Wastewater Treatment

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Faculty of Engineering
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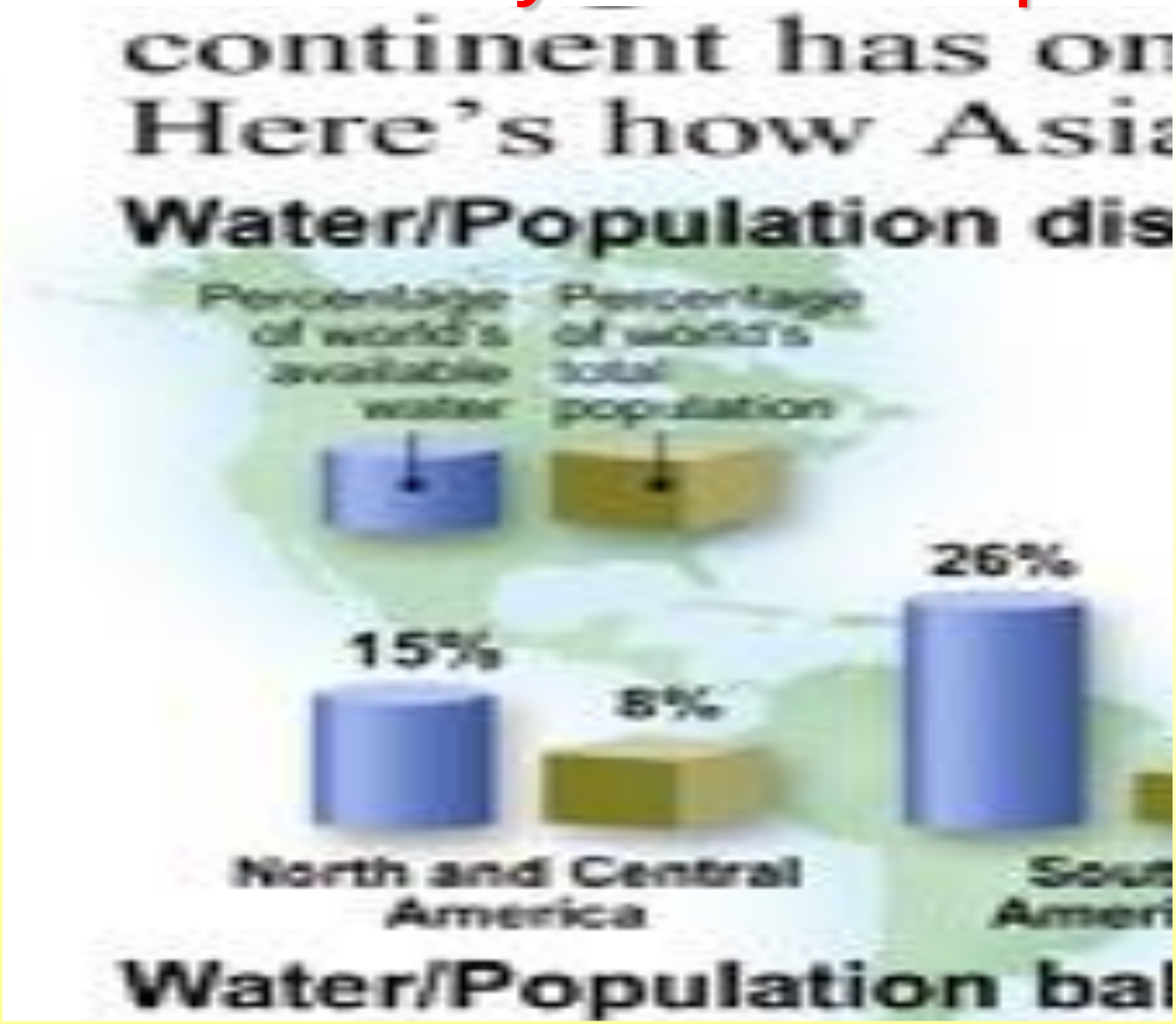
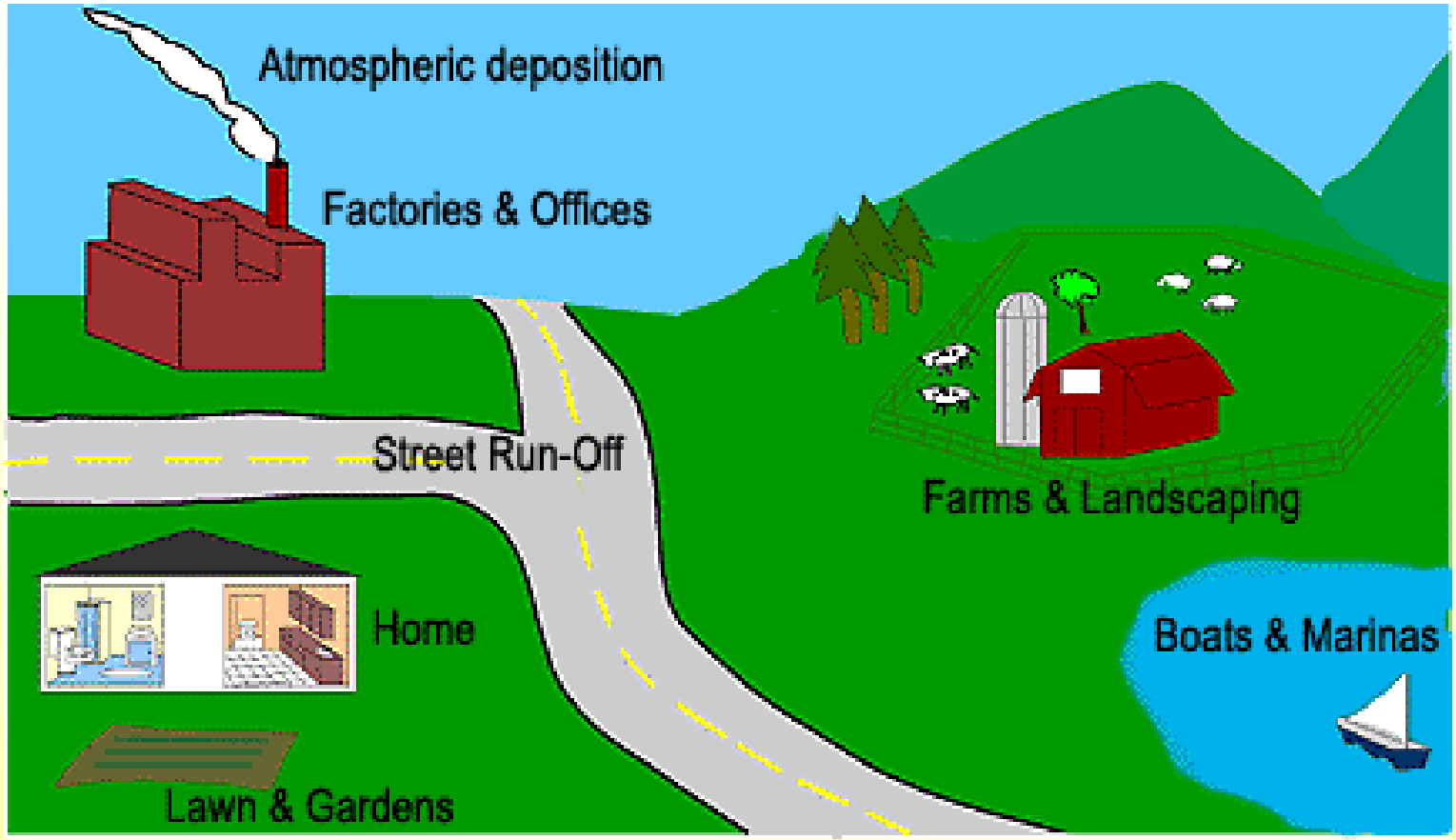
Water Availability Versus Population



Water Uses

- Domestic
- Agriculture
- Industrial
- Navigation
- Power generation
- Recreation

Waste Water Generation



Wastewater is generated from homes, industry, and business

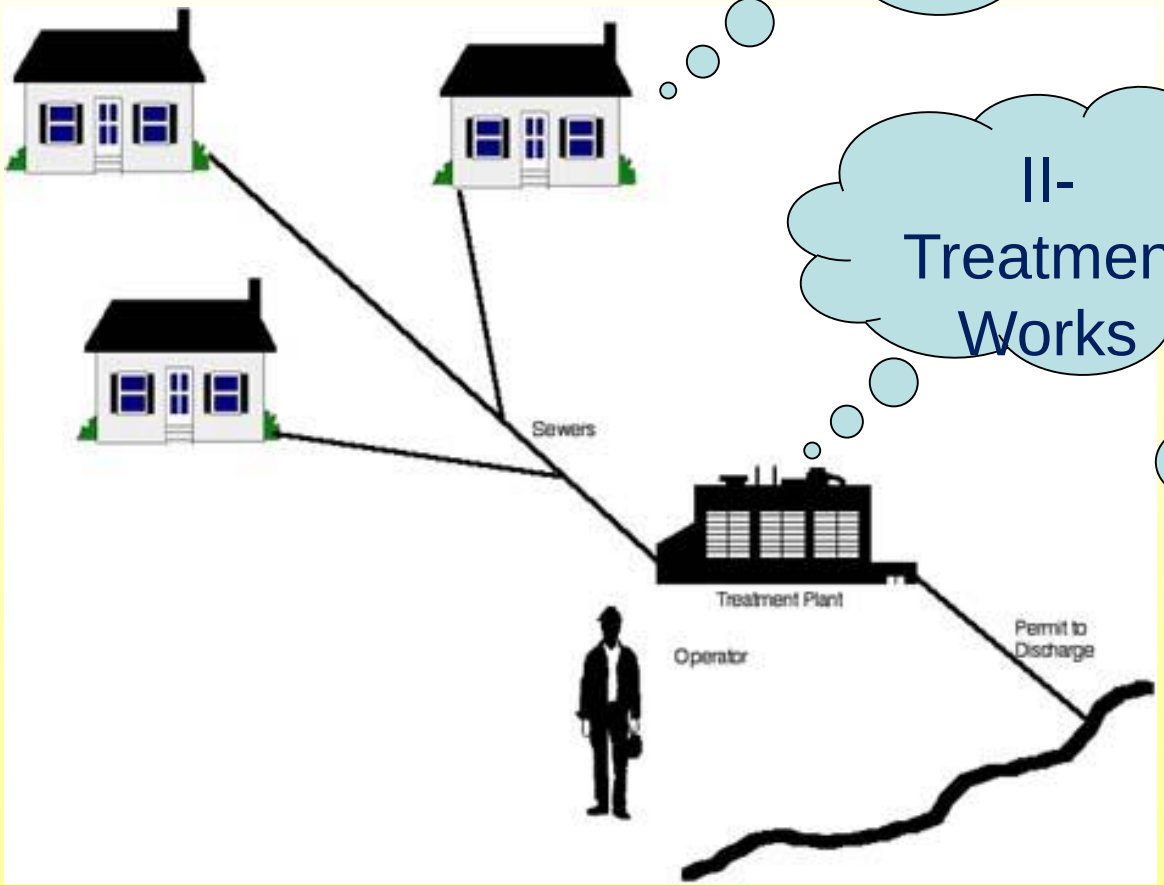
Domestic Wastewater – Its Journey to Treatment and Return to the Environment

Components of Wastewater Process

I- Collection Works

II- Treatment Works

III- Disposal Works

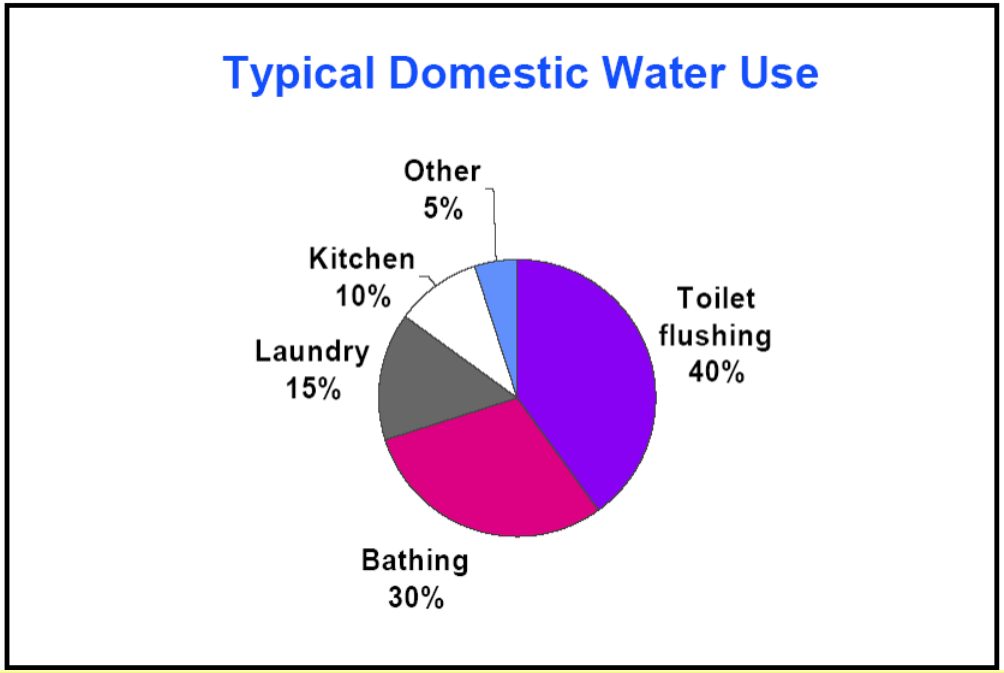


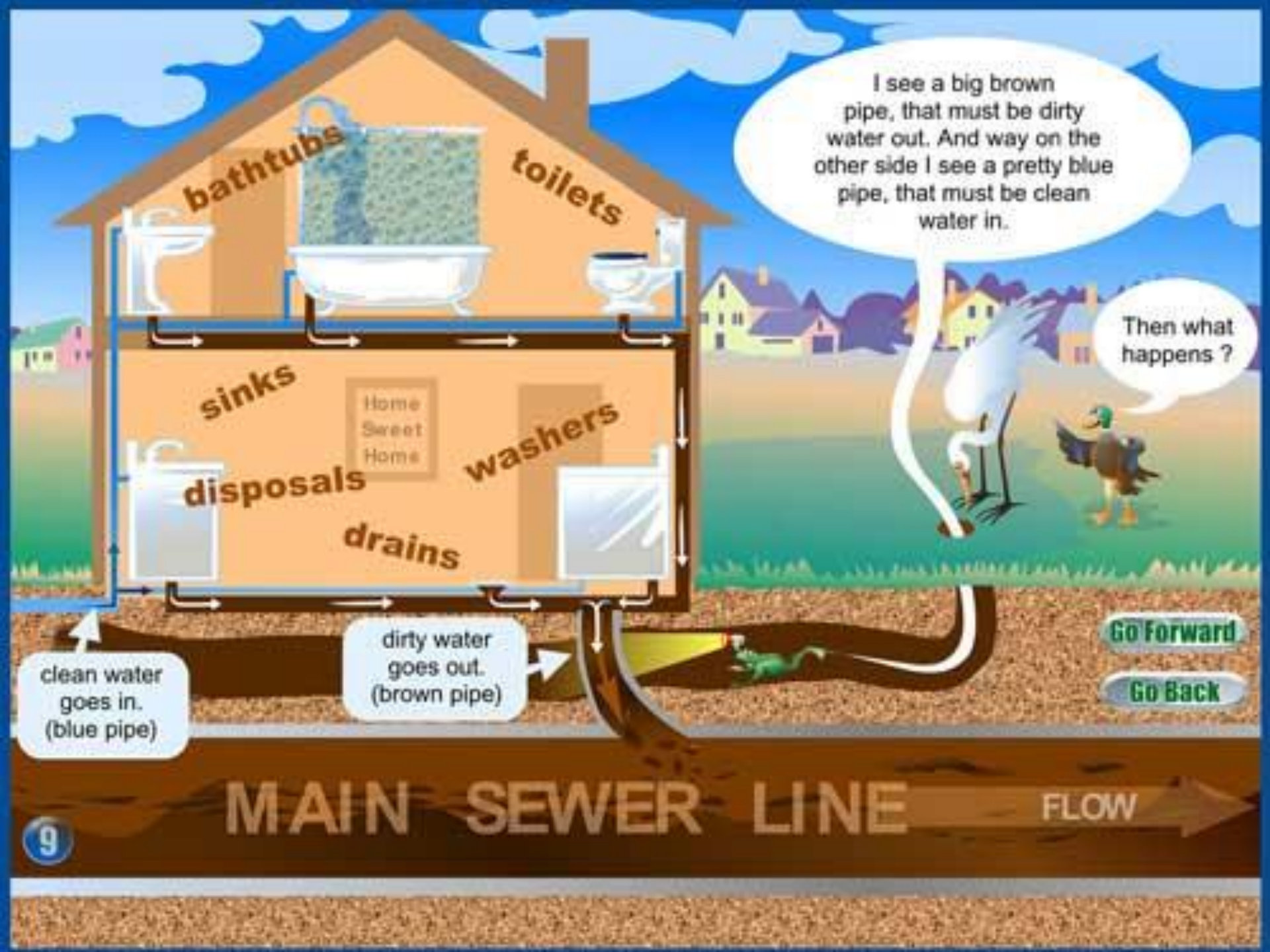
I- Collection Works

Where does it come from!

