PreliminaryTreatment

MCET
environmental, health, and safety training

CSM college of southern maryland
La Plata · Leonardtown · Prince Frederick · Waldorf

MCET Contacts

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Wastewater Treatment

Preliminary Treatment

MCET ENVIRONMENTAL, HEALTH, AND SAFETY TRAINING

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Process Training Sessions

Before class starts, please:

- **Check in**

During class, please:

- **Asks questions**
- Feel free to get up and leave the class at any time (i.e., rest rooms, phone calls, etc.)

After class, please:

- **Fill out** a Class Evaluation
- **Answer questions** on class quiz

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Housekeeping

- 1–day class
- Start class - 8:00 am
- Please mute/silence cell phones
- 10-minute Breaks – every hour
- Lunch ~ 11:30 am – 12:30 am
- End class ~ 3:30 – 4:00 pm

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Ice Breaker

- Before we start, does anyone have any questions about…

Preliminary Treatment

a) **Grit Removal**
b) **Screening**
c) **Flow Equalization**
d) **Odor Control**

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Instructor Expectations

- Begin and end class on time
- Be interactive
- Share experiences and needs
- Less lecture, more discussions
- ***Make this an enjoyable and informative experience!***

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Hints for Learning

- We all have valuable knowledge and experience
- This class is designed to *share that* knowledge
  - Please join class discussion
  - Share personal experiences about work successes, problems, etc.

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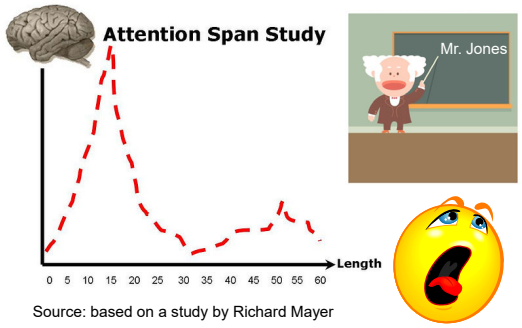
Student Attention Span - Lectures



Source: based on a study by Richard Mayer

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Groundrules

- Participate at your own comfort level
- Use terms we all understand
- Evereveryone is different, so please show respect for others
- Listen with an open mind
- Express opinions of things, not people
- Maintain confidences

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Focus, Objectives, and Agenda

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Preliminary Wastewater Treatment

- **Preliminary Treatment Facilities:** Physical treatment units that are specifically designed to remove large and small objects along with trash that can potentially cause mechanical and/or operational problems for downstream equipment
  - Bar racks, coarse screens, and fine screens
  - Grit chambers
  - Flow equalization facilities
  - Odor control facilities

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Agenda

- Introduction and Overview
- Screening
  - Bar racks
  - Coarse screens and fine screens
- Grit Removal
  - Horizontal flow grit chambers
  - Aerated grit chambers
  - Vortex grit chambers
- Flow Equalization
  - Inline
  - Offline
- Odor Control with Wet Scrubbers

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Purpose of Today's Class

- Discuss:
  - Wastewater sources
  - Screenings and grit sources in wastewater
  - Preliminary Treatment; need for:
    - Screening
    - Grit removal
    - Flow equalization
    - Odor control
  - Equipment O&M, and safety

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Preliminary Treatment

- The first step in wastewater treatment occurs at the headworks where debris (such as baby wipes) and grit (like sand) are removed from the wastewater stream
- This process is critical to protect downstream equipment, help control odors, and ensure efficiency of treatment plant operation

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Preliminary Treatment

- Typically includes bar racks, screens, grit chambers, and flow measurement
- Sometimes includes, flow equalization, comminutors (or grinders), pumping, odor control, septage receiving
- May include all, some, or none of these processes in different orders

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Preliminary Treatment

- Purpose:
  - To remove large objects and non-degradable materials
  - To protect downstream pumps and equipment from damage
  - To reduce odors
- Bar screens, grit chambers, and degritters
- Odor control with air and/or chemicals

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Wastewater Collection and Treatment

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Wastewater Collection and Treatment

- Measurement and sampling at head works:
  - Flow metering continuously records the volume of water entering the treatment plant
  - Samples are taken for determination of:
    - TSS
    - BOD
    - TN
    - TP
    - pH and alkalinity

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Wastewater Collection and Treatment

- Suspended Solids – the quantity of solid materials floating in the water column
- BOD – a measure of the amount of oxygen required to aerobically decompose organic matter
- TN – NH_3 + NO_2 + NO_3 + Org-N (Soluble and Particulate)
- TP – PO_4 + Org-P + Poly-P (Soluble and Particulate)
- pH – an expression of the intensity of basic or acidic conditions, 0 (most acidic) to 14 (most basic); 7 neutral
- Alkalinity – capacity of wastewater to neutralize acids, as $CaCO_3$

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Key Wastewater Constituents

- BOD – Biochemical Oxygen Demand
  - Typically, a five-day test is used to determine the quantity of oxygen used by microorganisms.
  - The higher the BOD concentration, the greater the wastewater strength (organic matter or food).
  - Raw sewage concentrations - 150 to 300 mg/l
  - Valid five-day BOD testing conditions:
    - BOD incubator temperature - 20°C
    - DO uptake - 2.0 mg/l
    - DO remaining after five days -1.0 mg/l

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Key Wastewater Constituents

- TSS – Total Suspended Solids
  - Substances in wastewater that can be removed by physical means
  - Sedimentation and filtration unit processes are used to remove TSS from wastewater
  - Raw sewage concentrations -150 to 300 mg/l
  - Valid TSS testing conditions:
    - Temperature in a drying oven - 103°C
    - VSS burn off at 550°C

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Key Wastewater Constituents

- Nutrients
  - TP – Total Phosphorus
  - TN – Total Nitrogen
- Phosphorus and Nitrogen compounds are nutrients that can stimulate algae production in receiving waters
- Typical concentrations:
  - TP – 3 to 5 mg/l
  - TN – 30 to 40 mg/l

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Definitions

Lift Station – Pumps wastewater from one level to a higher level if wastewater cannot flow by gravity to the plant.

Equalization Tanks/Ponds – Evens out flows to or in the wastewater treatment process by shaving peak flows during high flow events and returning stored flows to the process during low flow events. Improves plant process performances.

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Wastewater treatment Processes

- ***Preliminary treatment*** - physical process that removes screenings and grit
- Primary - physical sedimentation of suspended particulates
- Secondary - physical and biological treatment to reduce organic and nutrient loadings
- Tertiary – enhanced solids and nutrient removal

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Definitions

Bar Rack - removes coarse solids such as sticks, rags, and other debris in untreated wastewater by interception.

Grit Chamber – removes grit consisting of sand, gravel, cinders, or other heavy solid materials that have subsiding velocities or specific gravities substantially greater than those of organic solids.

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Definitions

Primary Clarifier - removes from 50 to 70 percent of suspended solids and 25 to 40 percent of the **BOD**.

Aeration Tank – Activated sludge is aerated with wastewater stimulating the growth of bacteria. The mixture of activated sludge and wastewater is called mixed liquor suspended solids (MLSS).

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Definitions

Secondary Clarifier – separates MLSS from water and settles the solids to the bottom of the tank. Solids are then either wasted or recycled back to the head of the aeration tank.

Disinfection - UV light or chemicals like chlorine are added to the discharge to kill disease-causing organisms.

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Definitions

Tertiary Clarifiers – final clarifiers for chemical addition; for phosphorus removal and enhanced solids removal.

Gravity Filters – final filters remove suspended solids and BOD to less than 5 mg/l. Filter media is typically sand and/or anthracite coal, or sometimes granular activated carbon

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Wastewater Collection and Treatment

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- pH – an expression of the intensity of basic or acidic conditions, 0 (most acidic) to 14 (most basic); 7 neutral
- Alkalinity – capacity of wastewater to neutralize acids, as $CaCO_3$

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Microorganisms

- **Aerobic** (Oxic) - Organisms requiring, or not destroyed, by the presence of free oxygen
- **Anoxic**: Organisms requiring , or not destroyed, by the absence of free oxygen; nitrates (NO_3) are present.
- **Anaerobic** - Organisms requiring, or not destroyed, by the absence of free oxygen and NO_3
- **Facultative** - Organisms able to function both in the presence or absence of free oxygen
- **Heterotrophic** - Organisms that use organic materials as their source of cell carbon
- **Autotrophic** - Organisms able to use carbon dioxide and other inorganic matter as their source of carbon
- **Filamentous** – Bulking organisms that grow in thread or filamentous form

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Why Collect and Treat Wastewater from Homes, Businesses, and Industries?

