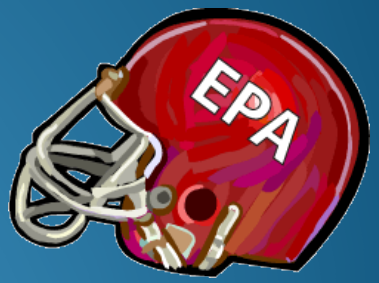
New Dischargers Tackle Issue of Stricter Phosphorus Limits

WWOA 47th Annual Conference
October 24, 2013



Dave Diehl
Applied Technologies, Inc.

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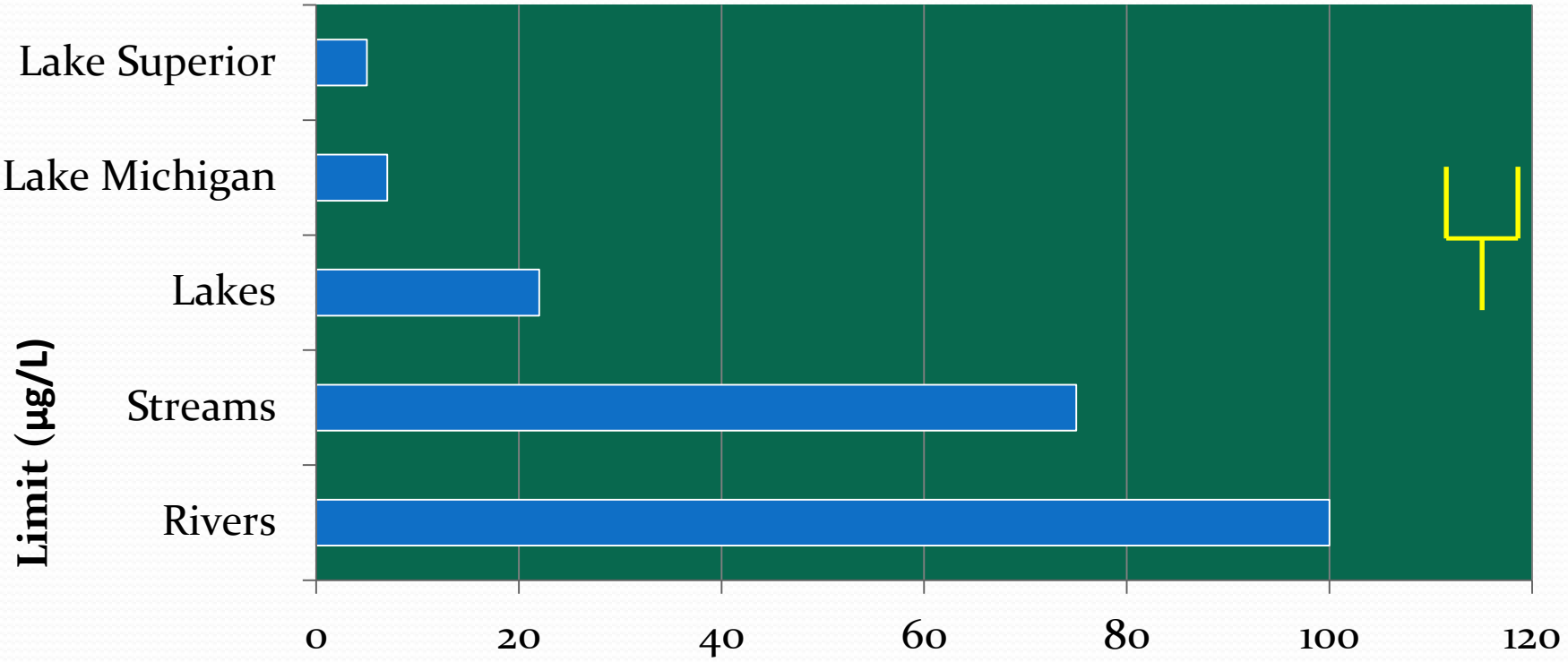
Overview

- Wisconsin phosphorus regulatory update
- Big Bend Facilities Plan
- Phosphorus removal alternatives and evaluation
- Alternative recommendation

Phosphorus Rules

- Revisions to Wisconsin's Phosphorus Water Quality Standard became effective on December 1, 2010
- Reflected in Wisconsin Administrative Code - Chapter NR 102 and Chapter NR 217

Phosphorus Limits



Exclusions: ephemeral streams, limited aquatic life, wetlands, small lakes less than 5 acres in surface area

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Phosphorus Rules

NR 217.17 Schedule of Compliance

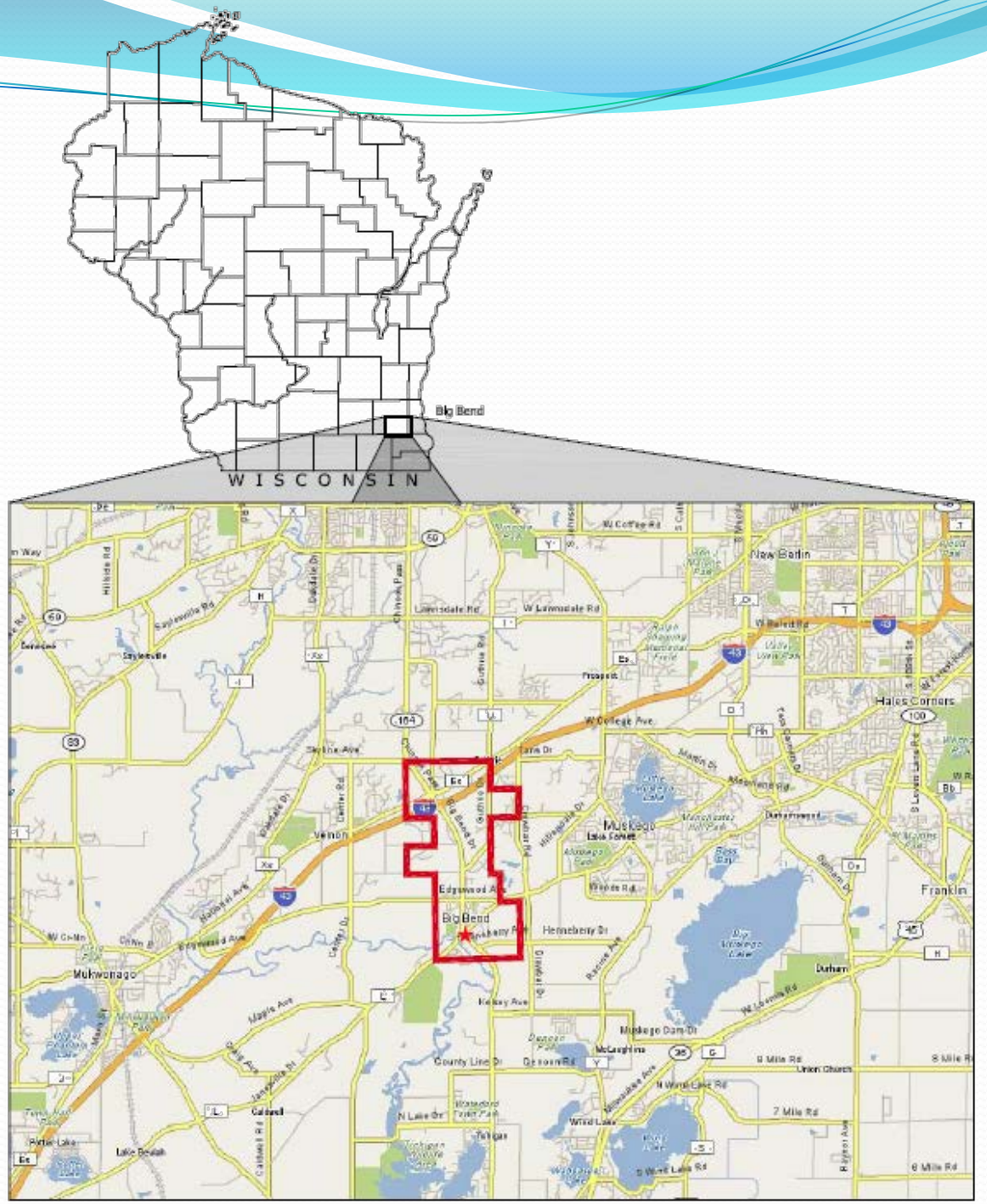
(2) Maximum Compliance Schedule Period – Where compliance with the water quality based phosphorus limit requires the construction of filtration or a similar phosphorus removal process, the department may grant a compliance schedule not to exceed **nine years** from the date that the permit is first reissued or modified to include effluent limitations developed under provisions of this subchapter

