

Transient, Non-Community Drinking Water Systems Training Class



Water Treatment Technologies for Chemical Contaminants

**Prepared by
Bureau of Reclamation,
Denver Federal Center**

**Prepared for
Bureau of Land Management
May 20, 1999**

Who is the Bureau of Reclamation



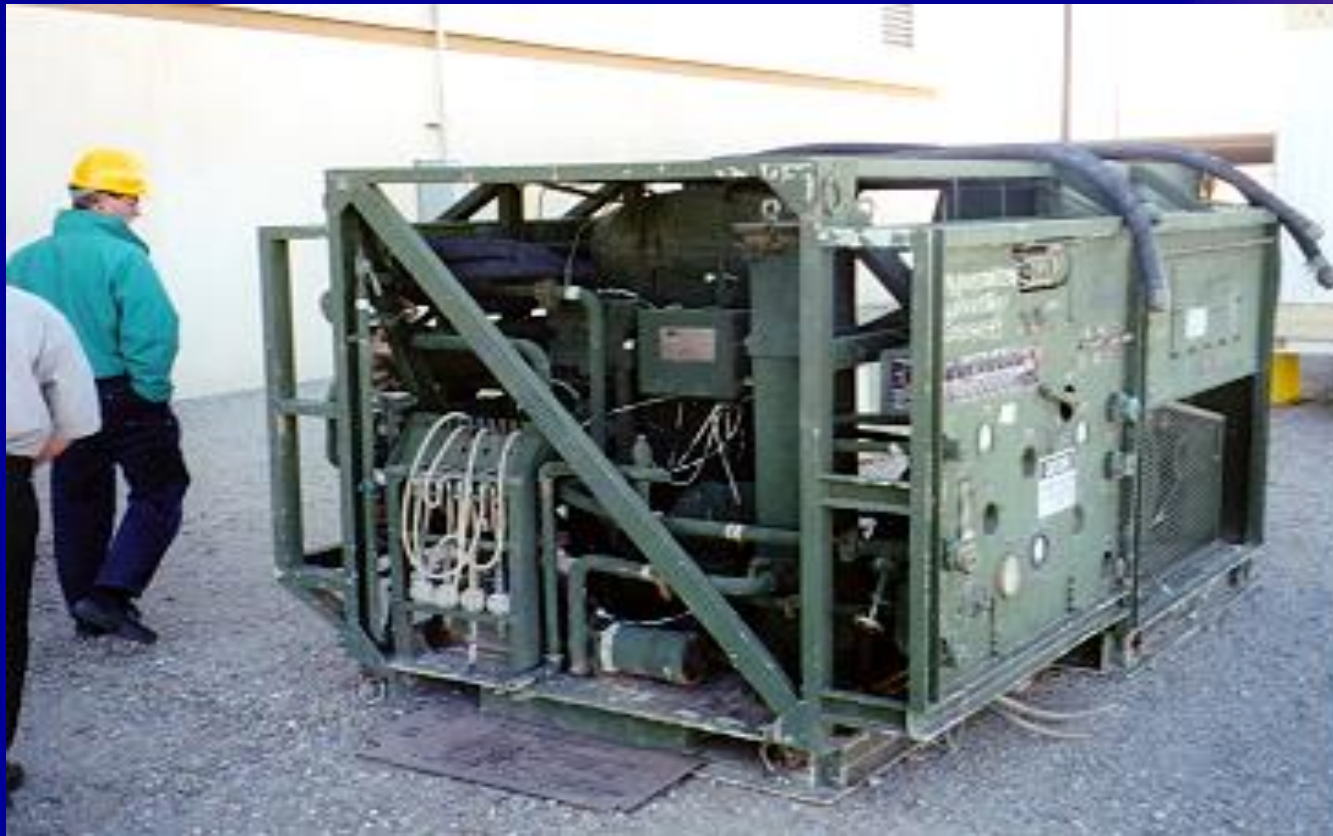
- (A bunch of dam engineers)
- Provider of Technical services to Tribes, State and Federal Agencies
- Not a Regulatory Agency
- Protector of Indian Trust Assets

World's Largest Desalting Plant

Yuma, Arizona



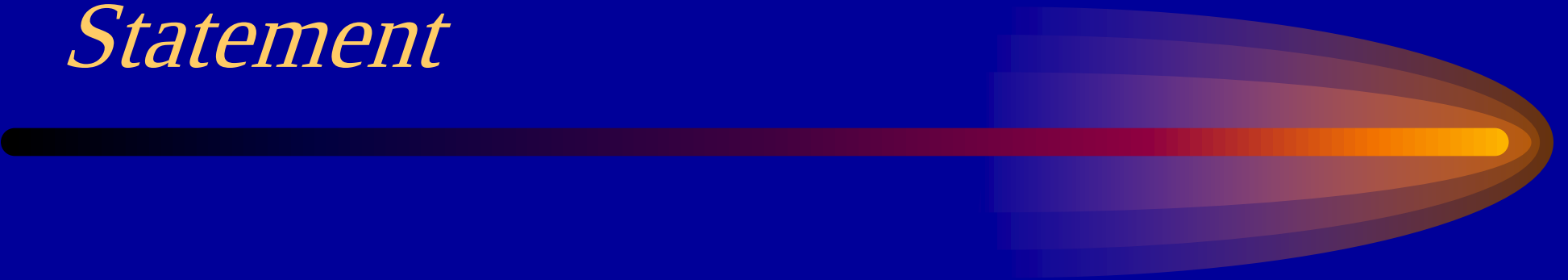
ROWPU's for Small Communities



Groundwater Remediation using Ion Exchange, Odessa Texas



Bureau of Reclamation's Mission Statement



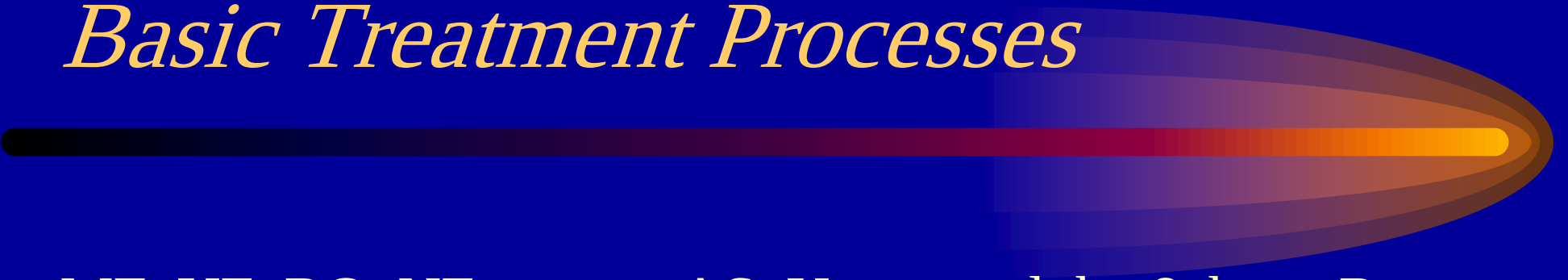
To manage, develop and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

TSC Organization



- Located at DFC, employs 685 FTE'S
- Directory of engineers and technical staff
- Service oriented to BOR facilities, EPA (Superfund), FEMA (Emergency disaster response), Tribes, and others
- Cost estimators provide official BOR estimates

Basic Treatment Processes



MF, UF, RO, NF

AS, U, gross alpha & beta, Ra,
Zn, NO₃, Se

ED

NO₃, Se

Lime-Soda Precipitation

Se(+4 or+6), As, U, Ra

GAC

Radon, Hg, Cd, organics, THM's

Ion exchange-anion

NO₃, alkalinity

IX- mixed bed

gross beta

Basic Treatment Processes

(continued)



Ion exchange-cation

radium, Cu, Zn

Lime Softening

Cu, Pb, Hg, Cd, Zn,
alkalinity

Coag'n/floc'n w/ FeSO_4 &filtr'n

Se=,+4,+6, As

Coag'n/floc'n w/alum&filtr'n

Se=,+4,+6, Cd, Hg, Pb, Cu

Greensand Filter & KMnO_4

Fe and Mn

Activated Alumina

F, As, Se

Air Stripping

Radon, Organics

Distillation

Zn

Basic Treatment Processes

(continued)



