Design and Construction of a New Surface Water Infiltration Gallery, Membrane Microfiltration Treatment Plant and Storage Tank with Pump Station for the City of Fruitland, Idaho

Carl Hipwell, P.E.
Jordi Figueras, E.I.T.

May 6th, 2011

Reasons for this project

1) The City of Fruitland entered into a compliance agreement with the Idaho Department of Environmental Quality (IDEQ) in 2005 to meet the new arsenic drinking water standard mandated by the Environmental Protection Agency (EPA) of 10 µg/L. Arsenic concentration in the water supply ranged between 20 and 39 µg/L

2) The water system did not have enough capacity to supply the City's water demand during the summer months. The City water system included 11 wells producing 1,371 gpm (1.98 MGD)

Short Term Approach

Temporary Surface Water Treatment Plant

1. Pall ARIA Trailer

- A temporary surface water plant was installed to provide the additional flow required during the summer months.
- Process included:
  - I. Taste and odor control with PAC (powder activated carbon)
  - II. Coagulation with PACl (polyaluminum chloride)
  - III. Membrane Microfiltration – 0.1 µm
  - IV. Disinfection (NaOCl)
- Operated during the summers of 2006 through 2009

<u>Pall ARIA Mobile Microfiltration System</u>

- Capacity = 600 gpm
- 2 membrane racks (40 modules per rack)
- Filter area = 538 ft^2 per module
- Module capacity = 22,500 gpd
- 100 % redundancy

2. Temporary Surface Water Treatment Plant

Long Term Approach

- Several alternatives were evaluated to improve the quality of the City's water supply, meet the new arsenic standard, and increase system capacity. The selected alternative included:
  1) A new river water infiltration gallery with a pumping station.
  2) A new surface water treatment plant that includes coagulation, membrane microfiltration, granular activated carbon adsorption, and chlorine disinfection.
  3) A new 1.2 million gallon bolted steel storage tank with a pump station.
  4) Several water distribution improvements.

Project Structure

Packet #	Name	Construction period
1A	Washoe/Allen Ave. Distribution Improvements	January 2008 to April 2008
1B	Horizontal Directional Drill Allen Ave. and NW 16th Ave.	March 2008
2	East 1st Street Distribution Improvements	February 2008 to April 2008
4	Water Treatment Plant	December 2008 to May 2010
5A	Water Transmission Line	July 2008 to December 2008
5B	Water Reservoir and Pumping Station	September 2008 to April 2009
6A	Intake Horizontal Directional Drill	August 2008 to October 2008
6B	Payette River Water Intake Pump Station	September 2008 to June 2009
7	Water Main Upgrades	February 2010 to June 2010

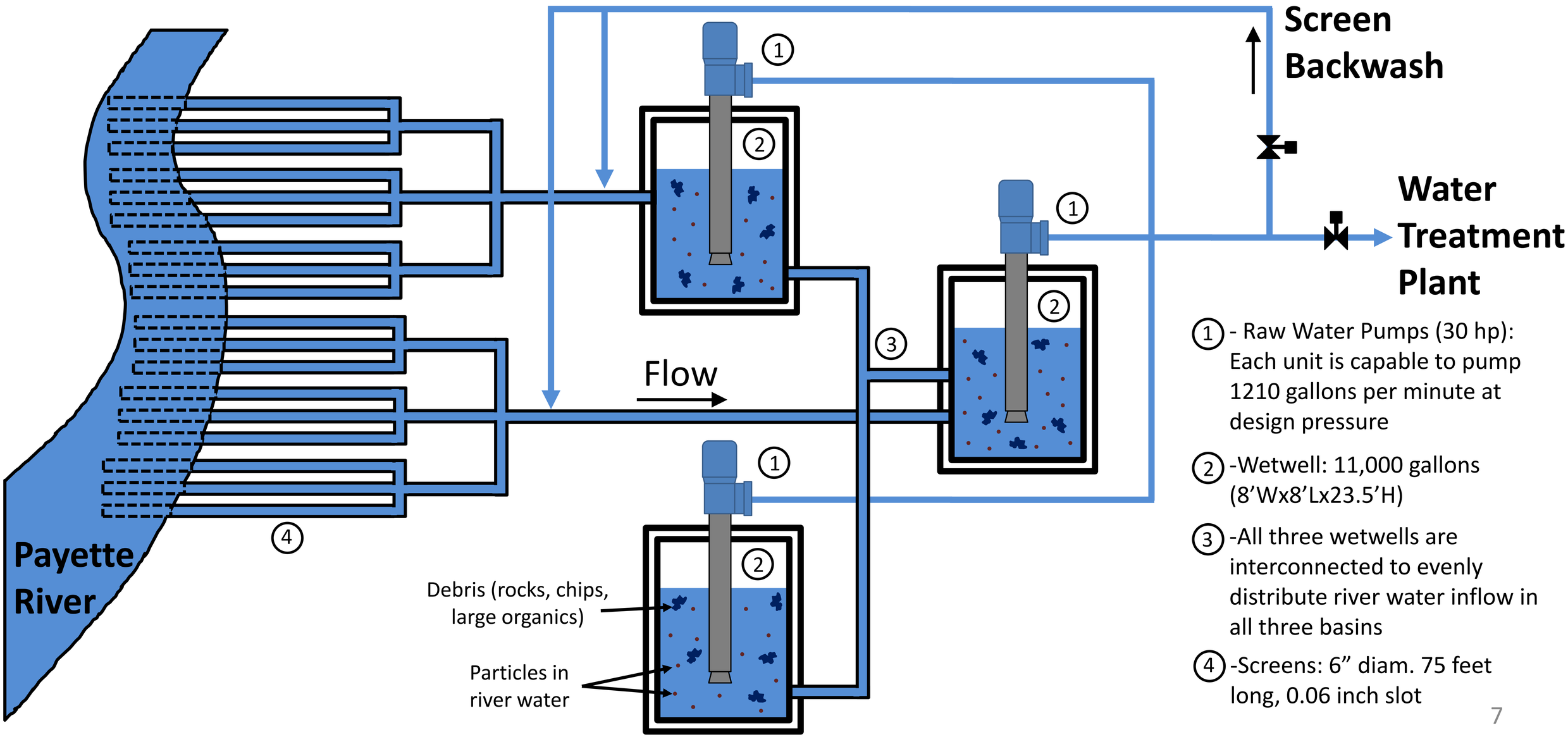
Water Distribution Improvements

Approximately 4 miles of new pipelines were installed throughout the distribution system to increase capacity and provide service to new developed areas:

- 20” pipe = 3061’
- 16” pipe = 5080’
- 12” pipe = 7994’
- 10” pipe = 1725’
- 8” pipe = 2056’
- Horizontal Directional Drill: 20” pipe = 280’

Payette River Intake

- The Payette River Intake is designed to pump 3.2 million gallons of water a day.
- River water infiltrates through 18 stainless steel screens installed in the river bed. Water flows by gravity into three concrete wetwells where it is pumped to the water facility for treatment.
- The intake facility includes a backwash system to periodically clean the screens to prevent clogging



1 - Raw Water Pumps (30 hp): Each unit is capable to pump 1210 gallons per minute at design pressure

2 -Wetwell: 11,000 gallons (8'Wx8'Lx23.5'H)

3 -All three wetwells are interconnected to evenly distribute river water inflow in all three basins

