Source and Treatment of Water

Maryland Center for Environmental Training
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Sources and Treatment of Water

7 contact hours

9 CC10 hours

Water operators will explore water treatment for both the ground and surface facilities. Students will be introduced to surface water source options and ground water wells and how they are constructed and maintained. other topics will include various treatment strategies such as Disinfection and Corrosion control, Iron and Manganese Removal, Arsenic and Organic removal. Various water treatment chemicals and their feed systems will also be covered.

1) Describe the hydrolic cycle;
2) Perform operation and maintenance of water systems;
3) Implement iron and magnesium removal in a water system; and
4) Identify treatment chemicals for water systems.

Agenda
8:00 – 8:30am: Greetings and Introductions (pre-test)
8:30 – 9:15am: Water Sources: Ground & Surface
9:15 – 9:30am: Break
9:30 – 10:15am: Well Construction and Maintenance
10:15 – 10:45am: Ground Water Treatment
10:45 – 11:00am: Break
11:00 – 12:00am: Water Treatment Chemicals & Feed Systems
12:00 – 1:00pm: Lunch
1:00 – 1:25pm: Disinfection & Corrosion/Scaling Control
1:25 – 1:50pm: Iron & Manganese Removal
1:50 – 2:15pm: Organics Removal
2:15 – 2:30pm: Break
2:30 – 2:55pm: Arsenic Treatment Options
2:55 – 3:20pm: Membrane Filtration

Sources & Treatment: Options for Water Systems

Maryland Center for Environmental Training

Introductions

- Instructor
- Course Participants
  - Name
  - Where you work
  - Type of system (s) that you operate
  - Expectations of this training

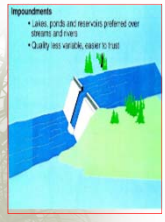
"Rules of Thumb" for Estimating Adequacy

- Average daily use in gallons/capita/day
  - 75 – 150 gallons/capita/day
- Maximum day multiplier
  - 2.0 – 2.5 X average day

Source Water Quality

- Proximity to contamination
- Substances that alter quality
  - Organic
  - Inorganic
  - Biological
  - Radiological
- Sources of impurities

Surface Water Quality



- Vulnerable to contamination
  - Natural
  - Man-made
- Streams and rivers
- Impoundments

Source Water Protection

- Define the watershed area
- Identify actual or potential sources of contamination in the defined area
- Determine the water supply's susceptibility to contamination from identified sources
- Implement measures to control sources of contamination
- Plan for the future and develop a contingency plan

Source Water Components

River Intake

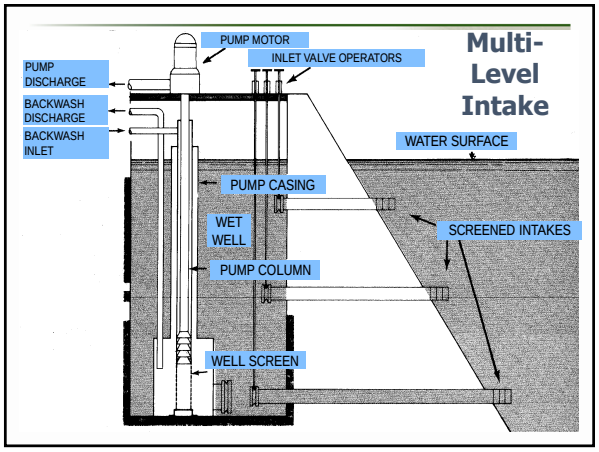
Impoundments

- Lakes, ponds and reservoirs preferred over streams and rivers
- Quality less variable, easier to trust

- Provides stored water
- Any down-sides?

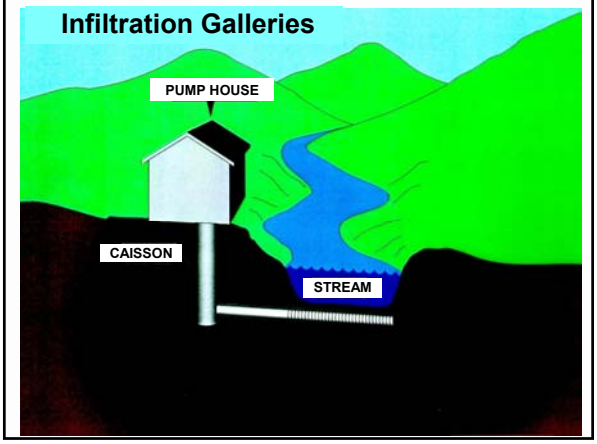
Dam


Reservoir


Multi-
Level
Intake
PUMP MOTOR
INLET VALVE OPERATORS
PUMP
DISCHARGE
BACKWASH
DISCHARGE
BACKWASH
INLET
WATER SURFACE
PUMP CASING
WET
WELL
SCREENED INTAKES
PUMP COLUMN
WELL SCREEN


Intake Screens

Infiltration Galleries



Checklist – Source Water Protection

- Protection area control / ownership?
- Characteristics of the protection area?
- Contamination sources inventoried?
- Emergency spill response plan?

Checklist – Source Water Quality

- ✓ Raw water quality monitored?
- ✓ Source quality adequate?
- ✓ Using the highest quality source available?
- ✓ No trend of worsening water quality?
- ✓ No imminent health risks?

Checklist – Source Water Quality

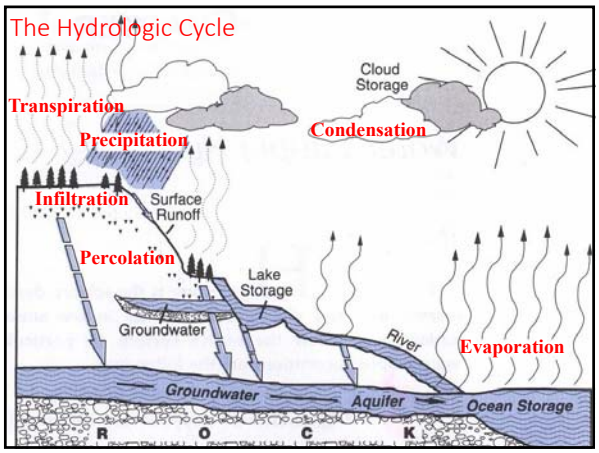
- Treatment provided in reservoir?
- Intake properly located?
- Water can be drawn from different levels?
- Intake inspected regularly?
- Causes of variable water quality determined?
- ✓ No safety concerns with dam?