TT1 Crypto/giardia, Turbidity

TT2 Turbidity

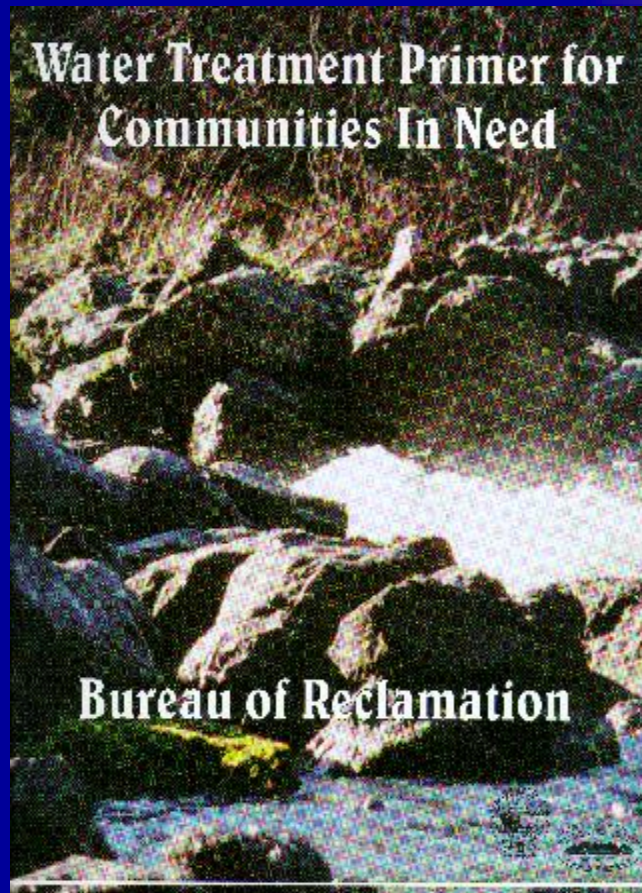
TT3 E-coli and Total Coliform, Turbidity

TT1= screening, rapid mix, polymer, alum, flocculation, clarification, dual media filtration, and chlorination

TT2= rapid mix, alum, flocculation, clarification, and filtration

TT3= Dual media filtration and chlorination

Water Treatment Primer



Contaminant Fact Sheets



Alkalinity

Arsenic

Copper

Cryptosporidium and Giardia Lamblia

Fluoride

Iron and Manganese

Lead

Mercury and Cadmium

Contaminant Fact Sheets

(Continued)



Nitrate

Organics

Radionuclides

Selenium

Total Coliform and E-Coli

Total Dissolved Solids

**Turbidity and Total Suspended
Solids**

Zinc

Primer Contents



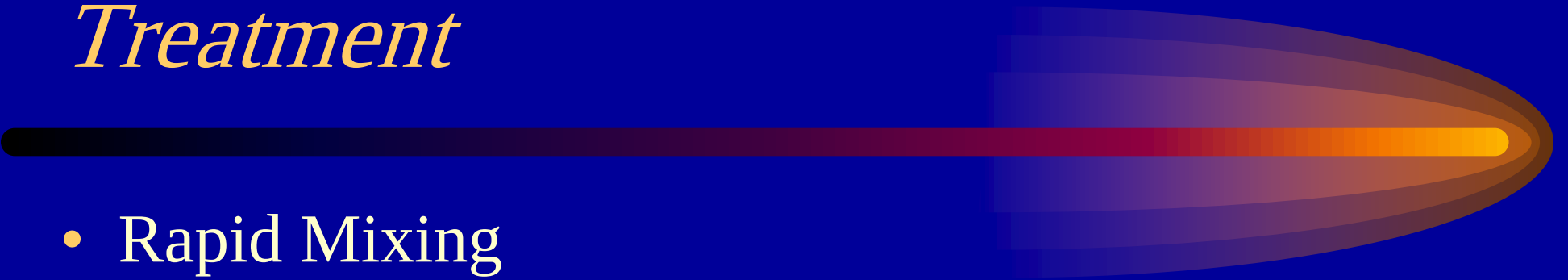
- Contaminant-Based Fact Sheets
- Most Removal Techniques Listed
- Process Descriptions and Cost Data for BAT
 - Description
 - Pretreatment
 - Maintenance
 - Advantages & Disadvantages
 - Construction and O& M Costs for 250,000 gpd

Primer (continued)

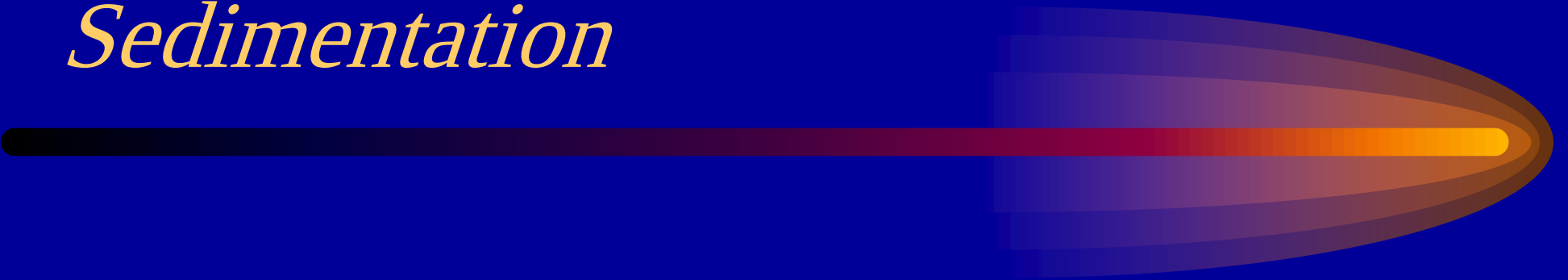


- Fact Sheet Costs are in November 1996 dollars
- Costs planned to be updated this year
- Contaminants to be completed this year:
 - chromium, thallium, nickel, cyanide,
 - beryllium, barium, asbestos, antimony
 - trihalomethanes and sulfates

Conventional Water Treatment

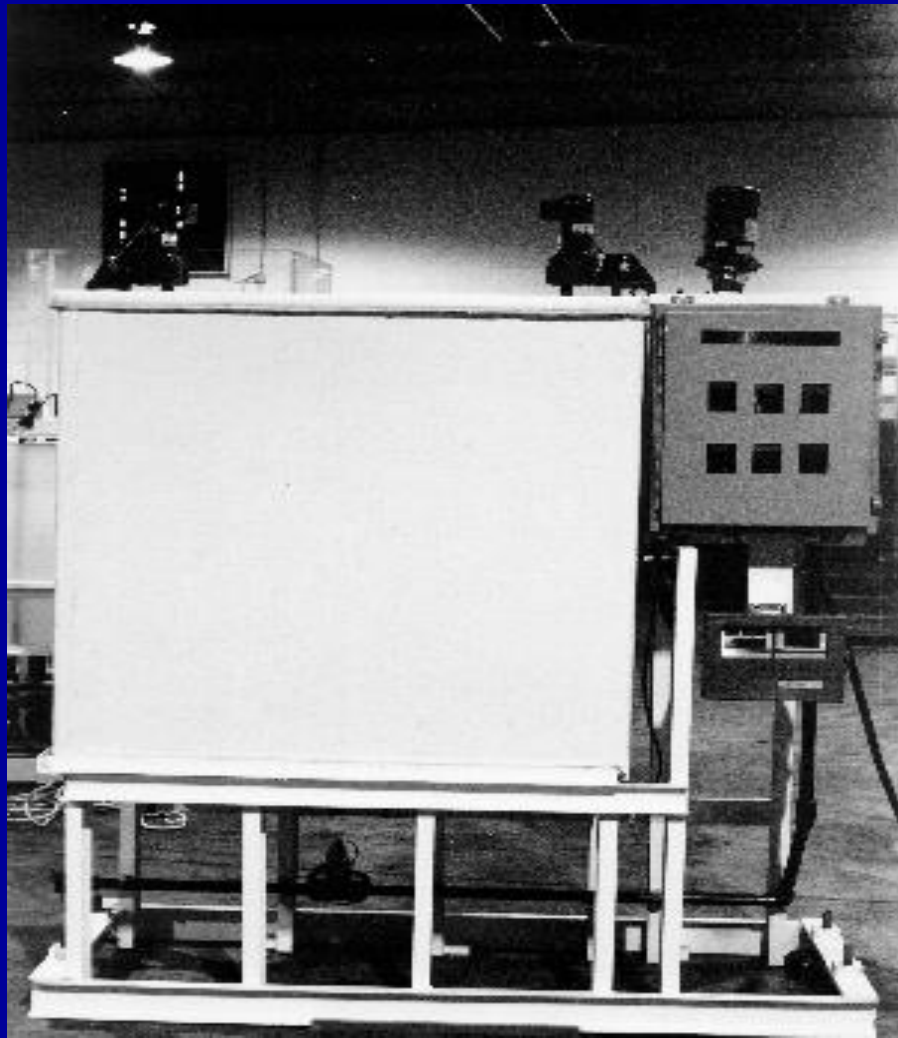
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- Rapid Mixing
 - Chemical Feed
 - Coagulation and Flocculation
 - Filtration
 - Disinfection