4 -Screens: 6" diam. 75 feet long, 0.06 inch slot

Payette River Intake

1. Screens in infiltration gallery

2. Filter Pack

3. Rip rap

4. Wetwells

5. Raw water pumps

6. Intake pump station

Pretreatment:
Coagulation/Flocculation

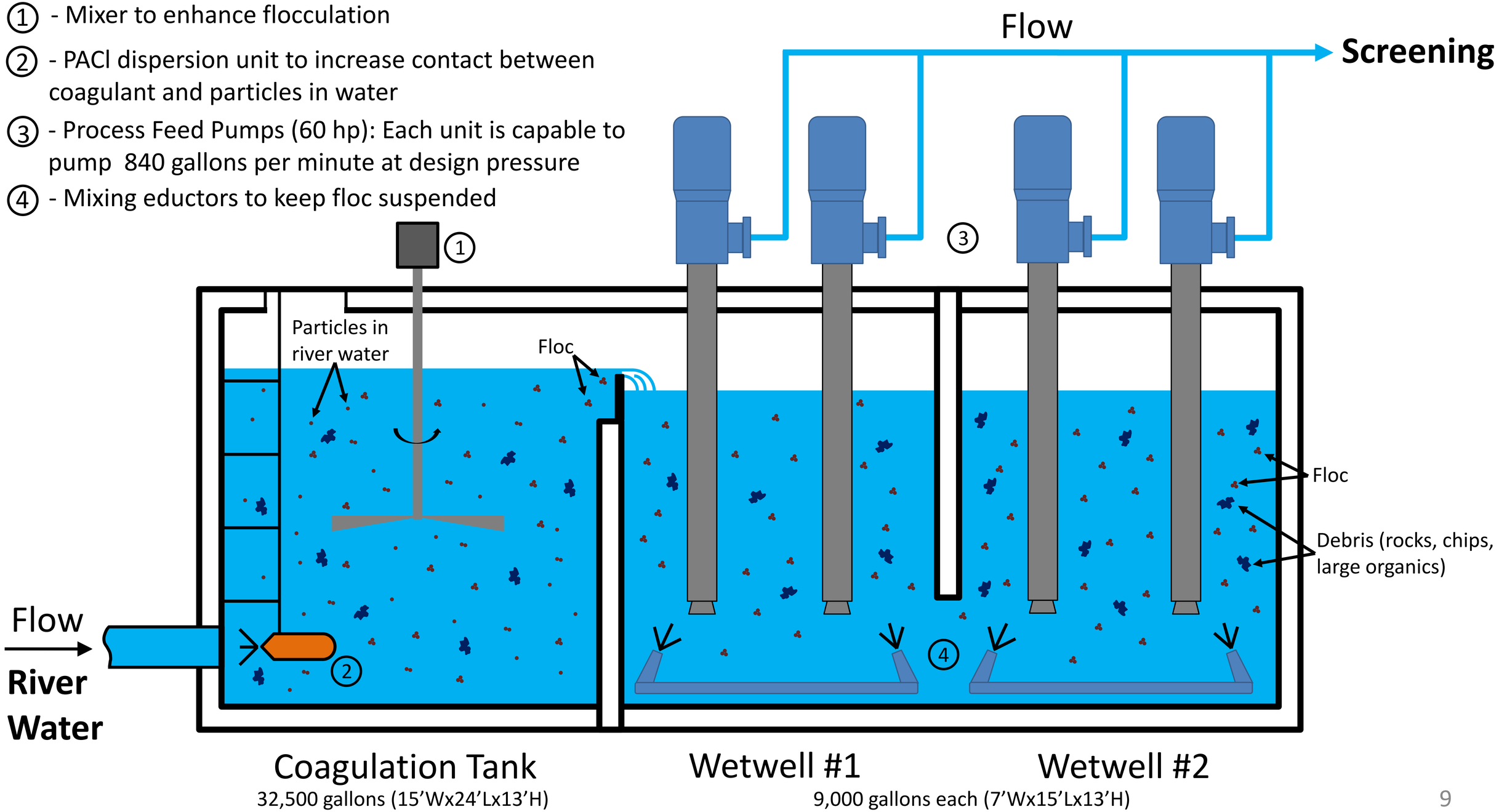
- River water is mixed with PACl to combine particles into larger floc to facilitate filtration

① - Mixer to enhance flocculation

② - PACl dispersion unit to increase contact between coagulant and particles in water

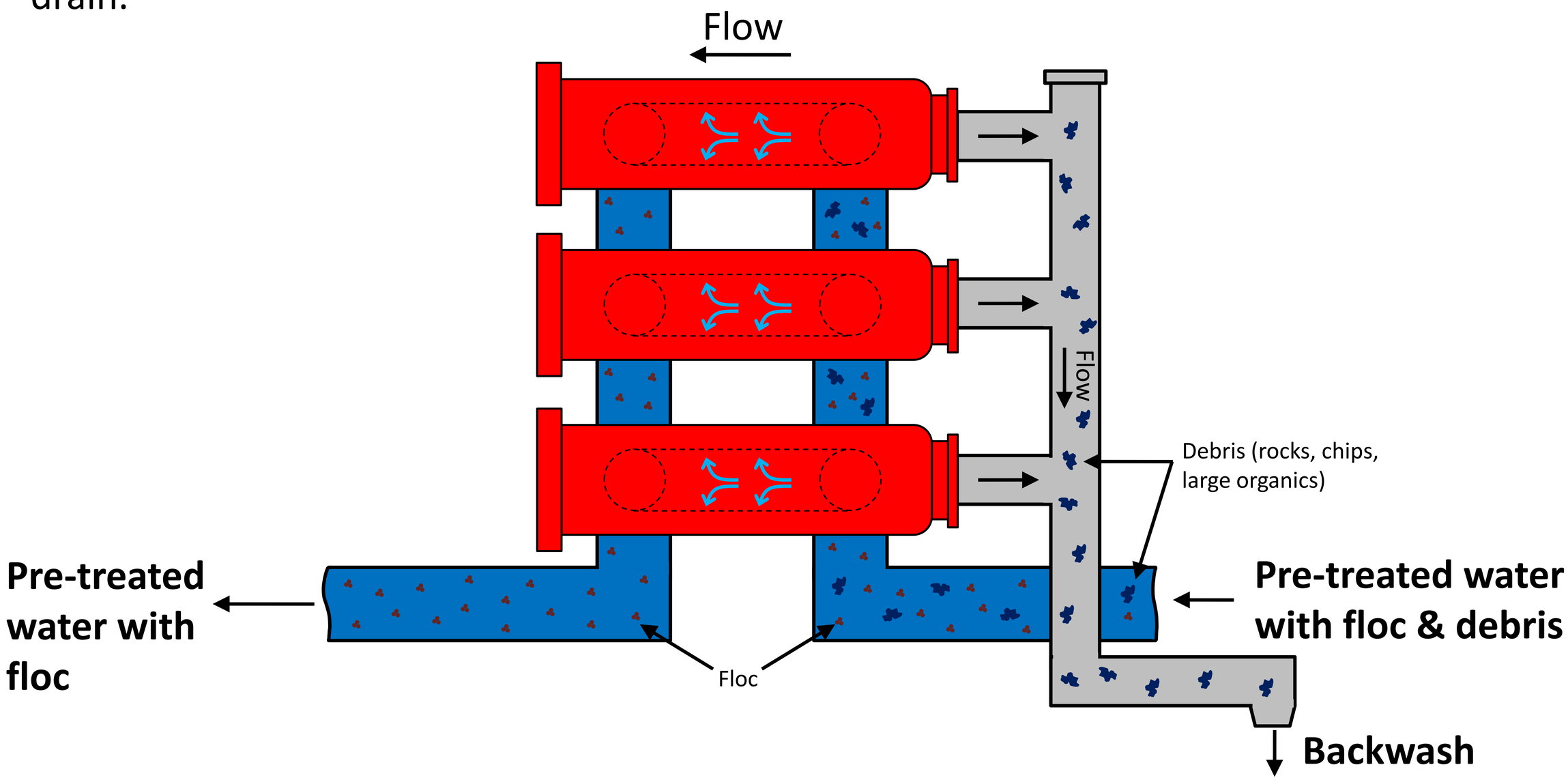
③ - Process Feed Pumps (60 hp): Each unit is capable to pump 840 gallons per minute at design pressure

④ - Mixing eductors to keep floc suspended



Screening

•Pre-treated water is pumped through a cylindrical internally fed screen with 300 micron (0.0118”) openings to remove any debris that could potentially damage the membranes. The screened debris is removed periodically with an automated backwash and discharged into the drain.



