Shenandoah Valley
SHENANDOAH VALLEY PURE H2O FORUM
Wastewater Treatment Plant Network

BIOLOGICAL NUTRIENT REMOVAL PROCESSES

CDM

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Milestones

1954 Wuhrman Proposes 2-stage, Aerobic/Anoxic Process

1957 Davidson Patent For A 2-stage, Anaerobic/Aerobic Process

1962 Ludzack And Ettinger Develop 2-stage Anoxic/Aerobic Process

1967 Phostrip^{tm}, Sidestream Phosphorus Removal Process Proposed By Leven Et Al

1967 Excess Biological Phosphorus Removal Reported By Connell And Vacker At San Antonio, Texas, Rilling Plant

1968 Barth Proposes Multiple Sludge Processes For Nutrient Removal

1969 Scalf, Et. Al., Report On Excess Biological Phosphorus Removal At Baltimore, Maryland Back River Wastewater Treatment Plant

Milestones

1970 Savage Patents Denitrification Filter

1971 Excess Phosphorus Removal Reported At Los Angeles, California, Hyperion Plant By Bargman, Et Al

1973 Barnard Proposes Modified Ludzack-ettinger Process

1975 Barnard Patents Bardenpho^{tm} Process

1976 Specter Patents A/O^{tm} And A^2/O^{tm} Processes

1976 Bio-denitro^{tm} Process Patented

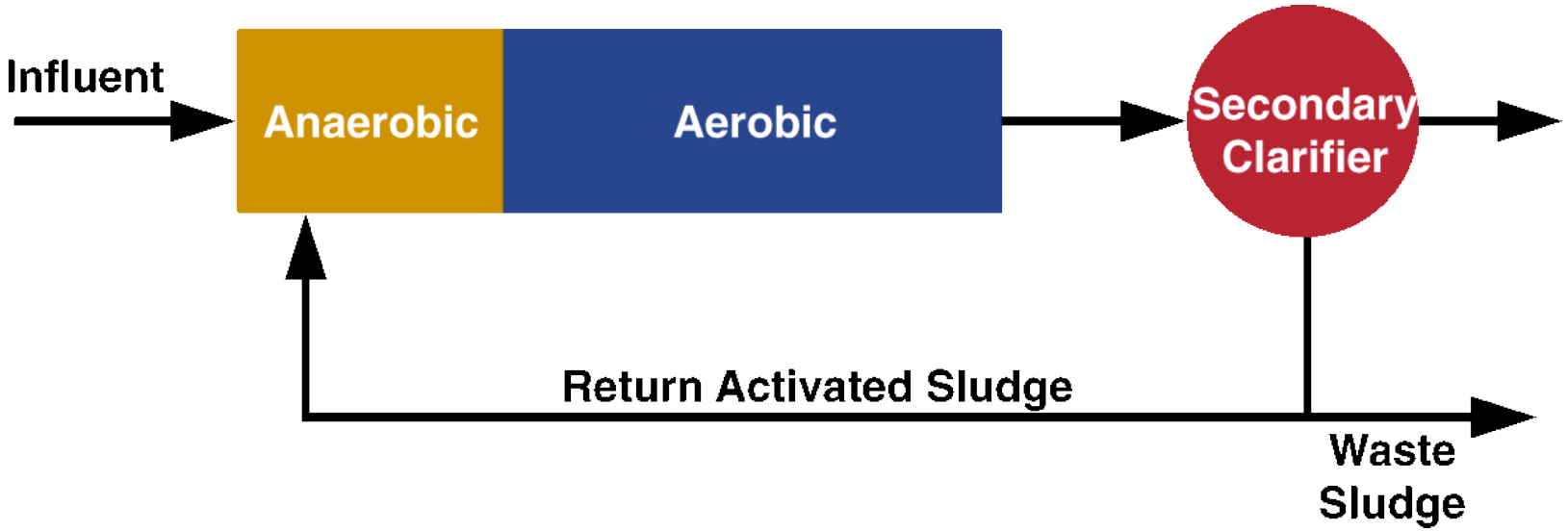
1977 Jervis Develops Fluidized Bed Reactor For Denitrification

