NANT

National Association of Nephrology Technicians/Technologists

NANT 35nd Annual National Symposium

SEDIMENT

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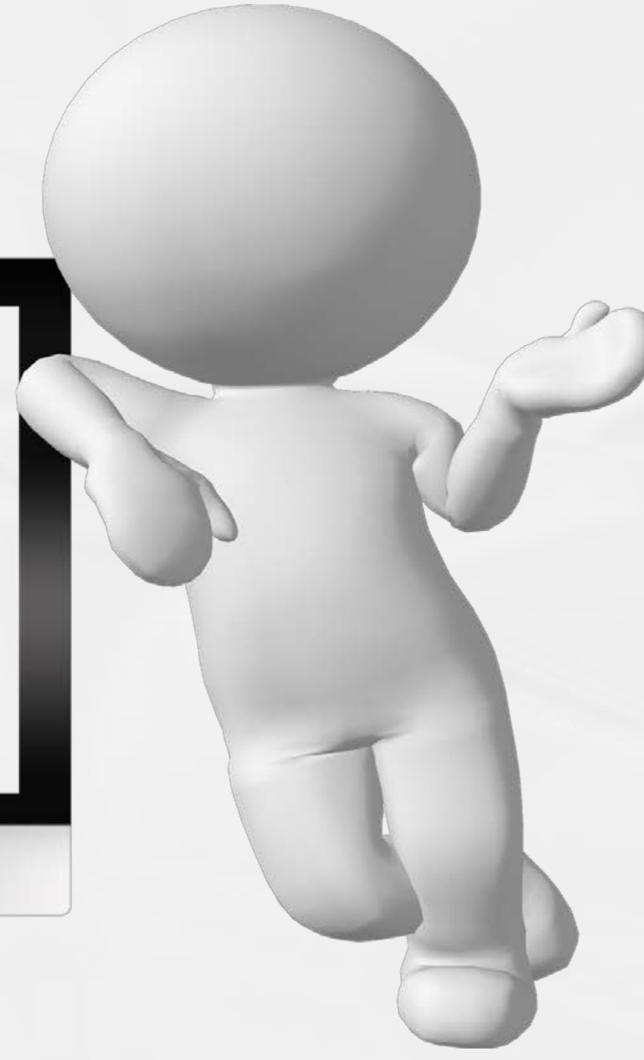


SEDIMENT

What Is Sediment?

SEDIMENT

- www.dictionary.com
- **sediment**. (sĕd'ə-mənt) Geology Solid fragmented material, such as silt, sand, gravel, chemical precipitates, and fossil fragments, that is transported and deposited by water, ice, or wind or that accumulates through chemical precipitation or secretion by organisms, and that forms layers on the Earth's surface.

SEDIMENT

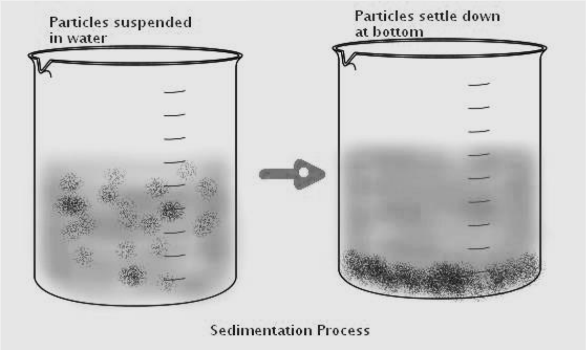
- www.merriam-webster.com/dictionary/sediment
- **sediment.**
- 1. the matter that settles to the bottom of a liquid.
- 2. material deposited by water, wind, or glaciers.

SEDIMENT

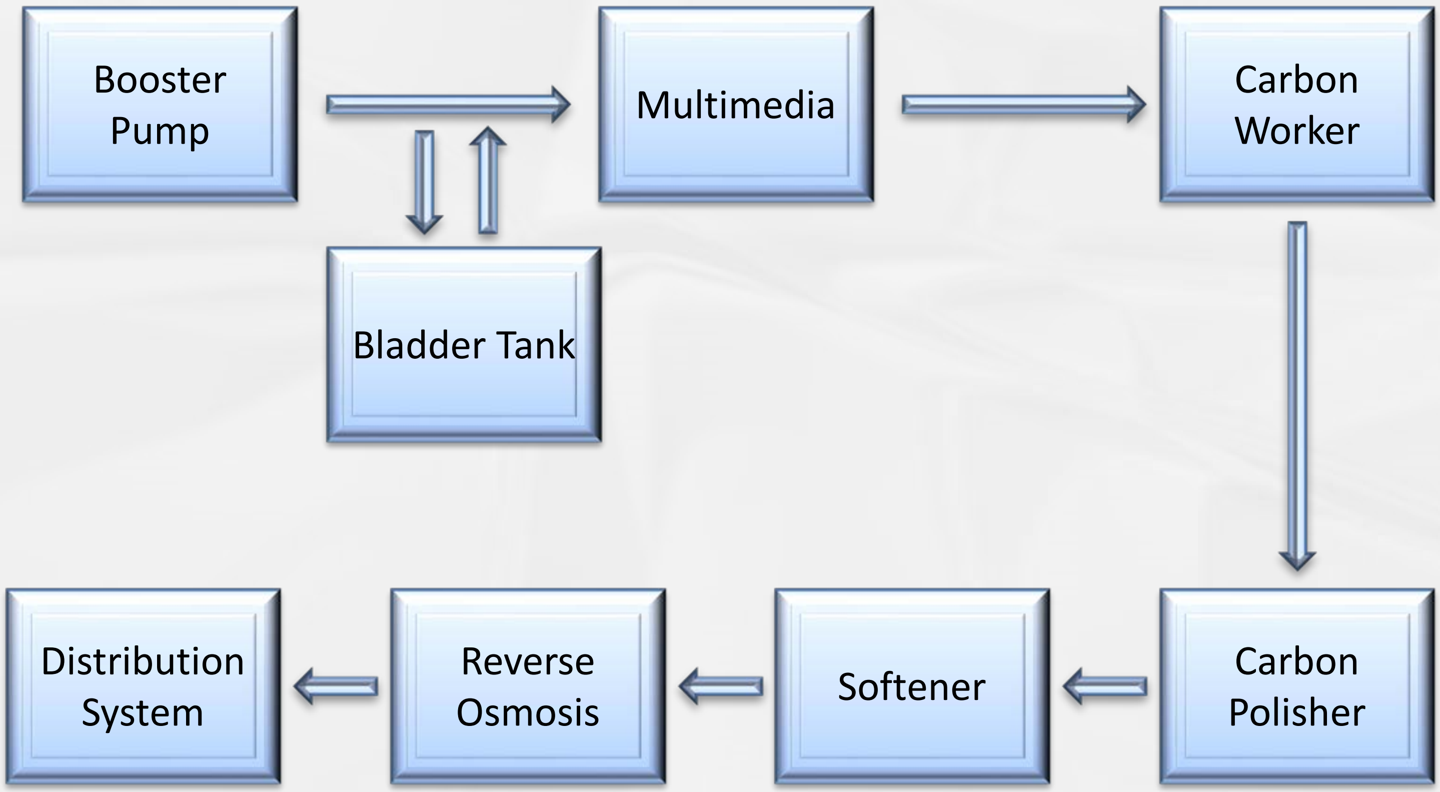
- www.urbandictionary.com
- noun; a large sum of cash awarded to the plaintiff whose case is upheld by Judge Joe Brown.

SEDIMENT

- For this presentation, sediment is defined as the settlable, solid matter that is transported by water in the hemodialysis water treatment system



Traditional Water Treatment System



Three Sources of Sediment

1. Incoming municipal water
2. Carbon fines
3. Biological growth in situ

Why is sediment still a problem Today? (2017)

Out-of-sight

Out-of-mind

Nanotechnology is a hot new development field today

New discoveries are being made daily because:

No longer

Out-of-sight

Out-of-mind

When we can see things, then we can understand what is happening and solve problems

