SEPTIC TANKS

Model Decentralized Wastewater Practitioner Curriculum
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Citation

Overview
Typical Septic System

- House
- Septic tank
- Trenches
- Well
- Basement
- Evapotranspiration
- Effluent baffle
- Soil absorption
- Treatment
- Ground water
- Streams, lakes
Tank Functions

- Solids removal by settling & floatation
  - 60-80% solids removal
- Anaerobic digestion
- Storage of solids
Septic Tank Function
Treatment Classes

- Primary – Settling and Flotation
- Secondary – Usually aerobic biological treatment
- Advanced – Enhanced nutrient removal and disinfection
Anaerobic Digestion

ORGANIC MATTER → GASES + HUMUS

CO₂, CH₄, H₂S, NH₃
Biological Activities in the Septic Tank

- Anaerobic (without Oxygen)
- Anaerobic digestion is
  - Incomplete
  - Cheap and easy
  - Reliable
- Gases produced are odoriferous
- Not all solids in the tank are biodegradable
Factors That Influence Anaerobic Digestion

- pH
- Chemicals
- Highly variable flow patterns
- Pharmaceuticals
- Process wastewaters
- Lack of tank maintenance
Factors That Influence Wastewater Strength

- FOGs
- Flow pattern
- Flow rates
- Nonbiodegradable items
Tank Design
Septic Tank Design

- Sizing
- Geometry
- Compartments
- Vehicular Traffic
- Appurtenances
Effective Volume (new tank)
Tank Sizing

- Generally prescribed by the permitting agency for individual homes based on home size

- Criteria: Hydraulic detention time plus solids storage
  - 1 to 2 days detention of design flow
  - Add solids storage volume equal to 1/3 – 1/2 of the above hydraulic detention
Septic Tank Sizing Example

- Consider a 3 – bedroom home

- Design flow: 3 br, 2 people/br, 75 gpd/person
  - Flow = 3 x 2 x 75 gpd = 450 gpd
  - Provide for 2 day detention => 2 x 450 = 900 gal

- Add solids storage
  - 1/3 of the above = 1/3 x 900 = 300 gal

- Total tank volume = 900 + 300 = 1200 gal
  - This is the minimum recommended tank size
  - The tank should have two compartments
  - Many regulatory agencies now require 1500 gal tank for a 3-br home, but sizing starts with a procedure like this.
Other Factors that Affect Tank Size

- Garbage grinders
  - Add to solids accumulation rate and organic load
  - May add grease and oil
  - Increase hydraulic load some
  - Though not recommended with septic systems, they will be used in many homes.
Other Factors that Affect Tank Size

- Sewage (basement) lift pumps
  - Will increase turbulence in the septic tank
  - Should discharge into sewer line – not directly to tank
  - Two compartment tanks highly recommended with pumps
  - Set pumps for minimum discharge volumes
Goal is Near Zero Velocity for Optimum Solids Removal

- Maximize distance between inlet and outlet
- Length:Width ratio at least 3:1
- Inlet to outlet drop ~ 2”
Tank Compartments

- Advantages of multiple compartments
  - More complete solids removal
  - Improved effluent quality
  - Protect against solids discharge due to lack of maintenance
Two Compartment Tank

Two Compartment Septic Tank

2/3 total volume

Clear Zone

1/3 total volume

Scum

Sludge
Tank Compartments
Meander Tank Example

Advantages of a meander tank
- Longer flow path
- Opportunities to drop solids as flow turns
- Most solids are removed in first chamber
Vehicular Traffic

- Standard concrete tanks are not designed to handle traffic loads
  - ASTM Standard C-857 provides information on these design issues
- Using other tanks in areas subject to traffic should be done only with manufacturer guidance and engineer approval
Tank Appurtenances

- Tees and baffles
- Effluent screens
- Access risers
Inlet and Outlet Baffles/Tees

- **Inlet baffle**
  - Directs the flow
  - Minimizes turbulence and short circuiting

- **Outlet baffle**
  - Assures outflow comes from clear zone
  - Holds floating scum in the tank
Tee-type baffle outlet