Mixing/Flocculation and Sedimentation

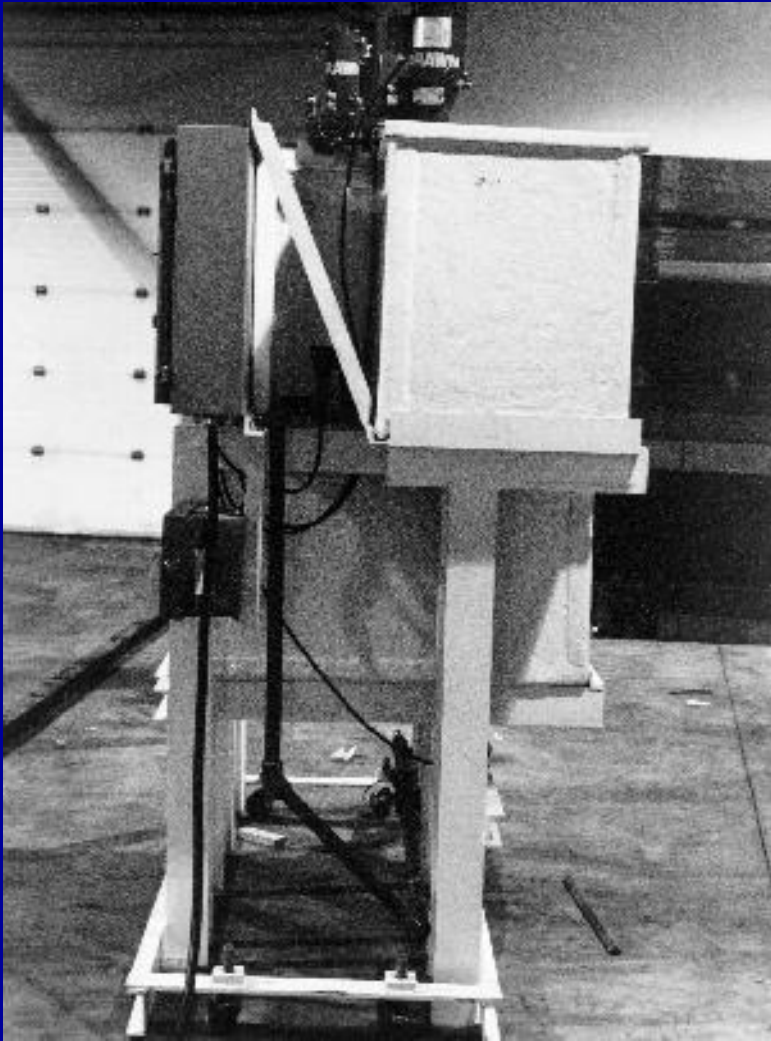


- Instantaneous mix of coagulants
- Neutralizes the negative charges on colloids
- During the gentle mixing of flocculation, allows particles to agglomerate into larger particles
- Heavier particles are removed by settling

Rapid Mix and Flocculation Tanks



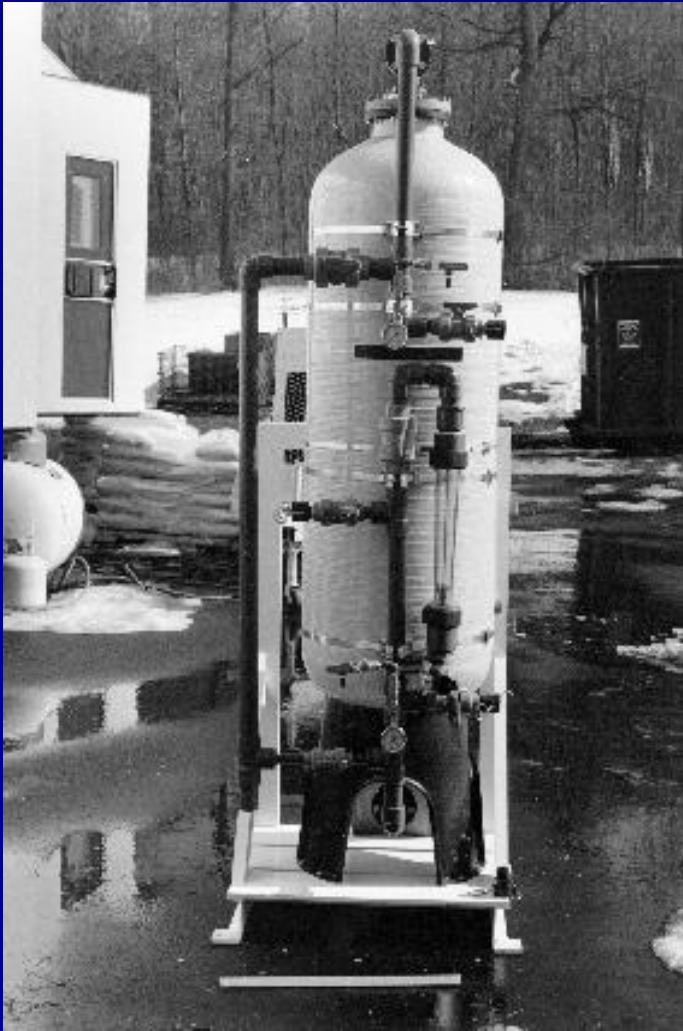
Rapid Mix and Flocculation Tanks



Clarifier



Pressure Clarifier



Filtration

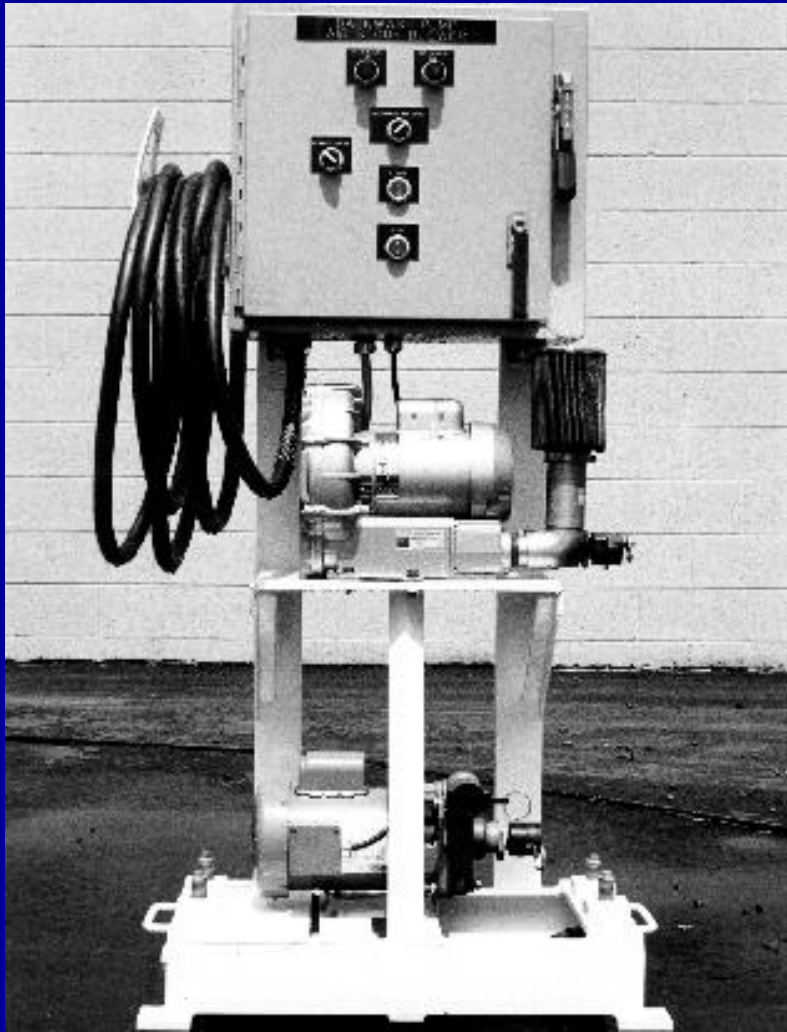


- May be mesh screens, cartridges with fibrous elements, or media (sand or carbon or both)
- Removes particles that are too small to be removed in sedimentation basins
- Carbon Filters
 - under-counter type or whole house

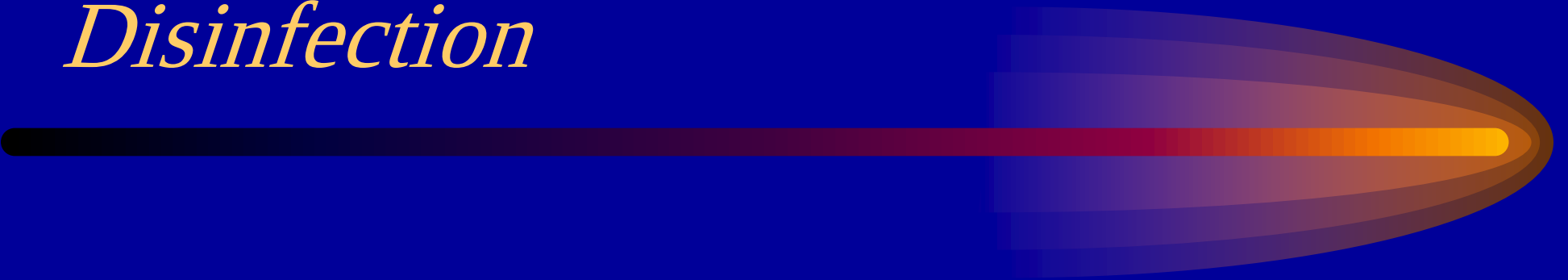
Pressure Filter



Filter's Blower and Backwash Pump



Disinfection



- Chlorine is most common method
 - Gaseous or tablet form
- May also be accomplished with :
 - Chlorine Dioxide
 - Chloramines
 - Mixed Oxidants
 - Ultra violet rays
 - Ozone

Performance Monitoring



- “Optimizing Water Treatment Plant Performance Using the Composite Correction Program”, A Handbook numbered EPA/625/6-91/027
- Pretreatment
 - Screens clog with moss or silt
 - variable raw water quality
 - potential upstream pollution
 - quantity limits
 - algae blooms or bacterial problems

Why Pre-treat?

