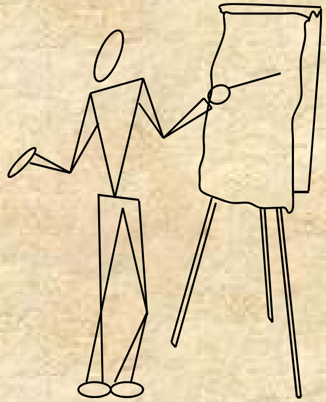
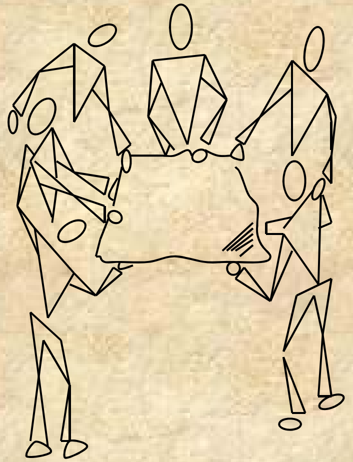
Developing Watershed Plans to Restore and Protect Our Waters



Wastewater Treatment Systems



Roger Miranda

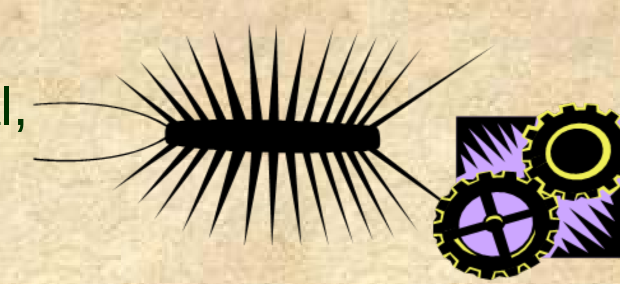
Texas Commission on Environmental Quality

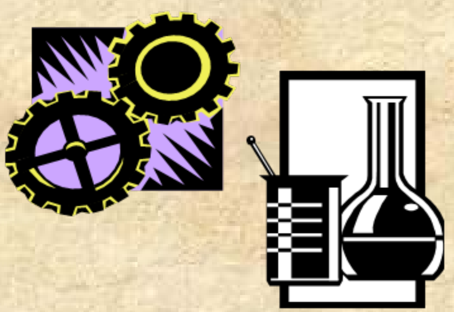
Texas Watershed Planning Short Course June 2-6, 2008
Bandera, Texas

Steps to Wastewater Treatment

Primary Treatment – use of mechanical and physical processes

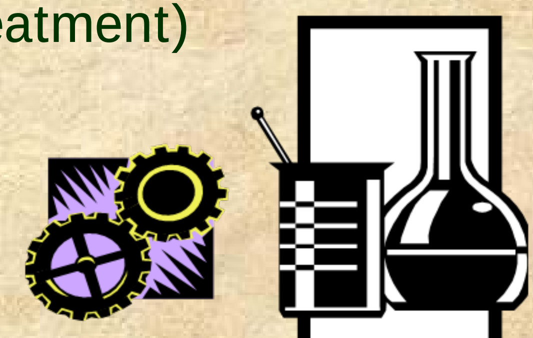
Secondary Treatment – use of mechanical, biological and physical processes





Tertiary Treatment – use of biological, physical and/or chemical processes (not all plants have tertiary treatment)

Final Treatment – Use of chemical or mechanical processes



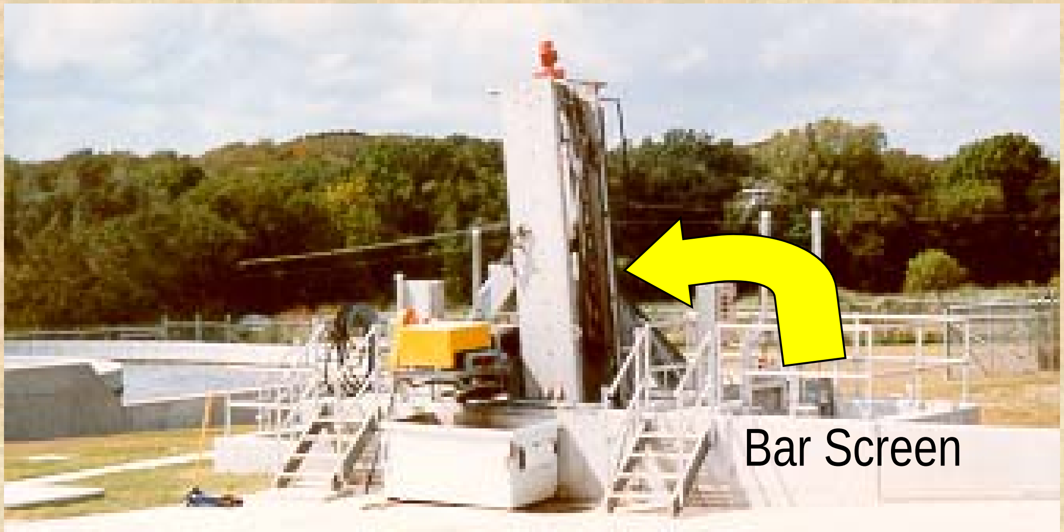
Primary Treatment

- Mainly physical treatment systems some chemical
- Collection systems bring raw sewage to the plant
- Ninety-five percent of the sewage entering a wastewater treatment plant is liquid.

Pumps such as these bring raw sewage to the treatment plant. They are also called lift stations

Primary Treatment

Physical processes are the first step in the wastewater treatment. This means that things are physically removed from the waste.



Bar screens remove large pieces of waste.

Raw sewage **(influent)** passes through bar screens which are simply metal rods immersed in the incoming flow to separate large objects such as sticks and rags from the water. They are used to protect pumps and other rotating mechanisms.

Primary Treatment

After the liquid passes through bar screens, it enters a large **settling tank,** sometimes called a **grit chamber**. The influent flow is slowed so that any large solids (such as sand and gravel) settle to the bottom of the tank.

The solids that fall to the bottom of the tank are removed from the treatment process and sent to a storage tank called a "**digester**."

Influent moves from bar screen to a settling tank like this. Here, the physical process of gravity pulls down any large pieces of sediment.

Primary Treatment

From the grit chamber, the liquid is often pumped to another tank called a **clarifier**.

A clarifier is typically a circular tank. Clarifiers allow further slowing of the wastewater so that heavier organics fall to the bottom.

The physical process of gravity enables the remaining solids to fall to the bottom of the clarifier.