- Baffle made from sanitary tee and 4-in pipe nipples
- Positioned directly under tank opening for access
- Some older tanks have (or had) tee-type baffles made of clay or concrete pipe
  - These deteriorate and fall off in time
  - Should be replaced when tank serviced
Inlet baffle of concrete cast into tank

- Curtain baffle penetrates to well below liquid depth
- Outlet ports are made like this too
- Groove at top allows gas transfer across tank and up sewer to roof vent
Baffle formed of plastic fastened to tank wall
Inlet and outlet baffles
Tank illustration with sealed inlet and outlet baffles, risers to grade

- Outlet 1-3” below inlet
- Spreading of flow is illustrated
- Flow is attenuated
  - Outlet flow rate is much less than inlet
  - More pronounced in a rectangular tank
Effluent Screens

- Designed to keep larger suspended solids in the tank
- Control outflow rate
- Protect the downstream components
- Typically replace the outlet baffle
- Require riser to grade for access to screen
Installation issues

- Location
  - Tank
  - Sump
  - Pump vault
- Can be equipped with alarm
- Screen in second compartment of a two compartment tank will require less service
- Should be secure in place
- No bypass flow if clogging occurs
- Housing should not interfere with normal tank cleaning
Choosing an Effluent Screen

- Ease of serviceability
- Size appropriately for the flow
- Openings of 1/16 – 1/8 inch
- Designed to prevent solids bypass during cleaning
- Locate so that access for pumping is not hampered
Proprietary effluent screens
Effluent Screen installed to replace outlet baffle
Location of Effluent Screen
Access risers

- Provide easy access to tank and components
- A must for tanks containing effluent filters or pumps
- Shallow tanks and short risers – the preferred situation
Riser Design
Safety
Tank Construction
Tank Materials

- Reinforced concrete (most common)
- Fiberglass reinforced plastic (FRP)
- Polyethylene/polypropylene (Poly)
Tank Materials

- Concrete
- Fiberglas
- Polyethylene
Structural Soundness

- Withstand handling and transport
- not be susceptible to damage during installation
- Resist external and internal pressures
- Support a 2500# wheel load in addition to soil load
- Tanks must be properly reinforced according to a standard
  - ASTM
  - NPCA
Manufacturing Tanks
Precast concrete

- Mix Design
- Structural reinforcement
- Manufacturing practices
- Joint design
- Sealing materials
- Proof testing for structural soundness
- Access risers
- Pipe penetrations
Mix Design

- Low water to cement ratio
- Minimum compressive strength of 4000 psi after 28 days
- Quality aggregates
  - Consistent gradation
  - Low moisture content
  - Free from deleterious substances
Mix Design (continued)

- Appropriate use of chemical admixtures to improve:
  - Mix flowability
  - Water reduction
  - Air Entrainment
  - Resistance to corrosion/degradation

- Selection of proper cement type
Structural reinforcement

- Reinforcement required for adequate strength
  - Rebar – required in top
  - Steel mesh – may be used in walls of some tanks with cross walls
  - Special fiber, fiberglass and other materials
Structural reinforcement (cont.)

- Tank integrity
- Prevent collapse

Wire mesh in top is not enough
Reinforcing wire in side wall

Proper placement of rebar in form using "chairs"

Cutaway of tank showing rebar
Manufacturing Methods

- Proper maintenance of forms or molds
  - Removal of excess form oil
  - Removal of rust
  - Elimination of voids to prevent spills
  - Maintenance of tolerances to prevent improperly fitting structures
Manufacturing Methods (cont.)

- Proper selection and placement of reinforcement
- Proper vibration techniques for uniform distribution
- Proper casting and curing to maintain correct moisture content and temperature
Joint Design for Concrete Tanks
“Monolithic” Concrete Tanks
Sealing Materials for Precast Tanks

- Blended sealant compounds
  - Butyl-rubber based
  - Asphalt-based (bituminous)
Mastic: Rules of thumb

- Quality mastic does not compress much between thumb and forefinger.
- Compressibility in cold-weather installations.
- Should not shred or snap when hand-stretched.
- Higher is better than wider: 50% compression is desirable.
- Knead joined ropes prior to placement.
Concrete Tank Seams

- Achieving a watertight joint:
  - Seams must be smooth, clean and dry
  - High quality mastics, seal gaskets
  - Proper placement of mastic
Concrete Tank Seams (cont.)