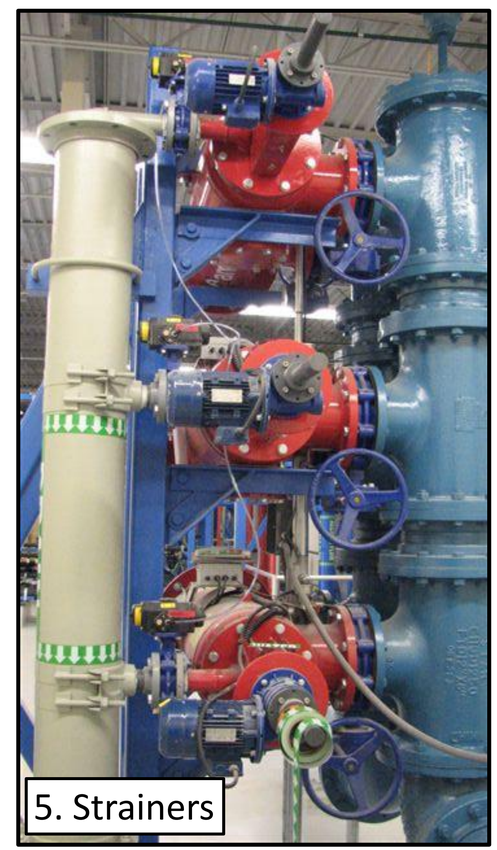
Pre-treatment and Screening

1. Process feed pumps

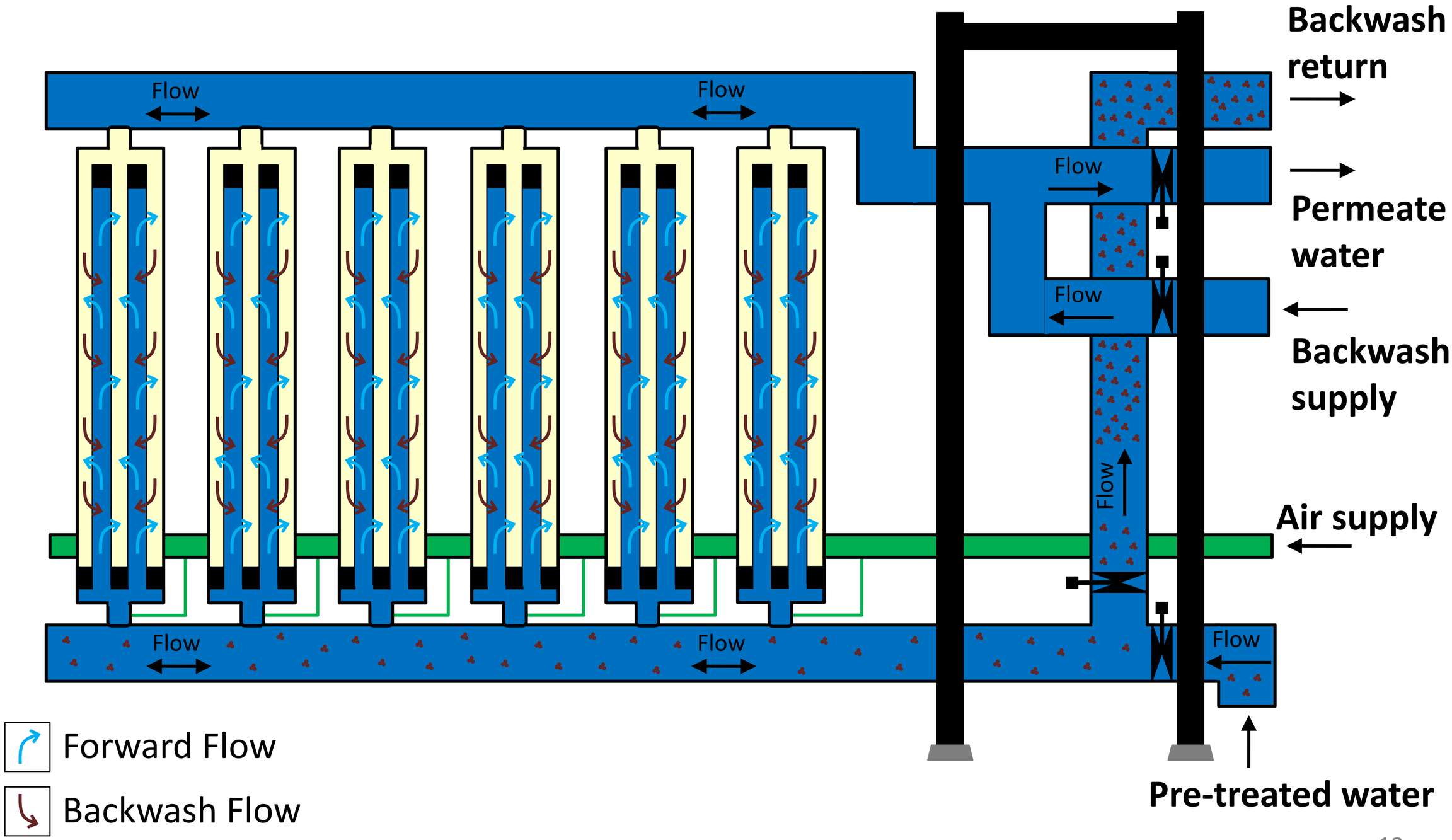
2. Strainers

3. Top mounted mixer

4. Pump lifting mechanism


5. Strainers

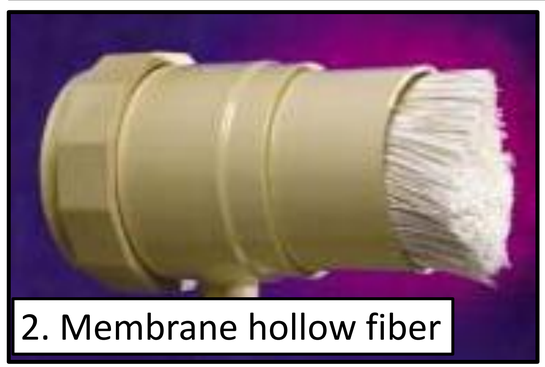
Membrane Microfiltration System



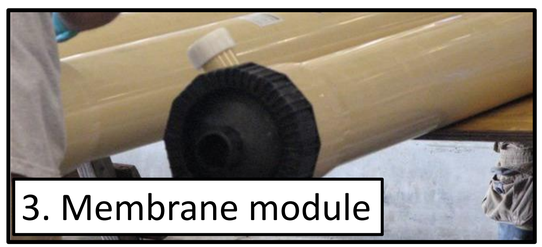
Membrane Microfiltration System

- The microfiltration system is a positive barrier for floc, organic carbon and microorganisms larger than 0.1 micron.
- The membrane microfiltration system includes 3 racks with 78 modules each.
- Each module is designed to filter a maximum flow of 15 gallons per minute.
- Each rack is capable to produce 1.6 million gallons of water per day.

1. Membrane racks



2. Membrane hollow fiber



3. Membrane module

4. Membrane rack under construction

Membrane Microfiltration Maintenance

•The microfiltration system includes three fully automated maintenance procedures:

1. **Air scrub / Backwash**: Permeate water is pumped in reverse mode (inside-out) to remove filtered particles. The process is enhanced by injected air which helps loosen particles that may be attached to the membrane surface. It is performed every 24,000 gallons of membrane permeate for 2 minutes.