Ground Water Under the Direct Influence of Surface Water

Applies to Wells and Springs:

- GWUDI defined by:
  - Significant occurrence of insects and other macroorganisms
  - Shifts in water characteristics
- Determination based on site-specific characteristics and state criteria
- Triggers Surface Water Treatment Rule

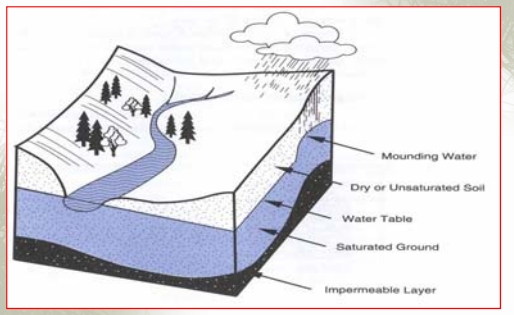
Groundwater Sources



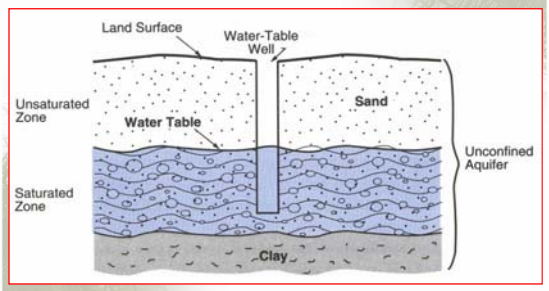
Groundwater…

- Result of the infiltration and percolation of water down to the water table, which is the upper zone of saturation in an aquifer

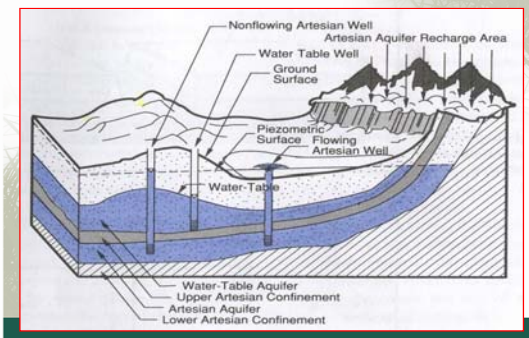
Formation of Groundwater



Unconfined Aquifer



Artesian Wells in a Confined Aquifer



Check Your Knowledge

- Does a well have to be "free flowing" to the surface to be considered Artesian?

a. Yes
b. No

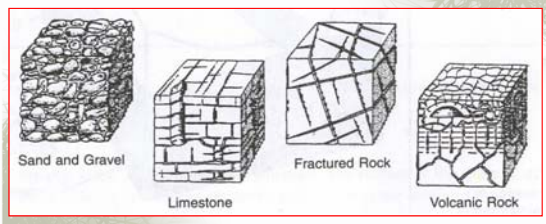
b. No

Does the composition of the material for an aquifer make a difference?

- What would water move through easier?

- Fine sand or coarse sand

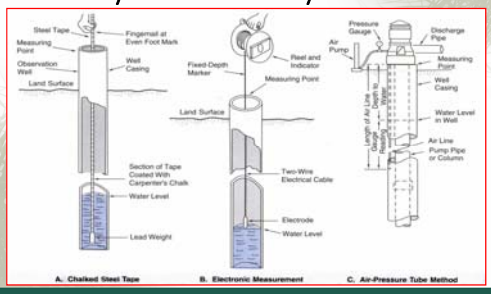
Aquifer Materials



Aquifer Performance…

- Changes in an aquifer are measured by a small diameter test well called an *Observation Well*
- Located near an operating well

Aquifer Evaluation can be Measured Manually or Mechanically



Well Yield- Rate of water withdrawal that a well can supply over a long period of time

- Example: Pumpage from an aquifer continuously exceeds the recharge to the aquifer, draw-down will extend and a safe yield will be reduced

Check Your Knowledge

- The amount of water in a water-bearing formation depends on the…
  a. Depth of the well
  b. Size of the pump
  c. Porosity of the formation
  d. Type of well casing

c. Porosity of the formation

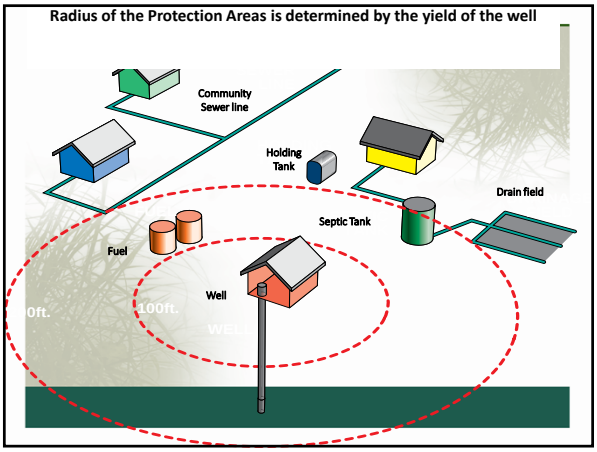
Source Protection

- A strategy designed to protect public drinking water supplies by managing the land surface around a well where activities might affect the quality of the water.

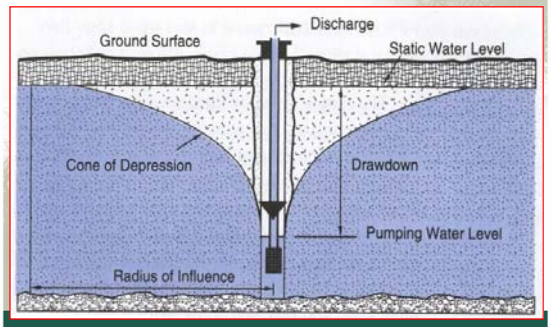
Steps in Wellhead Protection

1. Form a community planning team
2. Define wellhead protection area
3. Inventory actual or potential contaminant sources in the defined area
4. Manage the protection area
5. Plan for the future
6. Site new wells carefully

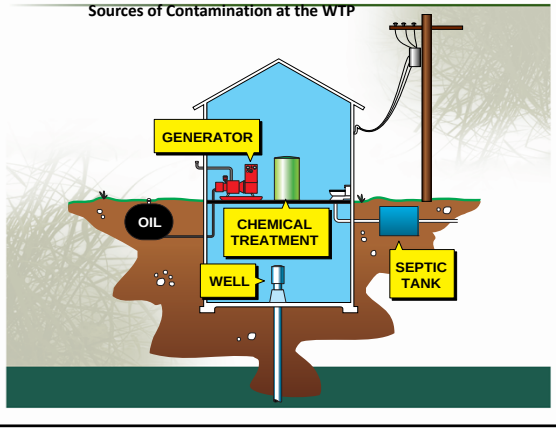
Radius of the Protection Areas is determined by the yield of the well



Static Water Level, Pumping Water Level, Draw-down, Cone Of Depression

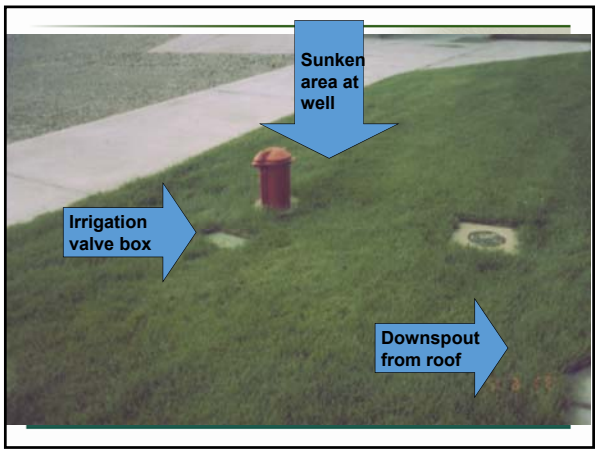


Sources of Contamination at the WTP



Basic Rules for Wellhead Protection

- Restrict access to well
- Inspect protective zones regularly
- Slope ground away from the well
- Locate maintenance sheds and chemical storage outside of protective zone
- Site new wells carefully