…to reduce the threat of water pollution in nearby waterways; i.e., the Chesapeake Bay and its tributaries

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Wastewater Treatment

- Sewage is an environmental health hazard (wastewater effluent)
- Purpose of wastewater treatment is to limit pollution in the receiving waterway
- Receiving waterways are usually sources of drinking water

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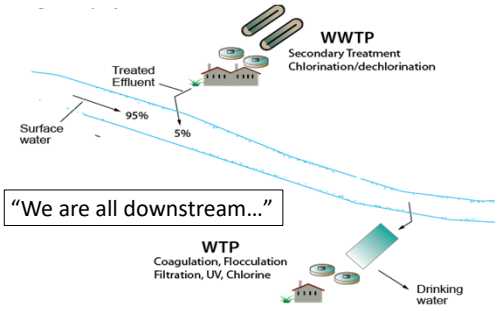
De facto Reuse of Wastewater



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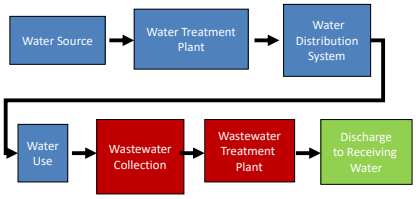
Water Use/Wastewater Cycle



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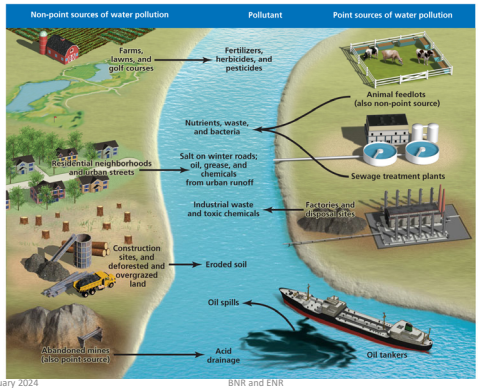
Pollution Sources



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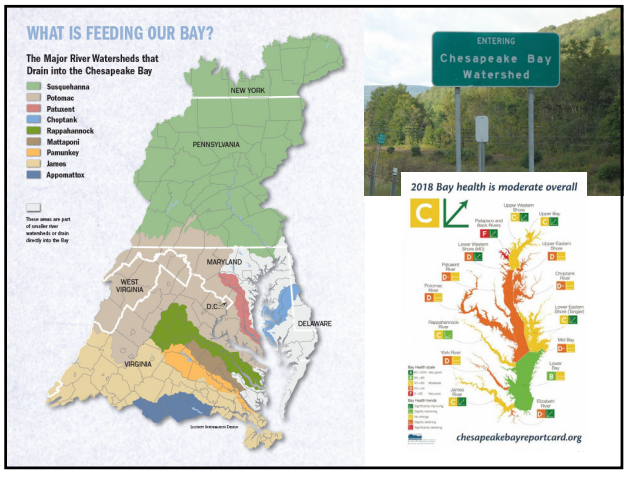

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Waterborne Diseases

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Waterborne Diseases

- ***Bacteria*** -Many types of bacteria are excreted in human feces and some, like *Salmonella* and *E. coli,* have the potential to cause disease.
- ***Viruses*** -More than 100 different types of viruses capable of causing disease are excreted by humans.
- ***Protozoa*** -Disease-causing protozoa like *Cryptosporidium* and *Giardia* may be found in wastewater

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Waterborne Diseases

Bacteria	*Escherichia coli* (gastroenteritis) *Salmonella typhi* (typhoid fever) *Vibrio cholerae* (cholera) *Shigella* (dysentery)
Viruses	Norovirus (gastroenteritis) Rotavirus (gastroenteritis) Hepatitis A virus (infectious hepatitis) Adenovirus (respiratory, gastroenteritis)
Protozoa	*Giardia lamblia* (gastroenteritis) *Cryptosporidium parvum* (cryptosporidiosis)

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Pathogens and Waterborne Diseases

- Enters water sources via:
  - Inadequately treated wastewater
  - Animal waste feedlots
- Causes more human health problems than any other type of water pollution
- Fecal coliform bacteria indicate fecal contamination of water
  - The water can hold other pathogens, such as giardiais, typhoid, hepatitis A

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Wastewater Sources

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Wastewater Collection

Collection system:

- Collect and convey wastewater from sewer connections to WWTP
- Consists of:
  - Gravity sewers
  - Lift stations
  - Force mains

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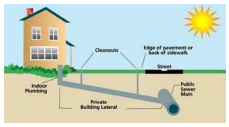
Wastewater Sources

- Residential, commercial, and industrial sources
- Infiltration/Inflow
  - Problems with excess I/I
- Industrial sources
  - Industries pre-treat wastewater
  - Discharge permit (Pretreatment Program)
  - Problems associated with industrial wastes
    - Harm to WWTP and waterways



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Wastewater Collection

- Water discharged from homes, businesses, and industries enter **sanitary** sewers
- Water from rainfall and snow melt:
  - Enter **storm water** sewers
  - Can enter **sanitary sewers** as inflow and infiltration (I/I)
- **Combined sewers** carry both wastewater and storm water

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Wastewater Collection

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Wastewater Collection

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Infiltration and Inflow

- Infiltration and inflow are two types of water that enter sanitary sewers
- Infiltration refers to groundwater that enters the sewer system through cracks, leaky pipe joints, and deteriorated manholes
- Inflow refers to stormwater that enters the sewer system through rain leaders, basement sump pumps, or foundation drains that are illegally connected to the sewer

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Roots - Tap (RT)

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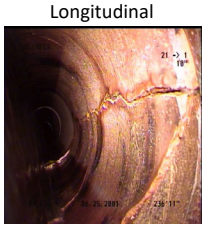
Cracks & Fractures can be. . .

Longitudinal



Circular

Multiple

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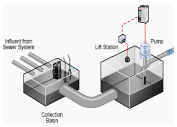
Wastewater Collection

- Wastewater moves primarily by gravity flow
- Pumping stations lift wastewater from low lying areas to higher elevations
- During wet weather events, wastewater flows increase because of I/I:
  - Inflow of surface rainwater
  - Infiltration of groundwater



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Infiltration and Inflow

- The amount of infiltration and inflow in a sewer system can be estimated by analyzing wastewater treatment plant influent flow data
  - Dry weather flows versus wet weather flows
- Excessive infiltration and inflow can cause overflows or bypasses

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Diurnal Flow Pattern

- Domestic wastewater has a 24-hour, diurnal flow pattern
- Influent flow is typically higher during the day than at night
- The flow pattern reflects activities in the service area
- Small service areas generally experience greater influent flow variations over a 24-hour period than larger service areas

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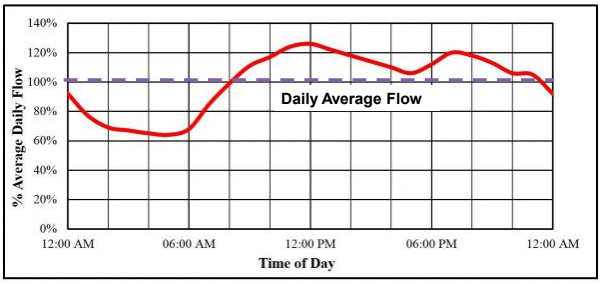
Diurnal Flow Pattern



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Diurnal Flow Pattern

- Diurnal means something is related to each day or that it takes place daily
- An influent flow pattern is diurnal because the pattern repeats every 24 hours
- Weekday diurnal flow

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Plant Flow Patterns

- Diurnal – Flows vary during the day:
  a. Low – in the morning hours (2 am – 6 am)
  b. High – during lunch through dinner hours (10 am – 10 pm)
- During wet weather events, flows can peak at 3 to 5 times dry weather flows

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Flow Quantities

- During wet weather events, the **peak flow** to a Wastewater Treatment Plant (WWTP) is the highest flow rate that the plant experiences for a sustained period, usually for one hour
- The peak flow dictates the hydraulic capacity of the treatment system

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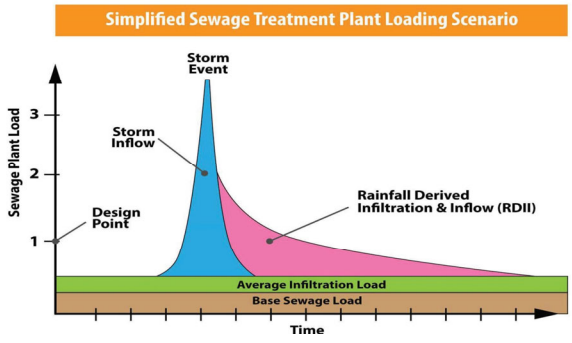
Infiltration and Inflow



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Flow Quantities

- Beginning in the 1970s, communities began lining sewer pipes to reduce I/I in sewer collection systems (<25%)
- Also, beginning in the 1990s, with strong water conservation efforts, water usage/sanitary wastewater flows generated per capita dropped nearly 20%, to 50 to 60 gpd/capita
- After 2010, including I/I, wastewater generated per person ranged from 70 to 80 gpd/capita

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Flow Quantities

- Some municipalities currently experience high peak influent flows during periods of wet weather that exceed the treatment capacity of existing biological or advanced treatment units

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Flow Quantities

- Under peak flow conditions, to prevent damage to the wastewater treatment plant and maintain future effective operations:
  1. Some plant operators divert or by-pass a portion of the excess flow around biological or advanced treatment units
  2. Others, divert flow to equalization tanks for temporary storage until flows subside; flows then are pumped back through the plant during low flow conditions

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Flow Quantities

- When wet weather events exceed the capacity of one or more treatment units at the plant;
  - Inadequate treatment
  - Operational difficulties
  - And/or National Pollutant Discharge Elimination System (NPDES) permit violations can result