New Dischargers

NR 217.17 Schedules of Compliance

(4) New Dischargers. Any new discharger may not receive a compliance schedule to achieve compliance with a phosphorus water quality based effluent limitation

Village of Big Bend



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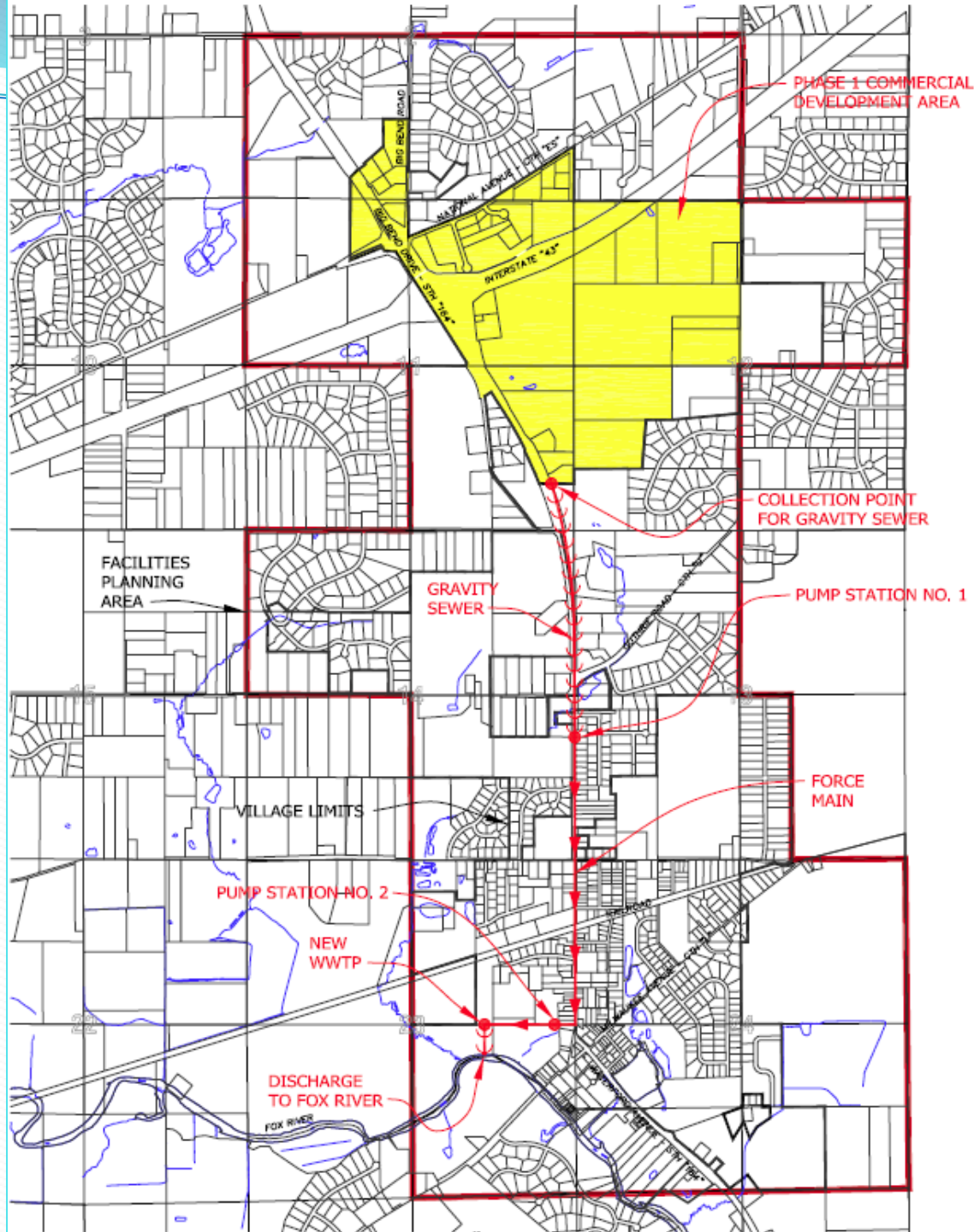
Statistics

- No current wastewater treatment plant
- No current collection system
- Original Facilities Plan written in 2007, approved in November 2010
  - Recommended alternative is construction of a new treatment plant

Original Playbook (Facilities Plan)

- New treatment plant
- Extended aeration activated sludge
- Design annual average flow: 366,000 gpd
- Two phases – First phase: 100,000 gpd from commercial area
- Discharge to Fox River
- Phosphorus limit of 1.0 established