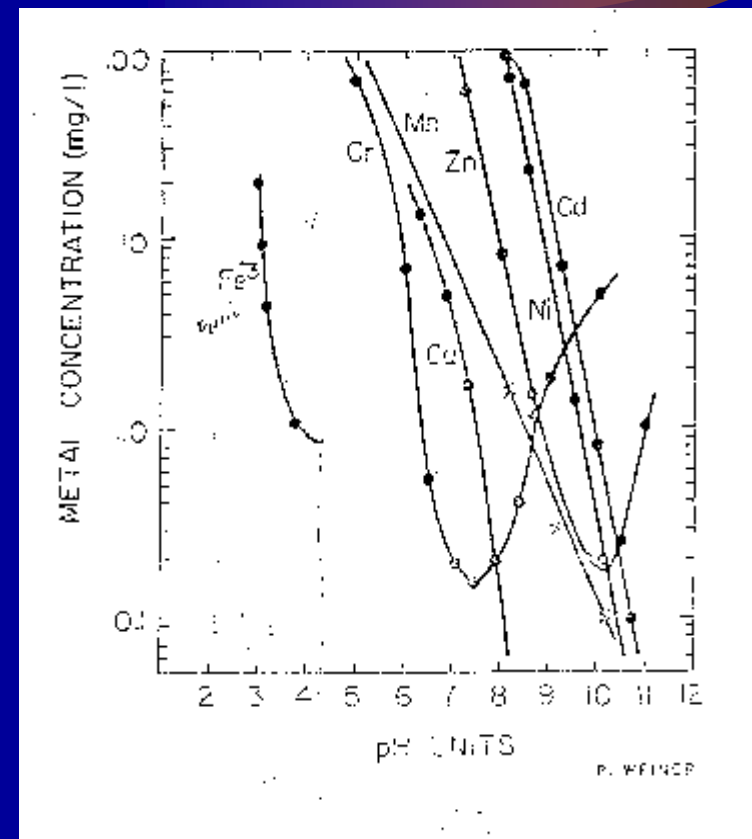
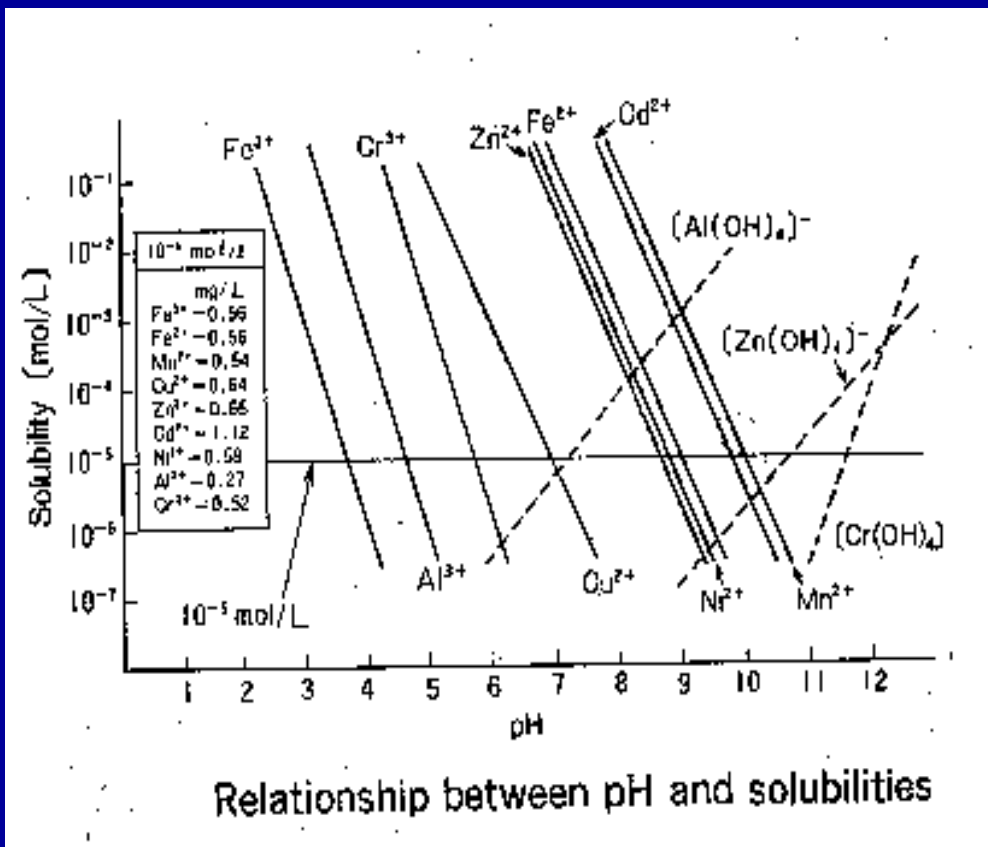


Performance Monitoring

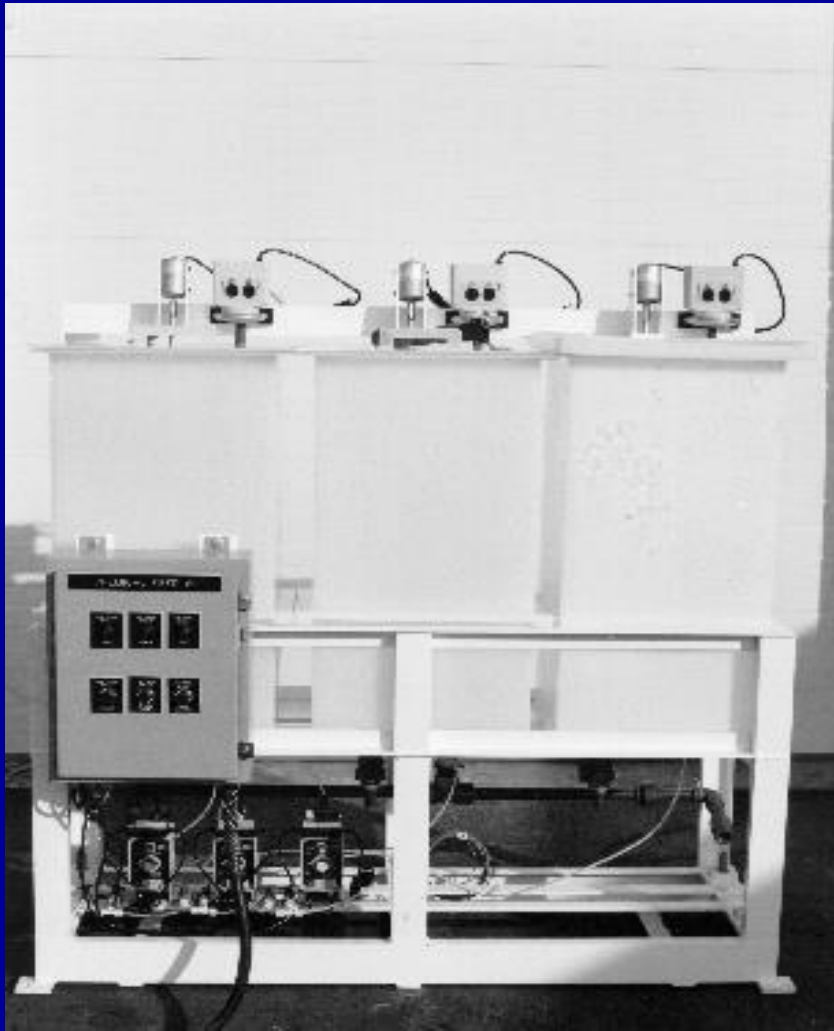


- Flow measurement is important to accurately establish chemical feed rates, wash water rates, and unit loadings
- Mixing needs to be adequate
- Chemical feed systems need dosage control
- Monitor pH for optimum conditions

