Piloting Conventional Treatment Region 9 Advanced Disinfection Byproducts Training

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Piloting conventional treatment

- This presentation will focus on piloting conventional treatment to evaluate the control of particulate contaminants

- Unit operations:
  - Coagulation
  - Flocculation
  - Sedimentation
  - Filtration

Piloting conventional treatment – design manual

Piloting conventional treatment – design manual

EPA/600/R-15/045 February 2015

Type “EPA Low Flow Water Treatment Pilot Plant” into search engine

Or:

https://nepis.epa.gov/Exe/ZyNET.exe/P100LXYJ.TXT?ZyActionD=ZyDocument&Client=EPA&Index=2011+Thru+2015&Docs=&Query=&Time=&EndTime=&SearchMethod=1&TocRestrict=n&Toc=&TocEntry=&QField=&QFieldYear=&QFieldMonth=&QFieldDay=&IntQFieldOp=0&ExtQFieldOp=0&XmlQuery=&File=D%3A%5Czyfiles%5CIndex%20Data%5C11thru15%5CTxt%5C00000014%5CP100LXYJ.txt&User=ANONYMOUS&Password=anonymous&SortMethod=h%7C-&MaximumDocuments=1&FuzzyDegree=0&ImageQuality=r75g8/r75g8/x150y150g16/i425&Display=hpfr&DefSeekPage=x&SearchBack=ZyActionL&Back=ZyActionS&BackDesc=Results%20page&MaximumPages=1&ZyEntry=1&SeekPage=x&ZyPURL

Piloting conventional treatment

- Pilot systems can be built in two distinct ways:
  - Portable – built with ease of transport in mind, and with the flexibility to simulate unit processes at a variety of sites
  - Permanent – built to replicate operations at a single site

Piloting conventional treatment

- Advantages of an on-site pilot system:
  - Provides a test platform for evaluating changes in treatment parameters → provides more information than a jar test but avoids the risks inherent in full-scale trials
  - Especially useful for estimating impact of a process change relative to a baseline
  - Can be used for initial scoping work prior to engaging design consultants:
    - Leads to more productive conversations with design consultants and state primacy personnel
  - Tool for staff training – increasing confidence

Piloting conventional treatment

- Jar testing is effective at helping predict impact of chemical addition on water chemistry and relative changes in settled water turbidity
- However, jar testing provides no information on the impact of water chemistry changes and settled water turbidity changes on filtration performance
- Piloting conventional treatment allows evaluation of coagulation/flocculation/filtration as an integrated system

Piloting conventional treatment

- Example questions that can be asked:
  - If I increase my coagulant dose, how do filter effluent turbidities and run times change?
  - If I change coagulants, how do filter effluent turbidities and run times change?
  - What happens to clean bed head loss if I change coagulants and/or doses?
  - What happens to filter performance if I change the pH of coagulation?
  - What happens to DBP formation if I change coagulants and/or doses?

Basic design details – materials of construction

- Pilot systems designed for evaluating particulate control permit significant flexibility in selection of construction materials:
  - Rapid mix, flocculation, sedimentation basins can be fabricated with plexiglass
  - Filters can be fabricated with transparent PVC pipe
  - Panels for mounting valves, etc. can be fabricated with ½" PVC sheets
  - These materials are readily available from multiple vendors – commodity pricing
  - Can be cut, shaped, and joined with tools, solvents, primers, and adhesives readily available from multiple vendors – commodity pricing
  - Fabrication skills readily available – often within a utility

Basic design details – parts and fittings

- Best to maintain flow rates with variable speed gear pumps instead of a single speed pump + throttling valve → higher upfront expense but → improved hydraulic stability → significant labor savings and higher quality results
- Best to purchase high quality chemical feed pumps → higher upfront expense but → improved feed rate stability → labor savings and higher quality results
- Use better quality valves in situations where the valves are operated frequently