Facilities Planning Area



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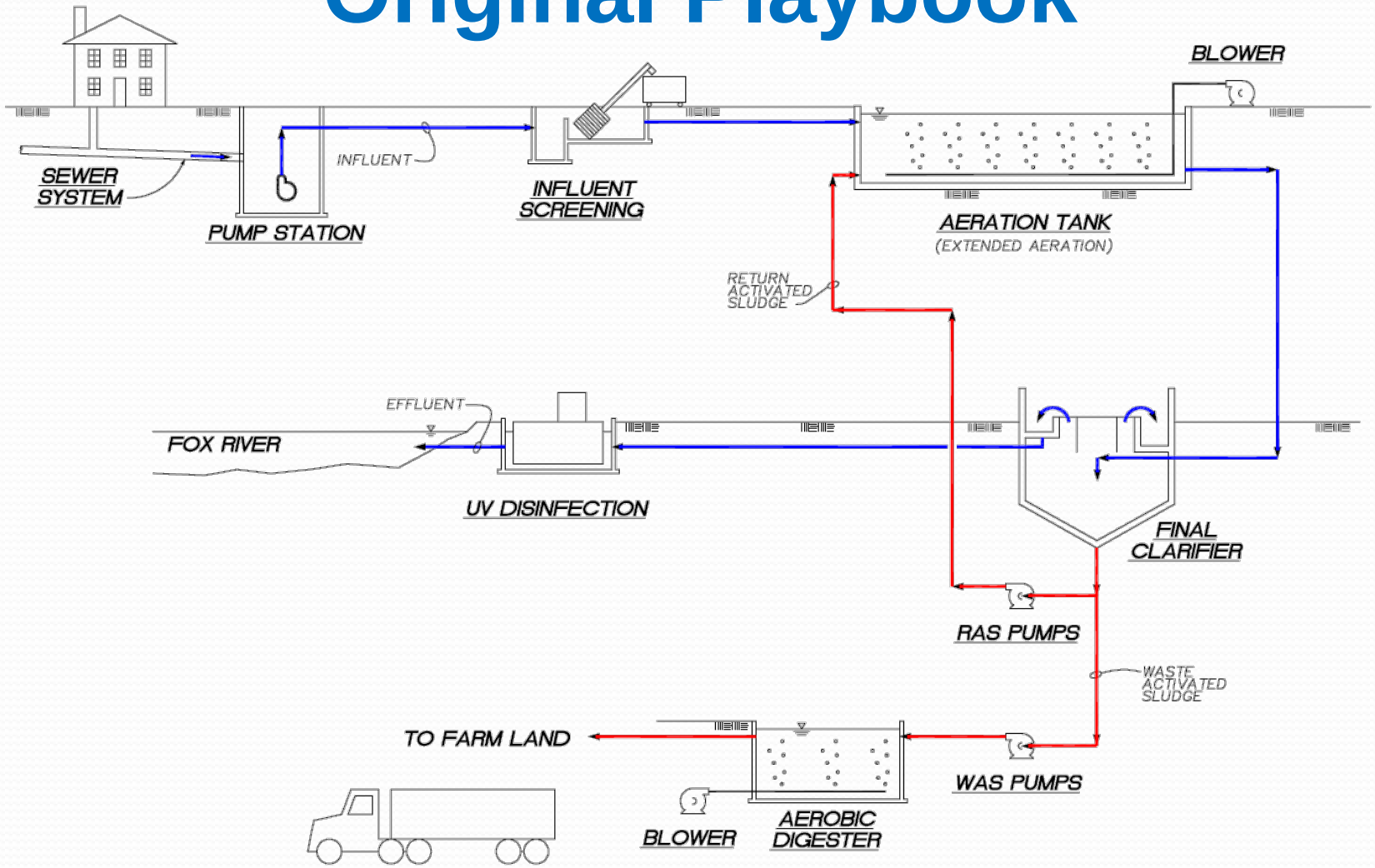
Original Playbook



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Rules Updates

NR 102.06 Phosphorus

(3) (a) A total phosphorus criterion of 100 ug/L is established for the following rivers or other unidirectional flowing waters

15. Fox River from confluence with Mukwonago River near Mukwonago to state line, excluding Tichigan Lake

New Rules

- Must meet new phosphorus effluent limit on Day 1
  - Permit will be expressed as an annual average concentration limit of 0.1 mg/L and an annual mass limit
    - Monthly average concentration limit of 0.3 mg/L
  - 1/10 of the previous effluent limit
  - Treatment technology included in 2007 Facilities Plan is not sufficient to meet limit

Challenges

- Challenges
  - No ability to pilot test
  - Phased construction

Phosphorus Removal Alternatives

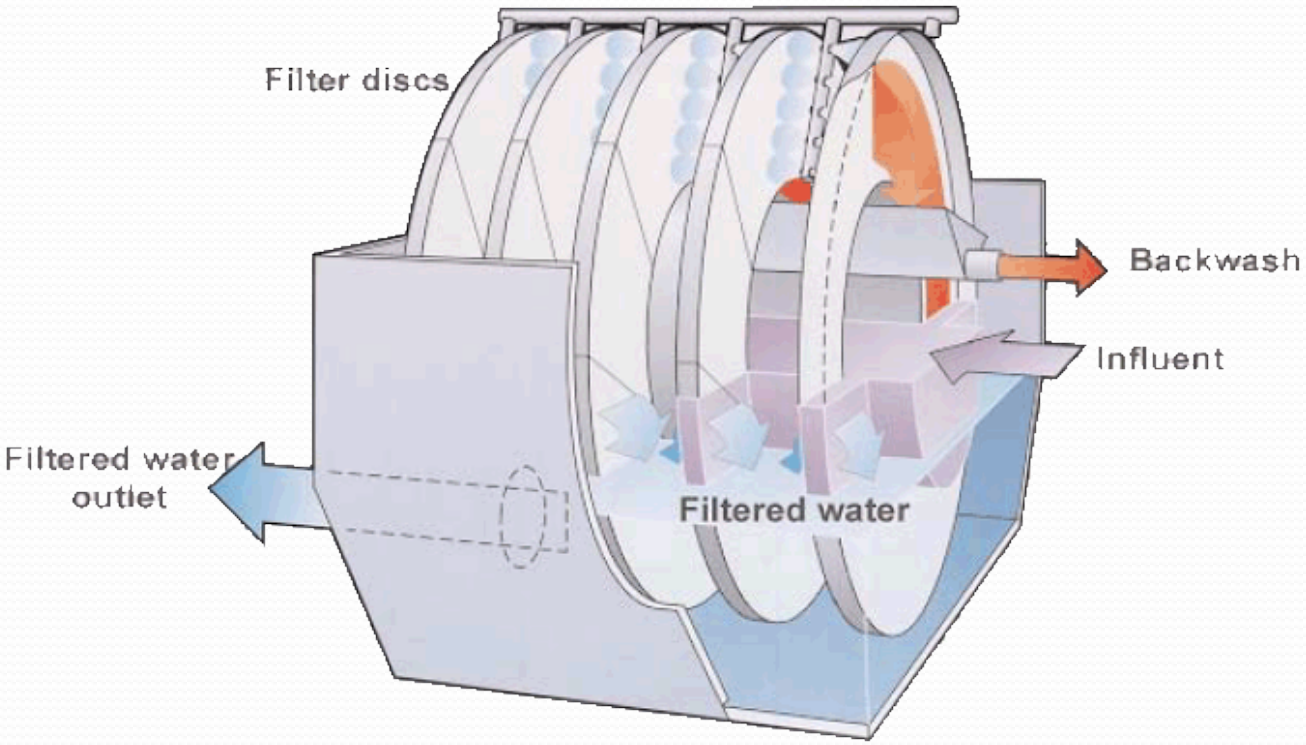
Alternatives

1. Disc Filters
2. Ballasted Flocculation
3. Upflow Gravity Filter
4. Membrane Filtration
5. Membrane Bioreactor

Disc Filters

- Tertiary treatment
- Cloth filters with approximate 10 μm pore size
- Backwashing to remove deposited solids
- Modular for easy expansion
- Chemical addition required