1980 University Of Cape Town Process Developed

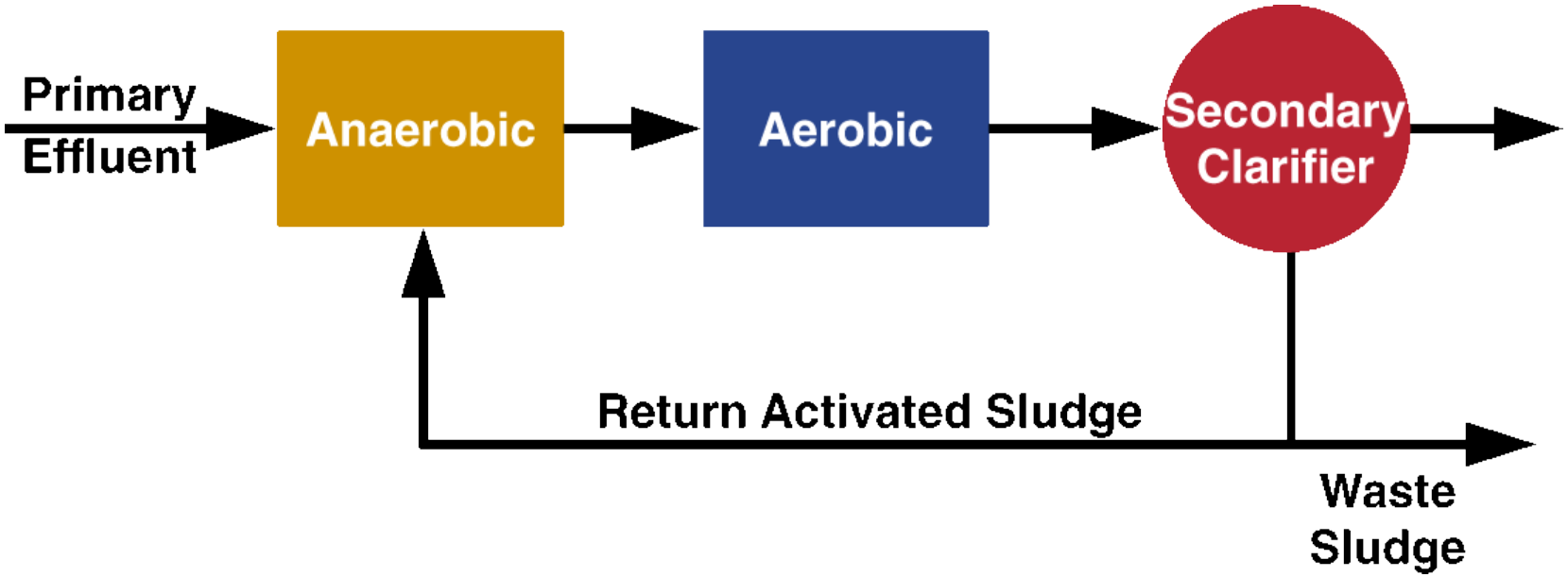
Historical Context of Phosphorus Removal

- In 1960's and 1970's several plants reported removal of phosphorus above 80 percent
- What they had in common:
  - Plug flow or compartmentalized aeration tank
  - Inadequate aeration at head of aeration tank provided low D.O.
  - High dissolved oxygen after low D.O. section
  - Phosphorus release at head of tank
  - Low SVI (less than 100 mL/gm) sludge (non-bulking)

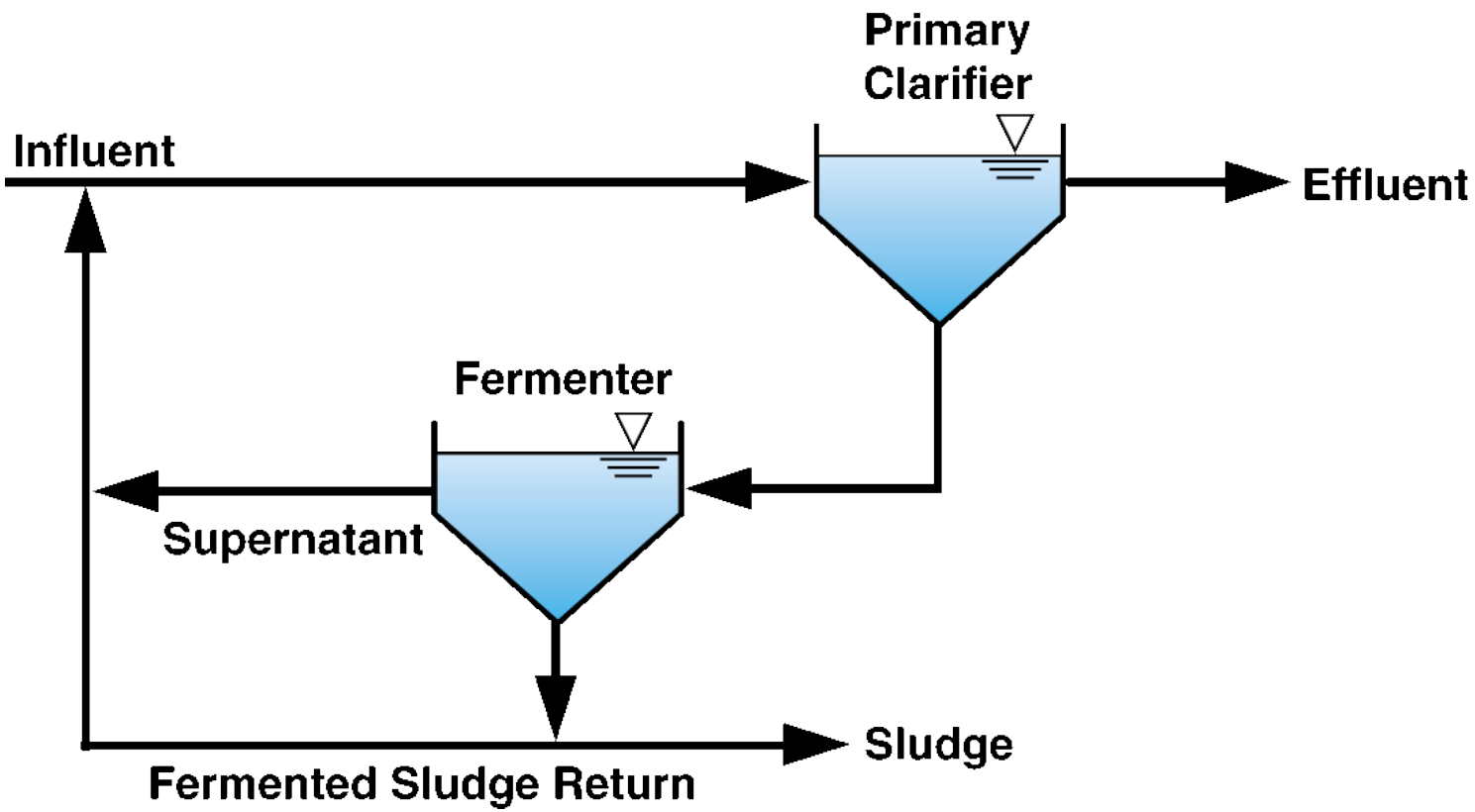
Plug - Flow


Influent
Anaerobic
Aerobic
Secondary Clarifier
Return Activated Sludge
Waste Sludge