Basic design details – parts and fittings

vs

vs

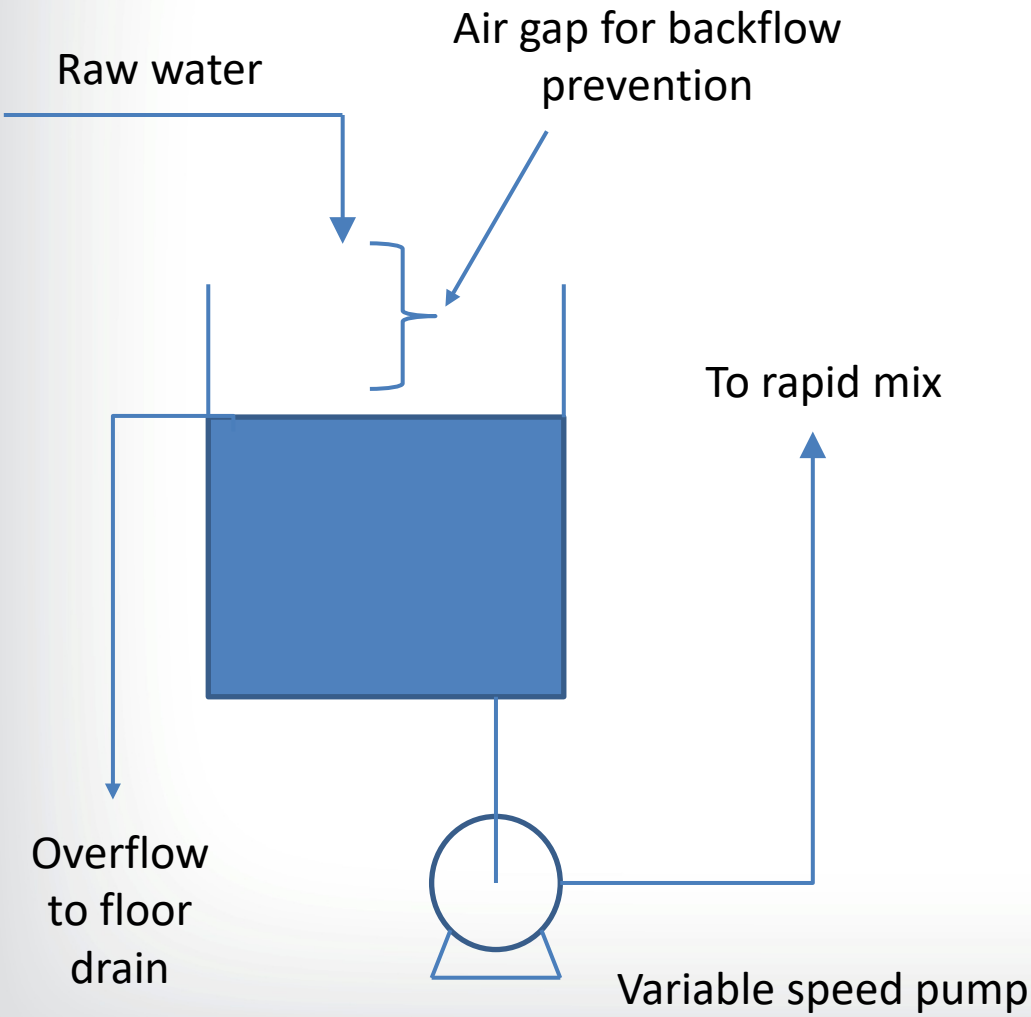
Basic design details - instrumentation

- Online instrumentation is not necessary → high quality data can be accumulated with a benchtop turbidimeter, conscientious grab sampling, visual observations of headloss, hand-recording of results in log books, and basic graphing in spreadsheets
- Avoid rotameters and paddle-type flow meters, especially if chlorine not present:
  - Biomass accumulation causes calibration drift due to changes in hydraulic friction
  - Calibration will also drift as temperature changes
- Set system up to measure feed and flow rates by hand (stopwatch and graduated cylinders) → with good quality pumps, feed/flow rate measurements and adjustment intervals can be done 1X/day and logged by hand

Basic design details – site selection

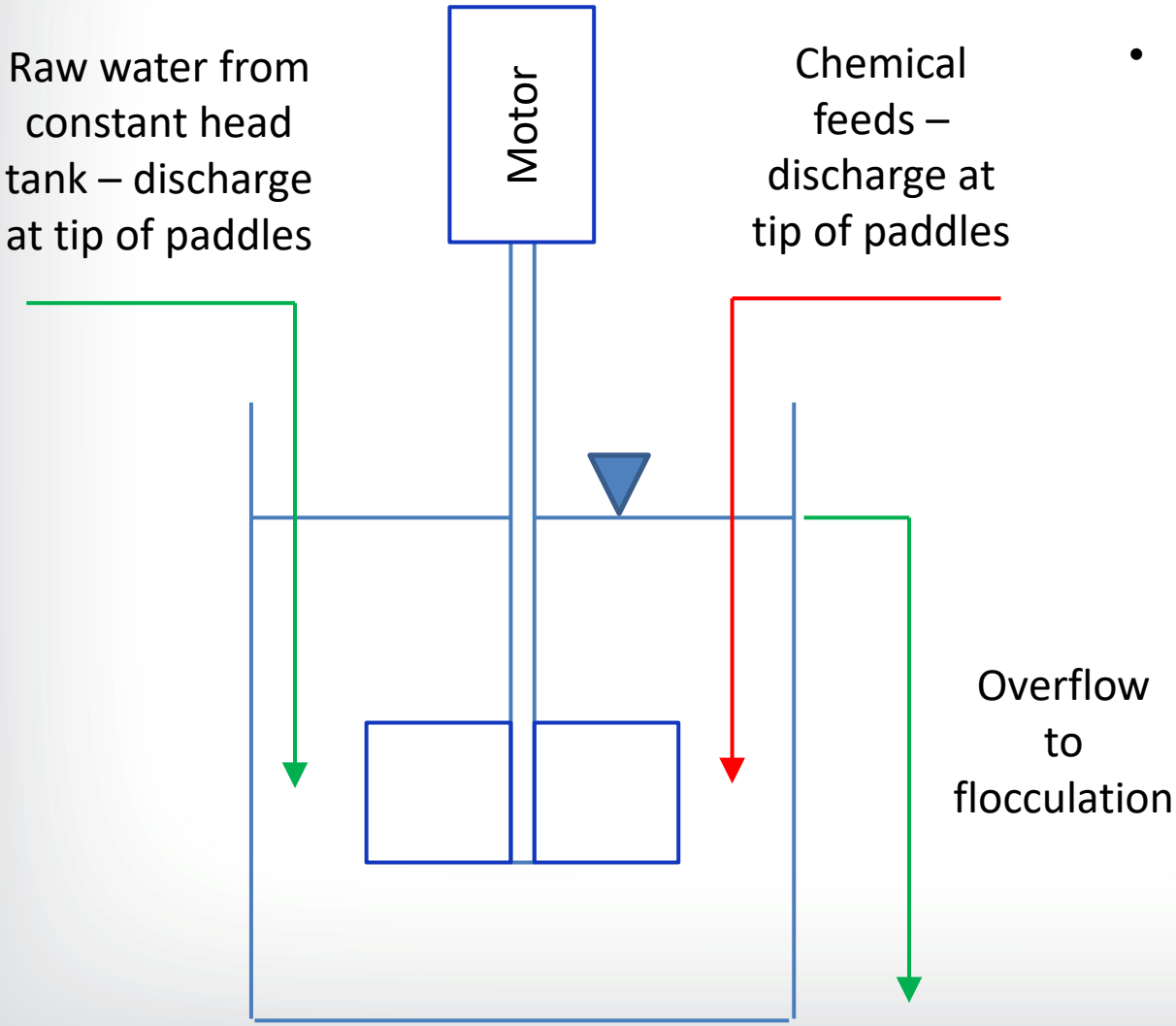
- Electrical service:
  - 120V, ground fault protected
  - Conduits and duplex/quad outlet boxes if possible
- Tap to raw water source, consider backflow prevention
- Gallery or high bay space with two levels → simplifies hydraulics and minimizes pumping → allows water to flow to filter influent by gravity
- Floor drain