Primary Treatment

In primary treatment, a mechanical process also takes place: a wand (sometimes called a 'rake') slowly skims the top of the water to remove the fats, oils, and greases that float to the top.

The fats, oils and greases that are scraped off the top are diverted to a holding chamber called a **'digester.'** The organics that fall to the bottom are also sent to the digester. These are collected by a rake at the bottom of the tank.

A rake in the clarifier moves slowly to allow the particles to stick together.

Primary Treatment

Water leaves clarifier through this ridged edge, called a weir.

After the fats, oils and greases have been removed from the top and the organics have fallen to the bottom, the remaining water flows over weirs, moving on to the next step in the treatment process.

Primary Treatment Review

Primary Treatment removes 60% of all suspended solids.

Steps in Primary Treatment

- Removal of solids in grit chamber – (mechanical)
- Movement of solids in settling tank – gravity - (physical)
- Removal of of fats, greases, oils in clarifiers – (mechanical)

Secondary Treatment

The extra air added to the tank creates the bubbling effect you see in this photo.

The use of biological processes to provide further treatment is referred to as **secondary treatment**.

The water, cleansed of most of the solids in primary treatment, next flows to an **aeration tank**. Air is added to the aeration tanks to activate **microorganisms**.

Secondary Treatment

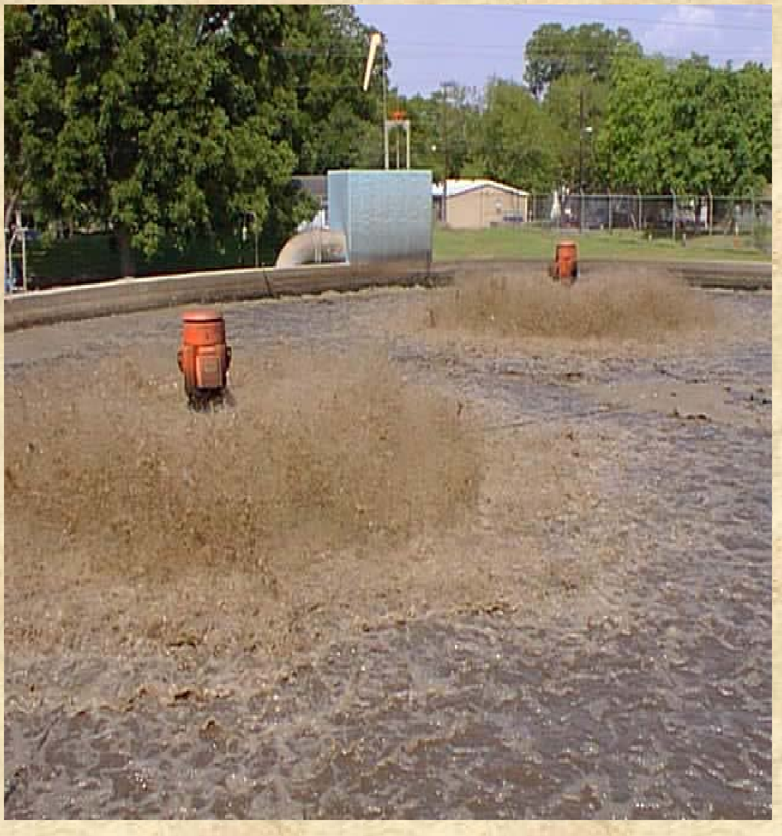
Notice the color of the water in the tank.

These microorganisms, or "microbes" are actually tiny microscopic bacteria and protozoans that will "eat" any remaining dissolved solids in the waste. These microbes only visible through a microscope.

The process of microbial breakdown actually begins in the sewer pipes along the way to the plant. However, aeration tanks provide the perfect environment for maximum consumption of the organic

wastes.

Secondary Treatment



The deep aeration tanks mix the air and the microorganisms and the sewage vigorously.

This process of microbial action breaking down wastes in vigorously moving and aerated water is sometimes called **activated sludge**.

Activated sludge looks like dark mud. It is rich with active (live) microbes: **bacteria** and **protozoans.** The bacteria and protozoans require oxygen to live and thrive, just like other living organisms. The aeration tank gives them extra oxygen so they will grow and consume the waste.

Secondary Treatment

There is an active food chain taking place within the activated sludge... The organic waste particles are eaten by the bacteria and the protozoans. These microbes grow in size as they consume (eat) the waste particles. So at the end of this food chain we have significantly increased the size of the microbes, which become waste particles themselves.

Secondary Treatment

The activated sludge from the aeration basin is removed via the overflow weir and sent to the secondary clarifier.

In the aeration tanks, the microbes (the "work force" of a wastewater plant) digest and break down the organic material and then begin to die out.

To keep the cycle alive and thriving, new food (waste) is added and new microbes are born. As the microbes die, their ‘bodies’ stick together in clumps.

This mushy mixture of living and dead organisms and their waste products at the bottom of a treatment tank is called “**sludge**”.

Secondary Treatment

After leaving the aeration tank, the water goes to a sedimentation basin. Here, without the mechanical addition of air, more solids (sludge) settle to the bottom of the tank.

A portion of the sludge is sent to the digester, which is another part of the treatment plant. Some of it is sent back to the aerobic basin for additional food for the next

batch of waste.

Notice the flow of the wastewater from the aeration basin to the two sedimentation basins. Here, the clarifier slowly removes scum from the top, and the sludge, or solids settle out at the bottom.

Secondary Treatment Review

Secondary Treatment removes more than 90% of remaining suspended solids and dissolved organic matter.

Steps in Secondary Treatment

- Oxygen added to the basin to stir up “bugs” – (mechanical)
- Conditions perfect for “activated sludge” process – (biological)
- Solids fall to the bottom of the sedimentation basin – (physical)
- Remaining solids diverted to digester – (mechanical)

Tertiary Treatment

Some wastewater treatment plants are now going one step further, using various means of **tertiary treatment**. This may be necessary because of the specific qualities of the water they are discharging to.

The goal of tertiary treatment is to further reduce solids and nutrients.

By state regulations, some plants cannot release water back to a creek or river if it could harm the quality of the stream.

Canyon Reservoir receives tertiary treated effluent from Canyon Park Estates Wastewater Treatment Plant.

Tertiary Treatment

Tertiary treatment can be classified as one of three processes: Biological, Chemical or Physical.

An example of biological tertiary treatment is to move the water though wetlands. The plants naturally remove excess nutrients and solids.

Heritage Middle School (East Central ISD) has its own wastewater treatment site, using biological treatment. Notice the cattails.