We are going to explore sediment on a nanometer scale

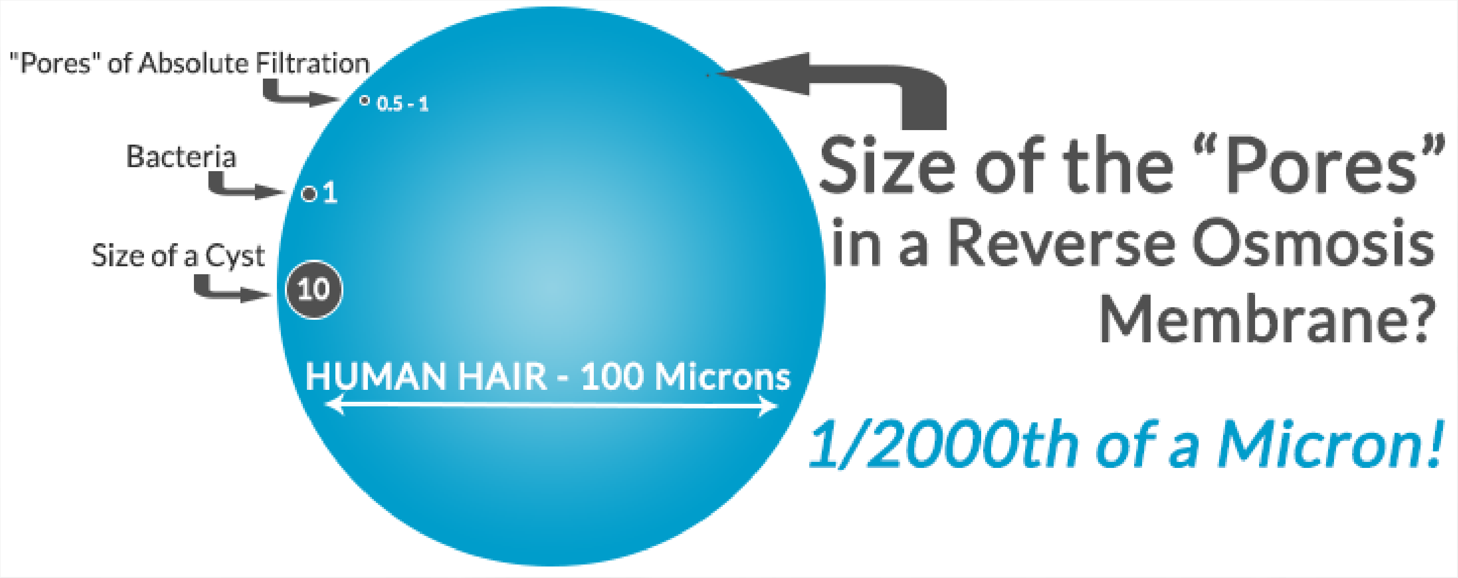
- 1mm = 1M/1,000 = 10^{-3} M

- 1 µm (micron)=1 mm/1,000 = 10^{-6} M

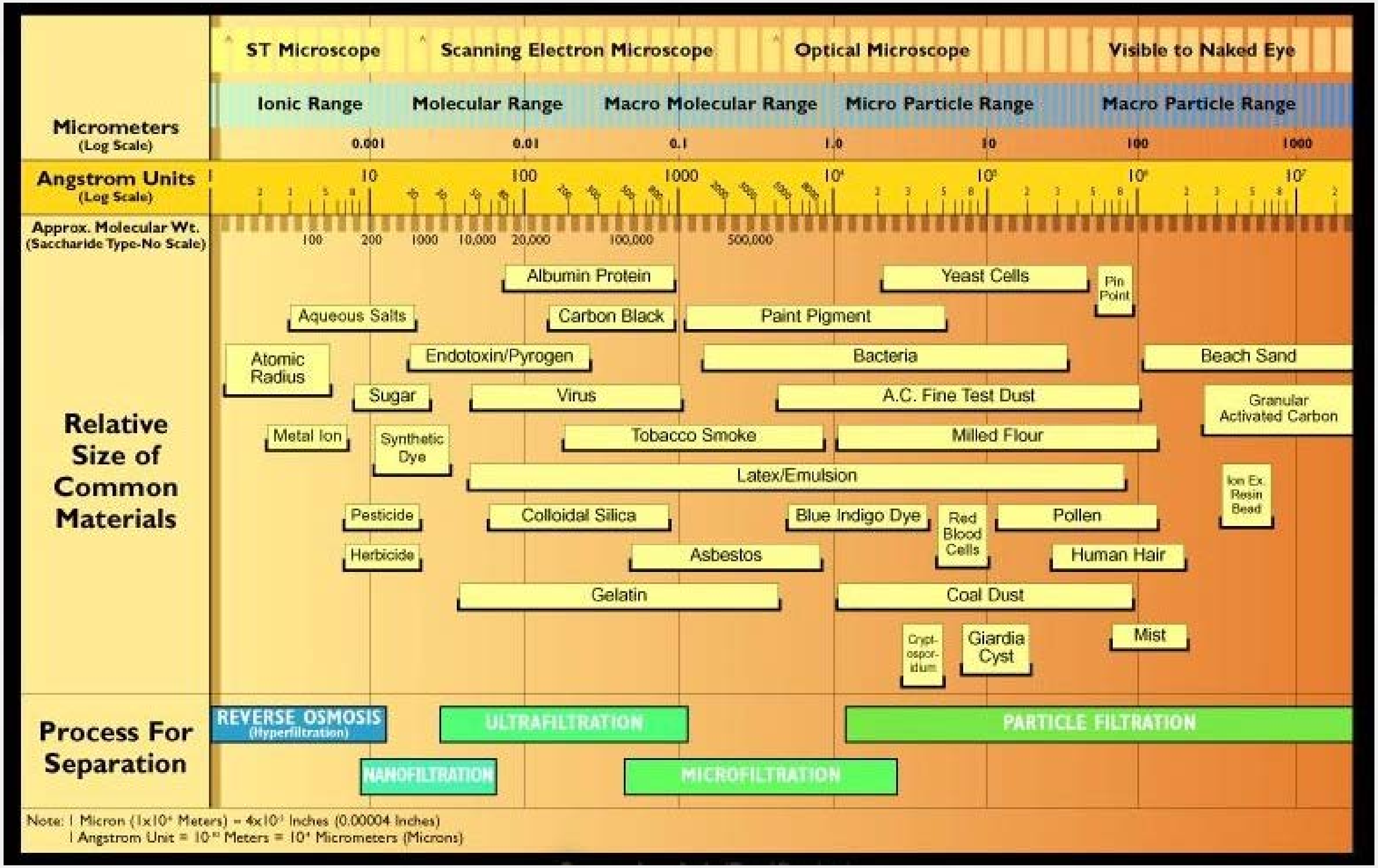
- 1 nm= 1µm/1,000 = 10^{-9} M

To get comfortable with nm:

