The Future of On-site Wastewater Treatment

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NOSTRA HAMMES

The Future is....

- Digital

If the work is repetitive, it could be done by a computer!

- paperwork and filing
- mapping
- sampling
- excavation
- installation
- inspection

The Future is....

- Digital
- Improved Treatment

New crystals store and release oxygen from air

CRYSTALS TURN BLACK WHEN SATURATED WITH OXYGEN

NEW AERATION MATERIAL for WASTEWATER TREATMENT?

- Denmark (October, 2014) - invented a crystalline material that absorbs and stores oxygen in high concentrations.
- Both a sensor, and container for oxygen - bind, store and transport oxygen – like a solid artificial hemoglobin. Reusable.
- Stored oxygen is released by heat or pressure.
- 10 liters of these crystals - can completely suck the oxygen out of a room.

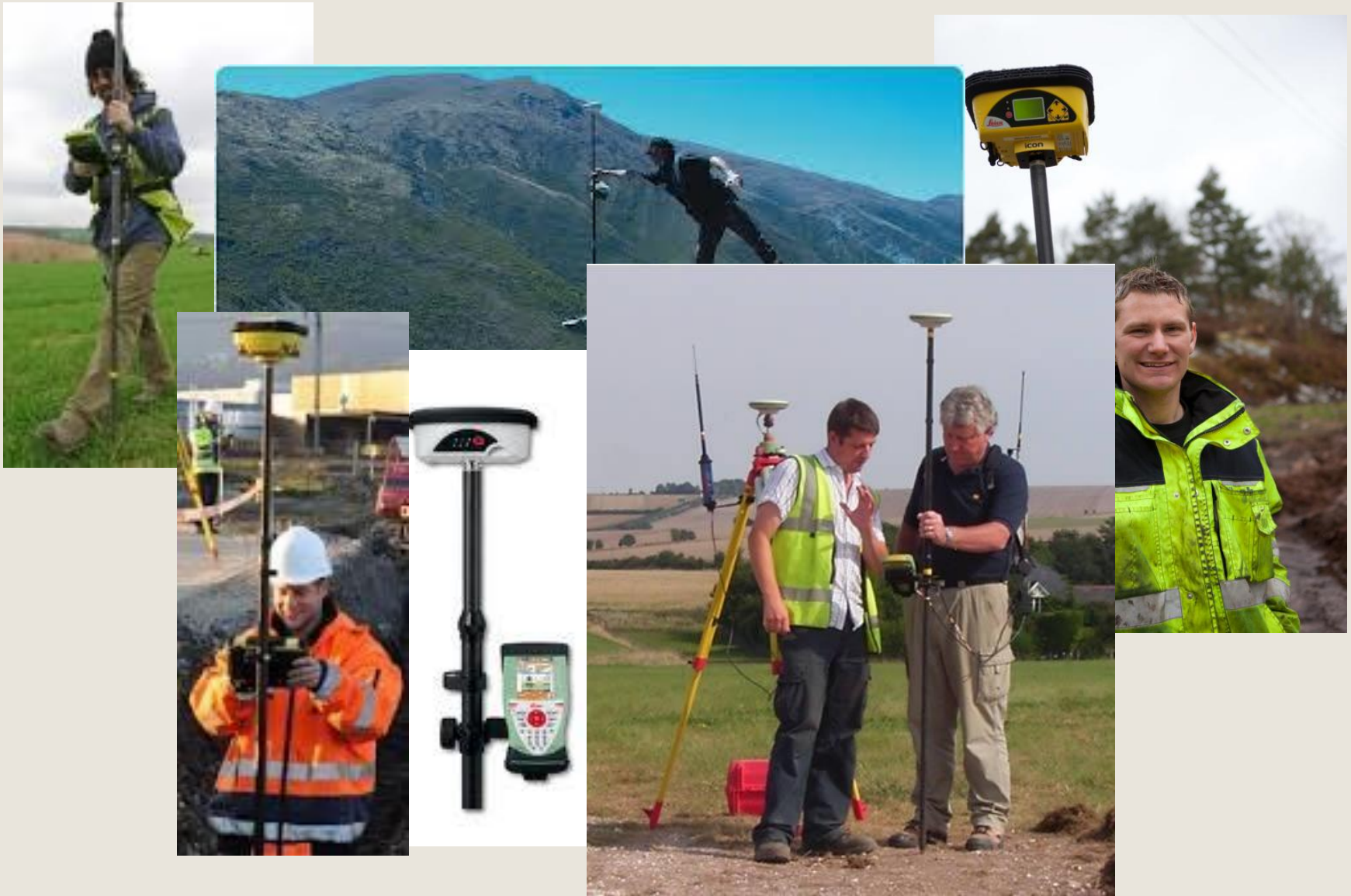
The Future is....

- Digital
- Improved Treatment
- More Management
- More Maintenance
- Recycling/Sustainability
- More Public Protection/Oversight
- More Environmental Protection

The Immediate Future for POWTS Tools

- GPS measuring, drones for super-surveying
- Off site wastewater sampling
- Need based treatment systems
- Ground Penetrating Radar

New GPS Survey Equipment – may become the Surveyor's Bane



GPS Surveying Equipment

- Started out +$18,000
- Current price for field equipment and software ~ $10,000
- As with all electronic equipment (Digital TV, Computers, Cell Phones) the price drops with new competition over time
- Simplified use, setup, handling
- Use by Excavators, Installers, CSTs

Drones

- Drones can transform land surveying
- Lightweight lithium batteries & cameras
- Rotor units can hover at a precise altitude and position
- A home made GPS-controlled drone with camera <$6,000

OctoXL Mikrokopter drone in Alexandria, La. The parts are made in Germany and the airframe was manufactured by Droidworx in New Zealand.

Off site sampling and testing of wastewater

We already have digital liquid samplers

We have digital analyzers for volatile compounds

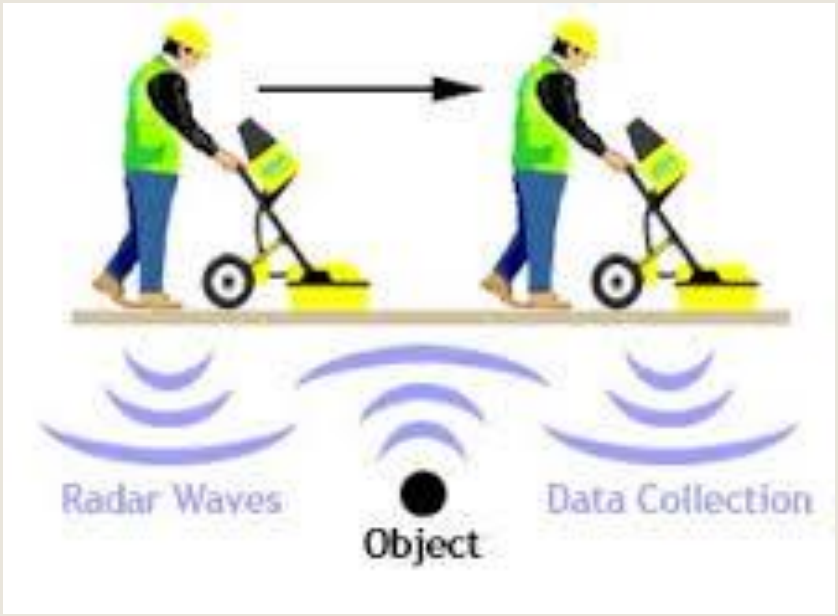
Nitrates?
BOD_5?
Total Suspended Solids?
Fats, Oils and Grease?

thermogravimetric analyzer

THE MARS CURIOSITY LAND ROVER CAN DO IT

IN MORE EXTREME CONDITIONS THAN A SEPTIC TANK!

GROUND PENETRATING RADAR



GROUND PENETRATING RADAR

- Current unit cost ~ $21,000
- Used in criminal investigations, locating graves, foundations, pipes, anything buried
- POWTS uses: locating septic tanks, drainfields, sewer piping, bedrock depth, fill soil, soil mapping

“SMARTER” PUMP CONTROLS of the Future

- Pretreatment unit processing based on digital sampling
- Remote monitoring and control
- Record all events/runtimes to calculate effluent volumes – overuse warning alarm
- Visual/webcam of mechanical devices
- All pumping is time dosed – lessen hydraulic overloading

IMMEDIATE FUTURE FOR SEPTIC TANKS

- Treatment for tank/concrete corrosion/deterioration; well water sulfur & iron content (iron sulfide) effects
- Increasing use of bleach/disinfectants calls for longer retention times
- Double septic tanks will become standard by code
- Tanks will get wider and longer

  not deeper


CLOROX
Toilet Wand
Refills


Whitens • Removes Stains • Disinfects
CLOROX
Regular
Tide
Washing Machine

Maybe not so good for Fido

Or the septic tank

Dechlorination of Wastewater

(from excessive chlorine bleach)

- Passive Methods: allows chlorine to dissipate over time. Need several tanks in series with long retention.
- Chemical Methods: use of sulfur compounds faster but are oxygen scavengers in the tank.
- Vitamin C can neutralize chlorine. Not a hazardous chemical. Vitamin C does not lower the dissolved oxygen as much.

IMMEDIATE FUTURE FOR EFFLUENT FILTERS

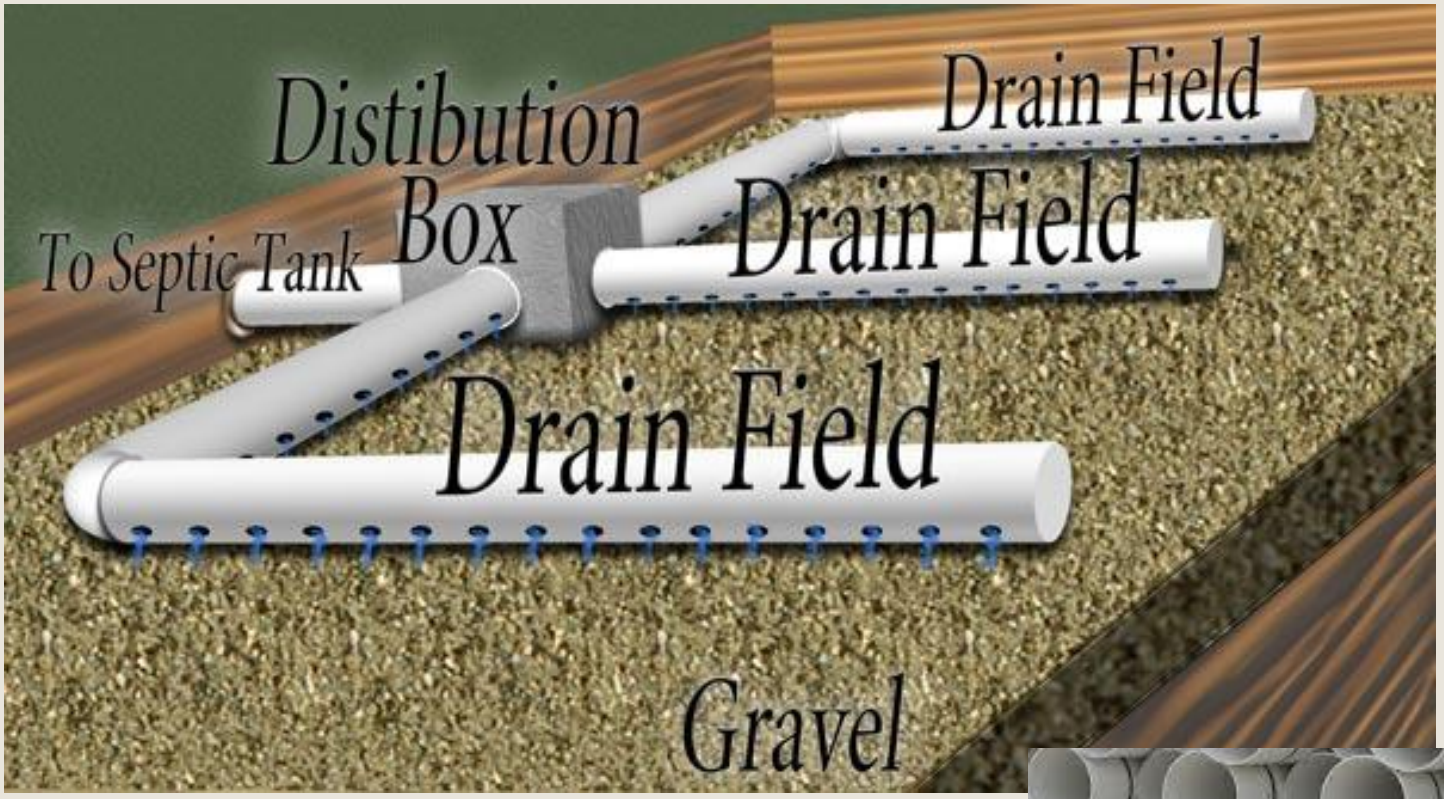
- More use of filter screens of 100 microns for residential effluent

  (1/8” = 3175 microns)
- Filter alarms are necessary.