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Wastewater Collection

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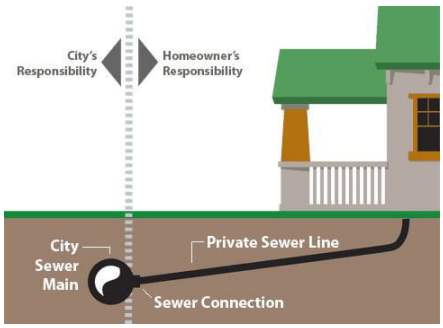
Typical Household Sewer Connection



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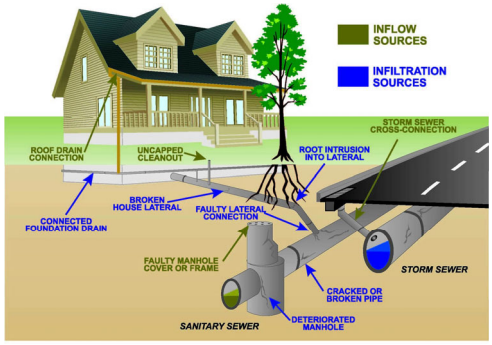
Sources of I/I



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Wastewater Collection

Collection system:

- Collect and convey wastewater from sewer connections to WWTP
- Consists of:
  - Gravity sewers
  - Lift stations
  - Force mains

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Collection Systems

- Connection to house, 6”
- Collecting sewers, from houses, 8-12”
- Interceptor or trunk sewers, to plant, 15-27” or larger
- Designed for gravity flow and to:
  - Prevent in-line sedimentation
  - Rapidly transport sewage; avoid anaerobic conditions and H_2S release
  - Avoid scour to pipe

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Most collection system problems fall into one of three categories:

- *Design Problems*
- *Maintenance Problems*
- *I&I Problems*

Give some examples of each?

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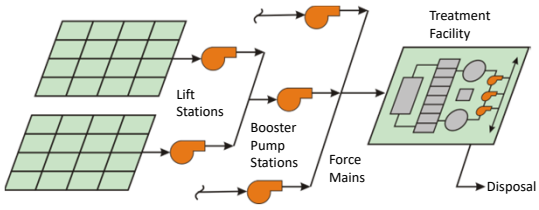
Wastewater - Collection and Treatment



Gravity/Low Pressure Collection | Lift Station/ Booster Station | Wastewater Treatment

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Wastewater Collection and Treatment

- ***Velocity*** plays a key role in solids and grit traveling through a collection system
- Average rates range between 2 to 3.5 ft/sec (fps); peak rates can exceed 10 ft/sec
- Solids stay mixed while grit concentrations travel like a moving bed along the bottom of the sewer pipe
- At higher velocities, flow becomes turbulent dispersing the grit with the solids; at velocities below 2 fps, grit will begin to settle out

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Lift Stations are installed at the end of gravity sewers where. . .

...Excavation costs to maintain gravity flow is excessive

...Soil stability is unsuitable for trenching

...Groundwater table is too high for installing deep sewers

...Amount of wastewater flow does not warrant the extension of large trunk sewers

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Purpose of Lift Stations

- Raise the wastewater to a higher level to restart its gravity flow
- If the station has a long force main or discharges to a pressurized system, it is considered a ***pumping*** station

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The Basic Lift Station contains. . .

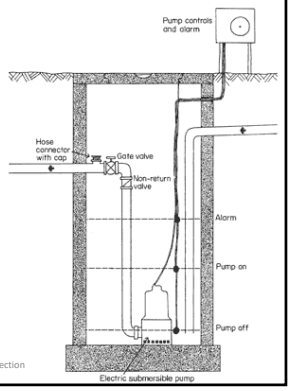
... A wet-well

... At least 2 pumps

... Suction and discharge piping (force main) with check valves and isolation valves

... Pump control devices

... A control panel



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Normal Operation. . .

- Wet well level determines pump operation
  - Pump off
  - Lead on
  - Lag on
  - High level
- The control system monitors the wet well level and activates the pumps
- Various level sensors can be used

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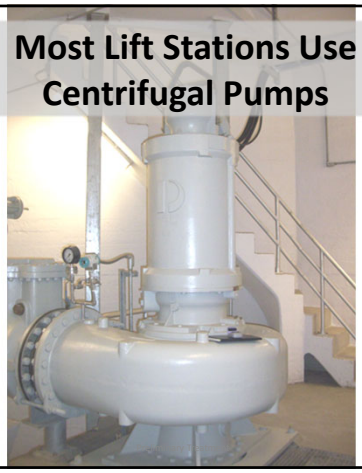
Most Lift Stations Use Centrifugal Pumps



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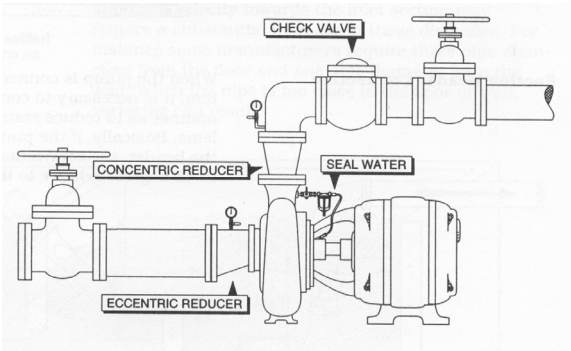
Pump Piping System



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The Lift Station

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Common Lift Station Types

- Wet Well (Submersible)
  - Pumps are submerged in the wastewater
- Wet well/Dry well
  - Pumps are in a dry chamber
- Above Ground
  - Pumps are above the wastewater
- Pneumatic Ejector
  - Uses compressed air to eject wastewater

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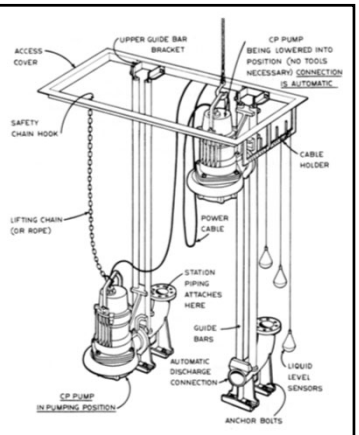
Submersible Station



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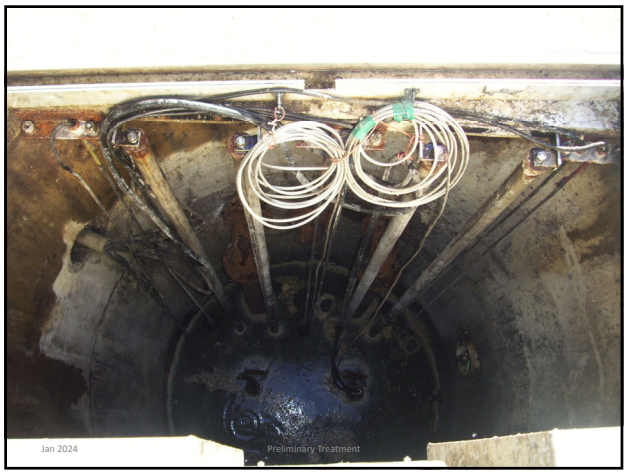

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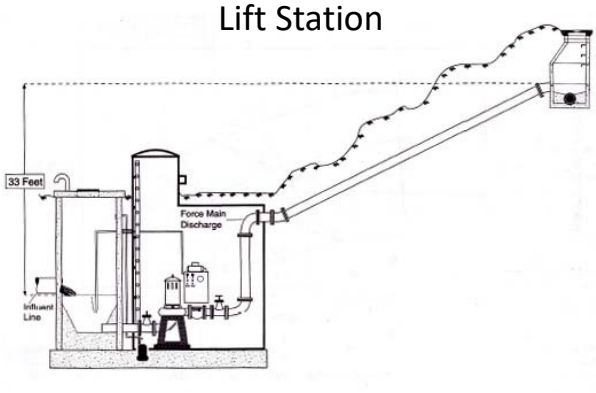
Lift Station



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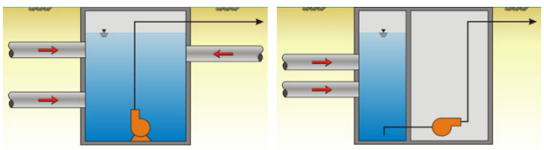
Lift Stations

- Pump wastewater from one level to a higher level if wastewater cannot flow by gravity



Wet Well **Wet Well/Dry Well**

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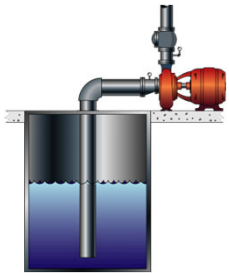
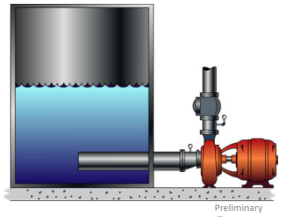
The pump can either be in a. . .

