The Metropolitan
Water Reclamation District
of Greater Chicago

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Metropolitan Water Reclamation District of Greater Chicago

FILTRATION TECHNOLOGIES FOR TERTIARY TREATMENT

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PRESENTATION OUTLINE

- Background/Introduction
  - Filter Problems at Hanover Park, John E. Egan, and James Kirie C. WRPs
  - M&O’s Filter Technology Investigation
- Filtration Basics
- Factors in Filter Technology Selection
- Objectives
- Methods
- Technology Discussion
  - Common/Emerging Filters
  - New Filters
- Results
- Conclusion

Background/Introduction

- Three of our WRPs Have Aged Gravity Filters:
  - Hanover Park WRP
    - High Rate, Single Media Sand Filters
      - Installation Date: 1966-1988
      - No of Filters: 8
      - Original-2@50 ft L × 12.5 ft W
      - 1st Expansion - 4@71 ft 10 in L × 16 ft W
      - 2nd Expansion - 2@110 ft L × 16 ft W

  - John Egan WRP
    - Installation Date:1975
    - High Rate, Dual Media Anthracite and Sand Filters
    - No of Filters: 12
    - 27 ft L × 19 ft W × 7.75 ft water depth

  - James Kirie WRP
    - Installation Date: 1980
    - High Rate, Dual Media Anthracite and Sand Filters
    - No of Filters: 12
    - 2 beds each@ 54 ft L × 13.5 ft W × 12.5 ft D

Filter Problems at Hanover Park WRP

- All 8 filters installed (1966-1988) had slowly degrading filter performance.
- Filter media is bypassed whenever secondary effluent was higher than filters can hydraulically handle.
    - At 14 MGD Flowrate, Bypass Occurs
- HPWRP noted that accumulation of sand media in the effluent channels of the filters (1-6) and jetting of filters cells showed that these filters were bypassing the flow internally (no treatment).
- Traveling bridge in filters (7-8) started to have alignment problems; rehabilitation did not help.
- Filters are taken off-line during backwash reducing overall hydraulic capacity of the filters.
- Filters attract midge fly.

Filter Problems at Egan WRP

- Filters are often bypassed under wet weather and certain process condition during non chlorination season if flow is more than 50 MGD.

- Filter media was replaced in 2009.

- Inefficient backwash system.

- Filters attract midge fly.

Kirie WRP Filters

- Currently, Kirie WRP does not use the filters because Kirie WRP meets its SS permit limit after secondary biological process (activated sludge) at Battery A, followed by final clarification.
- Also, Kirie WRP needs to pump prior to filtration, so they do not operate them in order to save on energy.
- If Kirie WRP determines that Battery B to be utilized for Bio P, then filtration will be required to meet Kirie WRP's SS limit.
- A feasibility study and our internal planning will determine whether Battery B needs to be converted for Bio-P or not.

Background/M&O's Filter Technology Investigation

- The multi-departmental vetting panel last year approved the Maintenance and Operations (M&O) Department's project of replacing the current gravity filter beds with disc filters:

  - Egan WRP – December 2016.
  - Hanover Park WRP–June 2016.

- With this approval, a request to M&O to investigate the applicability of an alternative filter technology as part of the final design was made.

- In response, the M&O Department earlier this year advised the M&R Department that disc filters are the only system found that will increase capacity in the same footprint as a gravity filter bed and address the midge fly problems.

How Vetting Panel Decided on Disk Filter Technology?

Three Key Criteria Used by M&O:

- Accountability
  - Disc Filters Have Less Maintenance Cost
- Excellence
  - Disc Filters Will Increase Capacity Which Will Reduce Suspended Solids Exiting the Plant
- Safety
  - Eliminate Midge Flies in the Filter Buildings and Surroundings

OTHER FILTER OPTIONS CONSIDERED BY M&O

- Replace Existing Media
- Replace Existing Media With Gravisand
- Retrofit to Aqua Diamond Cloth Media Filters
- All three options will continue to have the midge fly and bridge misalignment problems.
- The existing media or Gravisand will not increase filtration capacity.

What is Tertiary Filtration Treatment?

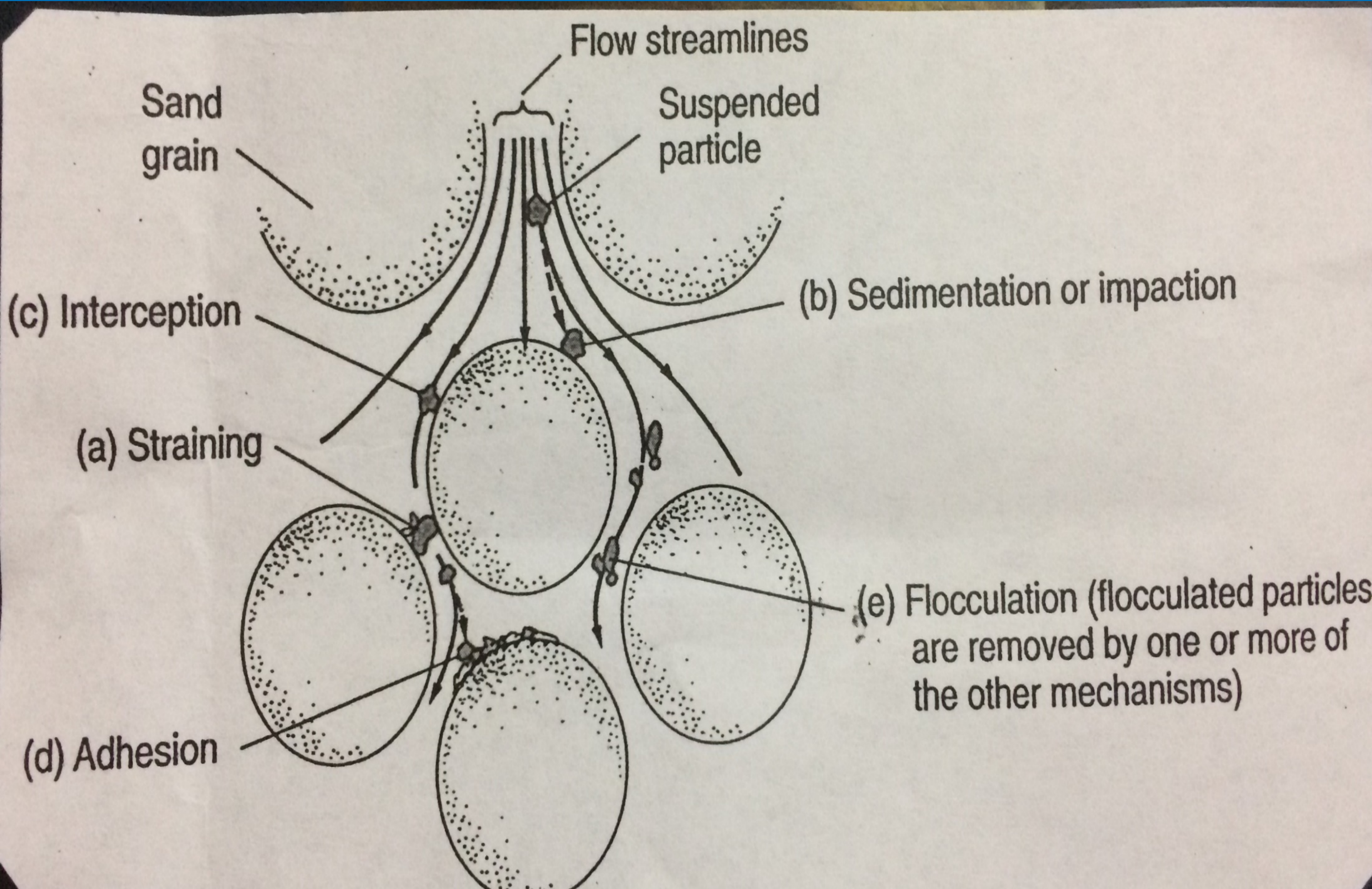
- Removal of residual suspended solids (after secondary treatment) usually by granular medium filters, cloth filters, or micro-screens.
  - Tertiary treatment is optional.
  - It is performed before disinfection to improve chlorination or UV radiation; and reuse applications.