Design details – front end



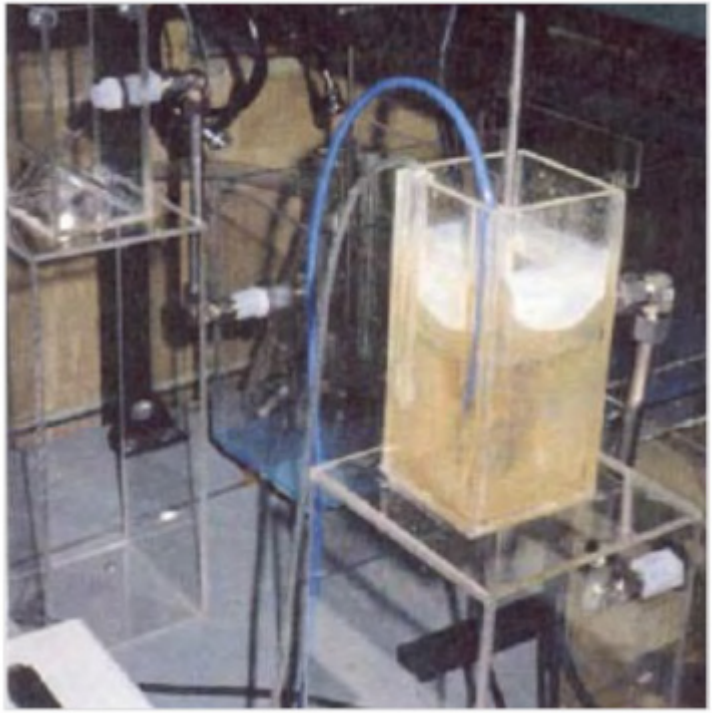
- Raw water flow rate > flow rate to rapid mix
- Difference goes to overflow
- Constant head over pump aids hydraulic stability
- Pump sits below constant head tank → needs to be rated for "washdown" service
- If sufficient elevation is available, water can flow by gravity from rapid mix to filter influent

Design details – rapid mix



- Achieve efficient mixing of raw water with chemicals
  - Short residence time
  - Mixing paddles large relative to internal dimensions
  - Mixing paddles turn at high rpm