Types of Wells & Well Construction

Types of Wells…

- Dug wells
- Bored wells
- Drilled wells
- Driven wells
- Jetted wells

- Dug wells
- Drilled wells

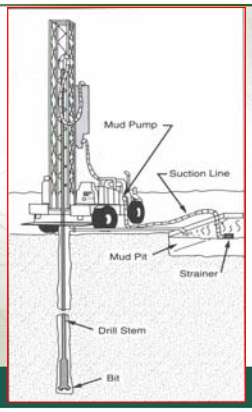
Dug Wells
(found in rural areas)

- Do not penetrate much below water table
- May fail during drought conditions
- Protection from surface contamination difficult
- Only type of well **always** treated as a surface water source

Drilled Wells Most Commonly Found In Public Water Supply

- Benefit - they can reach extreme depths and have large well diameters
  (up to 4 feet and larger)

Drilling Rig

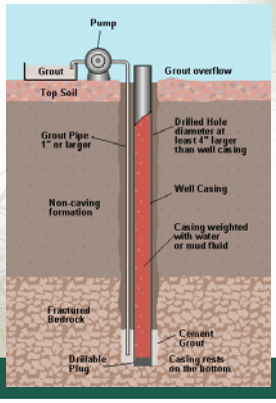


Mud Pit

Drilling a Water Well

Source: Ground Water and Wells, Johnson Well Screen Division

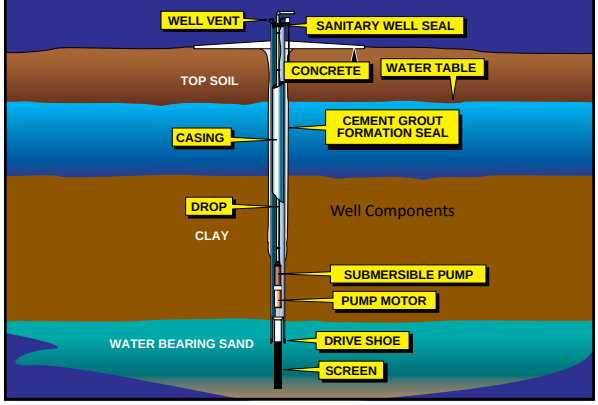
Ground Water Wells: Grouting Methods

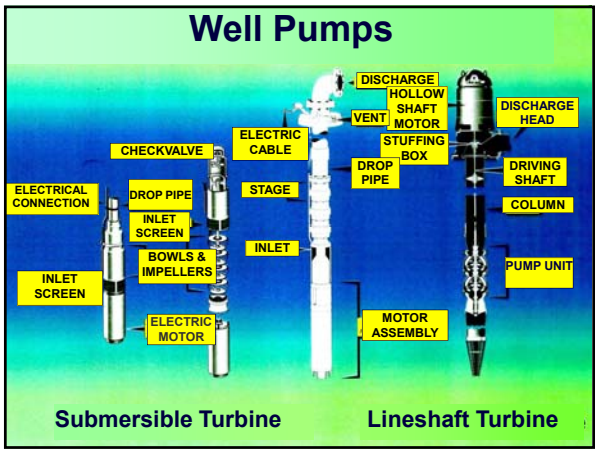


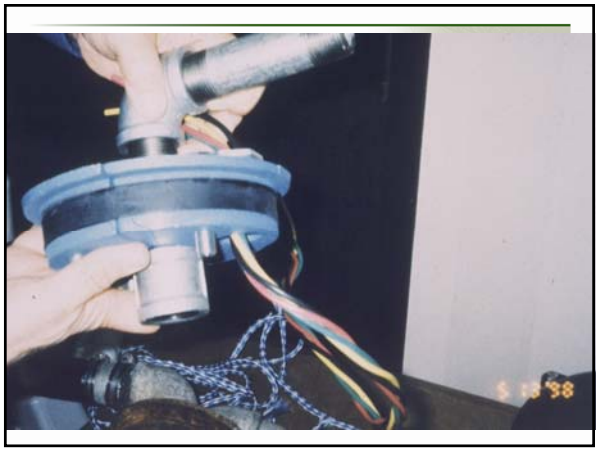
Well casing is cemented by pumping grout through a pipe lowered into the annular space outside the casing.

Source: Ground Water and Wells, Johnson Well Screen Division, 1975

Typical Well Configuration

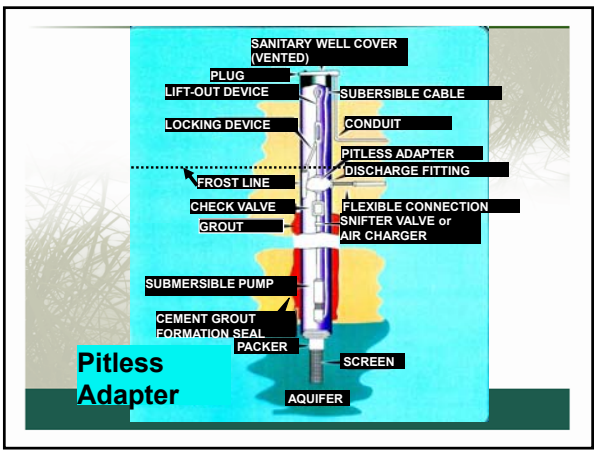


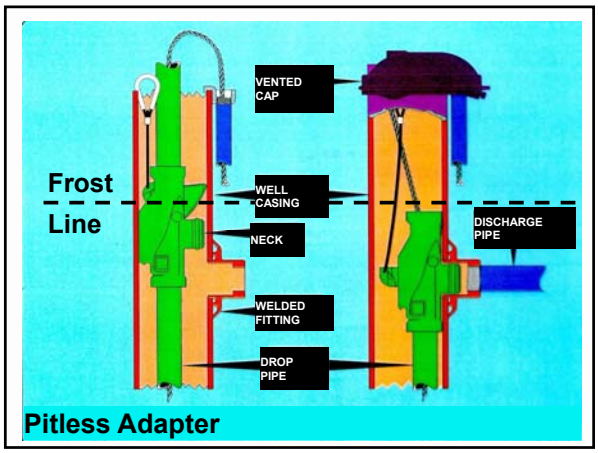

Well Pumps
DISCHARGE
HOLLOW SHAFT MOTOR
VENT
DISCHARGE HEAD
ELECTRIC CABLE
STUFFING BOX
CHECKVALVE
DROP PIPE
DRIVING SHAFT
ELECTRICAL CONNECTION
DROP PIPE
STAGE
COLUMN
INLET SCREEN
INLET
BOWLS & IMPELLERS
PUMP UNIT
INLET SCREEN
MOTOR ASSEMBLY
ELECTRIC MOTOR
Submersible Turbine
Lineshaft Turbine

