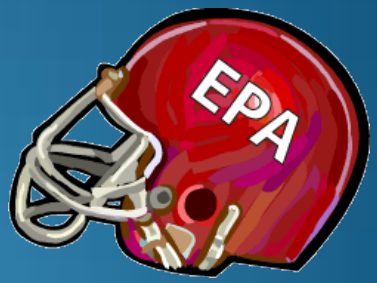
# New Dischargers Tackle Issue of Stricter Phosphorus Limits

WWOA 47th Annual Conference
October 24, 2013




Dave Diehl
Applied Technologies, Inc.

Applied Technologies
Engineers - Architects

# Overview

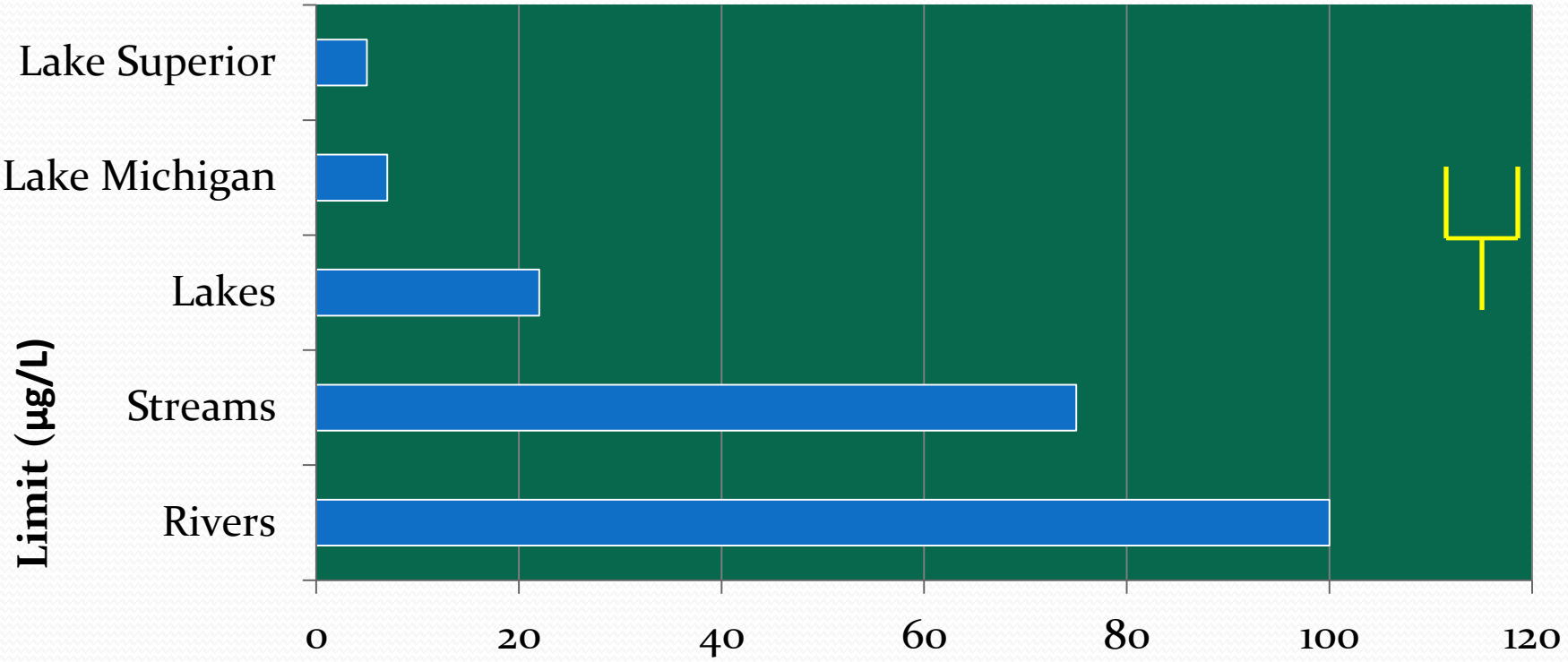
- Wisconsin phosphorus regulatory update
- Big Bend Facilities Plan
- Phosphorus removal alternatives and evaluation
- Alternative recommendation