. . .Suction lift condition



. . .Suction head condition



Preliminary Treatment

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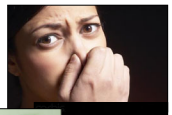
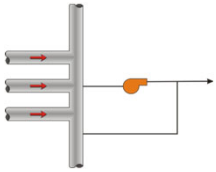
In-Line Booster Pump Stations

- In-line booster pump stations provide for:
  - Odor containment
  - Reduced maintenance
  - Reduced capital cost





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Sewer Overflows

Jan 2024 Preliminary Treatment Slide: 84

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Basic Definitions

- Sanitary Sewer Overflow (SSO)
  - Releases of untreated or partially treated wastewater to waters of the United States
  - Releases of untreated or partially treated wastewater that do not reach waters of the United States
  - Wastewater backups into buildings and on private property that are caused by blockages in the publicly owned portion of the sanitary sewer system

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Basic Definitions
(continued)

- SSO Reporting System
  - On-line spill reporting system hosted, controlled, and maintained by the state
- Untreated or partially treated wastewater
  - ANY volume of waste discharged from the sanitary sewer collection system upstream of a wastewater treatment plant

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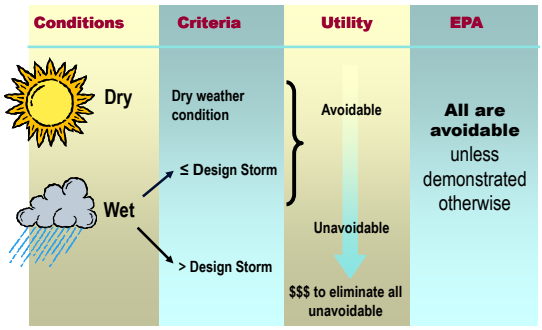
86

What SSOs are Avoidable/ Unavoidable



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Sanitary Sewer Overflow (SSO)

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Sanitary Sewer Overflow (SSO)

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SSO Categories

- Category 1
  - Exceeds 1,000 gallons, or
  - Results in discharge to surface waters, or
  - Discharge to storm drain and not captured
- Category 2
  - All other discharges from Enrollee's sewer system
- Private Lateral Sewage Discharge
  - Discharges caused by privately owned lateral

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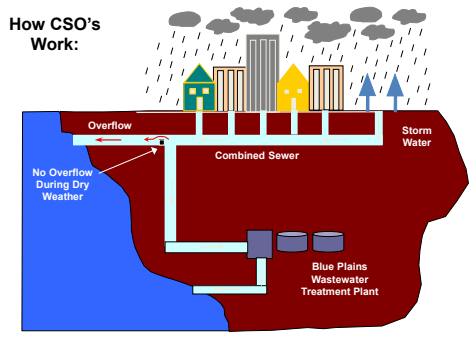
Combined Sewer Overflows

- Certain cities have sanitary and storm sewers combined
  - District of Columbia – Blue Plains AWT Facility
  - Alexandria, Virginia – AlexRenew WWTP
- During wet weather events, not all combined flows can be pumped to the WWTP
- Therefore, some Combined Sewer Overflow (CSO) is discharged directly to the waterways without treatment

91

What is a CSO?



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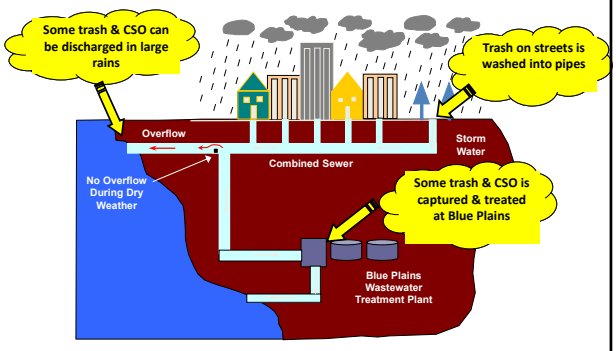
What is a CSO?



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Why are CSOs a Concern?

- Can adversely affect quality of receiving waters
- Primary concerns:
  - Bacteria levels
  - Low D.O. in water
    - Potential for fish kills
    - Affects other aquatic life
  - Aesthetics - contributes to trash on waterways

CSO 017 to Anacostia River during Hurricane Floyd

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Regulatory Framework

95

Clean Water Act (CWA)

- The 1972 Clean Water Act:
  - Set the basic structure for regulating point source discharges of pollutants into US waterways
  - Gives EPA authority to set **water quality standards** for contaminants:
    - Attain water quality levels that make surface waters safe to fish and/or swim in
    - Restore and maintain the chemical, physical, and biological integrity of the nation's waterways

96

Wastewater Collection

Pre-treatment Program:

- Certain industries must pre-treat and obtain a permit to discharge into a sewer system
  - Permit issued by sewer system owner
  - Inspected regularly
- Purpose:
  - To prevent toxic chemicals or excess nutrients from being discharged into sewer system

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Clean Water Act (CWA)

- The CWA makes it unlawful for any person to discharge any pollutant from a point source into navigable waters unless a NPDES discharge permit is obtained
- NPDES - National Pollutant Discharge Elimination System
- WWTPs are self-monitored
  - Monthly "Discharge Monitoring Reports" (DMRs)
- EPA has delegated monitoring responsibility to states, i.e., Maryland

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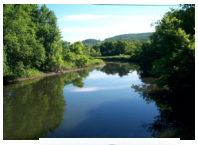
Water Use

- WWTP discharge standards are set to meet water quality standards:
  - In waterways
    - Aquatic and marine life
    - Water contact sports
      - Swimming
      - Boating
      - Fishing
  - For downstream water users:
    - Domestic water supplies
    - Industrial water supplies
    - Agriculture water supplies



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Wastewater Treatment

1

Goals of Wastewater Treatment

- Removal of:
  - **Suspended solids and organic matter** (cBOD and nBOD) to limit pollution
  - **Nutrients** (TP and TN) to limit eutrophication
  - **Microbiological contamination** to eliminate infectious diseases
- Required levels of treatment are based on NPDES regulations as prescribed in issued discharge permits

2

Wastewater Treatment Objectives

- Wastewater treatment systems take human and industrial liquid wastes and make them safe enough (from the public health perspective) to return to the aquatic environment
- In some cases, wastewater can be clean enough for reuse

3

Management Objectives for Wastewater Systems

1. Collect and accept waste from the generator (residential, commercial, industrial) and dispose of it in a cost-effective and efficient manner that protects public health and safety.
2. Return the waste and the water used to transport it back to the environment in an acceptable form.

4

Management objectives for wastewater systems

- Objective 1 is usually achieved under the guidance of local authorities and local public input
- Objective 2 is achieved by complying with state and federal regulations, which may be a result of non-local interests and over which local authorities have little control
- The two objectives are not always compatible, particularly from a funding perspective

5

Preliminary Treatment

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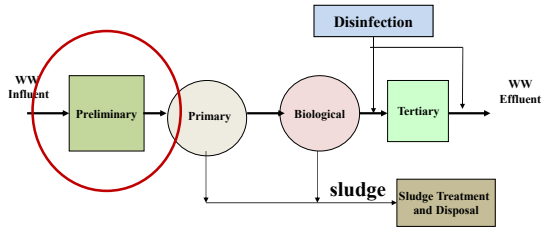

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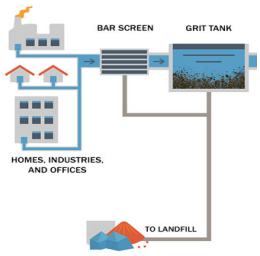
Preliminary Treatment

- Wastewater is screened to remove nuisance materials
- Grit is then removed in grit tanks
- Grit and screenings are then conveyed to dumpsters and hauled to landfills for disposal



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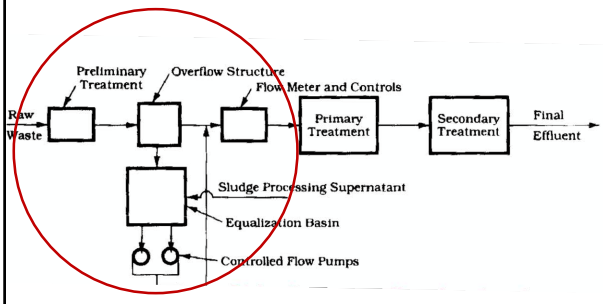
Preliminary Treatment



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Preliminary Treatment

9

Nuisance Materials

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10

Nuisance Materials

- Nuisance materials are unwanted materials that enter a treatment plant in wastewater influent
- Materials include items like rags, plastics, bottles, tree branches, and other items
- These materials can cause damage to downstream pumps and can be hazardous to other mechanical equipment in the treatment process

11

Preliminary Treatment

- Purpose:
  - To remove large objects and non-degradable materials
  - To protect downstream pumps and equipment from damage
  - To reduce odors
- Bar Screens, Grit Chambers, and Degritters
- Odor Control with Air and Chemicals

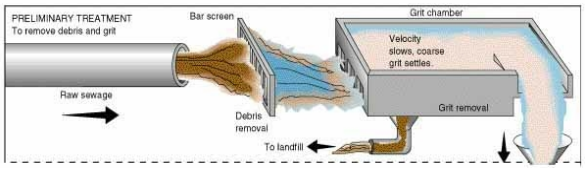
12

Preliminary Treatment

- Typically, includes bar racks or screens and grit chambers
- Sometimes includes flow measurement, flow equalization, pumping, odor control, comminutors (or grinders), and/or septage receiving