Where does the water from the washer go?

When you flush the toilet where does the contents go?




bathtubs
toilets
sinks
Home Sweet Home
washers
disposals
drains
I see a big brown pipe, that must be dirty water out. And way on the other side I see a pretty blue pipe, that must be clean water in.
Then what happens ?
Go Forward
Go Back
clean water goes in. (blue pipe)
dirty water goes out. (brown pipe)
MAIN SEWER LINE
FLOW
9

By gravity flow, the waste is on its way to your wastewater collection system!

Go Forward

Go Back

II- Treatment Works

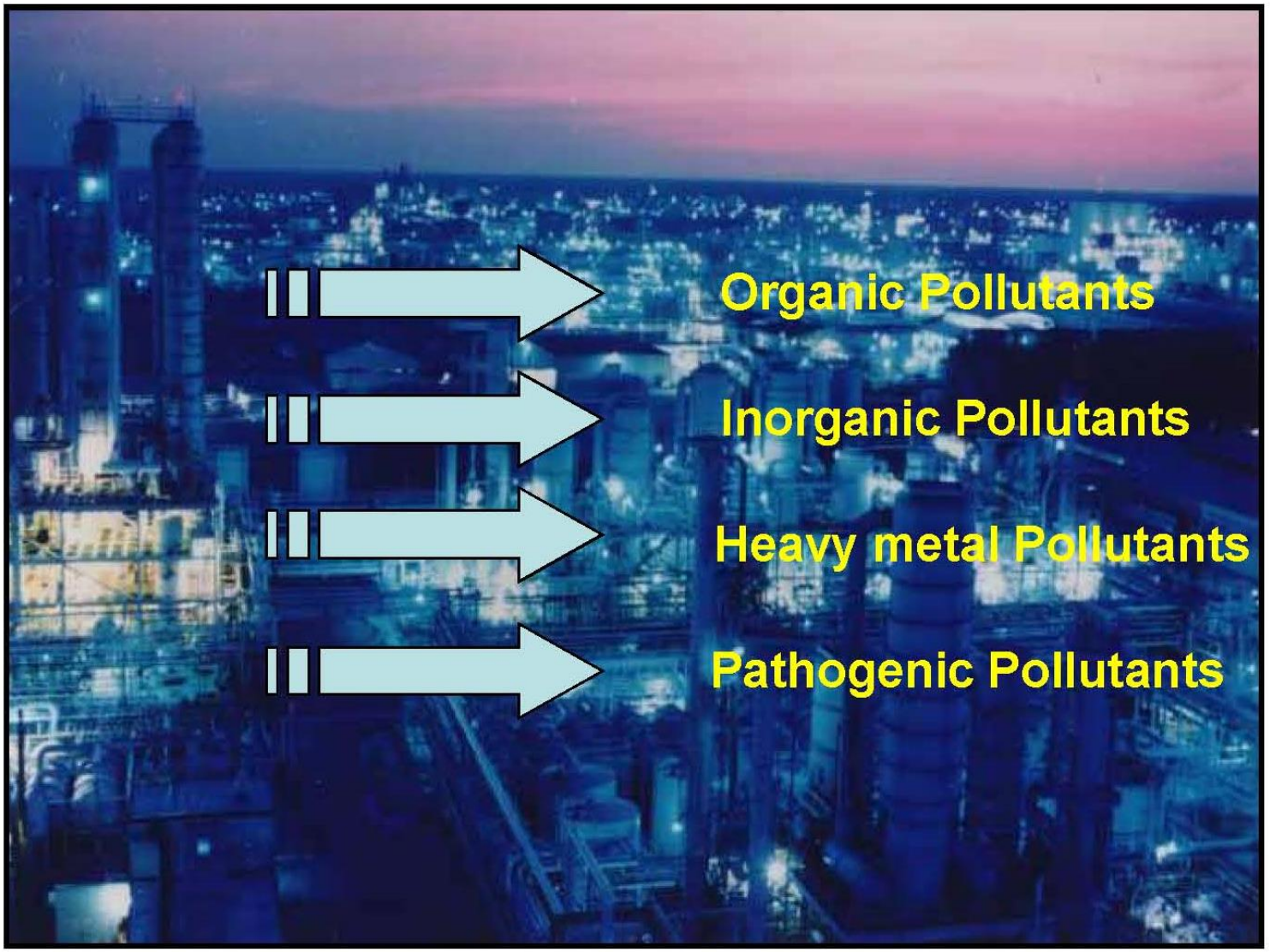
A- Wastewater Treatment

Sewage is ≈99% water with less than 1% dissolved or suspended material

But that 1% can be full of nasty stuff

Cloudiness of sewage caused by suspended particles

Pollutants in Wastewater



Pollutants in Domestic Wastewater

	High strength	Medium strength	Low strength
TSS, Total suspended solids (mg/L)	120	210	400
BOD, 5-day biochemical oxygen demand (mg/L)	110	190	350
Ammonia nitrogen (mg/L as N)	12	25	45
Organic nitrogen (mg/L as N)	8	15	25
Total phosphorus (mg/L)	4	7	12
Oil and grease (mg/L)	50	90	100
Total coliform bacteria (number/100 ml)	$10^6 – 10^8$	$10^7 – 10^9$	$10^7 - 10^{10}$
Fecal coliform bacteria (number/100 ml)	$10^3 – 10^5$	$10^4 – 10^6$	$10^5 - 10^8$
Cryptosporidium oocysts (number/100 ml)	0.1 - 1	0.1 - 10	0.1 – 100
Giardia lamblia cysts (number/100 ml)	0.1 – 10	0.1 - 100	0.1 - 1000

Based on Metcalf & Eddy Inc., G. Tchobanoglous, F. L. Burton, and H. D. Stensel, editors, 2003. Wastewater Engineering: Treatment and Reuse, Fourth Edition. McGraw-Hill, New York. Table 3-15, pg. 186.

Total Suspended Solids

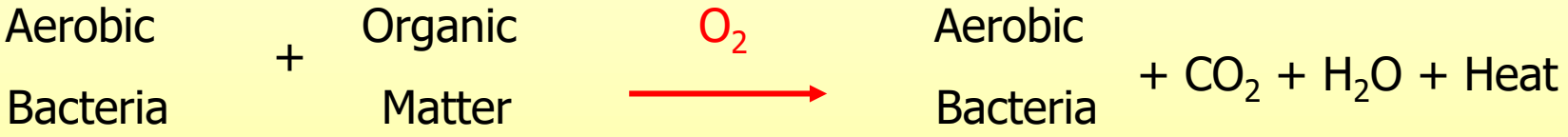
- Amount of material which can be filtered from the sample on a standard filter media. *(dissolved solids will not be trapped by filter media)*

Biochemical Oxygen Demand (BOD)

- Most commonly used parameter to define the strength of a polluted water.

Definition of BOD

- **Demand for oxygen over a period of time as a result of the decomposition of organic material by aerobic bacteria.**



Depletion of O_2

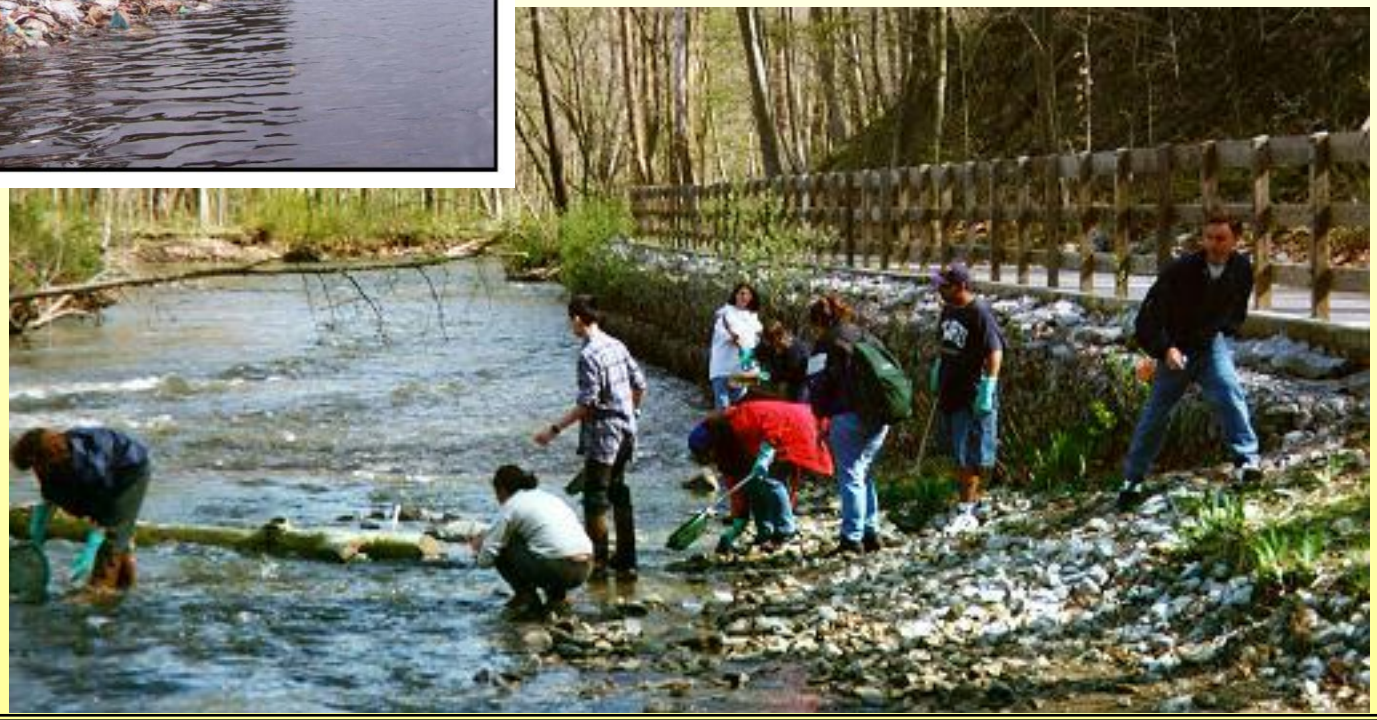
Nature has an amazing ability to cope with small amounts of waste

But it has its limit

Goals of Treatment

- Separate solids
- Reduce organic materials (BOD)
- Reduce nutrients
- Reduce pathogens
- Reduce toxic discharges

What if we don't treat Wastewater??



Cuyahoga River 18/10/1954

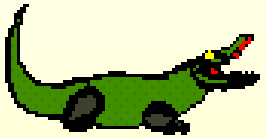
Cleveland, Ohio

Cuyahoga River

- Cleveland, Ohio 1969
  - River contained so many pollutants chemicals and industrial wastes and oil spills that it inadvertently caught fire
  - City has cleaned up river significantly, some parts now used for recreation