Applied Technologies
Engineers - Architects

# 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

Applied Technologies
Engineers - Architects

# Phosphorus Rules

**NR 217.17 Schedule of Compliance**

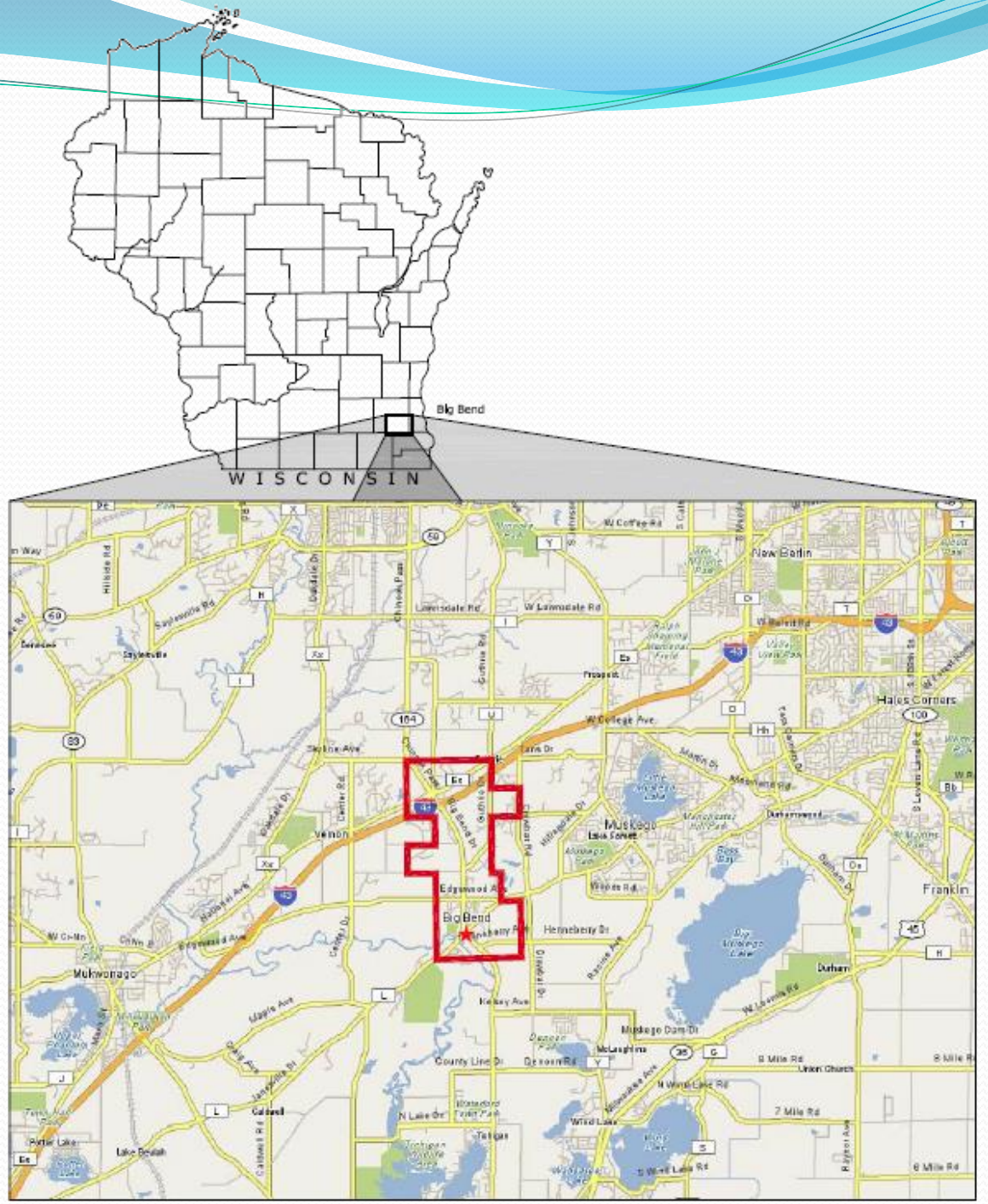
(2) Maximum Compliance Schedule Period – Where compliance with the water quality based phosphorus limit requires the construction of filtration or a similar phosphorus removal process, the department may grant a compliance schedule not to exceed **nine years** from the date that the permit is first reissued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


Applied Technologies
Engineers - Architects

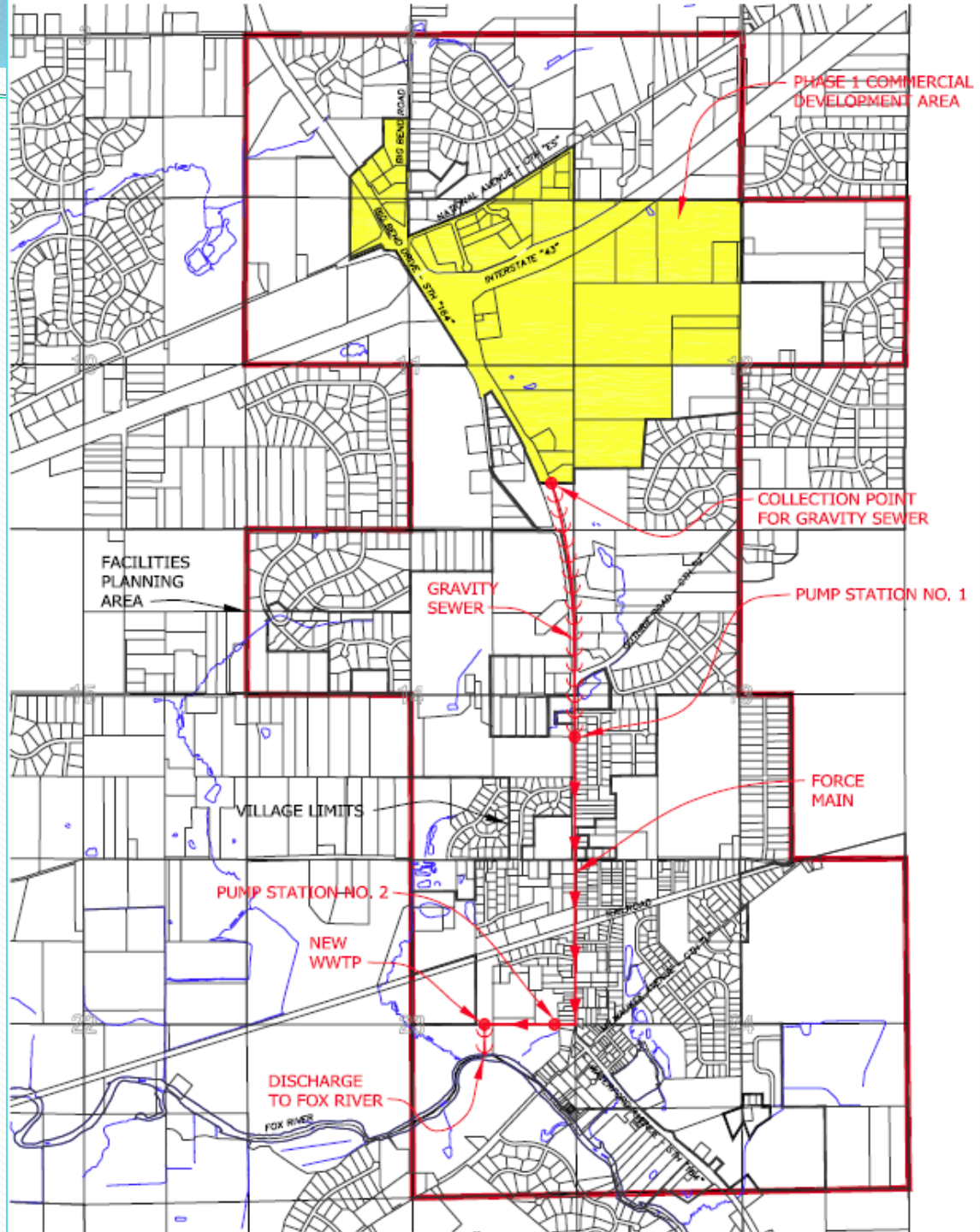
# Statistics

- 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)