13

Preliminary Treatment



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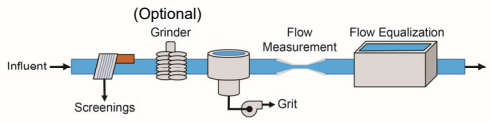
Typical Preliminary Processes



Source: WEF

15

Preliminary Treatment

- Screens:
  - Remove large debris
  - Openings range from fine screens to course screens
  - Course screens stop the largest debris but may allow rags and stringy material to pass
  - Course screens may be followed by fine screens
- Grit basins:
  - Remove heavy particles, such as sand and grit, through gravity settling
  - Include channels or small tanks where wastewater velocity is decreased to 1 ft/sec

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Grinders and Comminutors

- ***Grinders*** and ***comminutors*** reduce the size of debris entering the treatment facility
- They do not remove debris from wastewater
- Shredded debris can still damage downstream equipment, clog pipes and pumps
- They also take up valuable treatment space

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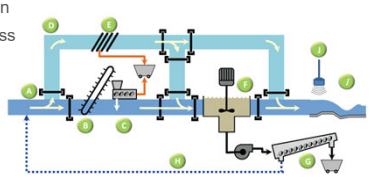
Typical Headworks

A – Slide Gate
B – Mechanical Bar Screen
C – Screenings Wash Press
D – Bypass Channel
E – Manual Bar Screen
F – Vortex Grit Basin
G – Grit Classifier
H – Water Recycle
I – Flume
J – Flow Measurement



Source: WEF

18

Septage Receiving

- Septage;
  a) …is domestic wastewater from cesspools, individual home septic systems, portable toilets, and campgrounds delivered to the plant by truck
  b) …should not include grease trap waste or other types of commercial or industrial waste

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Screening

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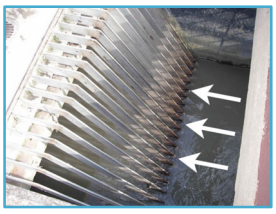
Bar Screens

- The first step in treating raw wastewater is to remove nuisance trash through screening
- One method to remove large debris items is by using **bar screens**



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Bar Screens

- Bar Screens catch:
  - Large objects
  - Pieces of wood, heavy rags, plastics, bricks, bottles, e.g. trash
- Approach velocity: < 2.0 fps

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The Bar Rack or Screen

- A screen composed of parallel bars placed at the plant entrance to catch debris
- Debris can be removed either manually or mechanically

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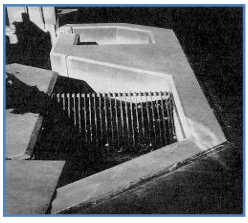
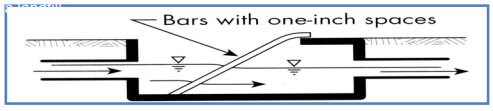
Bar Racks and Screens

Bar Racks and Screens





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Types of Mechanical Screens

- Front-cleaning rakes
- Back-cleaning rakes
- Chain-driven screens
- Cable-driven screens
- Step screens
- Static fine screens
- Rotary drum fine screens

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Bar Screens

- Bar screens can remove items that are larger than the spacing between the bars
- For example, a ¾" bar screen will hold back any debris that is larger than ¾" and anything smaller will pass through it
- Over time, the debris collected behind the bar screen will need to be removed either manually or automatically

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Bar Screens

- Screen openings:
  - Coarse, manually cleaned: 2 – 6 inches
  - Coarse, mechanically cleaned: 0.6 – 3.0 inches
  - Medium, manually cleaned : 0.8 – 2 inches
  - Fine, manually or mechanically cleaned: < 0.4 inches
- Screening quantities:
  - Separate sewers: 0.5 – 4 ft^3/mg
  - Combined sewers: 0.5 – 8 ft^3/mg
  - Bulk density: 40 – 70 lb/ft^3 (Specific gravity: 0.6 – 1.1)

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Screenings Quantity

- Dependent on:
  - Service area
  - Type of collection system
  - Type of screen used
- Varies between less than 0.1 to 20 cu ft/mil. gal
- In screens with openings between 1 and 2 in., for each 0.5-in. decrease in opening size, the volume of screenings will approximately double

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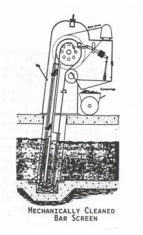
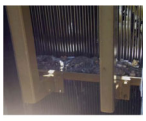
Mechanical Screening





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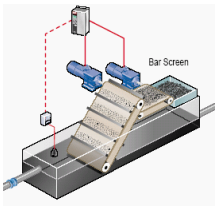
Bar Screens



30

Screening

- Coarse screens (12 -50 mm) are used to remove large debris like rags, sticks, rocks, and plastic.
- Fine screens (2 -6 mm) capture smaller items such as cigarette butts and some fecal matter
- Screens have to be cleaned often; this can be automated or manual.

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Screening

- Screen types grouped based on the size of their openings (from largest to smallest):
  - Coarse screens
  - Fine screens
  - Microscreens
- Many treatment plants use a combination of coarse screens and fine screens

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Basket Screen/Rack

Ladder
Guide
Pull cable

33

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Bar Screens with Screening Compactor

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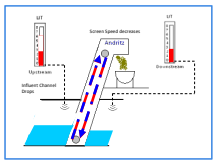
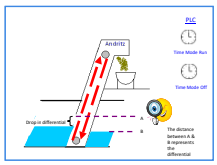
Bar Screens - Control

Differential Level Mode Operational Sequence



Time Differential Mode Operational Sequence



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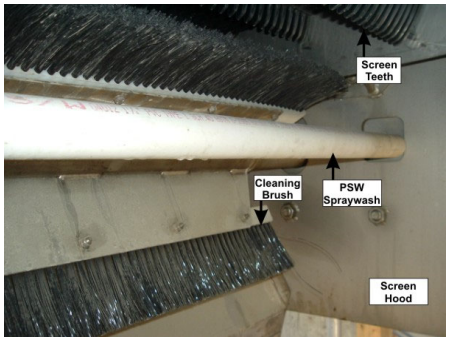

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Math Example

- Screenings removed
- Assumptions:
  - Q = 60 mgd
  - Screenings removed daily = 175 ft^3
  - Unknown: Determine screenings removal in **ft^3 per mg**.

Answer: 175 ft^3/day ÷ 60 mgd = 2.9 ft^3/mg

38

Math Example

- Screenings removed
- Assumptions:
  - Q = 40 mgd
  - Screenings removed daily = 90 ft^3
  - Specific gravity of screenings = 0.9
  - Unknown: How many **pounds per day** of screenings were removed?

Answer:
90 ft^3/day x 0.9 x 7.48 gals/ft^3 x 8.34 lbs/gal = 5053 lbs/day

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Grit Removal

40

Grit

- ***Grit*** consists of a variety of particles including sand, gravel, cinder, and other heavy, discrete inorganic materials
- ***EPA*** *Fact Sheet* (Screening & Grit Removal) - **defines grit** "as particles larger than 0.21 mm (.008 in.) (65 mesh) and with a specific gravity of greater than 2.65"
- ***Mesh sizing*** is a common way to classify grit particle sizes, particularly for influent grit profiling and performance testing

41

Grit Removal

- The purpose of grit removal is to remove inorganic solids, such as sand, gravel, coffee grounds, and other similar materials, that could cause excessive mechanical wear

Parallel Grit Basins

42

Grit Removal

- Various methods are employed to remove grit from wastewater, including:
  - —Gravity settling, where the flow velocity is reduced, allowing the grit to settle to the bottom
  - —Centrifugal separation, which uses rotational forces to separate grit particles from the liquid stream
  - —Flowing influent over/through a grit chamber

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Grit Removal

- ***Velocities*** between 2 - 3.5 ft./sec (fps) keep grit in suspension
- At velocities between 0.7 – 1.4 fps, grit will settle out
  - – **1.0 fps is ideal**
  - – Lighter organic materials will remain in suspension
  - – Organic materials will be removed in primary and secondary treatment

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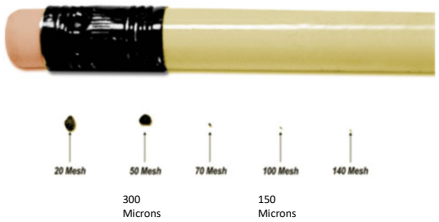
Grit Size

- Grit size is important:
  - – Large particles are abrasive
  - – Smaller particles are slightly buoyant
- Typical WWTP abrasive grit sizes range from 50 to 100 mesh
- Abrasive grit particles cause the most problems in downstream equipment
- At 140 mesh, particles begin to take on silt-like, buoyant properties

45

Grit Size



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Grit Size

- **Mesh values** correlate to the scale of measuring pan screens that sieve collected grit samples
- Increasing mesh values translates into smaller grit particle diameters
- Another unit of measure applied for grit particle sizing is microns
- Typically, 50 mesh particles convert nominally to 300 microns while 100 mesh particles, which are smaller, are nominally 150 microns

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Preliminary Treatment

- Grit removal
  - Removes rocks, gravel, broken glass
  - Aerated systems
  - Cyclone degritters

48

Grit Removal

- Grit removal is the forced separation of gritty material (gravel, sand, eggshells, seeds, etc.) from wastewater
- If not removed, this material could accumulate in the treatment system and cause damage to or abrasion of pipes and equipment