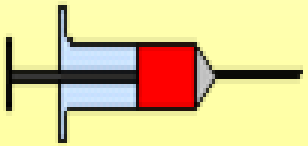
Blackstone River, Mass. circa 1970

Fisheries



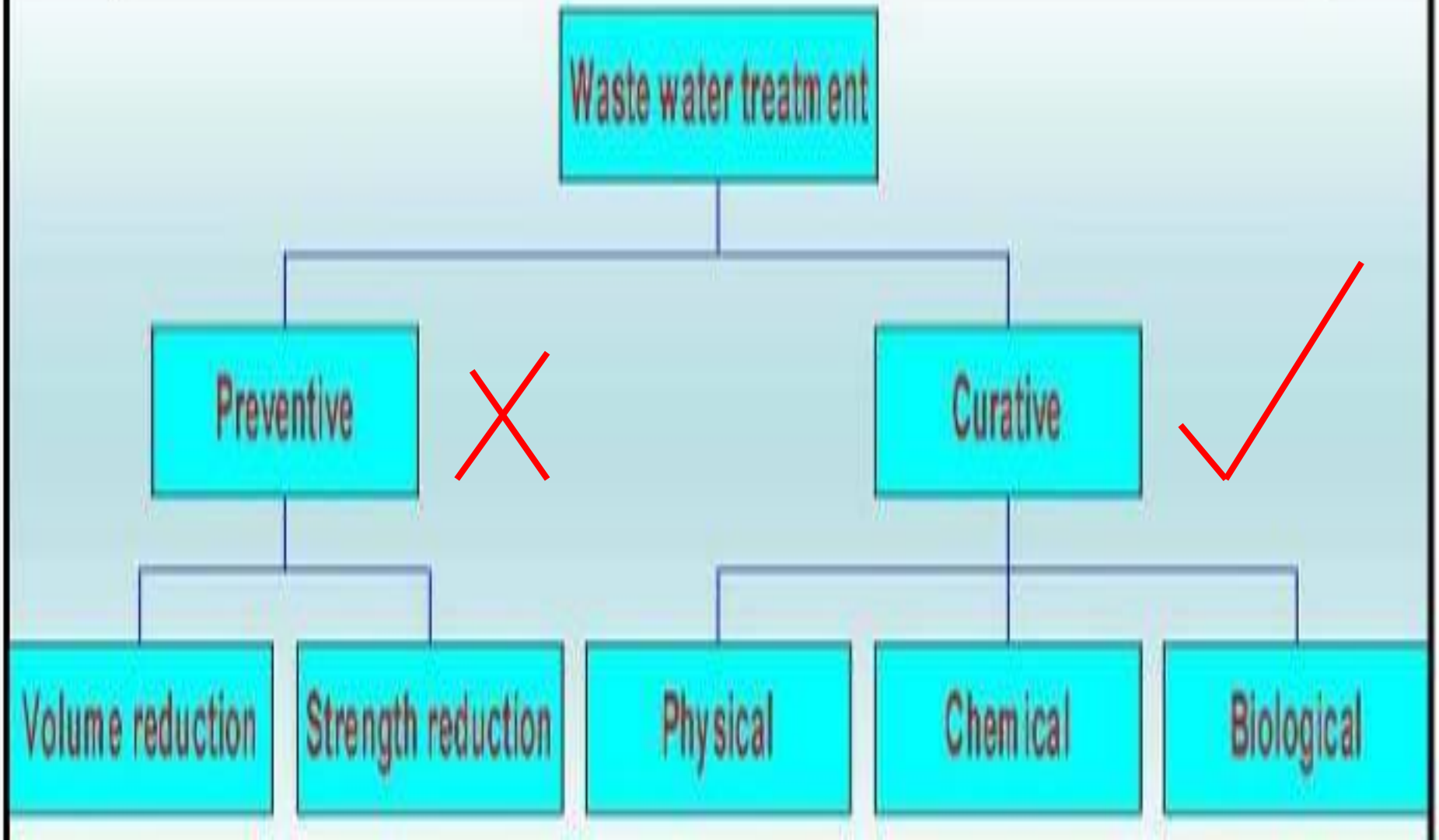
Wildlife Habitats

Recreation & Quality of life



Health concerns

Wastewater Treatment



Types of Wastewater Treatment

1- Mechanical Systems

- Activated sludge processes
- Fixed media process

2- Land-Based (Natural) Systems

- Lagoons
- Constructed wetlands

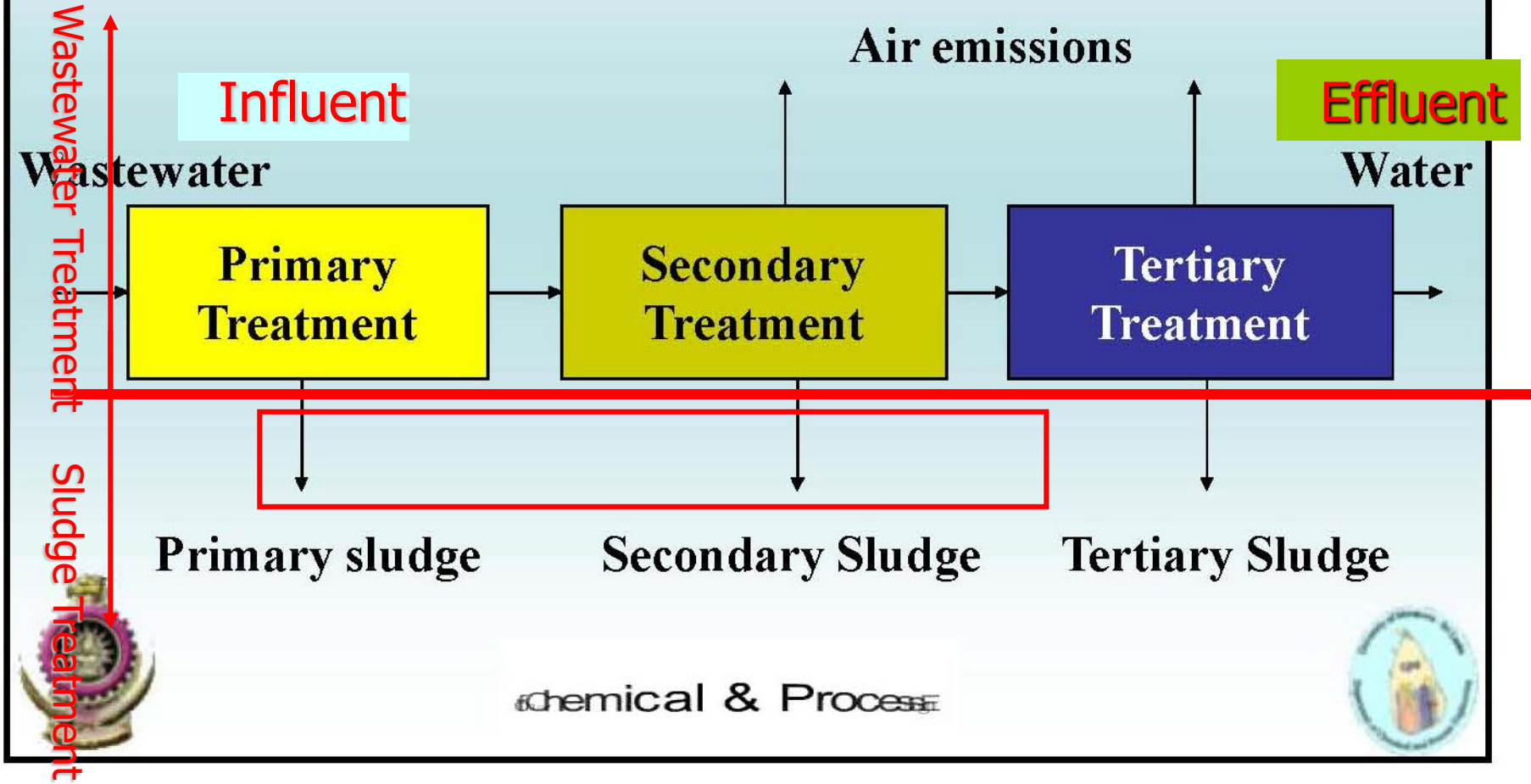
3- Soil-Based Systems

- Septic systems with absorption fields

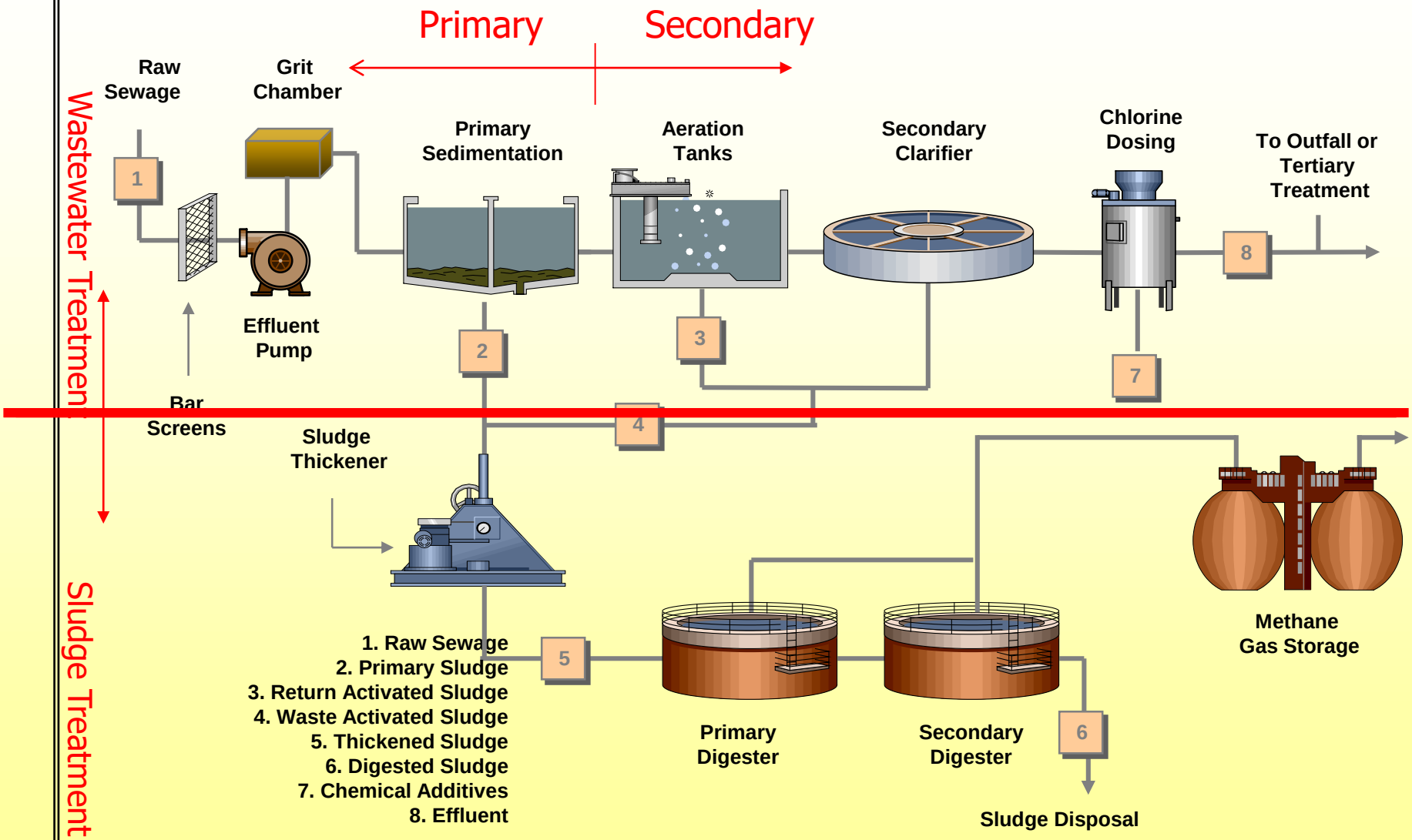
1- Mechanical System

Suspended Growth System

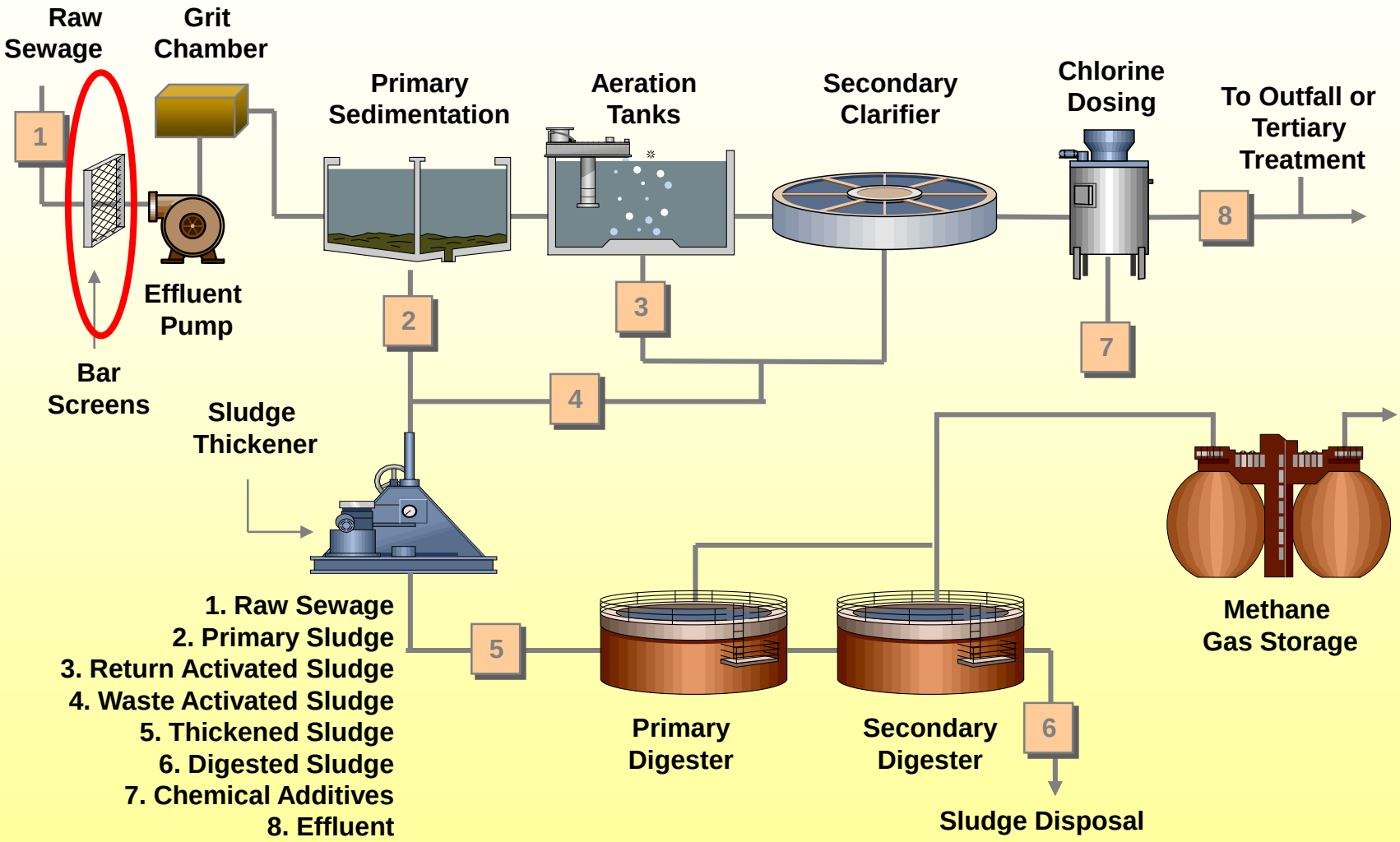
Typical Wastewater Processing



Typical Sewage Plant Layout



Screen


Raw Sewage
Grit Chamber
Primary Sedimentation
Aeration Tanks
Secondary Clarifier
Chlorine Dosing
To Outfall or Tertiary Treatment
1
Effluent Pump
Bar Screens
2
3
4
7
8
Sludge Thickener
1. Raw Sewage
2. Primary Sludge
3. Return Activated Sludge
4. Waste Activated Sludge
5. Thickened Sludge
6. Digested Sludge
7. Chemical Additives
8. Effluent
5
Primary Digester
Secondary Digester
6
Sludge Disposal
Methane Gas Storage