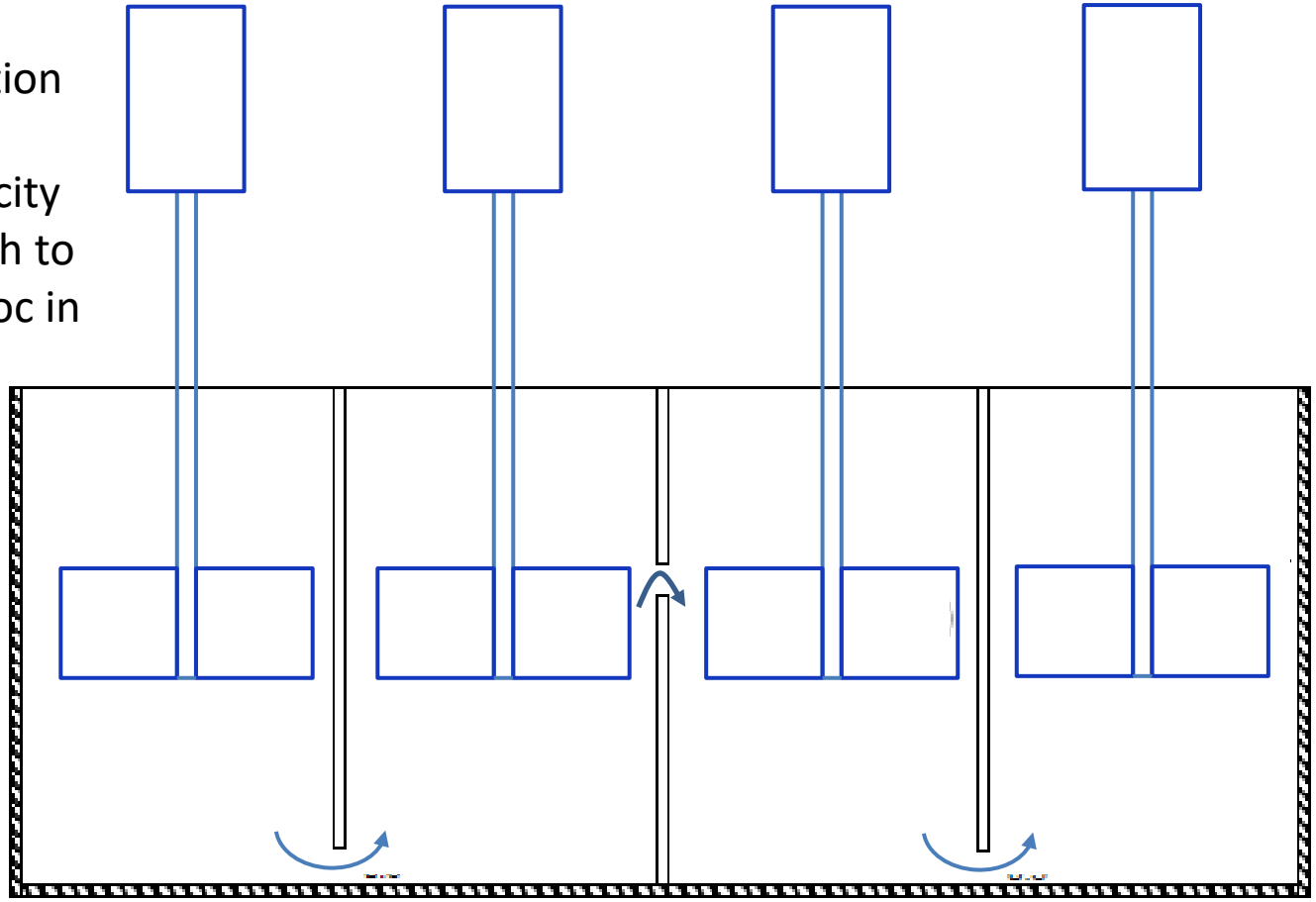
Design details – rapid mix



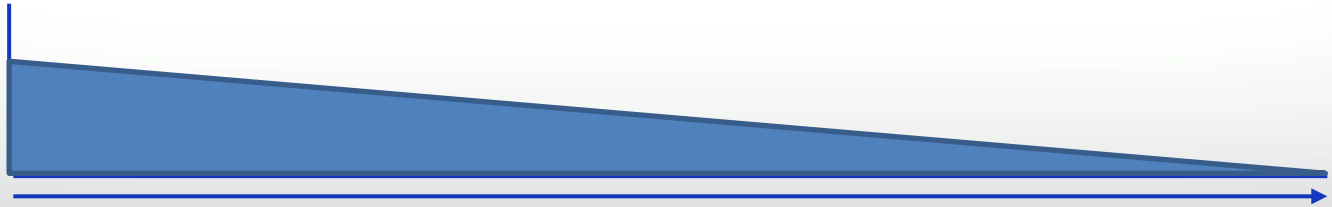
Mixing chamber and paddles sized for ≈ 0.45 L/min

Design details – flocculation

- Promote agglomeration of flocs
- Water velocity high enough to maintain floc in suspension without shearing