An example of chemical tertiary treatment is to add alum to precipitate out phosphorus. This helps settle out any excess solids.

Chemical tank and feed pump used to add alum to effluent.

An example of physical tertiary treatment is to run the water through sand filters, which further reduce solids.

A cut-away of a sand filter used to remove fine solids from effluent.

Tertiary Treatment Review

Tertiary Treatment removes any remaining solids or organic matter.

Possible Steps in Tertiary Treatment

- Flow through wetlands – uptake of nutrients by plants (biological)
- Flow through sand filters – (physical)
- Addition of alum or another coagulant to the effluent – (chemical)

Final Treatment

The first step in **final treatment** is to disinfect the effluent by adding chlorine or another chemical substance to kill any remaining bacteria.

It is vital that the treated wastewater be free of any bacteria at this point, because it will be put back into contact with various life forms (people, plants, animals) when it leaves the plant.

Chlorine and Sulfur Dioxide tanks

Final Treatment

Because of concerns about high chlorine levels in the discharged water, some wastewater systems are now using ultraviolet light as an alternative to using a chemical disinfectant.

Ultraviolet light is an environmentally friendly treatment process.

Ultraviolet light is a high - intensity light that disinfects wastewater in a much more environmentally friendly manner, but it is an expensive process.

Final Treatment Review

Final Treatment is necessary to ensure the water leaving the treatment plant is free of harmful bacteria.

Possible Steps in Final Treatment

- Water is treated with a disinfectant such as chlorine - (chemical)
- Water is treated with ultra-violet light – (mechanical)

Dealing with Sludge

In most cases, the sludge must be de-watered. Drying beds or belt presses can be used to remove the water from the sludge.

A large belt press is used to squeeze the water out of the sludge.

Drying bed for biosolids.

The sludge can be thickened by adding a polymer, which increases the "stickiness" of the particles to help them clump better.

Dealing with Sludge

An alternative to dewatering is to send sludge to large, heated and enclosed tanks called 'digesters.'

Here, more bacteria break down (digest) the material, reducing its volume, odors, and getting rid of organisms that can cause disease.

Digester is blue closed tank to the right.

The environment in the digester is **anaerobic**, which means it is completely free of dissolved oxygen.

Byproducts of anaerobic digestion include methane gas, ammonia, and hydrogen sulfide.

Wastewater plants are exploring ways to deal with these gases... for example, methane gas can be captured and burned to generate electricity or heat.

Biosolids

The material that is removed from the digester, drying bed or belt press has been processed into a product referred to as **biosolids**.

Biosolids are beneficially land-applied using a tractor and manure spreader.

These processed biosolids can be either:

1) applied directly on land as a fertilizer (in an agricultural setting);
2) sent to the landfill; or
3) used to make compost mixtures for people to purchase for lawn and garden use.

Biosolids

Until recent years, most biosolids have been sent to the landfill. However, many treatment facilities have come to recognize the biosolids as high quality fertilizers and soil conditioners, so they are exploring the possibilities of selling the biosolids to companies that make fertilizers and compost products.

Biosolids loaded on a truck for landfill.

Home landscape product containing biosolids from wastewater treatment plants.

Recycled – Reclaimed Water

Recent years of water shortages plus projected population growth have forced many water utilities to re-evaluate the value of treated wastewater. The quality of effluent that leaves the treatment plant is strictly regulated by state laws. Although not clean enough to drink, it can be used for other purposes that do not necessarily need pure water.

For example, industries can use the water for some of their processes, including cooling equipment.

Guadalupe Power Partners (Marion, Texas) uses treated wastewater for cooling.

Recycled – Reclaimed Water

Many cities are now using treated wastewater for watering golf courses and some public areas use treated wastewater for landscape or turf irrigation.

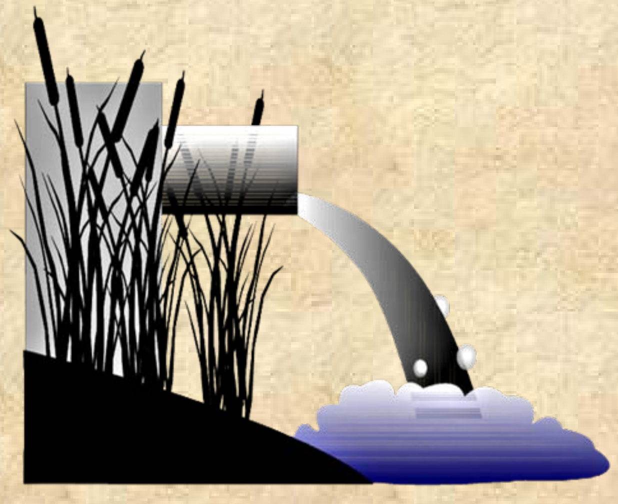
This Texas Department of Transportation Rest Area on IH 10 (east of Seguin) treats waste from the restrooms, and uses the treated wastewater to irrigate landscaping at the site.

Many golf courses are now “reclaiming,” or using treated wastewater for irrigation.

Effluent Discharge

The very last step in treatment of wastewater is to reintroduce the water into the water cycle. The majority of wastewater treatment plants release the water back into nearby rivers or creeks. The treated water that is released is called **effluent**.

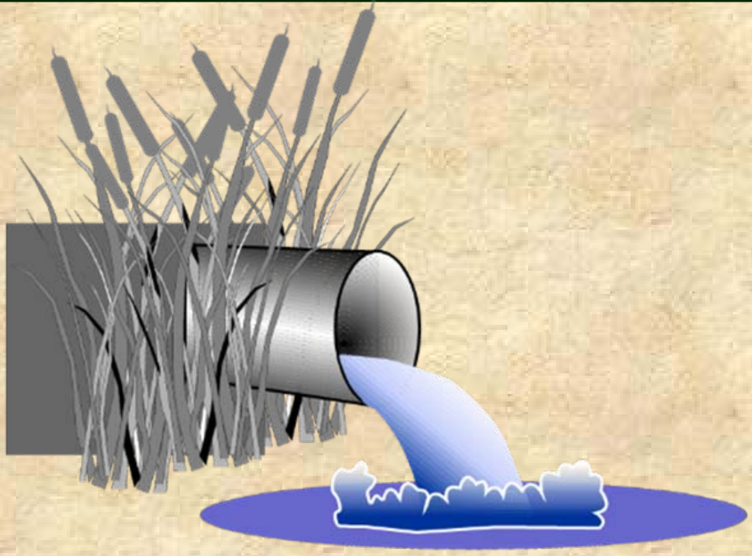
The Texas Commission on Environmental Quality issues permits to allow the discharge of treated effluents into the streams and strictly regulates the quality (cleanliness) of the effluent. It is tested daily to make sure it is well disinfected and does not contain excess pollutants.