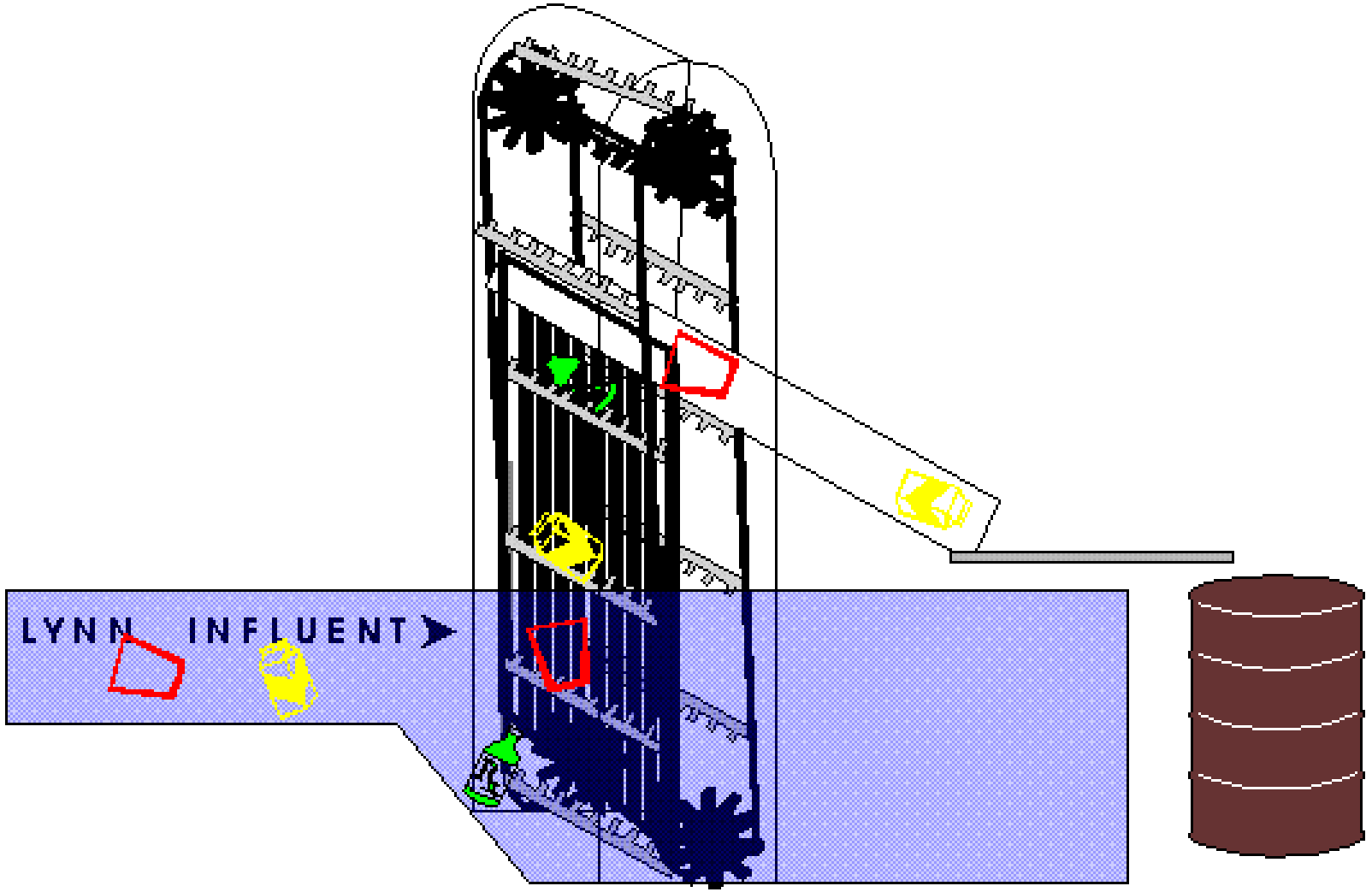
Screens

- **purely physical process**
- **bar opening:**

  50-150mm (coarse screen)

  20-50 mm (medium screen)
- **removes large material which could damage equipment**
- **screenings either manually or automatically**
- **screenings usually shredded and buried**

MECHANICAL BAR SCREENS

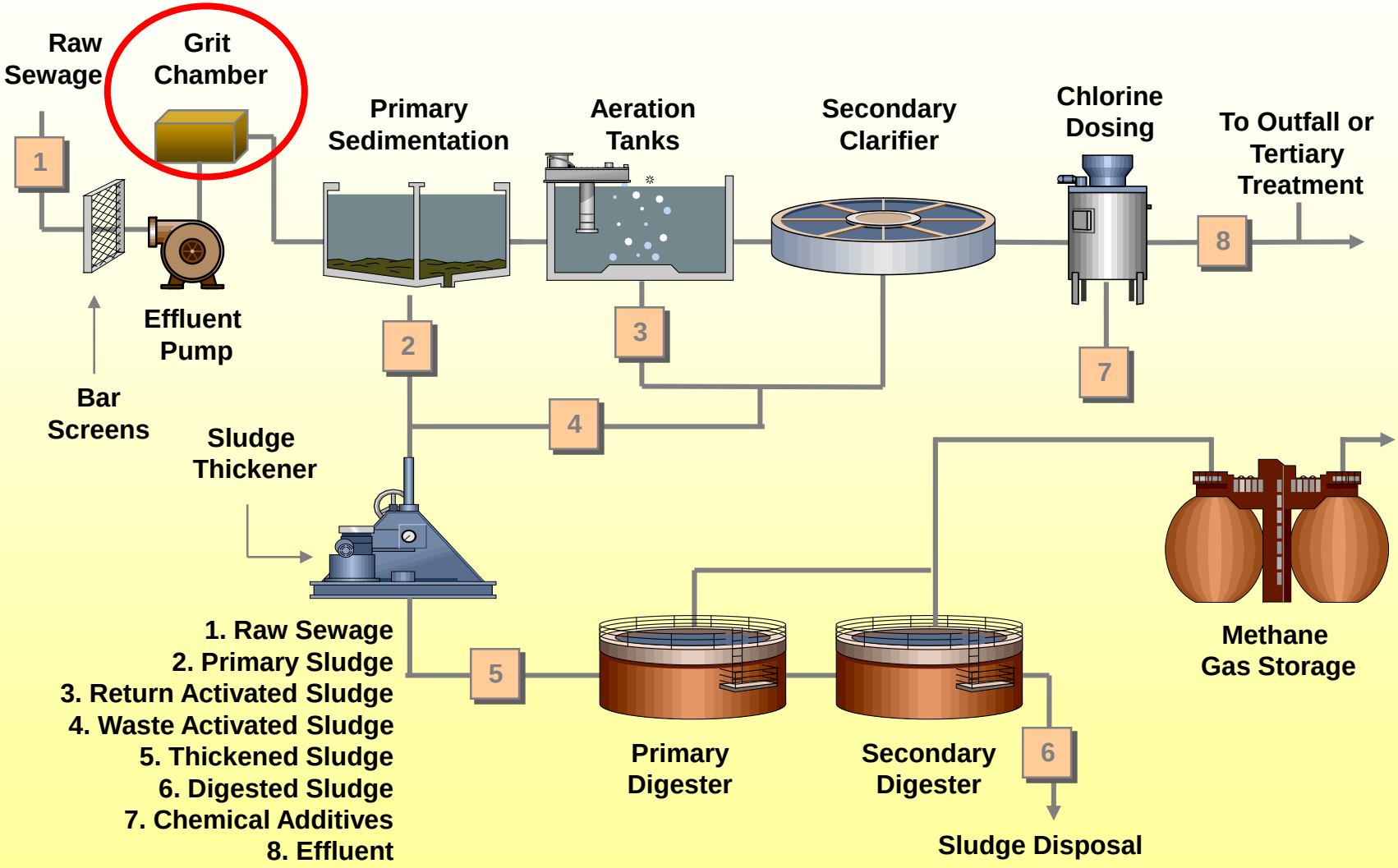


Mechanical Bar Screen

Go Forward

Go Back

Grit Removal Chamber

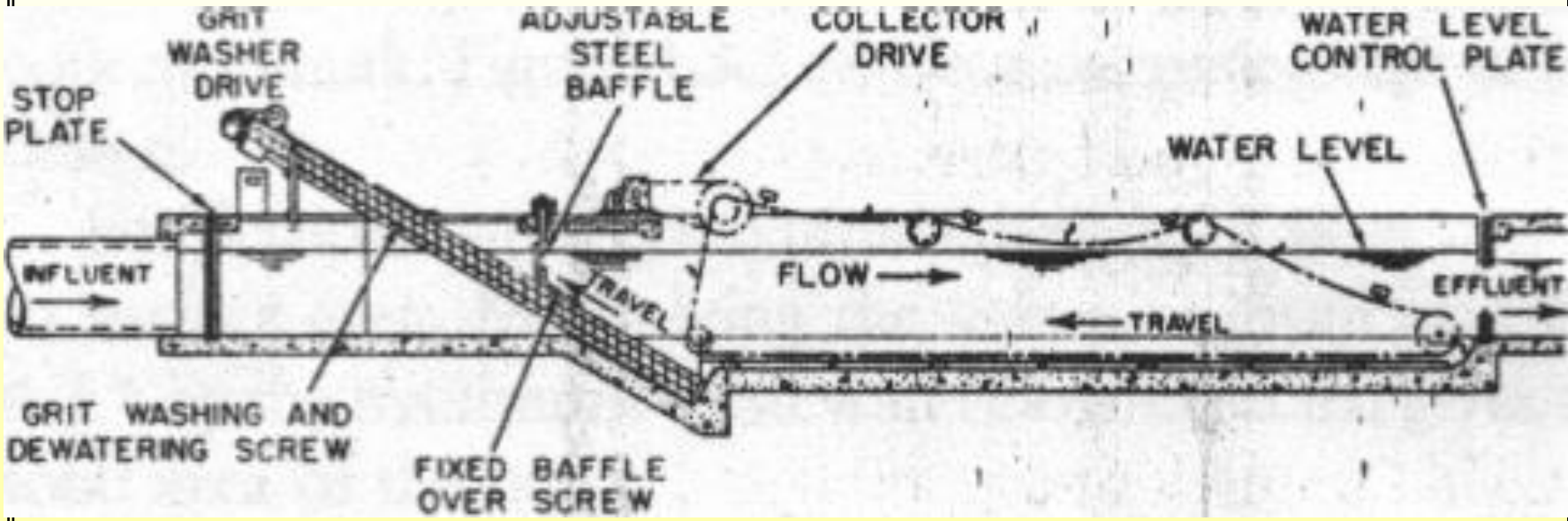


Grit Removal Chamber

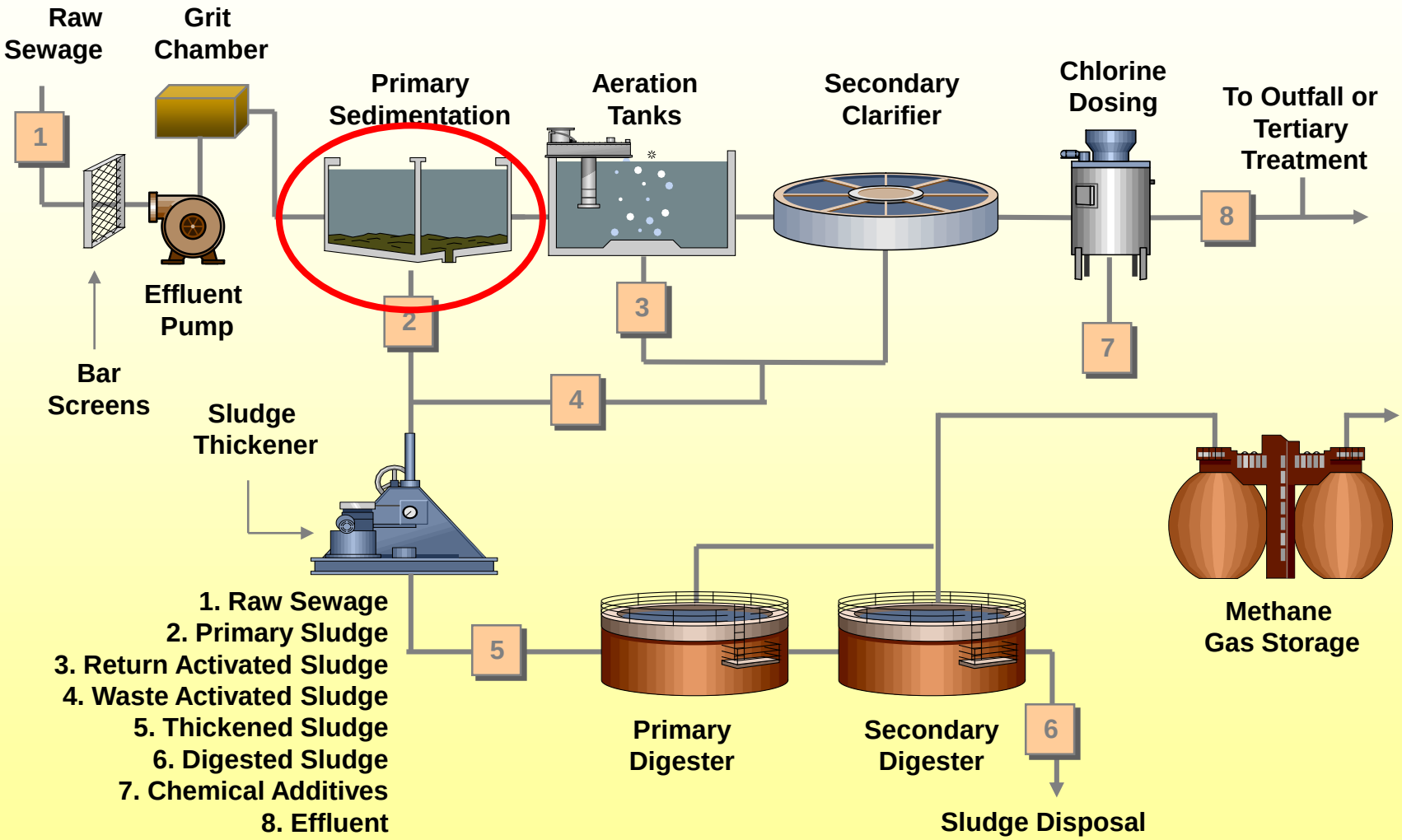
What is Grit?