Mixing intensity



Design details - flocculation

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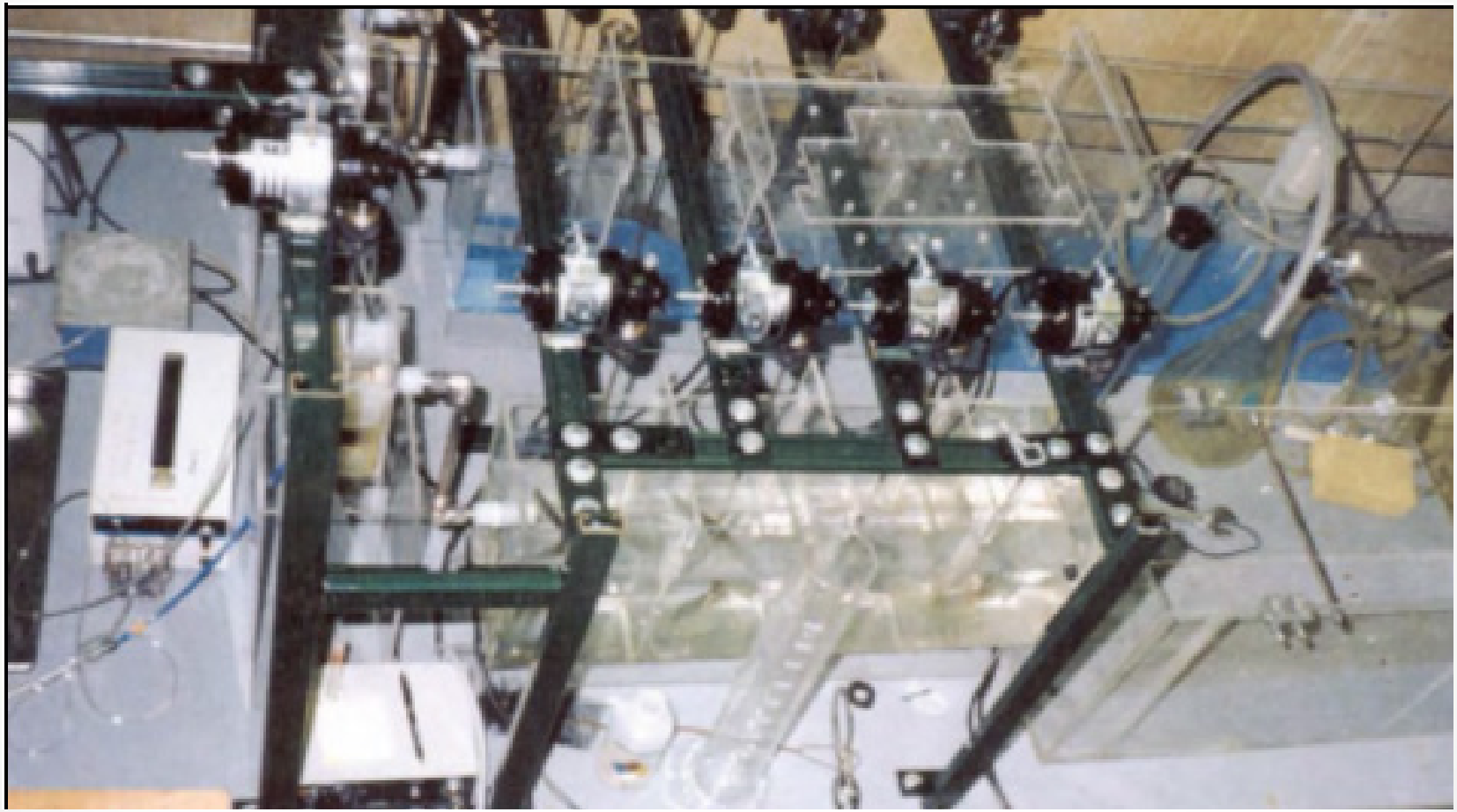
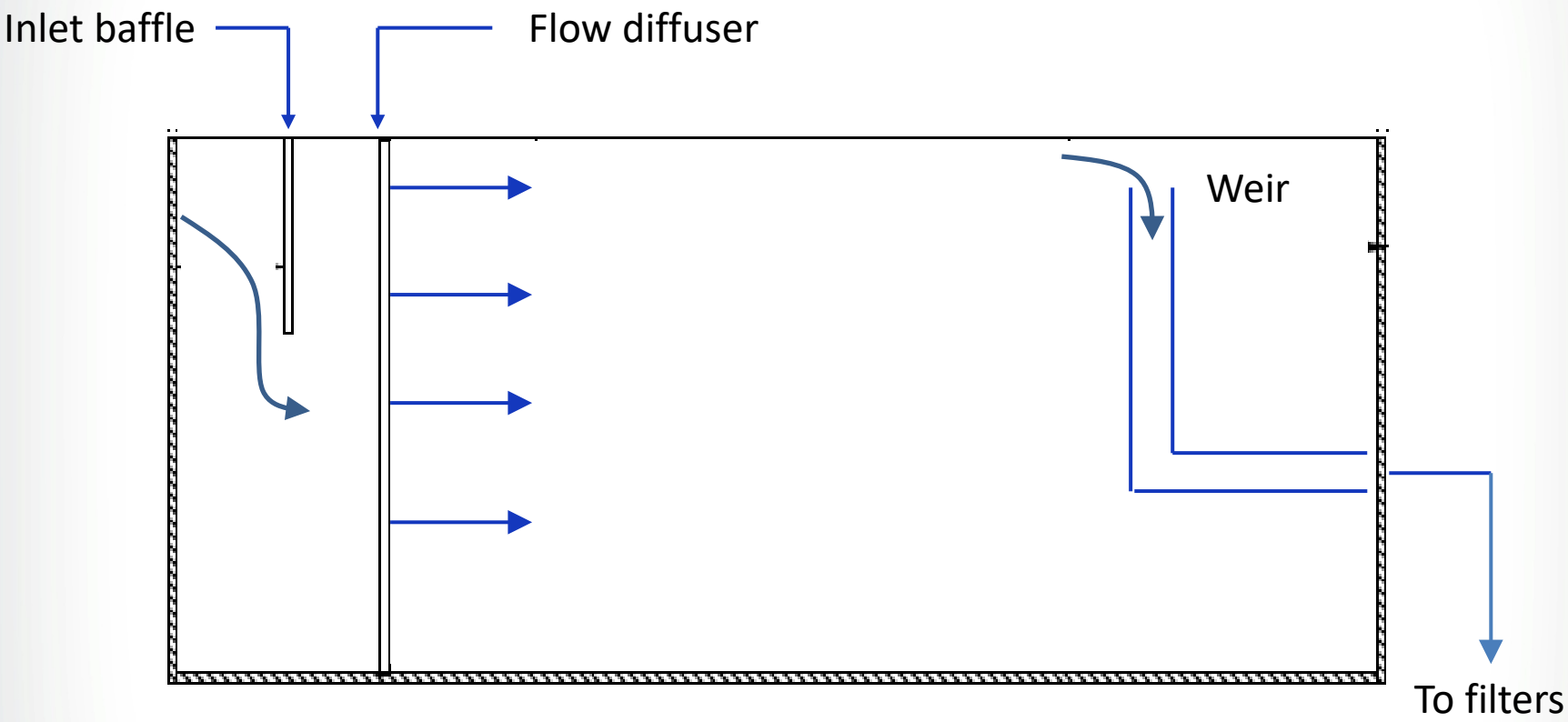


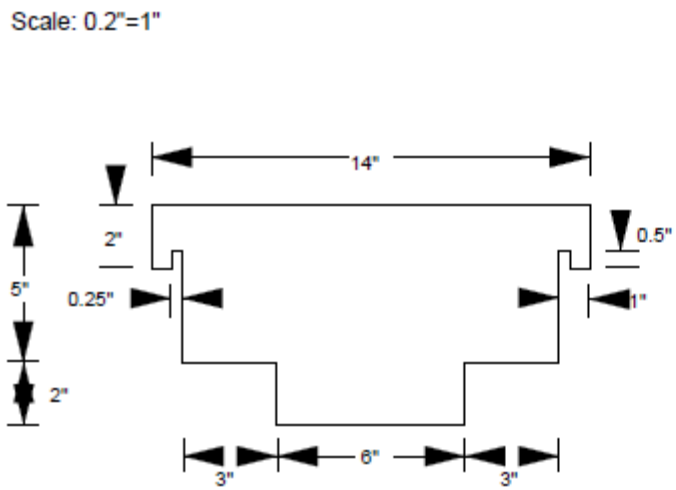
Design details – mixing & flocculation

- Mix motors and speed controllers for rapid mix and flocculation available from multiple vendors
- Off the shelf framing systems available in steel, aluminum, plastic, and fiberglass – can be cut/sized with basic shop tools
- Mixing paddles and shafts can be cut/sized with basic shop tools from commercially available steel stock and spot welded