Solubilities vs pH



Chemical Feed Skid



Chemical Feed Skid



Performance Monitoring, continued

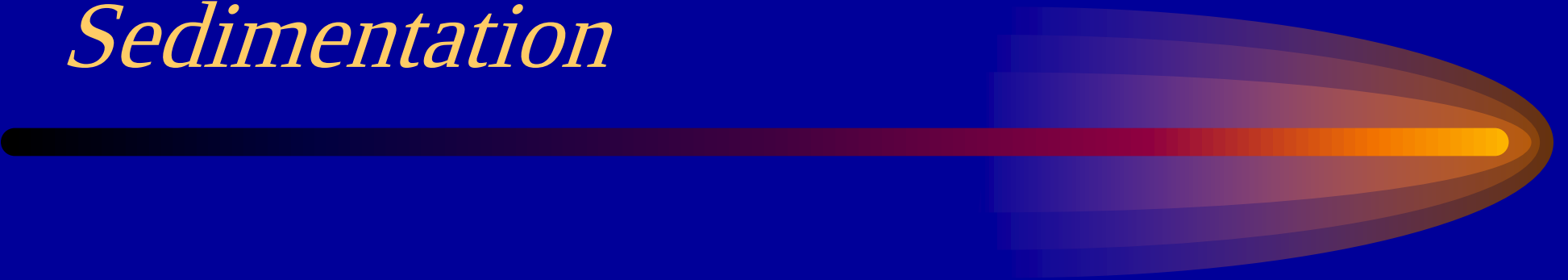
Flocculation



- Note inlet and outlet conditions
- Provide variable energy input
- Provide at least two-stage flocculation
- Baffles for even flow distribution; avoid velocity currents from disrupting settling conditions in adjacent settling tank
- Observe size of floc

Performance Monitoring, continued

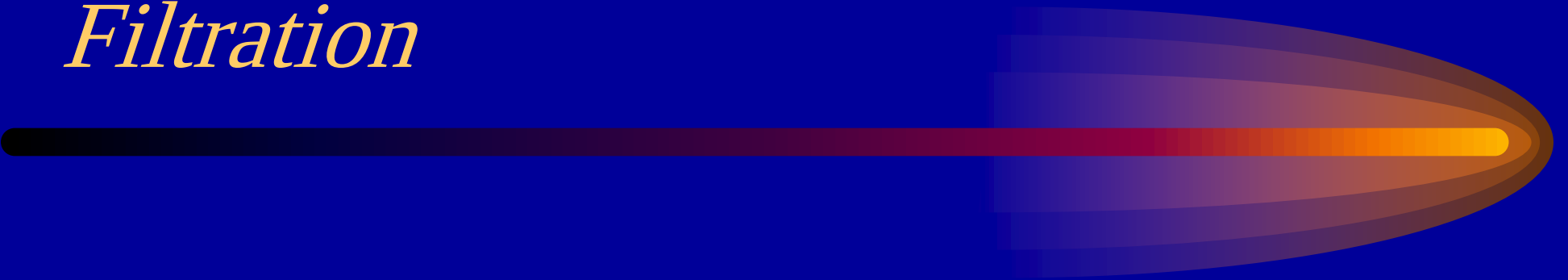
Sedimentation



- Observe clarity of settled water noting size and appearance of any suspended floc
- Avoid flow density currents by proper design of inlet and outlet pipes
- Note sludge removal mechanism

Performance Monitoring cont'd

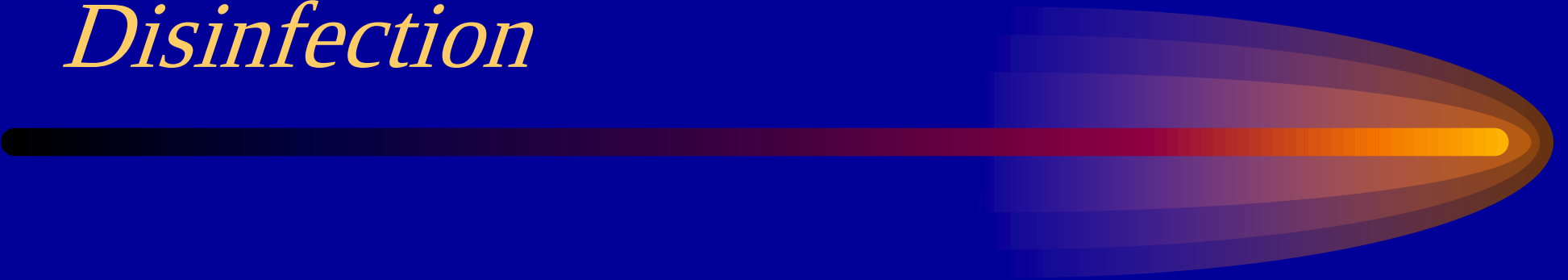
Filtration



- Regulate filter flow in an even consistent manner
- Provide backup backwash pump
- Note frequency of backwash
- Backwash on turbidity or headloss

Performance Monitoring continued

Disinfection



- Configuration and baffling of clearwell
- Proximity of “first user”
- Backup disinfection system
- Consider disinfection ahead of filter
- Flow paced system if flow varies

Performance Monitoring continued

Wastes and Their Disposal



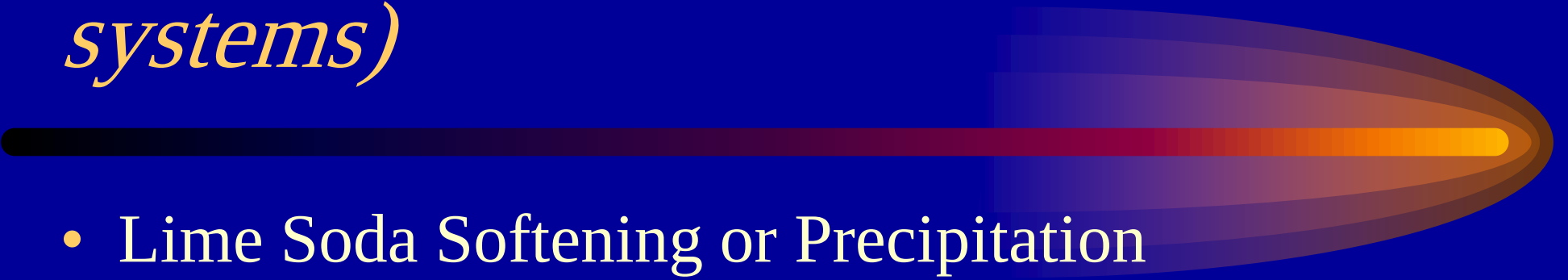
- Familiarize yourself with the filter backwash water and sedimentation tank sludge
- Is discharge permitted?
- Recycle of backwash water may return cysts

Performance Monitoring continued Laboratory and Maintenance



- Assess capability to perform process control tests such as pH, alkalinity, turbidity, etc.
- Maintenance requires tools, spare parts and storage
- Filing systems for equipment catalogs and records of plant operation, personnel, equipment condition and as-built drawings
- Preventative maintenance system recommended

TREATMENT (non-membrane systems)



- Lime Soda Softening or Precipitation
- Alum or Iron compound co-precipitation
- Ion Exchange
- Granular Activated Carbon
- Air Stripping

Advanced Water Treatment

(continued)



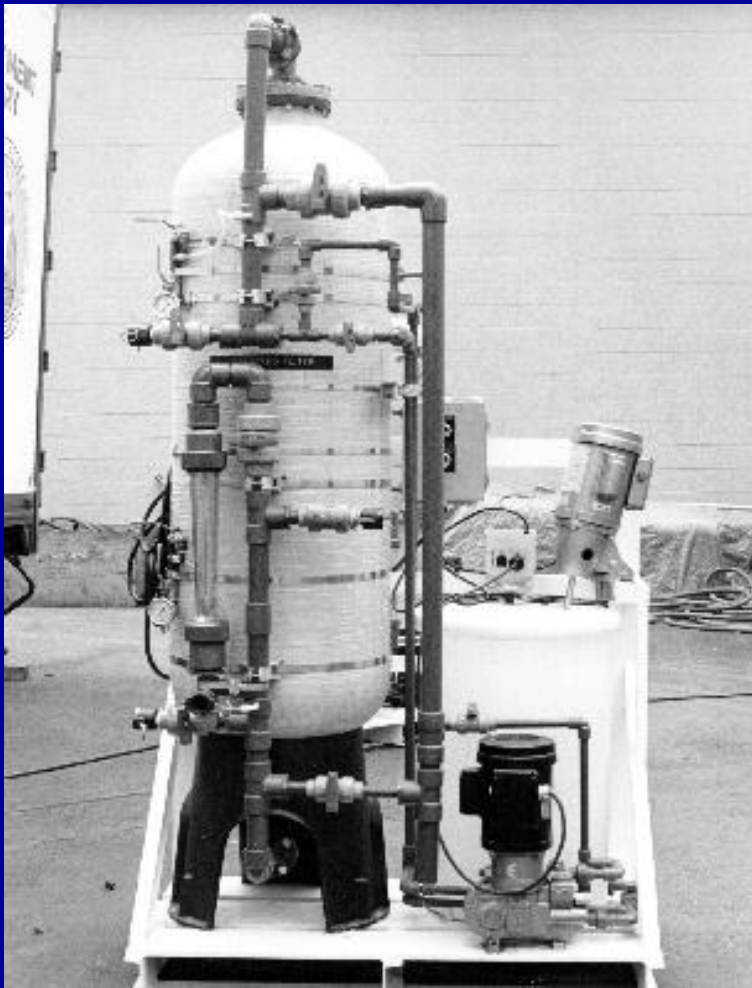
- Package Plants or Point of Use Units are available but not for all processes
- Lime Soda and Co-precipitation processes usually combined in an Upflow Solids Contact Reactor
- Combines rapid mix, flocculation, coagulation and sedimentation in one unit process