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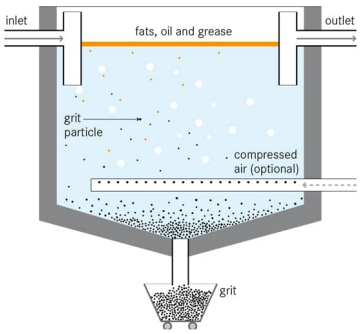
Aerated Grit Chambers

- Air requirements for aerated systems:
  - 3 – 8 ft^3/min per linear foot of tank length
- Detention Time: > 2 minutes
- Grit quantities: 0.5 to 5 ft^3/mg

50

Aerated Grit Chambers



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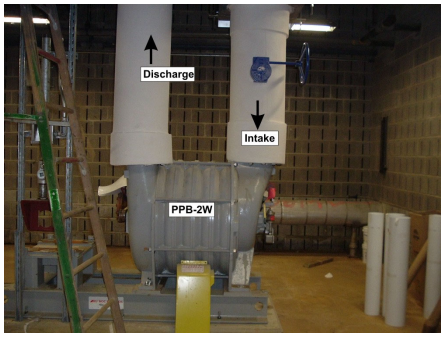
Centrifugal Blower



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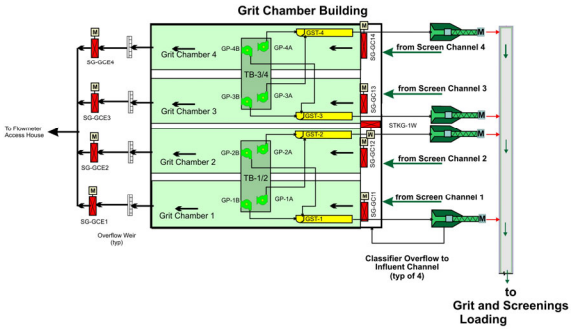
Grit Channels



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Grit Removal – Classifier

54

Vortex Aerated Grit Chamber

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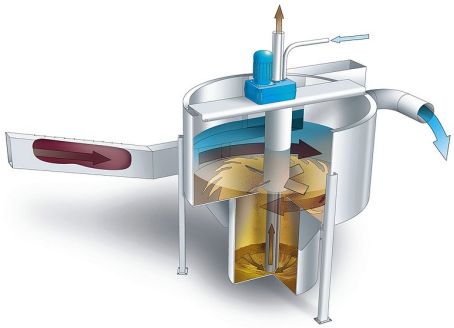
Vortex Aerated Grit Chamber



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Augers and conveyer Belts

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Grit Removal – Traveling Bridge

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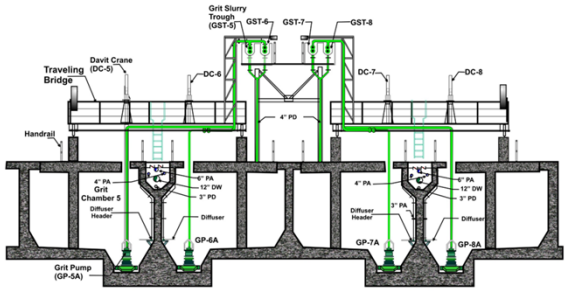
Grit Removal – Traveling Bridge



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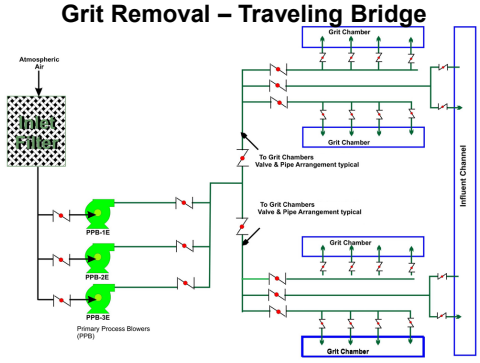
Grit Removal – Traveling Bridge



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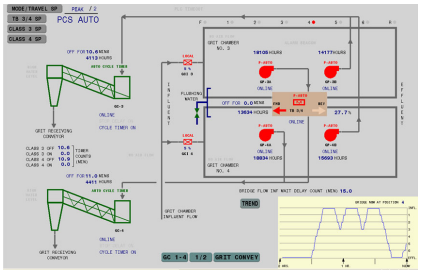
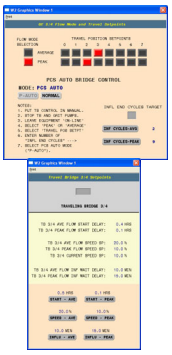
Grit Removal – Traveling Bridge – PCS Control





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Grit Removal

- Suspended solids that pass-through screens and grit chambers are removed from the sewage in sedimentation tanks (i.e., primary and secondary)

62

Math Example

- Grit removed
- Assumptions:
  - Q = 45 MGD
  - Grit removed daily = 65 ft^3
  - Unknown: Grit removed in **ft^3 per MG**.

Answer: 65 ft^3/day ÷ 45 MGD = 1.4 ft^3/MG

63

Math Example

- Grit removed
- Assumptions:
  - Q = 35 mgd
  - Grit removed daily = 55 ft^3
  - Specific gravity of grit = 2.6
  - Unknown: **Pounds per day** of grit removed

Answer:

55 ft^3/day x 2.6 x 8.34 lbs/gal x 7.48 gals/ft^3 = 8,921 lbs/day

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Flow Equalization

65

Equalization Basins

- Wastewater flows, in terms of volume and strength are cyclic
- Improved efficiency, reliability and control are possible when physical, biological and chemical processes are operated at or near uniform flow conditions

66

Equalization Basin

- ***Flow equalization*** basins temporarily store influent wastewater during peak hour flow and storm events
- The water level in the tank changes over the course of a day, filling up during peak-hour flows and emptying again during periods of low flow
- Ideally, the flowrate out of a flow equalization basin and into the WWTP will be at a constant rate

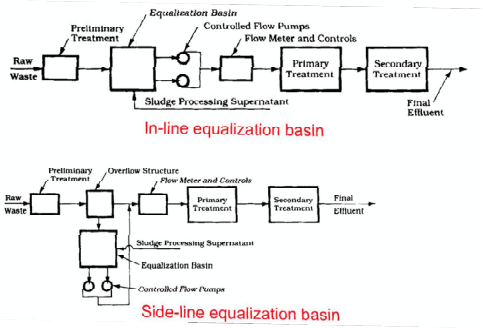
67

Equalization Basins

- Two types of basins are used:
  - In-line basins
  - Side-line basins

68

Equalization Basins



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Equalization Basins

- The primary objective of flow equalization basins is to dampen the diurnal flow variation, and thus achieve a constant or nearly constant flow rate through the downstream treatment processes
- Dampening of flow helps prevent short term, high volumes of incoming flow, or surges, from forcing solids and organic material out of the treatment process

70

Equalization Basins

- Flow equalization controls the flow through each stage of the treatment system, allowing adequate time for the physical, biological and chemical processes to take place

71

Equalization Basins

- Flow equalization has been widely used for commercial, municipal and industrial wastewater treatment systems, both in the design of new facilities and upgrades to existing systems

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Odor Control

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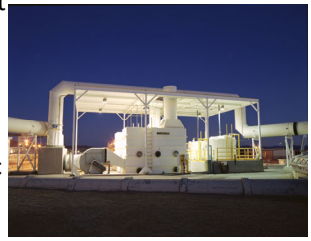
Odor Control

- Wastewater can have a variety of odors that range from being a nuisance to being toxic, each scent is caused by the breakdown of organic compounds



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Gases

- H_2S – Hydrogen sulfide
  - Gaseous
  - Rotten egg odor – old or septic sewage
  - Can dull your senses (olfactory fatigue)
  - Combines with oxygen to form sulfuric acid, which can dissolve concrete
  - Too much can cause respiratory irritation

75

Gases

- Carbon Dioxide (CO_2)
  - Odorless, tasteless
  - Heavy concentrations can cause death due to oxygen deprivation
- Gasoline vapors
  - Can cause fires and explosions in lift stations
  - Lift stations require proper ventalation

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Odor Control

- Odors originate when organics in wastewater breakdown, releasing a range of compounds with unpleasant smells that can be described as rotten eggs, decaying vegetation, ammonia and more
- All wastewater odors can be controlled with the right technologies, which:
  - Eliminate odor complaints
  - Reduce corrosion
  - Protect public health.