Effluent from a treatment plant re-entering the creek.

Today most wastewater treatment facilities can easily reach effluent concentrations of 5 mg/l BOD, 2.0 mg/l ammonia, 7 mg/l TSS, and 6.0 mg/l DO

Wastewater Treatment Summary



- Wastewater treatment facilities are capable of treating several million gallons of wastewater 24 hours a day, 365 days a year.
- Primary and secondary treatment (physical and biological) is the norm for most facilities; some facilities also use tertiary treatment (chemical).
- Highly-skilled plant operators and the TCEQ make sure all discharges meet strict permit requirements and state and federal standards.
- Treated effluent re-enters the water cycle as effluent or may be reused again by industry or for irrigation. Like all water, wastewater effluent also evaporates into the atmosphere and may return as rain in another place far away.

WBPs and Wastewater Treatment Facilities (WWTFs)

- Generally WWTF operators are used to responding to regulations and permit requirements
- WBPs are voluntary; incentives for WWTFs to implement additional pollutant load reduction measures must rely on a strong stakeholder process (outreach, education, public pressure, economic incentives, etc.)
- Funding sources can be illusive

Funding Sources for WWTFs

- State Revolving Funds (EPA and TWDB)
- Community Development Block Grants (HUD and ORCA)
- Rural Development Grants (USDA RD)
- Economically Distressed Area Program (EPA and TWDB)
- North American Development Bank Grants and Loans (NADB and EPA through NADB)
- Clean Water Act section 319(h) Grants (EPA and TCEQ)**

** only for non-wastewater treatment projects

Example of Use of 319(h) for Polishing Wastewater Effluent

- Arroyo Colorado Watershed Protection Plan (ACWPP)
- Part of Pollutant Reduction Plan (wastewater component of ACWPP)
- Phase I - four constructed wetland systems to polish treated effluent (San Benito, San Juan, La Feria, Mercedes)
- Not part of the WWTF's treatment train (wetlands not considered treatment units)
- Requires permit modification (modification of discharge route description; addition of second outfall)
- Constructed wetland considered waters of the state
- All four projects include a storm water component

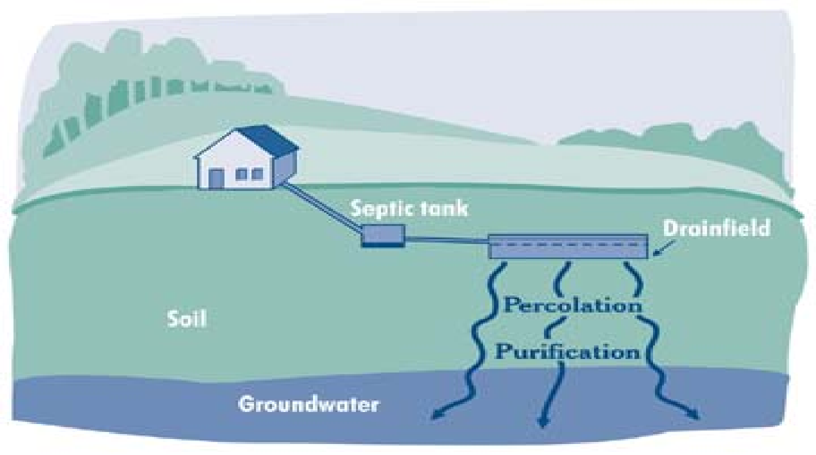
City of San Juan Constructed Polishing Wetland System

Onsite Sewage Facilities (OSSFs)

- Many different types of systems:
  - Conventional (tank and drain field)
  - Low pressure dosing
  - Aerobic
  - Subsurface Drip
  - Surface Spray
  - Experimental wetland systems →

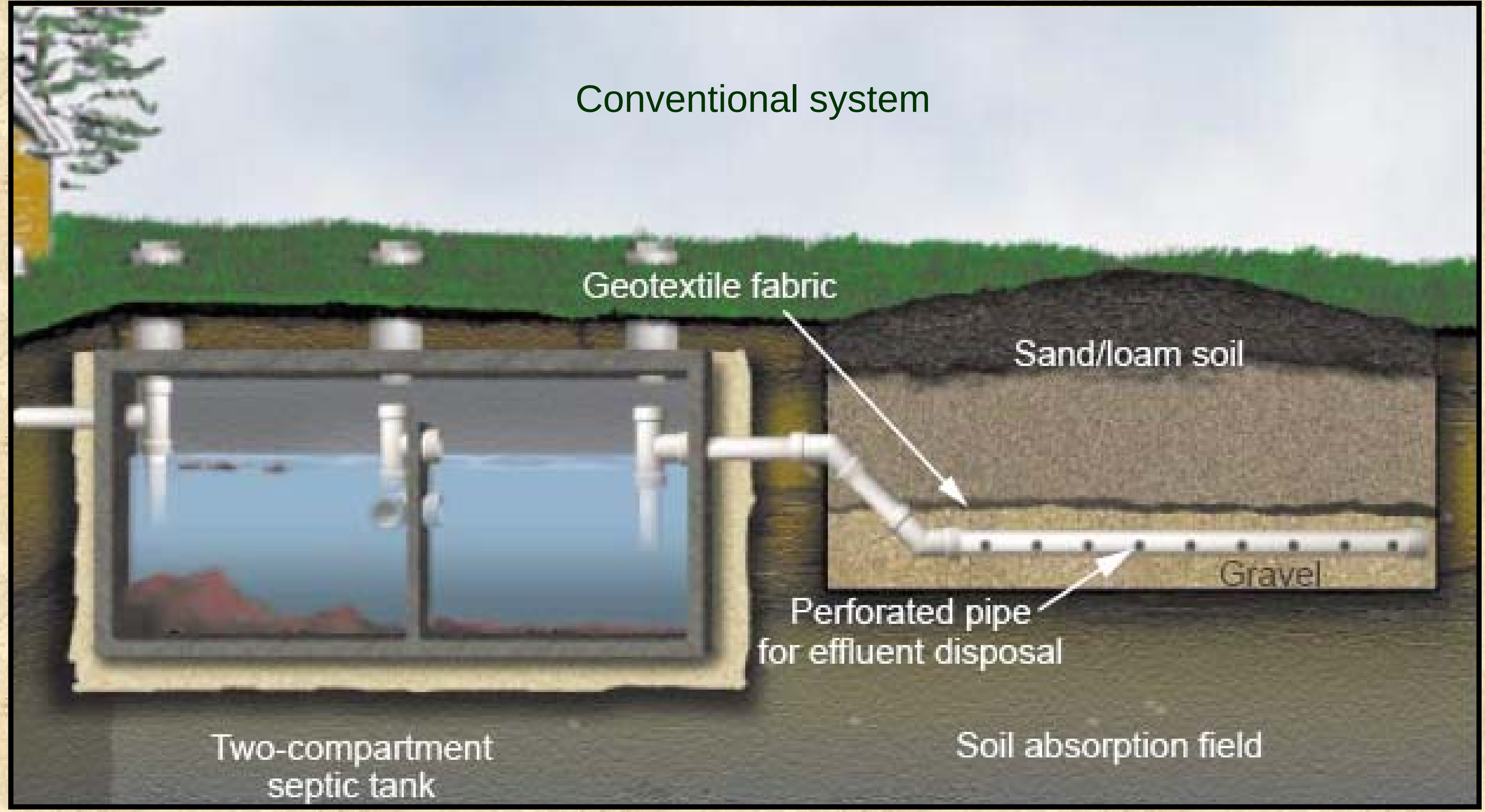
OSSF Wastewater Sources (residential/non-residential)