1. Hair grows at about 1 nm per second
2. Nails grow at about 0.5 nm per second

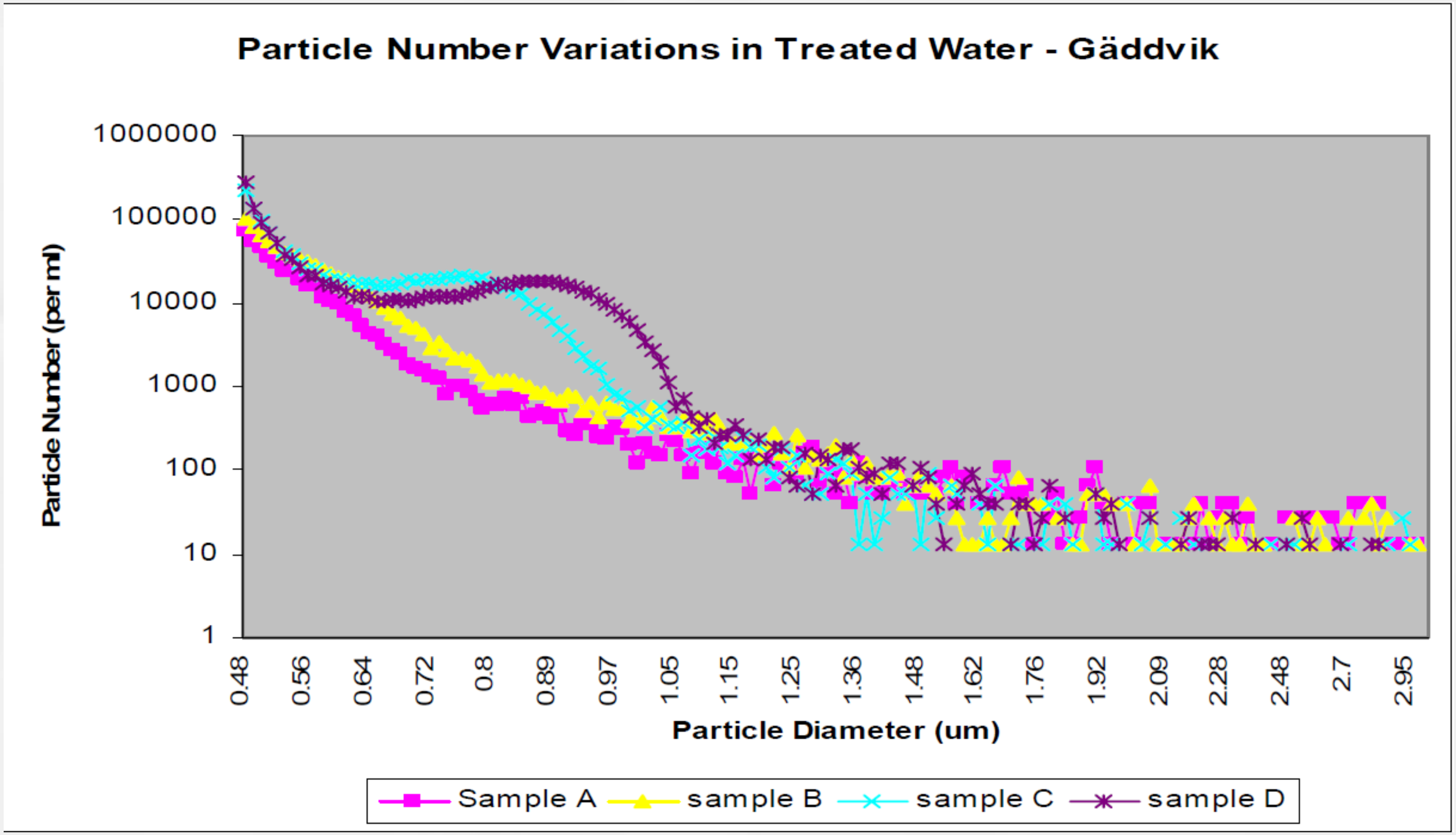


Filtration Spectrum



Municipal Water Particle Distribution Chart

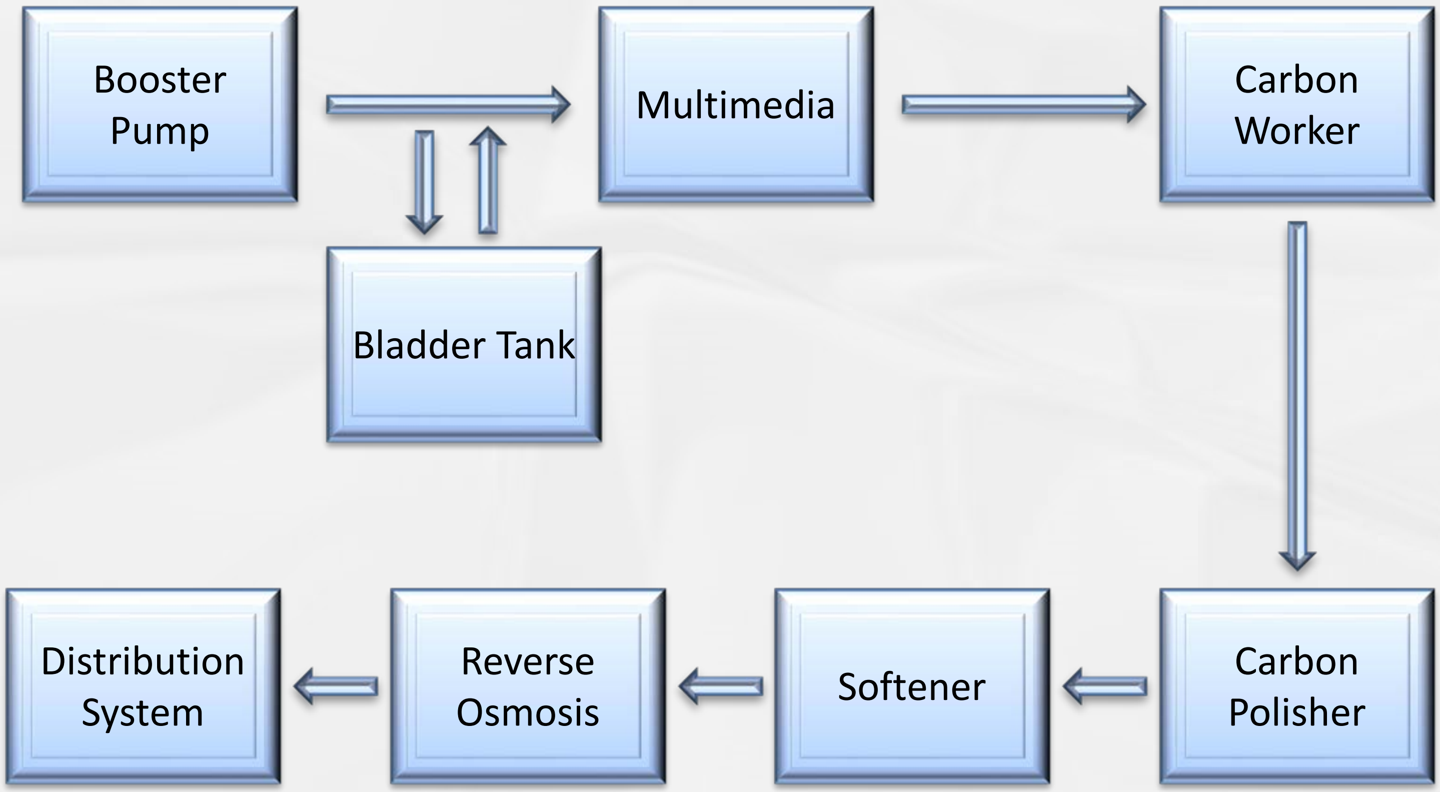
From Frederick Ayisi Sarpong's, Master Thesis *Particles in drinking water, Lulea, Sweden* at Lulia University of Technology in 2007


Particle Number Variations in Treated Water - Gäddvik
Particle Number (per ml)
1000000
100000
10000
1000
100
10
1
0.48
0.56
0.64
0.72
0.8
0.89
0.97
1.05
1.15
1.25
1.36
1.48
1.62
1.76
1.92
2.09
2.28
2.48
2.7
2.95
Particle Diameter (um)
Sample A
sample B
sample C
sample D

Sediment In Influent Water

99.9% of particles smaller than 1 micron (1,000 nm)

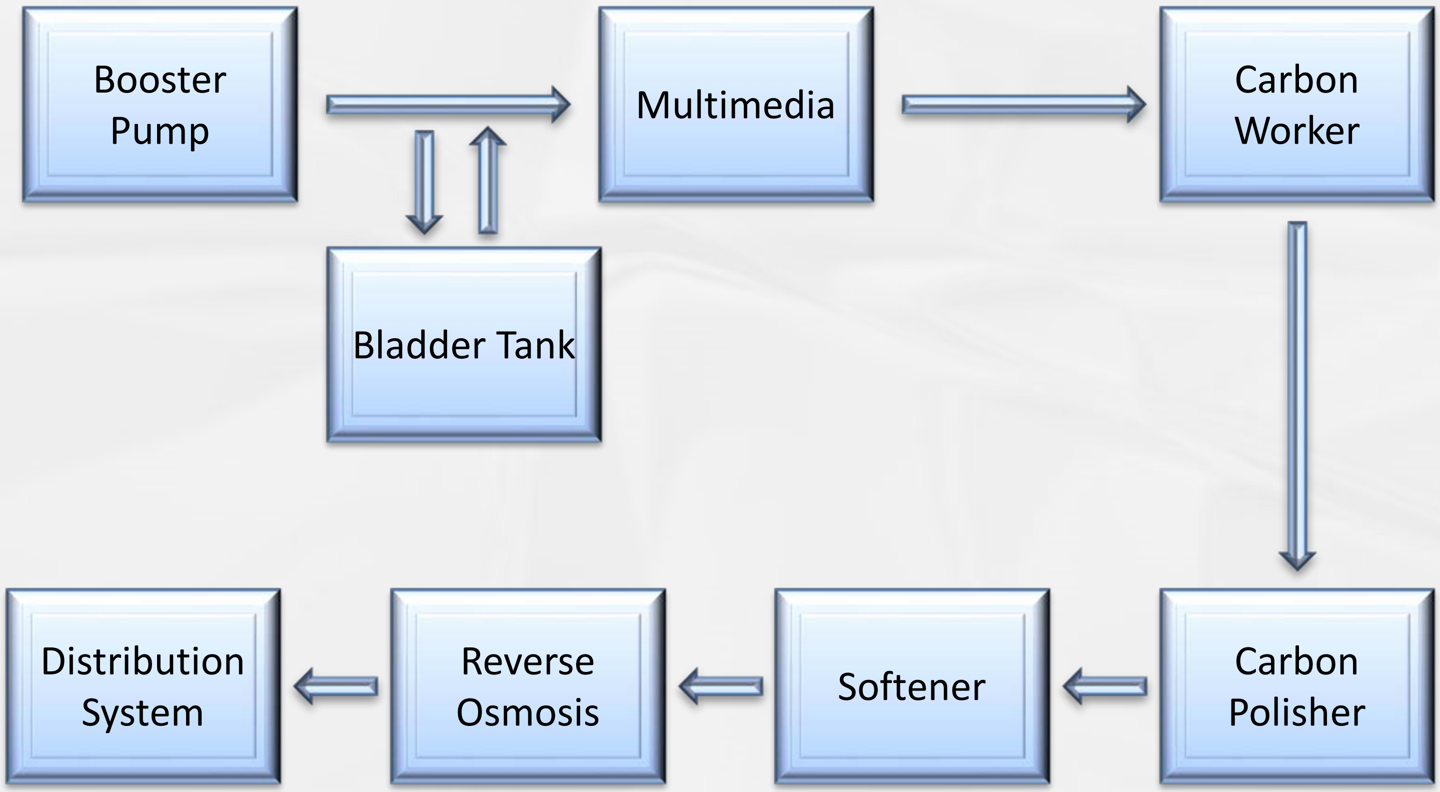
Traditional Water Treatment System



- Multimedia Filter filters down to 40,000 nanometers!
- Sediment Passing Through Multimedia Filter