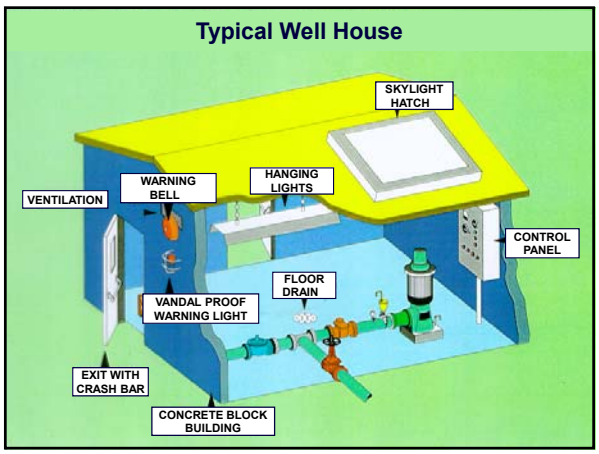


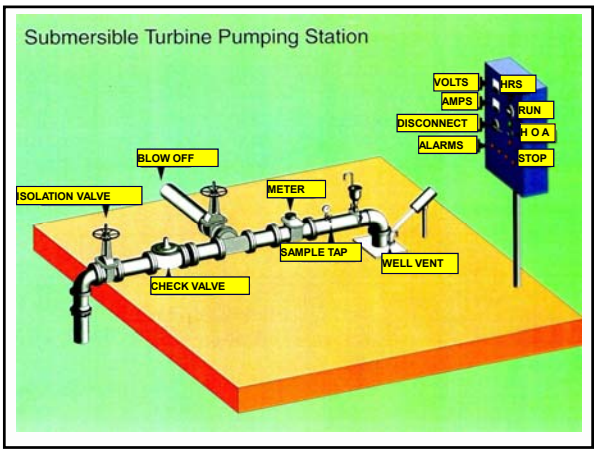

Vents

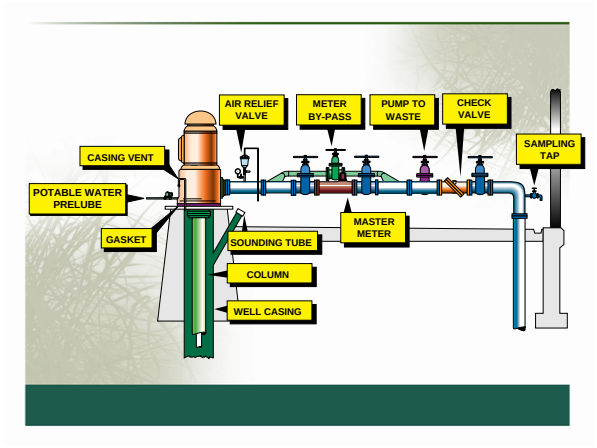

Wellhead Terminated Below Grade –
Subject to Contamination


SANITARY WELL COVER (VENTED)
PLUG
LIFT-OUT DEVICE
LOCKING DEVICE
FROST LINE
CHECK VALVE
GROUT
SUBMERSIBLE PUMP
CEMENT GROUT FORMATION SEAL
PACKER
AQUIFER
SUBERSIBLE CABLE
CONDUIT
PITLESS ADAPTER
DISCHARGE FITTING
FLEXIBLE CONNECTION
SNIFTER VALVE or AIR CHARGER
SCREEN
Pitless Adapter


VENTED CAP
Frost Line
WELL CASING
NECK
DISCHARGE PIPE
WELDED FITTING
DROP PIPE
Pitless Adapter


Typical Well House
SKYLIGHT HATCH
WARNING BELL
HANGING LIGHTS
VENTILATION
CONTROL PANEL
FLOOR DRAIN
VANDAL PROOF WARNING LIGHT
EXIT WITH CRASH BAR
CONCRETE BLOCK BUILDING





Check Your Knowledge

- The most common type of well used for public water supply systems is a
  a. Drilled well
  b. Jetted well
  c. Driven well
  d. Bored well

a. Drilled well

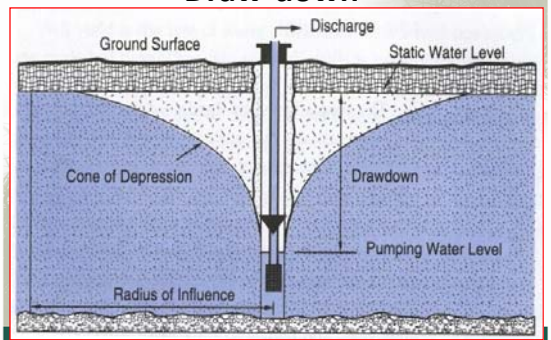
Check Your Knowledge

- How much total well pumping capacity should a community water system have?
  a. Enough to supply average daily demand
  b. Enough to supply the max day demand
  c. Enough to supply peak demand
  d. Enough to supply the average daily demand with the largest well out of service

d. Must supply average day demand w/ largest production well OOS

Well Operation & Maintenance

Draw-down



O&M

- Measure Drawdown
- Calculate Specific Capacity
  - GPM per Foot of Drawdown
- Check for presence of sand
- Check actual pump capacity
- Verify pressure cut-in and cut-out set points
- Ensure that connections & sanitary seals are intact
- Eliminate potential sources of contamination

O&M

- Test alarm systems
- Record daily water production and pump runtime
- Measure raw water quality
  - Watch for changes in contaminant levels
- Consult with a "Well System Professional"
  - Well Driller
  - Hydrogeologic / Engineering Firm
  - Electricians
    - Power
    - Industrial Controls

Check Your Knowledge

- Which of the following best defines the term specific capacity?

a. Amount of water a given volume of saturated rock or sediment will yield to gravity

b. Amount of water a given volume of saturated rock or sediment will yield to pumping

c. Rate at which water would flow in an aquifer if the aquifer were an open conduit

d. Amount of water a well will produce for each foot of drawdown

d. Amount of water a well will produce for each foot of drawdown

Water Treatment Methods

What is the main determining factor when deciding on the type of treatment needed ?

- The characteristics of the raw water source (the contaminants that must be removed)

Problems Caused by Contaminants

- Unpleasant taste
- Disease-causing organisms
- Odors
- Contaminants above recommended health related limits

Public Systems Using Groundwater...

- Previously, many systems provided acceptable quality without providing treatment
- Many more systems have turned to treatment for the following reasons:
  - Meet federal and state requirements for disinfection
  - Remove contaminants posing a threat to public health
  - Remove contaminants that reduce the aesthetic quality of the water

Groundwater...