- Disinfection/Nutrient removal are also typically a part of tertiary treatment.

What Are Fate Processes In Filtration?

- Suspended and colloidal solids are removed by:
  - Straining (mechanical and chance contact),
    - Mechanical straining:
      - Particles >> pore space of the filter medium are strained out mechanically
    - Chance contact:
      - Particles << pore space are trapped within the filter by chance contact
- Sedimentation or inertial impaction
  - Heavier particles that do not follow the flow streamlines settle on the filtering medium within the filter
- Interception
  - Many particles that move along flow streamlines are removed when they come in contact with the surface of the filtering medium
- Adhesion
  - Particles become attached to the surface of the filtering medium as they pass by.

Filtration Mechanism Schematic (Source Metcalf & Eddy, 5th Edition)



What Are Fate Processes In Filtration?

- Adsorption (physical or chemical): either one or both, may be responsible for holding particles right at the filtering medium surface.

- Biological growth: Occur within the filter, may enhance particle removal mechanisms discussed above, reduce the pore volume.

What Are Two Major Filtration Types?

- Depth Filtration
  - The removal of particulate matter suspended from a liquid by passing the liquid through a granular medium such as sand or anthracite coal.
  - This is what we have at Hanover Park, Egan and Kirie WRPs.
- Surface Filtration
  - The removal of particulate matter suspended in a liquid by passing the liquid through a thin septum, usually a cloth or metal medium.
  - Surface filtration is gaining in popularity because of the high quality effluent produced, smaller footprint, low backwash rates and reduced maintenance.
  - Disk filters belong to surface filtration.

What Are Some Important Factors in Selection of Filter Technology?

- Required effluent quality – depends on the final use of the effluent.
- Influent wastewater characteristics – less variation or stable turbidity of secondary treated effluent is better.
- Type of Filter: proprietary vs. individually designed.
- Proprietary – responsibility lies with the manufacturer.
- Individually designed – responsibility lies with the design engineer.

What Are Some Important Factors in Selection of Filter Technology?

- Filtration Driving Force – Gravity or Pressure (Gravity is less energy intensive).
- Number and size of filtration units – should be kept to a minimum to reduce the cost of piping and construction.
- Backwash water requirements – should be low.
- Chemical addition – site specific, depends on the final use of the effluent.
- Standby redundancy – one standby filter as minimum is recommended for standby service.

M&R Objectives

- Conventional/Emerging and New filter technologies for tertiary treatment currently available on the market;

- To briefly discuss each processes, its performance, advantages and disadvantages; and

- State any indication of use at other utilities if information are available.

Methods

- Internet Research.
- Reviewed 2013-2016 WEFTEC proceedings and exhibitor information.
- No New Filter Technology was found in 2017 WEFTEC Exhibit.
- Contacted utilities and filter manufacturers.

A LIST OF FILTER TECHNOLOGIES

Name	Classification	Filration Mechanism	Media
Disc Filters	Common/Emerging	Surface Filtration	Cloth, Nylon, Stainless Steel
Traveling Sand Filters	Common	Depth Filtration	Sand/Anthracite
Deep Bed Upflow Continuous Filters	Common	Depth Filtration	Sand
Membrane	Common/Emerging	Surface Filtration	Varies
Fuzzy Ball Filters	New	Depth Filtration	Synthetic media
Reactive Media Filters	New	Depth Filtration	Sand
VeSave	New	Surface Filtration	Not Known

Common/Emerging Technologies: Disc Filters

- They are based on a high-rate filtration process technology and are used under partially submerged conditions.
- They are composed of multiple rotating filter discs with a defined filter pore size from 10 to 100 microns.
- The filter medium is made up of materials such as cotton, polyester, or wool.

