## Project 1 – Treatment Cost

- The objective of this project is to utilize, within given constraints, a prototype water filter system to design a full-scale system.
- The effectiveness of the filter design will be evaluated by the yearly ***operational and maintenance costs***.

## Project 1 – Treatment Cost

### Group Problem - Treatment Cost

Consider a prototype system with the following characteristics:

1. coagulant dosage of 25 mg/L
2. flowrate 1,000 mL/min
3. run time of 60 minutes
4. 2 inches of anthracite and 4 inches of filter sand
5. replace filter material once every five years
6. 4 prototype sedimentation tanks

Compute the total yearly cost of this system

## Project 1 – Treatment Cost

### Coagulation and Flocculation Cost

The weight of coagulant (kg) required per gallon of treated water is estimated as:

$$wt_c\left[\frac{kg}{gal}\right]=\left(\frac{25\ mg}{L}\right)\left(\frac{3.785\ L}{gallon}\right)\left(\frac{kg}{10^6\ mg}\right)$$

$$=9.462\times10^{-5}\ \frac{kg}{gal}$$

## Project 1 – Treatment Cost

### Coagulation and Flocculation Cost

The number of coagulation and flocculation units, *NCF*, required are:

20% Factor of Safety

$$NCF=\left[\frac{2\times10^7\,(gpd)}{5\times10^6\,(gpd)}\right]\times1.2$$

$NCF = 4.8$ or 5 units

## Project 1 – Treatment Cost

### Coagulation and Flocculation Cost

The total yearly cost of the coagulation and flocculation system for 20 MGD is:

$$Cost_{CF}=5\left(\frac{\$25{,}000}{year}\right)$$

$$+\left(9.462\times10^{-5}\ \frac{kg}{gal}\right)\left(\frac{2\times10^7\,gal}{day}\right)\left(\frac{365\ days}{year}\right)\left(\frac{\$0.25}{kg}\right)$$

$$=\boxed{\$297{,}691}$$

## Project 1 – Treatment Cost

### Sedimentation System Cost

Step 1 - Compute the prototype sediment tank ***retention time*** $t_p$.

$$Volume_{tank}=360\ in.^3\left(\frac{gallon}{231\ in.^3}\right)=1.56\ gallons$$

Four tanks are in operation

$$t_p=\frac{4(1.56\ gallons)}{\left(1{,}000\ \frac{mL}{minute}\right)\left(\frac{L}{1000\,ml}\right)\left(\frac{gallon}{3.785\ L}\right)}=23.62\ min$$

## Project 1 – Treatment Cost

### Sedimentation System Cost

Step 2 - The full-scale ***treatment flowrate*** $Q_{ST}$ (gpm) per sedimentation tank is:

$$Q_{ST} = \frac{75{,}000 \text{ gallons}}{23.62 \text{ min}} = 3{,}175 \text{ gpm}$$

## Project 1 – Treatment Cost

### Sedimentation System Cost

Step 3 - The ***effective flowrate*** $Q_{SE}$ **(gpm)** in a sedimentation tank is:

$$Q_{SE} = 3{,}175 \text{ gpm}\left(\frac{60 \text{ minutes}}{90 \text{ minutes}}\right) = 2{,}117 \text{ gpm}$$

## Project 1 – Treatment Cost

### Sedimentation System Cost

Step 4 - The number of full-scaled sedimentation tanks, ***NS***, required to handle the daily volume is estimated as:

20% increase for cleaning

$$NS = \left[\frac{2\times10^{7}\,(\text{gpd})}{2{,}117\,(\text{gpm})}\right]\left[\frac{\text{day}}{1{,}440\,\text{min}}\right]\times 1.2$$

$$= 7.87 \text{ tanks} \quad \text{or} \quad 8 \text{ tanks}$$

## Project 1 – Treatment Cost

### Sedimentation System Cost

The operation and maintenance costs per tanks is $35,000/tanks

The yearly cost for the sediment tanks is:

$$Cost_S = 8 \text{ tanks}\left(\frac{\$35{,}000}{\text{tank}}\right)$$

$$= \boxed{\$280{,}000}$$

## Project 1 – Treatment Cost

### Filtration System Cost

Step 1 - Convert the average flowrate through the prototype filter (the 3.5 inch diameter prototype filter has an area of 0.0668 ft.$^2$) into a prototype ***filter loading rate*** $Q_F$ (gpm/ft.$^2$).

$$Q_F = \left(\frac{1{,}000\,\text{mL}}{\text{minute}}\right)\left(\frac{\text{L}}{1{,}000\,\text{mL}}\right)\left(\frac{\text{gallon}}{3.785\,\text{L}}\right)\left(\frac{1}{0.0668\ \text{ft.}^2}\right)$$

$$= 3.955\,\text{gpm}/\text{ft.}^2$$

## Project 1 – Treatment Cost

### Filtration System Cost

Step 2 - The full-scale ***treatment flowrate*** $Q_{FT}$ is:

$$Q_{FT} = 3.955\left(\text{gpm}/\text{ft.}^2\right)1{,}000\,\text{ft.}^2$$

$$= 3{,}955 \text{ gpm}$$

## Project 1 – Treatment Cost

### Filtration System Cost

Step 3 - Considering that each filter is inoperable during backwashing, the ***effective flowrate*** $Q_E$ is:

$$Q_{FE} = 3{,}955 \text{ gpm}\left(\frac{60 \text{ minutes}}{90 \text{ minutes}}\right)$$

$$= 2{,}637 \text{ gpm}$$

## Project 1 – Treatment Cost

### Filtration System Cost

Step 4 - The number of full-scaled filters ***NF*** required to handle the daily volume is estimated as:

20% increase for backwashing

$$NF = \left[\frac{2\times10^{7}\,(\text{gpd})}{2{,}637\,(\text{gpm})}\right]\left[\frac{\text{day}}{1{,}440\text{min}}\right]\times 1.2$$

$$= 6.32 \text{ filters} \quad \text{or} \quad 7 \text{ filters}$$

## Project 1 – Treatment Cost

### Filtration System Cost

The yearly cost for the filters is:

$$Cost_F = 7 \text{ filters}\left(\frac{\$75{,}000}{\text{filter}}\right) = \boxed{\$525{,}000}$$

## Project 1 – Treatment Cost

### Filtration System Cost

The yearly cost for anthracite is:

$$Cost_{FM_A} = (2\text{in.})\left(\frac{\$9.50}{\text{ft.}^3}\right)\left(\frac{\text{ft.}}{12\text{ in.}}\right)(1{,}000\text{ ft.}^2)\left(\frac{NF}{5}\right)$$

Material replaced every 5 years

The yearly cost for sand is:

$$Cost_{FM_S} = (4\text{in.})\left(\frac{\$5.90}{\text{ft.}^3}\right)\left(\frac{\text{ft.}}{12\text{ in.}}\right)(1{,}000\text{ ft.}^2)\left(\frac{NF}{5}\right)$$

$$Cost_{FM} = \$2{,}217 + \$2{,}753 = \boxed{\$4{,}970}$$

## Water Treatment Project

### Total Treatment System Cost

$$\text{Total Cost} = \$297{,}691 \quad \text{Coagulation}$$

$$+ \$280{,}000 \quad \text{Sedimentation}$$

$$+ \$525{,}000 \quad \text{Filtration}$$

$$+ \$4{,}970 \quad \text{Filtration Media}$$

## Water Treatment Project

### Total Treatment System Cost

$$\text{Total Cost} = \boxed{\$1{,}107{,}661}$$

## Water Treatment Project

Any questions?