- <u>Residential</u>
  - Single-family households
  - Condominiums
  - Apartment houses, etc.
- <u>Non-residential</u>
  - Schools
  - Restaurants, etc.

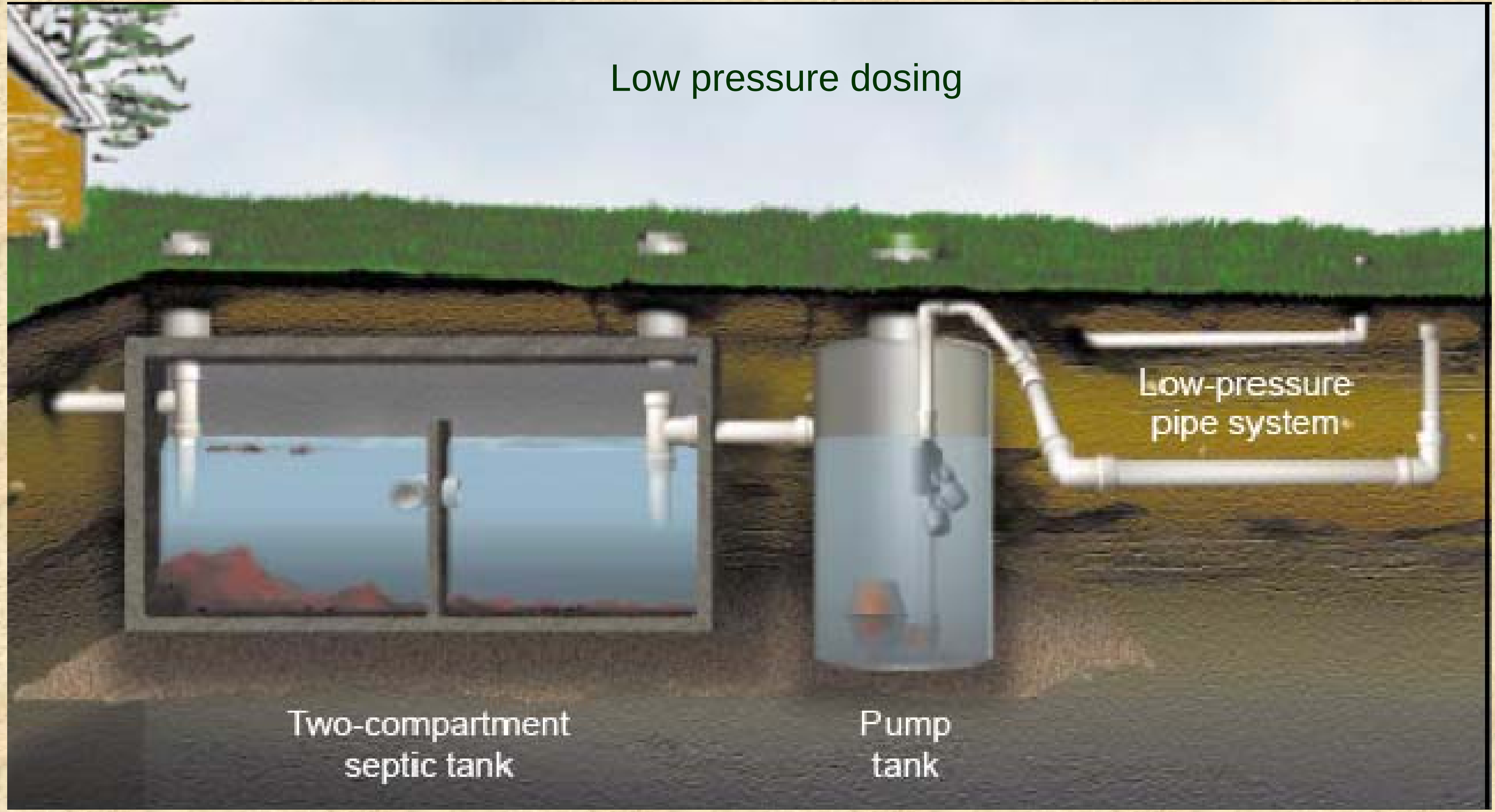


* tables that categorize these types of wastewater and their respective flows can be found in TCEQ TAC §285 Appendix B Table III and EPA Onsite Wastewater Treatment Systems Manual §3 Table 3-4, 5 and 6