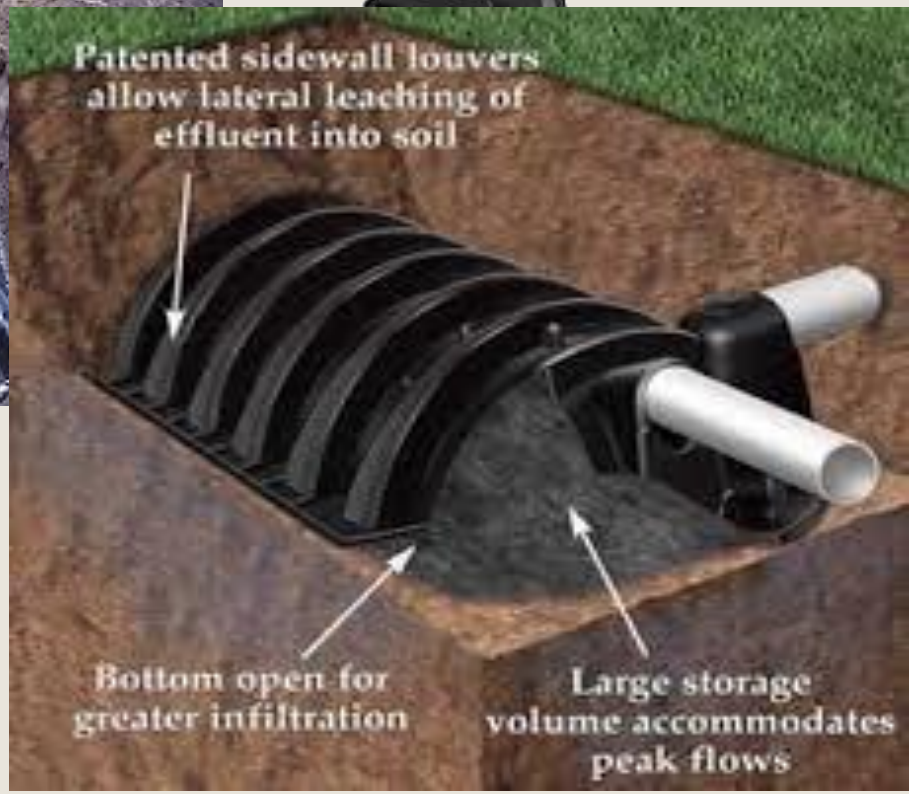
Future for Drainfields

- Gravity fed with aggregate – elimination of distribution piping

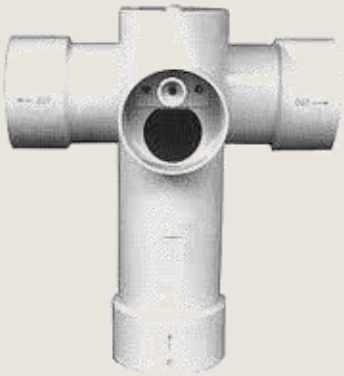
Do we really need all that piping?

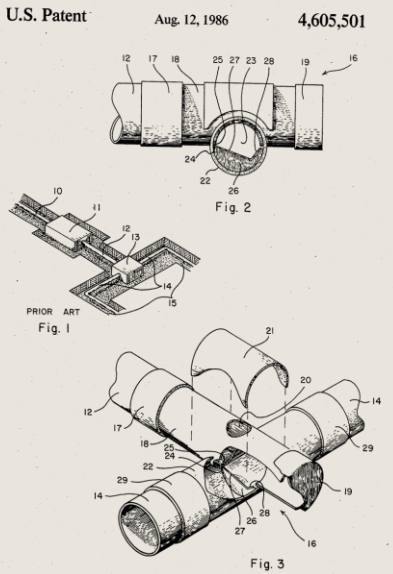


Chambers don’t use distribution pipes!



Use flow dividers to better distribute flow to several points in each cell





Future for Drainfields

- Gravity fed with aggregate – elimination of distribution piping
- Installation limited in cold weather

WINTER INSTALLATION PROBLEM?

- ANAEROBIC BACTERIA IN THE WASTEWATER PRODUCE POLYSACCHARIDES THAT ENTER THE SOIL PORES

- THESE POLYSACCHARIDES GEL AT TEMPERATURES BELOW 40^{o} F AND BECOME RUBBER-LIKE

- THIS MIGHT RESULT IN EARLY CLOGGING FROM EFFLUENT IF THE SOIL TEMPERATURE IS SLOW TO RECOVER

A.B. RONNER AND C.L. WONG,

University of Wisconsin, March, 1998

Biomat formation possibly accelerated

Future for Drainfields

- Gravity fed with aggregate – elimination of distribution piping
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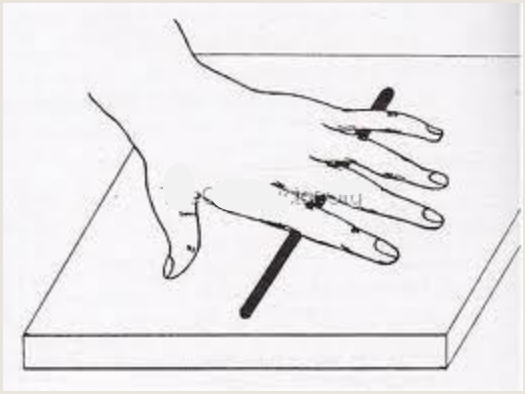
Future for Drainfields

- Gravity fed with aggregate – elimination of distribution piping
- Installation limited in cold weather
- Standardized digital measuring for soil plastic limit (forming a wire from soil) previous to plowing or excavating

Soil Moisture – forming a wire – not always an agreeable solution!



Future for Drainfields

- Gravity fed with aggregate – elimination of distribution piping
- Installation limited in cold weather
- Standardized digital analysis for soil moisture determination for plowing or excavating
- Mound cell minimum sizing will increase

LINT

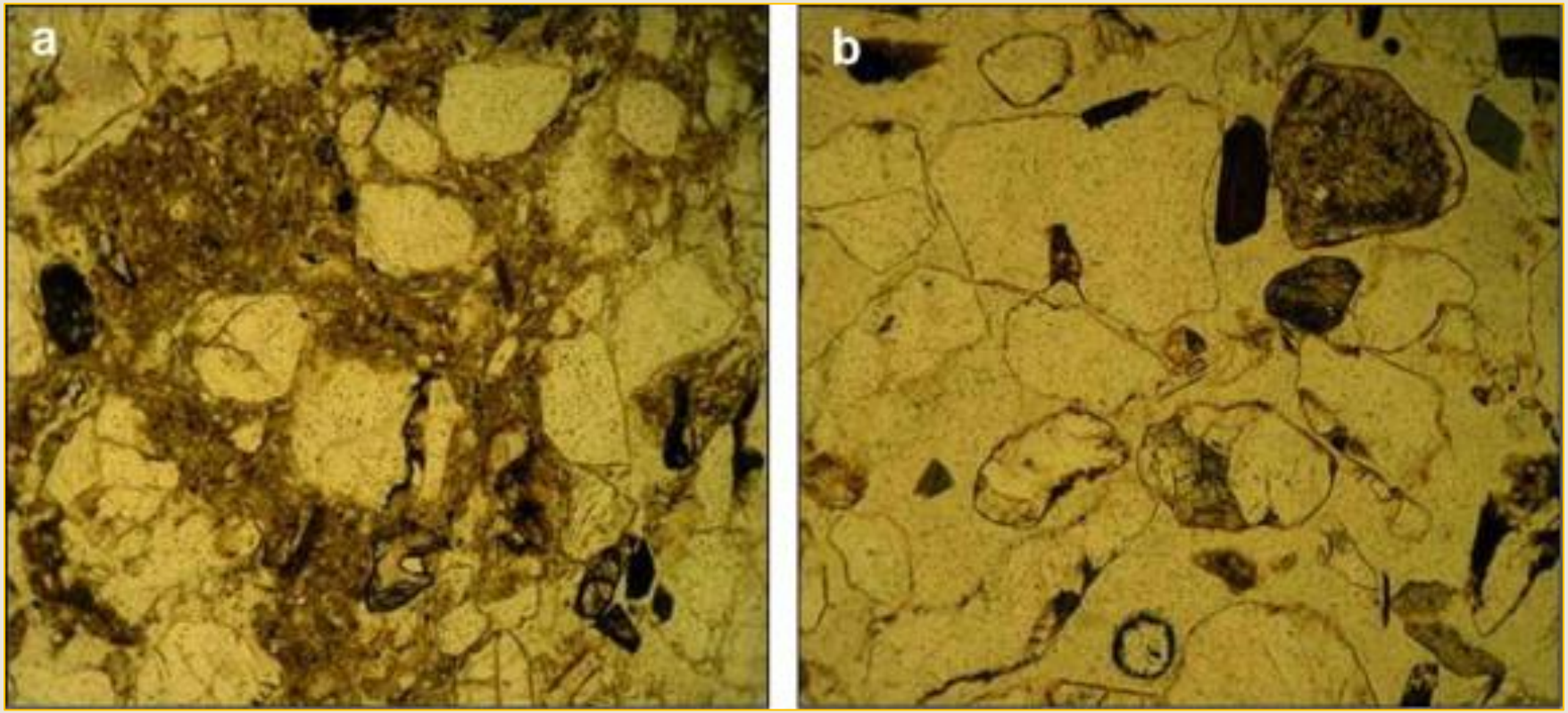
PARTICLE SIZES FROM 3 TO 300 MICRONS

THE BEST POLYFIBER LINT TRAP WILL RETAIN DOWN TO 180 MICRONS

Thin section images under uncrossed polarised light: a) sand sample showing silty matrix between quartz sand grains; b) sand sample lacking silty matrix. Size of individual grains range from 100 to 2000 microns.

MED. SAND & FINE PARTICLES

CLEAN MEDIUM SAND



MOUND CELL PONDING

- Overloading of natural **AEROBIC** bacteria in the sand creates a biologically active film from **ANEROBIC** bacteria
- This biomat further clogs up the the soil.
- Clogged soils = slow drainage
- Mound cell recores are increasing

Residential failures for POWTS <20 years old

Designs for replacing drainfields*:

Below Grade drainfields = 17

At-Grade drainfields = 3

Mound drainfields = 57

Mound cell recores (dry sand below cell)= 48

Mound toe discharges = 9

- Data for 2002 - 2012,
  Hammes Soil Testing & Design

The Immediate Future for POWTS Regulation

- All digital submissions
- Online availability and search capability
- Soil test reports modeled/configured to large scale maps by county - need for county on-site, individual soil test may be redundant... because...
- GPS data from drones will supply exact point on topographical measurements available for any parcel
- Inspection of existing POWTS at each real estate transaction will be statewide

Door County, WI

- Door County's Private Waste Disposal System Ordinance requires existing private septic systems to be evaluated prior to transfer of ownership.
- Is seller's responsibility to have the POWTS inspected. A soil test report performed by a licensed soil tester is required and submitted to the Door County Sanitarian's office.

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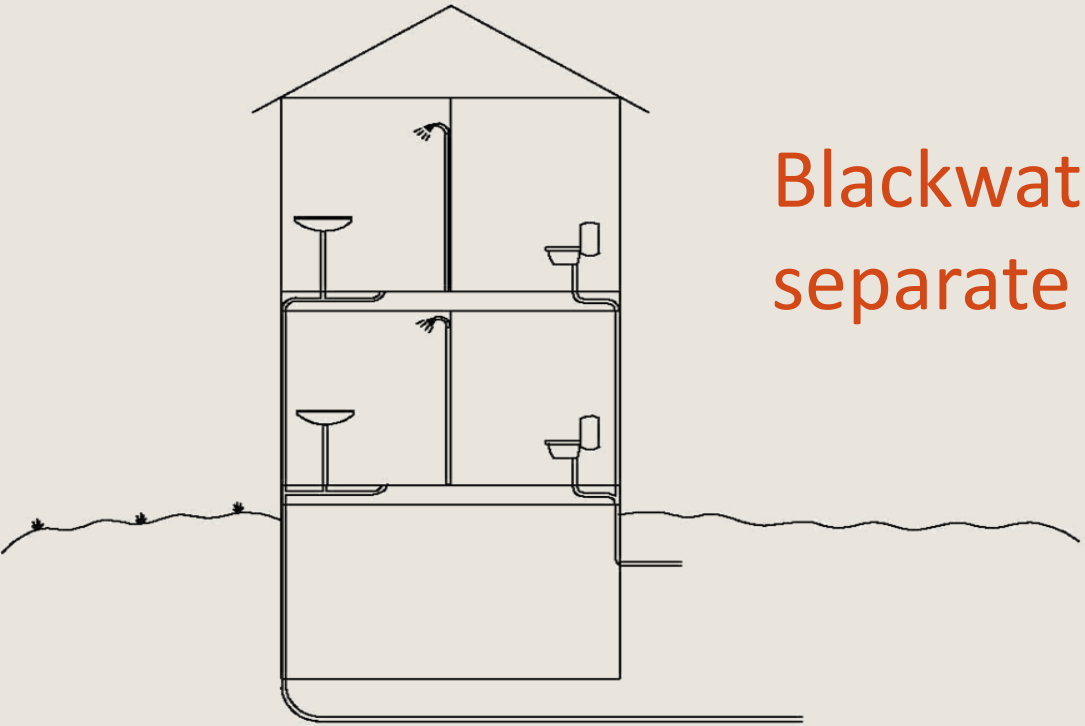
- DHHS DILHR COMM SPS DNR?

WASTEWATER RECYCLING/ SUSTAINABILITY

"…not being harmful to the environment or depleting natural resources, and thereby supporting long-term ecological balance."