- Grit consists of Sand, Gravel, or silt.
- Grit is Predominantly Inert & Relatively Dry

Grit Removal Chamber



Primary Sedimentation Tank

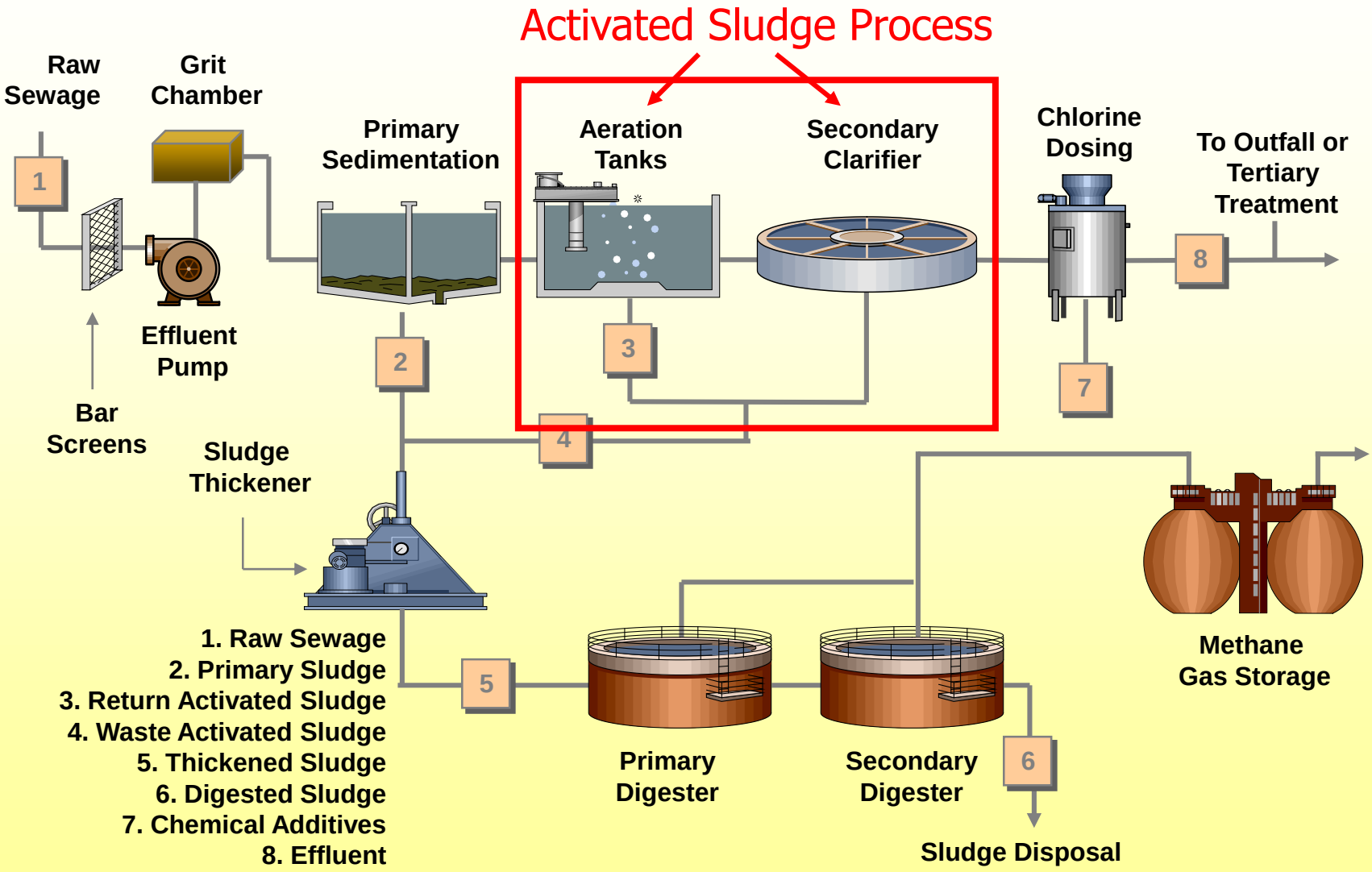


Primary sedimentation

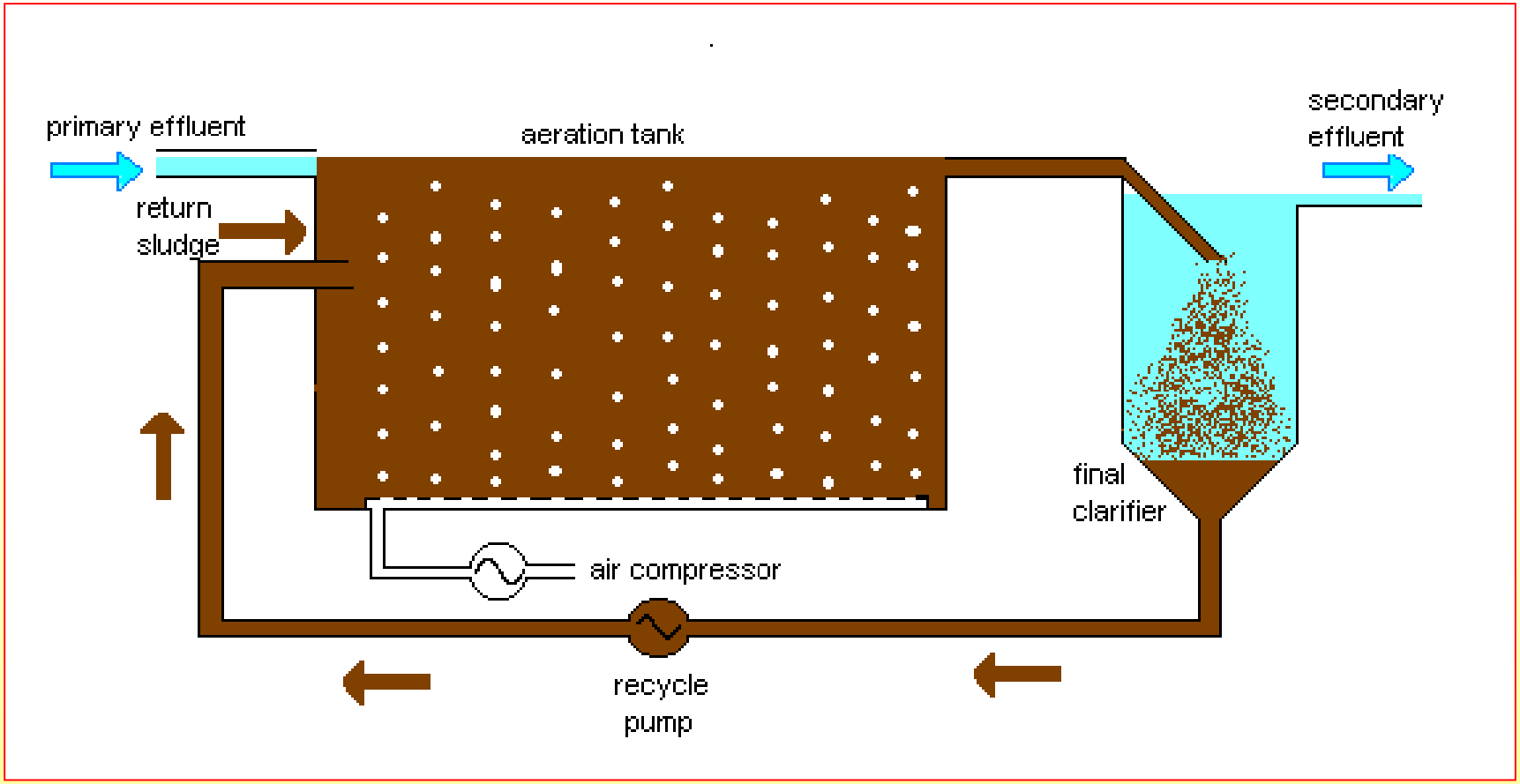
- **remove settleable solids (organic and inorganic) through sedimentation.**
- **remove scum, grease and fatty floating material.**
- **provide a slow flowing environment over a long enough time (detention time) for the solids to settle to the bottom of the tank.**
- **tanks can be of various shapes but usually rectangular with horizontal flow for primary sedimentation phase.**


Primary treatment removes about 50% of the pollutants in the wastewater.
Floatable solids such as grease and oil is skimmed from the top of the tank and pumped to incineration.
The material that was not removed by primary goes to secondary
pump
PRIMARY TREATMENT removes solids thru sedimentation.
Primary sludge settles to the bottom of the tank and is moved by flights to a sump and then pumped out to filters, incinerators & other means of disposal.
PUMP
Go Forward
Go Back
16

Activated Sludge Process

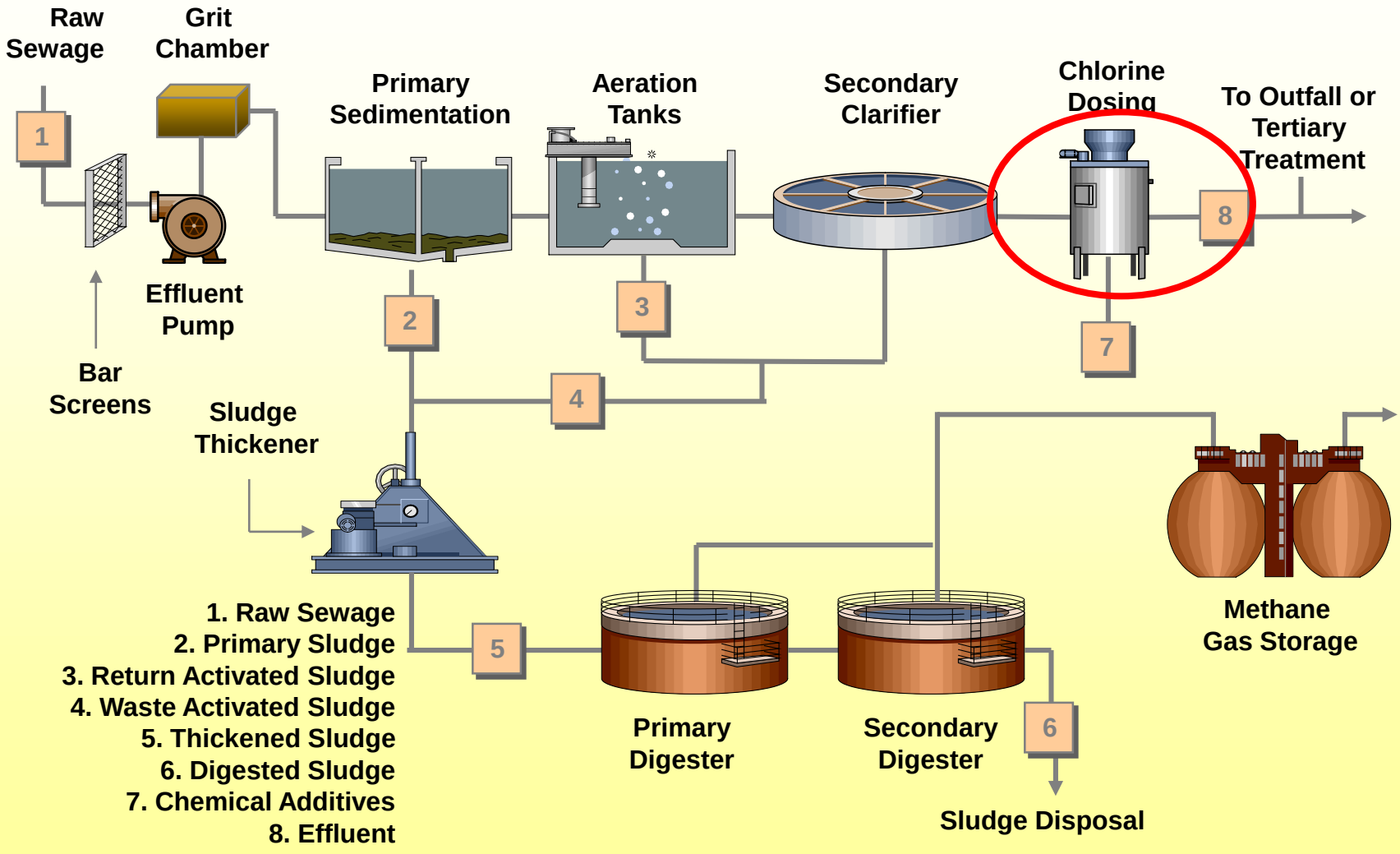


Activated Sludge Process



Secondary Clarifier Under Construction

Disinfection



Disinfection

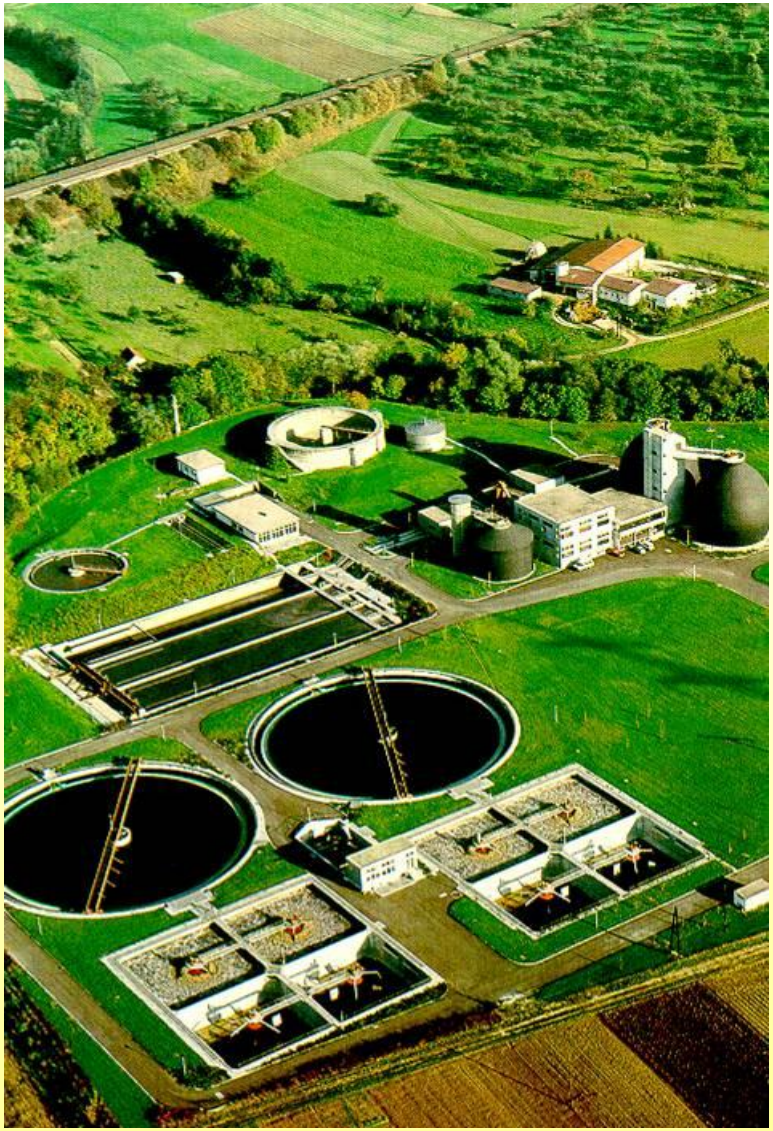
- Final step of wastewater treatment before discharge.
- Need to destroy pathogenic (disease-causing) microbes.
- Chlorine (Cl_2 – gas) is most common disinfectant.
- Problems with Cl : reacts with organic matter → chloroform (carcinogenic), toxic to aquatic organisms, and is hazardous to handle.