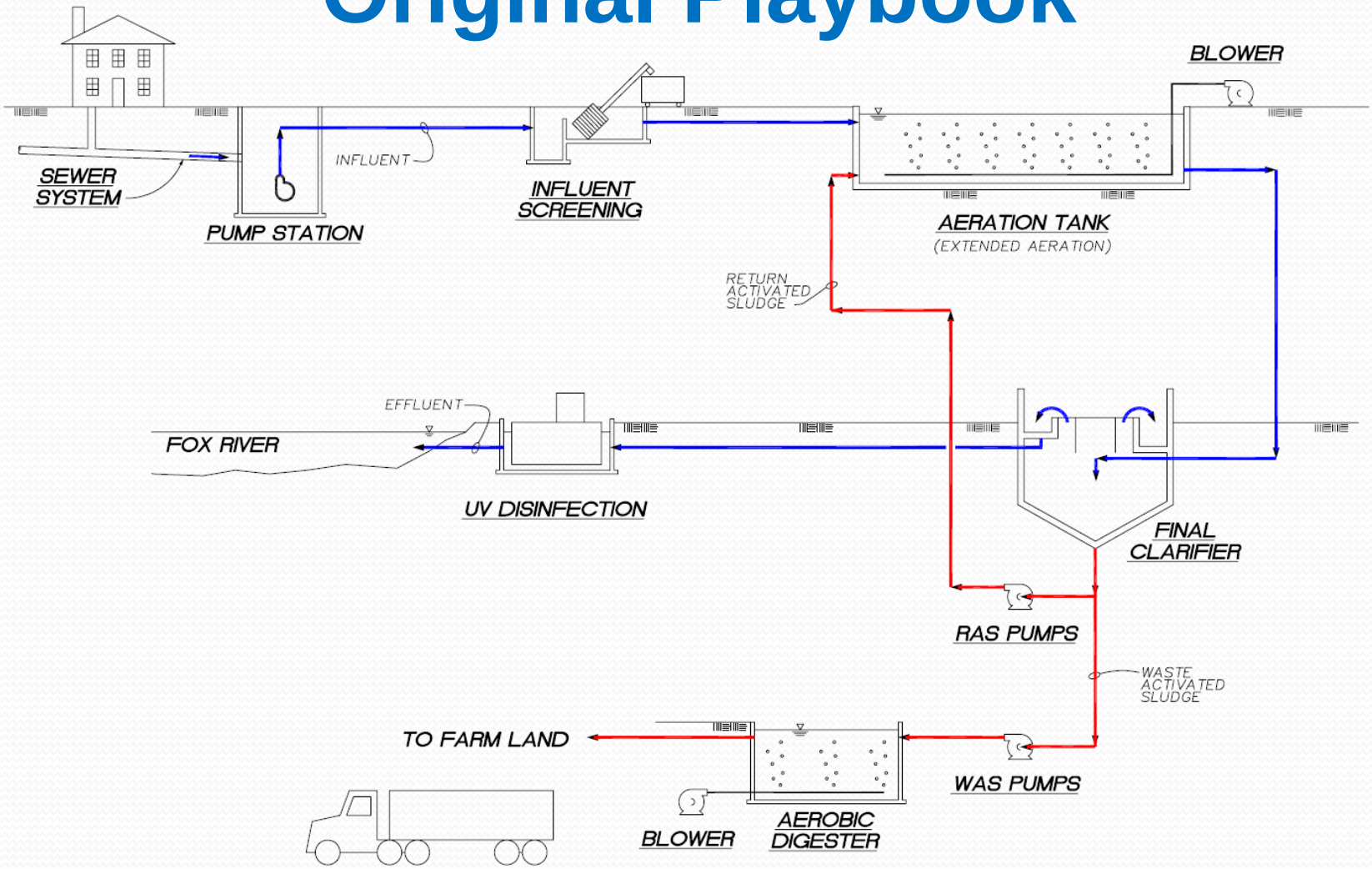
- New treatment plant
- Extended aeration activated sludge
- Design annual average flow: 366,000 gpd
- Two phases – First phase: 100,000 gpd from commercial area
- Discharge to Fox River
- Phosphorus limit of 1.0 established