Recycling POWTS in Norway

- 3 sites evaluated: POWTS serving 24 apartments, 43 condominiums & 33 townhouses.
- blackwater and greywater are separately plumbed.
- vacuum toilets are used to reduce water consumption
- aerobic hygienization of blackwater
- greywater treated to swimming pool water quality



Blackwater and greywater to separate building sewers

POLLUTANTS FROM RESIDENTIAL

P. Minnis, Pace University

	BOD_5	NITROGEN	PHOSPHATES
TOILET	300	200	100
BATH	200	2	1
BATHROOM SINK	200	2	1
KITCHEN	700	5	10
LAUNDRY	300	10	1
GARBAGE DISPOSAL	2380	79	13

BLACKWATER EFFLUENT

- principally toilet waste
- contains 90% of the nitrogen (N)
- contains 80% of the phosphorus (P)
- contains 30 – 75% of the organic matter (OM)

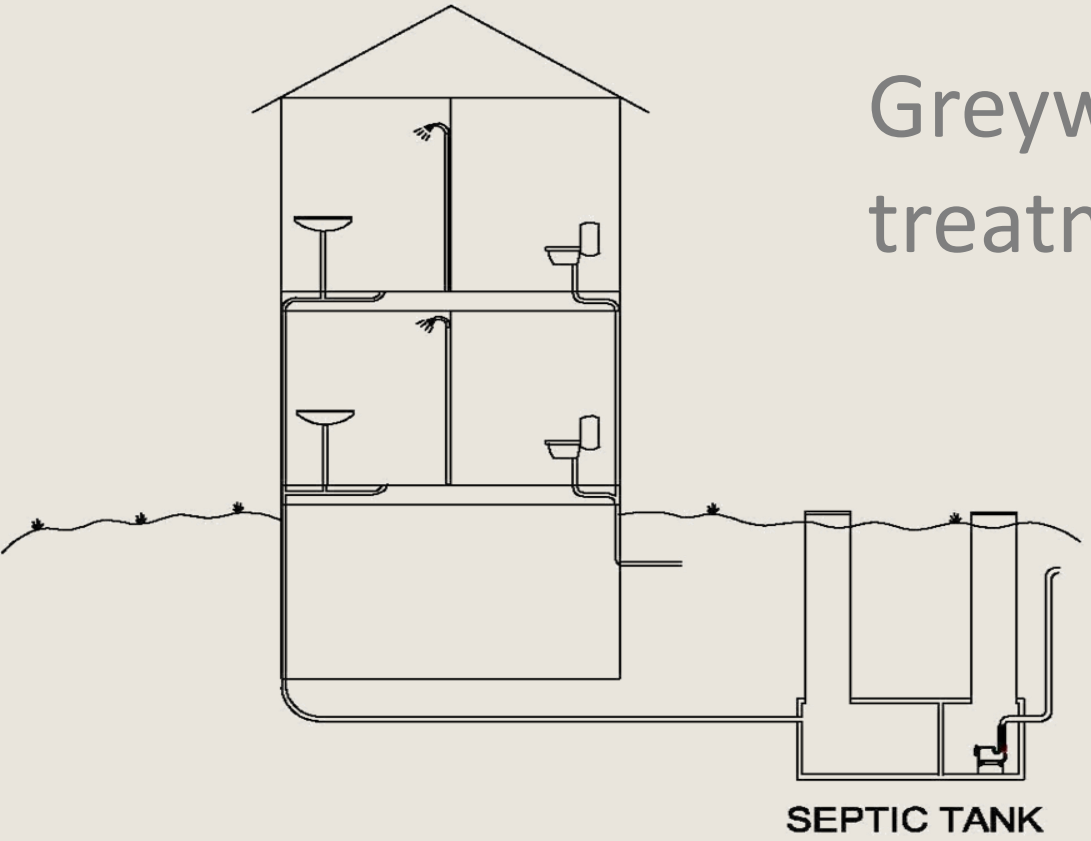
GREYWATER EFFLUENT

- minor amounts of N and P
- significant amounts of OM
- bacteria present
- settling tank used
- single pass sand filter or biofilter (peat) with pressurized dosing
- constructed wetland for treatment
- final destination: spray irrigation/subsurface groundwater recharge/local stream

Greywater uses include: showers, bathtubs, sinks, kitchen sink (no food grinder)

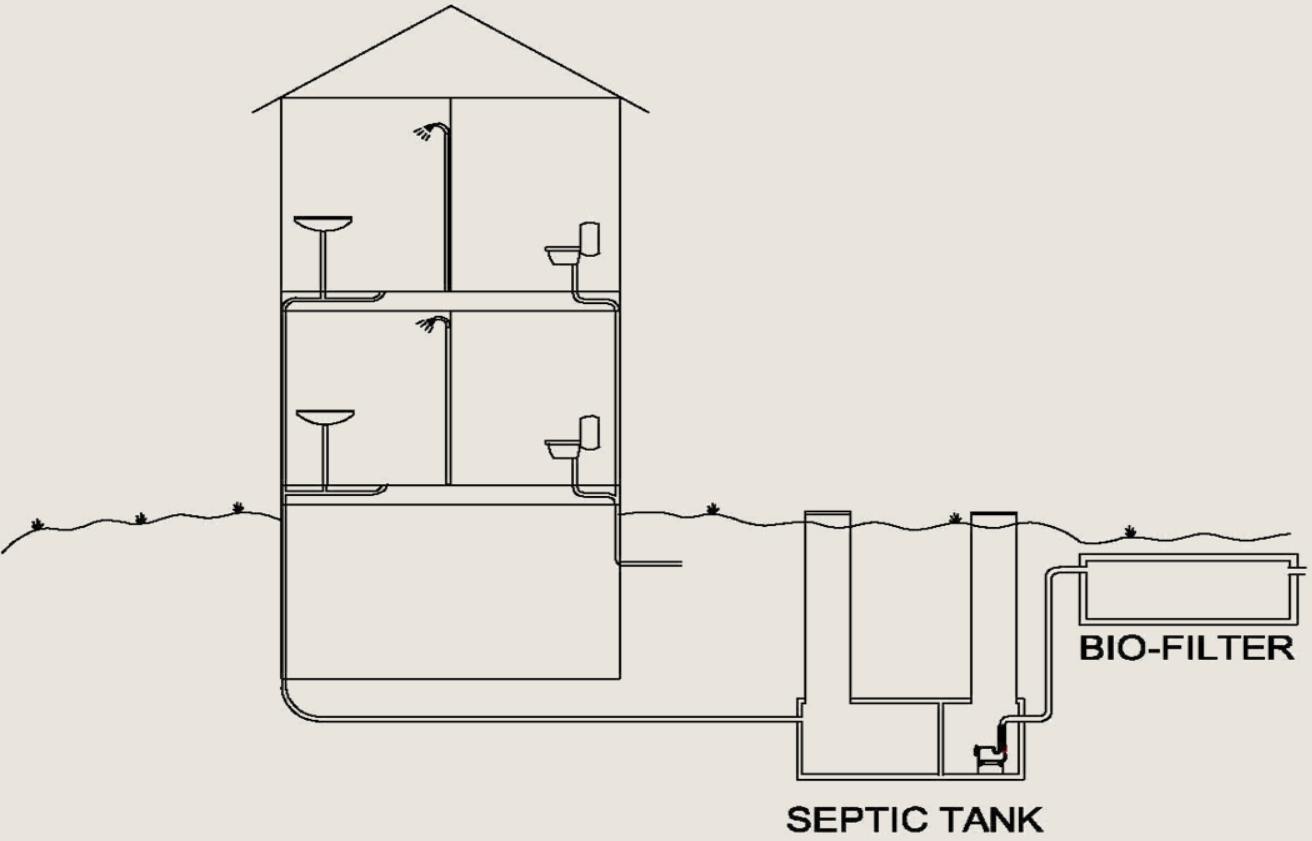
Blackwater uses: toilets, kitchen sink (with food waste grinder)

Greywater treatment



Septic tank allows for settling of particles/inorganics.

Filter on force main.

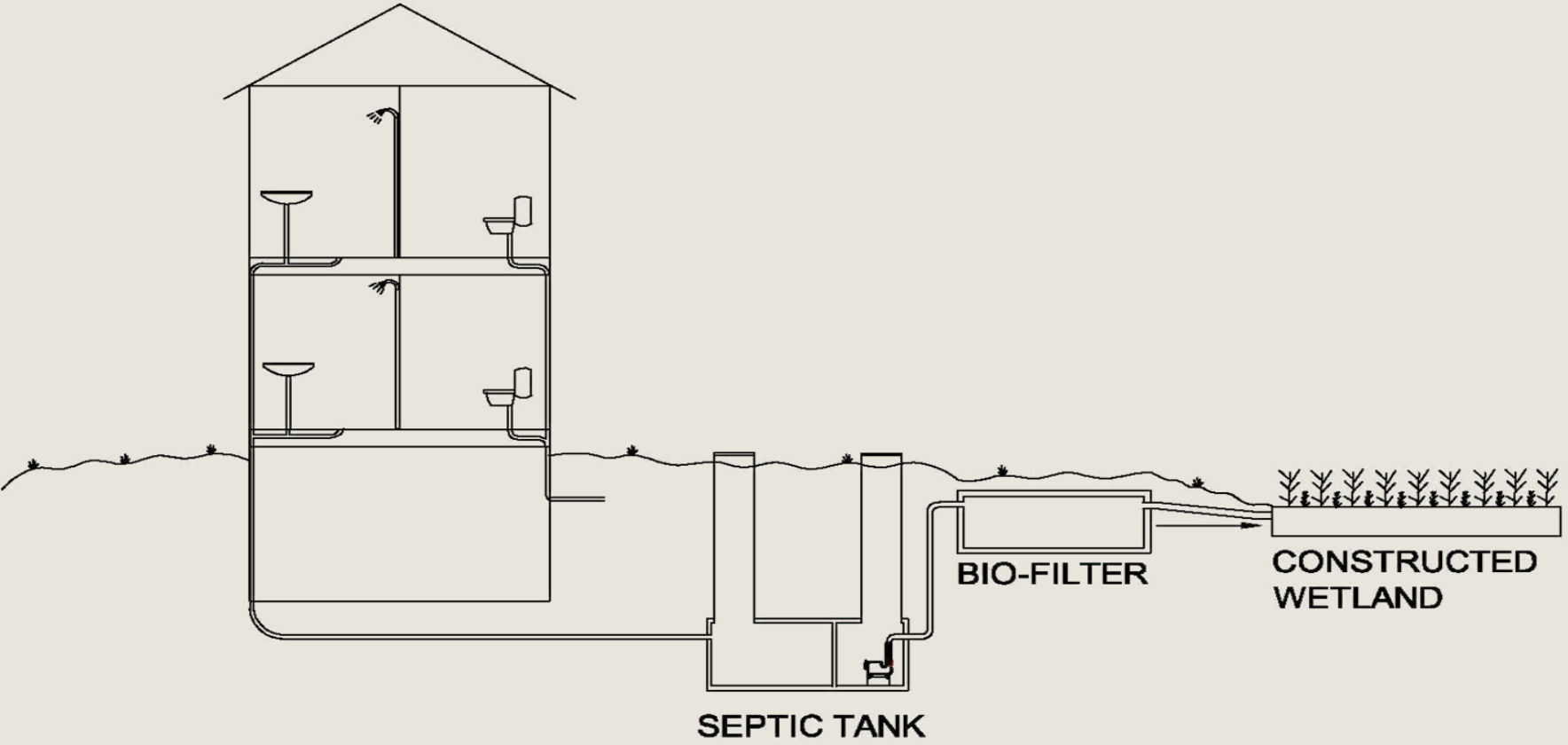


Pump provides for timed dosing and/or even distribution of effluent over a single pass peat biofilter.

PEAT FILTER

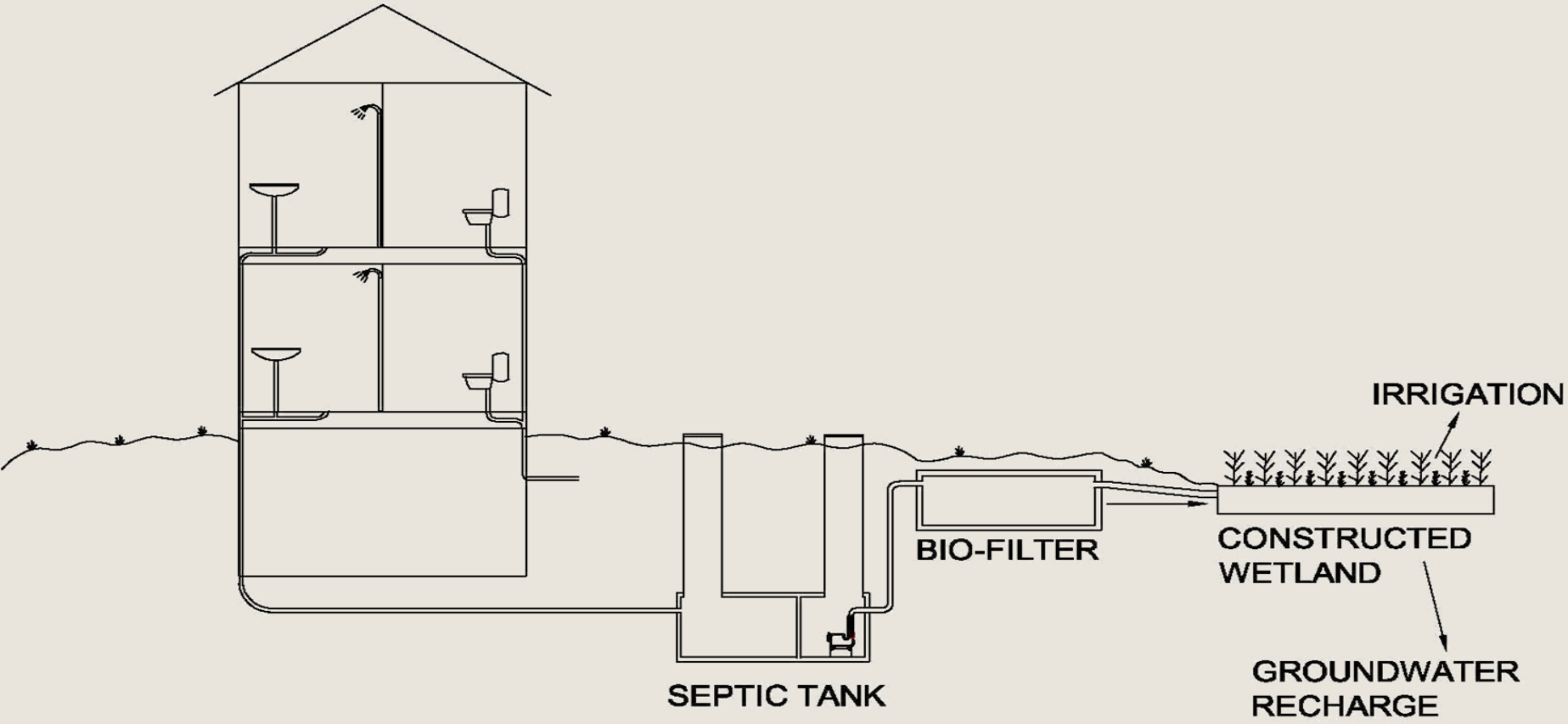
- Peat is lignin and cellulose
- High surface area improves adsorption
- Reduces BOD^5 (96%), fecal coliform (99%) and TSS (93%) in a peat column of 12”
- Thickness increased treatment efficiency
- Replace peat in 8 – 15 years
- Surface area sized

