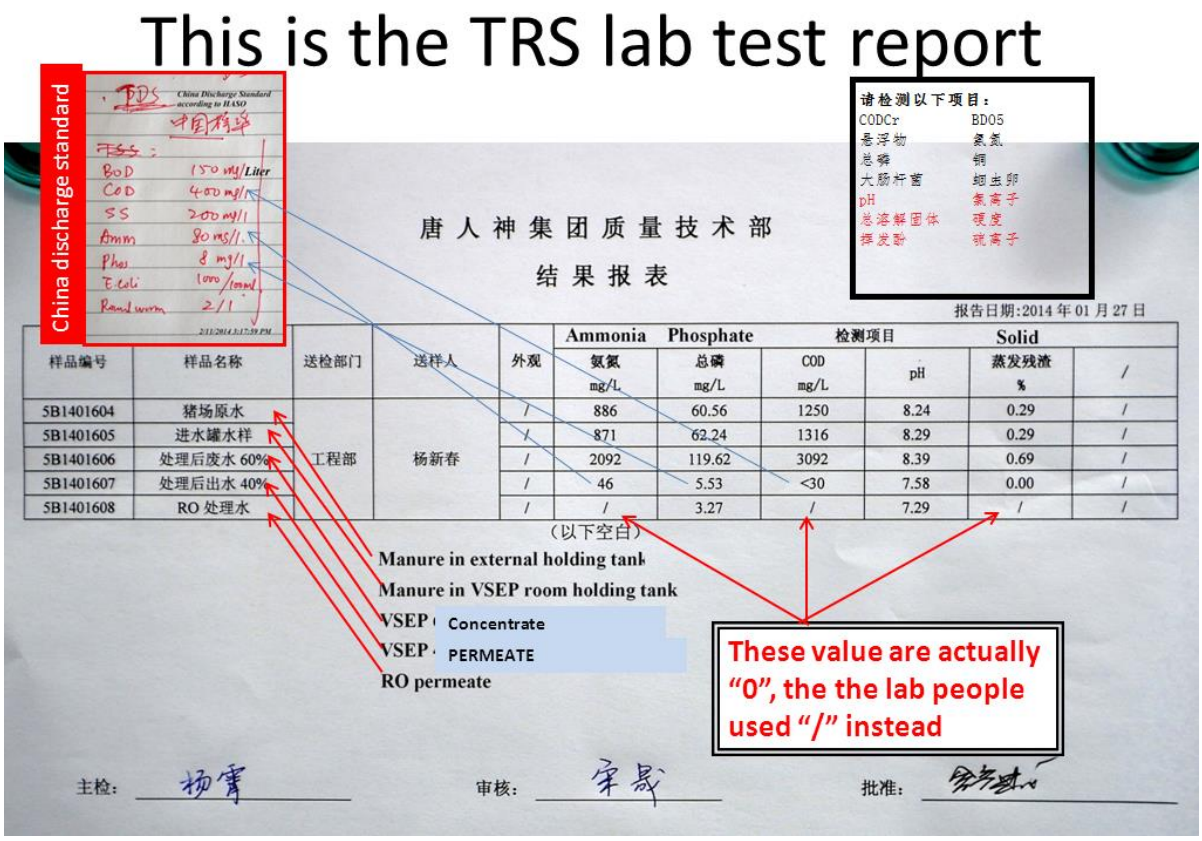
3D Schematic of VSEP plant.

Picture showing system installation and relative height of VSEP against staff at site.



Flow diagram of VSEP process including clean-in-place system.

Appendix C – Test Results of VSEP Filtration



Picture of water in each stage.

Appendix D – Operation Cost Summary

Operating Cost per m3 of wastewater (RMB)		
	VSEP	Spiral RO
Energy	2.64	0.28
Membranes	8.12	0.38
Cleaning chem	3.79	0.87
Sum per filter process	14.55	1.53

VSEP operation is fully automatic. Staff time is minimal each day on start-up of system and cleaning after end of operation. Staff cost is not entered into operation cost above. Electricity rate at location is RMB0.588/kWh.