

On-site Wastewater Management Training Course

Secondary Treatment

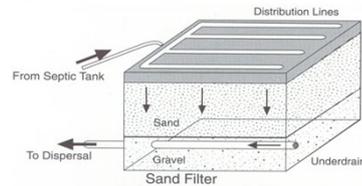
Sand Filters, Media Filters and Mound Systems

Centre for Environmental Training



Aerobic Sand Filters

- Historically gravity fed with demand dosing
- Can result in uneven distribution and may lead to creeping failure and clogging of media
- Primary (septic tank) pre-treatment required

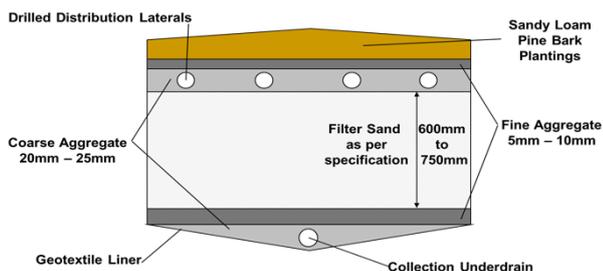


Source: NSFC

Centre for Environmental Training



Typical Form



Centre for Environmental Training



Typical ASF Installation

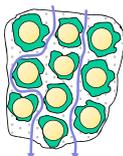
- Constructed within durable impermeable liner or container
- Installed above, partially above, or below ground
- Partial or full pressure distribution required
- Gravel (20-40mm washed aggregate) – used for underdrain and distribution bed
- Pea gravel (5-10mm) used for separation
- Filter surface may be open or covered – contact with atmosphere must be maintained

Centre for Environmental Training



Treatment Process

- 'Passive' aerobic treatment provided by trickling (primary) effluent through 600mm - 900mm of select sand (packed bed)
- Biofilm develops on media surfaces
- Biofilm in contact with air in media pore spaces
- Treatment acquired in a single pass through media
- Effectiveness dependent on hydraulic and organic load



Centre for Environmental Training



Treatment Performance

- Hydraulic Loading Rate (HLR) - rate at which effluent is added to the surface of the filter (L/m^2)
 - Significant effect on treatment effectiveness
 - If HLR too high, saturated conditions dominate and effluent may by-pass treatment, moving rapidly through the bed
- Organic Loading Rate – rate organic matter (BOD) is added to the filter surface (g/m^2)
 - Excess organic loading (high BOD) can also significantly impact treatment performance (clogging, anaerobic conditions)

Centre for Environmental Training



ASF Sizing

- In sizing ASF, we apply 2 general rules for design:
- Hydraulic loading rate = $50\text{L}/\text{m}^2/\text{d}$
- Organic (BOD) loading rate = $25\text{g}/\text{m}^2/\text{d}$
- ASF sized using these criteria will typically achieve minimum secondary effluent standard
- BOD (20mg/L) / TSS (30mg/L), or better

Centre for Environmental Training 

ASF Sizing - Example

- Effluent Spec = 1,200L/day and 150mg/L BOD
- Hydraulic Load rule
 - $1,200\text{L}/\text{day} \div 50\text{L}/\text{m}^2/\text{day} = 24\text{m}^2$
- Organic Load rule
 - $1,200\text{L}/\text{day} \times 150\text{mg}/\text{L} = 180,000\text{mg}/\text{day}$
 - $180,000\text{mg}/\text{day} \div (1,000\text{mg}/\text{g}) = 180\text{g}/\text{day}$
 - $180\text{g}/\text{day} (\text{BOD}) \div 25\text{g}/\text{m}^2/\text{day} = 7.2\text{m}^2$
- Suitable L:W ratio (2:1 to 10:1)
 - Assuming ~3:1 – ASF dimensions = 3m x 8m

Centre for Environmental Training 

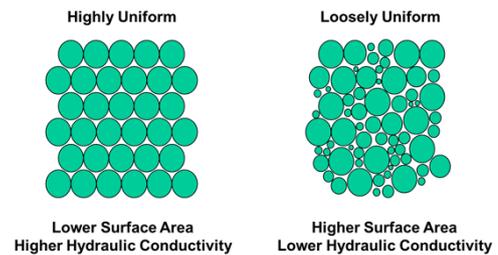
Filter Sand Considerations

To achieve 20/30 (secondary) standard, sand-fill:

- Free of clay, limestone or organic matter
- Contain <20% particles larger than 20mm
- Contain <3% clay and fine silt (<0.074mm)
- Effective Size (ES) (d_{10} - smallest 10% diameter) between 0.25mm and 1.00mm
- Uniformity Coefficient (UC) (d_{60}/d_{10}) <4
- Sand sieved for particle size analysis (PSA)
- Plot histogram and cumulative frequency curve