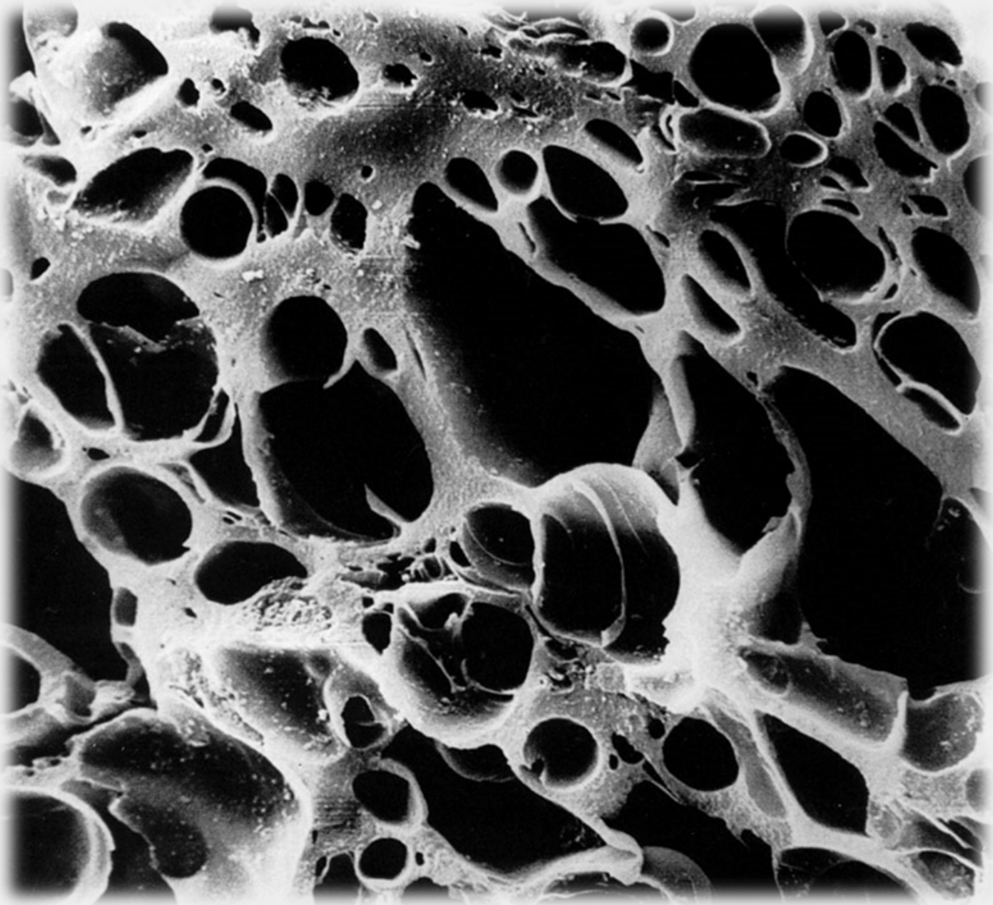
Reason why I have led a 15-year campaign against multimedia filters for hemodialysis

Traditional Water Treatment System



Coal-based, acid-washed 12x40 GAC(Granulated Activated Carbon) is an excellent sediment filter

Carbon Pore Size



On the nanometer scale the carbon structure is like a gigantic sponge, giving it the ability to trap sediment from 1,000 nanometers down to the smallest particle sizes.

Carbon media are fantastic sediment filters, but with one problem –

Releasing the sediment that they collect

They are backwashed in an attempt to remove the sediment. Unfortunately because the sediment is captured physically by trying to pass through a pore smaller than it is, it gets lodged into its resting place.

Backwashing:

1. Introduces sediment to the bottom of the bed
2. Expands the media by 50% to ensure sediment reaches all of the media
3. Tumbles the GAC in a turbulent stream
4. Causes scouring of the GAC due to its abrasiveness
5. Does a very good job of producing carbon fines
6. Requires forward rinsing after backwashing in an attempt to remove the generated carbon fines
7. Does a very poor job at releasing the debris because during the tumbling the water is not flowing through the GAC in the reverse direction to that which fixed it in place

The carbon fine particle size distribution is very large as the scouring process that produces the fines is not controlled and is subject to many contributing factors such as:

- the abrasiveness of the carbon,
- the hardness of the carbon,
- the fragility of the carbon (the structure of the grain),
- the temperature of the water, etc.

Net result of backwashing:

1. Effectively changes the incoming sediment to carbon fines
2. Much of the sediment is not backwashed out, decreasing the efficacy over time
3. Carbon bed releases sediment in an exponentially decreasing manner for long periods of time. This can be up to several hours

Wang Leilei at the College of Environmental Science and Engineering, at Hohai University in China documented particle emissions after GAC bed filter backwashing as part of a study and report, *Particle size distribution and property of bacteria attached to carbon fines in drinking water treatment* report.

His observations are interesting.

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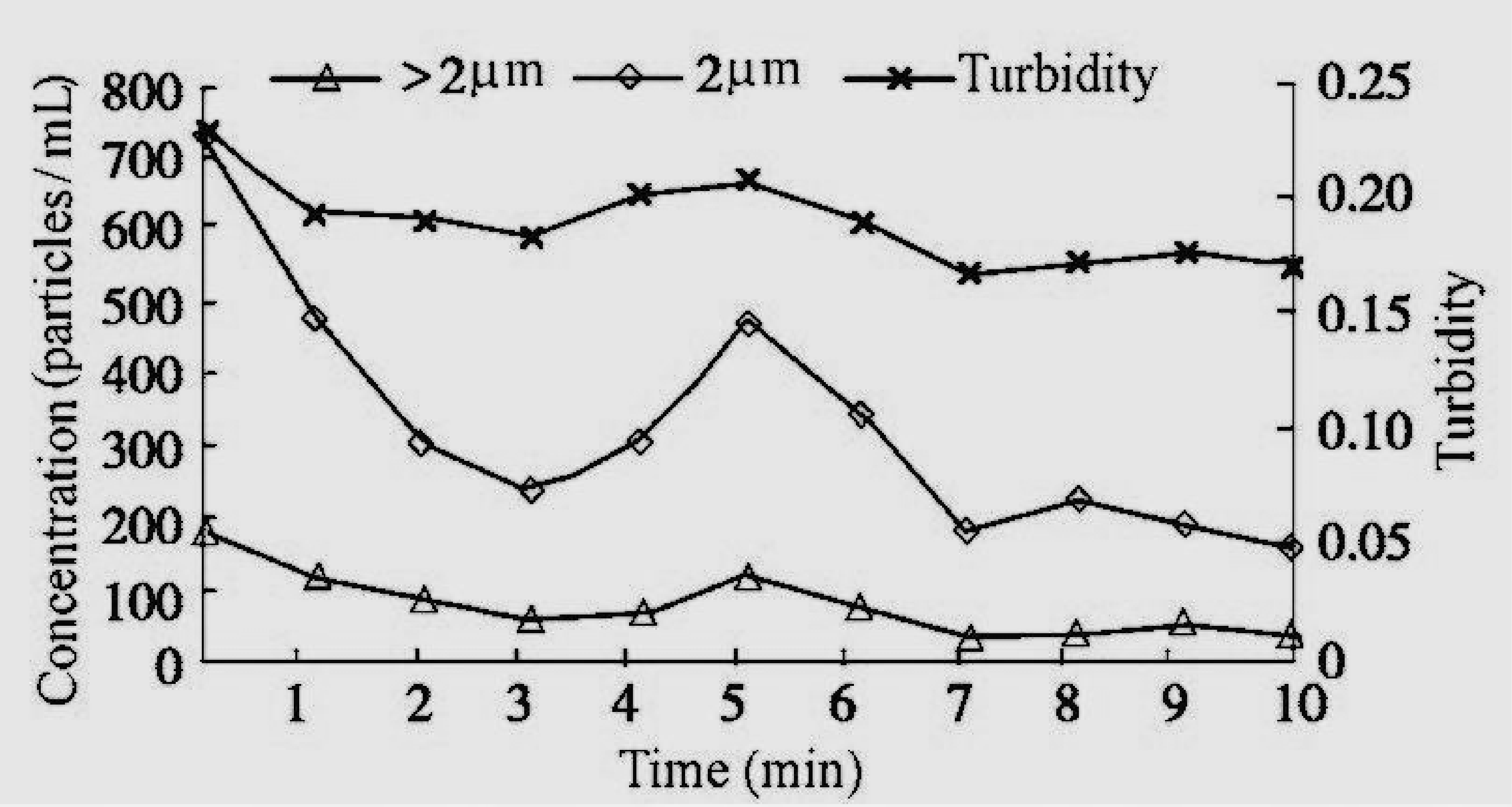
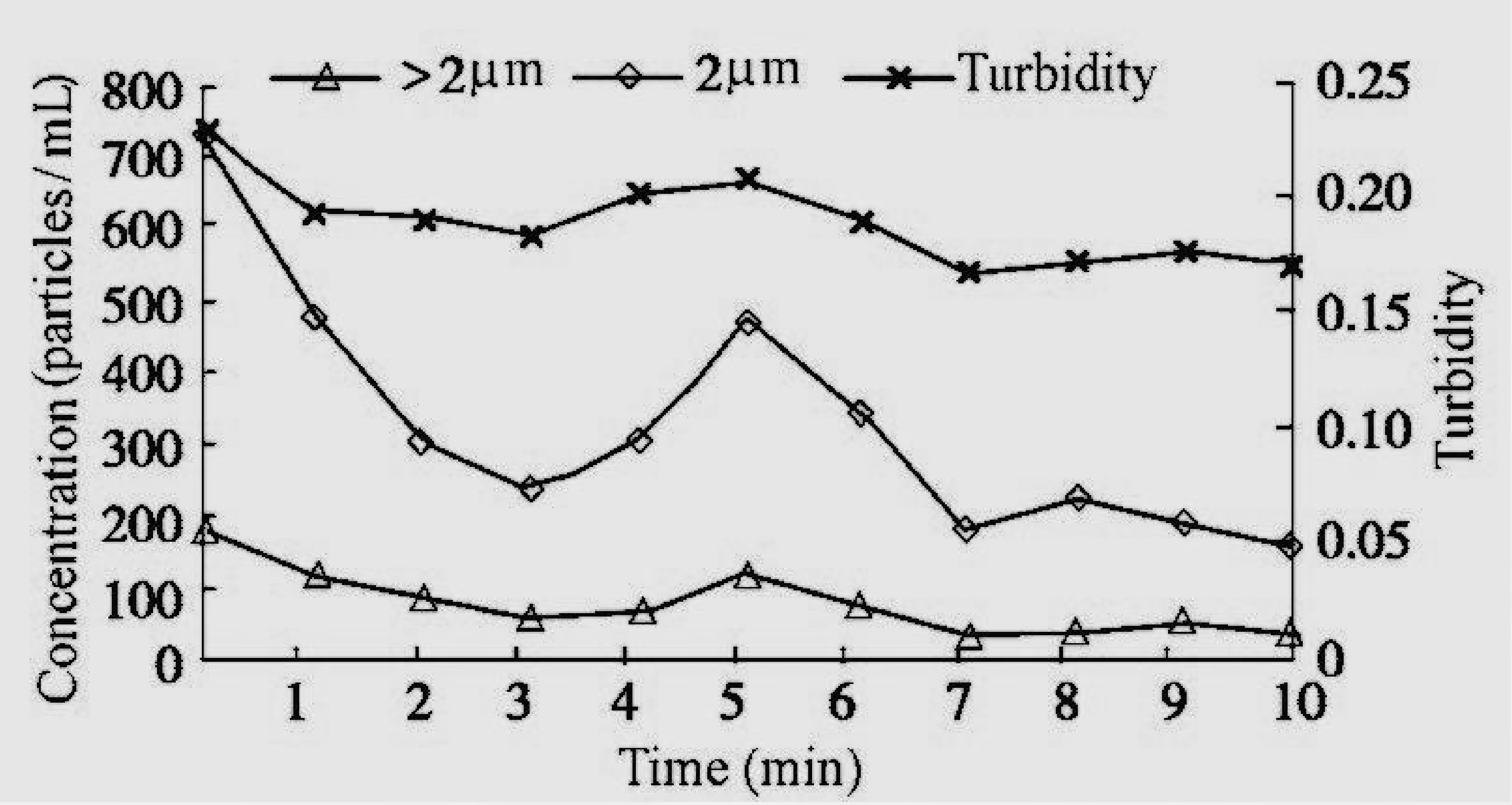
Three very important observations were recorded:

- Total sediment particle emission for 10 hours after GAC bed backwashing
- Carbon fines emission for 50 hours after GAC bed backwashing
- Carbon fines typically were 0.2 to 0.5 µm

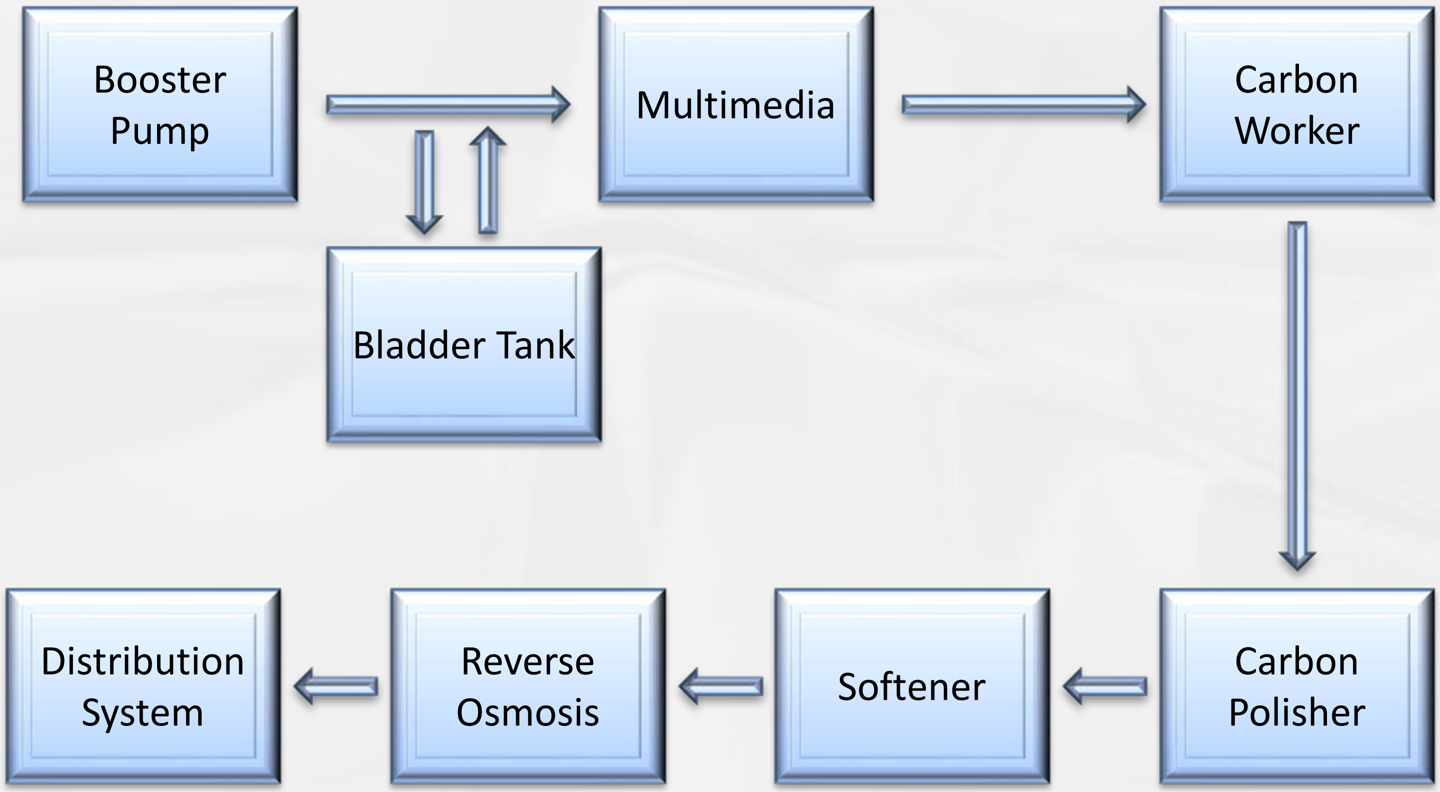
Changes of Particle Concentration And Turbidity In Initial GAC-filtered Water