Disinfection

- Ozone (O_3) is powerful
- Ultraviolet light - good alternative to Cl_2

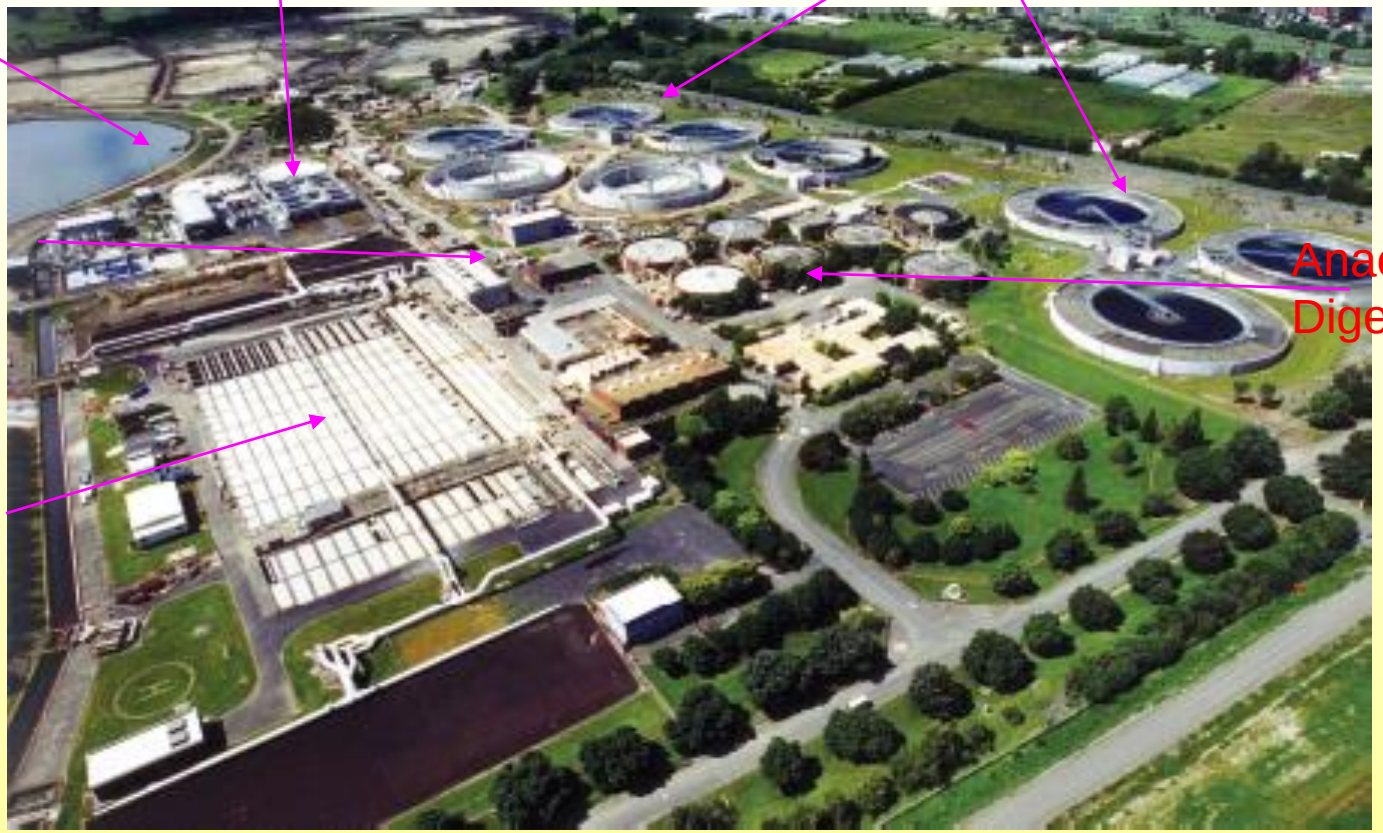
Water protection

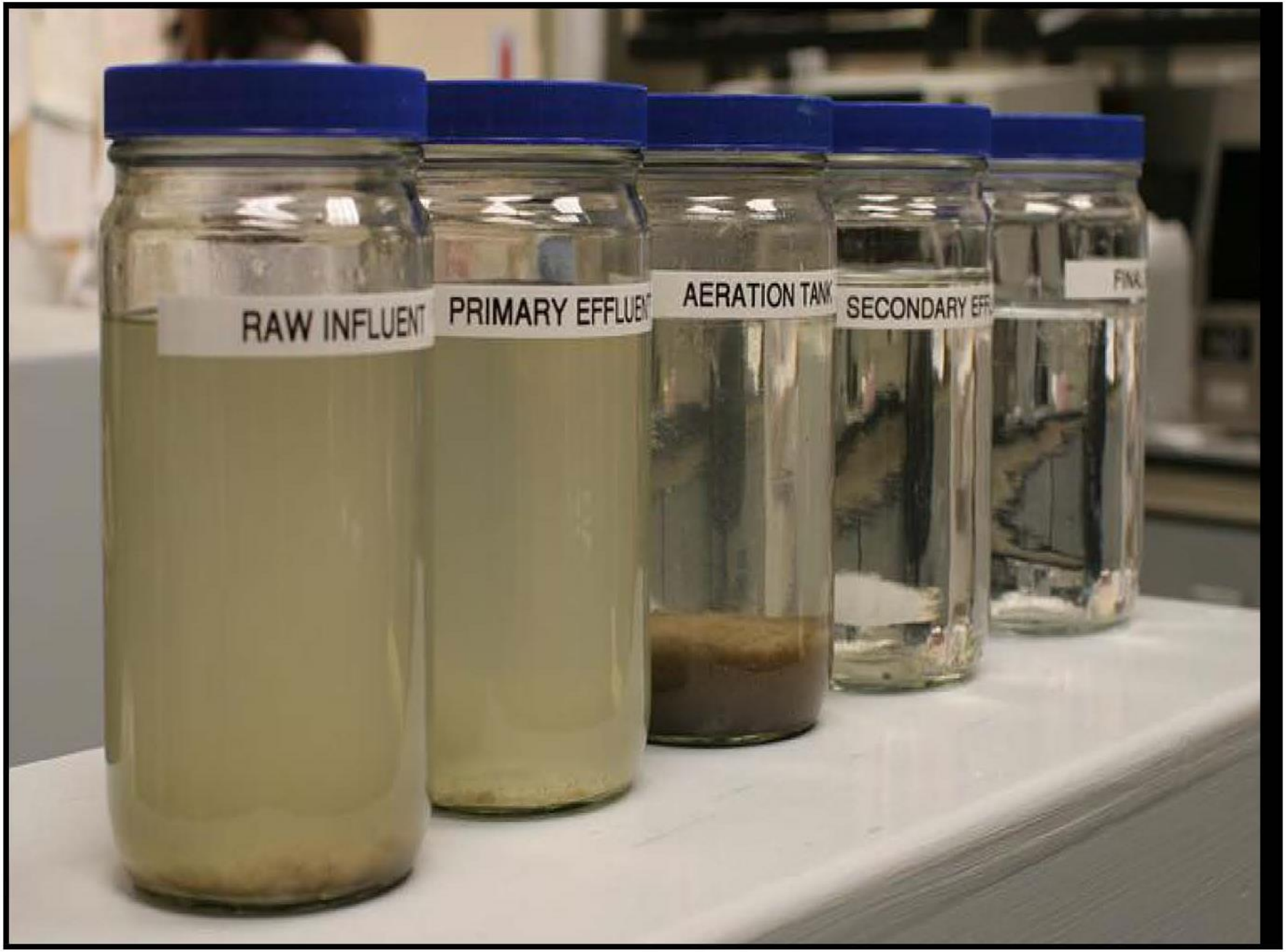
- Lake Constance is the drinking water reservoir and the polluted water. impacts the drinking water system.
- In 1975 a campagin for purification of water started.
- Big purification plants clean the polluted water only from big towns and villages.



Kaule: Environmental planning

Auckland's Wastewater Treatment Plant




RAW INFLUENT
PRIMARY EFFLUENT
AERATION TANK
SECONDARY EFF
FINAL

2- Land-Based System

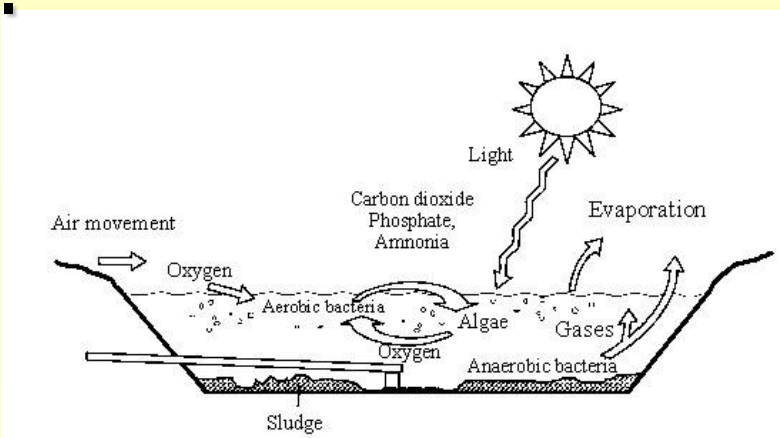
Lagoons

Lagoons

A lagoon is a shallow excavation in the ground (1 to 2 m deep).

It is generally unlined and percolation of wastewater into the soil and groundwater takes place.

A lagoon can be lined with a layer of clay or with an impermeable plastic membrane if protection of groundwater is desired, without affecting the performance of the lagoon.



Lagoon Treatment Process

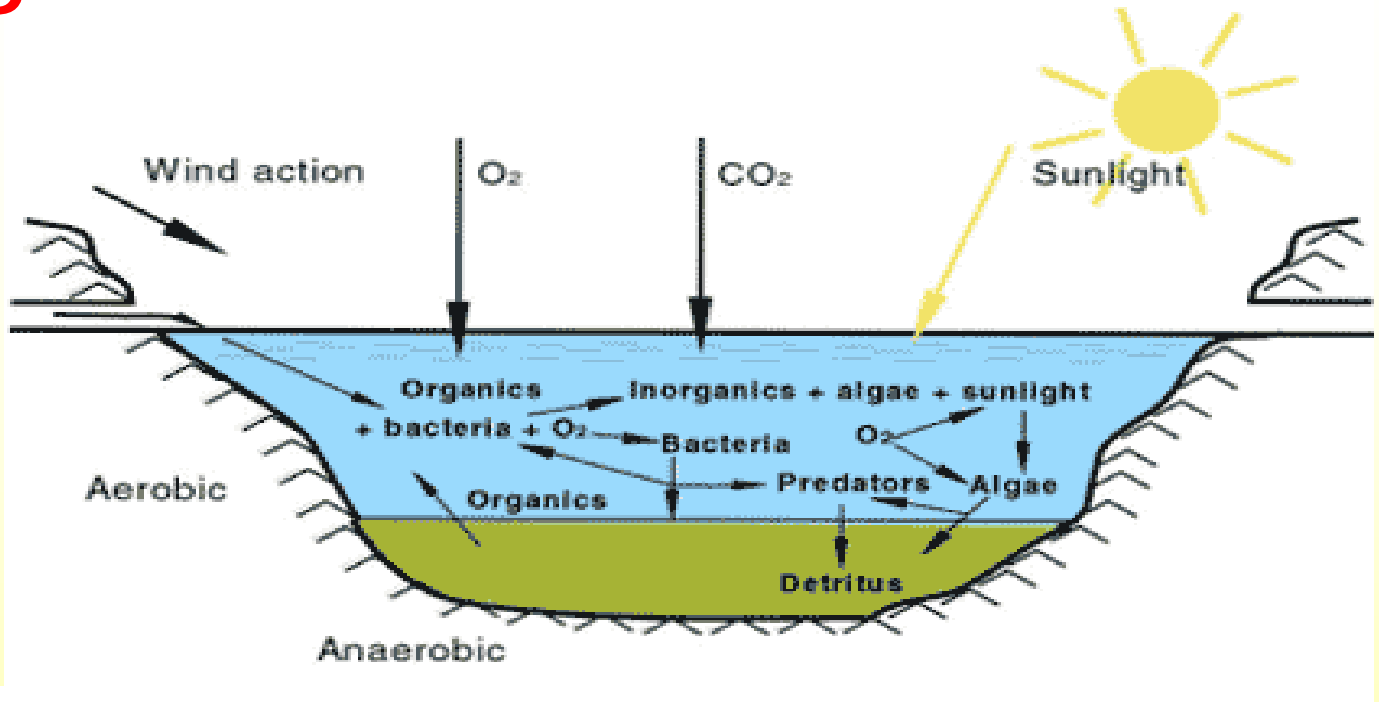
As wastewater enters a lagoon, sedimentation of solids occurs.

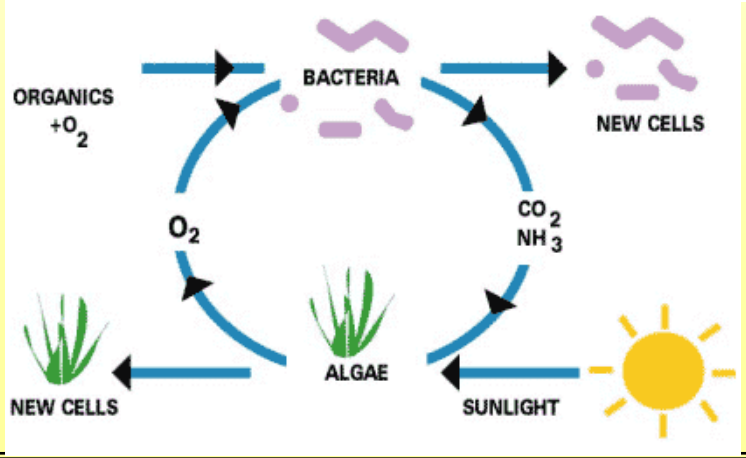
Long residence time, much of the solids is removed.

Aeration of the water from the atmosphere occurs by diffusion aided by turbulence caused by wind movement.

Evaporation of water can be significant in arid climate regions.

Lagoon Treatment Process



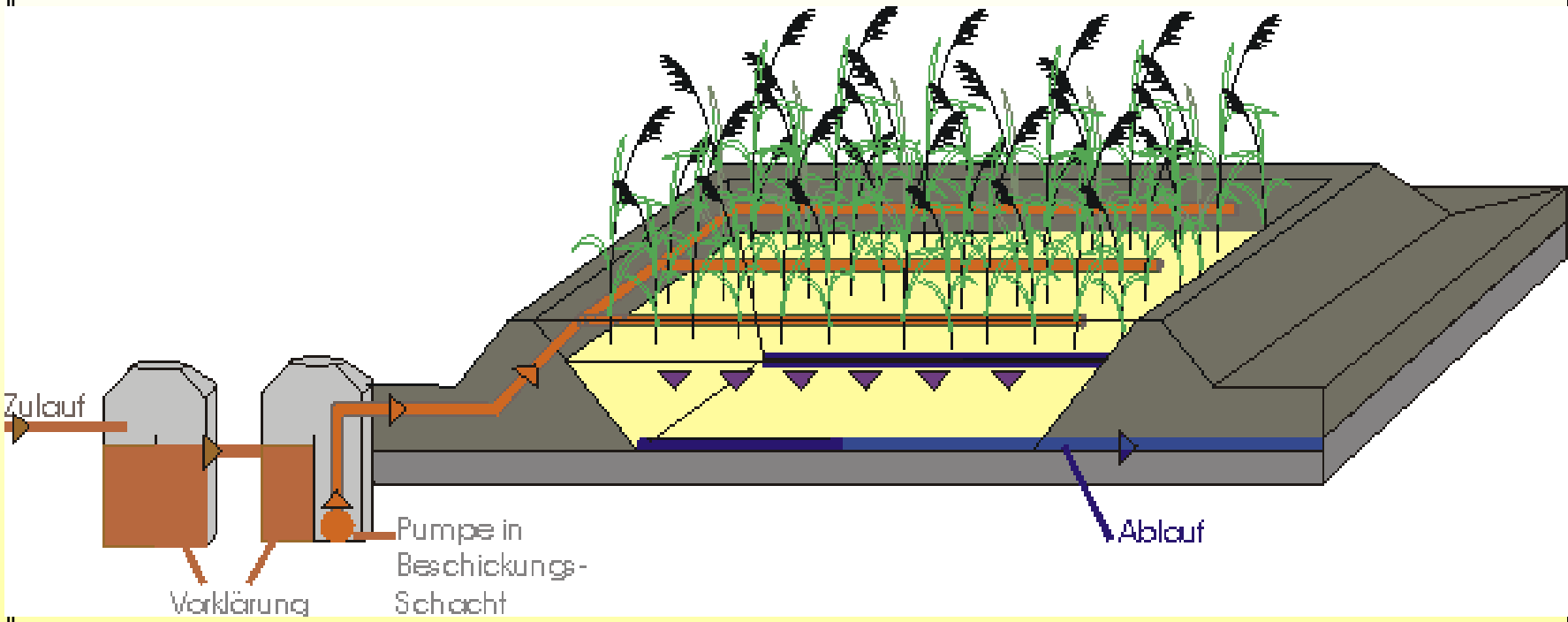



I93 Exit 4
Lagoon #1
Lagoon #2
Lagoon #3
Lagoon #4
Treatment Plant
Abandoned Chlorination Bldg

2- Land-Based System

Wetlands

Constructed Wetlands



Types of constructed wetlands

1- Free Water Surface Wetland

Free water surface wetlands, like most natural wetlands where the water surface is exposed to the atmosphere.