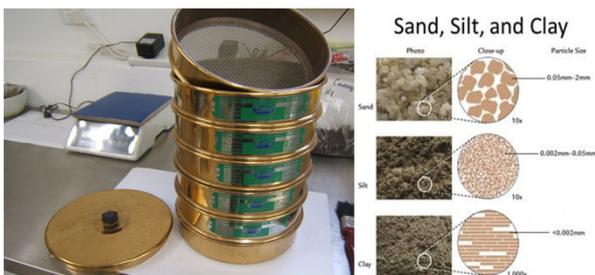
Centre for Environmental Training 

Media Size and Grading



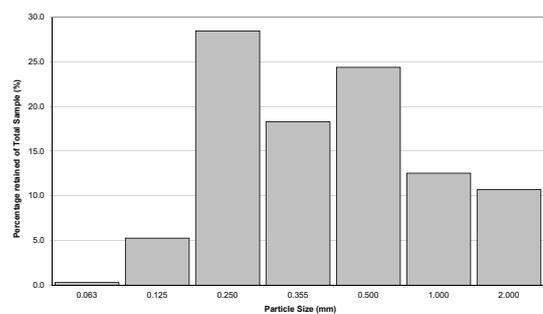
Centre for Environmental Training 

Sieve Analysis



Centre for Environmental Training 

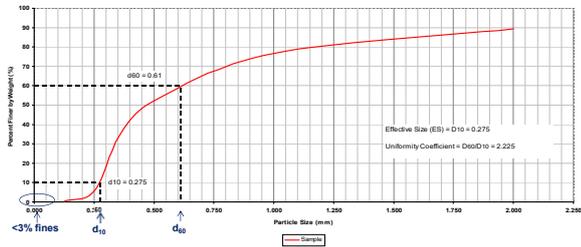
Histogram



Centre for Environmental Training 

Cumulative Frequency Curve

- <3% clay; ES = 0.25mm-1.00mm and UC = <4



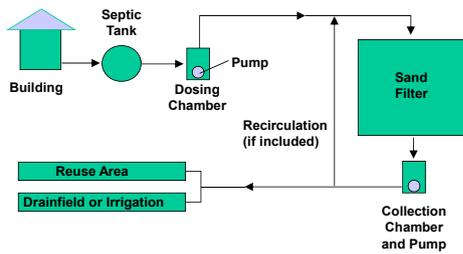
Centre for Environmental Training cet

Improving ASF Performance

- Septic outlet filter
- Pressure distribution – pump / drilled manifold
- Timed-dosing
 - Smaller dosing volumes
 - Regular application throughout day (12-24 times)
- Recirculation

Centre for Environmental Training cet

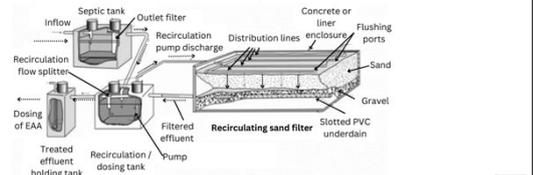
Typical System Configuration



Centre for Environmental Training cet

Recirculating Sand / Media Filter

- Allows treatment across several filter passes
- Higher hydraulic conductivity media – gravel
- Permits higher aerial loading rate
- Treated effluent proportionally released to LAA



Source: DPHI, 2025

Centre for Environmental Training cet

Sand Filter Construction



Liner installation

Centre for Environmental Training cet

Sand Filter Construction



Underdrain and gravel bed

Centre for Environmental Training cet

Sand Filter Construction



Filter sand and distribution bed

Centre for Environmental Training



Sand Filter Construction



Drilling manifold 'orifices'

Centre for Environmental Training



Sand Filter Construction



Distribution manifold

Centre for Environmental Training



Testing Distribution System



Uniform squirt height

Centre for Environmental Training



Completed Sand Filter



Centre for Environmental Training



Completed Sand Filter



Centre for Environmental Training



Bottomless Sand Filter

- Single-pass ASF, with soil absorption
- Treatment and land application in single footprint
- Critical to consider hydraulic contrast at interface



Source: W Cromer

Centre for Environmental Training



Alternative Filter Media

- Some modify or enhance performance of traditional sands and gravels:
 - Crushed glass / sandstone
 - Amended systems (i.e. adsorptive materials)
- Others are economically viable alternatives:
 - Peat
 - Coir
 - Foam
 - Fabric

Centre for Environmental Training



Peat Filter



Peat Biofilter installation, VIC

Centre for Environmental Training



Coir Filter

- Coconut husk fibres
- Very durable – high lignin content
- High specific surface area (90% void)



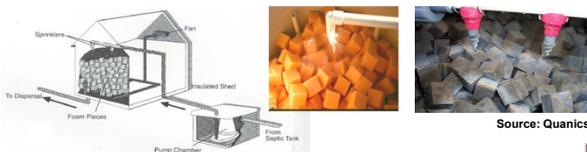
Source: Anua PuraFlow

Centre for Environmental Training



Foam Filter

- Foam filters
- Provide some physical filtration
- Combine porosity and high surface area
- Main function as surface for biofilm growth