- Contains little or no turbidity
- Few microorganisms

Groundwater can contain…

- High hardness
- Objectionable contaminants:
  - Iron
  - Manganese
  - Hydrogen Sulfide
- Radionuclides
- Synthetic contaminants:
  - Pesticides
  - Herbicides
  - Industrial solvents

Groundwater Treatment Options

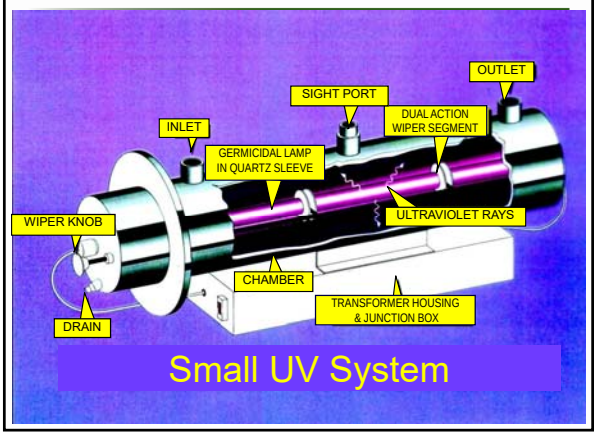
- All treatment must be approved by the state regulatory agency.

MARYLAND

Groundwater Treatment Options

Disinfection:
To prevent microorganisms from entering/forming in the distribution system.

Methods:
- Application of a disinfecting chemical
  - Chlorine
  - Sodium Hypochlorite
  - Calcium Hypochlorite
- Ultraviolet (UV) light



Groundwater Treatment Options

Corrosion Control:

To prevent corrosion in the distribution system and prevent leaching of lead & copper in household plumbing.

Methods:

- Feeding a pH adjustment chemical
- Feeding a corrosion inhibitor ch

Groundwater Treatment Options

Calcium / Magnesium (Hardness) Removal:

To prevent calcium / magnesium from…

- forming deposits inside pipes and fixtures
- causing customer complaints
  - Hard water will not allow soap bubbles to form

Methods:

- Ion Exchange
- Lime / Soda Ash Softening

Groundwater Treatment Options

Iron / Manganese Removal:

To prevent iron / manganese from…

- forming deposits inside pipes and fixtures
- staining laundry
- causing taste and odor complaints
- accumulating in distribution pipes and promoting biofilm growth

Methods:

- Feeding a chemical to sequester the iron / manganese
- Physical removal (oxidation / filtration)
- Ion Exchange

Groundwater Treatment Options

Organics Removal:

To prevent volatile and synthetic organics from entering the distribution system and causing chronic health problems.

Methods:

- Aeration
- GAC Contactors

Groundwater Treatment Options

Arsenic Removal:

To prevent arsenic from entering the distribution system and causing chronic health problems.

Methods:

- Membrane Filtration
- Ion Exchange
- Lime Softening
- Oxidation / Filtration
  - May also incorporate coagulation

Water Treatment Chemicals

Disinfection Chemicals

- Chlorine
- Calcium Hypochlorite
- Sodium Hypochlorite
- Ozone
- Ultraviolet

Chlorine Characteristics

- Liquefied gas under pressure – 100 % available chlorine Greenish – yellow Gas / 2.5 X's heavier than air
- Amber colored liquid / 1.5 X's heavier than water
- Boils @ -30 F / freezes @ -150 F atmospheric pressure
- *1 volume liquid = 460 volumes of gas
- Vapor pressure varies with the temperature
- Moisture & Chlorine = corrosive acids
- Very reactive with most elements especially with moisture present

Calcium Hypochlorite Ca(OCl2) HTH

- HTH – 65 % available chlorine
- White granular powder
- Used in swimming pools
- Very reactive with hydrocarbons
  - oils & paints
- Shelf life 60 – 90 days
  - if left open to high humidity loses strength faster

Sodium Hypochlorite NaOCl

- Household Bleach 1% - 5%
- Commercial Bleach 12% - 15%
- 15% = 1.25 lbs. Cl_2 per gallon
- Yellowish in appearance
- pH 10 – 12
- In storage, strength may drop 30 – 60 days
- Temperature > 85 degrees, weakens faster
- Sunlight also has an effect

Chemicals Used to Prevent Corrosion…

- Calcium Hydroxide….(lime)
- Calcium Oxide…….(quicklime)
- Sodium Hydroxide…..(caustic soda)
- Sodium Carbonate……(soda ash)
- Sodium Bicarbonate….(baking soda)
- Phosphates

All Chemicals Added to Drinking Water

- MUST be approved by the National Sanitation Foundation (NSF)

Incompatible Chemicals

- Mixing of incompatible chemicals can result in:
  - Generation of excessive heat
  - Fire
  - Explosion
  - Production of toxic gas

Safety Factors
Chemical Feed Systems

- Chemical storage areas:
  - Kept dry
  - Well ventilated
  - Heated (where liquid chemicals are stored)
  - Used *only* for the storage of chemicals
  - Secondary containment provided
  - "Incompatible chemicals" stored separately

Secondary Containment

Delivery of Chemicals

- Deliveries of chemicals and other supplies made in the presence of water system personnel?
- Procedures to ensure the security of chemicals?

Hazard Communication

Personal Protective Equipment

Lockout/Tagout

Check Your Knowledge

- Which chlorine chemical has a purity of 65-70%

a. Chlorine
b. Calcium hypochlorite
c. Sodium hypochlorite
d. Calcium hydroxide

b. Calcium hypochlorite

Check Your Knowledge

- What is the chemical name for lime?
  a. Sodium Carbonate
  b. Calcium Carbonate
  c. Calcium Hydroxide
  d. Sodium Hydroxide

c. Calcium Hydroxide

Chemical Feed Systems

Chemical Feed Systems at Small Water Systems

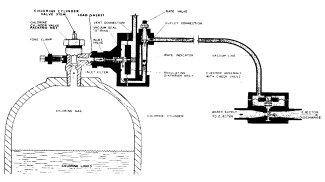
Gas Feed Systems

- Liquid Chemical Feed Systems
- Dry Chemical Feed Systems

Chlorine Gas

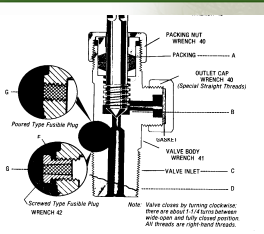
Typical 150lb. chlorine set-up

Simple vacuum controlled chlorinator



Cylinder valves are a common area for leaks.

Fusible plugs melt at 158 – 165 degrees F



TYPICAL VALVE LEAKS OCCUR THROUGH . . .

A - VALVE PACKING GLAND	E - VALVE BLOWN OUT*
B - VALVE SEAT	F - FUSIBLE PLUG THREADS
C - VALVE INLET THREADS	G - FUSIBLE METAL OF PLUG
D - BROKEN OFF VALVE	H - VALVE STEM BLOWN OUT*

*Not shown on above drawing.