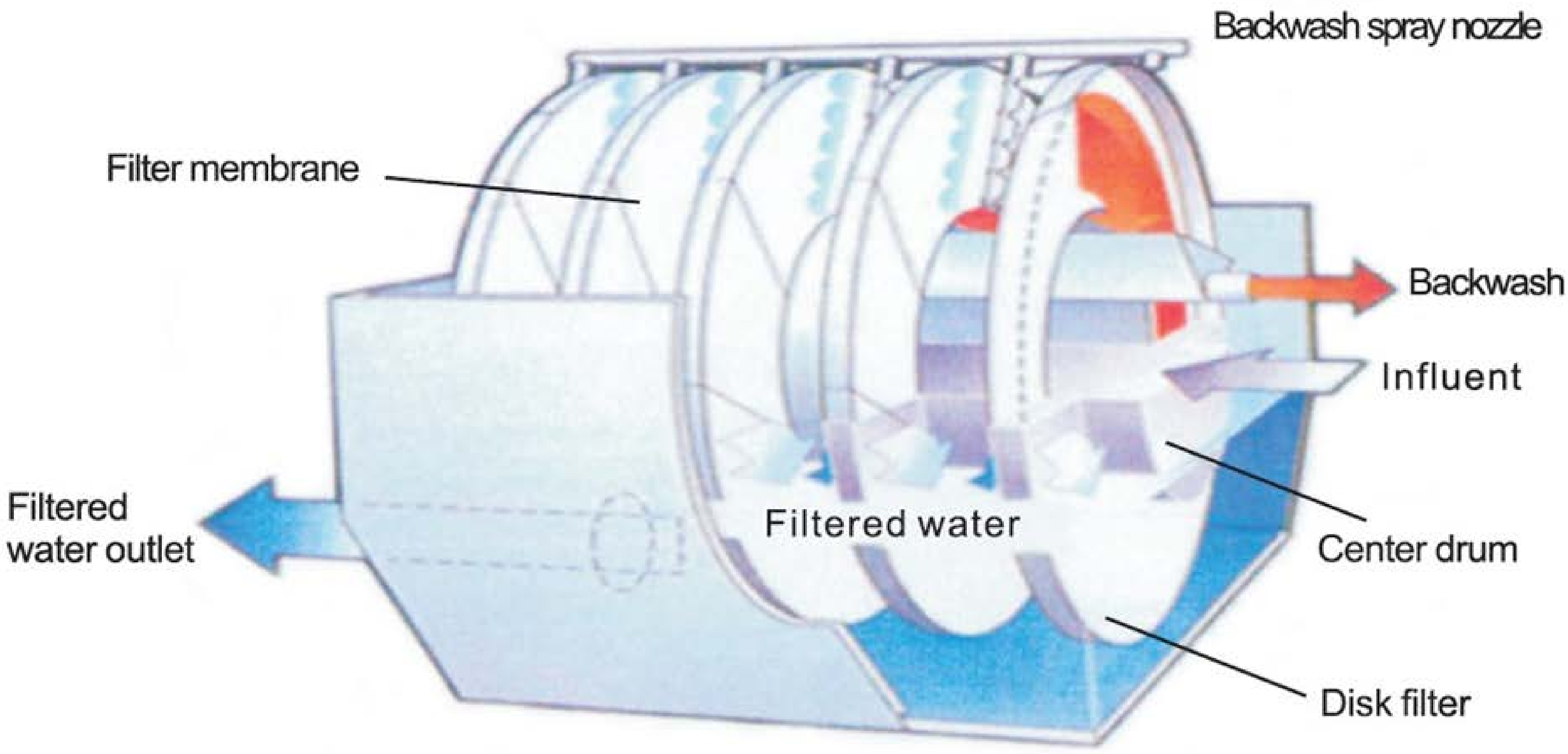
Disc Filters

- Influent wastewater is fed into the system and flows by gravity into the filter discs where the suspended solids are then separated and accumulate on the surface of the filter fabric.

- The filtered effluent is then directed to the discharge side of the filter.

- As the solids are collected on the filter media the influent level increases and signals a backwash cycle.

A Schematic Showing Disc Filters Operation



Disc Filters Advantages

- Provides a high quality effluent;
- Simple operation and maintenance;
- Reduced footprint;
- Operates with minimal head-loss;
- Needs small backwash volumes;
- Minimal site assembly;
- Fully automated;
- Continues to filter even during a backwash cycle;
- Easy for retrofit applications because they are modular in design; and
- Filter elements can be replaced while the filter remains in service

Disc Filters Disadvantages

- Difficulty meeting the peak flow if one filter is taken out of service without redundancy;
- Filter surface is susceptible to mineral fouling and chemicals used in upstream processes such as polymers;
- Short life span of filters; and
- If filters are not contained in an enclosed structure, midge fly problem may still exist.

Media Filters Replaced by Disc Filters Midwest Examples

- The Village of Glendale Heights, Illinois (2011)
- The City of Oconomowoc's Wastewater Treatment Plant/in Wisconsin (2008)
- The Cadillac WTP located in Cadillac, Michigan (2008)
- The Village of Sutton Bay's WTP located in Michigan (2006)
- Urbana-Champagne Sanitary District WTP (2006).
- The Flagg Creek Water Reclamation District (Flag Creek WTP)/ Burr Ridge, Illinois (2014)
  - A Flag Creek WTP representative stated that this technology uses less energy and provides better processing.