Disc Filters

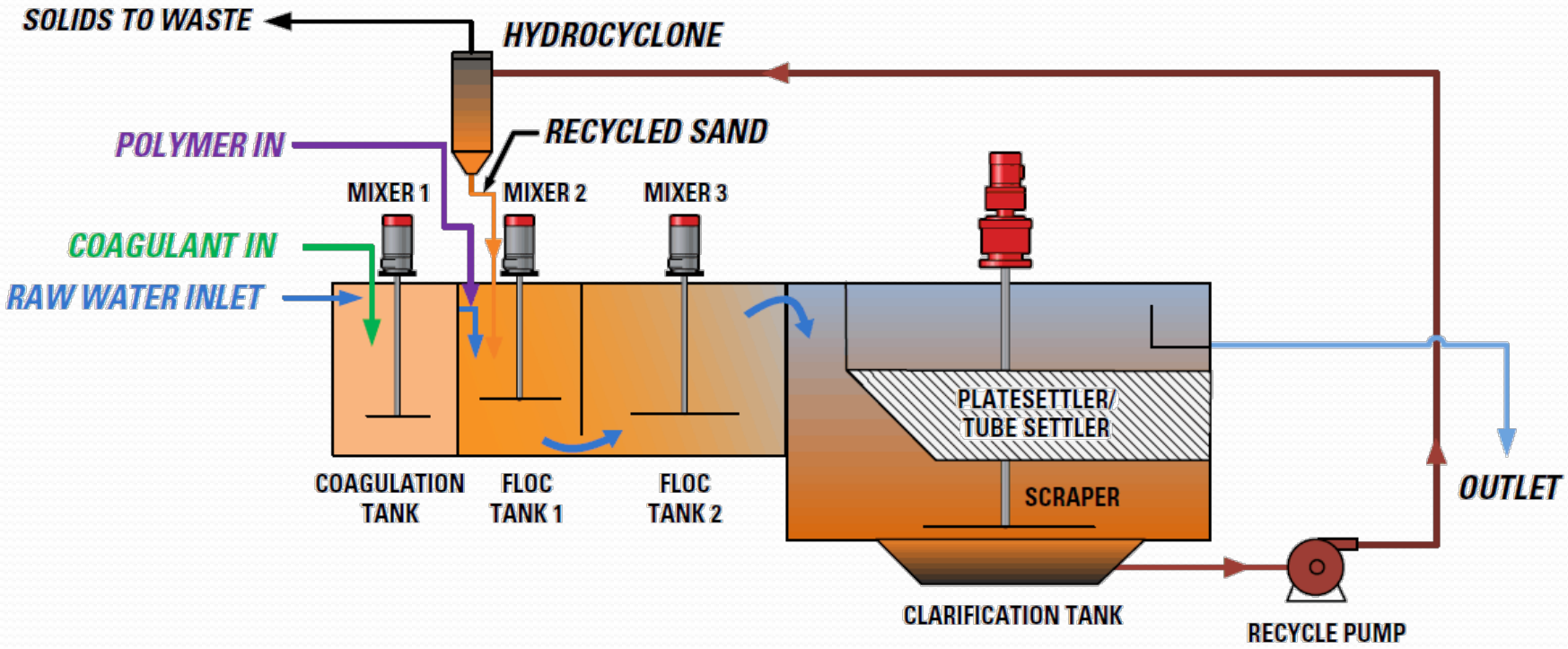


(Courtesy of Veolia)

Ballasted Flocculation

- Tertiary treatment
- Polymer coated sand or magnetite (proprietary) added
- High rate clarification
- Ballasted floc rapidly settles
- Chemical addition required

Ballasted Flocculation



(Courtesy of WesTech)

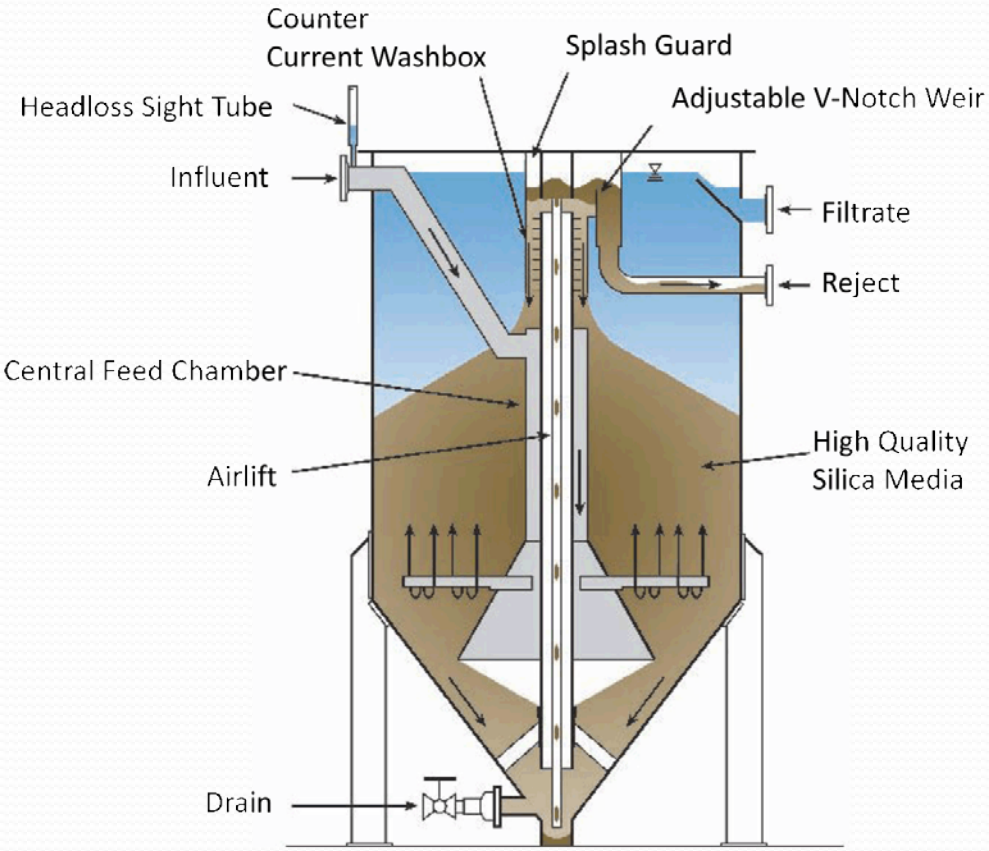
Ballasted Flocculation

- Advantages
  - Treat wide range of flows without reducing removal efficiency
- Disadvantages
  - Limited growth potential
  - Large amount operator judgment and attention
  - Long startup time

Upflow Gravity Filter

- Tertiary Treatment
- Chemical addition required
- Modular for easy expansion
- Lower operator attention
  - No moving parts, screens, level controllers, or valves