Fig. 7.20 Standard chlorine cylinder valve

Handling Chlorine Safely

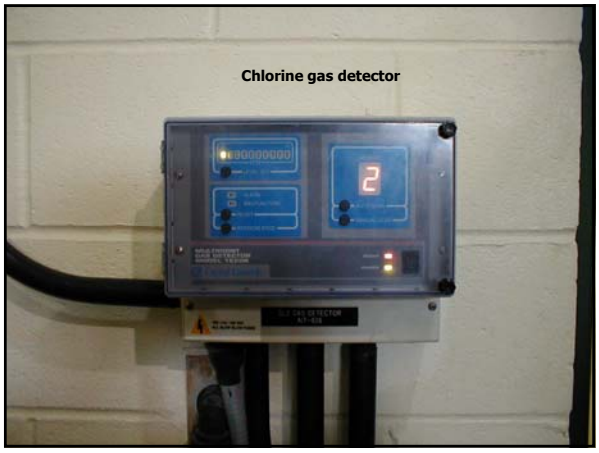
- Always treat it with respect
- Never work alone when changing cylinders
- Check for leaks using ammonia fumes
- Use only new lead washers when changing cylinders

Gas Cylinder

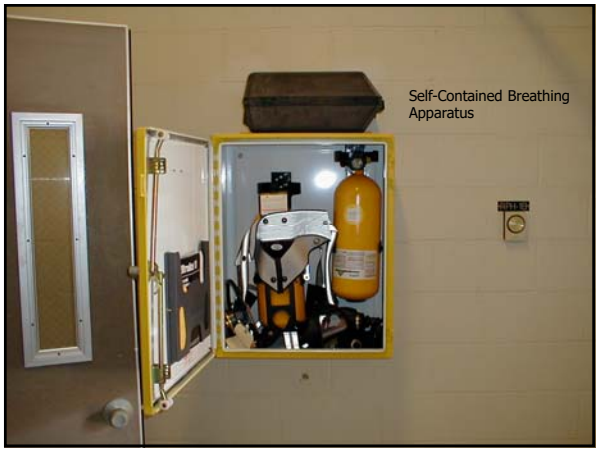
DO NOT:

- Store near heat systems or indirect sunlight
- Store below sub-surface areas
- Drop or store where heavy objects may fall
- Store empty & full cylinders together
- Store or move without hoods in pla

Always store full cylinders separate from empty cylinders



Chlorine gas detector



Gas Chlorination Systems

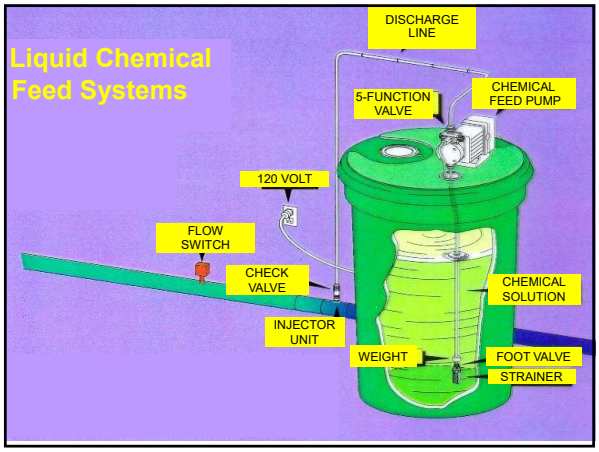
- Have alternatives to chlorine gas been considered?

Check Your Knowledge

- Fusible plugs on a chlorine cylinder melt at:
  a. 95-100 degrees F
  b. 180 -190 degrees F
  c. 158-165 degrees F
  d. 120-130 degrees F

c. 158-165

Liquid Chemical Feed Systems



Diaphragm-Type Metering Pump

Speed Control

Manual / Flow Pace Selector

Stroke Control

Peristaltic Pump

Dry Chemical Feed Systems

Calcium Hypochlorite Tablet Feeder

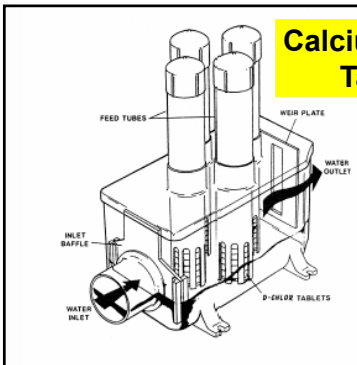
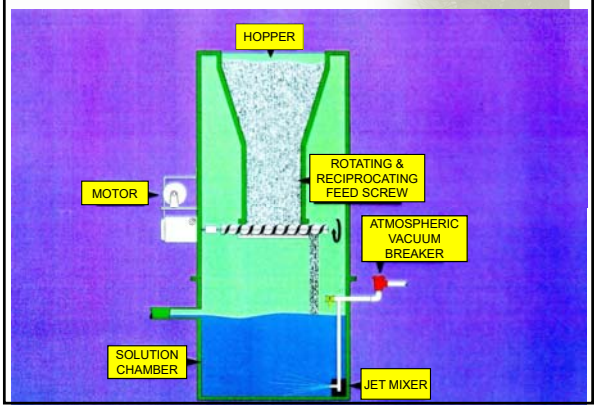


Fig. 10.22 Tablet dechlorination unit
(Permission of ELTECH International Corporation)

Calcium Hypochlorite Feed System

Volumetric Dry Chemical Feeder



Treatment Basics

Treatment Processes

Disinfection
- Corrosion / Scaling Control
- Iron & Manganese Removal
- Organics Removal
- Arsenic Removal

Disinfection

Disinfection !

The one process that we can't do without.

Gastroenteritis
Typhoid
Dysentery
Cholera
Hepatitis

Fecal Coliform is a specific type of organism that comes from the intestines of warm-blooded animals.

Coliform Bacteria is tested for by the presence or absence method….

Important Terms

Dosage : The amount of chlorine added mg/l or ppm

Demand : The amount of chlorine required to react with the organic and inorganic substances.

Residual : Dose (-) Demand = Residual

The amount remaining after contact time.

Free Residual : Exists as Hypochlorous acid or hypochlorite

Combined Residual : Chlorine which has combined with ammonia to form Chloramines.

Total Residual : Is the sum of free and combined residual

Factors Influencing Disinfection

- pH
- Temperature
- Turbidity
- Organic Matter
- Inorganic Matter
- Reducing Agents
  - Soluble iron & manganese
  - Nitrite
  - Hydrogen sulfide
- Microorganisms

Water Temperature

High : Rapid reaction of chlorine with water

Low : Slow reaction of chlorine with water.

C x T

C : Dose CONCENTRATION of chlorine

T : TIME chlorine is in contact with the water between the application point and first customer.