  1 ft^2 per person


BIO-FILTER
CONSTRUCTED
WETLAND
SEPTIC TANK

CONSTRUCTED WETLANDS
Subsurface flow

- 5 - 10 day retention period
- Wetland plants promote settling and bacterial growth on stems, aeration by oxygen transfer
- Surface area sized 20 ft^2 per person, wetland is 3’ deep


IRRIGATION
BIO-FILTER
CONSTRUCTED
WETLAND
SEPTIC TANK
GROUNDWATER
RECHARGE

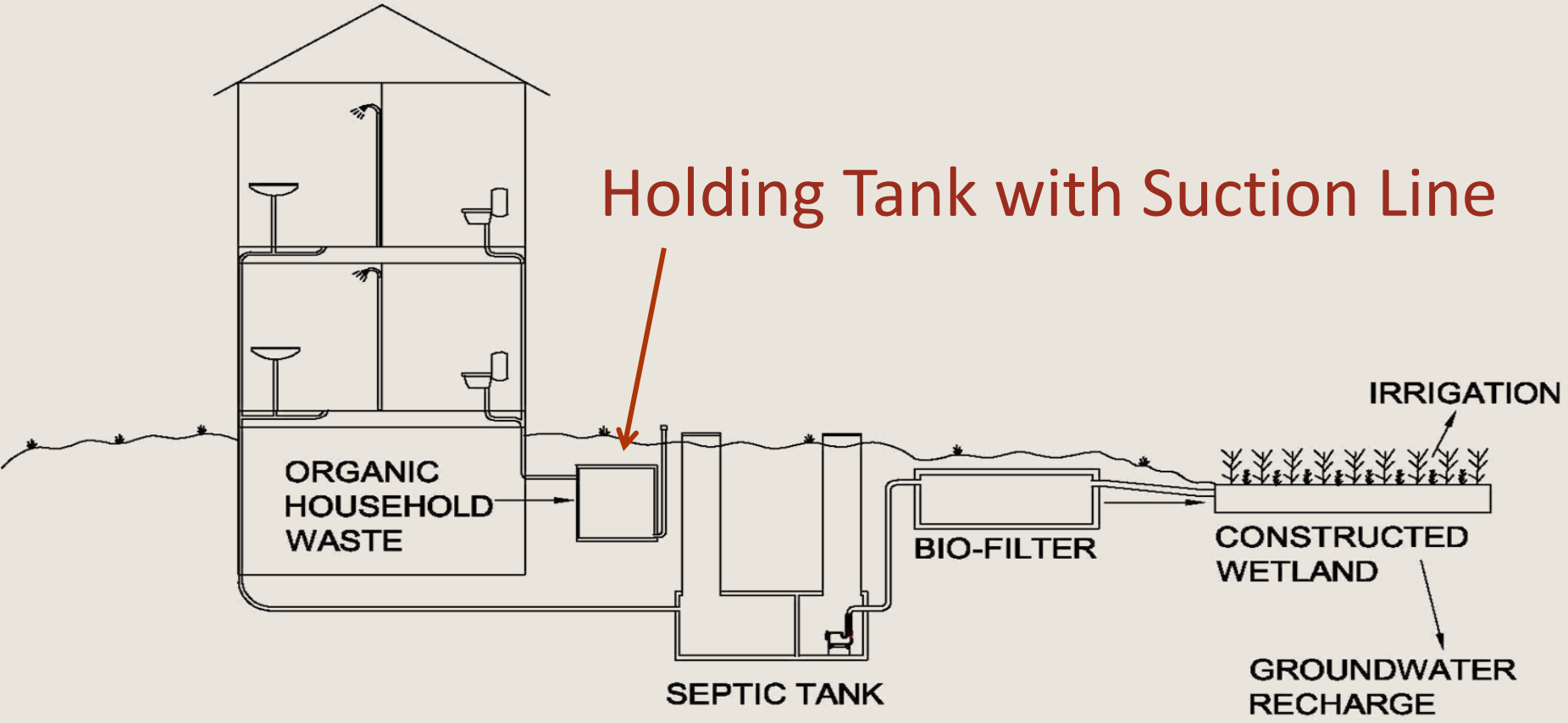
FINAL GREYWATER DISCHARGE
33 Townhouses

- The townhouses located in Oslo, Norway.
- Area over the biofilter used as a playground.
- Mechanical aeration of the greywater used in lieu of a constructed wetland after the biofilter, then discharged to a local stream.

FINAL GREYWATER DISCHARGE
24 Apartments & 43 Condominiums

- The apartments were dormitory rooms at the Agricultural University of Norway.
- The condominiums were located in the city of Bergen, Norway.
- The post-wetland treated effluent was used as spray irrigation in summer and discharged subsurface in winter and when spraying was not in use.

Holding Tank with Suction Line

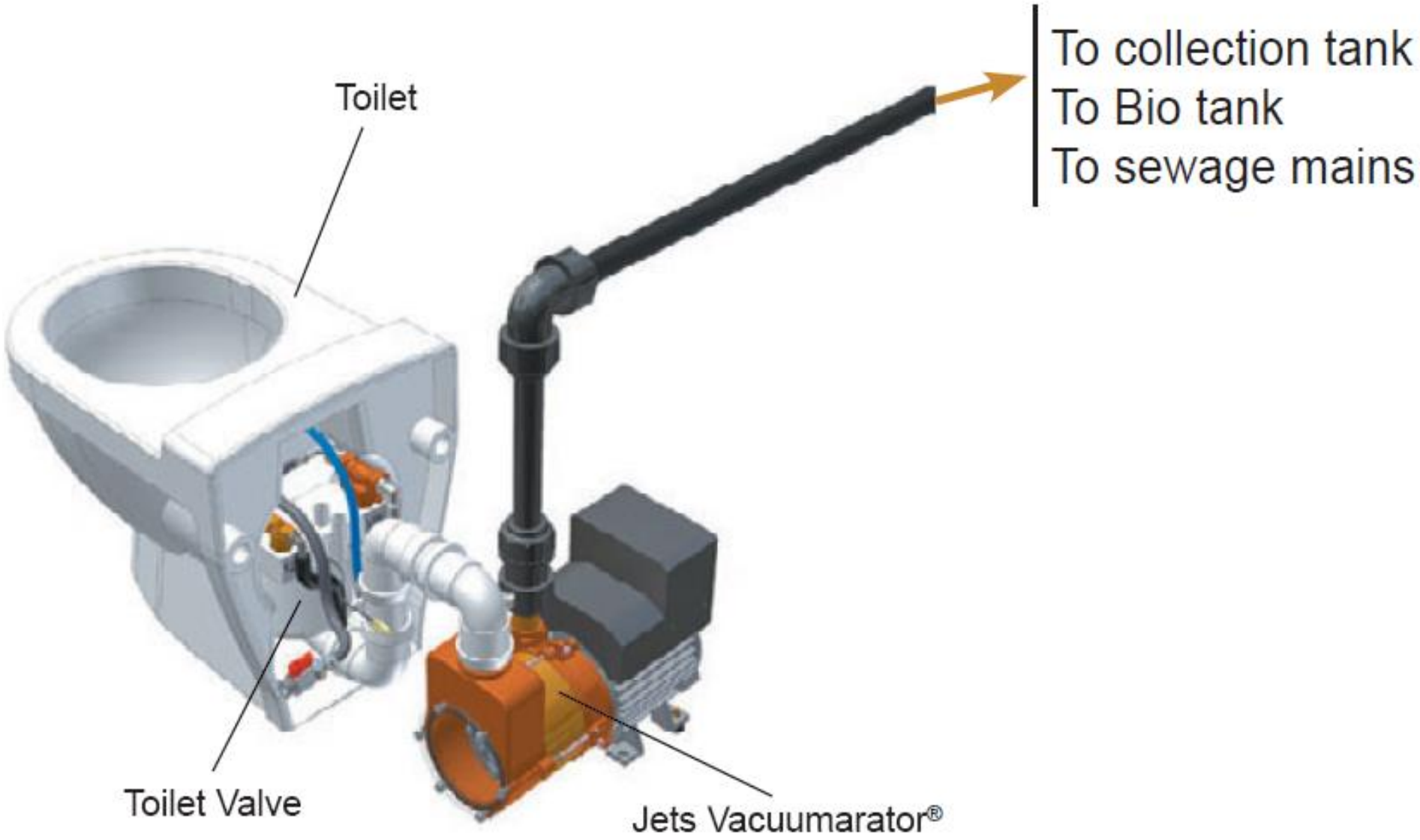


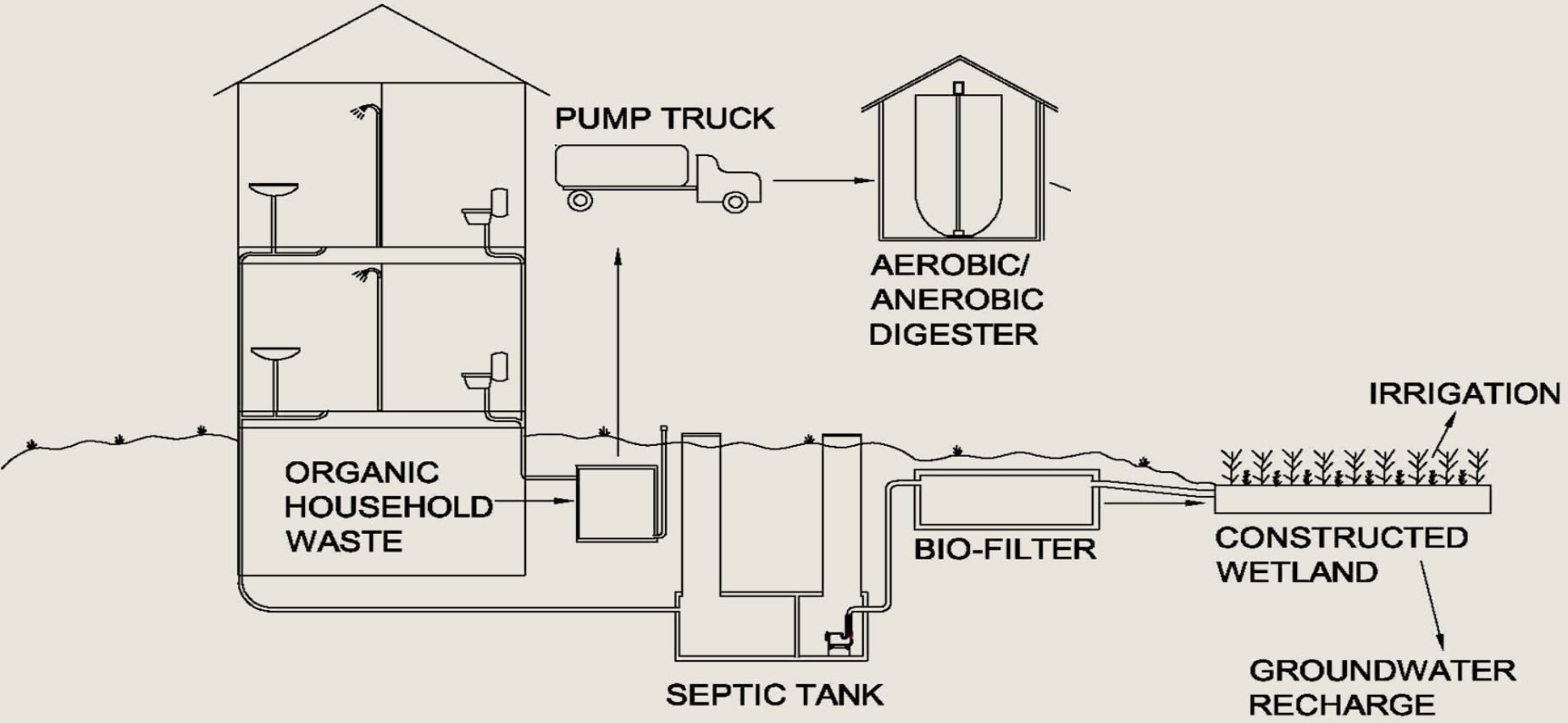
Holding Tanks for Blackwater Discharge in Norway

- Newer construction along with water saving toilets
- For entire villages
- Where there is thin soil over bedrock
- Required in the watershed serving Oslo – extending 30 miles from the city

Vacuum Toilets

- use about 30 ounces of water/flush
- an extreme water saving toilet
- composting toilets similar in efficiency
- avg. family toilet wastewater reduced to 1800 gallons/year


To collection tank
To Bio tank
To sewage mains
Toilet
Toilet Valve
Jets Vacuumarator®