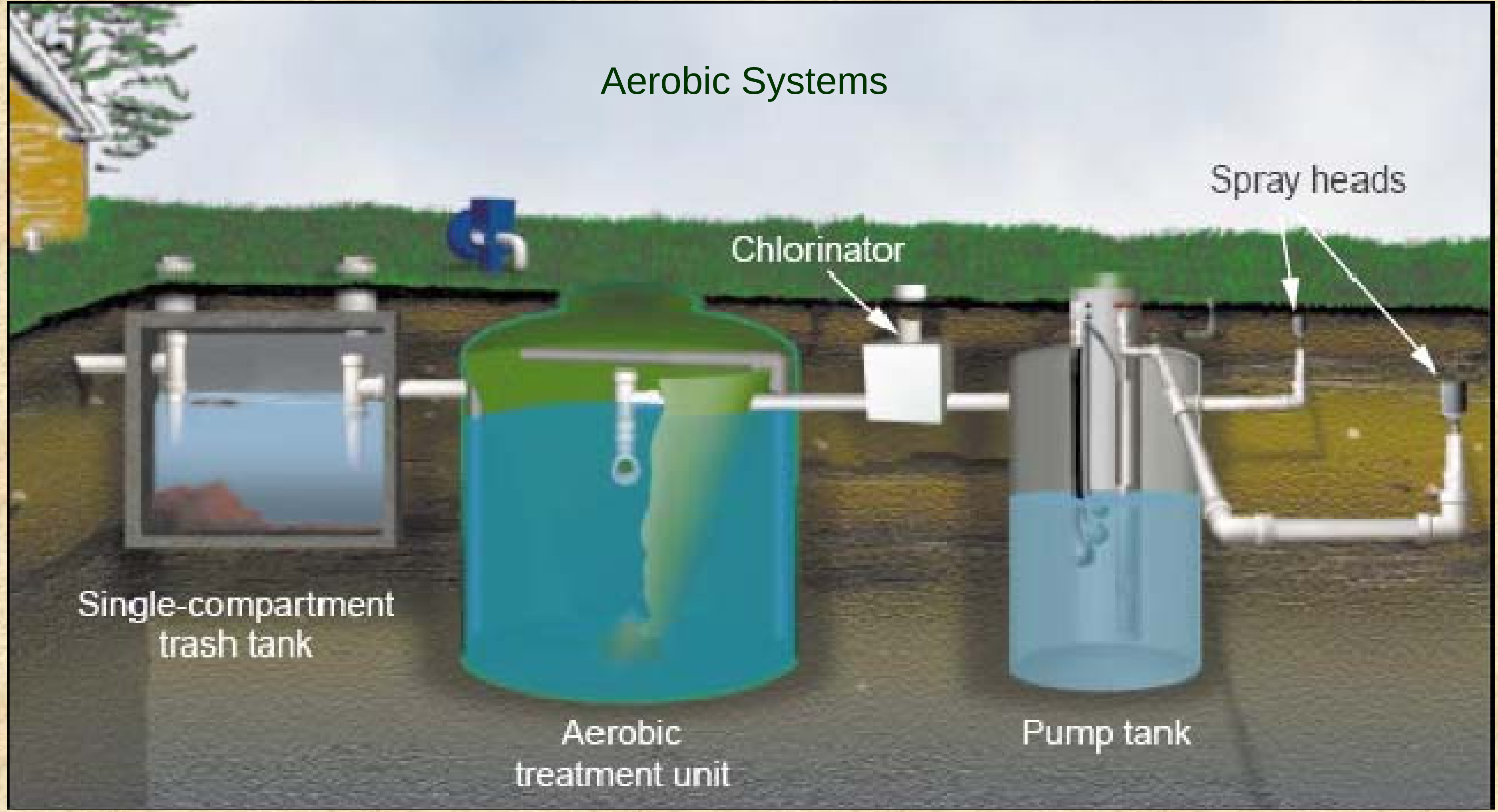
OSSF Treatment Systems



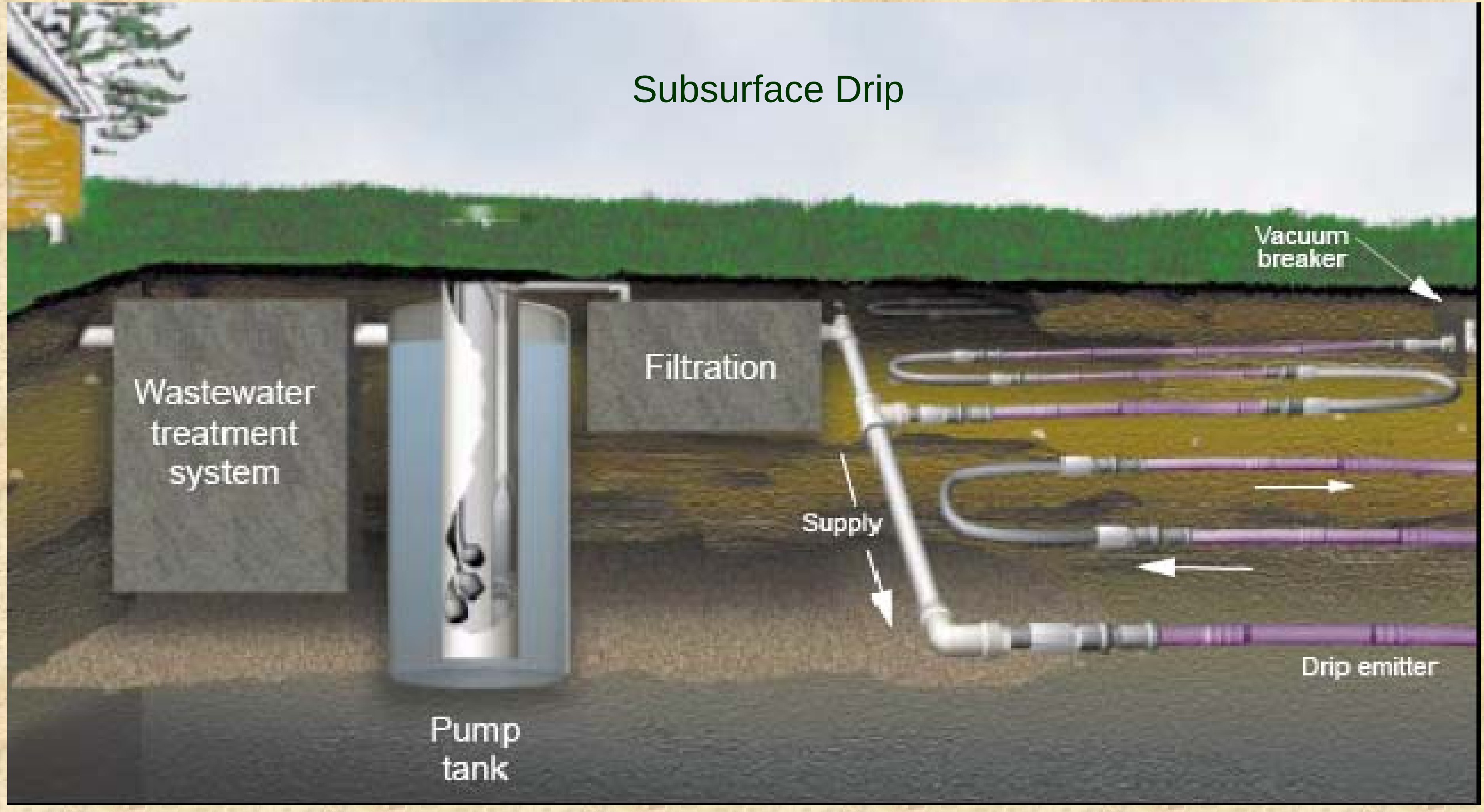
OSSF Treatment Systems



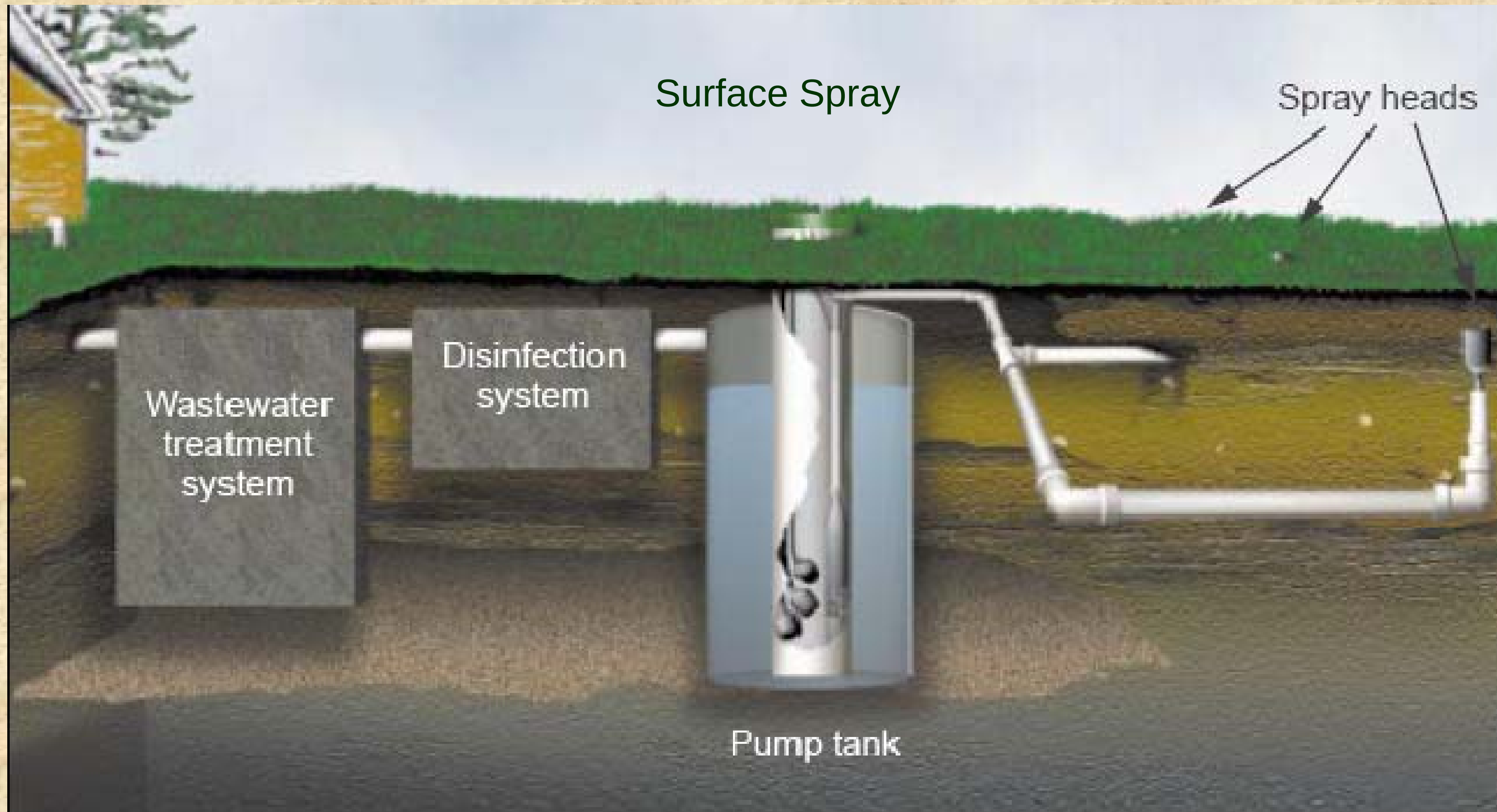
OSSF Treatment Systems



OSSF Treatment Systems



OSSF Treatment Systems



OSSF Efficiencies

Table 3-19. Wastewater constituents of concern and representative concentrations in the effluent of various treatment units

Constituents of concern	Example direct or indirect measures (Units)	Tank-based treatment unit effluent concentrations					SWIS percolate into ground water at 3 to 5 ft depth (% removal)
		Domestic STE[1]	Domestic STE with N-removal recycle[2]	Aerobic unit effluent	Sand filter effluent	Foam or textile filter effluent	
Oxygen demand	BOD_5 (mg/L)	140-200	80-120	5-50	2-15	5-15	>90%
Particulate solids	TSS (mg/L)	50-100	50-80	5-100	5-20	5-10	>90%
Nitrogen	Total N (mg N/L)	40-100	10-30	25-60	10-50	30-60	10-20%
Phosphorus	Total P (mg P/L)	5-15	5-15	4-10	<1-10[4]	5-15[4]	0-100%
Bacteria (e.g., *Clostridium perfringens, Salmonella, Shigella*)	Fecal coliform (organisms per 100 mL)	10^6-10^8	10^6-10^8	10^3-10^4	10^1-10^3	10^1-10^3	>99.99%
Virus (e.g., hepatitis, polio, echo, coxsackie, coliphage)	Specific virus (pfu/mL)	0-10^5 (episodically present at high levels)	0-10^5 (episodically present at high levels)	0-10^5 (episodically present at high levels)	0-10^5 (episodically present at high levels)	0-10^5 (episodically present at high levels)	>99.9%
Organic chemicals (e.g., solvents, petro-chemicals, pesticides)	Specific organics or totals (µg/L)	0 to trace levels (?)	0 to trace levels (?)	0 to trace levels (?)	0 to trace levels (?)	0 to trace levels (?)	>99%
Heavy metals (e.g., Pb, Cu, Ag, Hg)	Individual metals (µg/L)	0 to trace levels	0 to trace levels	0 to trace levels	0 to trace levels	0 to trace levels	>99%

[1] Septic tank effluent (STE) concentrations given are for domestic wastewater. However, restaurant STE is markedly higher particularly in BOD_5, COD, and suspended solids while concentrations in graywater STE are noticeably lower in total nitrogen.
[2] N-removal accomplished by recycling STE through a packed bed for nitrification with discharge into the influent end of the septic tank for denitrification.
[3] P-removal by adsorption/precipitation is highly dependent on media capacity, P loading, and system operation.