Upflow Gravity Filter



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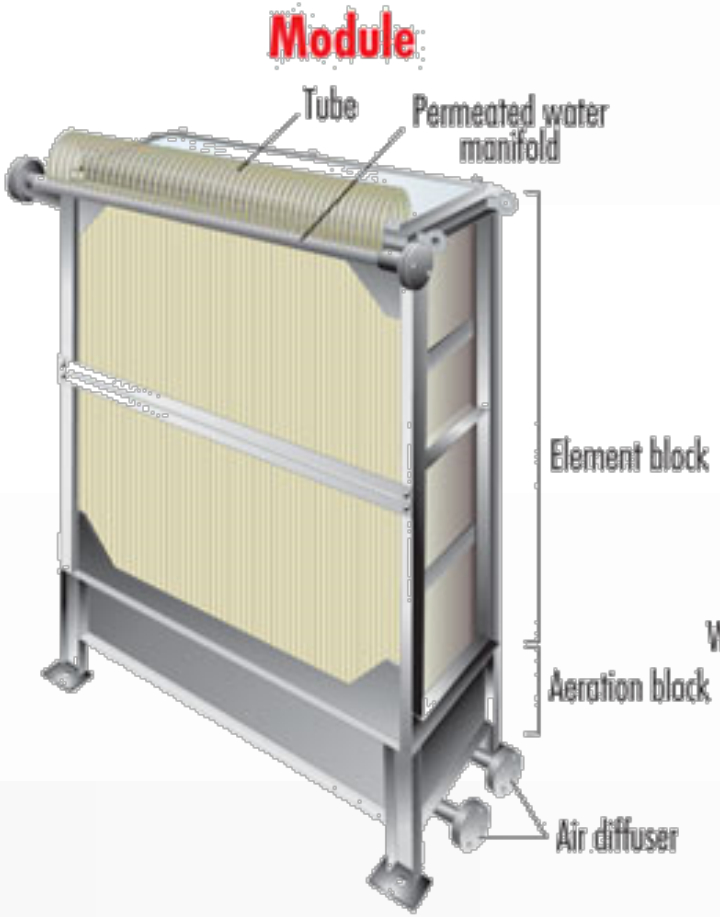
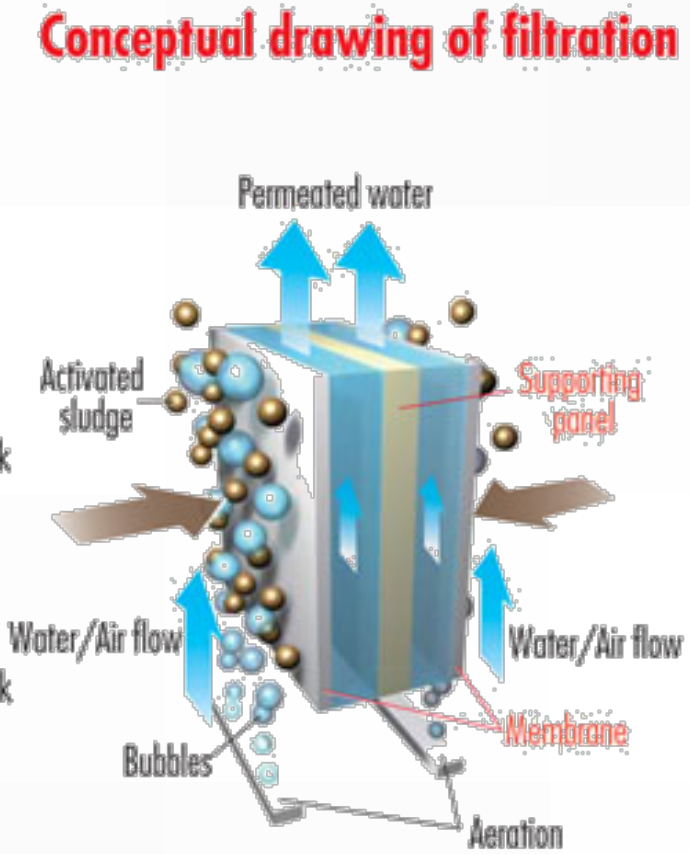
(Courtesy of Five Star Filtration)

Membrane Filtration

- Tertiary treatment
- Chemical addition required
- Ultrafiltration: ~0.04 to 0.4 μm pore size
- Sized to handle peak flow of twice the daily influent flow
  - Less flexibility adapting to flow rates
- Modular for easy expansion
- Automated for reduced operator attention

Membrane Filtration





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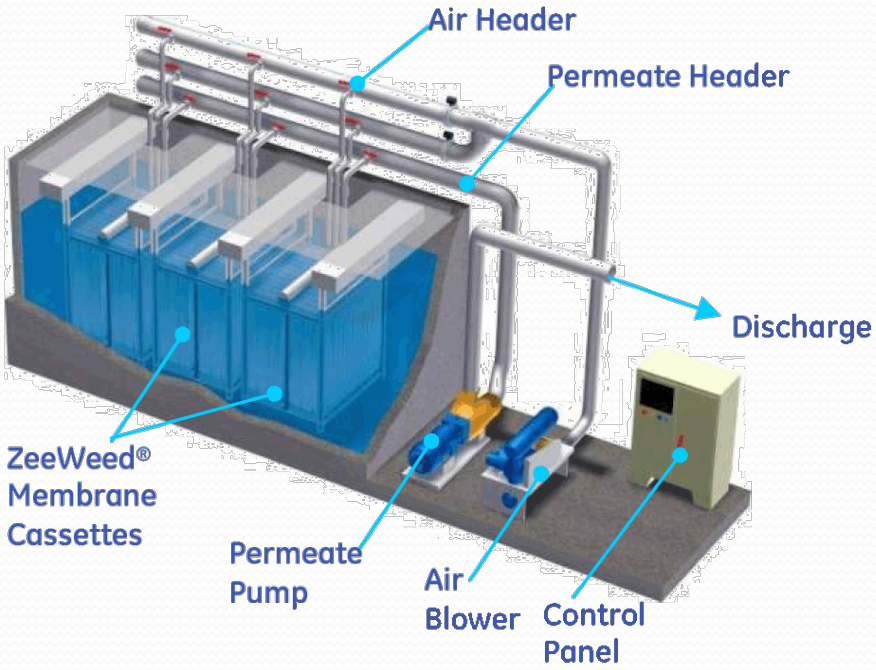
(http://www.pure-aqua.com/package-membrane-bio-reactor.html#)