- Achieving a watertight joint:
  - Extra butyl rubber wrap around joint
  - Joint must be tested to be sure it does not leak
Proof Testing for Structural Soundness

- Tanks should reach 4000 psi before delivery to site
- Should comply with ASTM and NPCA standards
- Other engineering tests also available
Access Risers for Precast Tanks

- Made from various materials
- Cast-in-place or added after tank construction
Cast-in-place concrete risers
Cast-in-place poly risers
Adding concrete risers

Mastic provides a better seal than mortar.
Adding concrete risers (cont.)
Adding poly risers to concrete tanks

- Adapter rings for riser attachment can be cast-in place or bolted in place.
Adding poly risers to concrete tanks

- Riser can then be attached to adapter using adhesive and stainless bolts
Pipe Penetrations: Rubber Boot Seals

- Boot may be cast into the tank or pressed into a smooth hole with an expanding clamp.
- Stainless steel hose clamp seals boot to pipe.
- Flexible – allows some pipe movement but maintains sealed.
Plastic pipe penetration seals

- Cast-in plastic fitting
- Flexible – allows some pipe movement
PVC Pipe Penetration Seal

- Cast-in PVC fitting
- Connecting pipe cements into fitting
- Inflexible connection
- Pipe will need support during backfill
- Stress created if any settling occurs
Polyethylene/polypropylene Septic Tanks
Tank Construction: Poly

- Rotationally molded
- One-piece construction
Pipe seals and access risers for poly tanks
Fiberglass-reinforced Plastic (FRP) Septic Tanks
Tank Construction: Fiberglass

- One- or two-piece construction
Two-piece FRP Tank Construction
Assembling tank halves
Joining 2-piece fiberglass tanks
Pipe seals for FRP tanks
Access Risers for FRP tanks
Overall Quality of Septic Tanks

- Looks aren’t everything
  - Cosmetic deficiencies may not affect performance
  - Good-looking tanks may have structural deficiencies
Summary: What to look for in concrete tanks

- Reasonably smooth surface
- No honeycombing or cracks
- No efflorescence
- No exposed rebar or wire inside or outside
- Smooth, well made tongue and groove or shiplap joint with mastic
- Flexible, watertight pipe seals at all pipe penetrations
- Cast-in-place or mechanically-attached riser with tight fitting lid
Summary: What makes a good poly tank?

- Even wall thickness – no thin areas
- No pin holes
- No deformation of riser openings
- Flexible pipe seals at all pipe penetrations
- Mechanically attached riser with tight fitting lid
Summary: What makes a good fiberglass tank?

- Properly sealed mid-seam
- No imperfections in lay-up
- No de-lamination
- No cracks and dings from handling
- Flexible pipe seals at all pipe penetrations
- Mechanically attached riser with tight fitting lid
Problems with non-concrete tanks
Ultimately, it is essential to TEST.

- Good-looking tanks may have defects
- Poor appearance does not necessarily indicate problems
- Irregularities in tank of any material should be investigated thoroughly
- If unsure, consult with manufacturer or engineer
- Testing will ensure quality, watertight installations.
Tanks must be watertight

- Exfiltration could release untreated sewage deep in the soil
- Infiltration may occur
  - Disrupt settling
  - Overload drainfield or downstream components
Possible points of leakage

- Weep holes at the base of the tank
- Mid-seam joint
- Inlet/outlet pipe penetrations
- Top-seam joint
- Tank top/access riser joint
- Access riser/lid joint
- Any damaged, improperly-formed location or area where material is too thin.
Watertightness

- Watertight seals
  - All joints
  - Pipe penetrations
  - Riser and lid
Watertightness Testing