Changes of Carbon Fine In GAC Filter Cycle



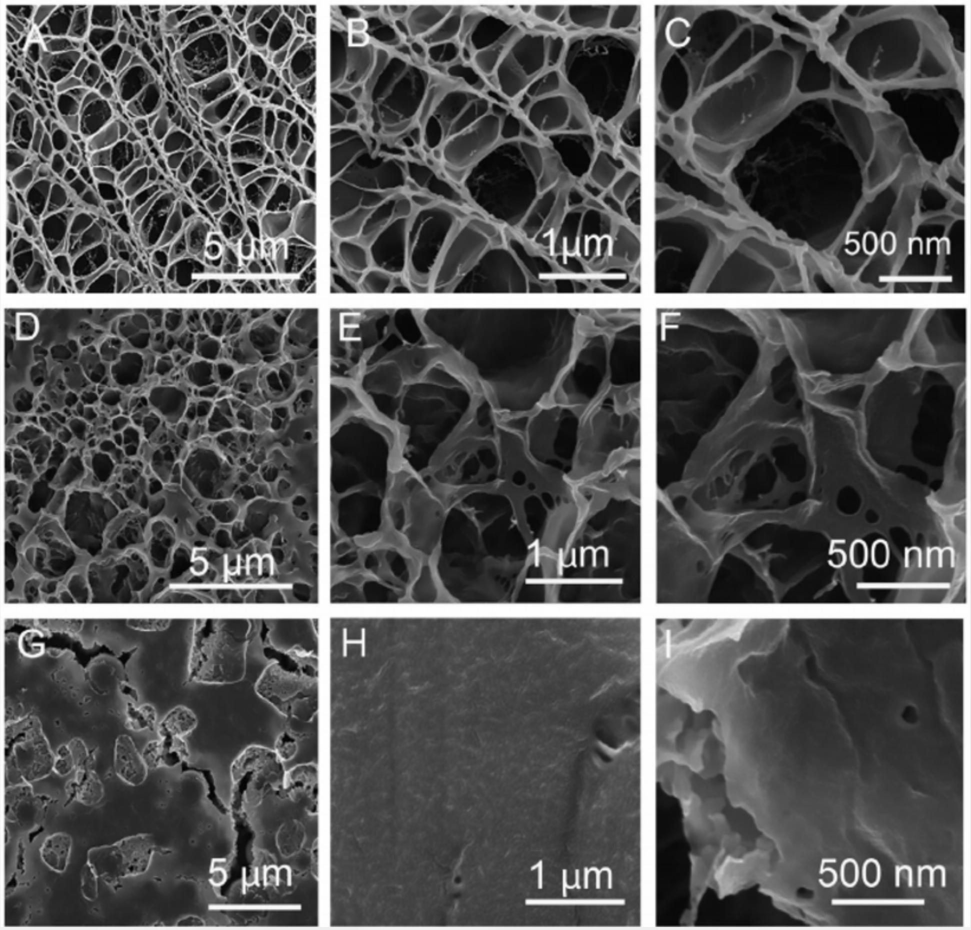
Traditional Water Treatment System



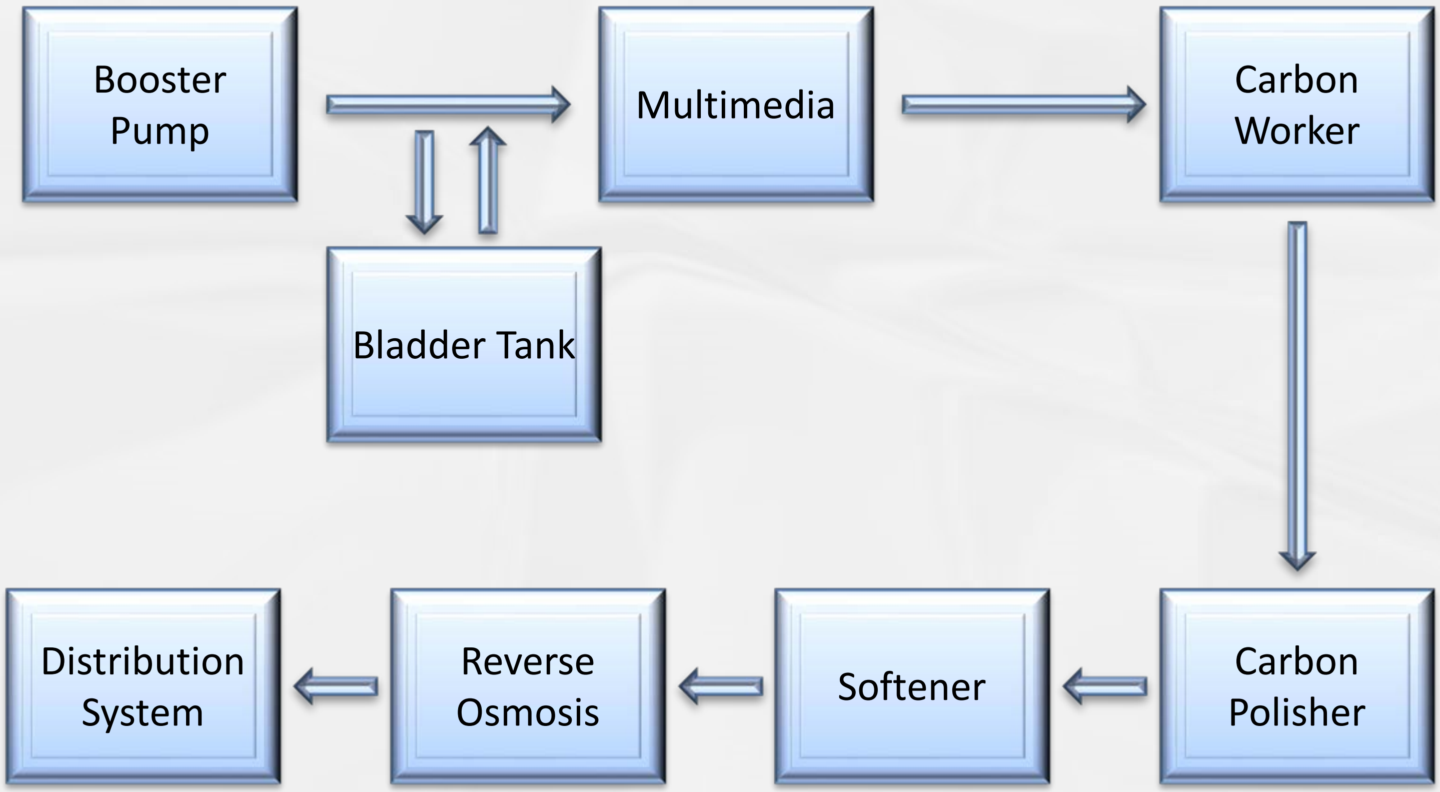
Softener beads:

1. are about 1,500,000 nanometers in diameter
2. are very porous
3. are consistent as to pore size
4. don't trap sediment.

Softener Media



Traditional Water Treatment System



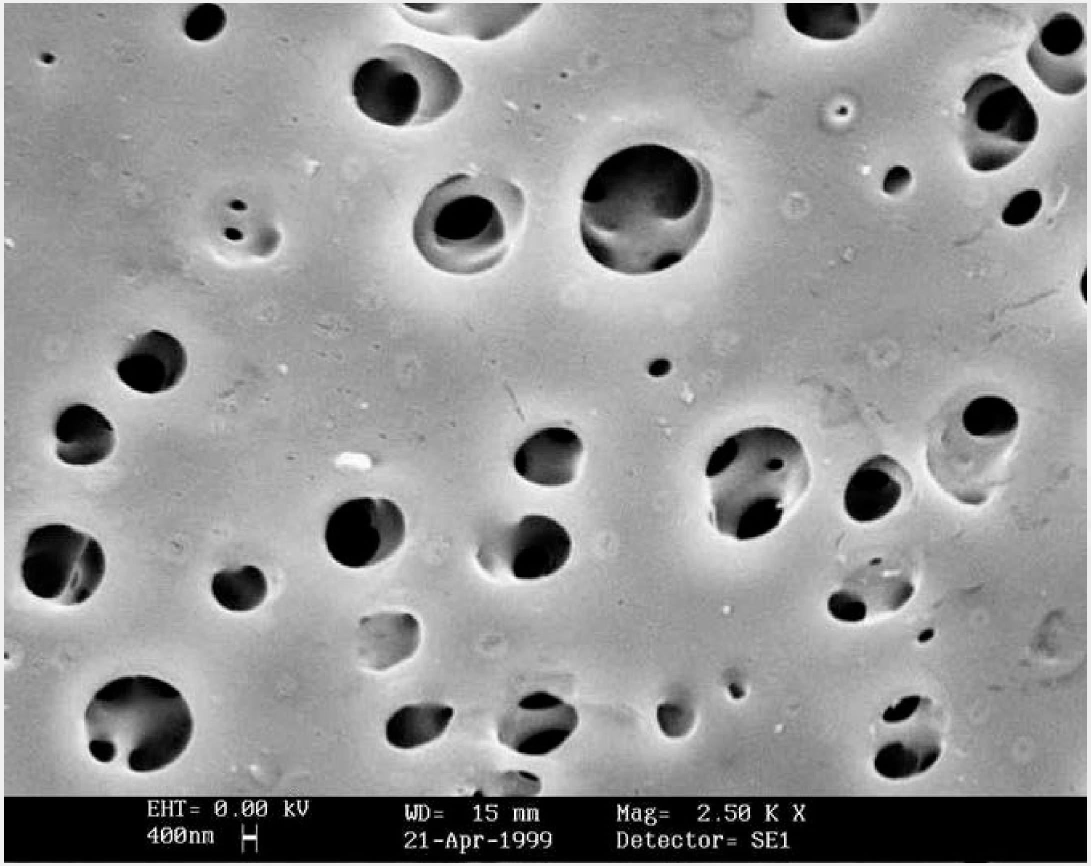
RO Pre-filter

First water treatment component on RO machine

1. Typically dual 2 ½” x 20” cartridge depth filters.
2. Filters typically rated at 5 micron (5,000 nm) nominal.
3. Nominal means 90% of particles sized at the nominal value are retained by the filter.

- The depth filters are effective for the larger sizes of carbon fines above 1,000 to 5,000 nanometers in size. If left in service long enough they will build a cake that will filter down to less than 1,000 nanometers size
- But, they are usually changed out before that happens
- Thus, all particles usually found in the water system pass through the RO depth filter onto the RO membranes
- The RO membrane pore size is approximately 1 nm
- Therefore, no measurable quantity of sediment gets past the RO membranes

RO Membrane Pore Size



Does that mean that all of the sediment goes down the concentrate stream from the membrane?

That depends:

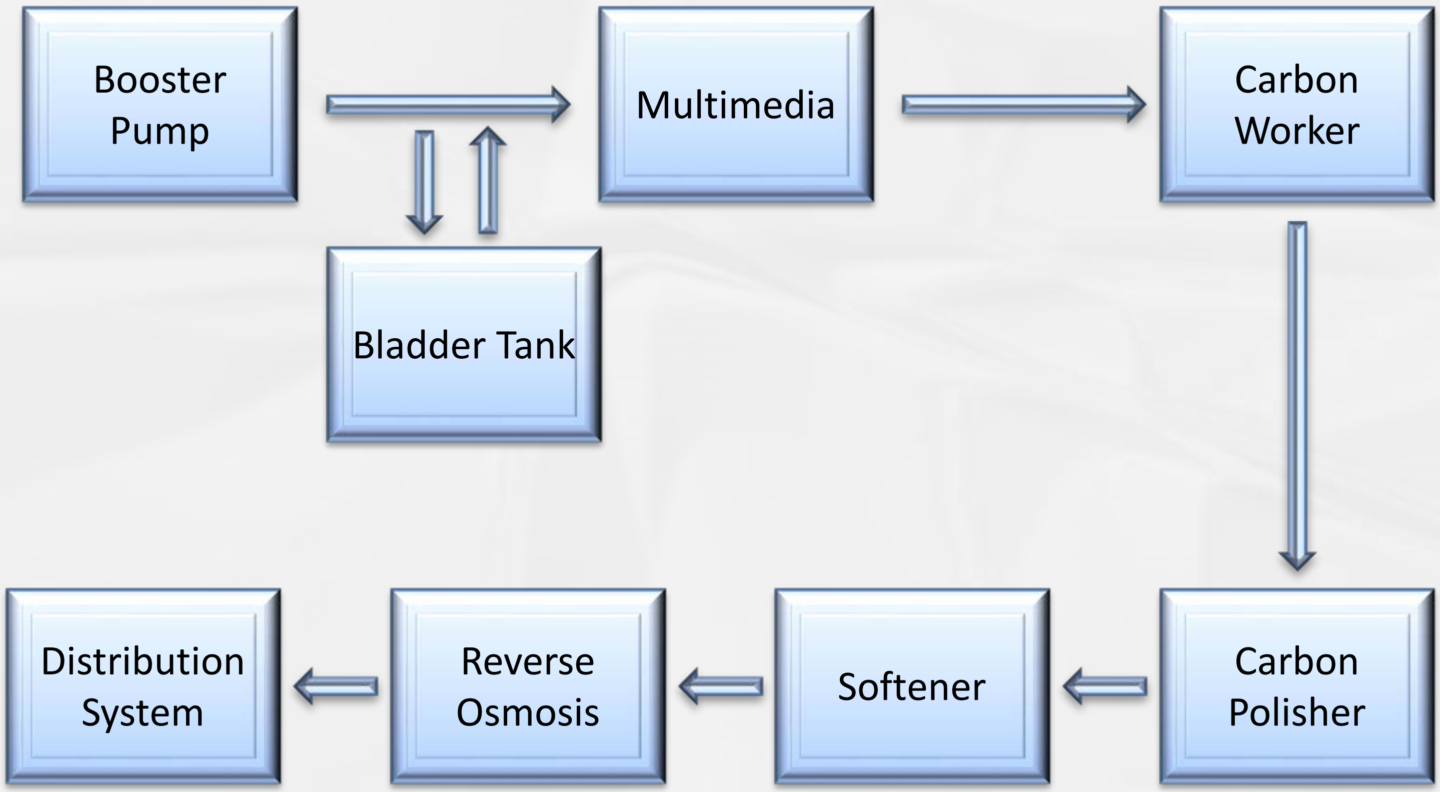
Remember we have three types of sediment:

1. Incoming municipal water
2. Carbon fines
3. Biological growth in situ

Let’s talk about the third sediment:

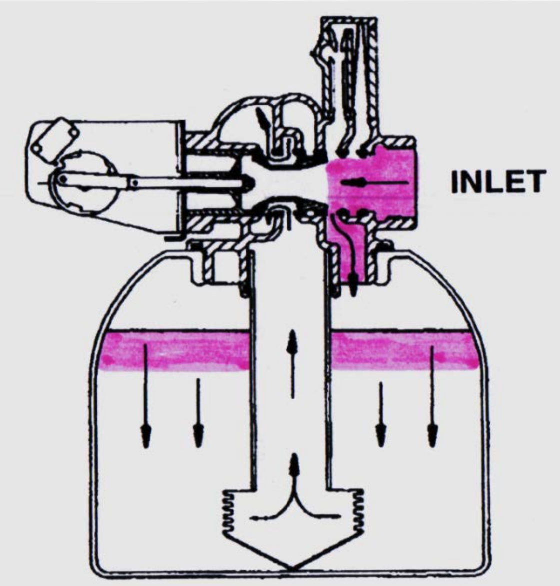
Biological Sediment

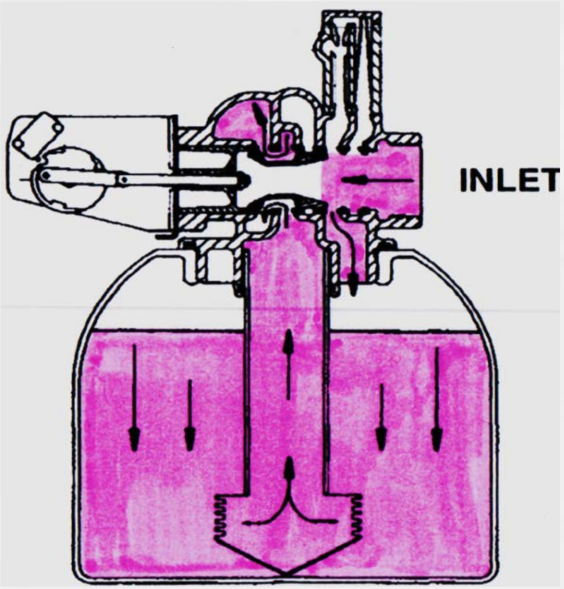
Traditional Water Treatment System



- Influent water from the municipality is chlorinated:
  (no live bacteria)
- Can we say no live biological organisms?
  No – cysts such as giardia and cryptosporidium can survive municipal chlorination
- Is there dead organic material?
  Yes.

This biological sediment is filtered out in the carbon bed (except that which enters the bottom of the bed during backwash and is subsequently sloughed off in the following service cycle).





The carbon beds do an excellent job of removing the incoming chlorine from the water:

1. If there is any free residual chlorine, it is removed on contact with the GAC (by chemical reaction)
2. The combined chlorine (chloramines) are adsorbed by the GAC. This is a time dependent process that typically takes less than one minute.
3. To ensure that the process has adequate time, the AAMI standard is a minimum of 5 minutes for the worker carbon filter and 10 minutes for worker and polisher filters.

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4. for the majority of the time that the water is flowing through the worker carbon bed and for all of the time that the water is flowing through the polisher bed, the water is chlorine free
5. no chlorine = bacteria growth opportunity
6. Some bacteria love to eat carbon, carbon beds make a perfect nursery
7. No protection against biological growth after GAC filters

The bacteria

- typically are above 200 nanometers in size.
- pass through the 10,000 nanometer softener media pores
- land on the RO membrane surface which appears to be perfect for attaching to
- once attached by a layer of polysaccharide slime, they form colonies, if they have food to survive

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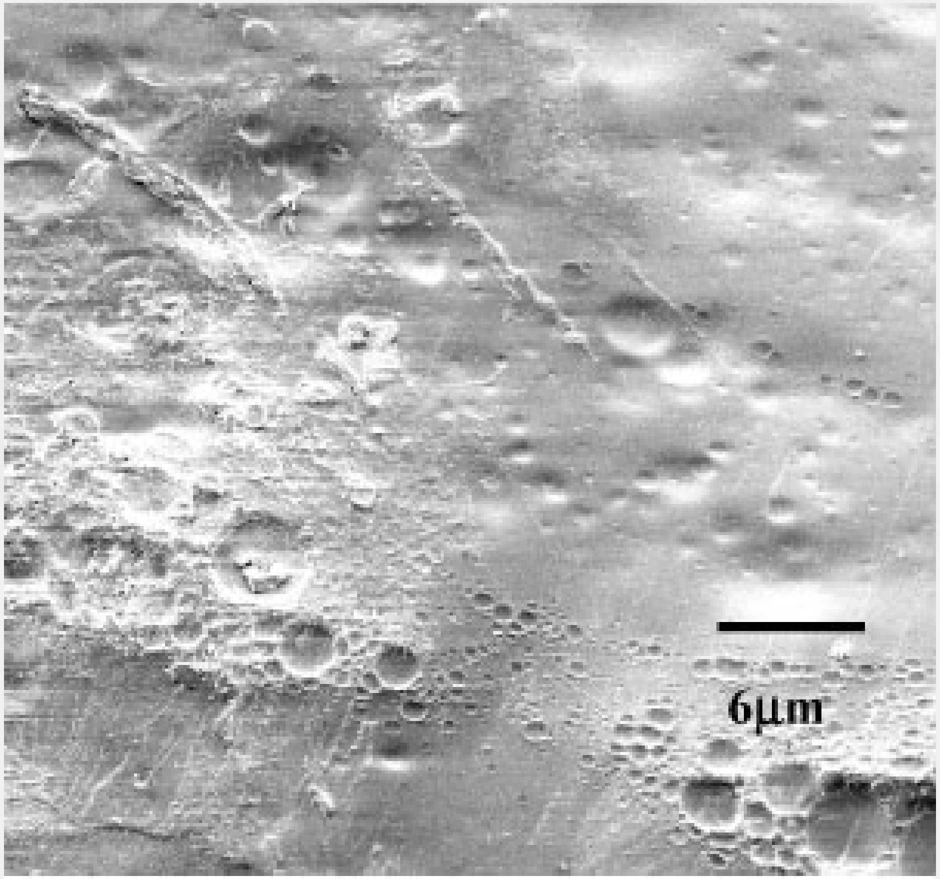
- and they do have lots of food from the carbon fines which are constantly being fed to them as well as the influent organic material which passes through the system by frequent backwashing of the carbon filters
- eventually they clog up the membrane pores if the membranes are not cleaned regularly
- once a biological colony is established, it cannot be removed – only controlled (the colony's gelatinous cover protects the bacteria under it from biocides)