- Has long been a factor when treating surface water
- Now applies under the

Disinfection Operational Considerations

- Follow your "approved" coliform sample site plan
- Measure FREE & TOTAL residual using DPD method at…
  - Point of application
  - Representative sites **throughout** distribution system
- Maintain AT LEAST a trace residual at all points in the system.
- DO NOT exceed MCL of 4 mg/L

Disinfection Operational Considerations (cont)

- Test Temperature and pH
- Ensure there are no interruptions in disinfection
- Size chemical feeders and/or dilute chemicals so there is capacity available to increase dose
- Prepare and follow written procedures
- Flush dead-ends where needed to maintain disinfectant residual
- Keep good records

Check Your Knowledge

- Is disinfection the same as sterilization?
  a. True
  b. False

b. False

Check Your Knowledge

- Free chlorine residual exists in what two forms:
  a. Dose & Demand
  b. Organic & Inorganic
  c. Mono & Di Chloramines
  d. Hypochlorous Acid & Hypochlorite

d. Hypochlorous acid & hypochlorite

Check Your Knowledge

- Dose - _____ = residual
  a. Concentration
  b. Monochloramine
  c. Demand
  d. pH

c. Demand

Check Your Knowledge

- What happens to the disinfection process in warmer water?
  a. Remains the same
  b. Process is faster
  c. Process is slower

b. Process is faster

Check Your Knowledge

- How do we know if the disinfection process is working?
  a. UV disinfection at every home
  b. Turbidity reduction
  c. Coliform testing
  d. Voc testing

c. Coliform testing

Check Your Knowledge

- The coliform bacteria is best tested using what method:
  a. DPD
  b. Presence/Absence
  c. Atomic absorption
  d. Conductivity

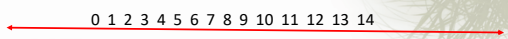
b. Presence/Absence

Corrosion / Scaling Control

Stabilization…

- Controlling of damaging corrosion or deposit scaling on pipelines due to source water

pH Scale



Acid (N) Base

Why Corrosion and Scaling Control?

- Protect public health
- Improve water quality
- Extend life of plumbing equipment
- Meet state and federal regulations

Protecting Public Health…

- Corrosion can raise toxic metal levels in the water
  - example - lead and copper
- Corrosion can cause tubercles
  - Tubercles can protect bacteria from disinfection

Water Quality…

- **Taste** - Metallic taste from corrosion of copper
- **Odor** - Dissolved iron from corrosion acts as a food source for iron bacteria which can cause taste and odor problems
- **Color** - Corrosion can cause stains such as red, blue or green

Plumbing Equipment Longevity…

- Scaling of boilers can reduce the life span of the boiler

Meeting Regulations…

- Meeting Lead and Copper regulations enacted in 1991
- Corrosion control when levels reach Action Levels

Water…
Causes Corrosion to Almost Any Metals

- Factors
  - Type of material
  - Chemical and biological characteristics
  - Electrical characteristics

Factors Effecting Corrosion…

- Dissolved oxygen
- Total dissolved solids
- Alkalinity and pH.
- Temperature
- Flow velocity
- Type of metal
- Electrical current
- Bacteria

TABLE 9-2 Galvanic series for metals used in water systems

Corroded End (Anode)	MOST ACTIVE
Magnesium	+
Magnesium alloys	
Zinc	
Aluminum	
Cadmium	
Mild steel	
Wrought (black) iron	
Cast iron	
Lead–tin solders	
Lead	
Tin	
Brass	
Copper	
Stainless steel	−
Protected End (Cathode)	**LEAST ACTIVE**

Corrosion Potential

Scale Formation…

- Small amount of scale on the inside of pipes can protect against corrosion
- Too much scale can reduce the carrying capacity of pipe or system

Creating a Protective Barrier Against Corrosion

- Raising the pH just above the saturation point will allow a thin layer of calcium carbonate to deposit onto the pipes surface where corrosion occurs

Methods to Control Corrosion

- Adjustment of pH and alkalinity
- Formation of calcium carbonate coating
- Use of corrosion inhibitors

Chemicals Used to Prevent Corrosion…

- Calcium Hydroxide….(lime)
- Calcium Oxide…….(quicklime)
- Sodium Hydroxide…..(caustic soda)
- Sodium Carbonate……(soda ash)
- Sodium Bicarbonate….(baking soda)
- Phosphates

Methods to Control Scaling

- Lime / Soda Ash Softening
  - Precipitation of Calcium & Magnesium by increasing pH to above saturation point, then stabilizing with CO_2
- Sequestering Agents
- Ion Exchange Softening

Chemicals Used to Prevent Scaling…

- Carbon Dioxide
- Sulfuric Acid
- Phosphates

Selecting a Method Depends on…

- Source water characteristics
- Number of sources
- Hydraulics
- Flow patterns

What is Hard Water?

- Water having high concentrations of calcium and magnesium ions

0-60 mg/l $CaCO_3$ – Soft Water
61-120 mg/l $CaCO_3$ – Moderately Hard Water
121-180 mg/l $CaCO_3$ – Hard Water
>180 mg/l $CaCO_3$ – Very Hard Water

Distribution Conditions Holds Many Clues…

- Records of main breaks and leaks
- Operation of older valves
- Reduced flow rates in system

Customers Can Help…

- Plumbers can tell you about conditions and problems with home plumbing caused by scaling and corrosion
- Pressure reduction
- Red water complaints
- Staining of plumbing fixtures

Water Quality Data Needed…

- pH.
- Alkalinity
- Conductivity
- Temperature
- Hardness

Compare Raw Water to Finished Water…

- If finished water has contaminants that the raw doesn't have, then the finished water is most likely corrosive

Coupon Testing…

- Installed in water mains to determine the corrosion or scaling rate of the water
- Provides long term information

Coupons after they have been cleaned.

Side Effects with Other Treatment Process…

- Corrosion control chemicals containing sodium may exceed sodium standards in the drinking water system
- Reaction with other minerals to create an undesirable deposit on pipe walls

Side Effects with Other Treatment Process… (cont)

- Increase in pH may make it harder to meet C x T disinfection values
- Phosphate corrosion inhibitors can cause biofilm development in the distribution system
  - Must monitor Ortho-P and Chlorine Residual

Check Your Knowledge

- Controlling of damaging corrosion or deposit scaling on pipelines is called:
  a. Coagulation
  b. Stabilization
  c. Galvanic
  d. Electro dialysis

b. Stabilization

Check Your Knowledge

- Corrosion can raise what toxic metal levels in the water?
  a. Lead
  b. Calcium
  c. Copper
  d. Both a and c

d. Both a and c

Check Your Knowledge

- The scale thickness on the interior of a pipe should be no more than:
  a. Human hair
  b. Egg shell
  c. Orange peel
  d. Watermelon rind

b. Egg shell

Check Your Knowledge

- How much more flow can you get from a pipe that is twice the size of another?
  a. Same flow
  b. 2x
  c. 4x
  d. 8x

c. 4x

Check Your Knowledge

- If a coupon is installed on January 1st and it weighs 3 oz., and it is removed July 1st and it weighs 3.4 oz., what is the system doing?
  a. Scaling
  b. Disinfecting properly
  c. Corroding
  d. Reducing the flow

a. Scaling

Check Your Knowledge

- What does pH mean?
  a. Presence/Absence
  b. Agglomeration
  c. Scaling or corroding potential
  d. Power of the hydrogen ion

d. Power of the hydrogen ion

Check Your Knowledge

- What does alkalinity mean?
  a. Ability of water to neutralize acids
  b. Ability to disinfect
  c. Ability to remove pathogens
  d. Ability meet system demands

a. Ability of water to neutralize acids

Iron & Manganese Removal

Regulatory Issues

- SDWA identifies Fe and Mn as secondary contaminants.
- Effect aesthetics of water as opposed to primary contaminants which are associated with health risks.
- Secondary limits.
  - Fe limit is 0.3mg/l.
  - Mn limit is 0.05mg/l.