# Facilities Planning Area




Applied Technologies
Engineers - Architects

# Original Playbook




Applied Technologies
Engineers - Architects

# 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

Applied Technologies
Engineers - Architects

# Phosphorus Removal Alternatives

Applied Technologies
Engineers - Architects

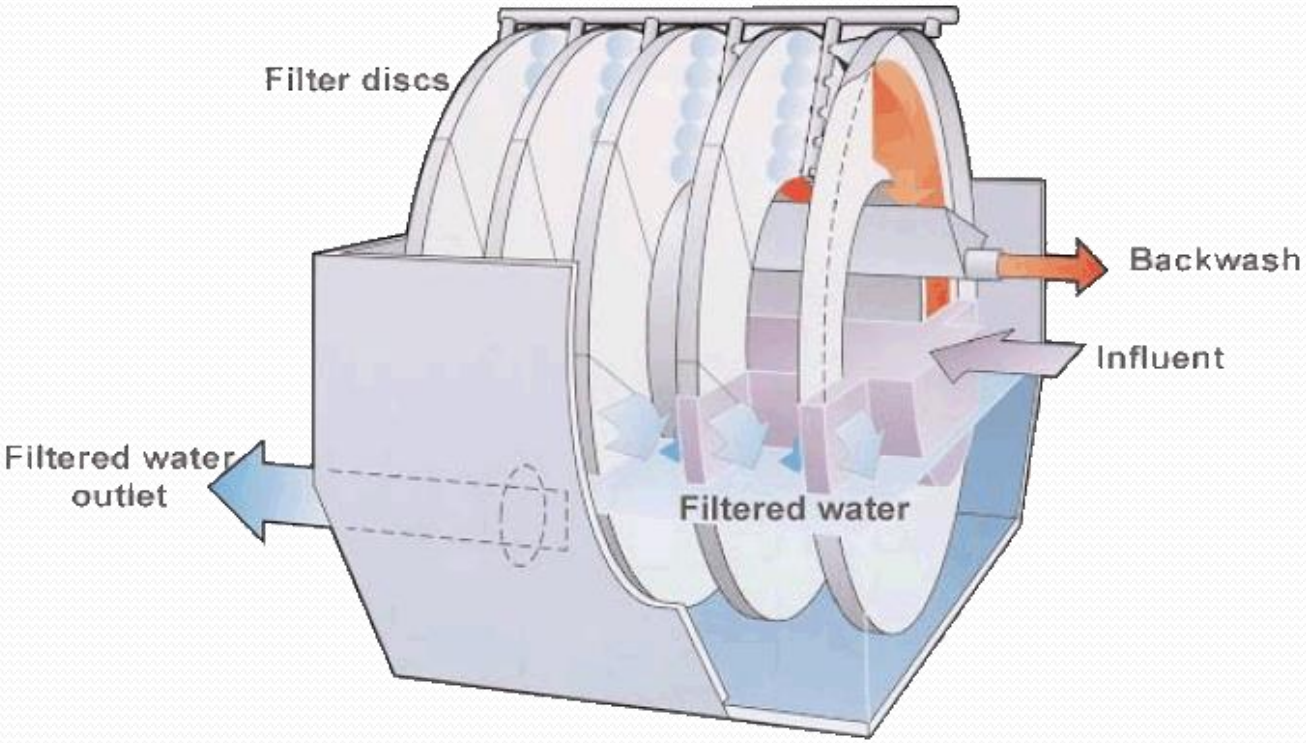
# Alternatives

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

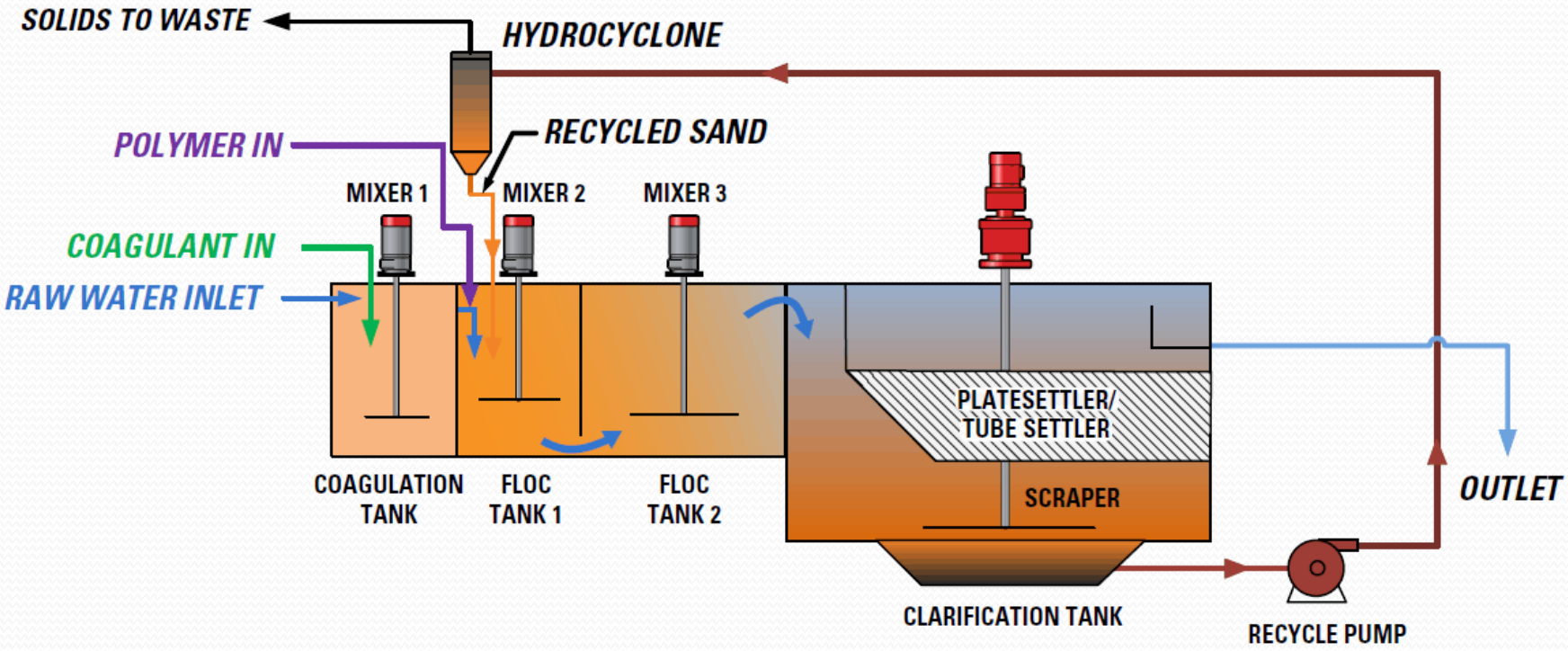



(Courtesy of Veolia)