Membrane Filtration

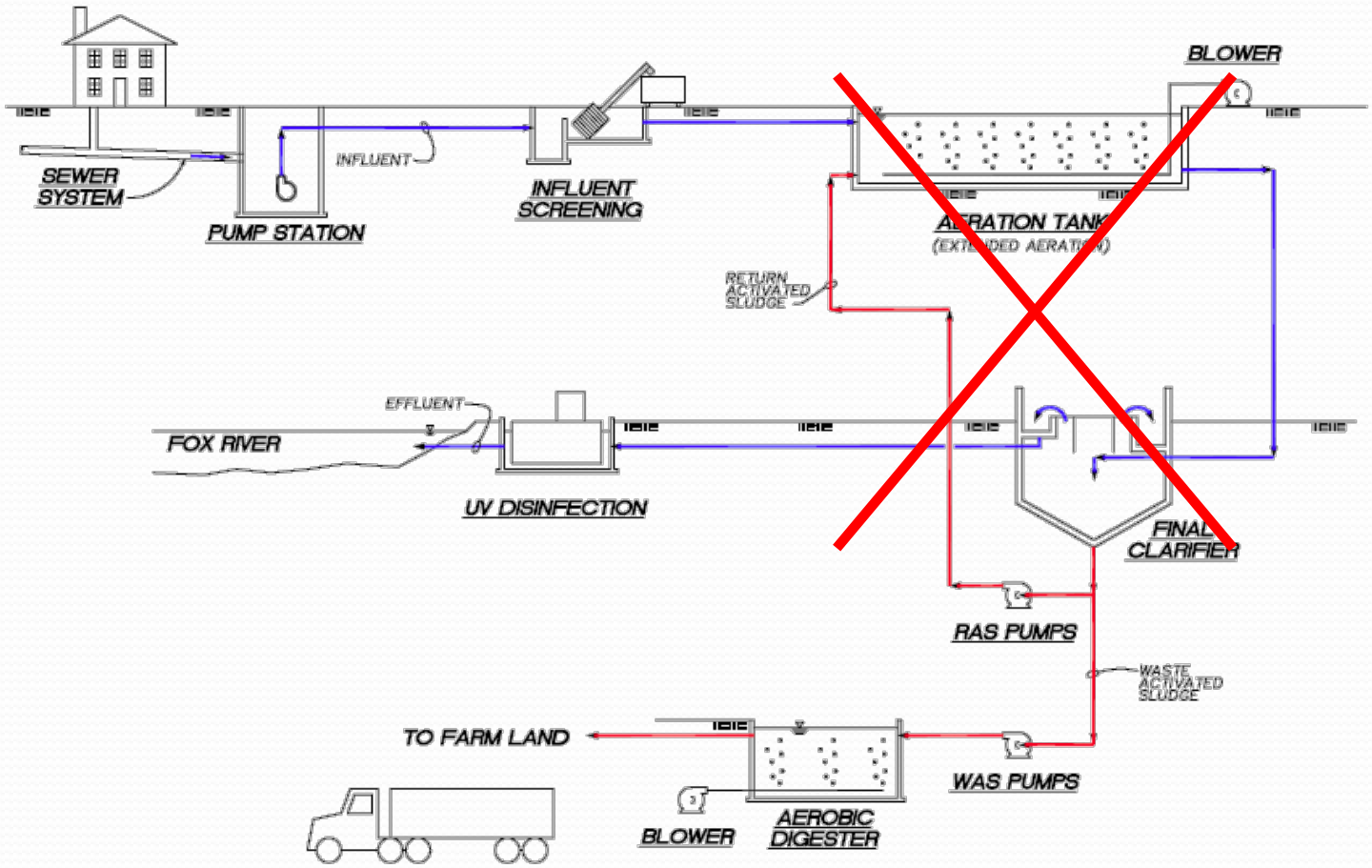


(Courtesy of GE)

Membrane Bioreactor

- Activated sludge reactor
- Functions of biological treatment, secondary clarification, tertiary filtration combined on one unit
  - Eliminates construction of extended aeration and final clarifier
- Ultrafiltration: ~0.04 to 0.4 μm pore size
- Sized to handle peak flow of twice the daily influent flow

Original Facilities Plan



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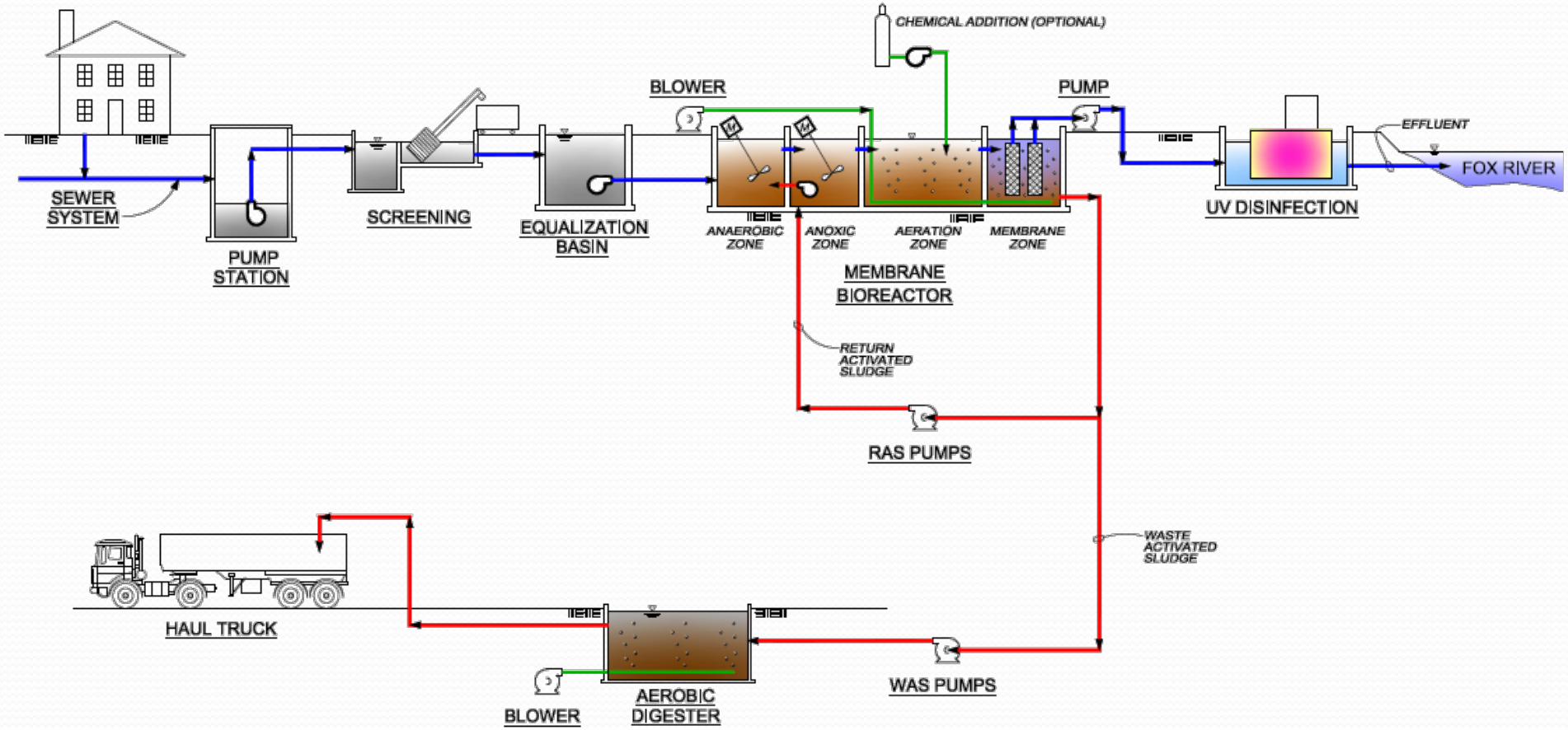
Membrane Bioreactor



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Membrane Bioreactor

- Advantages
  - High effluent quality
  - Lower space requirement
    - Lower HRT
    - Combine functions of biological treatment, secondary clarification and tertiary filtration
  - Automated process
  - Higher SRT = Reduced sludge production and hauling
  - Modular for easy expansion
  - Tertiary disinfection?