- Hydrostatic (water) testing
- Vacuum testing
Hydrostatic Testing

- Prior to backfilling
  - Cap pipes
  - Fill 2” into riser
  - Soak for 24 hrs
  - Refill if concrete
  - Check in 24 hrs
  - Allowable loss is less than one gallon
Vacuum Testing

Pipe seal

Vacuum pump

Plate seal to top of riser or tank

Gage to measure vacuum
Checking Existing Tanks for Watertightness

- Care is needed in preparation for test
  - Have to plug inlet and outlet
  - Must have no flow
- Could then either water or vacuum test
Checking Existing Tanks for Watertightness

- Other physical evidence
  - Root intrusion
  - Outflow when there is no inflow
  - Evidence of fluctuating water levels
  - High water table area:
    - Pump during wet season and look for infiltration
    - Beware of flotation
  - Excavate outside of the tank and look for evidence of exfiltration – blackness, odor, etc.
Tank Installation
Safety

- Maintain a safe working environment: comply with OSHA standards
- Protect excavations from sidewall collapse
  - Excavate back
  - Use trench boxes
- Stay safely clear of the tank during installation
Safety (cont.)

- Use proper slings
- Slings properly placed in grooves prepared by the manufacturer for handling the tank
Planning and Excavation

- Check building stub-out elevation
- Tanks should be kept as shallow as possible
  - Minimize soil pressure
  - Minimize potential of ground water effects
  - Keep soil treatment system as shallow as possible
Planning and Excavation (cont.)

- Tank must be set level
- Building sewer must slope 1-2% (1/8 – ¼” per foot)
- Know tank dimensions before excavation
Planning and Excavation (cont.)

- Set tank on undisturbed material or granular bedding
- Always work safely!
Bedding Material
Setting the Tank and Joining Seams

- Tank must be set level
Setting the Tank and Joining Seams

- All workers should be safely positioned relative to suspended tanks during installation.
Installation of two-piece concrete tanks

- Handling and installing two piece tanks to assure no leaks
  - Mating tank edges must not be damaged
  - Proper sealant must be used and correctly placed
Applying mastic
Undamaged edges must be properly fit together

- Mastic uniformly compressed
- Watertight seal properly formed
Setting the Tank

- Tanks must be carefully set to avoid damage during installation.
Backfilling the Installation
High Water Table Conditions
Pipe Penetrations

- Penetrations must be water tight after backfill
- Use Sch 40 PVC or stronger across excavations
- Tamp the soil under the pipe for support
- Flexible boot seals recommended
Questionable Seals
Proper final grade: access risers to the surface

Slopes Away From Riser and Tank in all Directions
Operation and Maintenance
Operation and Maintenance

- In most cases, the homeowner is the operator
- Homeowners need basic information on operation
  - How the system works
  - How to use the system
  - What should not be put into septic systems
- Homeowner must be encouraged to
  - Have the system inspected periodically
  - Pump the tank as needed
Operation and Maintenance of Septic Tanks

- Solids accumulate in septic tanks
  - sludge in the bottom
  - scum on top
- Pump before solids begin to increase in the effluent
Frequency Of Pumping

- Calendar recommendation
  - Every 3-5 years

- As needed
  - Measurement of sludge and scum
Determining Need for Pumping

Pump when:
- scum clear space is <3” or
- sludge clear space is <9”
Measuring Scum
Devices for Measuring Sludge

- Clear plastic tube with a foot valve on the end
- Infrared eye on a pole
- ???
Pumping as Needed According to Actual Measurement

- Not done much
  - Most tanks are buried – no riser to grade
  - “If you have to dig up the tank, you might as well just pump it”
  - Lack of skill
- Opinions vary on frequency
- May be dictated by state regulation
- Recommendations here are based on actual measurements of when accumulated solids affect effluent quality – i.e. science
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<td>Number of occupants</td>
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<td>Pump-out interval (yrs)</td>
<td>9  7  5  4</td>
<td>1  2  9  6  4</td>
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Always be safe