# 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)

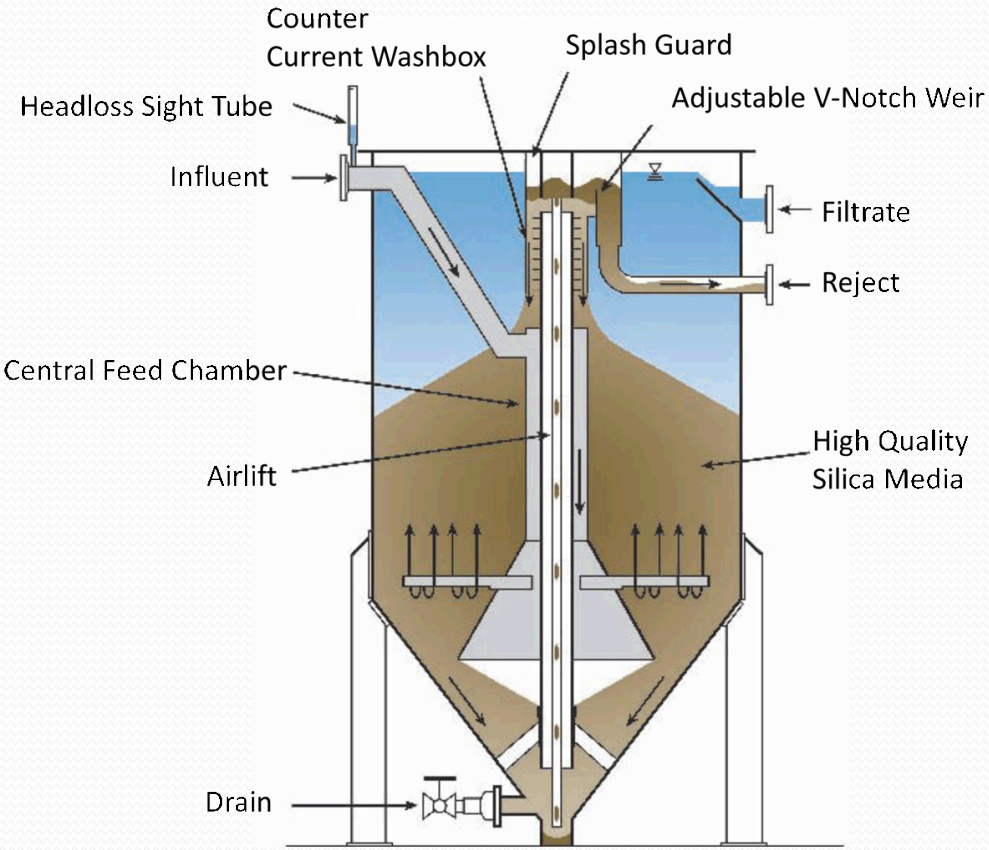
# Ballasted Flocculation

- 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



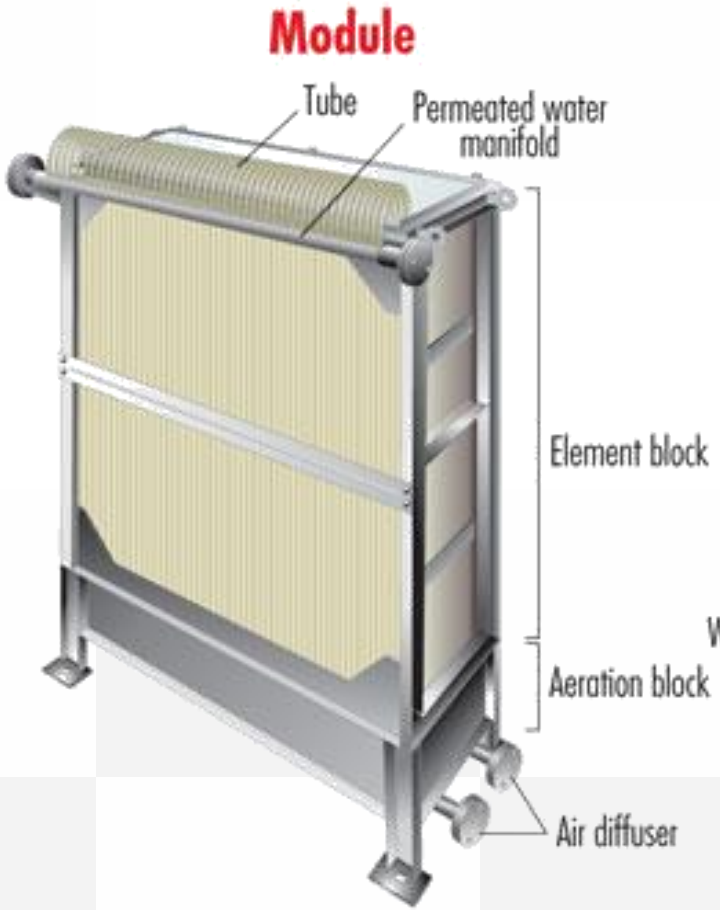

Applied Technologies
Engineers - Architects

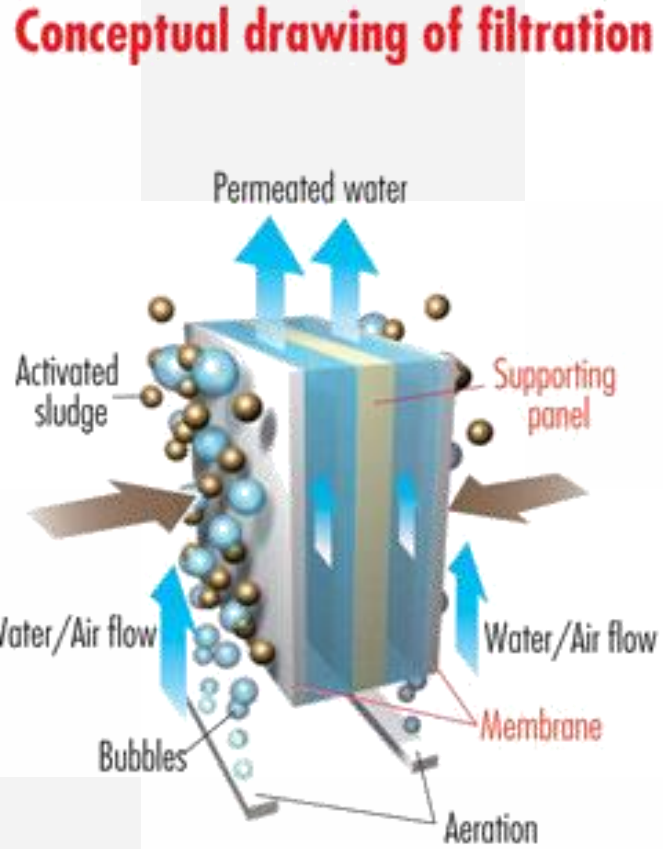
(Courtesy of Five Star Filtration)

