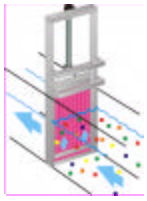
Preliminary Unit Operations and Processes

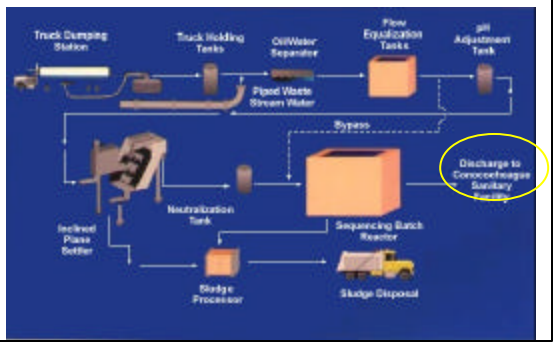


Preliminary Treatment

remove materials that will interfere with further treatment

- Physical size separation
  - Bar racks
  - Screens
- Size reduction
  - Grinders
  - Barminutor
  - Comminutor
- Grit Removal
- Flow measuring
- Pumping
- Pre-aeration

Industrial Pretreatment

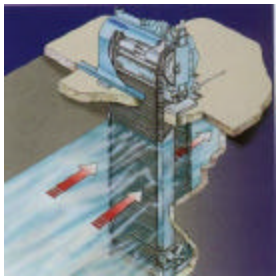


WT - Intakes

- Source water screening
  - Intake location
    - Rivers, streams, and lakes
  - Coarse bar racks to remove large debris
    - Spacing of 2" – 4"
  - Fine traveling screens for smaller debris
    - Spacing of approximately 0.5 inch
    - Intake velocity < 3.5 inches/sec

Traveling Water Screen

(Figure 7.1 page 129)



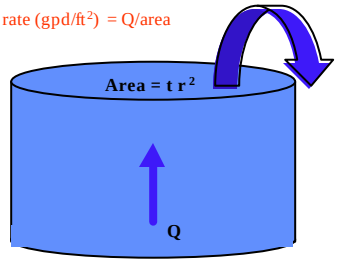
Courtesy: http://www.usfilter.com

WT - Presedimentation

- May be required for high turbidity waters
- Short detention time basins
  - T = 0.5 – 1.0 hours
  - Surface overflow rate = 1000 – 3000 gpd/ ft^2
- Long detention time basins
  - T = 30 – 60 days
  - Sediment removal
  - Disinfection – settling and sunlight (uv)
    - 80 – 90% removal of bacteria and viruses
  - River / reservoir systems

Surface Overflow Rate

Overflow rate (gpd/ft^2) = Q/area



WT – Aeration

- Removal of undesirable gases (gas stripping)
  - Carbon dioxide (corrosion control)
  - Hydrogen sulfide (taste and odor problem)
- Preoxidation (addition of oxygen)
  - Iron
  - Manganese
- Several common devices
  - Cascade aerator
  - Multiple-tray aerator
  - Spray aeration (spray nozzles)
  - Diffused compressed air tanks

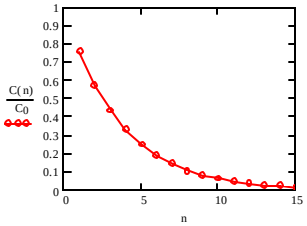
Cascade Aerator

Multiple-tray Aerator

Carbon Dioxide Removal

$n := 1,2..15 \quad k := 0.28 \quad C_0 := 8 \cdot \frac{mg}{L}$

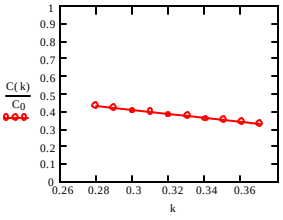
$C(n) := C_0 e^{-k \cdot n}$



Carbon Dioxide Removal

$k := 0.28, 0.29..0.37 \quad n := 3 \quad C_0 := 8 \cdot \frac{mg}{L}$

$C(k) := C_0 e^{-k \cdot n}$



WT - Adsorption

- Activated carbon
  - Taste, odor, and color problems
  - Organics
- Dosage 2 – 70 lbs / million gallons
  - Presedimentation basin
- Threshold odor number

Threshold Odor Number

- Flavor profile analysis
  - a panel of selected persons attempt to detect taste and odor causing contaminants at various dilutions.
  - panelists define the nature of the taste or odor, either in their own words or through the use of standard descriptions.
  - point at which the compound is just detected determines the threshold number
- TON = (A + B) / A
  - A = volume of sample tested
  - B = volume of distilled dilution water

WT – Pre oxidation (chlorination)