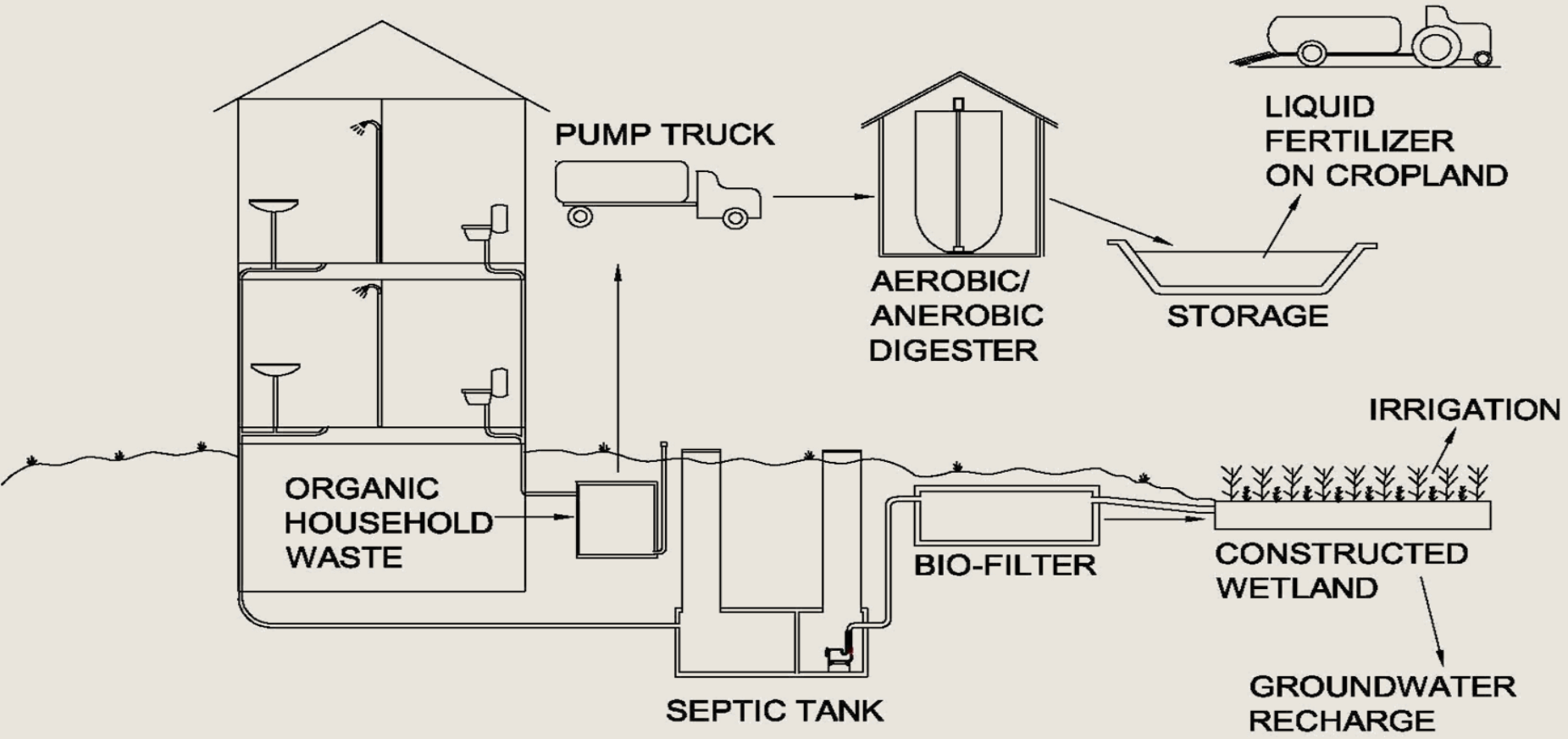

PUMP TRUCK
AEROBIC/
ANEROBIC
DIGESTER
IRRIGATION
ORGANIC
HOUSEHOLD
WASTE
BIO-FILTER
CONSTRUCTED
WETLAND
SEPTIC TANK
GROUNDWATER
RECHARGE

CONVERTING BLACKWATER to FERTILIZER

- Goal is to sanitize (remove pathogens: bacteria, viruses, parasites) and remove odors
- LIQUID COMPOSTING REACTOR: Blackwater mixed with organic household waste, animal manure or food processing waste to speed up composting by increasing concentration of OM.
- Biomass composted at 130 – 140^{o} F

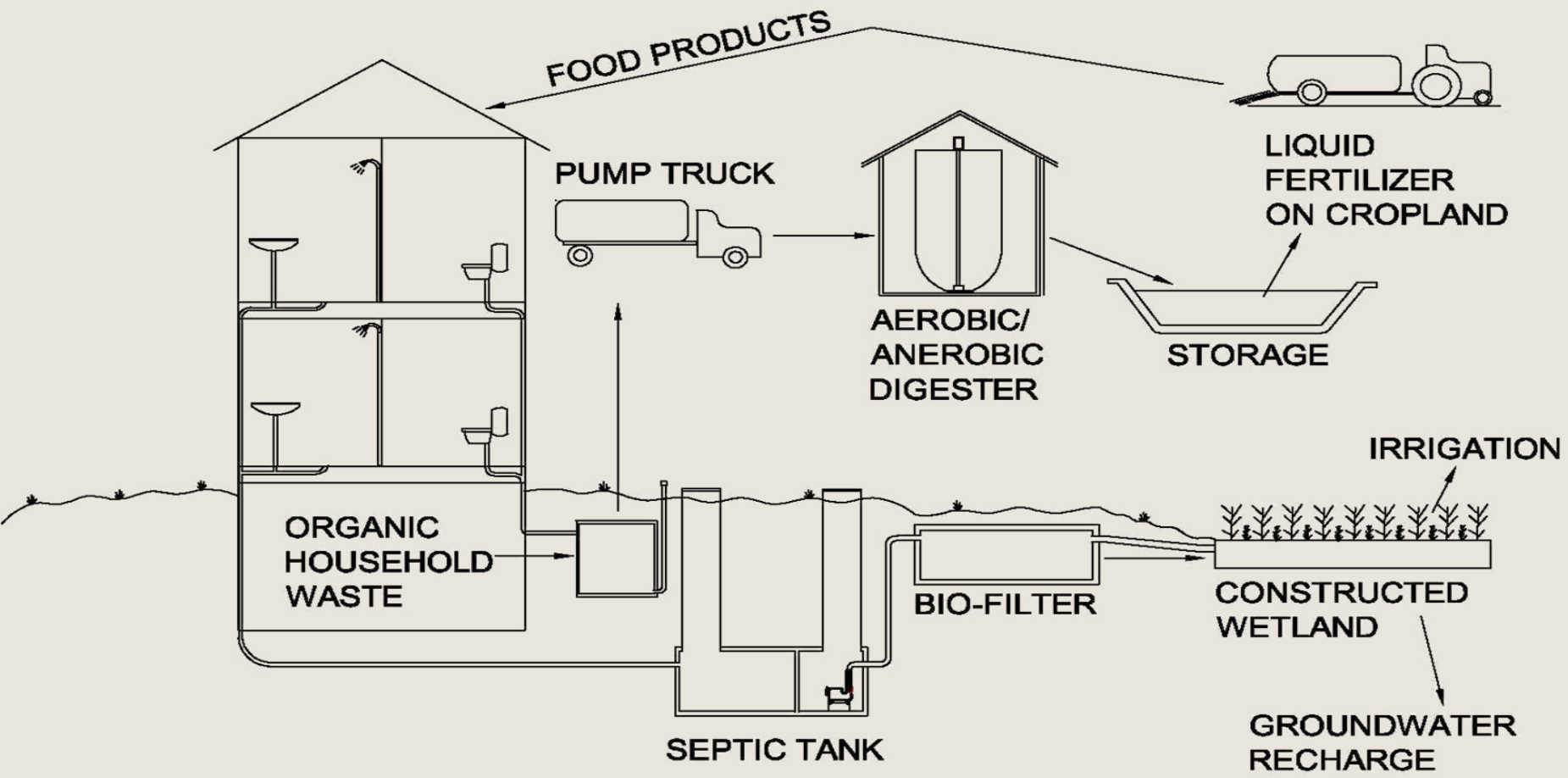
CONVERTING BLACKWATER to FERTILIZER (cont…)

- End product is odorless fertilizer slurry
- Biogas from reactor could be usable energy byproduct


PUMP TRUCK
LIQUID
FERTILIZER
ON CROPLAND
AEROBIC/
ANEROBIC
DIGESTER
STORAGE
IRRIGATION
ORGANIC
HOUSEHOLD
WASTE
BIO-FILTER
CONSTRUCTED
WETLAND
SEPTIC TANK
GROUNDWATER
RECHARGE

DIRECT GROUND INJECTION TECHNOLOGY

- Slurry injection inhibits runoff on slopes and to sensitive areas
- Nearly 100% of the nitrogen/ammonia is utilized and unevaporated
- Slurry can be monitored for toxic compounds



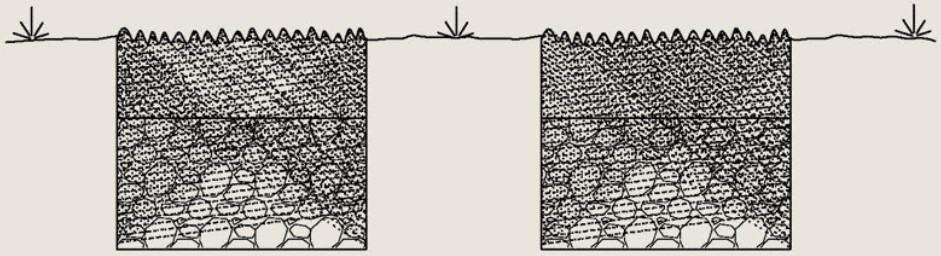
RECYCLING SYSTEM USING BLACK & GREYWATER SEPARATION

(Jenssen, P.D. 2003. "Design and performance of ecological sanitation systems in Norway")

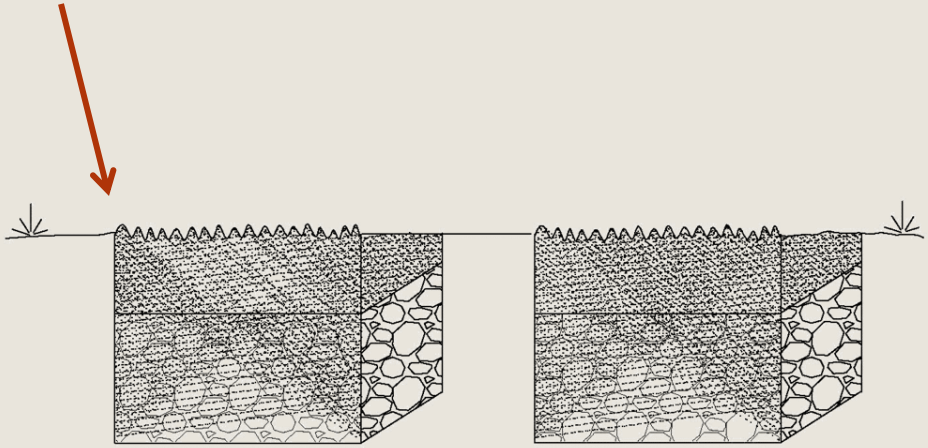
POPULATION INCREASE

- URBAN AGRICULTURE
- WATER CONCERNS – ECOLOGICAL? FINANCIAL?
- WATER RE-USE & RECYCLING
- TRANSPORTATION COSTS
- VERTICAL EXPANSION

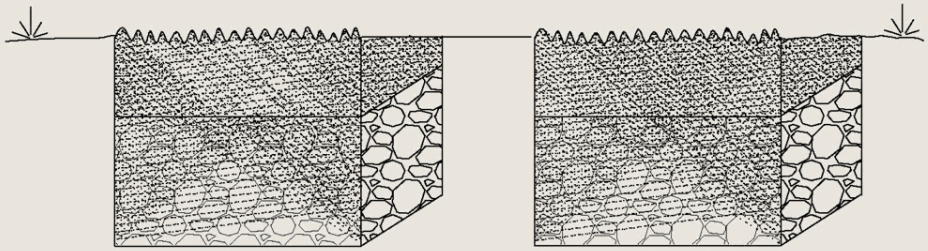
BUILD YOUR OWN POWTS!

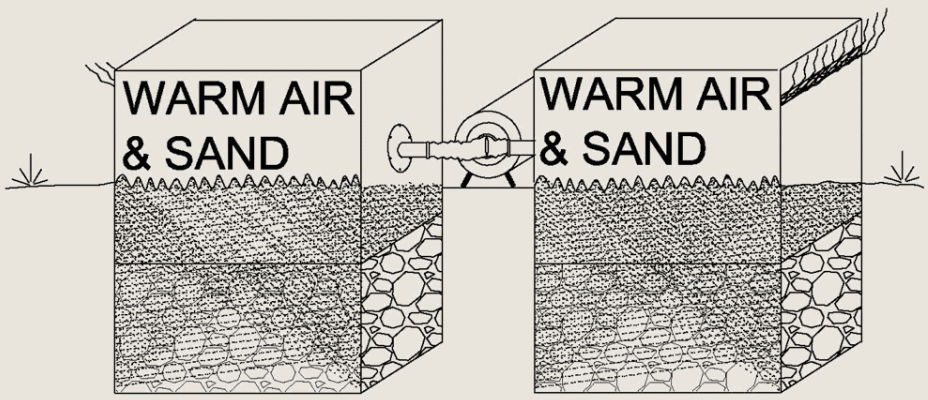


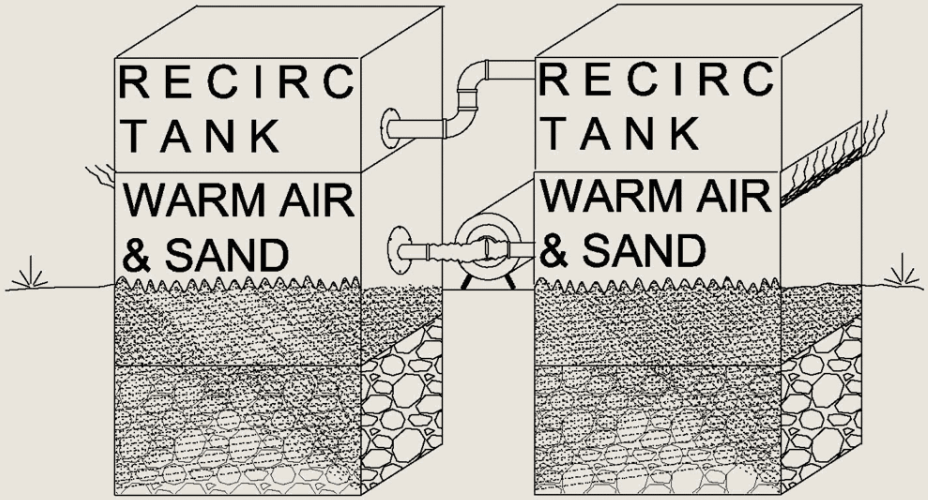
Engineered soil mix based on *in situ* soil