Advanced Water Treatment (continued)



- Physical-Chemical Processes
 - Granular Activated Carbon, Carbon Filters
 - Ion Exchange, Softeners
 - Air Stripping
 - Iron Filters, Greensand Media
 - Distillation

Manganese Greensand Filter (Iron and Manganese Removal)



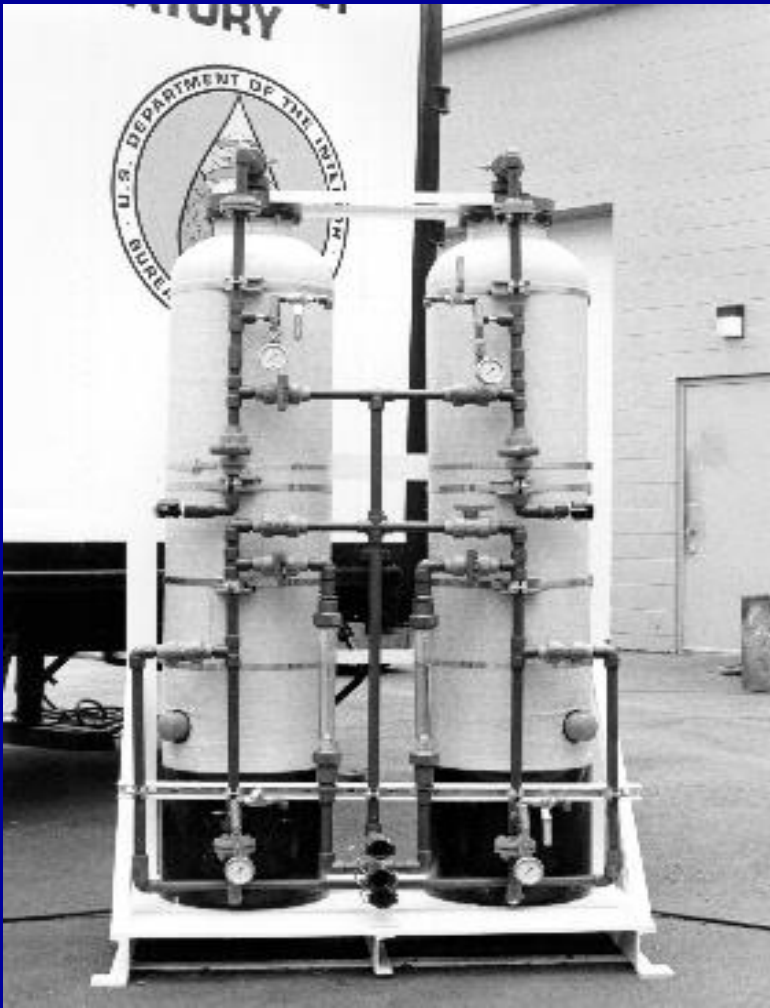
Advanced Water Treatment

(continued)



- Ion-Exchange (softeners)
 - ion-replacement due to chemical bond attraction affinity
 - if sodium enriched resin is used, sodium is added to the water
 - removes up to 10 ppm dissolved iron
 - oxidized iron or iron bacteria may clog the resin

Ion Exchange



Ion Exchange vessels for Chromium



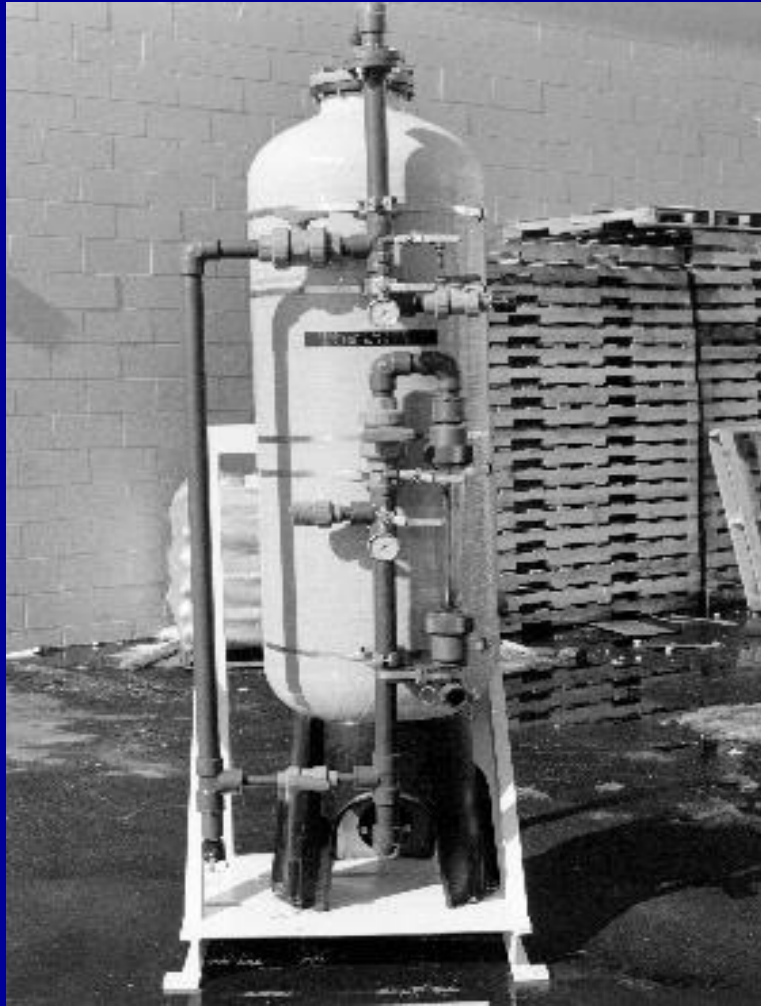
Advanced Water Treatment

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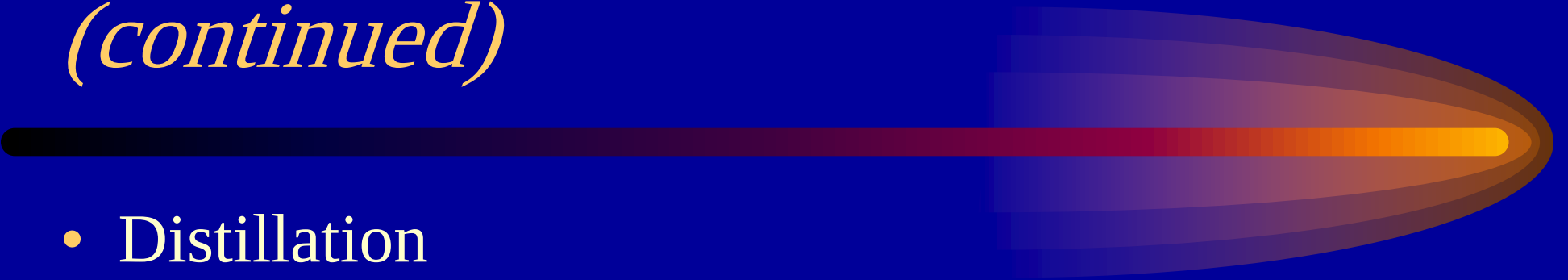
- Granular Activated Carbon
 - activated by heating the charcoal to provide additional surface area for adsorption
 - available as under the sink or whole house
 - removes some inorganics, chlorine, organics, THM's, pesticides, radon, and taste and odor
 - does not remove nitrates, bacteria, or dissolved minerals