# 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

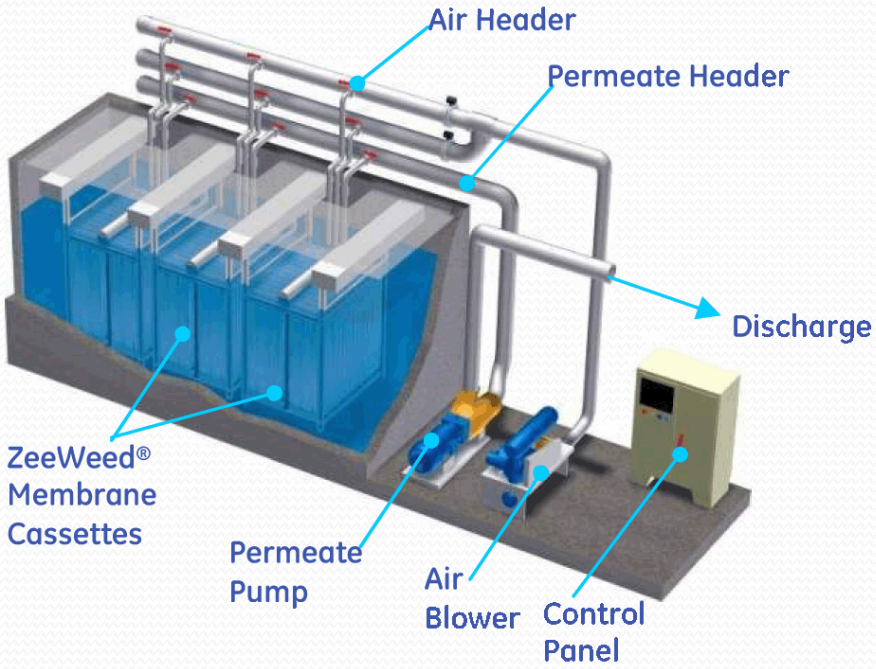



Applied Technologies
Engineers - Architects

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

# Membrane Filtration

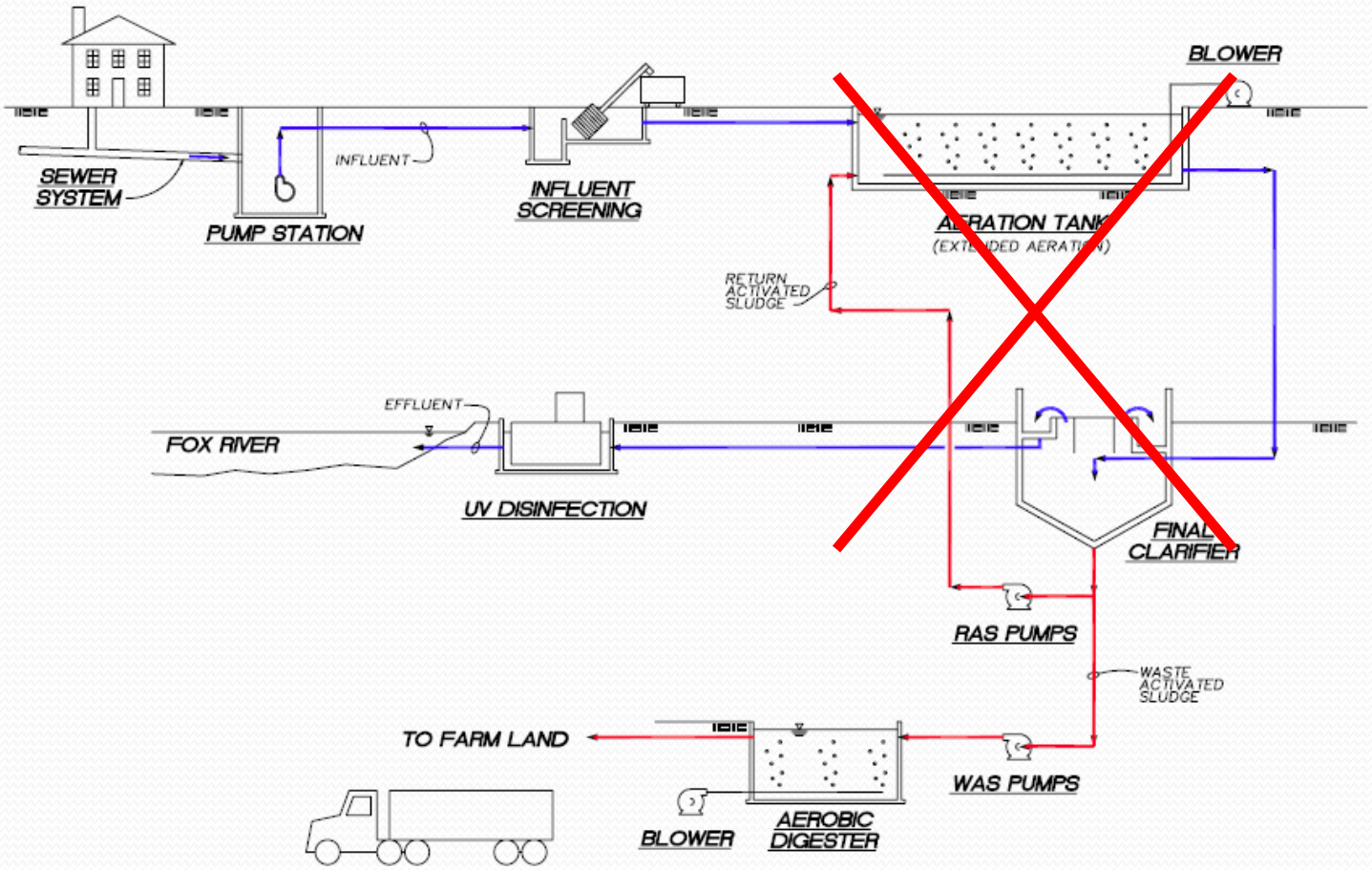



(Courtesy of GE)