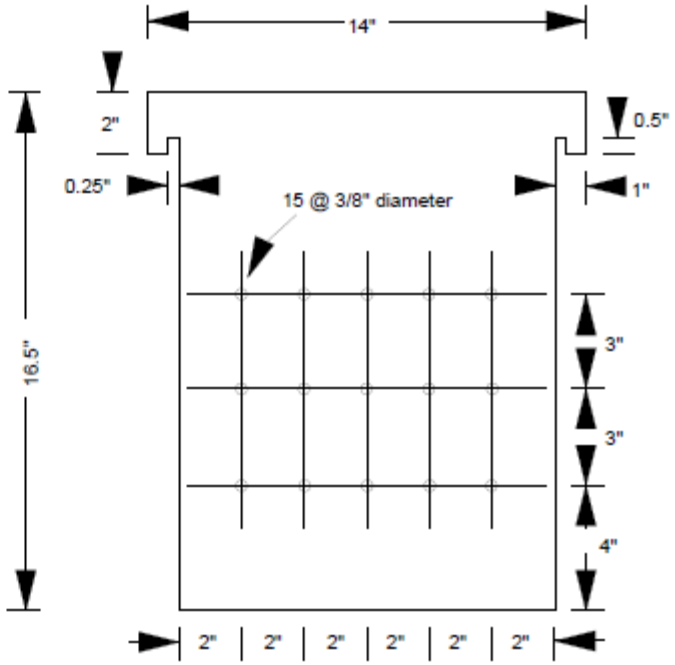
Design details - sedimentation



Design details - sedimentation



Baffle SB1



Baffle SB2

Design details - sedimentation

Flocculation & sedimentation – big picture

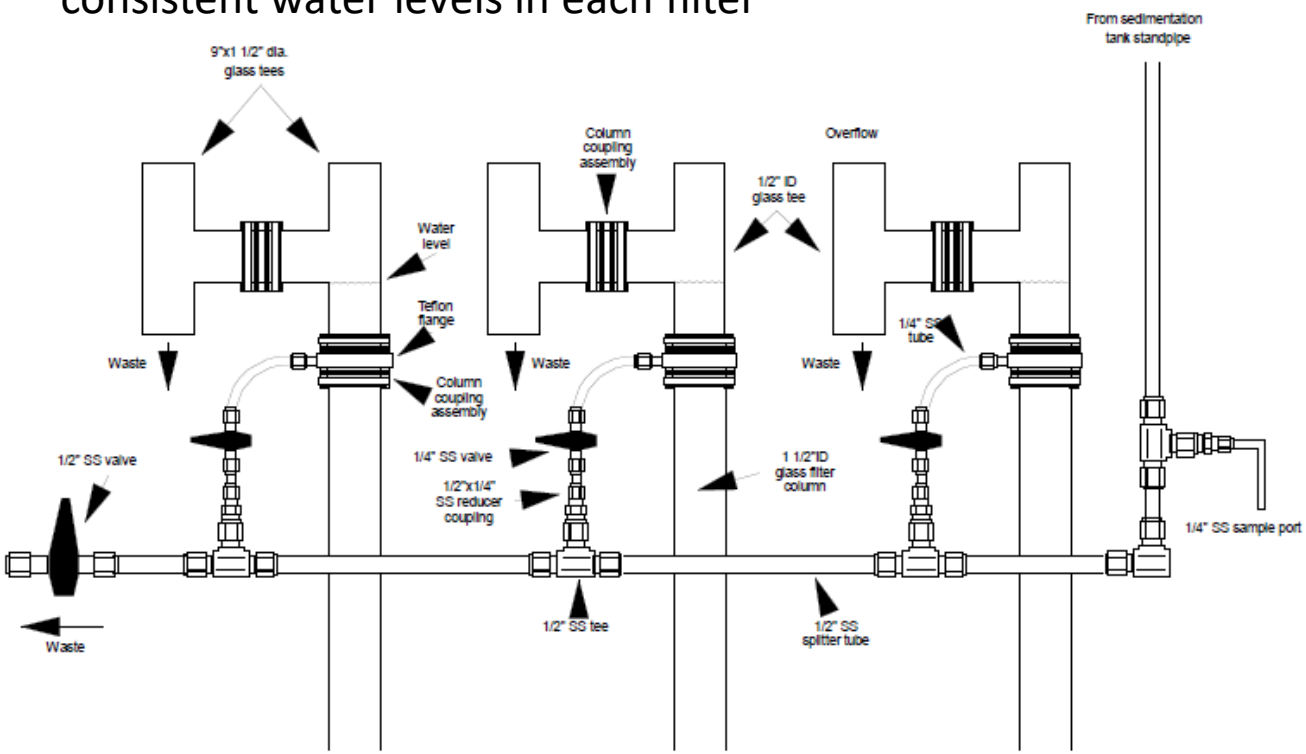
- Flocculation and sedimentation are the most difficult unit operations to pilot – floc can't be scaled down
- Focus on replicating mixing intensities, detention times, and maintaining fluid velocities that don't shear flocs
- Tracer testing to find dead zones and short circuiting – be prepared to make empirical adjustments