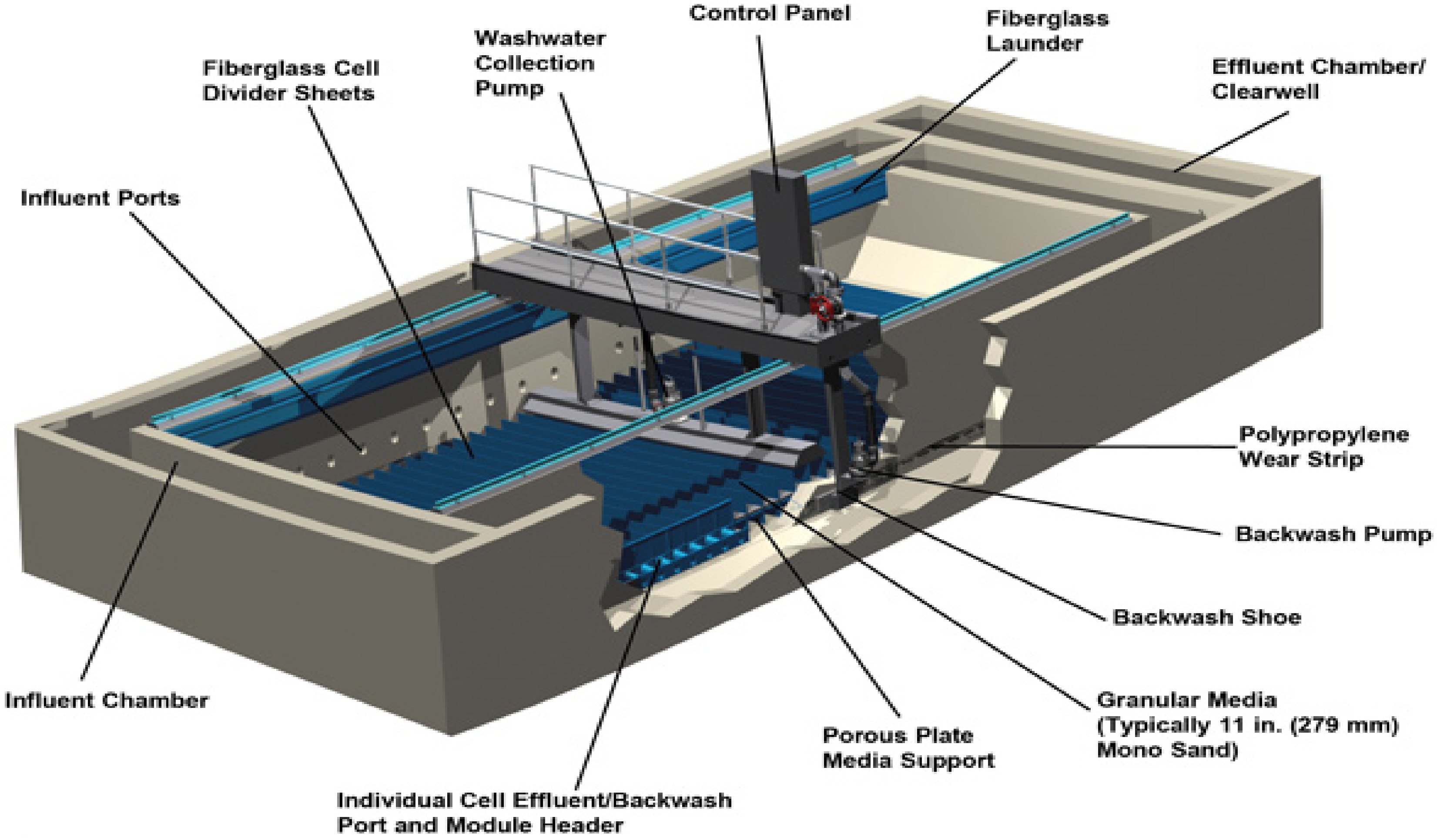
Common Filters: Travelling Bridge Sand Filters

- For traveling bridge sand filters:

  - Influent wastewater flows through deep granular sand beds by gravity and exits into a clear well through a porous plate underdrain.

- A filter bed is divided into independent filter cells and each cell is backwashed separately by an overhead traveling bridge assembly, while the other cells remain in service.

Schematic of a Travelling Bridge Sand Filters



Advantages and Disadvantages and Local Use of Travelling Bridge Sand Filters

- The advantage of this technology is infrequent media changeover.
- Disadvantages of this technology are:
  - Large foot-print;
  - High power consumption;
  - Large volume of backwash water; and
  - Potential midge fly problem.
- Fox Metro Water Reclamation (Fox Metro) installed Aqua-Aerobic System’s traveling bridge sand filters for tertiary filtration in the late 1970s.
- In 2005, Fox Metro retrofitted one of the traveling bridge sand filters with Aqua-Aerobic System’s diamond cloth filter to better handle high flows with high solids loading.

Common Filters: Deep Bed Upflow Continuous Backwash Sand Filters

- For this technology, influent is introduced into the bottom of filter where it flows upward through a series of riser tubes and exits the filter.
- Sand particles and trapped solids are drawn downward into the suction of an airlift pipe.
- A small volume of compressed air draws sand, solids, and water upward.
- At the top of the airlift, the dirty slurry spills over into a central reject compartment.
- Sand settles and is cleaned further as it moves down through a washer.

A Schematic of a Deep Bed Upflow Continuous Backwash Sand Filters

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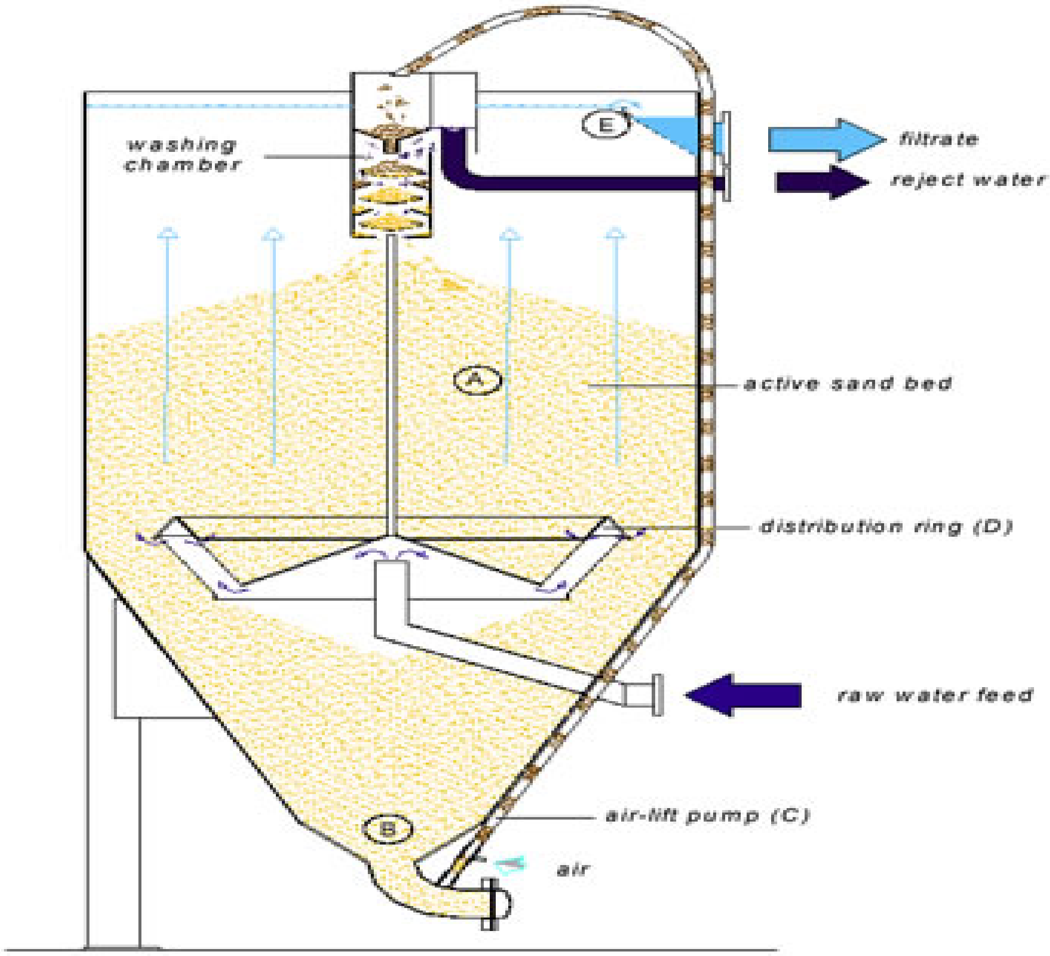