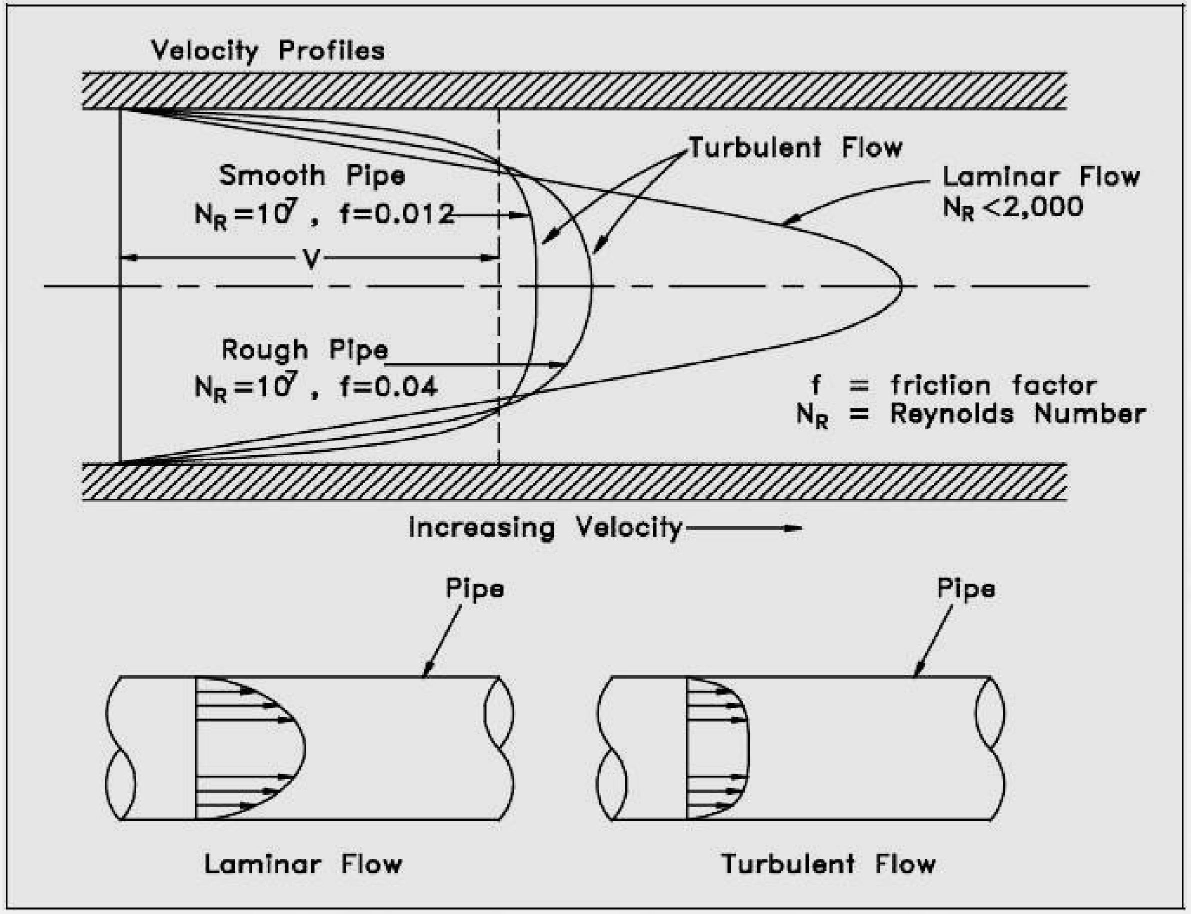
Bio Fouled Membrane

- Traditionally piping after the RO including the patient water loop was constructed using PVC80 pipe and fittings that are glued together. The PVC80 pipe surface is perfect for bacteria to attach to.
- Unfortunately, this allows much variation in the quality of the joints.
- Improperly glued fittings in the loop creates large incubation sites for bacteria.

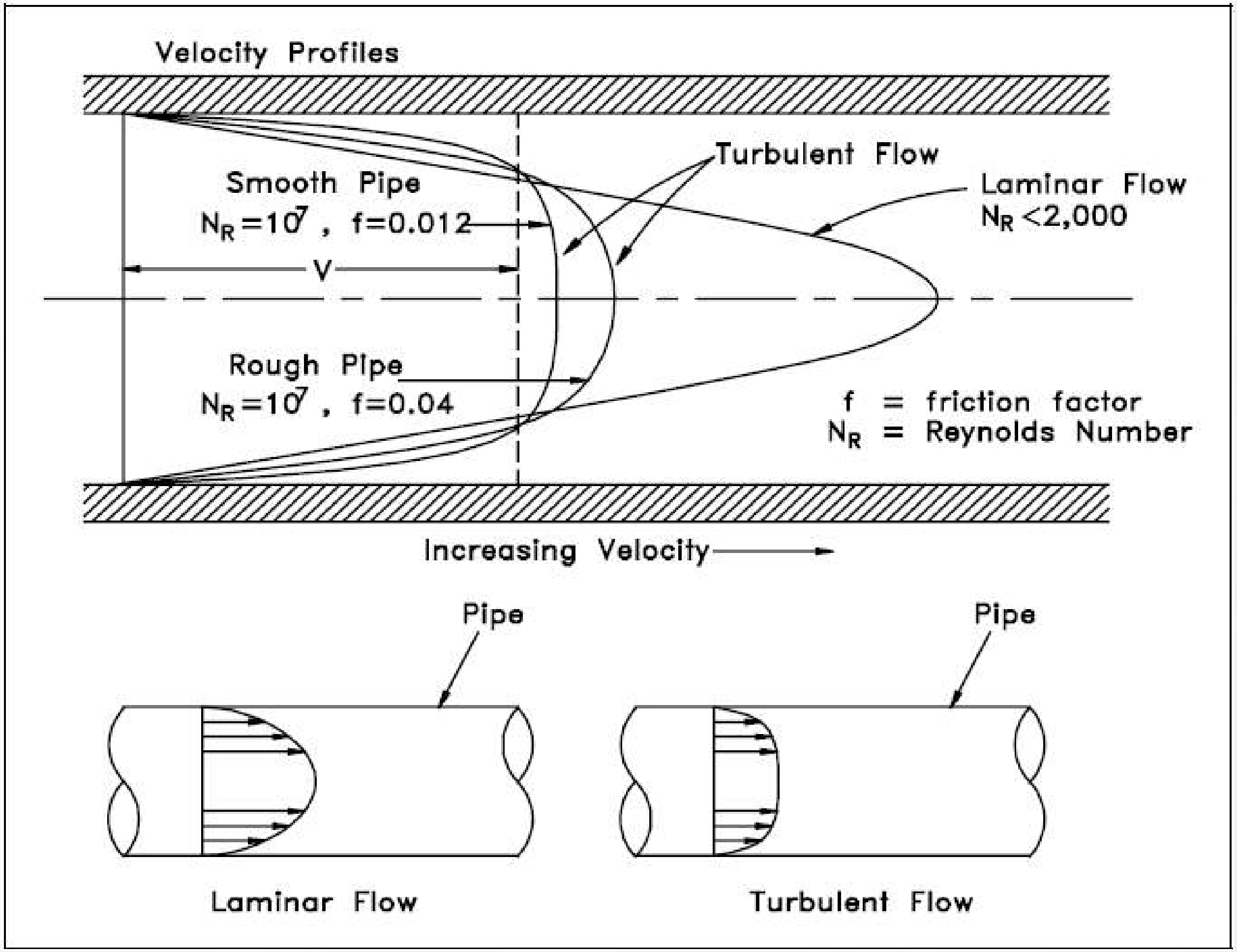
Micrograph of Virgin Films



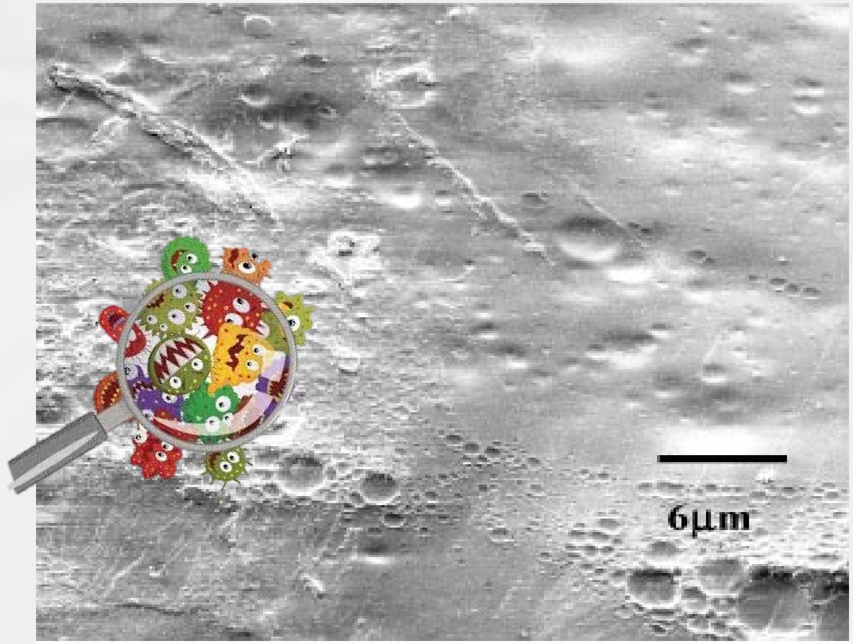
Flow Velocity In The Pipe



Flow Velocity In The Pipe



The water at the surface of the pipe is very slow in relationship to the average flow velocity – perfect for bacteria attaching to the pipe wall.



Control Sediments by:

1. Adequate influent water filtration before carbon filters
2. Reduce carbon filter backwashing to once a month or less
3. Use Teflon tubing in patient water loop

Question & Answer

Burke A. West, P.E., MWS