Filtration

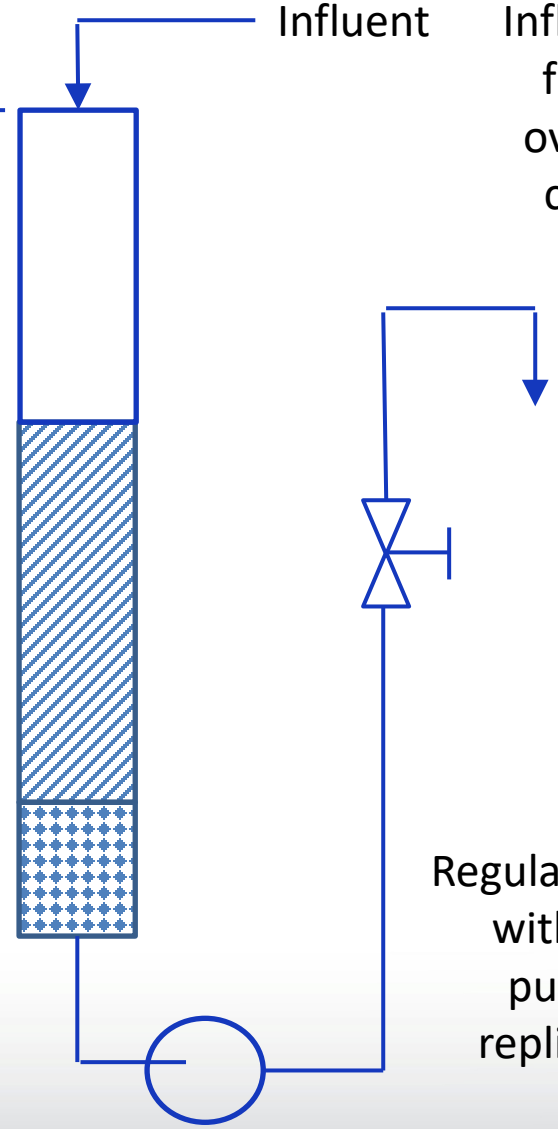
Design details – transition to filtration

Critical to ensure even distribution of settled water to multiple filters & consistent water levels in each filter

Important to allow easy cleaning of inlet manifold



Design details - filtration



Influent flow rate > filter flow rate – excess to overflow → maintains constant water level

Allow space for ≥ 50% bed expansion during backwash

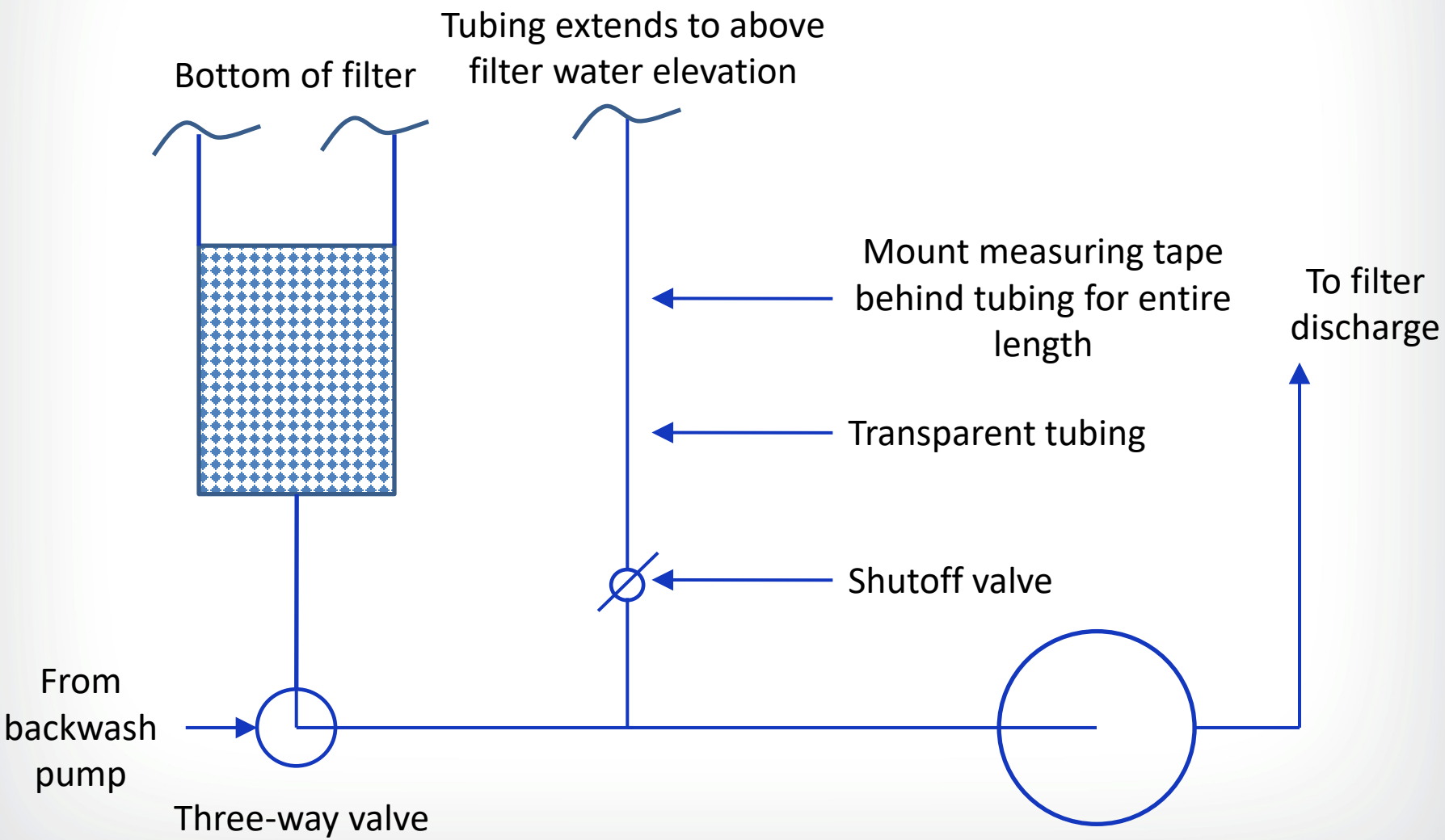
Media type & depth to replicate full-scale filter