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Wastewater Odors

Substance	Characteristic
Allyl Mercaptan	Strong garlic, coffee
Amines	Fishy
Ammonia	**Ammoniacal**
Amyl Mercaptan	**Unpleasant, putrid**
Benzyl Mercaptan	**Unpleasant, strong**
Crotyl Mercaptan	**Skunk**
Diamines (cadaverine)	Decayed flesh
Dimethyl Sulfide	Decayed vegetables
Ethyl Mercaptan	Decayed cabbage
Hydrogen Sulfide	**Rotten Eggs**
Methyl Mercaptan	Decayed cabbage
Propyl Mercaptan	Unpleasant
Skatole	Fecal
Sulfur Dioxide	Pungent, irritating
Tert-Butyl Mercaptan	Skunk
Thiocresol	Skunk, rancid
Thiophenol	Putrid, garlic

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78

Odor Control

- \ fxyj | fyjw&wjfyr jsy&ucfsyx%give off hydrogen sulfide (H_2S) gas which most people recognize as a rotten-egg odor; H_2S gas forms in acidic conditions
- Mt | j{jw&m~iwtljs%xzqkmij%lfx%nfs%nfzxj%r twj% uwtgqjr x%ymfs%xzxy%fs%tkkjsxn{j%citw
- N%x%ntwwtxn{j%yt%r jyfqx% | mnhm%nfs%nwjfyj%xxzjx% | nym%jvznur jsy
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79

Odor Control

- Many of today's wastewater treatment plants still utilize the same processes from generations ago to control H_2S and other gases
- Others have begun diversifying treatment technologies to improve not only water quality, but air quality as well

80

Odor Control

- To Minimize release of hydrogen sulfide (H_2S) from channels and tanks, many facilities:
  - Remove screenings, grit, sludge, and scum daily
  - Hose down/clean/flush channels and tanks when taken out of service
  - Wash down all spills and grease coatings
- If wastewater is septic, adding chemicals will work:
  - Chlorine
  - Permanganate

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Chemicals Applied in Treatment

Application	Chemical Name
Pretreatment - Odor	Granular Activated Carbon
Pretreatment - Oxidation	Chlorine
	Chlorine Dioxide
	Ozone
	Potassium Permanganate
	Sodium Hypochlorite
	Sodium Permanganate

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Gases

- Chlorine
  - Gas (Cl_2) or liquid bleach
  - Extremely toxic
  - Very irritating to skin, eyes, and mucous membranes
  - Cl_2 gas can cause death by asphyxiation
  - Breathing equipment should be readily available

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Odor Control

- To address hydrogen sulfide odor problems, many facilities:
  - Increase aeration to promote oxidation of H_2S gas
  - Pre-treat wastewater to remove H_2S-producing compounds: i.e., ferrous chloride
  - Raise wastewater pH level:
    - Hydrogen sulfide can be solubilized with a solution of sodium hydroxide
    - Helps control the growth of H_2S-producing bacteria

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Aeration

85

Odor Control

Odors and Odor Control

Odor Control

If aerobic conditions cannot be maintained in the collection system, the use of chemicals such as chlorine, iron salts, potassium permanganate, and hydrogen peroxide may be used to control odors.

86

Wet Scrubbers

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87

Wet Scrubbers

- Wet scrubbers are very effective in removing hydrogen sulfide, "organic" odors, and ammonia
- In a wet air scrubber, the odor contaminants are solubilized from the vapor phase into an aqueous chemical solution
- The removal mechanism is purely chemical and is not subject to upsets as are biological processes

88

Wet Scrubbers

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89

Wet Scrubbers

- Hydrogen sulfide can be solubilized with a solution of **sodium hydroxide**
- Other odor-causing compounds, liked mercaptans and amines, are best treated by **sodium hypochlorite**
- Two types of wet scrubbers are used:
  - Single-stage
  - Two-stage (or multi-stage)

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Wet Scrubbers

- In single-stage systems, sodium hydroxide and sodium hypochlorite are added together in sufficient quantities to oxidize hydrogen sulfide and maintain a residual to treat other odor compounds
- In multi-stage systems;
  - Sodium hydroxide is used alone in the first stage to solubilize hydrogen sulfide
  - Sodium hypochlorite is added to the last stage only

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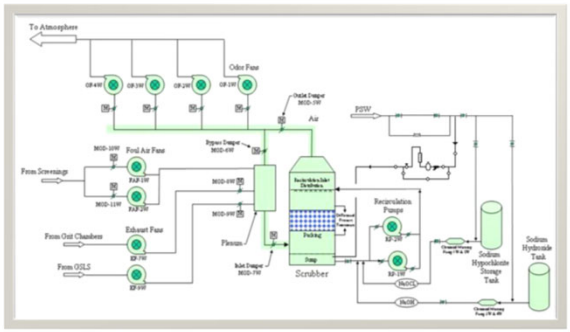
Single-stage Wet Scrubber



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Wet Scrubbers

- Wet scrubber systems start by drawing large amounts of process-air from the fume source to the scrubber unit
- The air is drawn under negative pressure to help ensure that contaminants are not released prior to reaching the scrubber itself

93

Wet Scrubbers

- One of the chemicals used to remove hydrogen sulfide is sodium hydroxide
- In a two-stage system, sodium hydroxide solubilizes H_2S before passing it to a second round of cleansing
- The second stage of the scrubber will recycle the effluent back through another scrubber chamber where sodium hypochlorite is added to remove the sodium hydroxide

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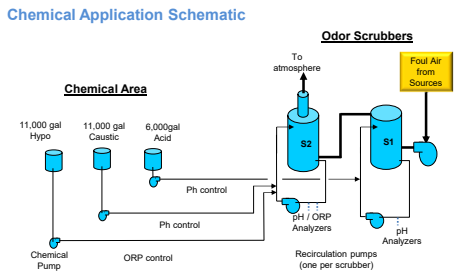
Wet Scrubbers

- The chemical balance in the system is automatically and continuously maintained with ORP and pH probes
- Use of a multi-stage scrubber allows the utilization of a different chemical solution in each of the stages to efficiently use chemicals and target a wide range of odor contaminants for treatment

95

Two-stage Wet Scrubber



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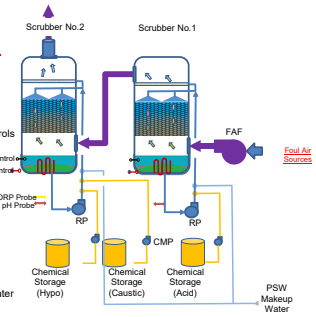
Two-Stage Odor Control System

System Components

1. Odor Scrubbers
2. Foul Air Fan (airflow)
3. Scrubbers Packing (media)
4. Scrubber Sump
5. Scrubber Sump Level Controls
6. Scrubber Heaters & Temp Controls
7. Recirculation Pumping
8. Spray Nozzles
9. Mist Eliminator
10. Chemical Storage
11. Chemical Metering Pumps
12. pH & ORP Probes
13. Scrubber Sump Makeup Water



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Wet Scrubbers

SYSTEM OVERVIEW

Scrubber No. 1

Scrubber 1 is used to remove ammonia from the foul air

The foul air is blown in through the bottom of the scrubber and recirculated water sprays down

Ammonia is transferred from the air to the water at the surface of the water droplets.

Spraying water over media increases the surface area of water that meets foul air and improves the ammonia transfer

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SYSTEM OVERVIEW

Scrubber No.1

Adding sulfuric acid lowers the pH.

Maintaining a low pH (i.e., 2) in the recirculation water helps transfer ammonia from the foul air to the water

Sulfuric acid also combines with NH_4^+ to produce ammonium sulfate $(NH_4)_2SO_4$.

Ammonium sulfate is removed from the system via the scrubber overflow (fresh PSW is continuously added to the system to maintain sump level).

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SYSTEM OVERVIEW

Scrubber No.2

Second Stage

Scrubber 2 is used to remove reduced sulfide compounds from the foul air

The partially treated air from Scrubber 1 is directed to the bottom of Scrubber 2 and a separate supply of recirculated water is discharged at the top

Hydrogen Sulfide is transferred from the air to the water at the surface of the water droplets; pH about 9.5

Spraying the water over the media increases the surface area of water that meets the foul air and improves the transfer of Hydrogen Sulfide and other reduced sulfur compounds.

100

SYSTEM OVERVIEW

Scrubber No.2

An elevated pH causes the sulfides to be solubilized

Raising the ORP of the scrubbing liquid with sodium hypochlorite provides oxidation of the dissolved sulfides to elemental sulfur. Sodium hypochlorite and dissolved sulfides combine to form Na_2SO_4 (Sodium Sulfate), NaCl (Sodium Chloride) and water

The Na_2SO_4 is removed from the system via the scrubber overflow (fresh PSW added continuously to system to maintain sump level)

The pH setpoint of 9.5 ensures correct alkalinity conditions sufficient for the chemical reactions. The ORP setpoint of 600 mV ensures that sufficient sodium hypochlorite is available for oxidation/removal of the sulfides in solution

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SYSTEM OVERVIEW

Function

Foul air is passed upward through the two scrubbers via the foul air fan

Each scrubber consists of a cylindrical vessel with filter media above a sump. The sump captures the spray water injected at the top of the media while the foul air enters at the bottom of the media and exhausts at the top, countercurrent to the spray.

A Low Sump Level signal triggers the opening of a solenoid valve located in the make-up water manifold that provides a rapid fill of the sump under this condition.

The scrubber sump capacity is the water supply for the recirculation pumping system. A sump heater maintains liquid temperature (freeze protection).