Granular Activated Carbon



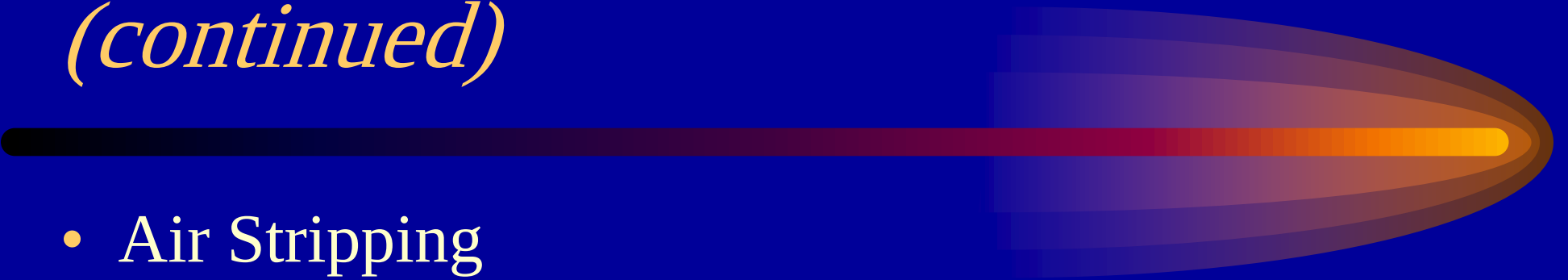
Advanced Water Treatment

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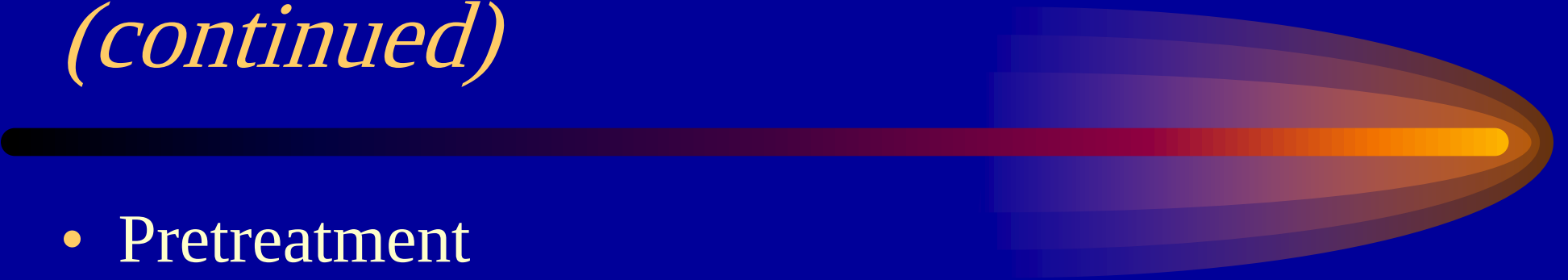
- Distillation
 - Process of boiling water; impurities are left behind; condenser using cooling coils to collect clean water
 - Good for nitrates, sodium, sulfates, most organics
 - Heat destroys bacteria
 - Sizes range from 1 quart /hr to 0.5 gal/hr.
 - Disadvantage of bland taste

Advanced Water Treatment *(continued)*



- Air Stripping
 - contaminants moved from the water phase to the vapor phase through volatilization
 - off-gas may require vapor phase carbon treatment
 - good removal for pesticides and volatile organics

Advanced Water Treatment *(continued)*



- Pretreatment
 - understanding the raw water quality
 - turbidity, pH, alkalinity, etc.
- Residuals
 - spent carbon or ion exchange resin, or air stripping media
 - hazardous or non-hazardous

Advanced Water Treatment Residuals



- If hazardous, special requirements for:
 - labeling
 - storing
 - transporting
 - approved disposal site (RCRA)
 - permitting

Advanced Water Treatment Residuals, continued



- Non-hazardous residuals
 - regenerate by others
 - lined ponds
 - no groundwater contamination
 - no discharge to septic tanks
 - obtain approval from Local Health Authority

Costs of Water Treatment

Total cost/1000 gallons



Package Plants Filtration

- Coagulation/Filtration with tube settlers \$1.73
- Pressure depth clarifier/Pressure filter \$1.90
- Pressure depth clarifier/Pressure
- Filter with GAC adsorber \$2.47

Costs of Water Treatment

Total cost/1000 gallons



Inorganic Contaminant Control

- High pressure reverse osmosis \$4.03
- Low pressure reverse osmosis \$3.40
- Cation exchange \$1.44
- Anion exchange \$1.46
- Activated alumina \$1.47

Costs of Water Treatment

Total cost/1000 gallons



Organic Contaminant Control

- GAC in pressure vessel

6-mo carbon replacement	\$1.92
12-mo carbon replacement	\$1.67
- Packed tower aerator \$0.45

Costs of Water Treatment



Relative Costs of Organic Removal

- From Lowest to Highest Cost
 - Air Stripping
 - Air Stripping w/Vapor Phase GAC
 - Oxidation +Air Stripping + VPGAC
 - 2 STAGE Air Stripping +VPGAC
 - Oxidation +LPGAC
 - Liquid Phase GAC

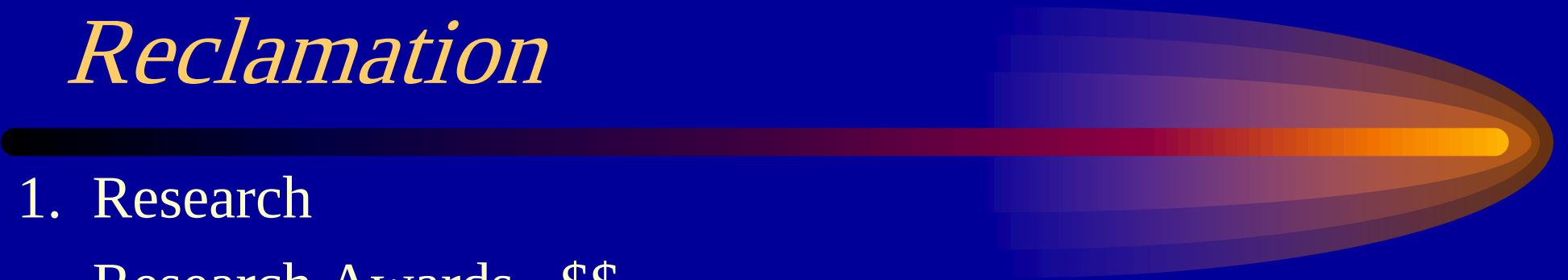
Costs of Water Treatment

Total cost/1000 gallons



- Disinfection
- Gas feed chlorination \$0.26
- Hypochlorite solution \$0.33
- Pellet feed chlorinators \$0.23
- Ultraviolet light (57,600 GPD) \$0.49
- Ozonation-high pressure^b \$0.53

Opportunities from the Bureau of Reclamation



1. Research

Research Awards \$\$

Water Treatment Primer

Mobile Pilot Water Treatment Plant

Water Quality Improvement Center

2. Technical Assistance

Needs Assessments

Design Services

Plant Operations and Maintenance Manuals



Technology Transfer



- Desalting and Water Treatment Membrane Manual
- Water Treatment Primer for Communities in Need
- DesalNet CD-ROM of abstracts for 785 OSW/OWRT reports, with AWWA, demonstration version
- Updating Desalting Handbook for Planners
- Newsletter three times a year
- 25 previous desal reports available

Technology Transfer

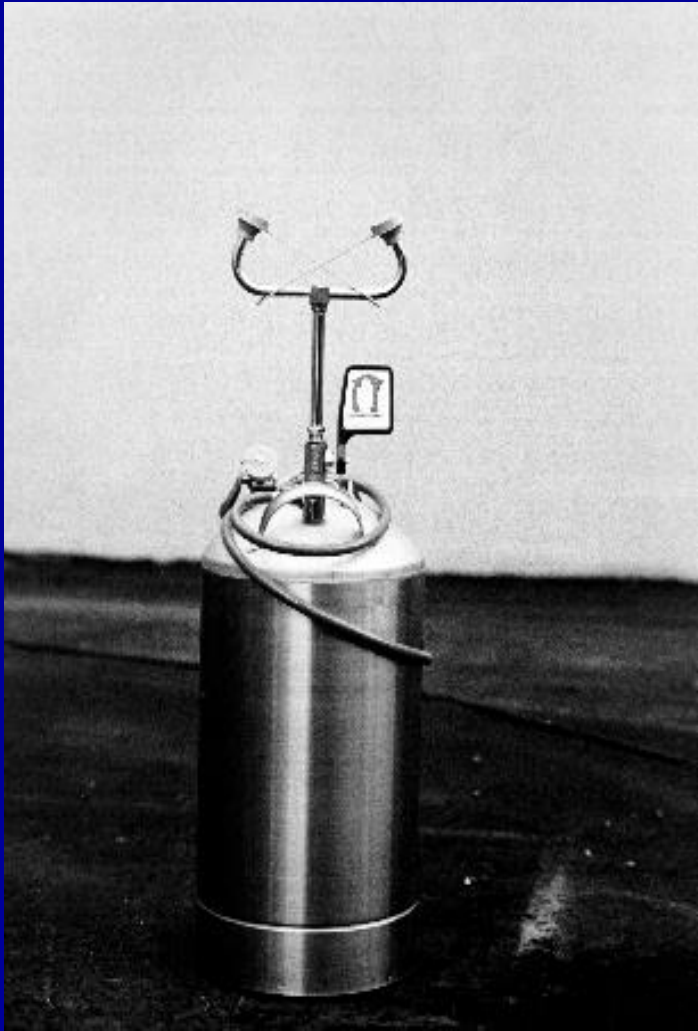


- Updated Internet homepage:
- www.usbr.gov/water/water.html
- www.usbr.gov/water/desalting.html
- Sponsoring technical conferences and workshops