Separate Blackwater and Greywater treatment columns




WARM AIR
& SAND
WARM AIR
& SAND


RECIRC
TANK
WARM AIR
& SAND
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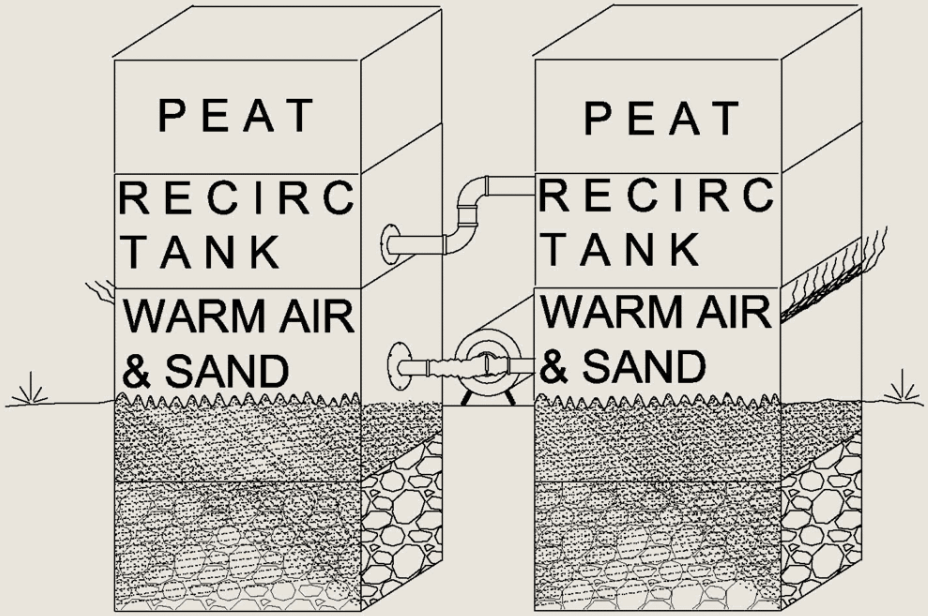
& SAND


PEAT
RECIRC TANK
WARM AIR & SAND
PEAT
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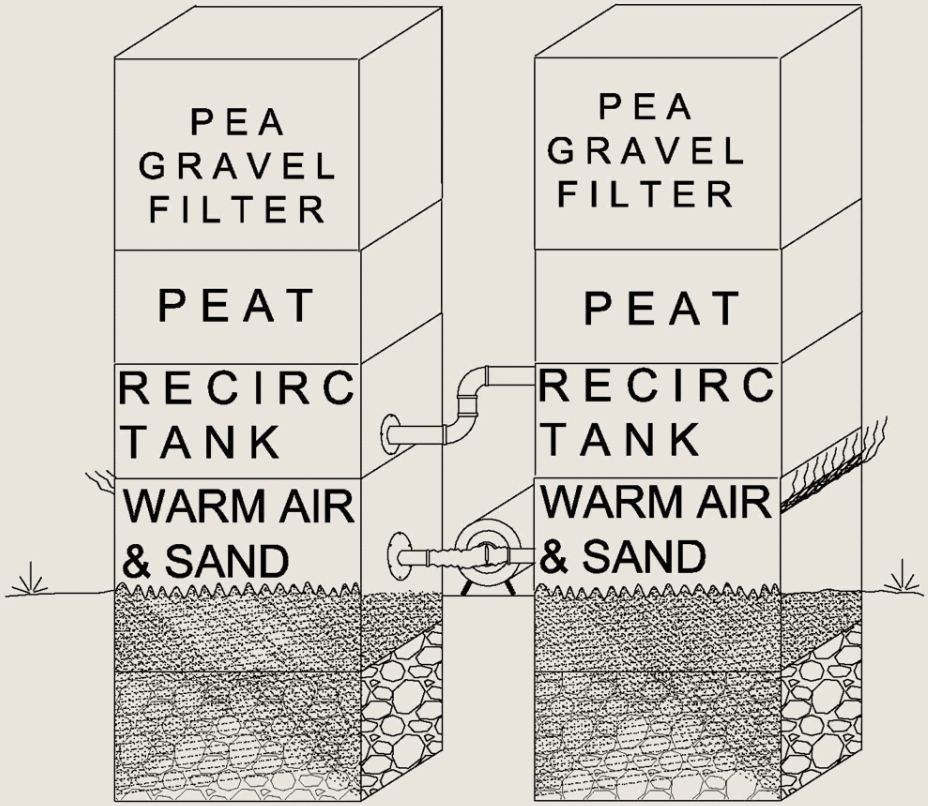
WARM AIR & SAND