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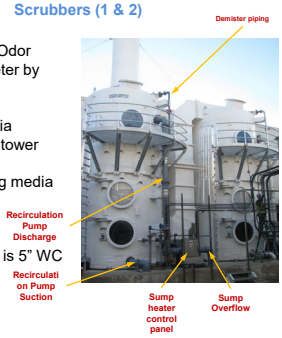
Component Description

Scrubbers (1 & 2)

Type: Vertical Packed Bed Odor Control Scrubber, 12' diameter by 26'.6" height
Media: 2" RVPT Hi-Flow Polypropylene packing media
Minimum 10' bed depth per tower

The estimated clean packing media pressure drop is 1.0" WC

Maximum working pressure is 5" WC



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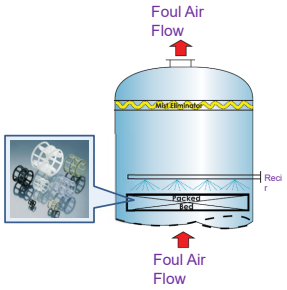
Component Description

Scrubbers (1 & 2)

Packing Bed Media

The packing material provides increased surface area and detention time for contact between odorous gases and chemical solutions

Gases flow up through the media; the chemical solution is down over the media creating large contact areas for odor scrubbing



Packing Information

Packing Type	Hiflow Rings 50-6
Material	Thermoplastic
Nominal Size	2 inch
Weight	3.04 lb/ft³
Surface Area	27.4 ft²/ft³

104

Component Description

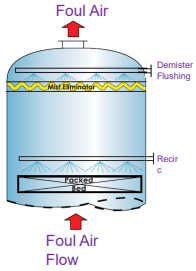
Scrubbers (1 & 2)

Mist Eliminator

A mist eliminator, also called a "demister," is used to eliminate extraneous fluid particles from the flow of vapor

The mist eliminator captures water droplets as they flow in a vapor. These obstacles along the path of flow cause a drop in pressure, drawing moisture to a collection area

Mist eliminators help reduce droplet emissions to environmentally acceptable levels



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Component Description

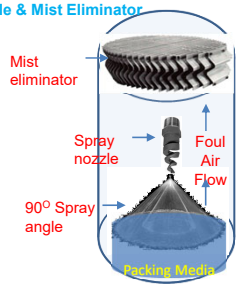
Scrubbers (1 & 2)

Spray nozzle & Mist Eliminator

Spray nozzle features:
- High discharge velocity
- Clog resistant
- Full cone

Spray nozzle characteristics:
- Fine atomization
- Spray angles (90º & 150º)

Mist Eliminator:
- Polypropylene



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SCRUBBER INSTRUMENTATION

Scrubber pH and ORP Analyzing Sensors

Sensors continuously measure pH and ORP levels of the scrubber sump liquid and communicate values to the sensor's controller

The controller compares actual values to set points and controls start/stop of chemical metering pumps for chemical application to maintain desired pH level and oxidation reduction potential

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SCRUBBER INSTRUMENTATION

- Scrubber No.1 & No.2 Sump Liquid pH Sensors
- Scrubber No.1 Sump Liquid pH Transmitters
- Scrubber No.2 Sump Liquid ORP & pH Transmitters

PLC converts the measured pH/ORP value of the sensor to a 4-20 milliamp analog signal

The signal from these transmitters control the H_2SO_4 & NaOH chemical metering pumps

pH Controller located by the recirculation pumps

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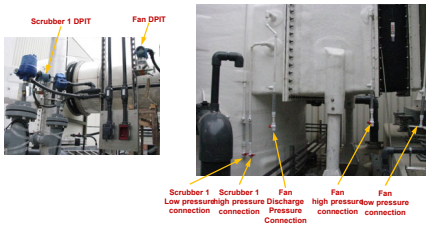
SCRUBBER INSTRUMENTATION

Foul Air Fan Differential Pressure Transmitters
Scrubber 1 & 2 Differential Pressure Transmitters



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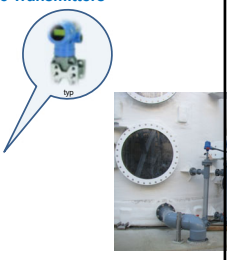
SCRUBBER INSTRUMENTATION

Scrubber 1 & 2 Differential Pressure Transmitters

Scrubber DPIT devices measure the pressure drop across the packing media at a range of 0-10" WC with a maximum working pressure set point of 5" WC. A high pressure drop indicates fouling of the media.

As packing media fouls the foul air fan can be adversely affected. The Fan DPIT device measures the differential pressure drop between the fan suction & discharge at a range of 0-20" WC with a maximum working pressure of 17" WC. As scrubber differential pressure increases so will fan differential.



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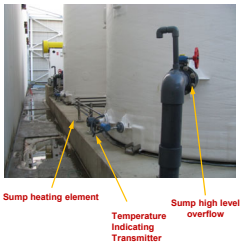
SCRUBBER INSTRUMENTATION

Scrubber Sump Temperature Transmitters



These devices measure the temperature of sump The signal is transmitted to the PCS and controls the sump heating elements.

The sump heaters are set to maintain the liquid temperature between 50-55 ºF.

The thermostat is adjustable from 0-100 ºF

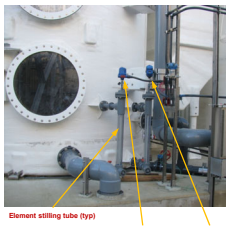
111

SCRUBBER INSTRUMENTATION

Scrubber Sump Level Transmitters

These devices measure the liquid level in each scrubber sump and controls the PSW solenoid valve at each scrubber makeup water manifold.

A scrubber sump capacity is achieved based on scrubber diameter and the normal operating range in the sump is between 21-24 inches.



Interlocks

- Sump high level - closes make-up water solenoid valve (hardwired)
- Sump low level opens make-up water solenoid valve (software)

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Recirculation Pumps

Function

The function of the recirculation pumps is to recycle the water in the scrubber sumps by drawing the water directly from the scrubber sumps and pumping it to the spray headers above the scrubber media to "wash" the foul air as it is flows upward through the media. The recirculation pumps operate continuously and are controlled through the Process Control System.

113

MAKE-UP WATER

Function

PSW makeup water is used to maintain a target level in the scrubber sump and help waste the dissolved sulfides from the Hydrogen Sulfide out through the sump overflow.

A Rotometer with adjustable valve controls PSW flow into the scrubber sump between 0-10 gpm.

Typical makeup water flow is ~ 2 - 3 gpm. This flow needs to include water lost to the air + overflow.

A make-up water solenoid valve will open on sump low level to recover sump level faster. The valve closes when the level has recovered.

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Chemical Unloading Stations

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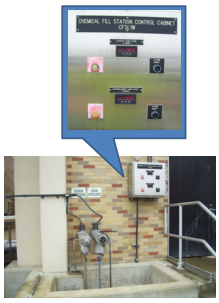
Wet Scrubbers

Chemical Unloading Station



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Chemical Safety for Sodium Hydroxide

OVERVIEW

Sodium hydroxide (NaOH or caustic) is a corrosive nonflammable clear odorous liquid that has a pH of 14, which assists in the removal of H_2S. It is rated to be completely soluble in water and has a specific gravity of 1.275

NaOH reacts violently with water, generating a large amount of heat. If the chemical is added to fast it can accumulate at the bottom of the tank, where excess heat may boil with splattering results. This chemical can react explosively with acids, aldehydes and organic compounds.

Sodium Hydroxide NFPA Chemical Hazard Label

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Chemical Safety for Sodium Hypochlorite

OVERVIEW

Sodium Hypochlorite (NaOCl) is used as an oxidizing agent, which assists in removal of sulfides.

The ORP measurement provides an indication that enough hypochlorite has been added.

Sodium hypochlorite is a nonflammable yellow-green corrosive liquid that has a pH between 12.5 to 13.5. It is rated to be completely soluble in water and has a specific gravity of 1.224

Sodium Hypochlorite NFPA Chemical Hazard Label

118

Chemical Safety for Sulfuric Acid

OVERVIEW

The Sulfuric Acid (H_2SO_4) feed pump serves to adjust the pH of the chemical solution in Odor Scrubber No.1 by driving the pH down, thereby maintaining a pH value of 2.0.

- This product is a clear corrosive solution and can be damaging to unprotected tissue.
- Ingestion or inhalation of large quantities can be fatal.
- This product may decompose to produce a variety of compounds (i.e. carbon monoxide, carbon dioxide and oxides of sulfur).
- Emergency responders must wear the proper personal protective equipment suitable for the situation to which they are responding.

Sulfuric Acid NFPA Chemical Hazard Label

Types of Hazards		Hazard Rating
BLUE Hazard	= Health	0 = Minimal
RED	= Fire Hazard	1 = Slight
YELLOW	= Reactivity	2 = Moderate
WHITE Hazard	= Specific	3 = Serious 4 = Severe

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The Bar Rack or Screen

- A screen composed of parallel bars placed at the plant entrance to catch debris.
- Debris can be removed either manually or mechanically

120

Preliminary Treatment

- Bar Screens
  - Catches large objects
  - Pieces of wood, heavy rags, plastics, bricks, bottles, e.g. trash
- Approach velocity: < 2.0 fps
- Manually cleaned
- Mechanically cleaned

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Summary

Helpful Hints - Final Comments

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Questions?

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Survey https://form.jotform.com/212915438135152

Test https://form.jotform.com/202546700565150

Thank You

"Anyone who can solve the problems of water will be worthy of two Nobel prizes – one for peace and one for science."

- John F. Kennedy

Ed Jones
Maryland Center for Environmental Training
College of Southern Maryland
La Plata, MD

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Let's Call it a Day

See you next time

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