Deep Bed Upflow Continuous Backwash Sand Filters

- One example is the Parkson's DynaSand Filter.

- Our search was not able to find a local application.

- Advantages of this technology are:
  - Low power requirement;
  - Reduced operator attention; and
  - Very high filtrate quality.

- A disadvantage: is difficult to retrofit our current system.

Common/Emerging Technologies: Pressure Filters

- They operate in the same manner as gravity filters and are used at smaller plants.

- Filtration operation is carried out in a closed vessel under pressure condition; this is the only difference from gravity filters.

- Pressure filters are normally operated at higher terminal head-losses, resulting in longer filter runs and reduced backwash requirements.

Membrane Filters

Advantages

- An order of magnitude (x 10) better effluent turbidity than other filtration technologies.
- Provides adequate pretreatment ahead of reverse osmosis

Disadvantages

- Higher construction and operating cost than other disk and media based filtration technologies

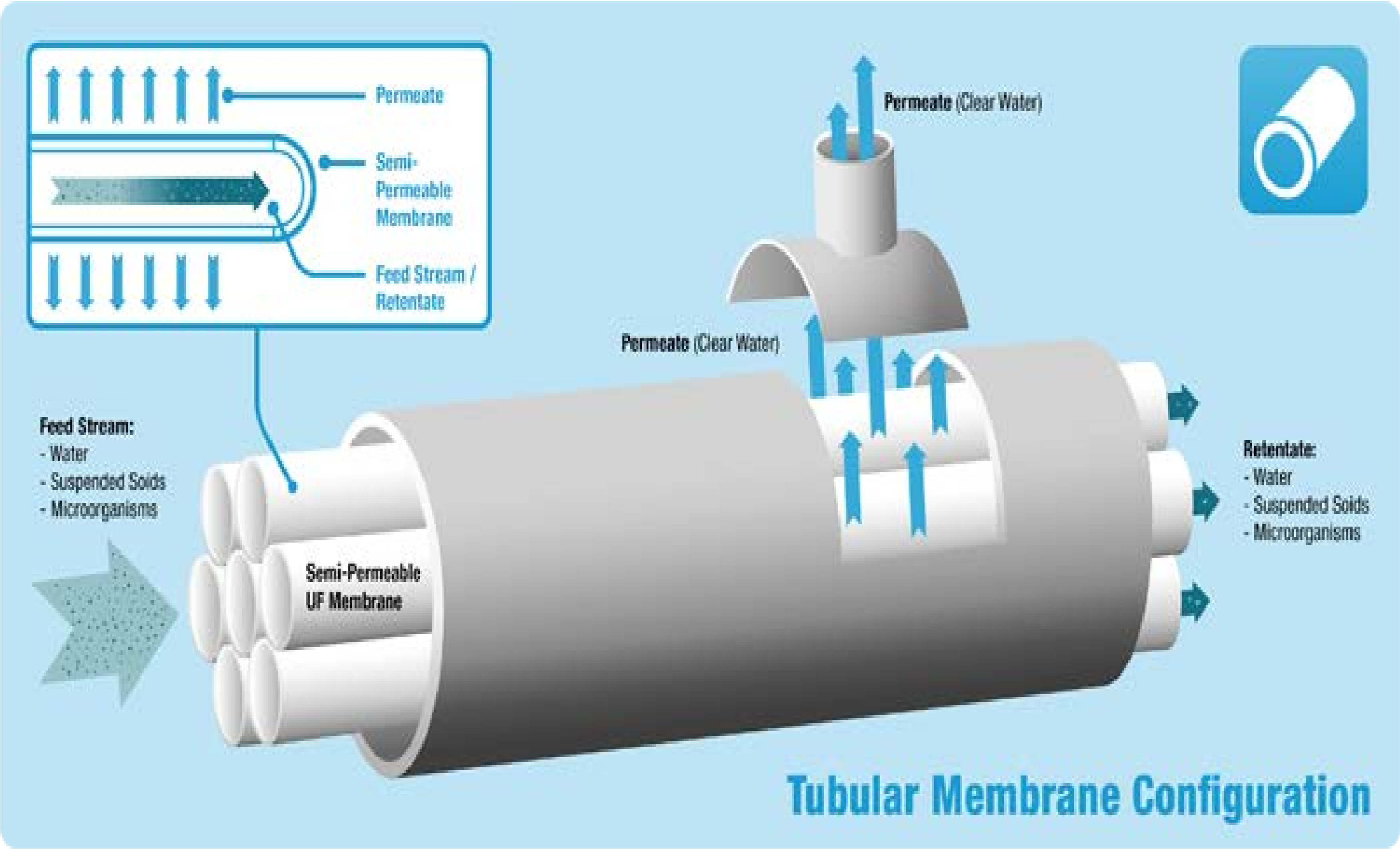
Remarks

- May require flow to be pressurized through membrane filters.
- Energy intensive.

Notes:

- Due to energy intensive in nature and flow limitations, membrane filters were not researched.