PEA
GRAVEL
FILTER
PEAT
RECIRC
TANK
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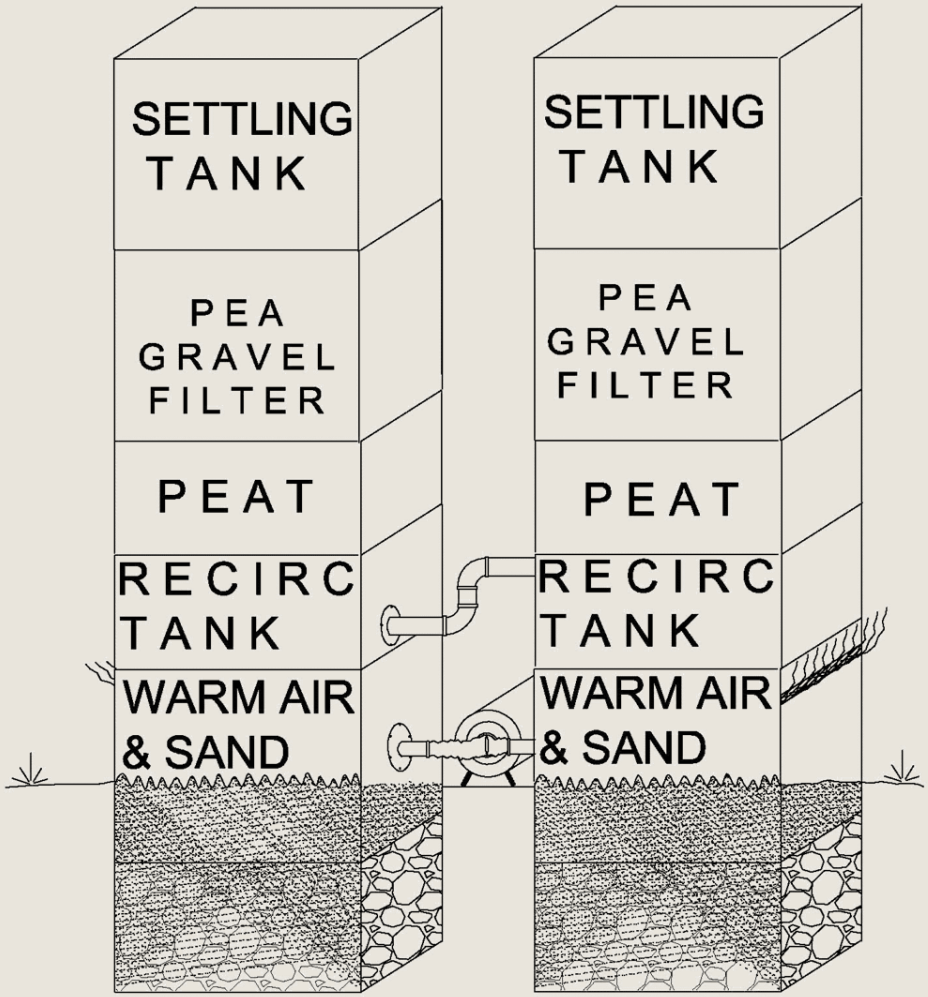
SETTLING TANK
PEA GRAVEL FILTER
PEAT
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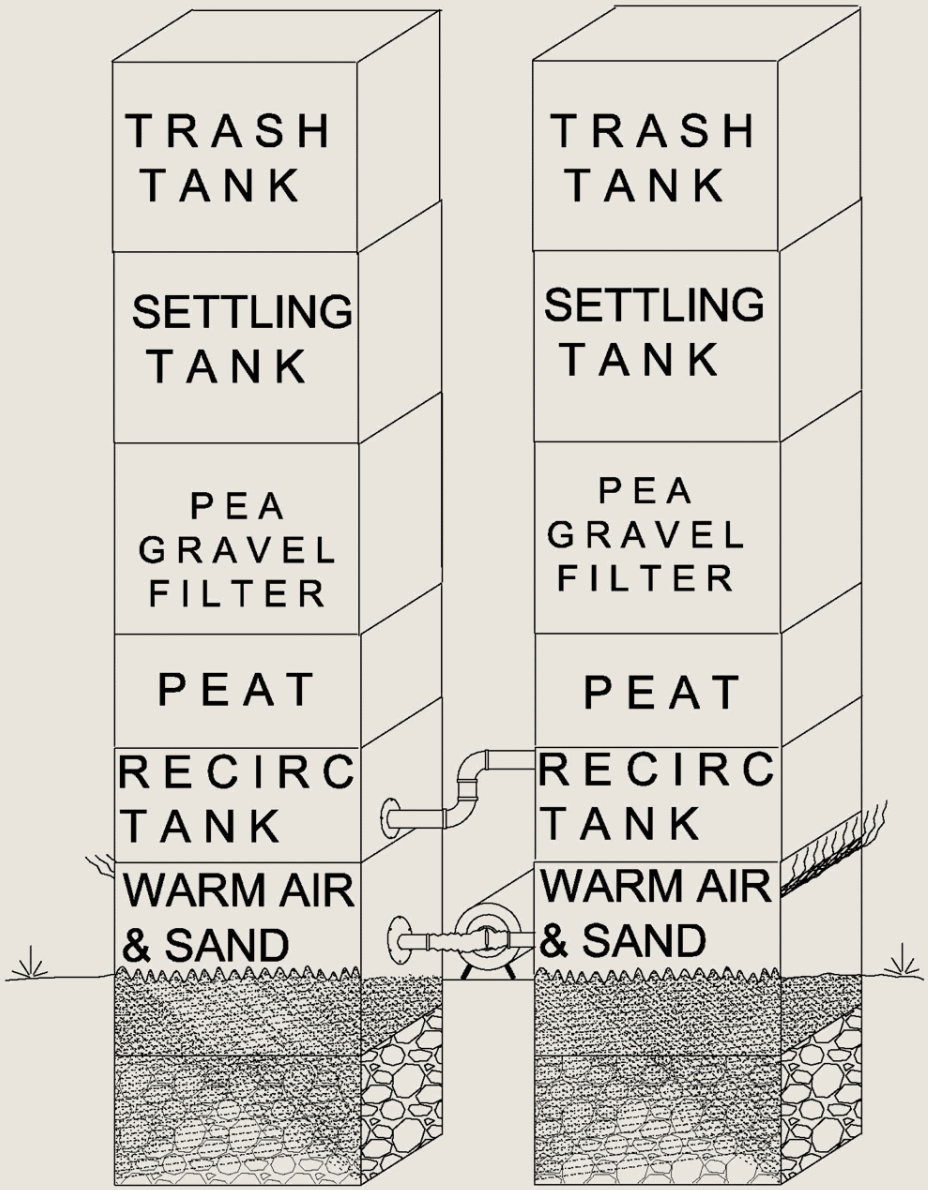
TRASH TANK
SETTLING TANK
PEA GRAVEL FILTER
PEAT
RECIRC TANK
WARM AIR & SAND
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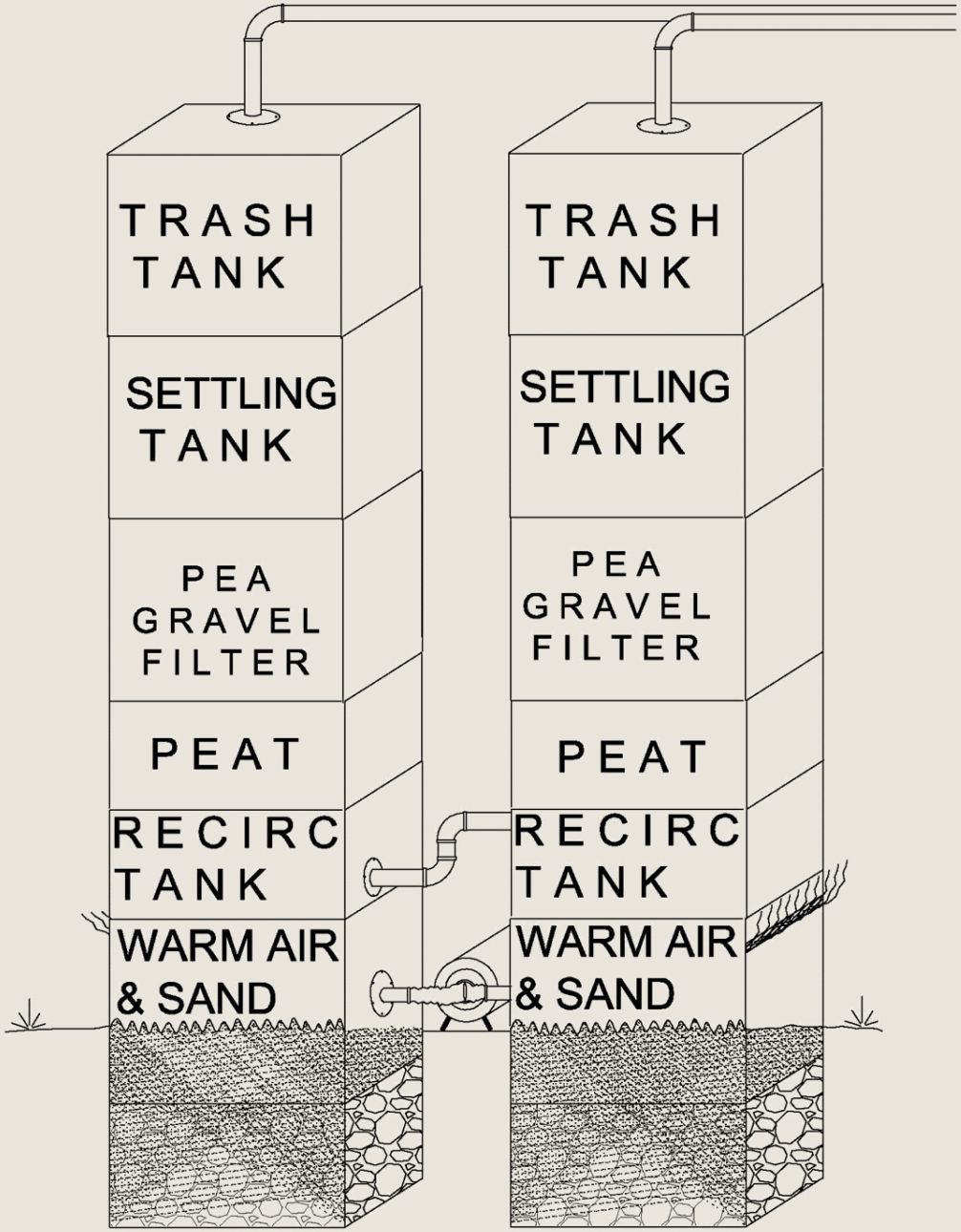
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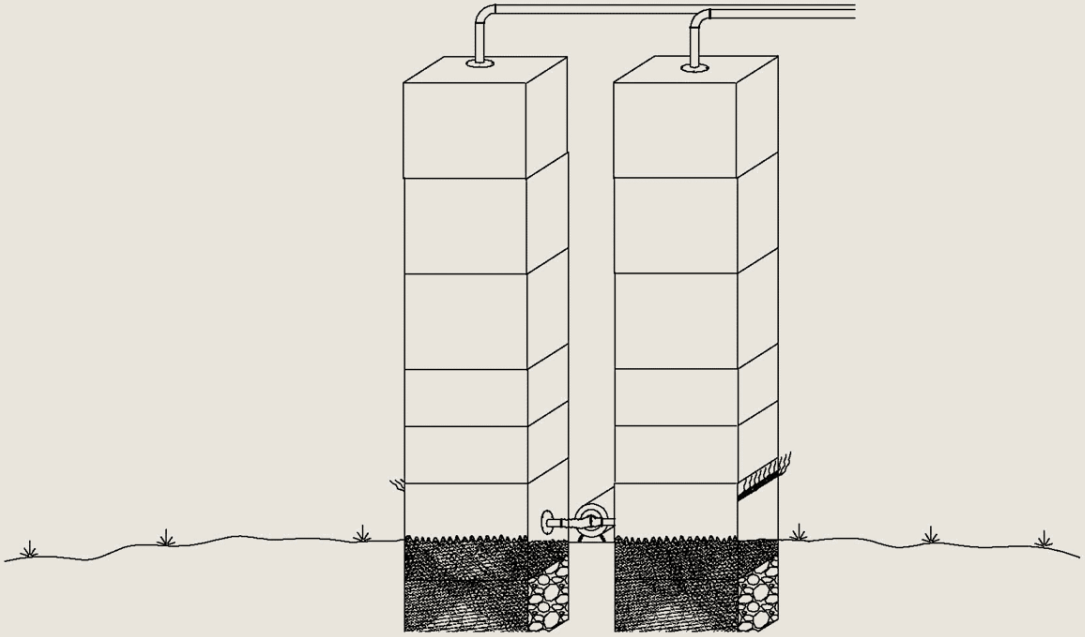
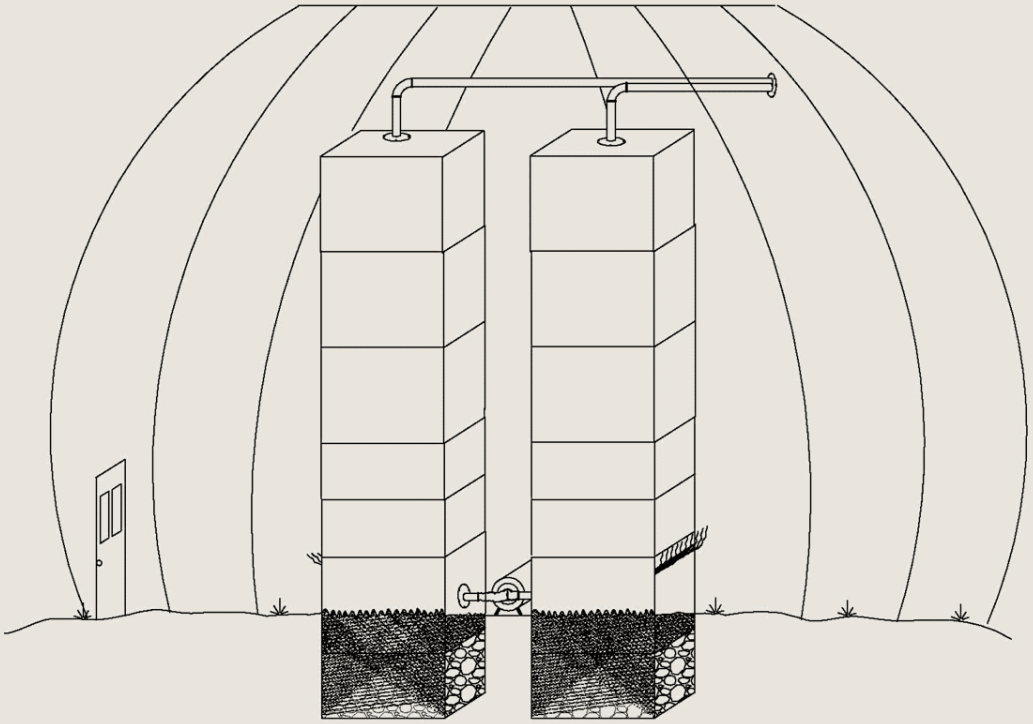
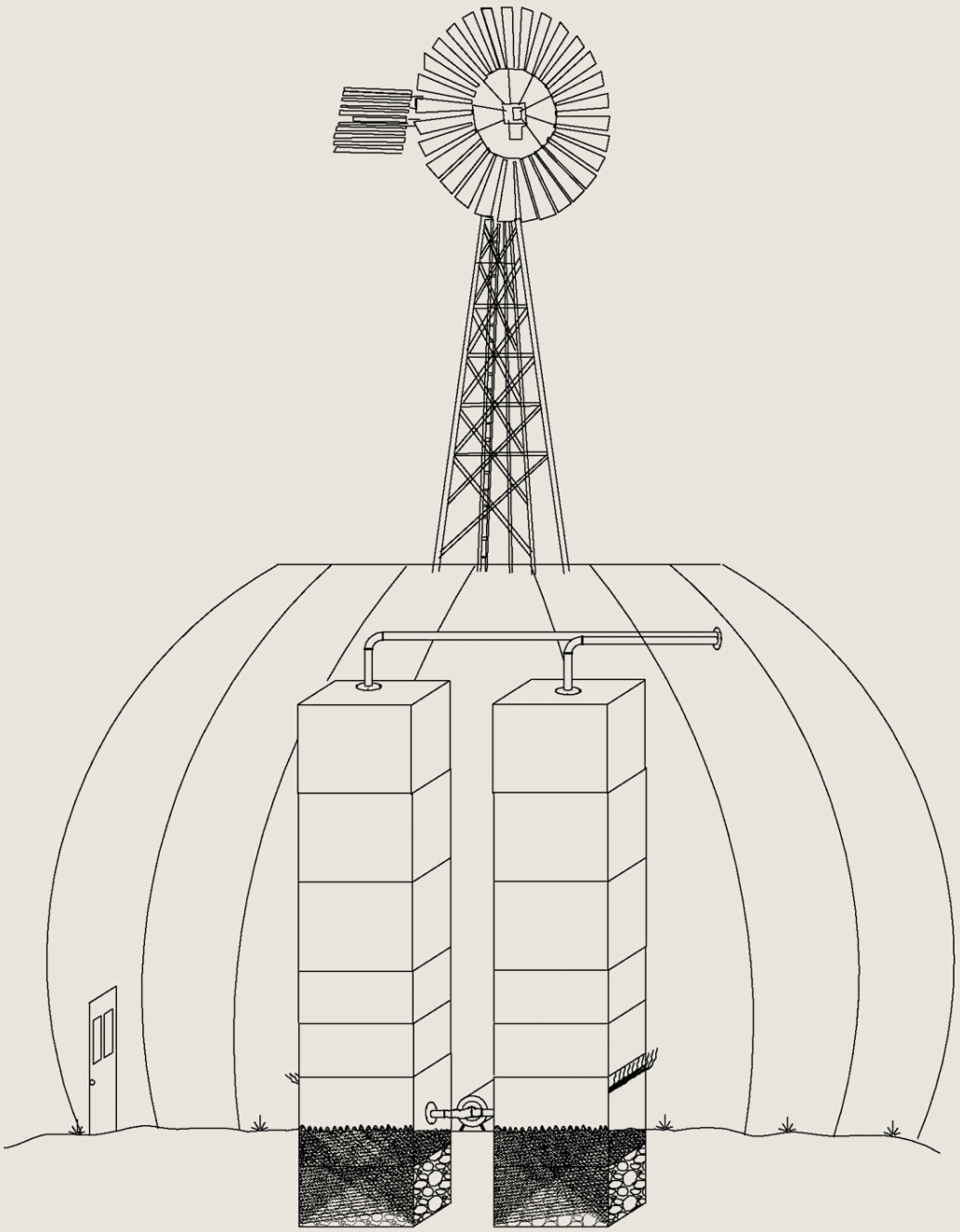
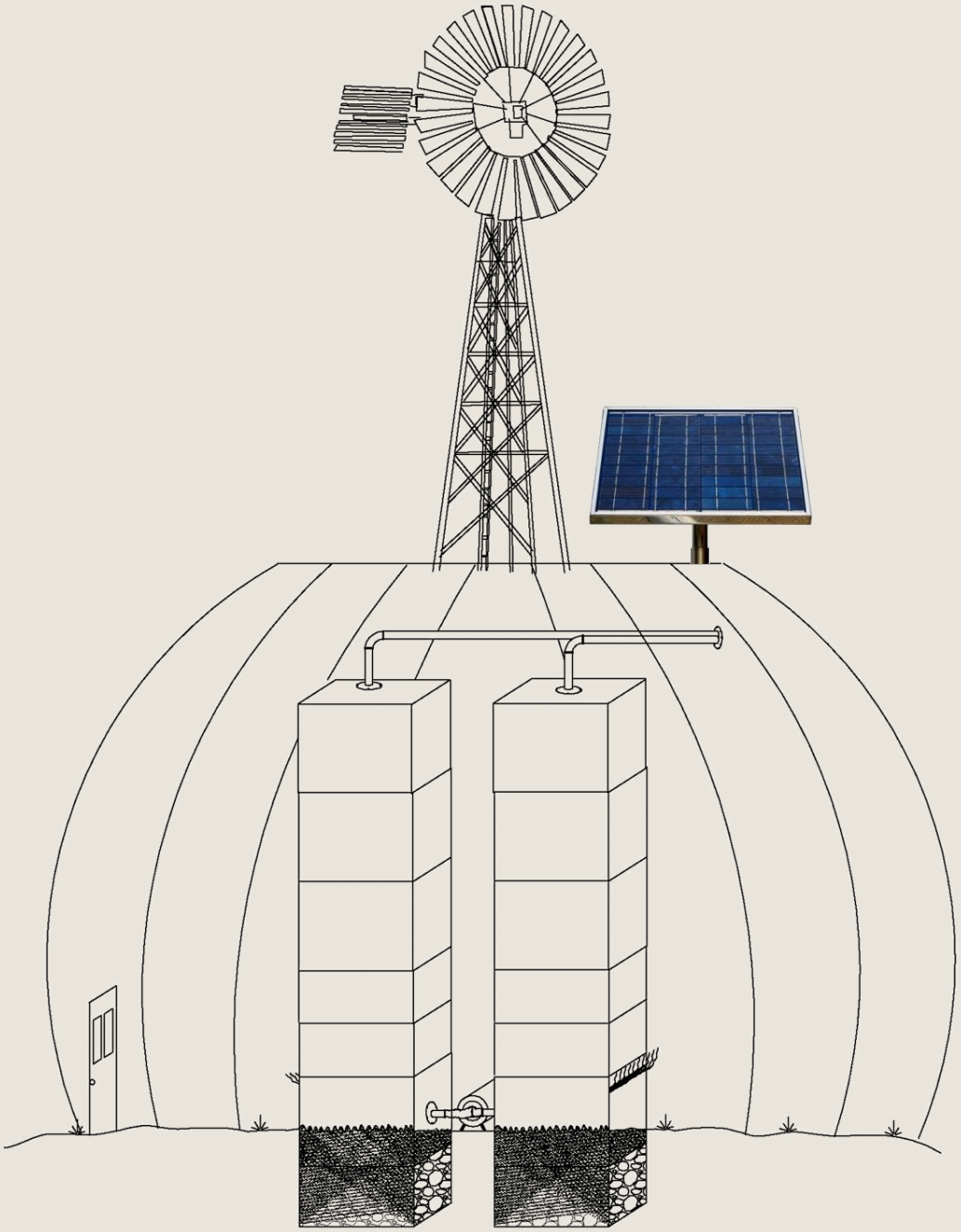
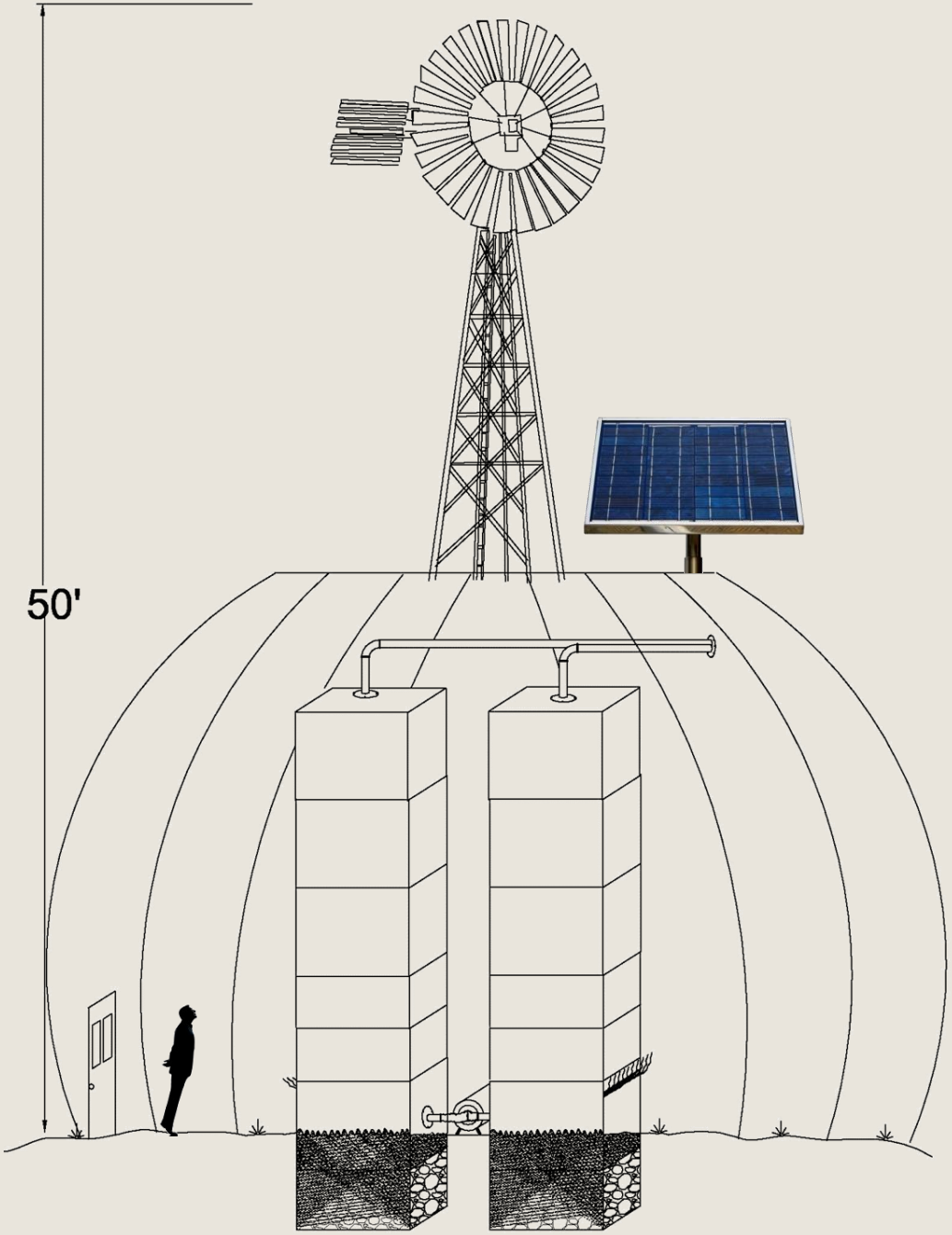