# Membrane Bioreactor

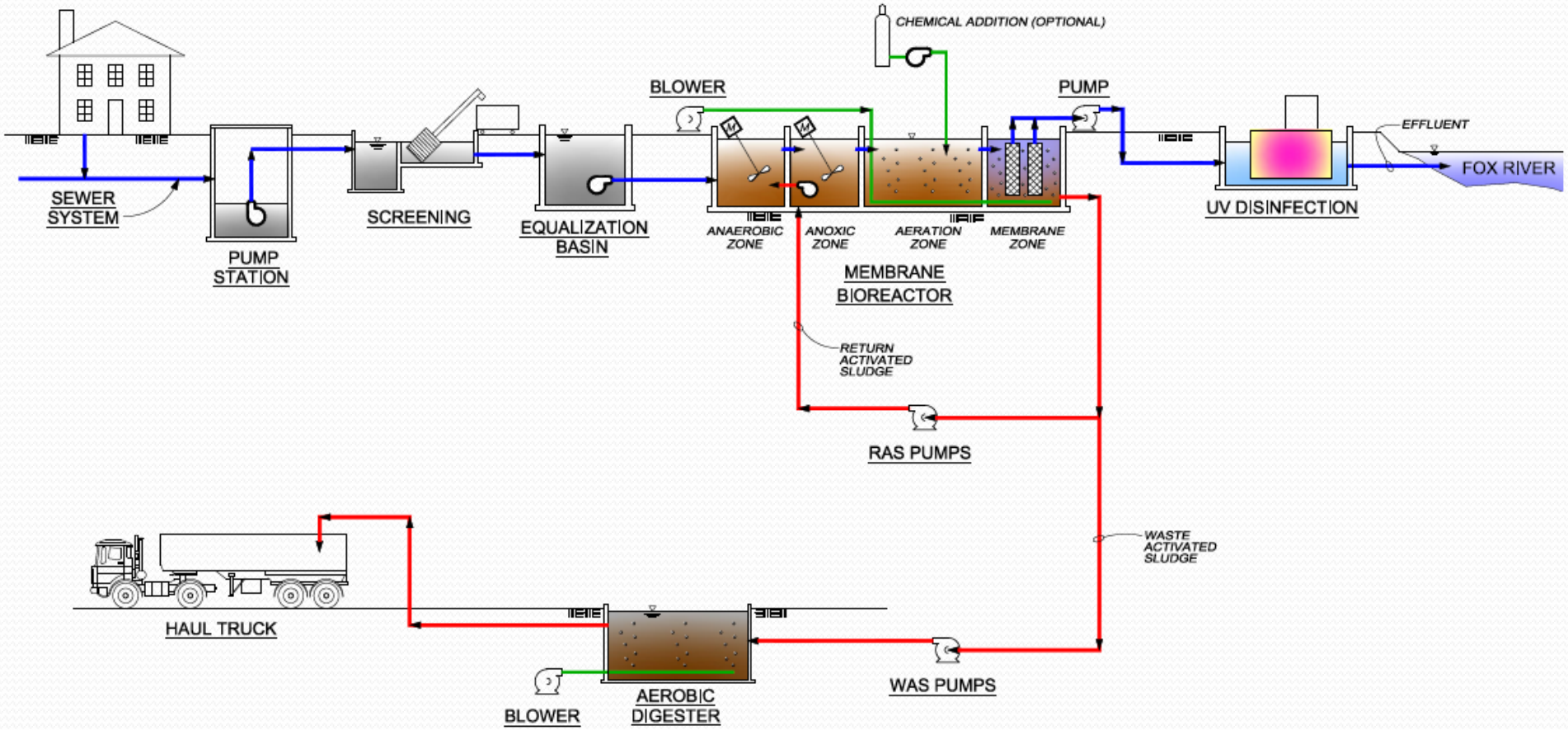
- Activated sludge reactor
- Functions of biological treatment, secondary clarification, tertiary filtration combined on one unit
  - Eliminates construction of extended aeration and final clarifier
- Ultrafiltration: ~0.04 to 0.4 μm pore size
- Sized to handle peak flow of twice the daily influent flow

# Original Facilities Plan




Applied Technologies
Engineers - Architects

# Membrane Bioreactor




Applied Technologies
Engineers - Architects

# 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.

Applied Technologies
Engineers - Architects

# Non-Monetary Cost Evaluation

| Item | Alternative 1<br>Disc Filters | Alternative 2<br>Ballasted Flocculation | Alternative 3<br>Upflow Gravity Filter | Alternative 4<br>Membrane Filtration | Alternative 5<br>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.

Applied Technologies
Engineers - Architects

# And the winner is…

Applied Technologies
Engineers - Architects

# Membrane Bioreactor (MBR)

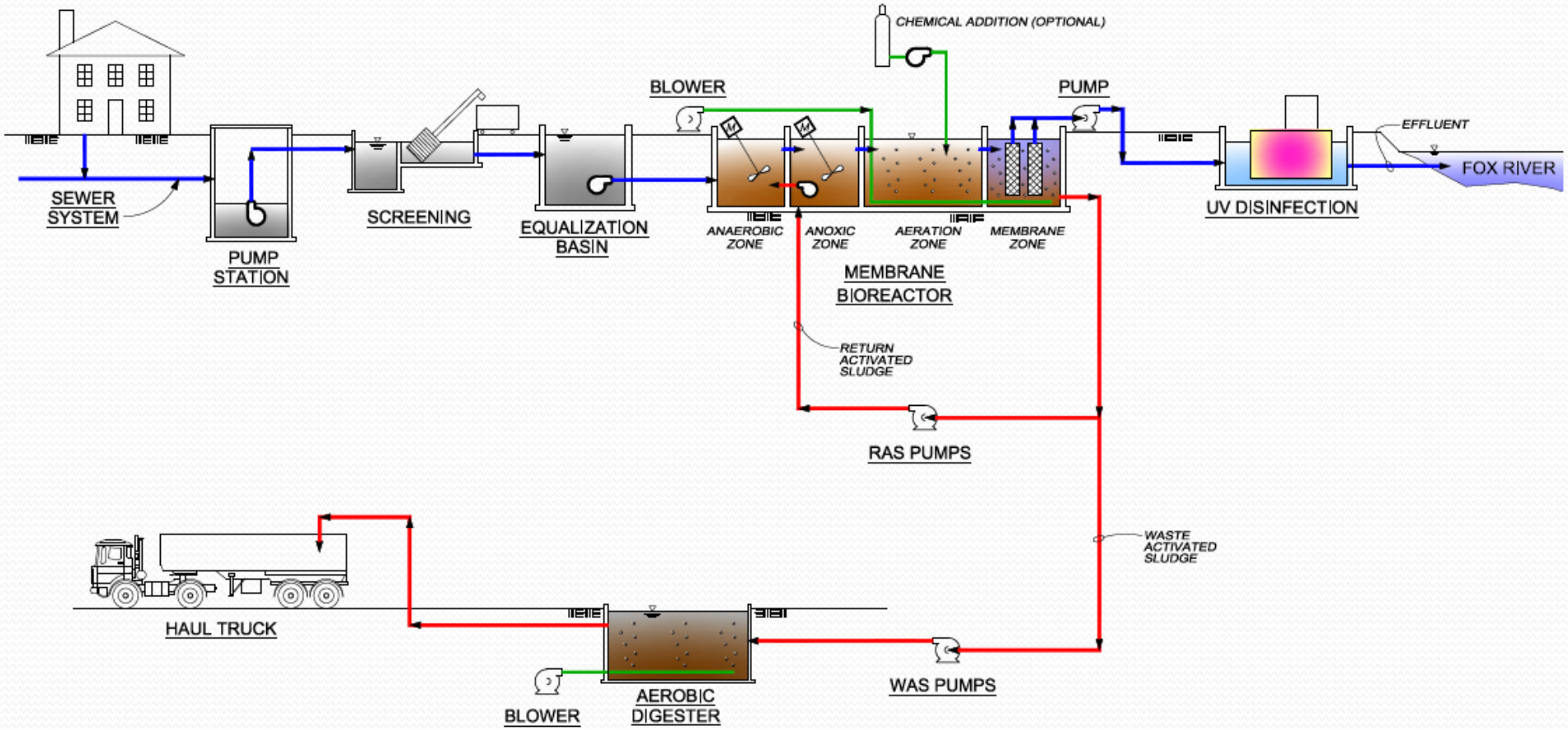
(Courtesy of GE)