- Chlorination of water prior to filtration
  - Oxidation of iron and manganese
  - Oxidation of hydrogen sulfide
  - Minimize formation of biological slime of downstream
  - Control of zebra mussels at plant intakes
- WWTP – has been used for odor control

WWT – Screening / Shredding

- Mechanically cleaned bar screens
  - Bar spacing – 0.5” to 1.5”
- Coarse and fine screens

Screens

Coarse Bar Screen

Fine Bar Screens

Mechanical Bar Screen

Fine Screening

solids removed by endless sieve band consisting of folded elements of perforated stainless steel sheets

diameter of the holes range from 0.125 inch to 0.25 inch (3 - 6 mm)

Fine Screening

solids removed by means of an endless stainless steel mesh belt

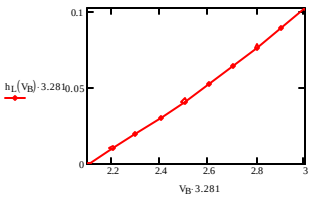
mesh openings can be as small as 0.04 inch by 0.61 inch (1 mm x 15.5 mm)

Bar Screens – Head Loss

$V_A := 2.1 \frac{ft}{sec}$ $V_B := 2.1 \frac{ft}{sec}, 2.2 \frac{ft}{sec} .. 3.0 \frac{ft}{sec}$

$h_L(V_B) := \frac{V_B^2 - V_A^2}{2g} \cdot \frac{1}{0.7}$

$h_L\left(2.8 \frac{ft}{sec}\right) = 0.076ft$



Comminutor

Grit Chamber

- Designed to remove grit
  - Sand, gravel, cinders, and other material with specific gravities substantially greater than organic solids
- Several types
  - Horizontal
  - Aerated
  - Flavor Profile Analysis Panel
  - Vortex

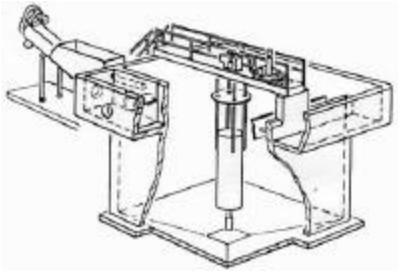
Grit Chambers

Grit Chamber

Aerated Grit Chamber

Rolling Grit Chamber

Figure 7.15 page 153)



Courtesy: http://www.walker-process.com/

Grit Removal

9 ft. diameter
designed to remove 95% of sand and grit particles greater than 150 microns (100 mesh) with a specific gravity of 2.65 at flows up to 6 MGD
headloss across the unit is less than 12 inches at the design flow of 6 MGD.

Prestonsburg, KY WTP

Vortex Grit Chamber

Grit Removal

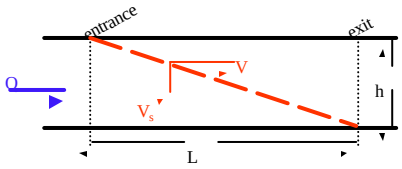
The Grit King, in conjunction with a 4 ft. static screen, was designed to remove 95% of grit particles greater than 100 microns at flows up to 0.5 MGD.

Randall, MN WWTP

Typical Design Information for Grit Chamber

Items	Range of Values (Typical Value)
Detention Time (s)	45 –90 (60)
Horizontal velocity, m/s	0.25 – 0.40 (0.30)
Settling Velocity, m/min	1.0 – 1.3 (1.15) for 65-mesh 0.6 – 0.9 (0.75) for 100-mesh
Allowance for inlet and outlet turbulence	2 * max depth in grit chamber 0.5 * theoretical length in grit chamber

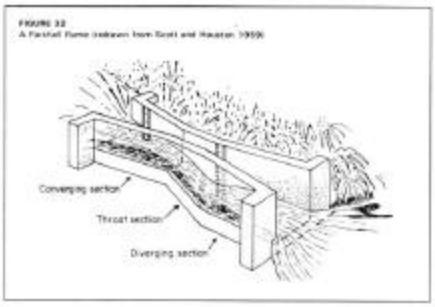
Critical Trajectory in Horizontal-Grit Chamber



$$t = \frac{h}{V_s} \qquad L = V\,t$$

Parshall Flume

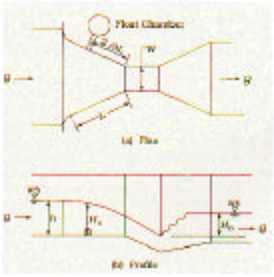
Parshall Flume



Parshall Flume

Parshall Flume

Parshall Flume



Equalization Basins

Equalization Basin

2.5 million gallon in-line equalization basin

Equalization Basins with Mechanical Preaerators - WWT

Primary Settling

Empty Primary Settling Basins

Primary Clarifier