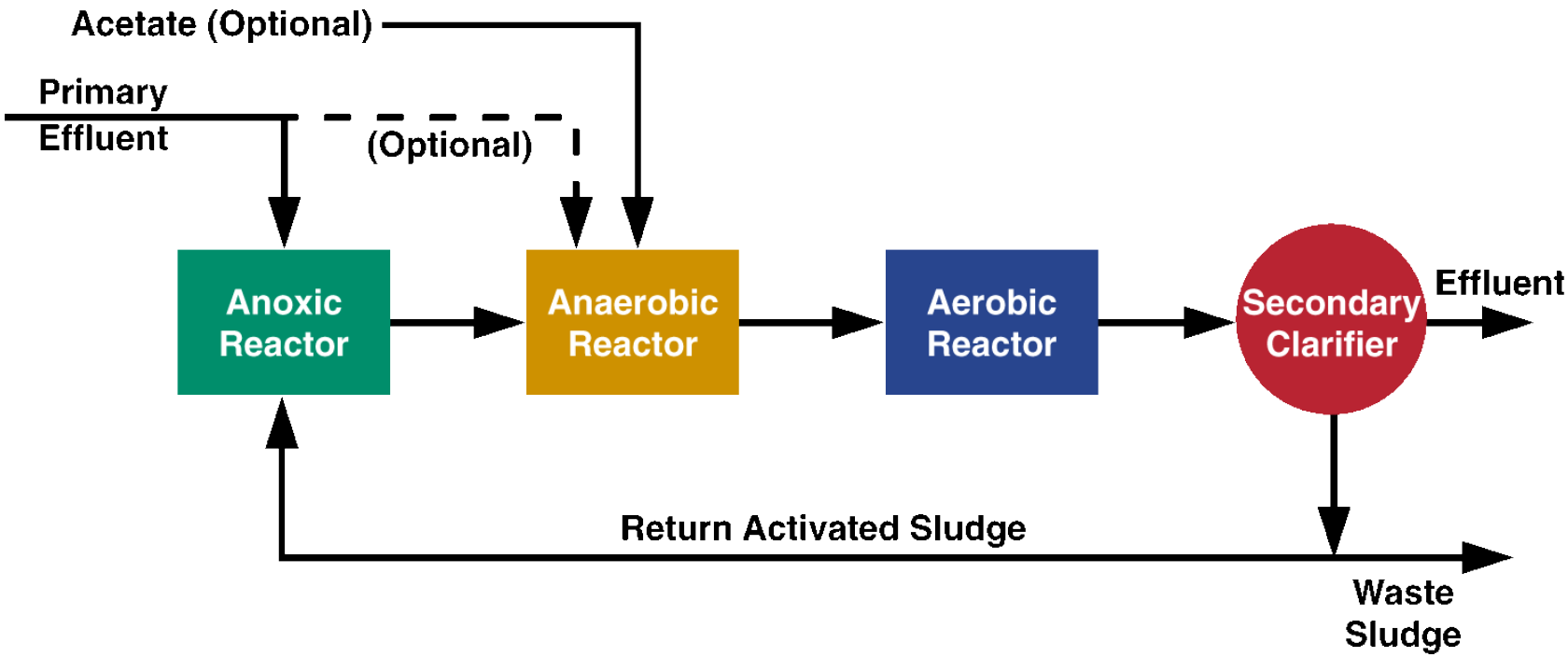
A/O Process


Primary
Effluent
Anaerobic
Aerobic
Secondary
Clarifier
Return Activated Sludge
Waste
Sludge