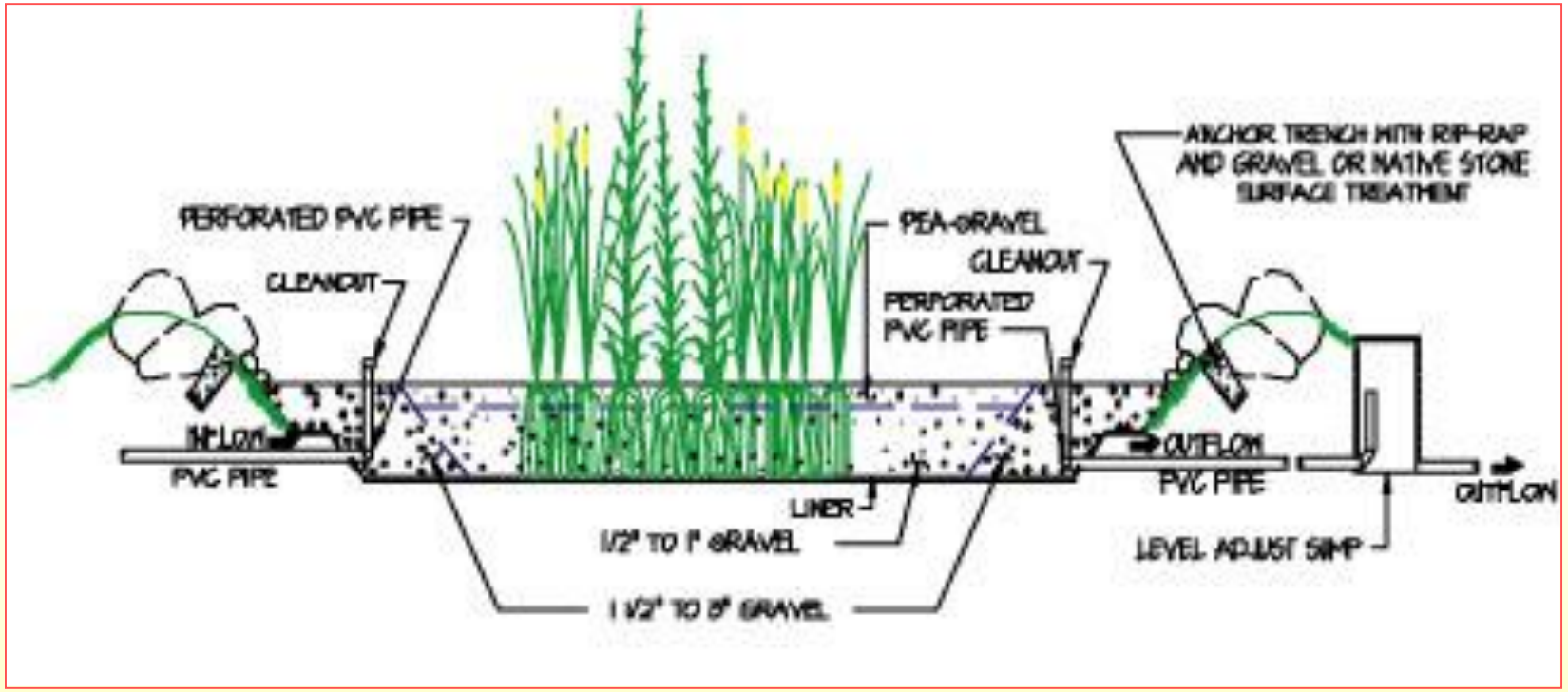
*Photo courtesy of Earthpace Resources

2- Subsurface Wetland

Subsurface wetlands, where the water surface is below ground level.

The use of subsurface constructed wetlands for water treatment began in Western Europe in the 1960's and in the U.S. in the 1980's.

Research and the use of constructed wetlands have increased rapidly over the last 15-20 years.

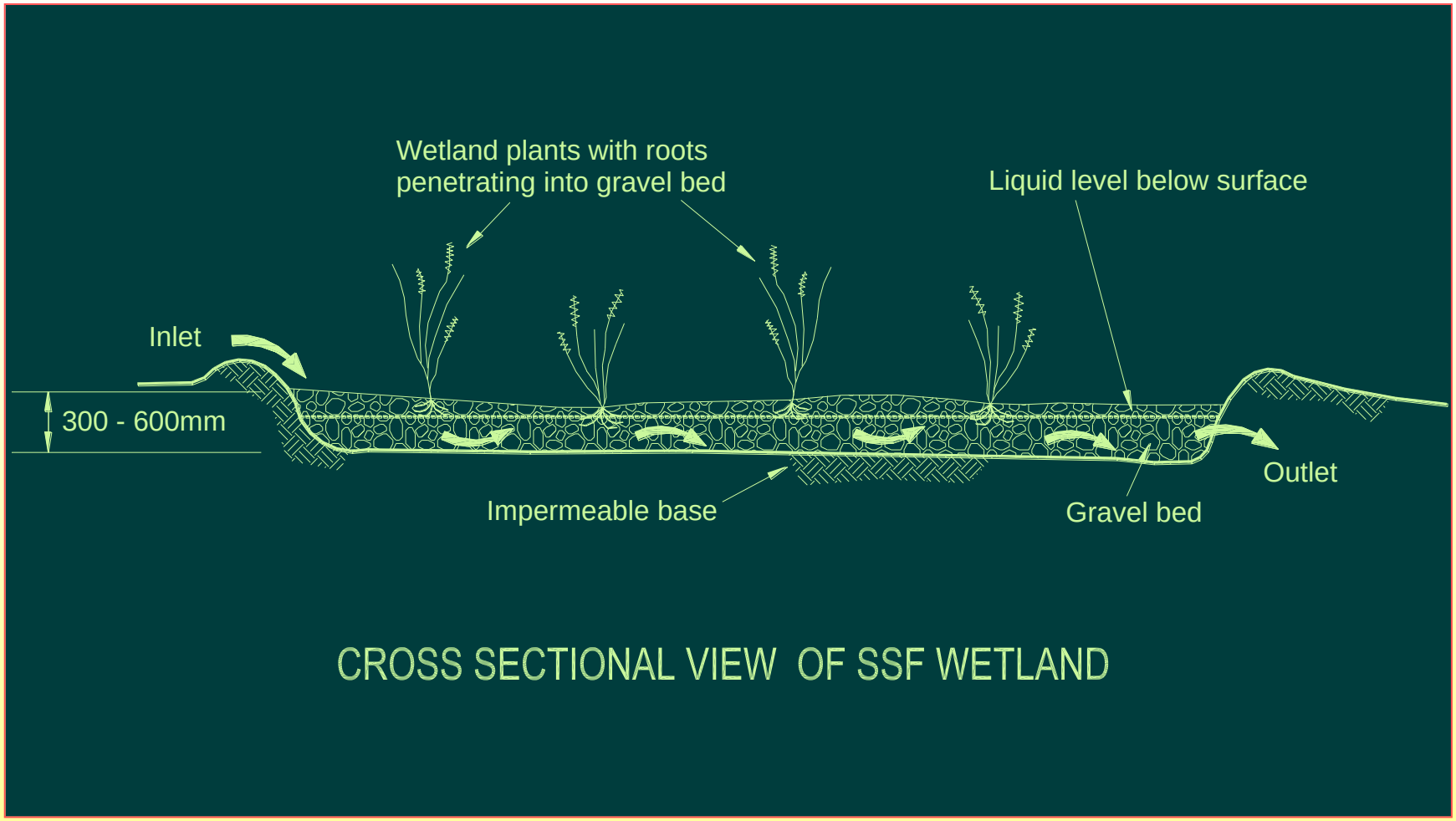


*Brix Oddie, M.L. Constructed Wetlands For Wastewater Treatment

The typical subsurface system consists of:

- Liner
- Inlet structure
- Bed (including media and plants)
- Outlet structure

Layout of Subsurface Wetland System



Examples of Wetland System

Kaule: Environmental planning

Various Plant Types

Water Hyacinths	*Eichhornia crassipes*
Forage Kochia	*Kochia spp*
Poplar Trees	*Populus spp*
Willow Trees	*Salix spp*
Alfalfa	*Medicago sativa*
Cattail	Typha latifolia
Coontail	*Ceratophyllum demersvm L*
Bullrush	Scirpus spp
Reed	*Phragmites spp.*
pondweed	*Potamogeton nodosus*
Common Arrowhead	*Sagittaria latifolia*

3- Soil-Based System

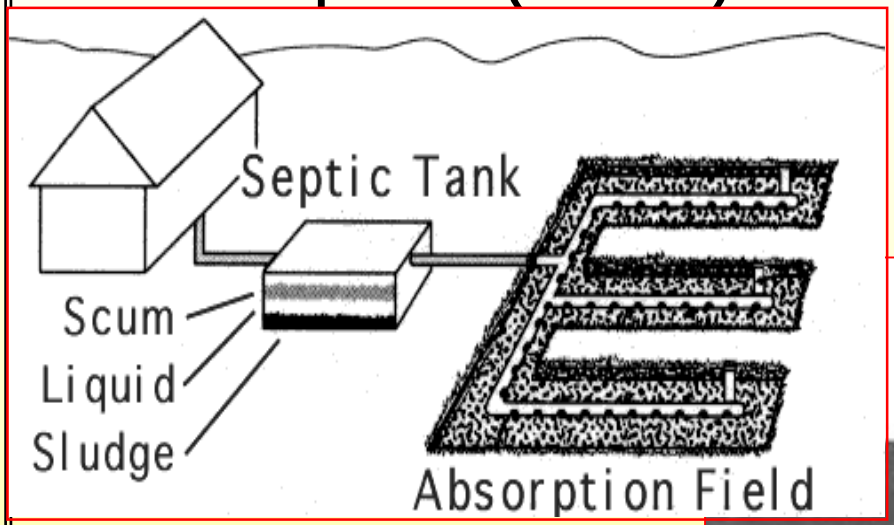
Septic System

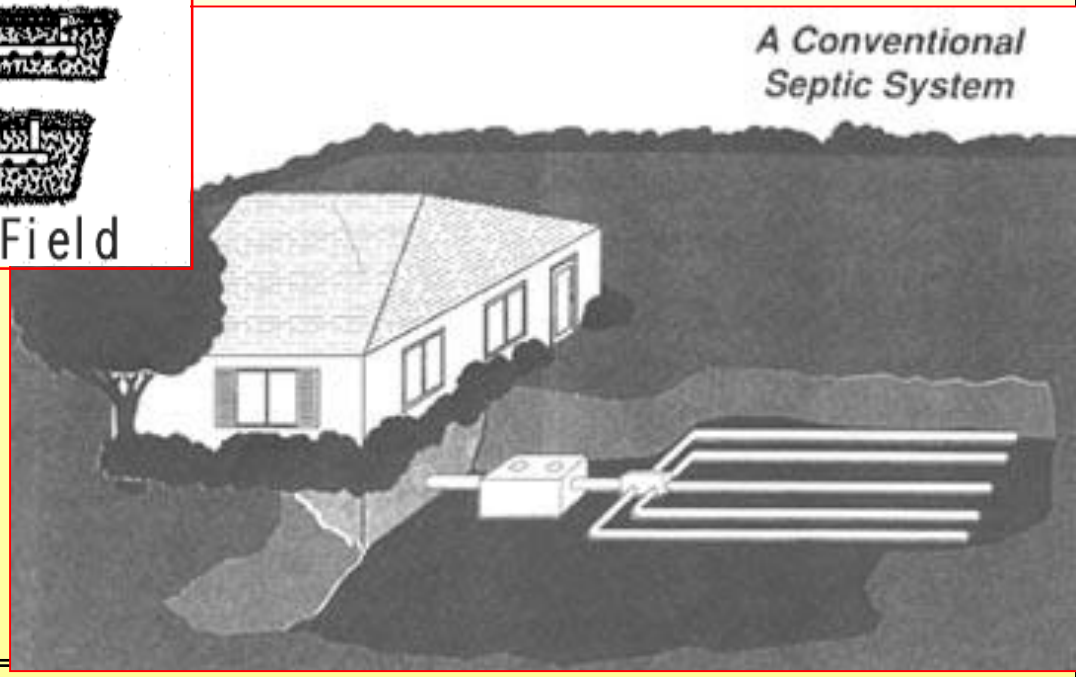
Septic System

A conventional septic system consists of two parts:

1-Septic tank

2- Absorption (Drain) field





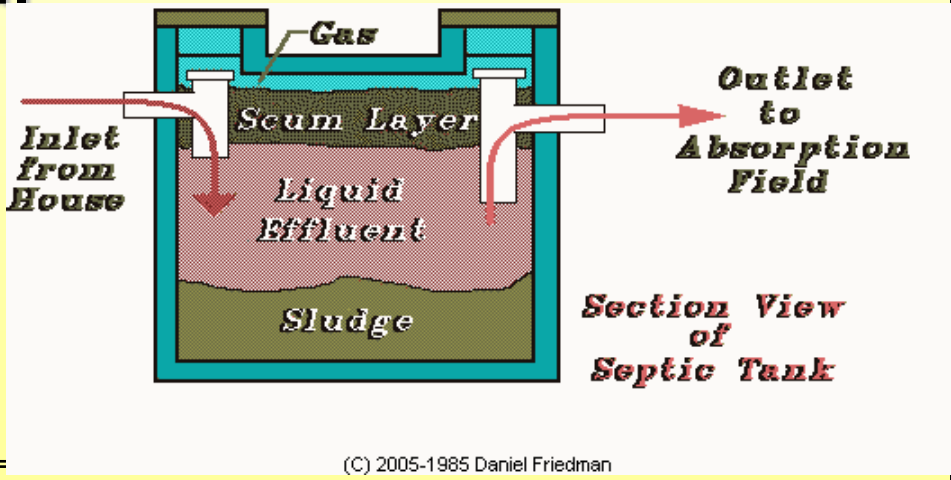
1-Septic tank

large, underground, watertight container rectangular or cylindrical and made of concrete, fiberglass or polyethylene.