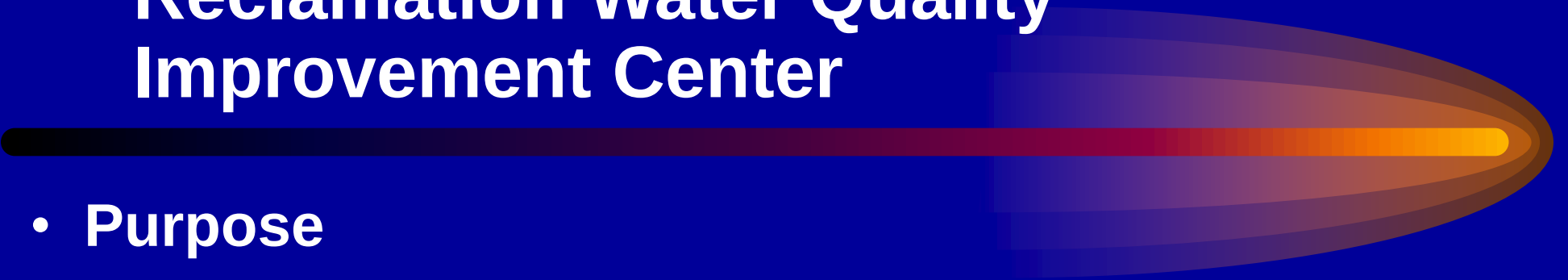
Mobile Water Treatment Pilot Plant



Eye Wash



Reclamation Water Quality Improvement Center

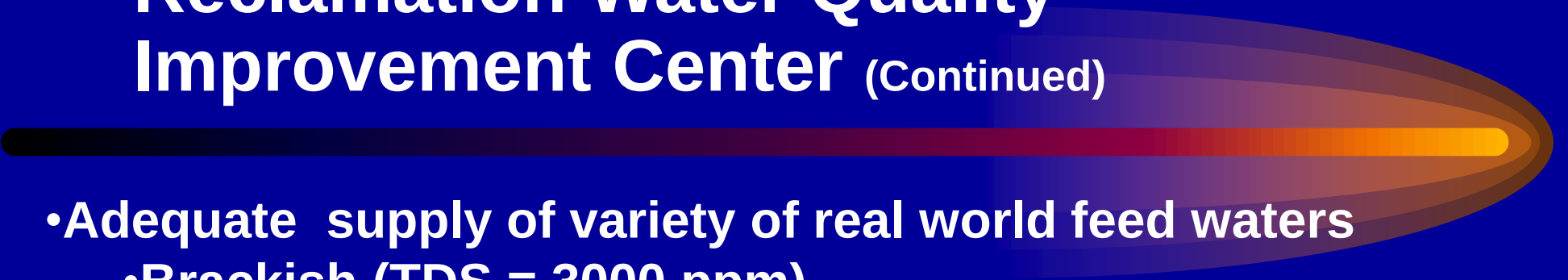


- **Purpose**
 - **To Provide a Cost Effective Pilot Testing Facility for Private Industry, Municipalities, Universities, Tribal Organizations, and U.S. and Foreign Governmental Agencies to Test Improved Water Treatment Technologies in the Field**
 - **Is Offered On a Cost-Shared or Cost-Reimbursed Basis**

Water Quality Improvement Center

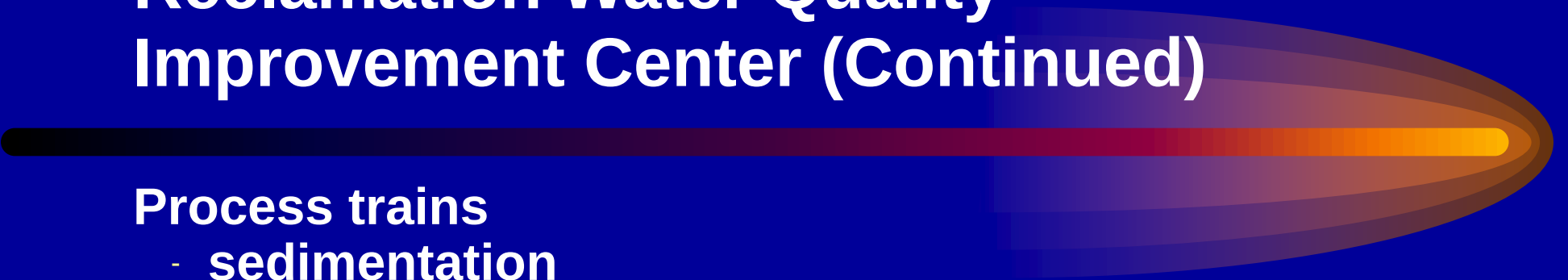


Reclamation Water Quality Improvement Center (Continued)



- Adequate supply of variety of real world feed waters
 - Brackish (TDS = 3000 ppm)
 - Colorado River & Well Water (TDS = 800ppm)
- Services
 - licensed operators
 - experienced engineering staff
 - on-site water quality lab
 - data access via internet
 - customized use agreements
 - permits in place
 - furnished office space
 - hands-on operator training

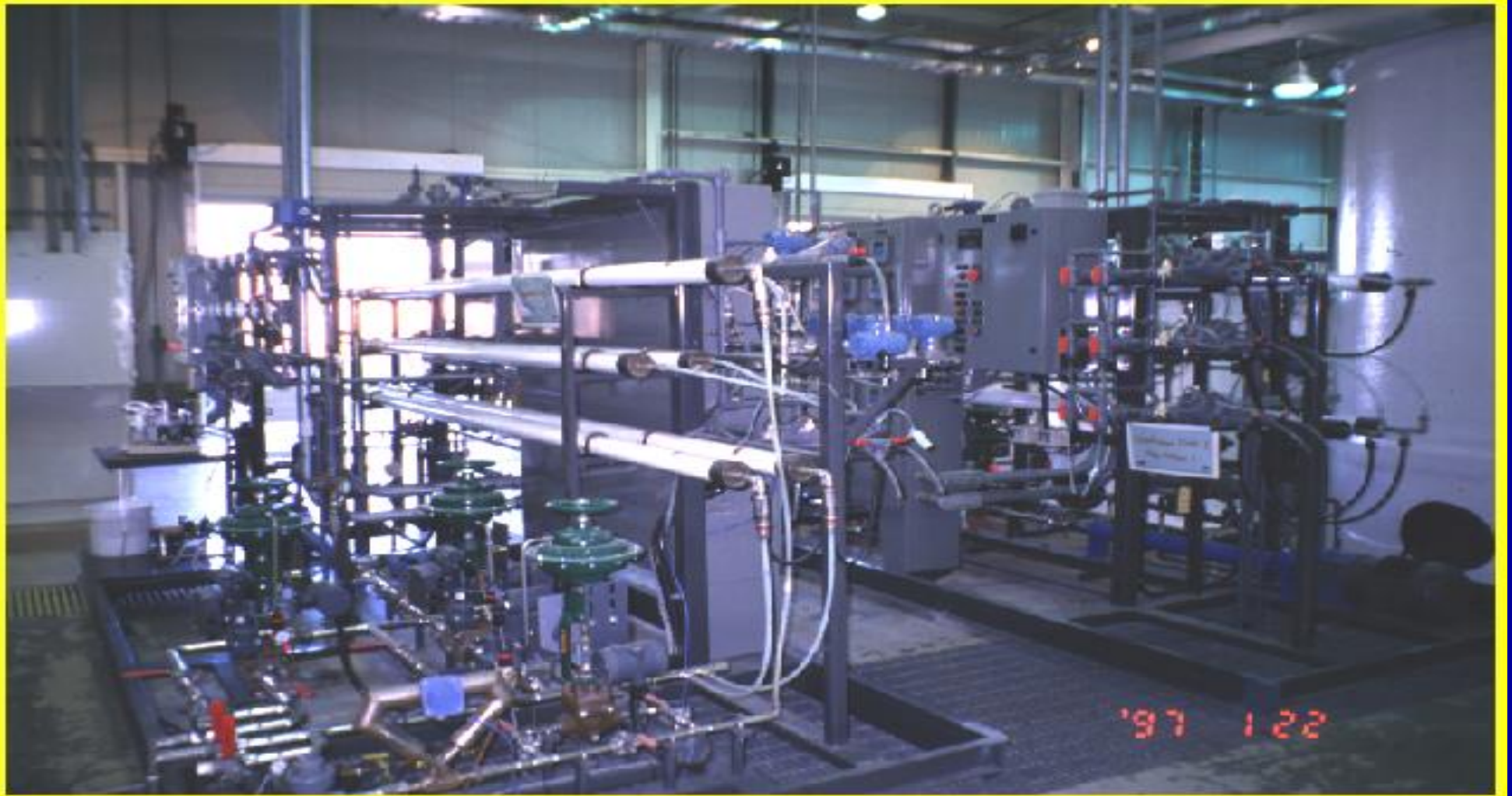
Reclamation Water Quality Improvement Center (Continued)



Process trains

- sedimentation
- lime softening
- chemical addition
- multi-media filtration
- microfiltration
- ultrafiltration
- nanofiltration
- reverse osmosis

Water Quality Improvement Center



Water Quality Improvement Center