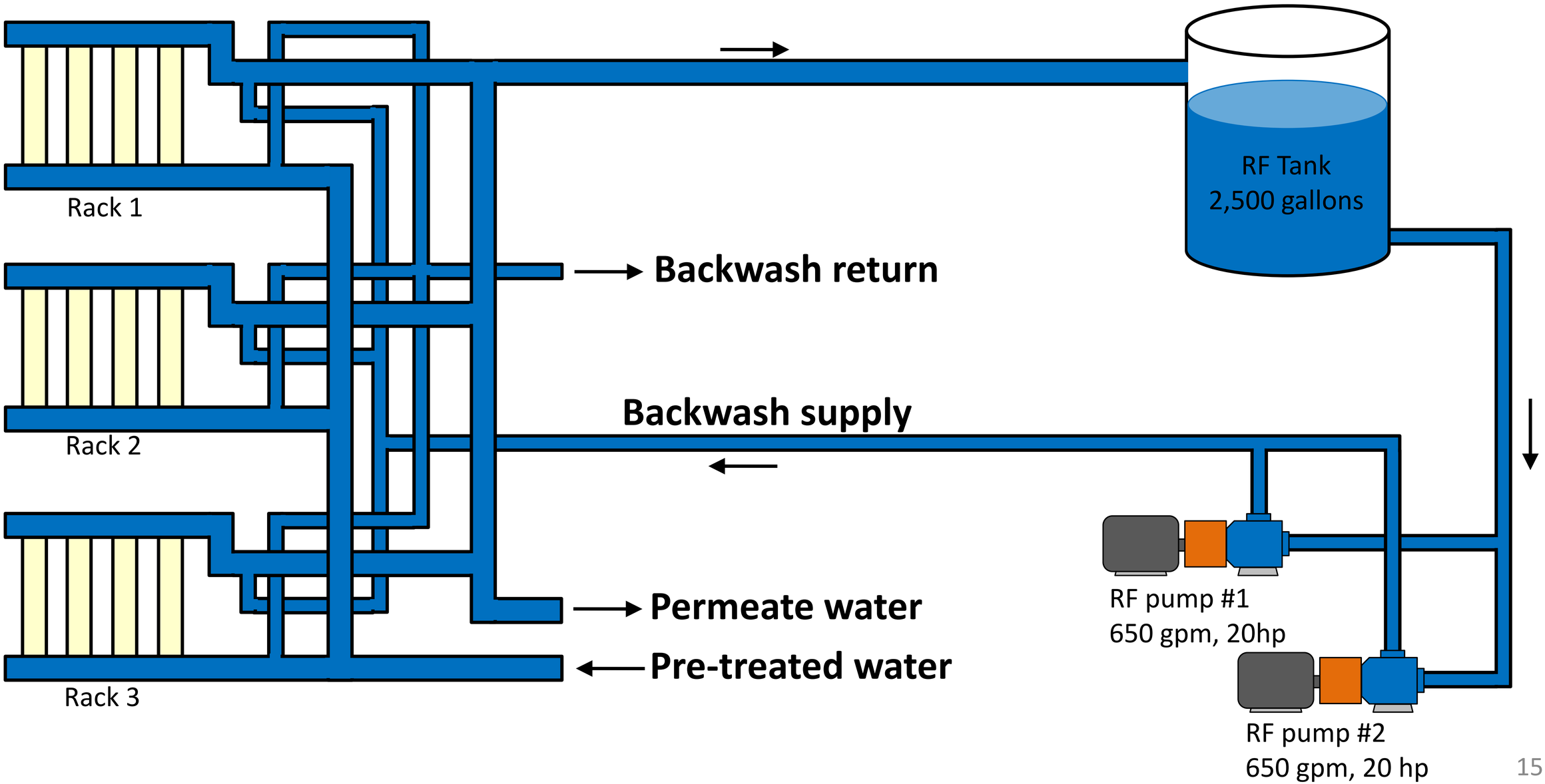
2. **Enhanced flux maintenance**: A chlorine solution is circulated through the microfiltration system, and then rinsed twice to inhibit any biological process.

3. **Clean-in-place**: A caustic chlorine and an acid solution are circulated sequentially through the microfiltration system with two rinses in between solutions and two rinses at the end. This process chemically removes the remaining foulants after a backwash or an EFM.

Membrane Microfiltration Maintenance

Reverse Flow - Backwash

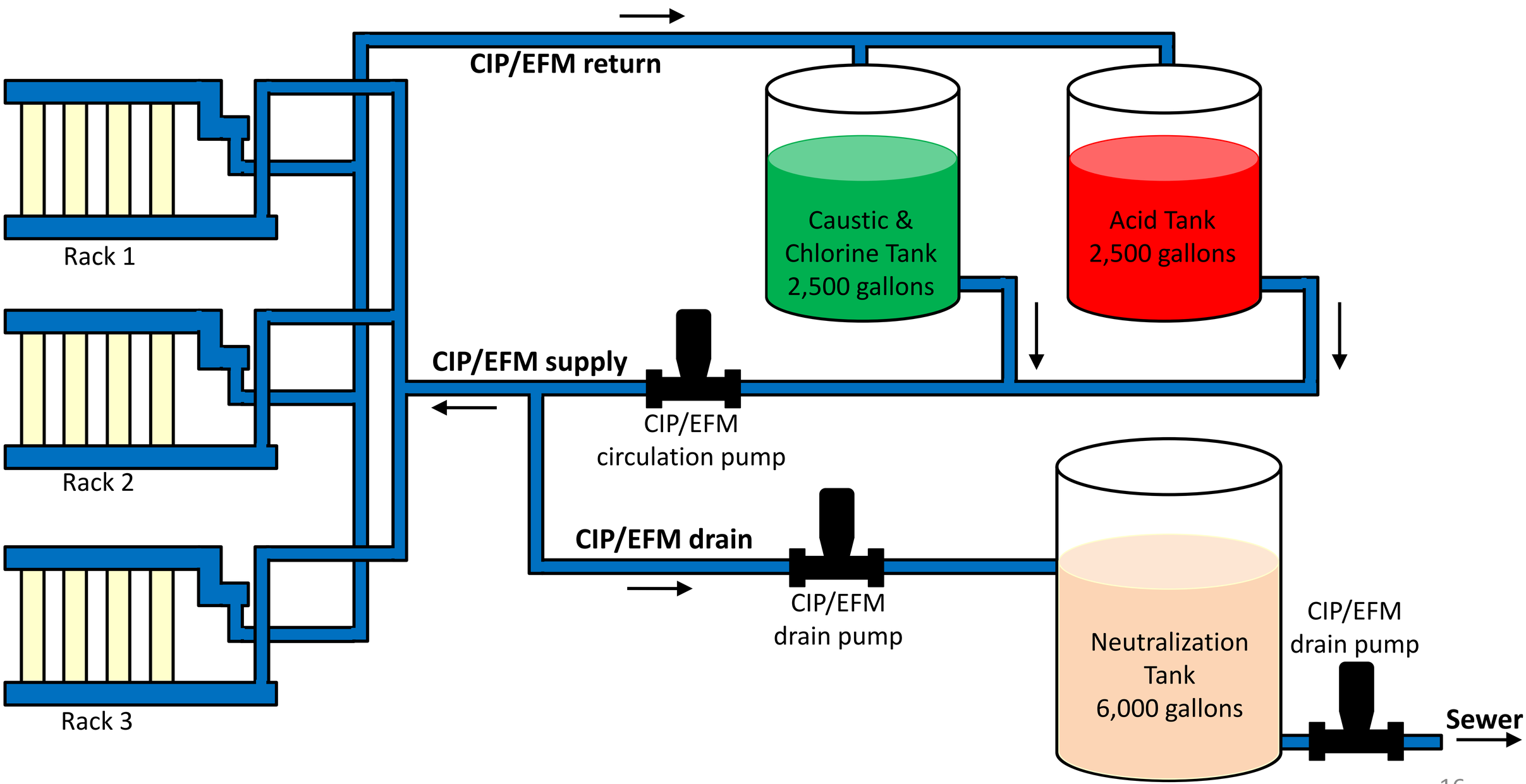
- Permeate water is pushed in the opposite direction as filtration to remove any solids accumulated in the membrane surface



Membrane Microfiltration Maintenance

Chemical Clean in Place (CIP) & Enhanced Flux Maintenance (EFM)

- Chemical clean processes help inhibit any biological processes and remove remaining solids