- Beware of pumping tanks during times of high water table conditions
Tank Inspection at Time of Pumping

- Tank should be thoroughly inspected
  - Damaged or missing baffles
  - General tank deterioration
    - especially in the head space above the water level
  - Honeycomb in concrete surface
  - Pin holes or non-uniform wall thickness in fiberglass or plastic
  - Root intrusion
Root Intrusion
Tank Inspection at Time of Pumping

- Other indications of leaks
  - Fluctuating tank levels
  - Damaged seams
  - Cracks
- Consider adding an effluent screen
- Inspect risers and lids for leakage or damage
Additional Considerations

- Two compartment tanks: open and inspect both chambers

- Pumping too often may be detrimental
  - Normal development of scum and sludge layers
  - Normal population of beneficial microbes
  - Increased the burden of septage disposal
  - Unnecessarily adds to cost for owner
Servicing Effluent Screens

- Clean screen when pumping tank
- Wash material back into tank
- If cleaned at other times:
  - Remove and clean elsewhere
  - Clean over inlet end
  - No solids bypass
Effluent Screen Cleaning

- Wear gloves!
- Wash off directly into the inlet end
- Solids bypass protection
Effluent Screen Cleaning

- Often, a tool is needed to remove the screen for cleaning and then to replace it into the housing.
- Note that riser opening allows easy access to filter.
Factors that Increase Screen Cleaning Frequency

- High fat, oil and grease in sewage
- Extensive hair or laundry lint
- Backwash from water softener
- High water usage or high peak flows
- Screen too small for the application
Excessive screen clogging may indicate:

- Lack of proper biological activity in the tank
- Excessive flows
  - Infiltration
  - Leaky plumbing fixtures
- Neglecting to pump the tank when needed
Myths and Additives

- Tanks typically do not require additives
  - No need to “start” a tank with a dead chicken
  - Adding yeast, while harmless, is not needed
  - Commercial additives are normally not needed

- Beware of any additive that suggests it will reduce pumping frequency
  - Normal function means some accumulation
    - Nonbiodegradables – e.g. synthetic fabric lint
  - Solids may be washed out to next downstream treatment component
  - Independent research shows no benefit
Recommendations to Homeowners
Things In The Tank That Degrade Slowly…

…and accumulate as scum

- Toilet paper
- Hair
- Laundry lint
- OIL and GREASE
What Does *Not* Belong In The Tank?

- Cigarette butts
- Coffee grounds
- Cooking fats
- Paints & chemicals
- Paper towels
- Female sanitary products
- Disposable diapers
- Condoms
Septic System Use Recommendations

- Avoid simultaneous discharges
  - Showers, washing clothes and running the dishwasher all at once
- Spread laundry out – avoid consecutive loads,
- Install a laundry lint filter
- Keep non-sewage water out of the system
  - Water softener backwash
  - Footing drain sump pump discharge
  - Floor drains
Inspections and Troubleshooting
Procedures to determine if problems exist

- Must remove all lids to the tank
- Check if liquid level normal: at the outlet invert
  - If low, tank is leaking
  - If high, blockage or backup from drainfield
- Pump the tank to determine reason for high condition
  - Pipe breakage?
  - Root intrusion?
  - Failed drainfield?
- Measure sludge and scum levels
Troubleshooting: Odor

- **Around the septic tank**
  - Check for pipe breakage
  - Unsealed riser lid or inspection port

- **From roof stack**
  - Abnormal development of tank biology
  - If only during still air or temperature inversion
    - Extend roof stack to above the ridge
    - Install activated carbon filter on the stack(s)

- **In the house**
  - Drift from the roof stack?
  - Dry plumbing trap?
Tank Abandonment Procedures

- Tanks no longer used must be properly abandoned
- Check local codes for requirements
- Goal is to render the area of the tank safe
Typical Abandonment Procedures

- First pump out completely
- Three possible procedures
  - Remove tank and properly dispose
  - Crush completely, backfill, and compact the soil
  - Fill the tank completely with granular material or a flowable fill (concrete grout)
DISCUSSION AND QUESTIONS?