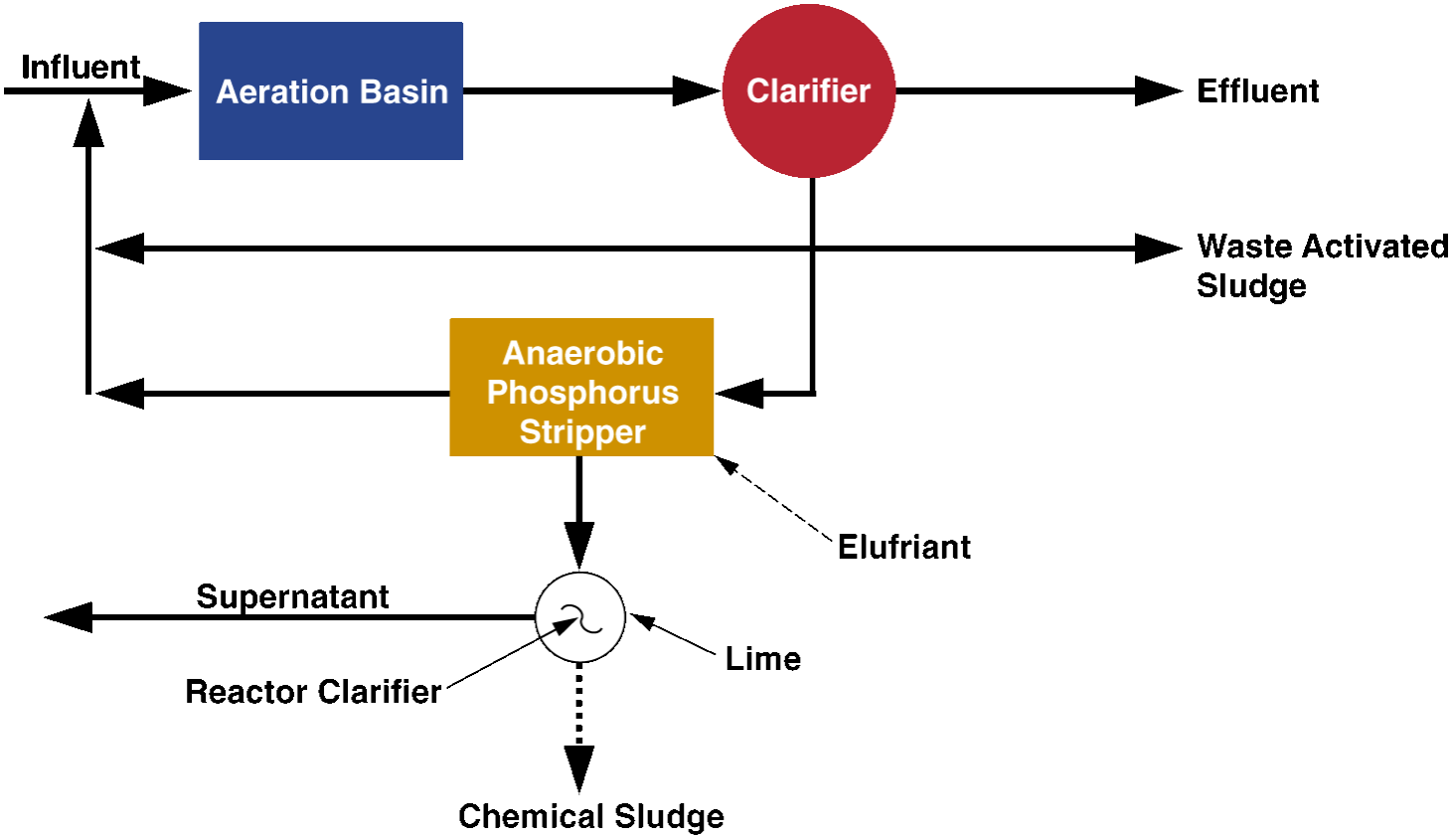
Fermentation



Volatile Fatty Acid Induced Phosphorus Removal (VIPR)