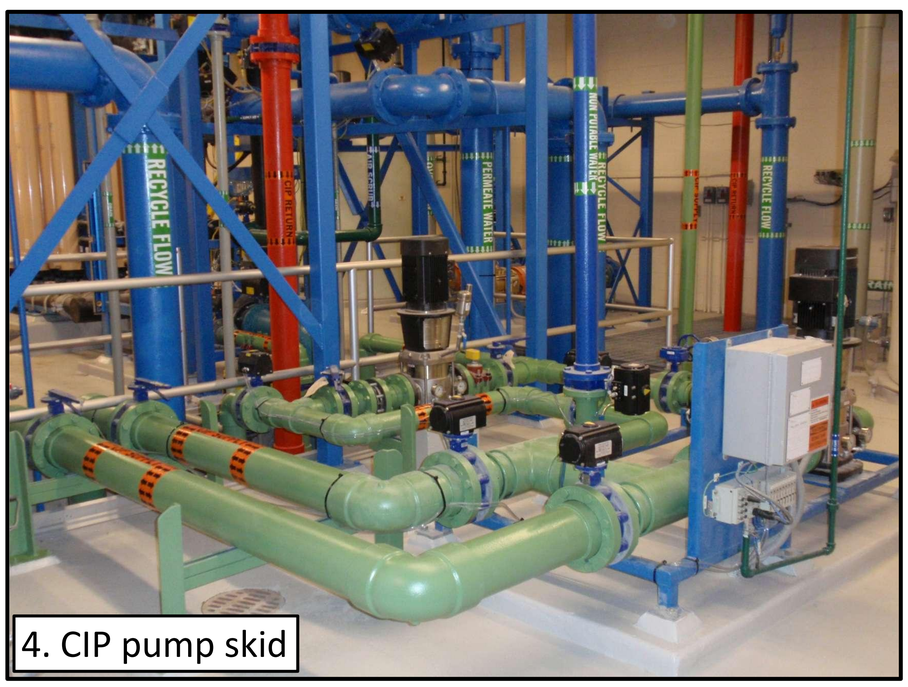


Membrane Microfiltration Maintenance

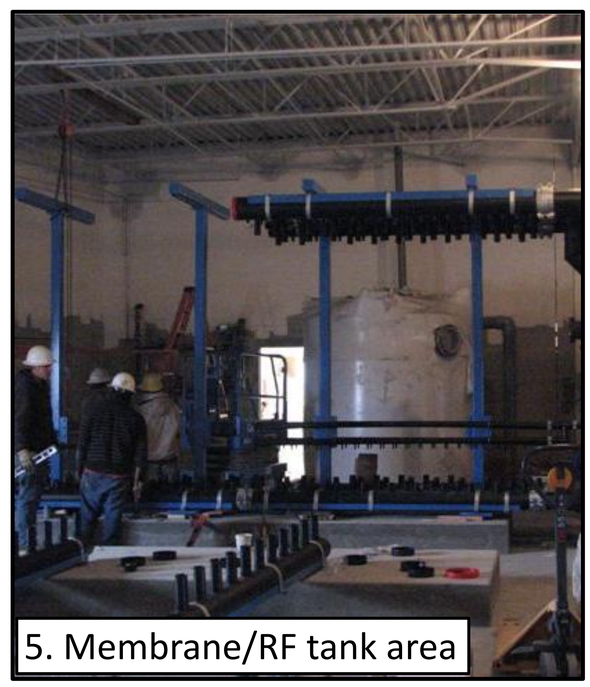
1. CIP area

2. CIP area

3. RF tank and pumps



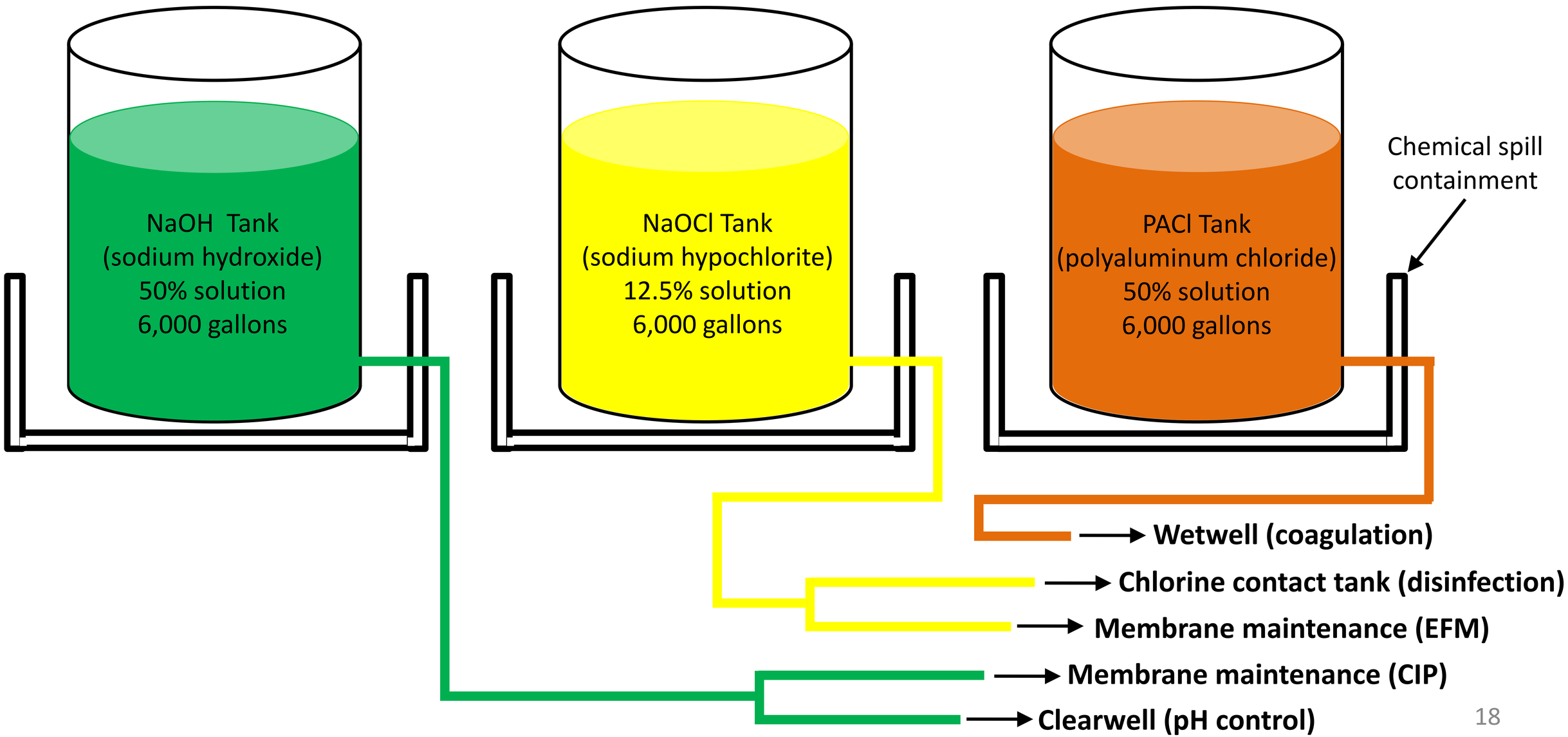
4. CIP pump skid


5. Membrane/RF tank area

6. Membrane backwash water

Chemical Storage Facilities

•Chemicals used during the water treatment process are stored in three 6,000 gallon tanks including polyaluminum chloride (coagulation), sodium hypochlorite (disinfection and membrane maintenance), and sodium hydroxide (pH control and membrane maintenance)