Source: Siegrist, 2001 (after Siegrist et al., 2000)

Source: Siegrist, 2001 (after Siegrist et al., 2000).

OSSF Regulation

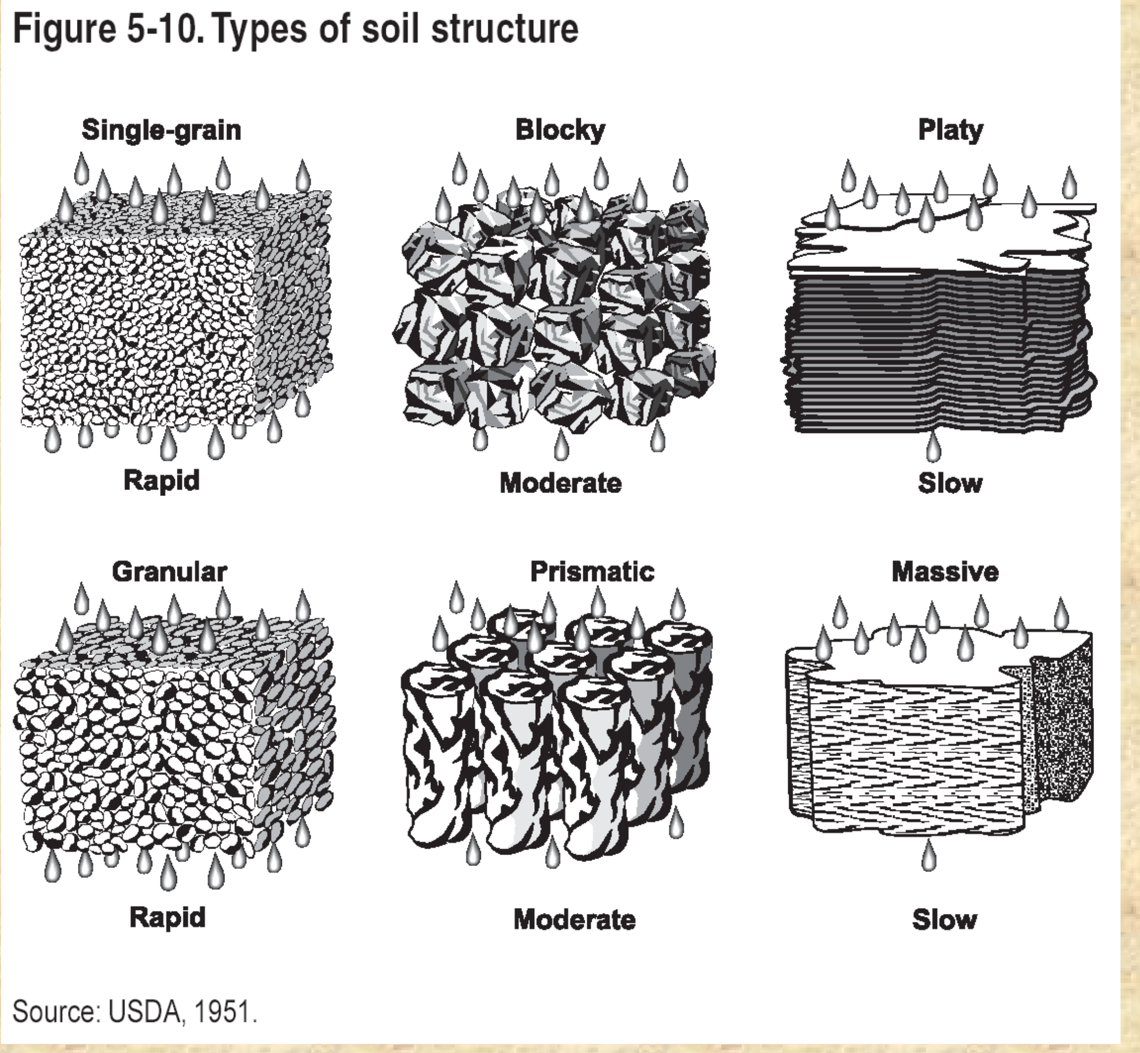
- HB 1875, passed in 1987, regulates OSSFs
- Calls for Authorized Agents (i.e., regional and local governments such as counties, cities, river authorities and special districts) to implement and enforce on-site sewage regulations with approval and oversight by the TCEQ
- A permit must be obtained from an AA or the TCEQ before construction

OSSF Problems

- The question is not if an OSSF will fail, but when
- Many AAs do not have the resources to conduct regular inspections
- Repair of failing septic systems is expensive as is regular maintenance of some of the newer systems
- Some Individuals simply do not see a problem with skirting regulation or are not trained well enough

OSSF Problems

Wrong Soil



Under sizing

OSSF Problems

Straight Pipes

OSSF Loading Calculations

- Data Sources
  - **U.S. Census Bureau**
    - **Septic systems per county (1990)**
    - **Occupied housing units per county (1990 and 2002)**
    - **Population per county (2004)**
  - **TCEQ**
    - **Number of applications for septic systems per county (1990-2004)**
    - **Authorized Agents (AA) Monthly Report submitted to TCEQ – OSSF Activity Report**
      - **Lists monthly "Complaints Investigated" and "Court Cases Filed" per county for OSSFs**
  - **Comprehensive Sanitary Surveys**
    - **Example –TDH Copano Bay**

OSSF Good News

- Orange County OSSF Project
  FY 2007 Section 319 Grant
- Federal NPS Grant Administered by TCEQ and TSSWCB
- Funding:
  - 60% federal, 40% non-federal (can be "in-kind")
  - Orange Co. project = $350,000 over 3 years
- Task 1: Identify OSSFs to be upgraded
  - Complaint investigations
  - Proximity to surface water, household income, flood potential, soils
- Task 2: Upgrade, replace, or decommission OSSF
  - Contract with licensed OSSF installer; Establish timeline
- Lake Houston OSSF Project
  FY 2007 Section 319 Grant

Acknowledgements

A big thank you to Debbie Magin and the Guadalupe-Blanco River Authority for helping me put this presentation together

The Guadalupe-Blanco River Authority is a recognized leader in providing wastewater services and protecting our natural resources and the environment in the Guadalupe-Blanco River Basin.