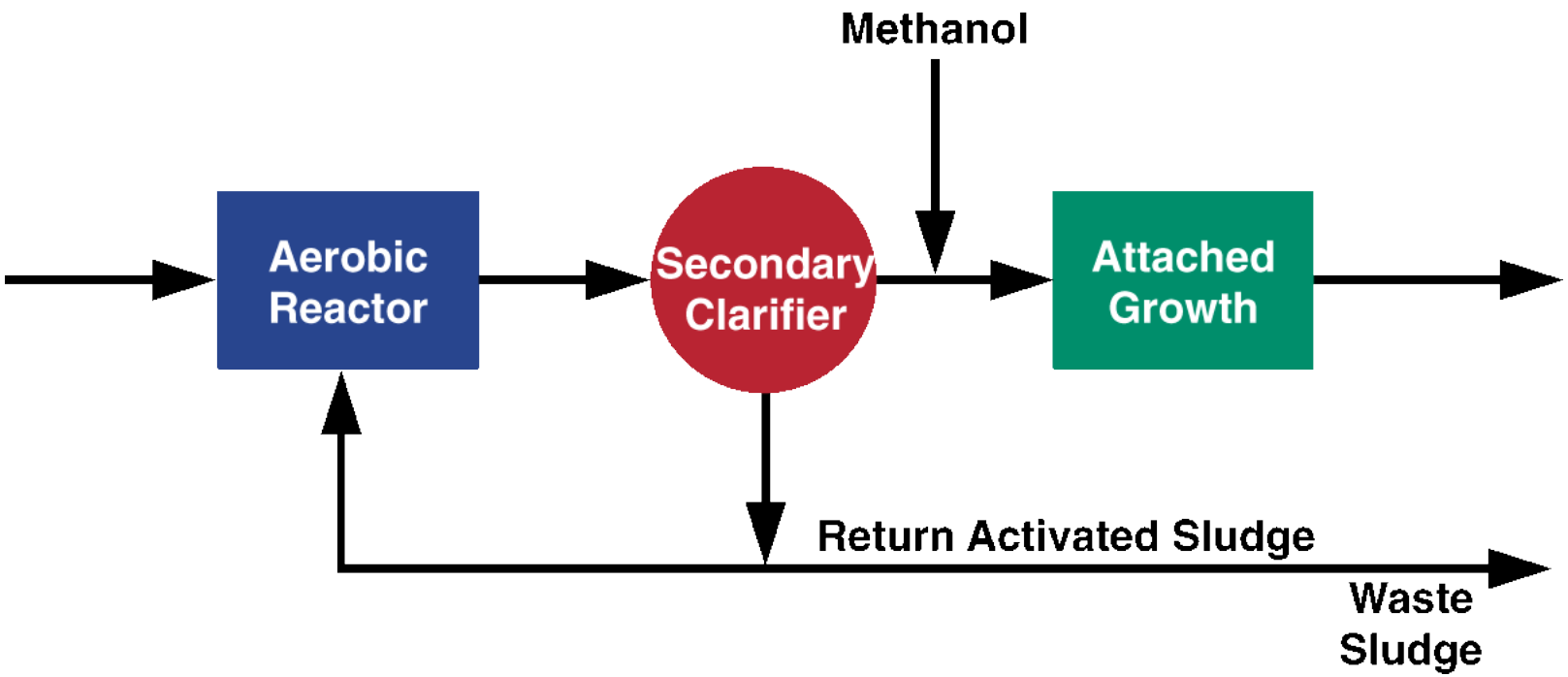


PhoStrip Process

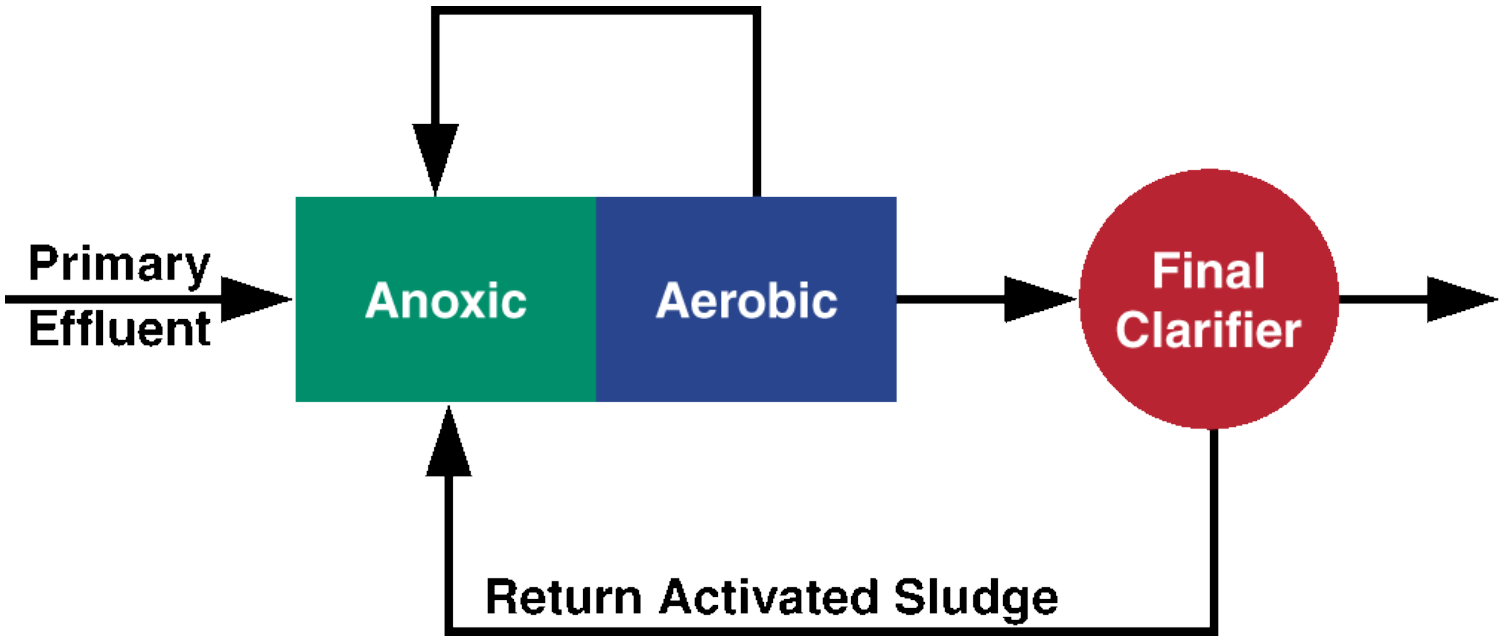


HISTORICAL CONTEXT OF NITROGEN REMOVAL

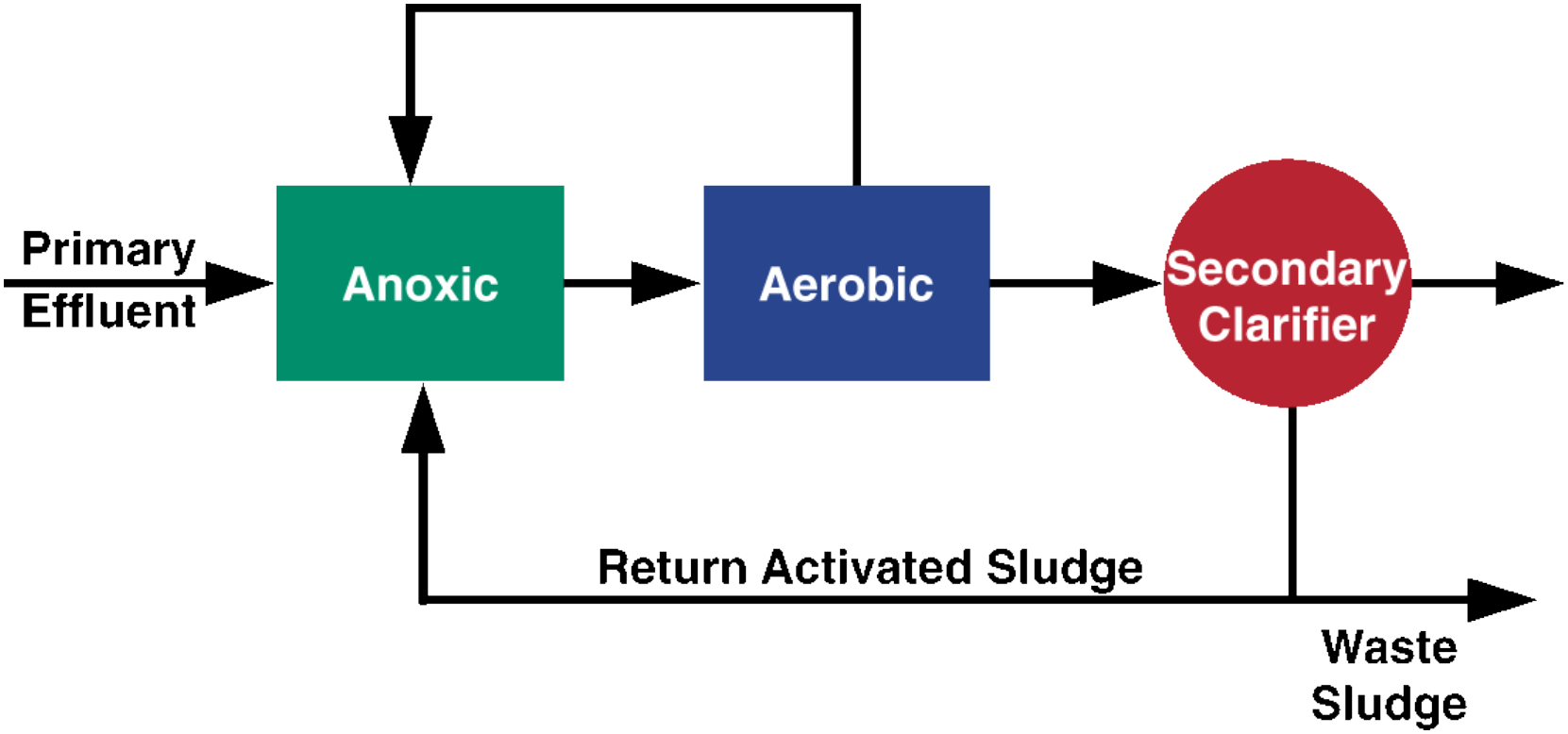