HEATED ONION DOME





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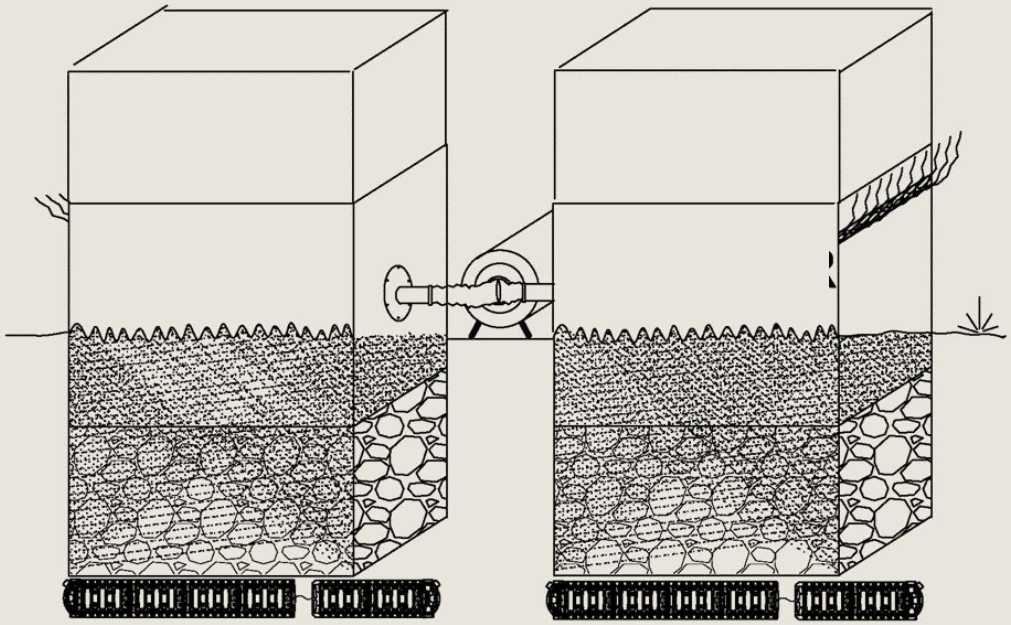


40% SOIL CREDIT FOR USE OF CHAMBERS

WASTEWATER DIGESTERS AND BIOGAS REMOVAL UNITS

LASER GUIDED EXCAVATION

Using GPS coordinates, preset the excavation outline and depth. Sit back and monitor.

BUT SERIOUSLY…

WHAT CAN WE EXPECT FROM HAVING MORE PEOPLE IN LESS SPACE?

WHAT WILL THIS MEAN FOR ONSITE WASTEWATER TREATMENT SYSTEMS?

POPULATION PRESSURE WILL CHANGE THE POWTS INDUSTRY – INITIALLY NEAR LARGE URBAN AREAS

ABOUT THOSE LARGER URBAN AREAS...

Centralized wastewater treatment systems:

- usually follow centralized public water mains.
- do not recycle the used water back to the same aquifer – it's sent downstream.
- installation and management is costly for smaller communities and low density areas.
- have problems expanding - cost and public acceptance.

THE FUTURE FOR POWTS?
A Proposal from a decade ago

Voluntary National Guidelines for Management of Onsite and Clustered (Decentralized) Wastewater Treatment Systems (EPA, 2003)

5 Steps/Levels for Management of Wastewater Treatment Systems

1. Homeowner Awareness
2. Maintenance Contracts
3. Operating Permits
4. Responsible Management Operation (RME) and Maintenance
5. RME Ownership

Level 1 – Homeowner Awareness

POWTS owned & operated by individual property owners.

Conventional systems that require little attention.

County provides maintenance reminders at specified intervals

Level 2 – Maintenance Contracts

For complex designs to enhance capacity of conventional systems.

For improved treatment capability.

Contracts with qualified technicians required for proper and timely maintenance.

Level 3 – Operating Permits

Specifies activities and types of treatment designs to protect public health and water quality

Limited term maintenance contracts – renewable if POWTS in compliance.

Performance based designs allowed with proper management controls in place.

Level 4 – Responsible Management Entity (RME) Operation and Maintenance

Specifies highly reliable POWTS to ensure health and water quality protection.

Operation permit issued to RME, not property owner to assure appropriate maintenance.

Level 5 – RME Ownership

Specific POWTS owned, operated and maintained by RME.

Property owner removed from responsibility for system.

Analogous to municipal treatment systems in procedure.

Who could be the RMEs?

- The local public municipal wastewater treatment utility.
- A private/public utility monopoly.
- A private sewer utility.
- Private companies/co-ops/insurance.

Why?

(EPA)

- POWTS serve 25% of US population.
- POWTS serve 33% of new construction.
- >50% of POWTS are >30 years old.
- 20% are malfunctioning to some degree.
- Most owners are unaware of problem.
- Improperly managed POWTS contribute to water quality problems .....

Why? (cont.)

- Protection of public health and local water resources.
- Protection of property values.
- Groundwater conservation.
- Preservation of tax base.
- Life-cycle cost savings.

Minnesota (1997) Allowed Water Quality Cooperatives to provide Management Services for POWTS.

Public Management Structures including:

- municipal utilities
- sanitary sewer districts
- subordinate service districts
- public utilities (city, town or county)

A fee is levied for services provided.

The Future of Onsite Wastewater Systems by Kevin M. Sherman

- 2002 article for Florida Onsite Wastewater Association.
- Small communities can't get grants/loans to repair/replace wastewater treatment facilities.
- POWTS community must speak same language as centralized sewer counterparts.
- Failure to properly manage technology is the POWTS Achilles' heel.
- System management must be in the hands of trained professionals not homeowners.

The Future of On-site Wastewater

by Amish Jantrania, Virginia Dept of Health

- 1998 article
- Onsite community - gain public acceptance and confidence for decentralized wastewater treatment.
- Develop operation and maintenance infrastructure.
- Define roles for installers, pumpers, designers, soil testers, regulators - “players” - to create efficiency.
- Onsite systems must guarantee operational and environmental safety.
- Management/maintenance must be done by a public utility

Urban Wastewater Management in the US: Past, Present and Future

by S. Burian, S. Nix, R. Pitt & S. Durrans

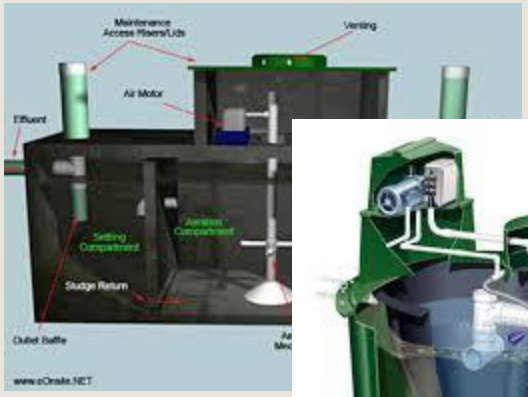
- 2000 article in *Journal of Urban Technology*
- Onsite wastewater industry have produced viable alternatives to centralized/municipal treatment.
- Decentralized wastewater systems (onsite wastewater treatment) save money and promote watershed management.
- Future options will need an integrated combination of centralized and decentralized with emphasis on reuse.
- Primary difficulty for POWTS industry is overcoming years of institutional inertia that favor centralized systems.

Example: Clark County, WI

- 1990s experiment with Clark County Electrical Cooperative
- Own and manage POWTS
- Provided soil testing, design, installation, maintenance
- Not enough interest – idea dropped

INVASION OF THE POWTS SNATCHERS!!!

It started innocently with mechanical treatment devices



Municipal Wastewater Treatment Proponents (including many urban and land use planners)...

looked down their noses at the smelly, incomplete and unmanageable POWTS!

Municipal Wastewater Treatment Plants awashed in dollars from federal and state government grants, increasing tax base...

and Engineering Firms/Planners in love with large design schemes and their profitability!

but then …

the federal block grant money dried up, the tax base bubble collapsed and recession arrived.

A likely scenario…

- “Yourtown, Wisconsin”
- population 1000
- old wastewater treatment plant needs upgrading – under WDNR orders to repair or replace – polluting local stream
- no grant funding available
- on-site treatment (decentralized) may be 1/2 the cost of new central treatment system

but...

management/maintenance is the perceived issue with OWTS!

(the “P” is now gone)

Yourtown decentalized wastewater treatment using pretreatment

- Revises existing sanitary district to own all the existing and new OWTS in vicinity.
- Sanitary district initially contracts with installers, designers, soil testers, pumpers and maintainers for technological expertise and maintenance.
- Later the public sanitary district adds own employees to perform “sanitation work” similiar to original business model for the sanitary district.

YOURTOWN SANITARY DISTRICT

- regular Water & Sanitation fees to residents.
- constant monitoring of all OWTS systems for operation & performance.
- homeowners are free of obligations.
- homeowners are educated for what can be flushed into toilet/disposed of, reminded of ongoing wastewater monitoring/fines possible.

APPLIED TO LARGER URBAN AREAS

- Fringes of urban areas using POWTS are larger lots
- Failing POWTS in fringe areas are of more concern to urban watershed
- No funding/grants for extension of centralized sewer district
- No room to expand centralized treatment

DECENTRALIZED WASTEWATER TREATMENT

- A community OWTS (cluster) and/or individual systems owned by the local sanitary utility
- Sanitary district operates, manages and maintains the OWTS
- Public employees - soil testers, designers, pumpers, installers

POWTS Snatcher Summary

- Consider the problems we have with POWTS mechanical components.
- Do they all produce the same high quality effluent?
- Are they 100% maintained?
- Owners don't like the +$500/year maintenance charge for pretreatment units.
- Counties don't have time or personnel to monitor them.
- State washes their hands of the management once plan is approved.

ENVIRONMENTAL PROTECTION of the Future

Remember the *alternative* Mounds of 1979 to 1983?

- The technology was proven to work yet was prohibited in Wisconsin ... why?
- Before the introduction of the Mound drainfield all POWTS were, essentially, land use control tools by governmental planners.
- Mounds for new construction were limited to a few thousand/year assigned on first come/first served basis – stated “for research purposes”
- Finally University POWTS researchers said “NO MORE”

Planning and Land Use Control Advocates:

- Failed to foresee the new MOUND alternative and had to fight for many controversial new rules for managing land use depending on location.
- Previously had been pushing for restricted POWTS use based on nitrate contamination of groundwater.
- Know that the recent recession has only delayed the debate.

The Future for POWTS and the Environment

- Nitrate reduction systems will become standard.
- Phosphorus reduction systems next.
- Heavy metal, VOC, hazardous and toxic compound concerns will follow.
- Management and maintenance needs will increase exponentially.
- Who will do this? Who will be responsible?

How to Keep the P in POWTS?

- The many treatment devices available have to be independently certified for influent/effluent comparison & capability for degrees of treatment.

- The management of mechanical treatment devices has to be formalized, upgraded and highly regulated.

A POWTS Insurance Company?

- Owners pay a monthly fee
- All management & maintenance Company responsibility
- Company provides for cost of replacement
- Company monitors POWTS for overuse
- What would be a monthly fee?

POWTS Insurance Company

Monthly fee analysis:

- Cost for replacement = $10,000 after 20 years
- Cost for maintenance = $500 per year ($10,000 total)
- Interest/inflation = 5% per year

$20,000 + interest $20,000 = $40,000

$40,000/ 240 months = $167 monthly fee

Profit gain: longevity, maintenance, interest, many systems to manage

We have to encourage the creation of PRIVATE management entities to take over the management/maintenance from the owners

But the key to success would be the ability to monitor the POWTS for overuse before it does damage to the system

The POWTS industry has something to prove to the public, now...

before the public provides it...

later!