Graded gravel or other system to support filter media and evenly spread backwash flow over cross sectional area of filter

If discharge is below the filter water elevation, then the pump will have to work against a slightly closed needle valve for optimum hydraulic stability

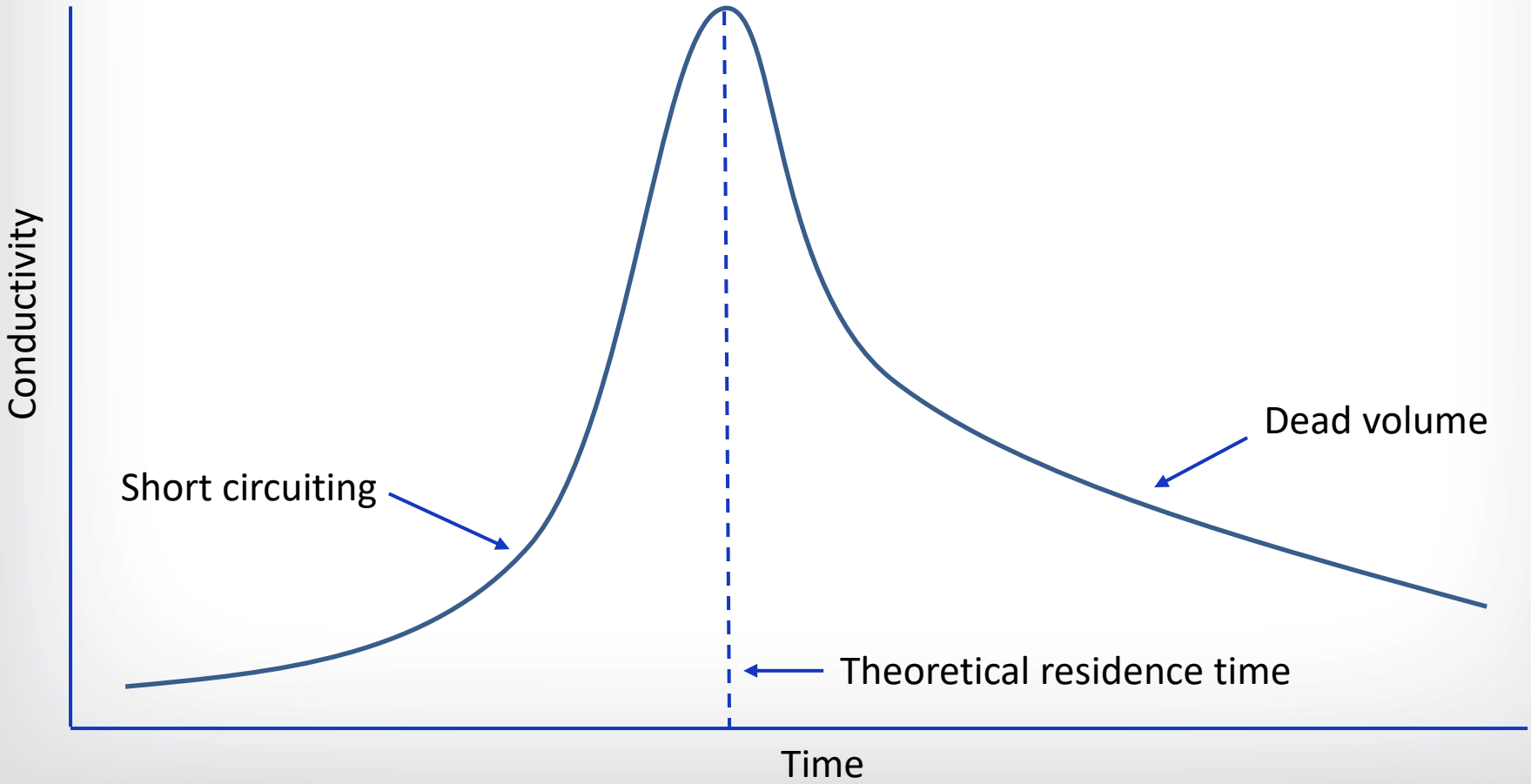
Regulate filter flow rate mostly with variable speed gear pump. Set flow rate to replicate full-scale surface loading rate

Design details – filter bottom



Tracer testing – the basics

- Sodium chloride is an effective tracer
- Measure changes in concentration with a conductivity probe
- Pulse input – application time interval << residence time of unit process to be tested



Conclusions

- Conventional treatment pilot testing provides treatment insight beyond that provided by jar testing:
  - How do changes in coagulant type and/or concentration affect downstream filtration performance?
  - How do coagulant changes interact with changes in filter media type?
  - How do coagulant changes interact with changes in filter operation?
- Materials of construction are readily available and relatively inexpensive
- Chemical feed and variable speed pumps are largest single expense item – but single upfront investment can last for years
- Working through detailed design (from manual) is well within the capabilities of entry-level engineers and scientists