Tubular Membrane



Membrane Filters Variation

- Hollow Fiber
- Spiral Wound
- Plate and Frame

New Filters

- The WEFTEC review identified two new filter technologies beyond the known conventional media, membrane, and disc filters.

- They are:
  - Fuzzy ball technology; and
  - Reactive media filter technology.

Fuzzy Ball Technology

- Technology Origin

  - It was developed originally in Japan;

  - Based on a synthetic medium filter (as discussed in next slide); and

  - Is used for reclaimed water filtration.

Fuzzy Ball Technology

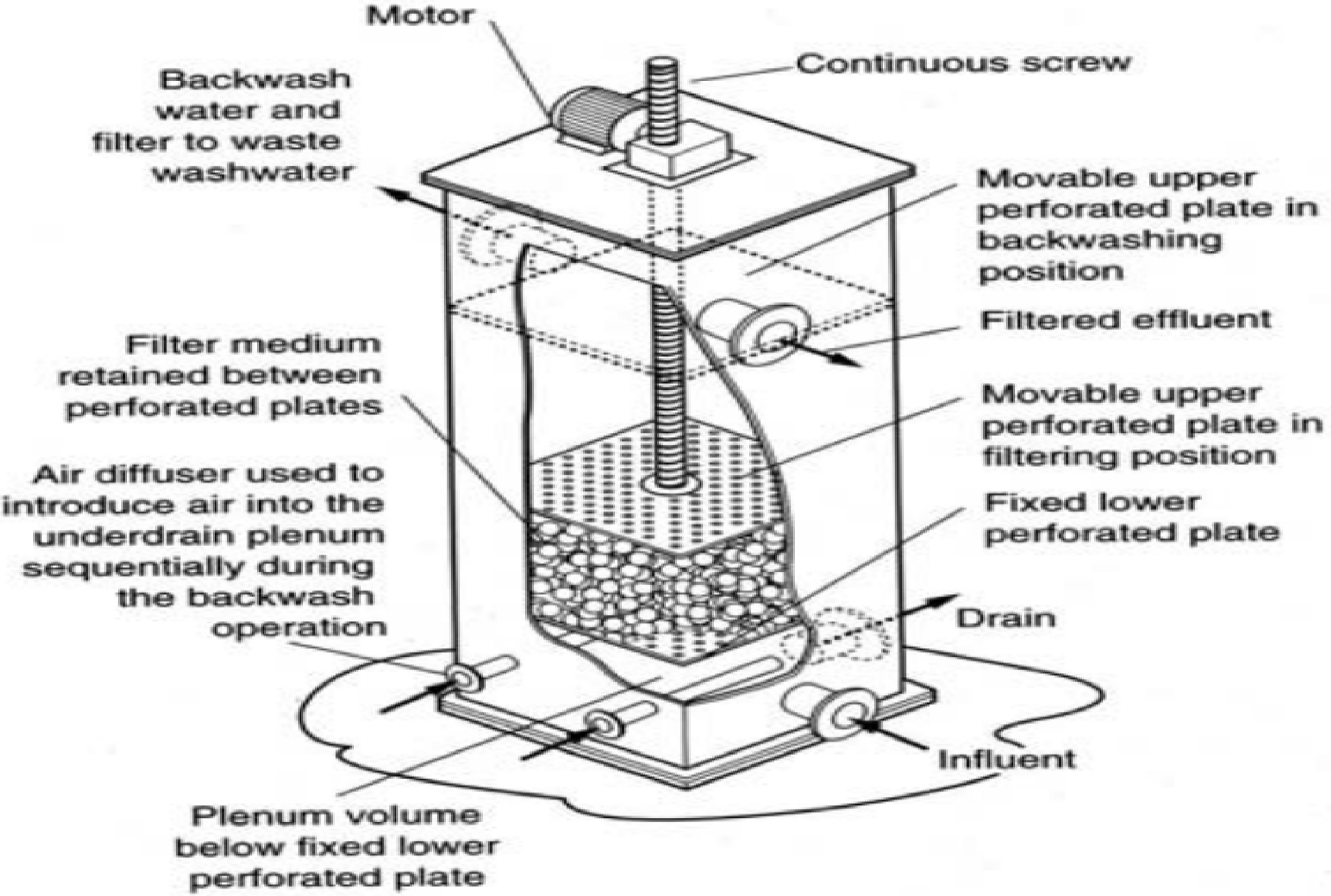
- Description of Technology

  - This is a compressible media, high-rate filtration technology that uses a synthetic media made from a high grade polymer (polyphenylene sulfide).

  - Influent is introduced in the bottom of the filter and flows upward through filter medium (as opposed to flowing around the media as in sand and anthracite filters).

  - The upper porous plate is lowered mechanically, compressing the media, and filtering the influent.

Fuzzy Ball Technology-Schematic



Fuzzy Ball Technology

- Benefits of the fuzzy filter consist of:
  - High-rate filtration up to 40 gallons per minute/square foot,
  - Small footprint,
  - Low-backwash reject water, and
  - Easy maintenance.