Attached Growth Nitrogen Removal



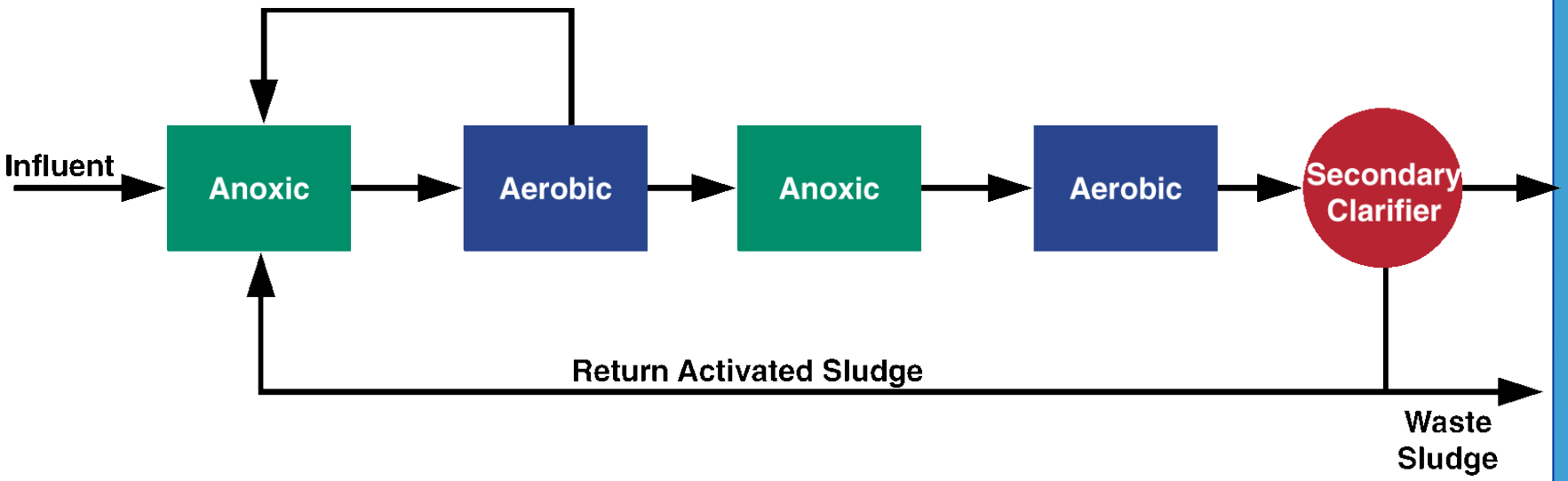
Ludzack-Ettinger Process



Modified Ludzack-Ettinger Process (MLE)