Chemical Storage Facilities

1. Access area

2. North section of the building under construction

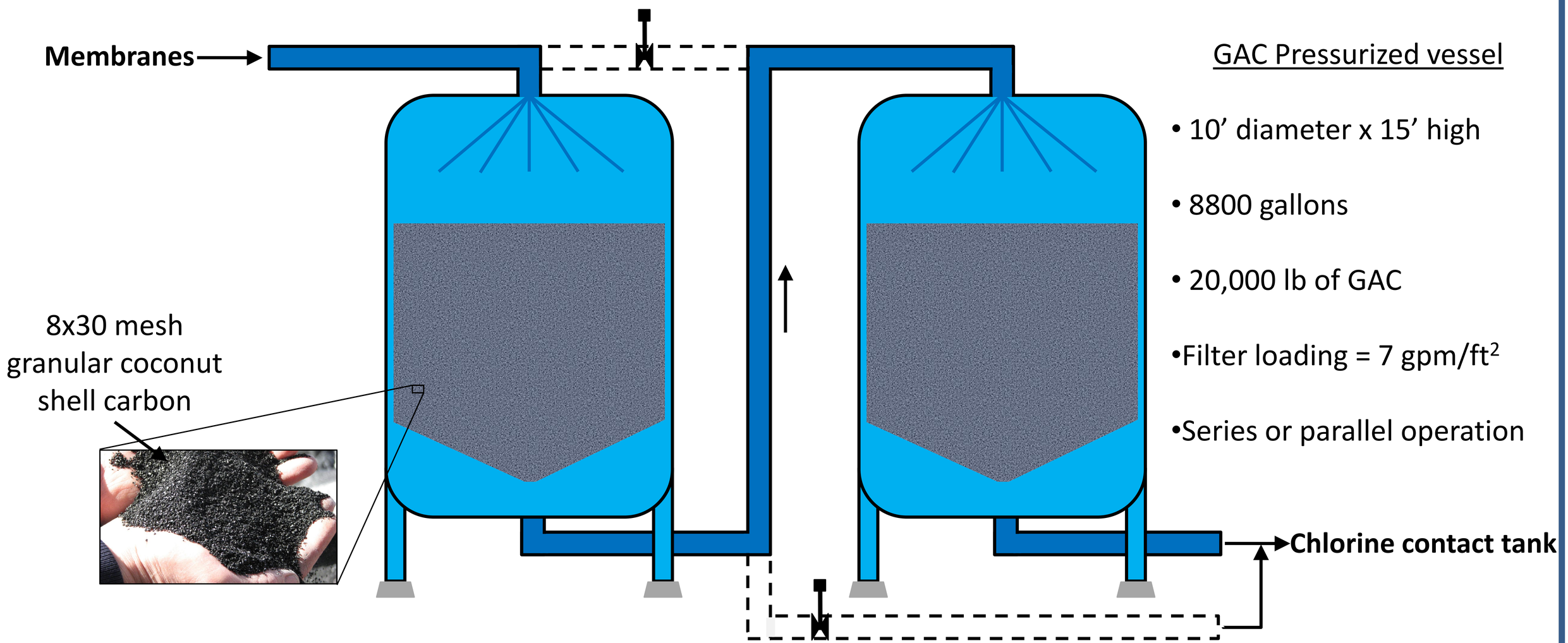
3. Fill stations under construction

4. Tank flexible connections

5. Storage area under construction

Granular Activated Carbon Filters

•Filtrate from the membranes is pumped through granular activated carbon (GAC) beds to adsorb any organics still present in the water for odor and taste control and to prevent the formation of disinfection byproducts (THAs, HAAs) in the distribution system.



GAC Pressurized vessel

- 10’ diameter x 15’ high
- 8800 gallons
- 20,000 lb of GAC
- Filter loading = 7 gpm/ft^2
- Series or parallel operation

Granular Activated Carbon Filters

1. GAC vessel installation

2. GAC vessel installation

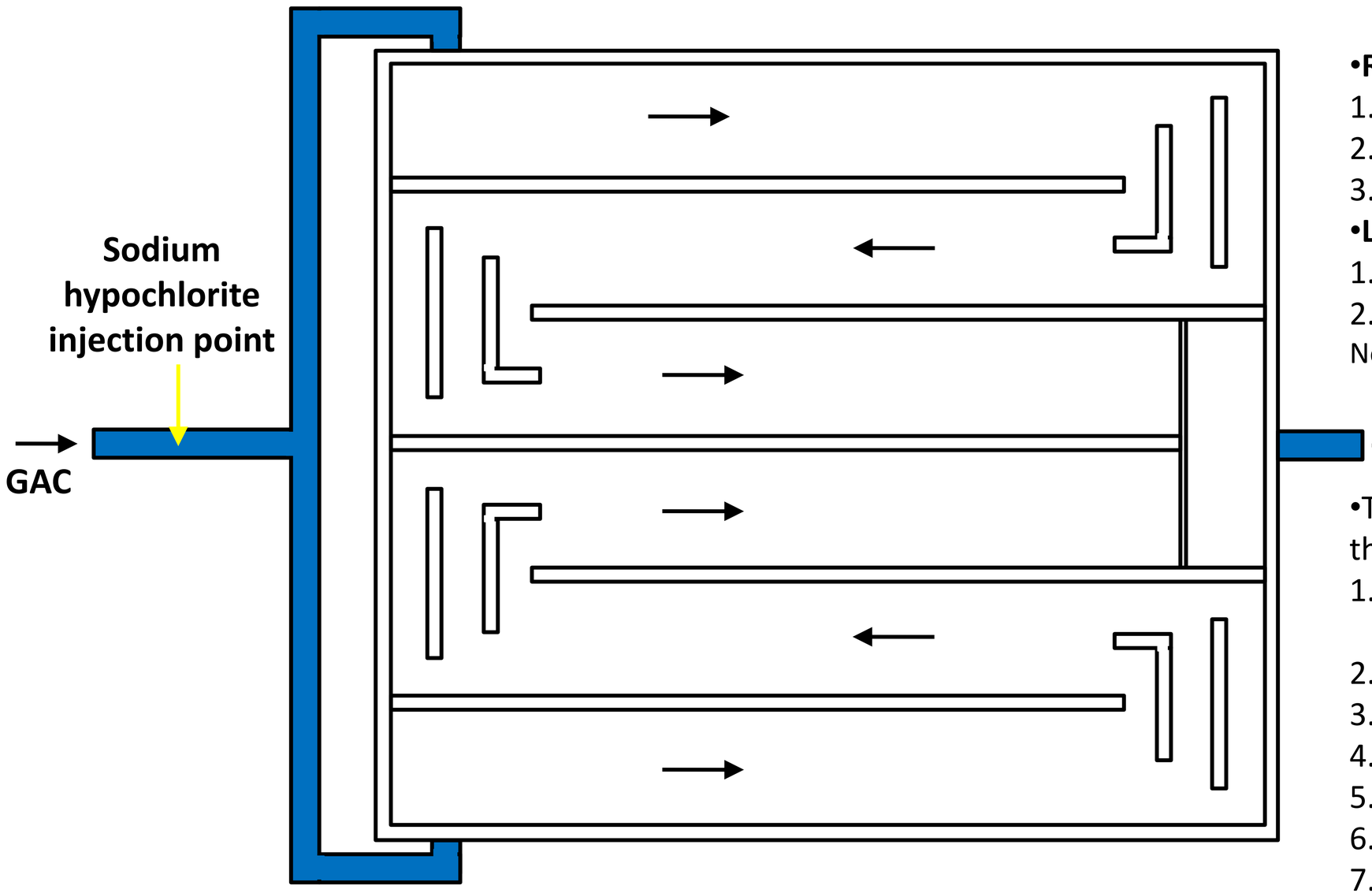
3. Process piping

4. GAC building

5. Process piping

Disinfection

•Filtrate from the granular activated carbon beds is sent to the chlorine contact tank for disinfection. Sodium hypochlorite is injected into the water stream, mixed, and allowed a contact time to inactivate harmful microorganisms.



•**Removal requirements:**

1. Giardia = 3-log (99.9%)
2. Viruses = 4-log (99.99%)
3. Cryptosporidium = 2-log (99%)

•**Log removal credit awarded:**

1. Giardia = 2.5-log
2. Cryptosporidium = 2-log

Note: 0.5 log Giardia = 4-log cryptosporidium

•The disinfection basin is sized to meet the following criteria:

1. CT=61 (equivalent to 0.5-log removal of Giardia)
2. Baffling factor = 0.7
3. Maximum water pH = 8.5
4. Minimum water temperature = 0.5 °C
5. Chlorine concentration = 1 mg/L
6. Contact time = 87 minutes
7. Basin volume = 190,000 gal