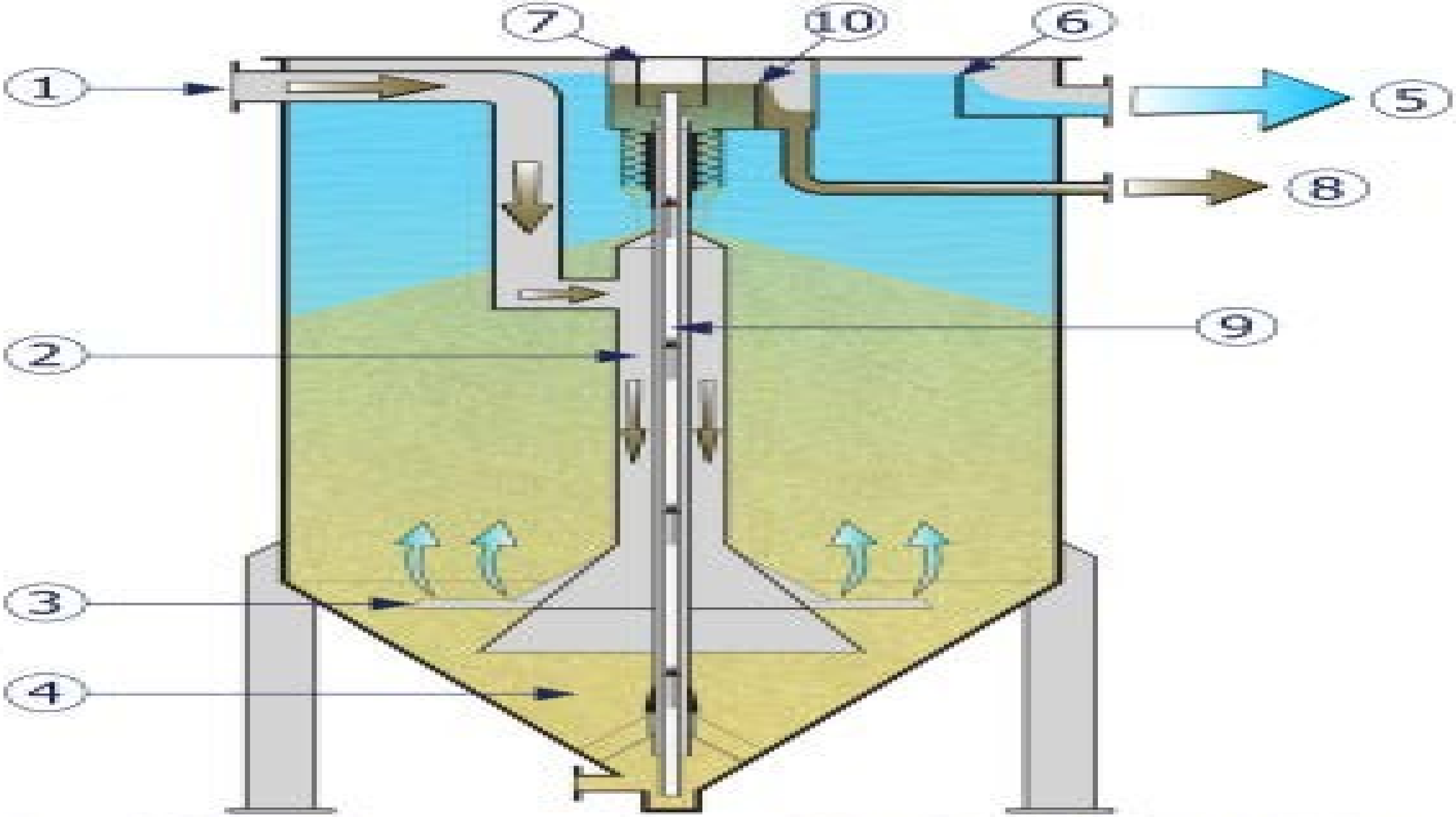
Fuzzy Ball Technology

- Local US Installations:
  - Northeast Water Reclamation Facility, Clayton County, Georgia;
    - Nine Filters
    - Monitor Turbidity and Ortho-P
    - Meet TP limit (monthly average 0.3 mg/L)
    - $52K/Filter
  - The Lakes Area Sewer Authority Wastewater Treatment Plant, Cass County, Michigan; and
  - Upper Montgomery Joint Authority Wastewater Treatment Plant, Montgomery, Pennsylvania.
    - No filters currently.
    - Filters are totally a new upgrade to meet TP limit of 1 mg/L, and TN limit of 6 mg/L.

Reactive Media Filter Technology

- This is a local technology from Blue Water Technologies Company (Idaho).
- Technology Description:
  - This is a continuous backwash gravity sand filter.
  - The sand media is coated with hydrous ferric oxide to achieve low level phosphorous in the effluent.
- Our review identified three completed installations of this technology as stated below:
  - Hayden wastewater treatment plant (WTP), Idaho
    - Just pilot for arsenic removal
  - Georgetown WTP, Colorado, and
  - Westerly WTP, Marlborouh, MA.

Reactive Media Filter Technology Schematic



1. Influent
2. Central Feed Chamber
3. Radial Arms
4. High Quality Silica Media
5. Filtrate
6. Fixed Effluent Weir
7. Washbox
8. Reject
9. Airlift
10. Adjustable Weir

FILTERS REMOVING MICROPLASTICS

- KD Group, a Danish Wastewater Equipment Company claims their own special membrane technology (VeSave®) captures:

    - All microplastics along with bacteria, impurities and other particles from wastewater.

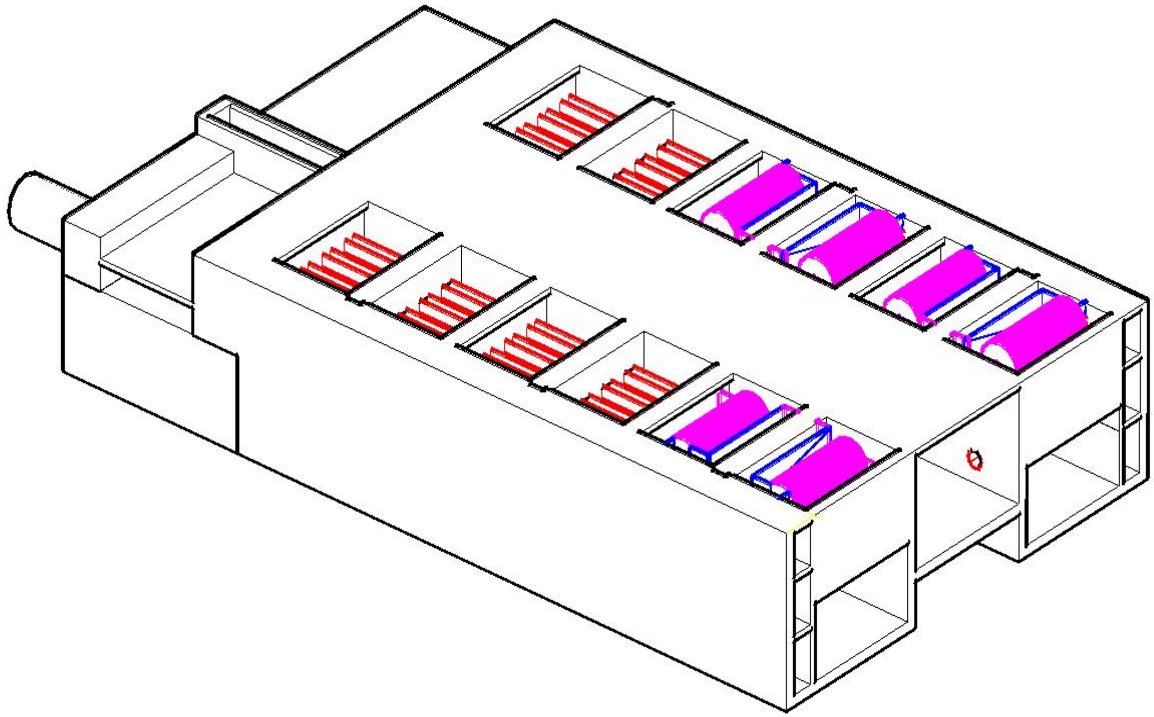
HPWRP/Egan WRP Filter Replacement Status