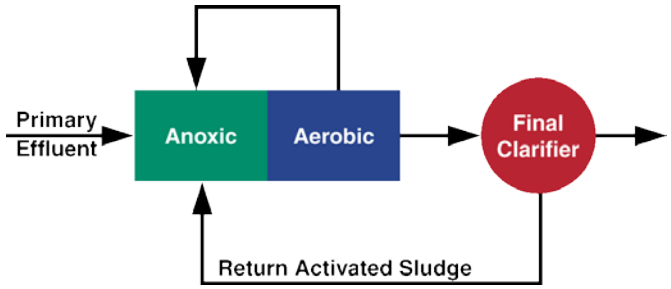


Bardenpho Process

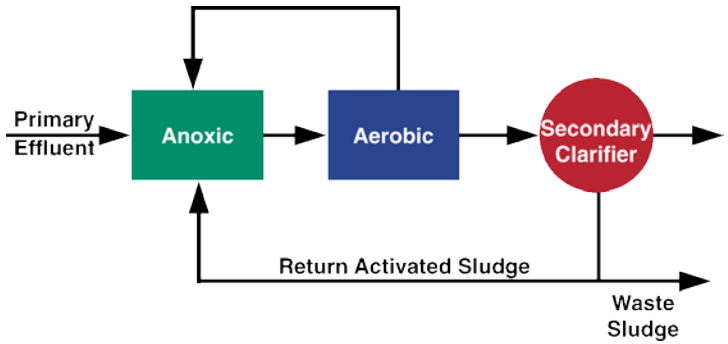


Progression for Nitrogen Removal Only

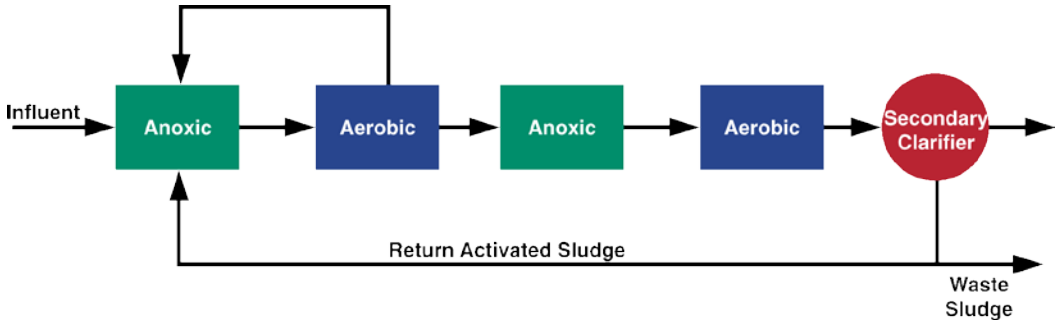
Ludzack-Ettinger