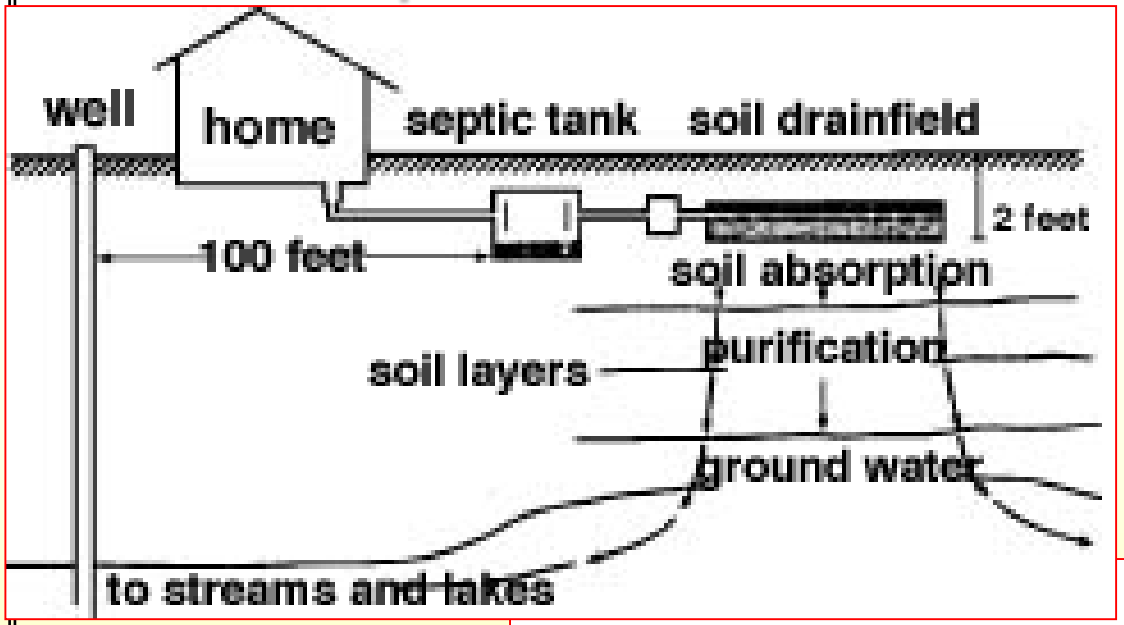
Light solids form a scum layer. This layer remains on top and gradually thickens until the tank is cleaned

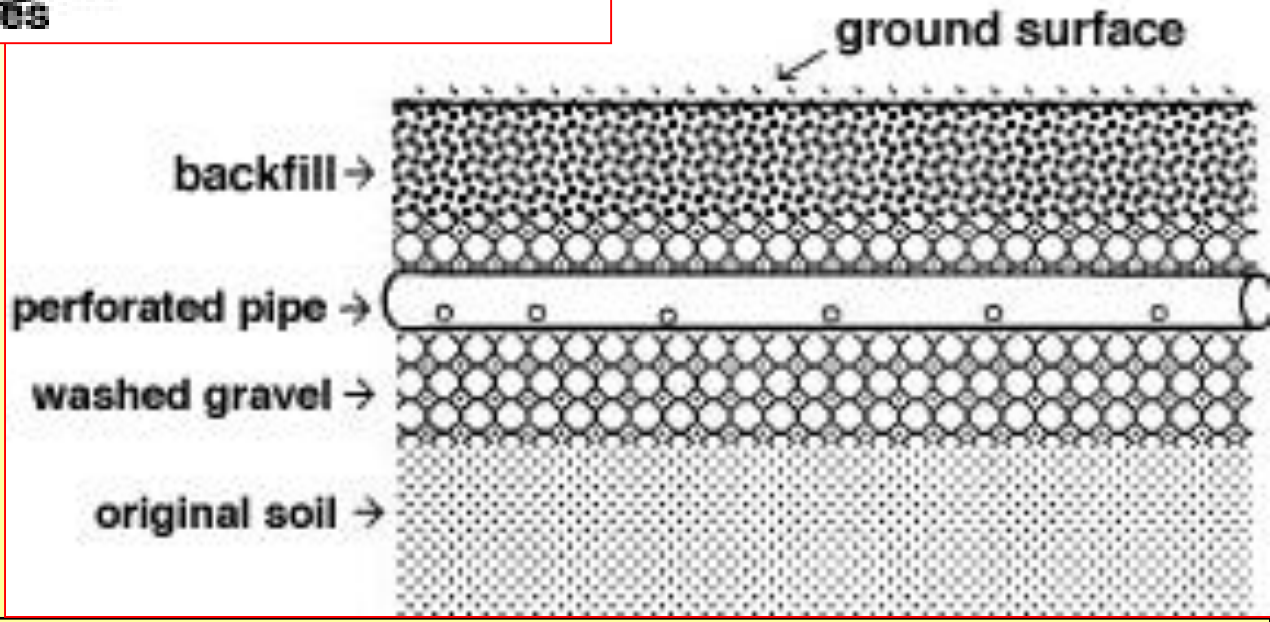
Liquid waste goes into the absorption field

Heavier solids settle down where they are decomposed by bacteria.



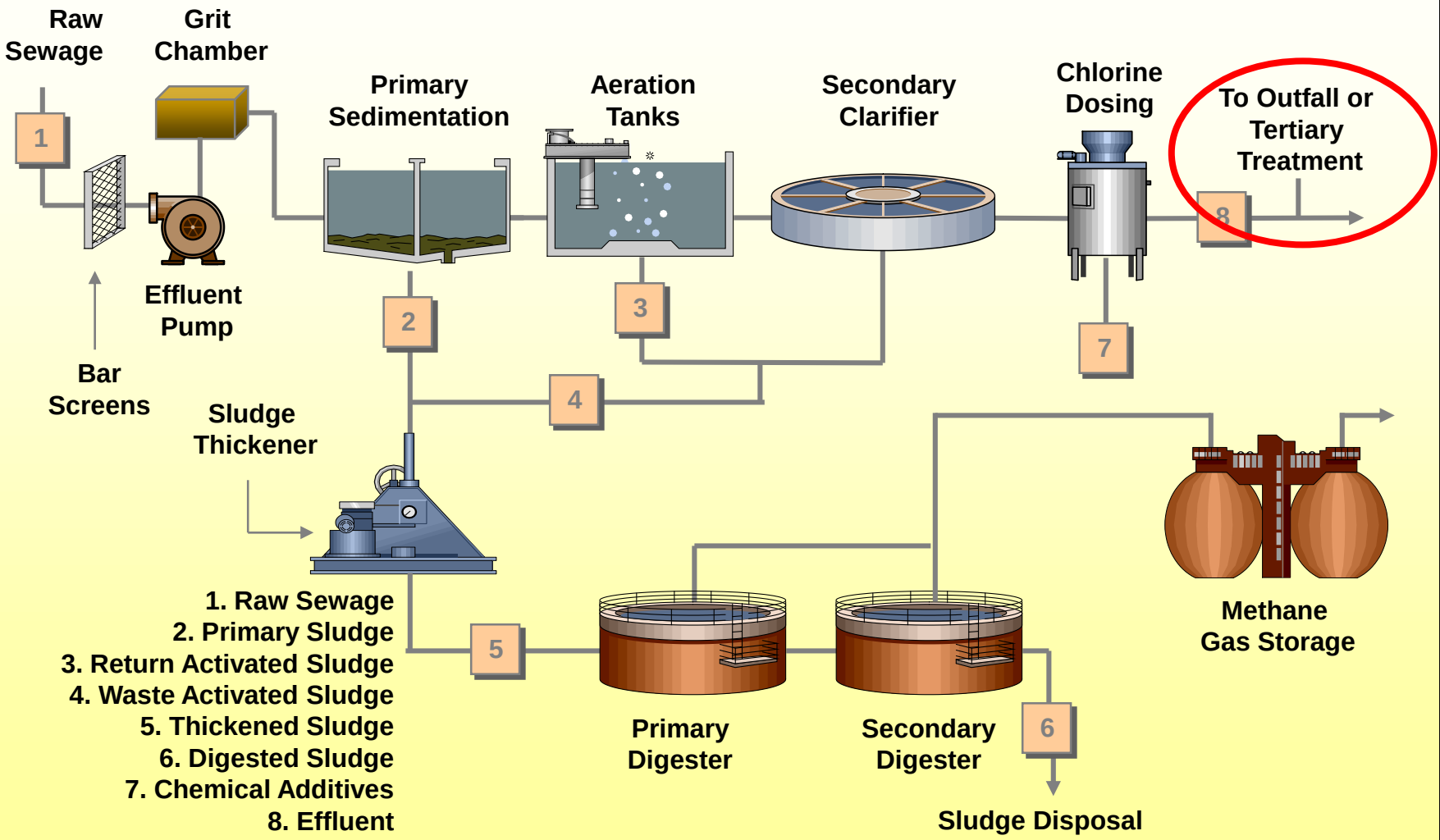
2- Absorption Field





III- Disposal Works

Disposal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6. Digested Sludge
7. Chemical Additives
8. Effluent

Methods of Wastewater Disposal

1- Surface disposal

2- Percolation

3- Evapotranspiration

4- Reuse / Recycling

Methods of Wastewater Disposal

1- Surface Disposal

- Treatment requirements may be stringent
- Must meet standards of the EEAA
- Requirements based on the characteristics and uses of the receiving water
- Requires regular monitoring

Methods of Wastewater Disposal

2- Percolation

- Percolation is the Downward Migration into Soils
  - Principle disposal process of soil-based systems
  - May lead to groundwater contamination
  - Not suitable for all areas

Methods of Wastewater Disposal

3- Evapo-transpiration

- Evapotranspiration
  - Combination of evaporation and transpiration processes
  - Effectiveness varies with climate and weather
  - Most Effective in arid regions

Methods of Wastewater Disposal

4- Reuse and Recycling

Irrigation:

- Some crops
- Managed Forests
- Golf Courses
- Landscaping

Gray water Recycling:

- Use for flush toilets

Sludge Disposal

- Method depends on regulations and quality of sludge
  - Land Spreading (High quality sludge)
    - lawns, gardens
    - agricultural land
    - forest land
    - golf courses and other public recreational areas
  - Municipal Solid Waste Landfill or incineration (Low quality sludge)

Application of Sludge to land/cropland

- Can provide nutrients like N and P
- Can build up soil organic matter in low organic matter soils
- However, sludge might contain: heavy metals, pathogens, toxic organic compounds

Incineration of Sludge

- Eliminates pathogens
- Greatly reduces volume
- Air emissions of heavy metals is big problem

Factors Influencing Wastewater Treatment Selection

Each treatment process must be selected after careful evaluation of three kinds of factors:

- Regulatory factors
- Physical factors
- Financial factors

Regulatory Factors

- Effluent quality requirements
  - for surface water discharge
- Effluent disposal requirements
  - for land treatment
- Requirements governing the disposal of residuals
  - for the disposal of (sludge) resulting from treatment
- Operator certification requirements
  - for operators of wastewater treatment facilities
- Local / regional restrictions or requirements
  - special requirements of local origin

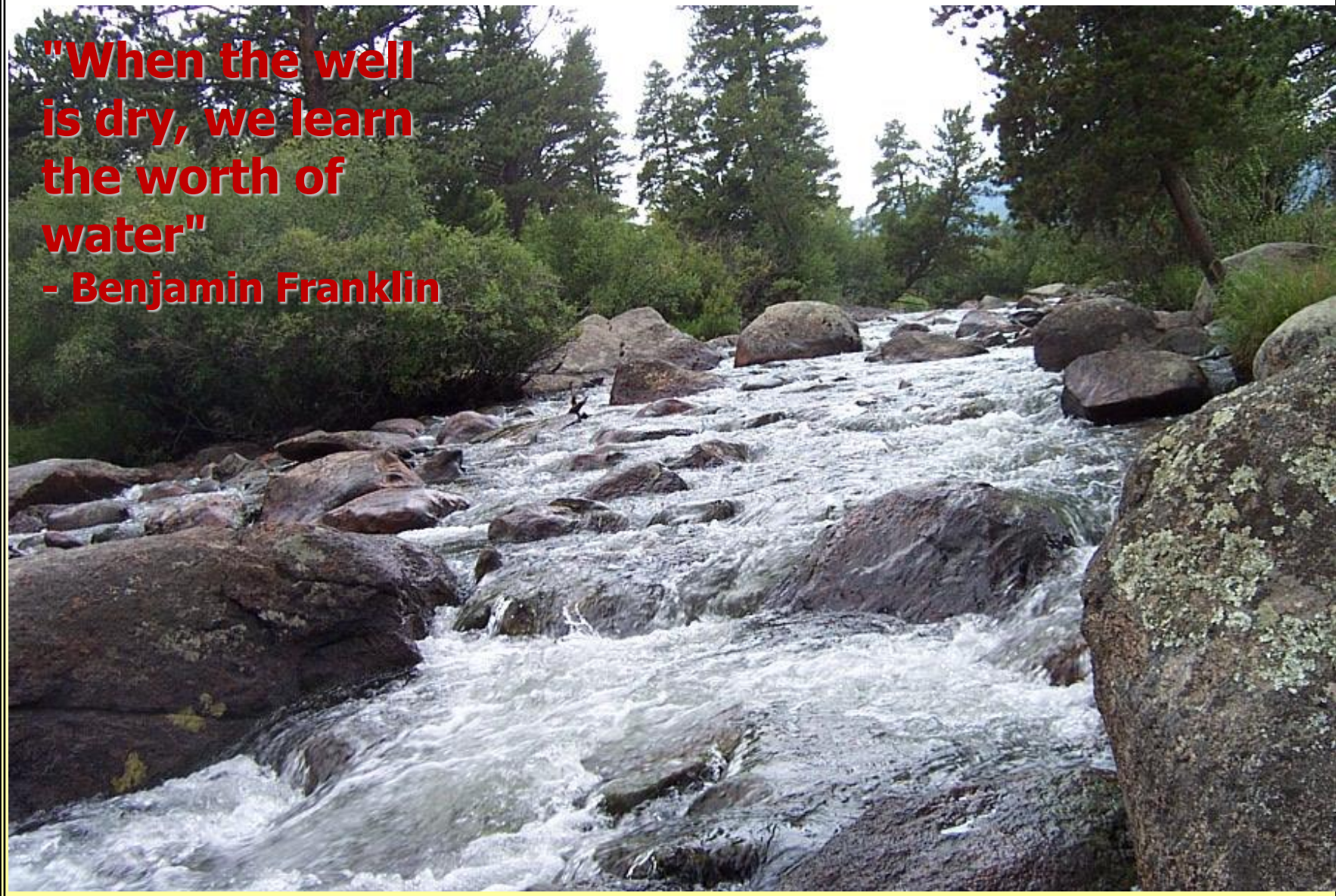
Physical Factors

- Location and distribution of customers
- Geology and soil characteristics
- Wastewater characteristics
- Existing infrastructure
- Anticipated growth
- Topography
- Climate

Financial Factors

Usually the most significant factor small communities face when selecting a new treatment system:

- Capital costs
- Operation and maintenance (O&M) costs


"When the well is dry, we learn the worth of water"
- Benjamin Franklin

THANK YOU!