- Hanover Park and John Egan WRPs are in the process of replacing their gravity filters with disk filters.

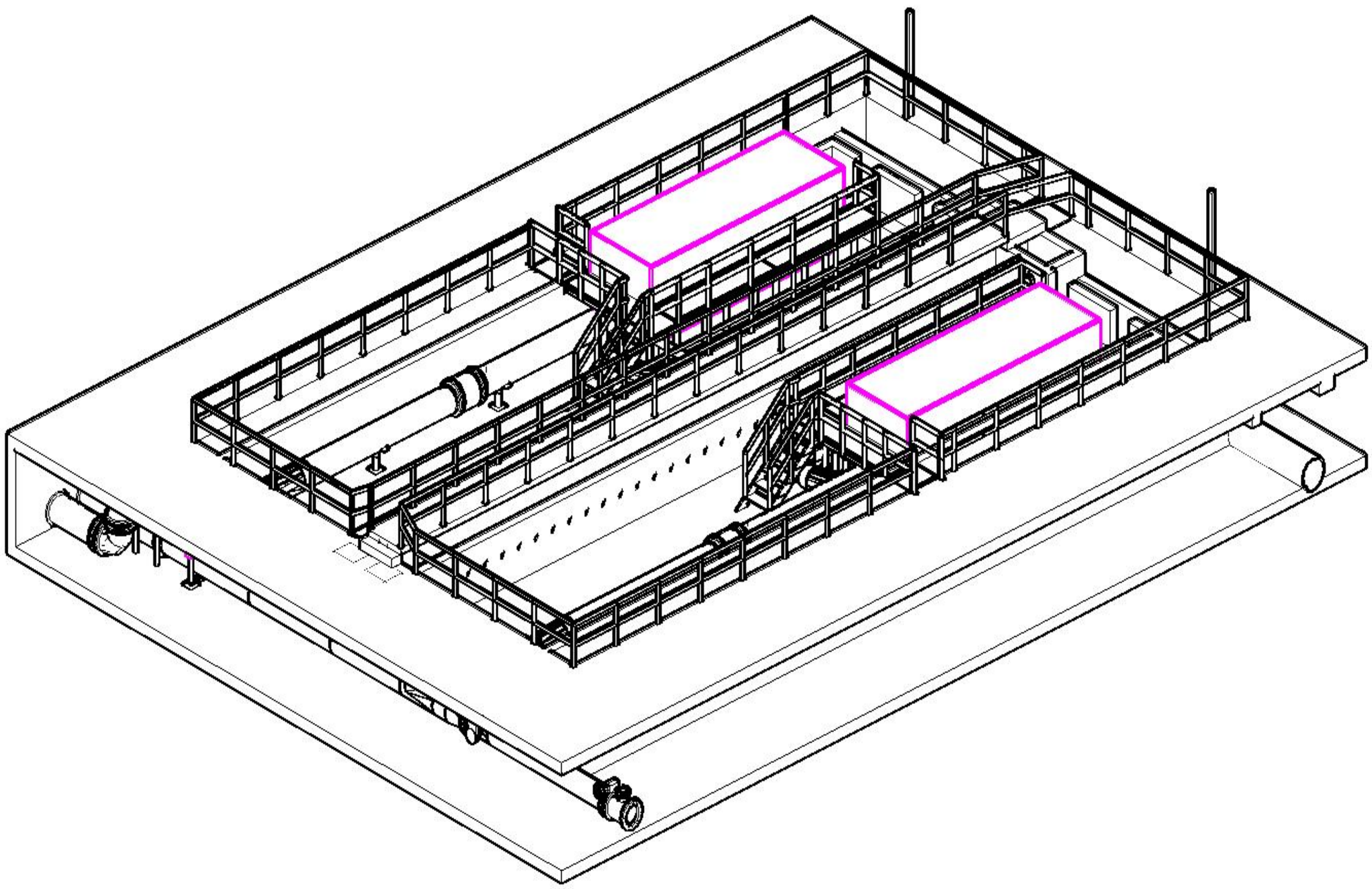
- HPWRP
  - Furnish, Deliver and Install Type Contract
    - Two new disc filters
    - Filter Bed: 1149 sq.ft. Disc Filter: 167 sq.ft.
    - $1.3 M Capital Cost,
    - O&M cost data N/A (but will be less than the existing system)
    - Contract Awarded Recently
    - 2018 1st Quarter Installation

- Egan WRP
  - Furnish, Deliver and Install Type Contract
    - Six -10 MGD new disc filters,
    - Sand Filter: 486 sq.ft. Disc Filter: 170 sq.ft.
    - $3.2M Capital Cost,
    - O&M cost data N/A (but will be less than the existing system)
    - Contract Not Awarded Yet
    - Tentative Installation Date: 2018 3rd Quarter

PLAN VIEW OF EGAN'S PROPOSED NEW FILTERS LAYOUT



PLAN VIEW OF HPWRP's PROPOSED NEW FILTERS LAYOUT



Summary/Conclusion

- EM&RD’s separate investigation supports M&O Department’s decision to go with disk filters at our Egan and Hanover Park WRPs.

- This is mainly due to disk filters’ smaller footprint, less energy and avoids midge fly problem.

Disclaimer

- Mention of proprietary equipment/technology, any commercial venture’s or company name, in this presentation is just for illustration purpose only, does not constitute endorsement by MWRD of Greater Chicago.

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