# 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

Applied Technologies
Engineers - Architects

# MBR Xs and Os




Applied Technologies
Engineers - Architects

# 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

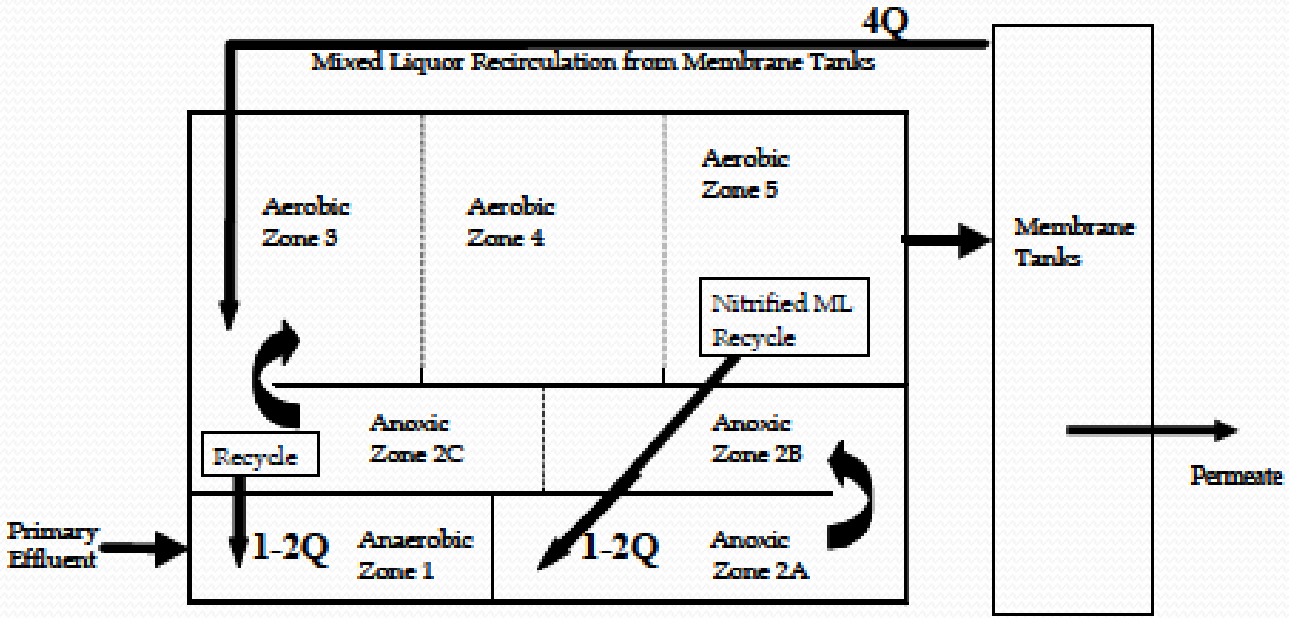
(Crawford, Daigger, Erdal – WEFTEC 2006)

# 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)

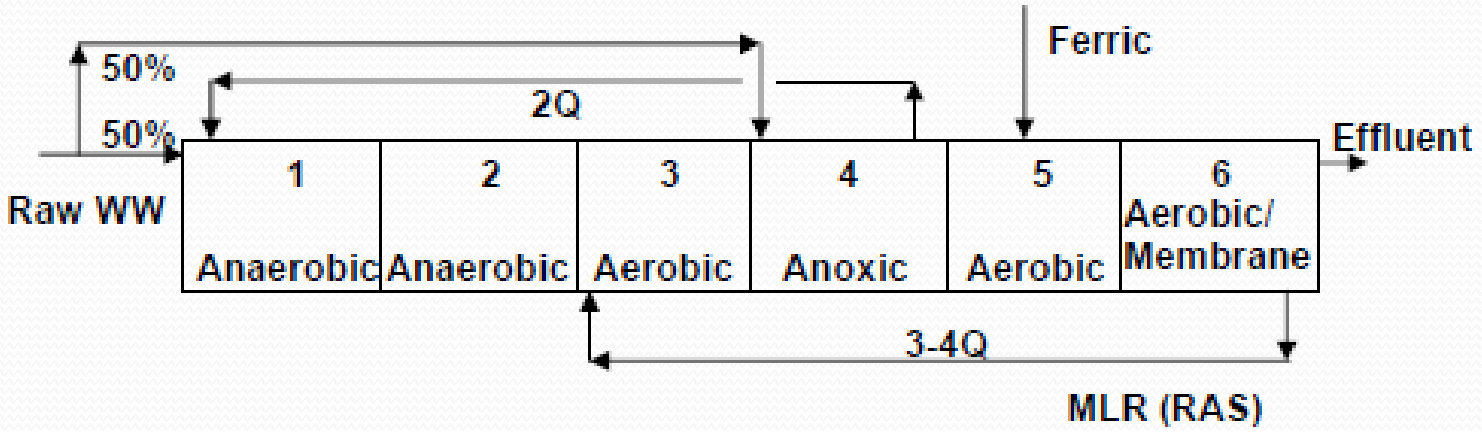
# Traverse City, Michigan

Applied Technologies
Engineers - Architects

(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

Applied Technologies
Engineers - Architects

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

# Henderson, Nevada

Applied Technologies
Engineers - Architects

(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?


Applied Technologies
Engineers - Architects

# Contact

Dave Diehl
Applied Technologies, Inc.
16815 West Wisconsin Avenue
Brookfield, WI 53005
Phone: (262) 784-7690
Fax: (262) 784-6847
dldiehl@ati-ae.com

Applied Technologies
Engineers - Architects