Source: Quantics

Centre for Environmental Training



Fabric Filter

- Hydraulic loading rate = up to 1,000L/m²
- 96 'doses' per day (15 min intervals)
- Recirculation rate ~3-5 times flow



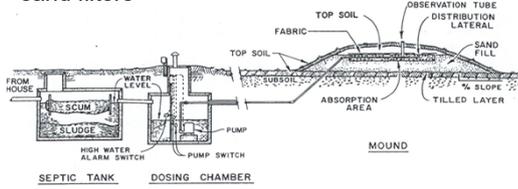
Orengo Advantex fabric filter

Centre for Environmental Training



Wisconsin Mound Systems

- Developed in 1970s
- Over 30,000 Wisconsin mounds in Wisconsin
- In effect, bottomless intermittent (single-pass) sand filters



Source: Converse, 2000

Centre for Environmental Training



Wisconsin Mound Systems

- Soil absorption systems
- Elevated above natural soil surface
- Uses suitable fill such as quality sand media
- Pretreated effluent is dosed to the mound
- Overcome site restrictions such as:
 - slowly permeable soils
 - shallow permeable soils (300-600mm) over porous bedrock or hardpan
 - permeable soils with high water table

Centre for Environmental Training



Wisconsin Mound Systems



Centre for Environmental Training



Sand Mound Design

Design considerations:

- Aligned on contour
- Ground suitably prepared
- Appropriate materials and construction
- Key Sizing Criteria:
 - Sand loading rate – at distribution manifold
 - Linear loading rate – across slope
 - Basal loading rate – on soil at base of mound

Centre for Environmental Training



Sand Loading Rate

- Sand loading rate (SLR) – mm/day
 - at distribution gravel / sand interface
 - influenced by effluent quality
 - AS/NZS 1547:2012 suggests <40mm/day
 - acceptable range - 40 (primary) to 50 (secondary)
- Rate at which effluent contacts the sand surface (base of distribution)

Centre for Environmental Training



Basal Loading Rate

- Basal loading rate (BLR) – mm/day
 - at sand / natural soil interface
 - from Table N1 in AS/NZS 1547:2012
 - select for the limiting soil layer below mound
 - 8 (light clay) to 32 (sand) mm/day
- Rate at which effluent will infiltrate the natural (underlying) soil
- Critical to ensure sufficient depth (~400mm) if topsoil BLR selected

Centre for Environmental Training



Completed Wisconsin Mound



Source: B. Baiers

Centre for Environmental Training



Completed Wisconsin Mound



Centre for Environmental Training



Alternative Vegetation Cover



Centre for Environmental Training



Treatment Performance of Sand Filters and Mound Systems

	BOD ₅ (% removal)	TSS (% removal)	TN (% removal)	FC (% removal)
Intermittent sand filter / Mound	90-98	90-95	14-50	97-99
Recirculating sand filter	95-99	81-95	45-82	97-99

Source: Crites and Tchobanoglous (1999)

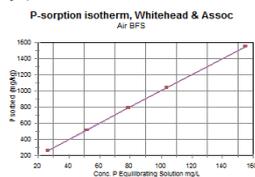
Centre for Environmental Training



Amended Soil Systems

Use soil or alternative media for nutrient reduction

- P-sorption
 - Gypsum amended red mud (by-product of bauxite refining for aluminium)
 - Air-dried Blast Furnace Slag
- N reduction
 - Zeolite



Centre for Environmental Training



Ecomax System, WA



Source: Ecomax WA

Centre for Environmental Training



Ecomax System, NSW



Source: Ecomax NSW

Centre for Environmental Training



Ecomax System, NSW



Source: Ecomax NSW

Centre for Environmental Training



Amended Ecomax Design



Source: Ecomax NSW

Centre for Environmental Training



Ecomax Hydraulic Overload



Flat bed limits rainfall runoff and evapotranspiration

Centre for Environmental Training



References

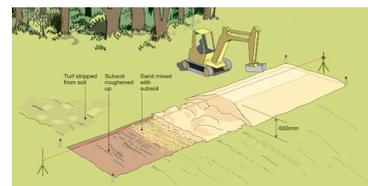
- Converse, JC & Tyler EJ (2000). Wisconsin Mound Soil Absorption System: Siting, Design and Construction Manual, #15.24, University of Wisconsin-Madison, Small Scale Waste Management Project. https://soilsfacstaff.cals.wisc.edu/sswmp/SSWMP_15.24.pdf
- Cromer, WC (2013). Bottomless sand filters: Notes for designers, installers and regulators July 2013. Land application systems for domestic wastewater management. Unpublished report by William C Cromer Pty Ltd, 1 December 2013.
- Whitehead, J & Geary P (2009). Sand Mounds for Effective Domestic Effluent Management, Water 36, 1 (pp 27-32).

Centre for Environmental Training



References

- A guide to installing a sand mound to manage onsite wastewater, WaterNSW, <https://vimeo.com/72859822>



Centre for Environmental Training