Membrane Bioreactor

- Disadvantages
  - Less flexibility adapting to flow rates
  - WAS has lower settling rate
  - Maintenance
    - Air scouring
    - Cleaning

Monetary Cost Evaluation

Item	Alternative 1 Disc Filters	Alternative 2 Ballasted Flocculation	Alternative 3 Upflow Gravity Filter	Alternative 4 Membrane Filtration	Alternative 5[1] MBR
Initial Capital Cost	$370,000	$826,000	$657,000	$1,089,000	$981,000
Present Worth O&M	$737,000	$411,000	$379,000	$461,000	($153,000)
Less Salvage Value	($7,000)	($15,000)	($12,000)	($20,000)	$31,000
Total Present Worth Cost	$1,100,000	$1,222,000	$1,024,000	$1,530,000	$859,000

Note:

1) Includes the elimination of the extended aeration and final clarifier structures and equipment costs.

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Non-Monetary Cost Evaluation

Item	Alternative 1 Disc Filters	Alternative 2 Ballasted Flocculation	Alternative 3 Upflow Gravity Filter	Alternative 4 Membrane Filtration	Alternative 5 MBR
Water Quality	2	2	3	3	3
Land Use	2	2	2	2	3
Growth Potential	3	1	3	2	2
Ease of Operation	2	1	3	3	3
Process Stability	2	1	2	2	2
Flexibility	2	3	2	1	1
Total	13	10	15	13	14

Note: Higher value means more desirable.

And the winner is…

Membrane Bioreactor (MBR)

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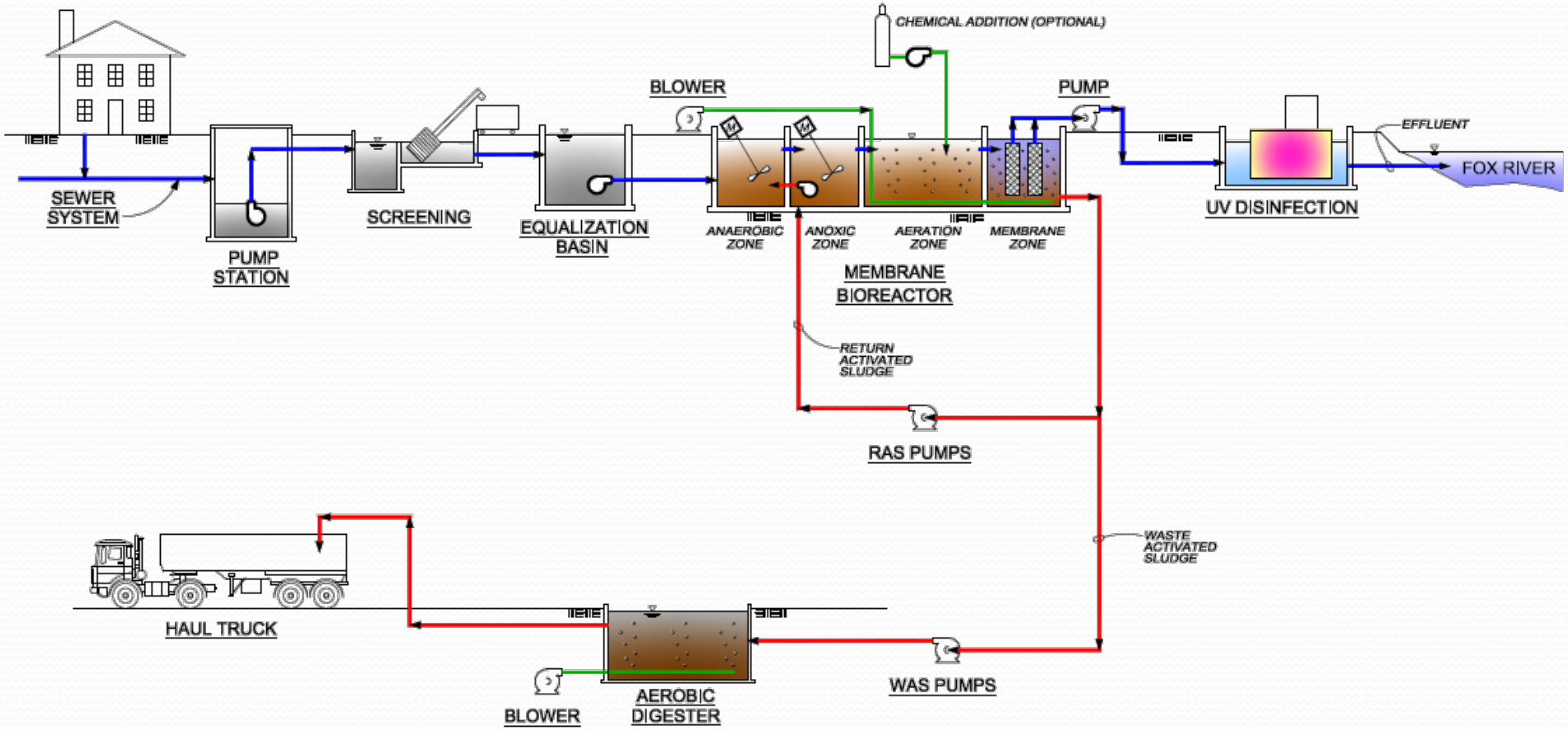
(Courtesy of GE)

Statistics

- Plant includes pump station, fine screen, anaerobic basin, anoxic basin, aeration basin, equalization basin, MBR, UV disinfection, aerobic digester, control building
- Membrane racks and modules, air scour, compressed air, process and backpulse skids included w/ MBR
- Costs
  - Original: $5,871,000
  - Increase: $981,000
  - Revised: $6,852,000

MBR Xs and Os



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Statistics

- MLSS is 3-4 times higher for MBR facilities
  - Conventional: 2,000 – 4000 mg/L
  - MBR: 8,000 – 12,000 mg/L
- RAS Recycle
  - Conventional: 0.5 – 1.5 times the influent flow
  - MBR: 2 – 4 times the influent flow

- Current Wisconsin installation: Stockbridge-Munsee Community WWTF

Statistics

- Big Bend will utilize biological phosphorus removal with optional chemical addition
  - Anaerobic, anoxic, and aerobic tanks
  - Equalization basin

(Crawford, Daigger, Erdal – WEFTEC 2006)