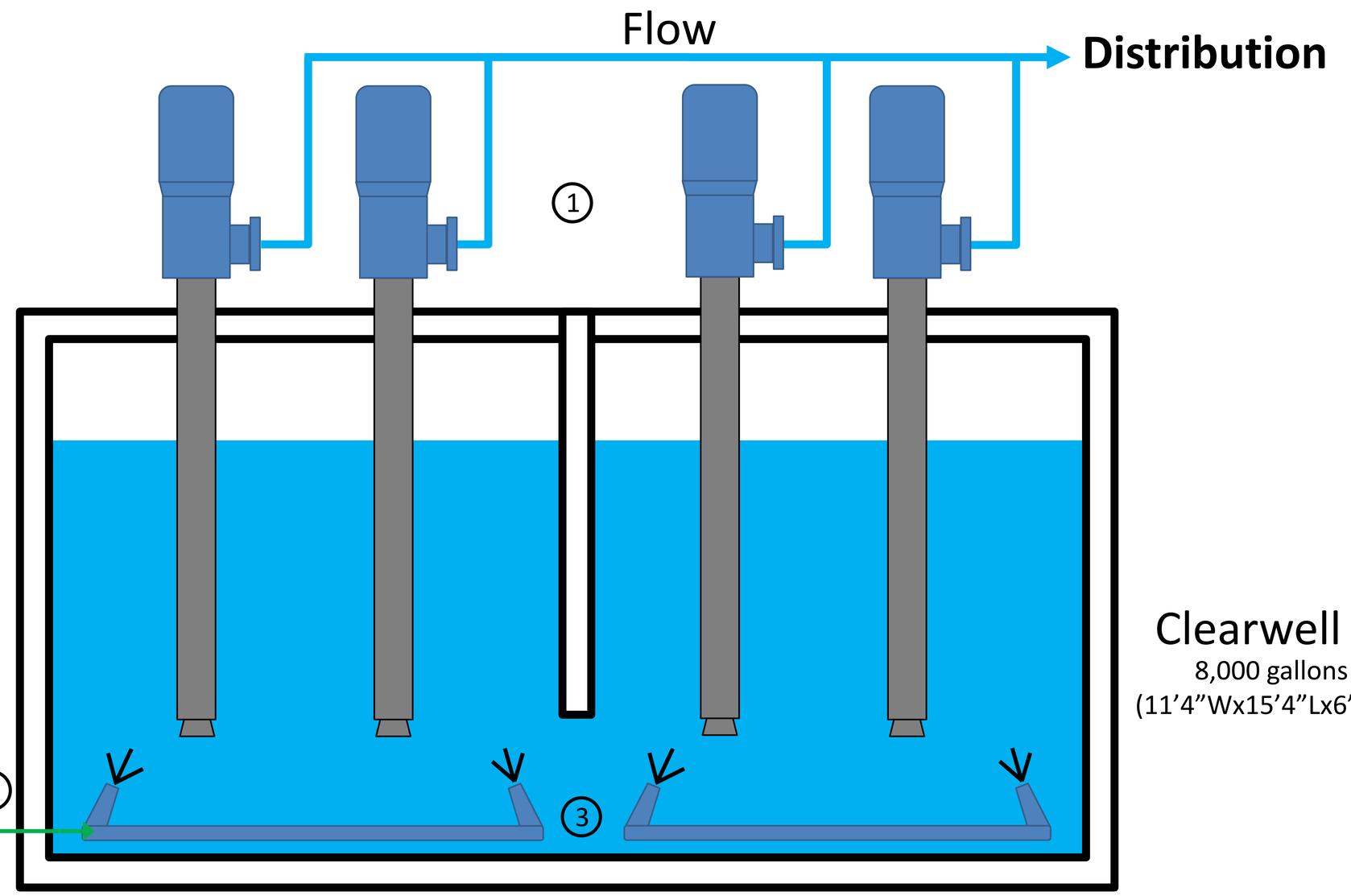
Clearwell: Finished Water

- Finished water is stored in two clearwells ready to be pumped into the distribution system
- Sodium hydroxide is mixed with finished water as required to adjust pH.
- Discharged water into the system is monitored continuously for chlorine residual, pH, flow and system pressure.

① - High Service Pumps (60 hp): Each unit is capable to pump 840 gallons per minute at design pressure

② - NaOH is injected in the clearwell recirculation lines

③ - Mixing eductors enhace mixing between water and sodium hydroxide

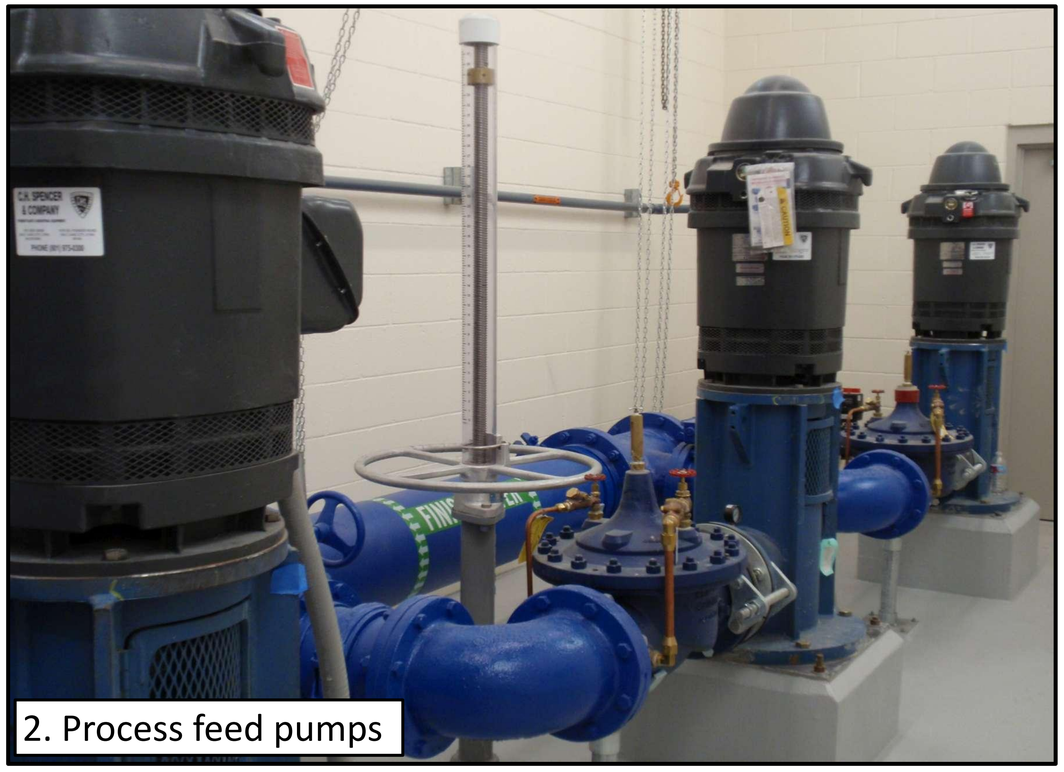


Clearwell #1
8,000 gallons
(11'4"Wx15'4"Lx6'7"H)

Clearwell #2
8,000 gallons
(11'4"Wx15'4"Lx6'7"H)