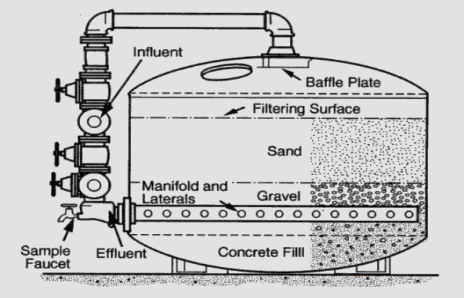
The Problem with Iron

- Iron exists in groundwater in ferrous iron and is in the soluble form (Fe^{2+})
- When soluble iron comes into contact with oxygen (or oxidizing compound), insoluble precipitate (ferric iron) is formed (Fe^{3+})
- Ferric iron stains plumbing fixtures, laundry, etc.
- Iron supports the growth of iron reducing bacteria which causes a biofilm (slime) to form inside pipes.
- Also, iron can cause encrustation inside water mains

Iron and Manganese Removal

- Iron and manganese in surface water and ground water
- Treatment Processes
  - Oxidation and filtration
  - Oxidation, clarification, and filtration
  - Manganese greensand filtration
  - Ion exchange
  - Sequestering

Pressure Filters



Pressure Operated Filter

Figure 6-37

The Filtration Process

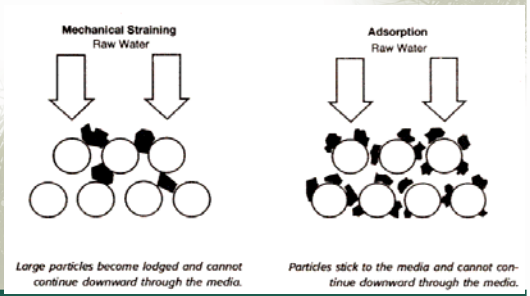


Figure 6-1

Check Your Knowledge

- Aeration is best described as:
  a. Process used to remove dissolved gases
  b. Process used to mix the water to keep elements in suspension
  c. Process to change solids from a into a dissolved form from a suspended form so they can be removed
  d. Process to remove microorganisms

a. Process used to remove dissolved gases

Check Your Knowledge

- A filter should be backwashed when it has a high….
  a. Solids loading
  b. Head loss
  c. Chlorine dosage
  d. Influent turbidity

b. Head loss

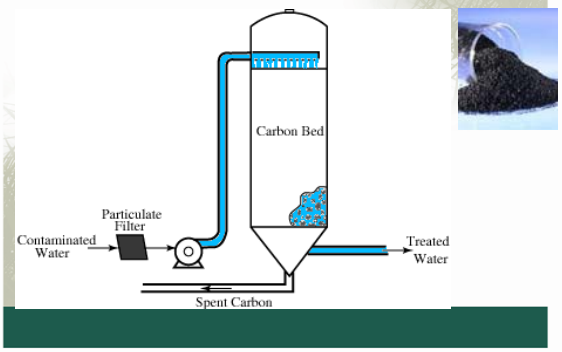
Organics Removal

Organics Removal– Carbon Adsorption

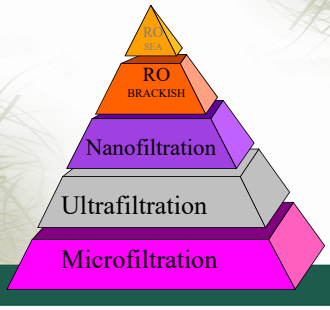
Carbon adsorption methods

- Powdered activated carbon
- Granular activated carbon

GAC Contactor



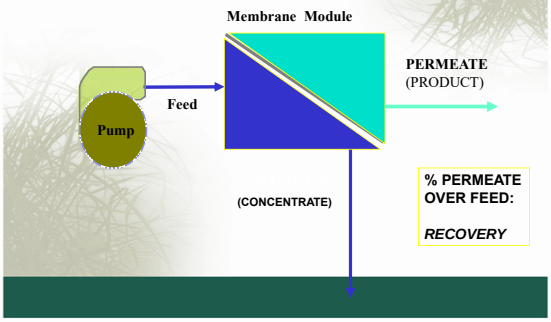
Membrane Filtration Processes



WHAT IS MEMBRANE ?

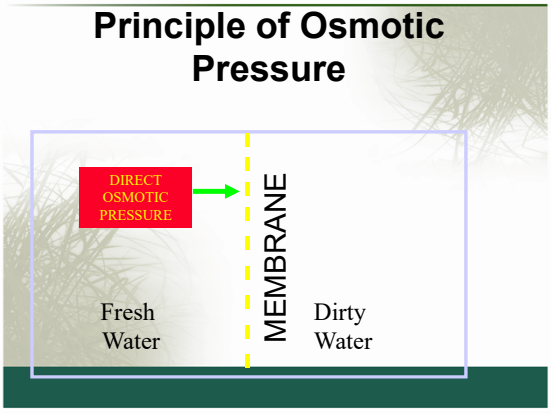
- IT IS A SEMI-PERMEABLE THIN LAYER OF MATERIAL CAPABLE OF SEPARATING CONTAMINANTS AS A FUNCTION OF THEIR PHYSICAL / CHEMICAL PROPERTIES
- DESPITE VARIATIONS IN CONFIGURATIONS AND TYPES, THEY ARE ALL PRESSURE DRIVEN EXCEPT EDR WHICH IS ELECTRICAL POTENTIAL DRIVEN

SIMPLIFIED SCHEMATIC



Membrane Filtration Plant

Principle of Osmotic Pressure



Check Your Knowledge

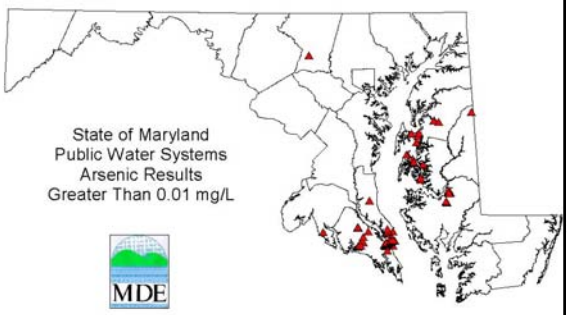
- Which one best defines “adsorption”
  a. Assimilation of one substance into the body of another by molecular or chemical action
  b. Adhesion of a gas, liquid, or dissolved substance onto the surface or interface zone of another substance
  c. Converting small particles of suspended solids into larger particles by use of chemicals
  d. Chemical complexing of metallic cations with certain inorganic compounds

b. Adhesion of a gas, liquid, or dissolved substance onto the surface or interface zone of another substance

Arsenic Removal

Regulatory Issues

- SDWA identifies Arsenic as a Primary Contaminant
- Chronic health effects
- MCL
  – 10 parts per billion (0.01 mg/L)



Arsenic Removal Processes

- Ion Exchange
- Reverse Osmosis / Nanofiltration
- Lime Softening
- Oxidation / Filtration
  - Conversion of As (III) to As (V)
  - Conventional Fe / Mn treatment systems are effective
  - Activated Alumina for coagulation

Final Questions