Biological Phosphorus Removal

- Microorganisms release phosphorus while consuming and storing food as PHB in anaerobic zone
- Microorganisms consume the stored food and absorb excess phosphorus in anoxic/aerobic zone
- Stored phosphorus is removed when excess sludge (WAS) is wasted
- Saves on chemical costs
- Install chemical phosphorus system for backup

Chemical Phosphorus Removal

- Coagulant addition to precipitate phosphorus
  - Aluminum: Al^{3+}
  - Iron: Fe^{3+}
  - Calcium: Typically as lime, $Ca(OH)_2$
- Precipitated material captured as part of sludge removal
- Chemical removal increases sludge production approximately 25%

Potential Design Issues

- High mixed liquor recirculation
  - Protect against excessively high MLSS concentrations in MBR
  - Highly aerated recirculating flow can consume substrate, making unavailable for PAOs
- Low HRT in anaerobic and anoxic zones
  - Provide adequate mixing to avoid short-circuiting
- Flow equalization can simplify potential design issues

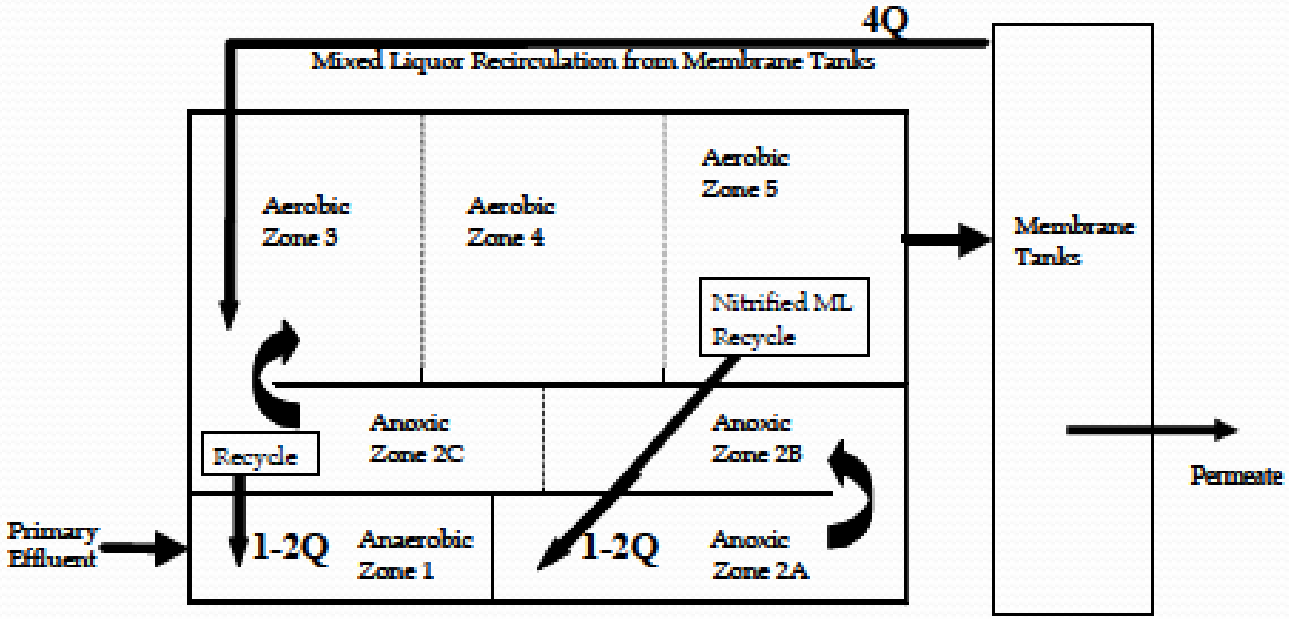
(Crawford, Daigger, Erdal – WEFTEC 2006)

EBPR with MBR

- Traverse City, Michigan
  - Design average annual flow: 8.5 mgd
  - Average effluent TP: < 0.5 mg/L
  - Most successful when mixed liquor recycle rate is greater than four times the influent flow
  - Chemical addition included

(Crawford, Daigger, Erdal – WEFTEC 2006)

EBPR at Traverse City



(Crawford, Daigger, Erdal – WEFTEC 2006)

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Traverse City, Michigan

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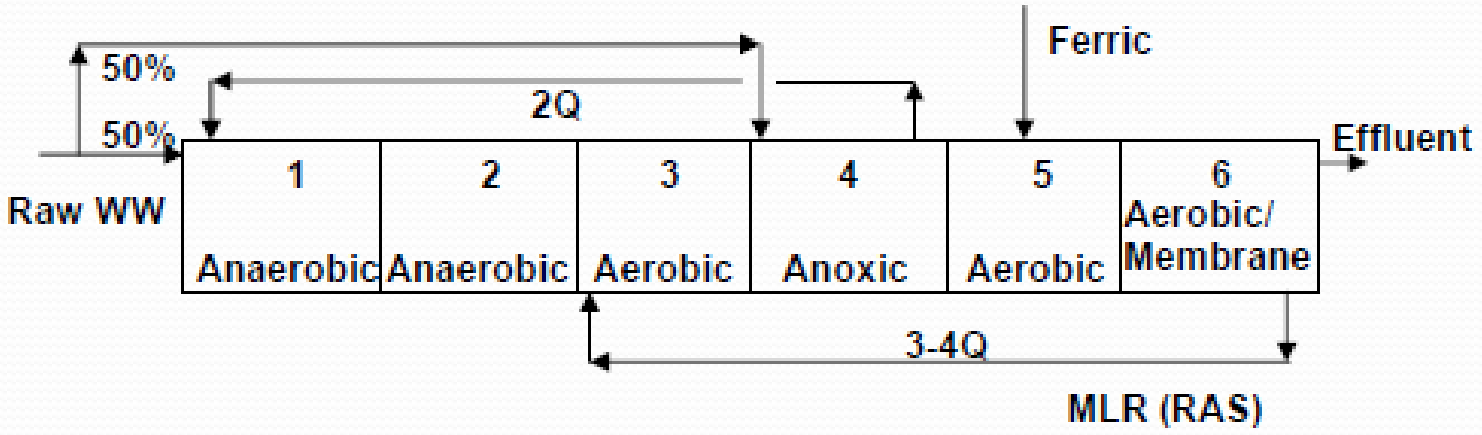
(http://www.glslcities.org/TraverseCity_Treatment_Plant.pdf/)

EBPR with MBR

- Southwest Water Reclamation Facility – Henderson, Nevada
  - Initial capacity: 4.5 mgd
  - Can meet 0.1 mg/L Total P with no chemical addition



(Crawford, Daigger, Erdal – WEFTEC 2006)

Henderson, Nevada

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(http://www.lasvegassun.com/news/2011/sep/17/sewage-treatment-facility-open-henderson/)

Henderson, Nevada

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(http://www.lasvegassun.com/news/2011/sep/17/sewage-treatment-facility-open-henderson/)

Instant Replay

- New phosphorus regulations require Big Bend to meet 0.1 mg/L Total Phosphorus effluent limit from Day 1
- MBR with biological phosphorus removal chosen as cost-effective alternative

(Courtesy of Siemens)

Questions?

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