Chlorine Contact Tank and Clearwells

1. Clearwell room


2. Process feed pumps

3. Chlorine contact tank

4. Rebar installation

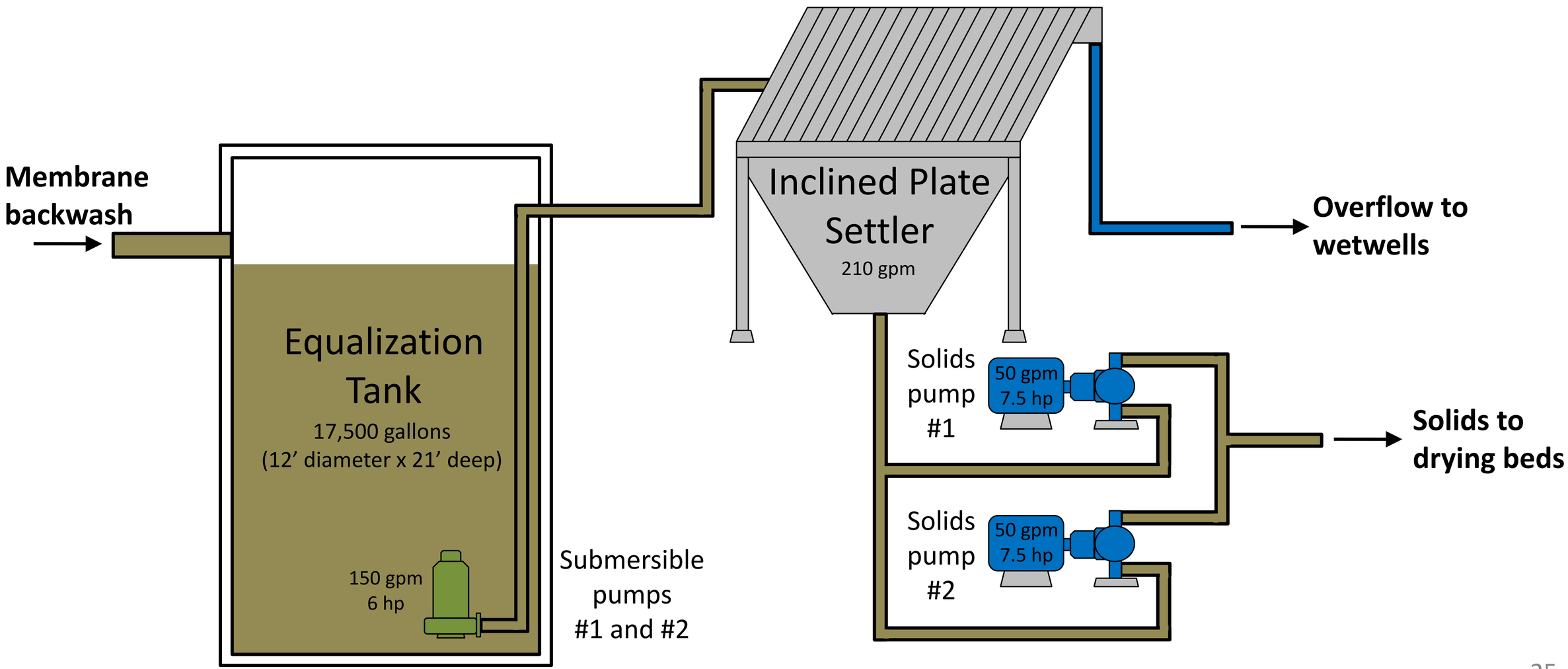
5. Chlorine contact tank completed

6. Precast roof members

7. Chlorine contact tank

Membrane Backwash Recycle

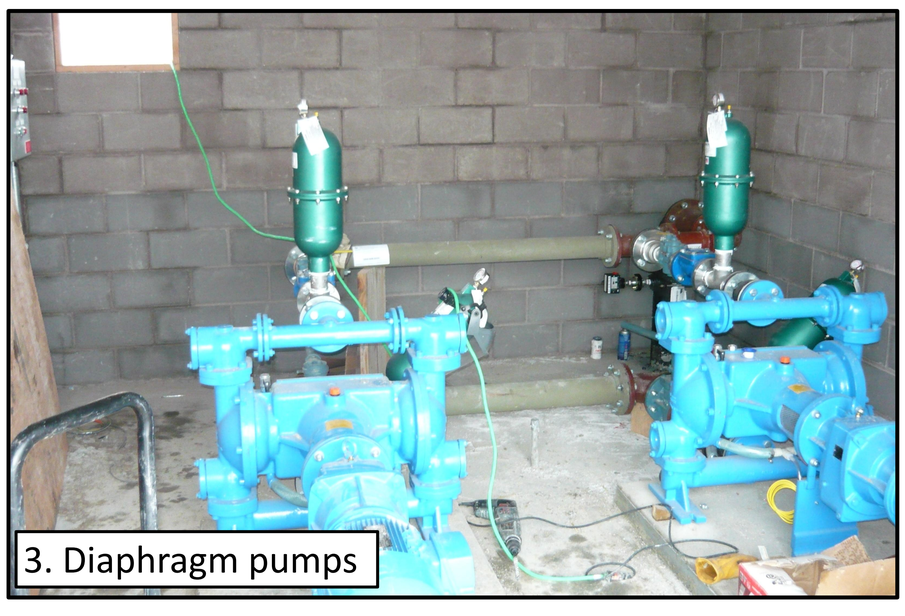
- Approximately 5% of the filtered water from the membranes is used for backwash.
- Backwash water is pumped through an inclined plate settler. In this unit solid particles settle to the bottom and the clarified overflow is recycled back to the wetwells.
- Approximately 50% of the membrane backwash flow is recycled.

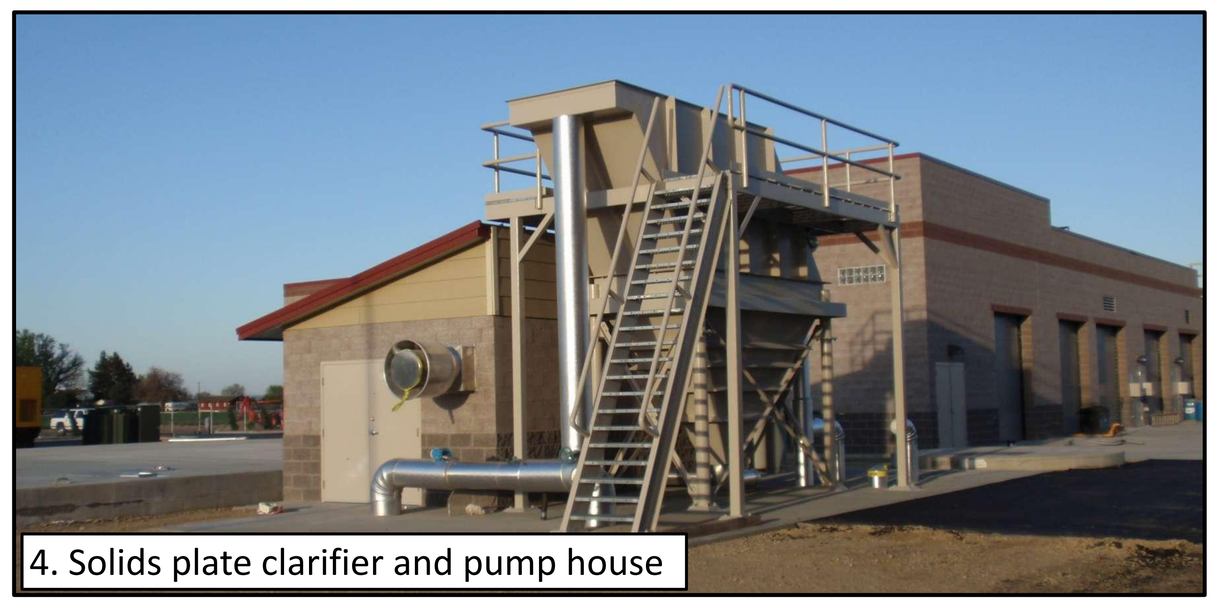


Membrane Backwash Recycle

1. Equalization tank under construction

2. Drying bed


3. Diaphragm pumps


4. Solids plate clarifier and pump house

Storage Reservoir and Pump Station

- The existing water system included a 200,000 gallon elevated storage tank and a 1 million gallon ground storage tank.

- Additional storage was required to meet MDD and fire flow.

Tank:

1. Bolted steel
2. 1.2 million gallons
3. 92’ diameter, 24’ high

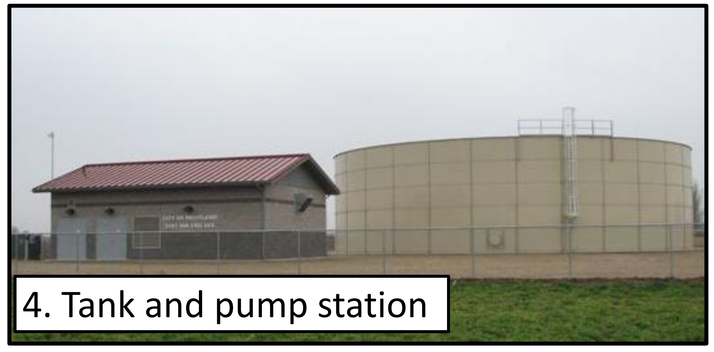
Pump station:

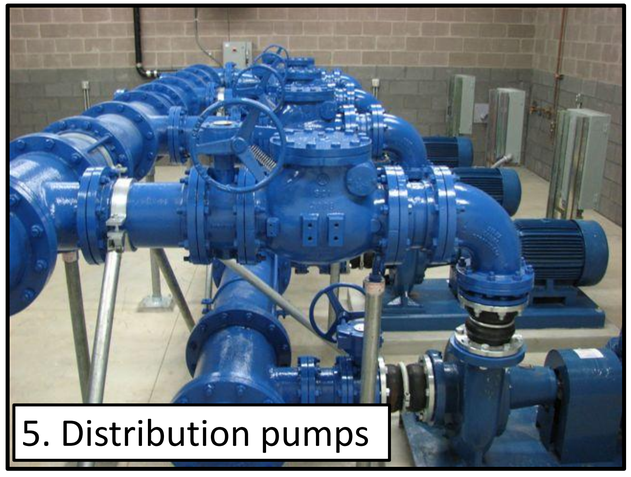
1. Four (4) 1000 gpm, 75 hp, distribution pumps
2. One (1) 100 gpm, 5 hp, booster pump

1. Tank rafters and cover

2. Process piping

3. Tank under construction


4. Tank and pump station


5. Distribution pumps

Summary

- Major upgrades have been implemented in the City of Fruitland's drinking water system to comply with State and Federal water quality standards and meet future demand

1. A 3.2 MGD river infiltration gallery and pump station
2. A 3.2 MGD surface water membrane microfiltration treatment plant
3. A 1.2 MG bolted steel storage tank and pump station
4. Near 4 miles of new or upgraded water transmission lines

QUESTIONS?

THANK YOU