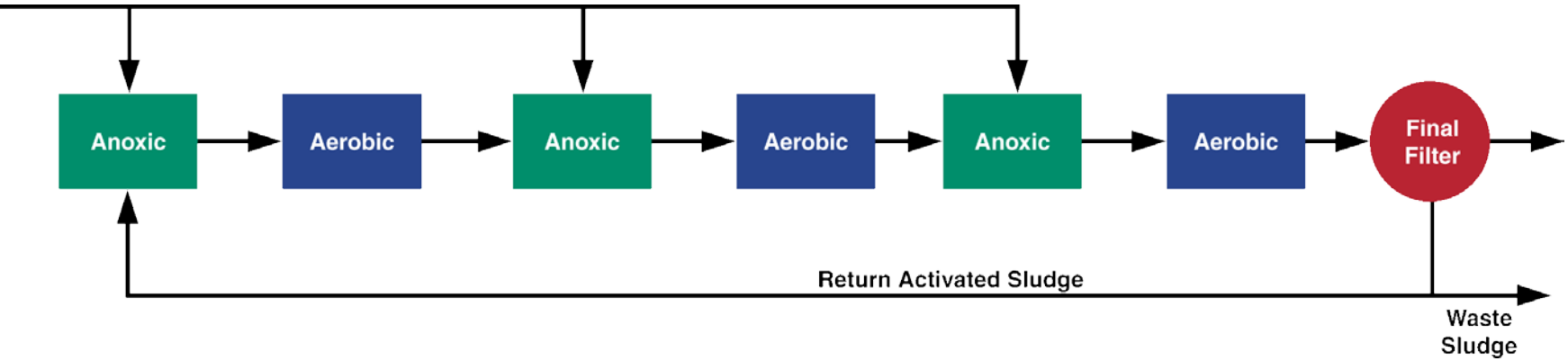
Modified Ludzack Ettinger



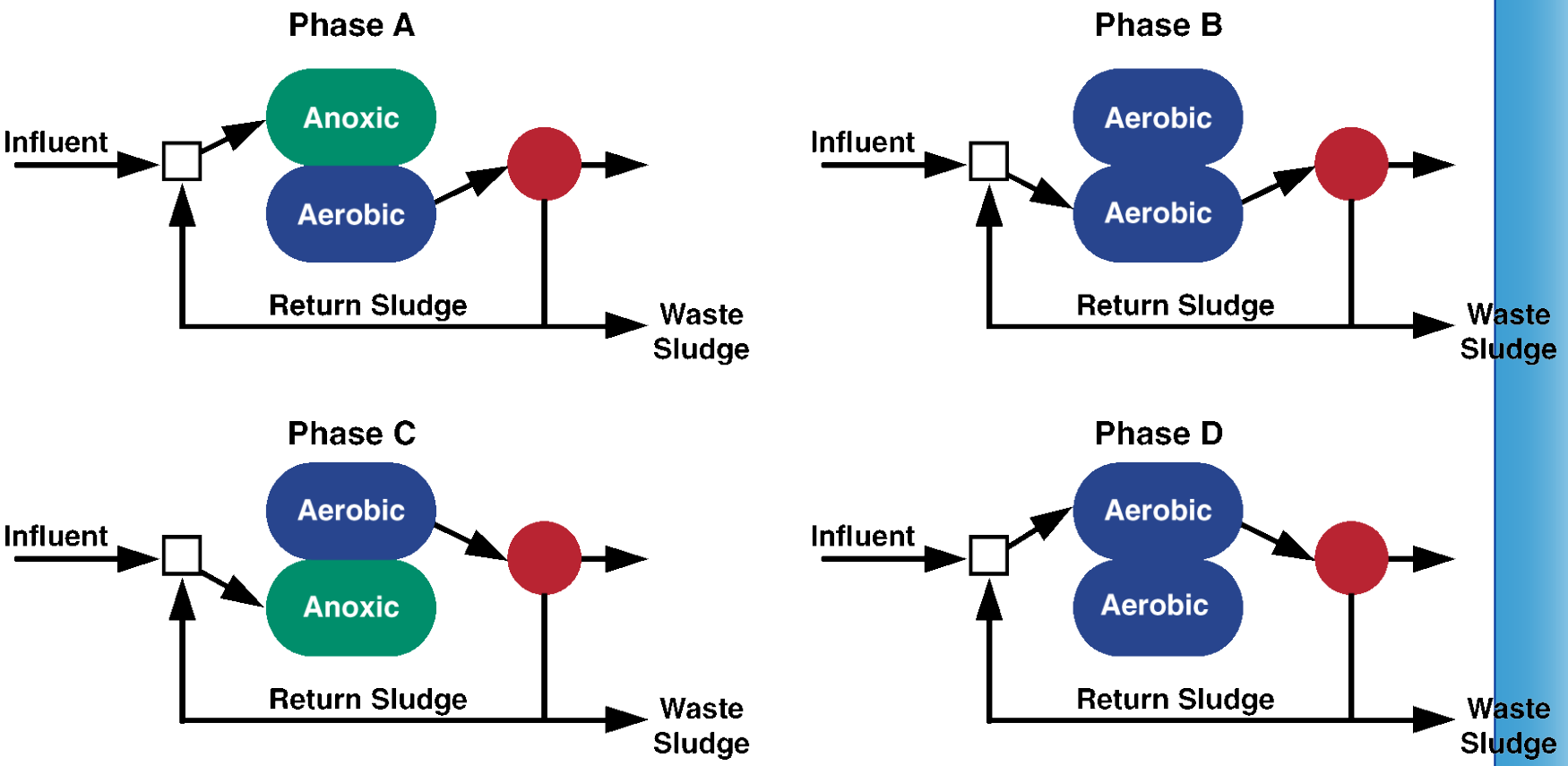
Bardenpho



Step-Feed Process

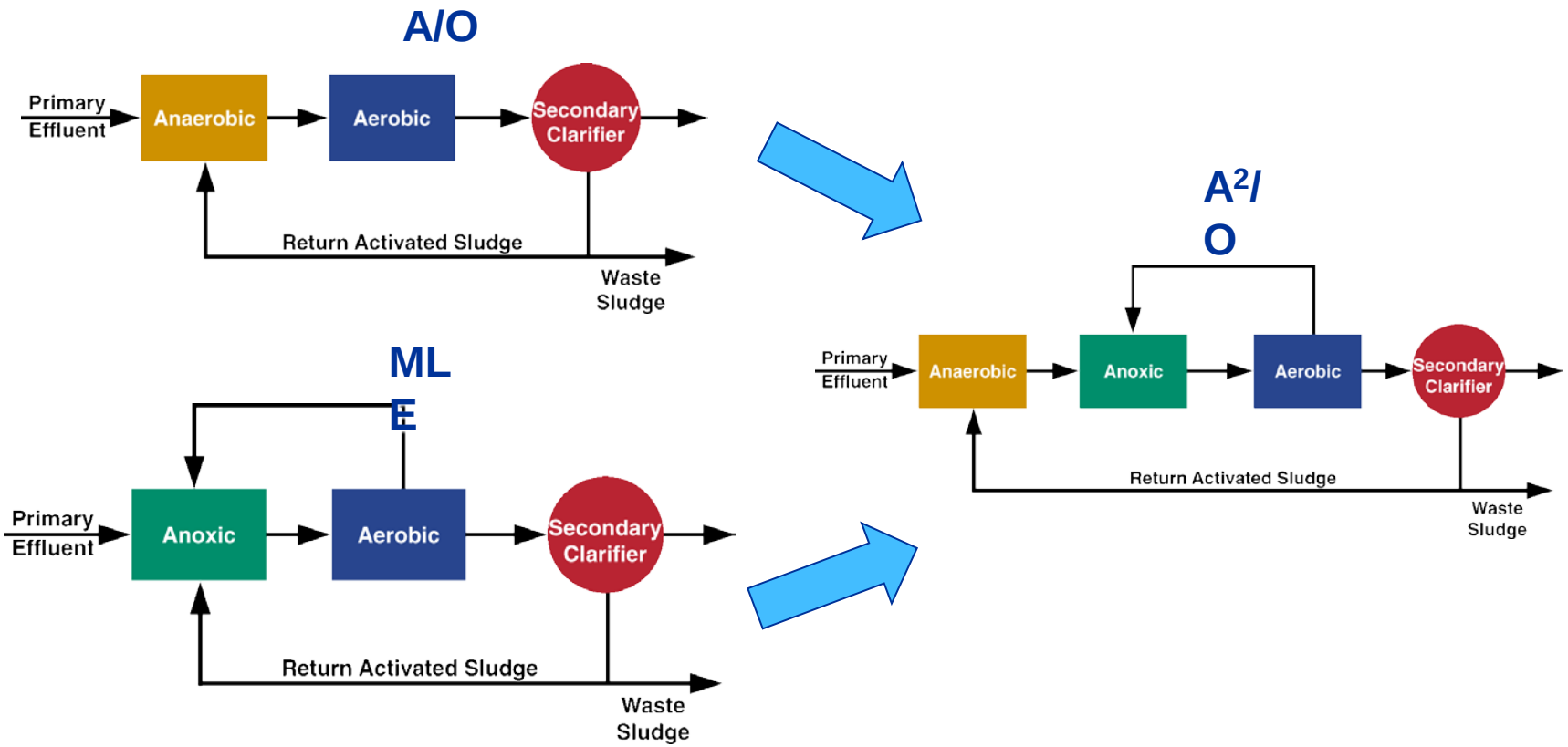


Bio-Denitro System

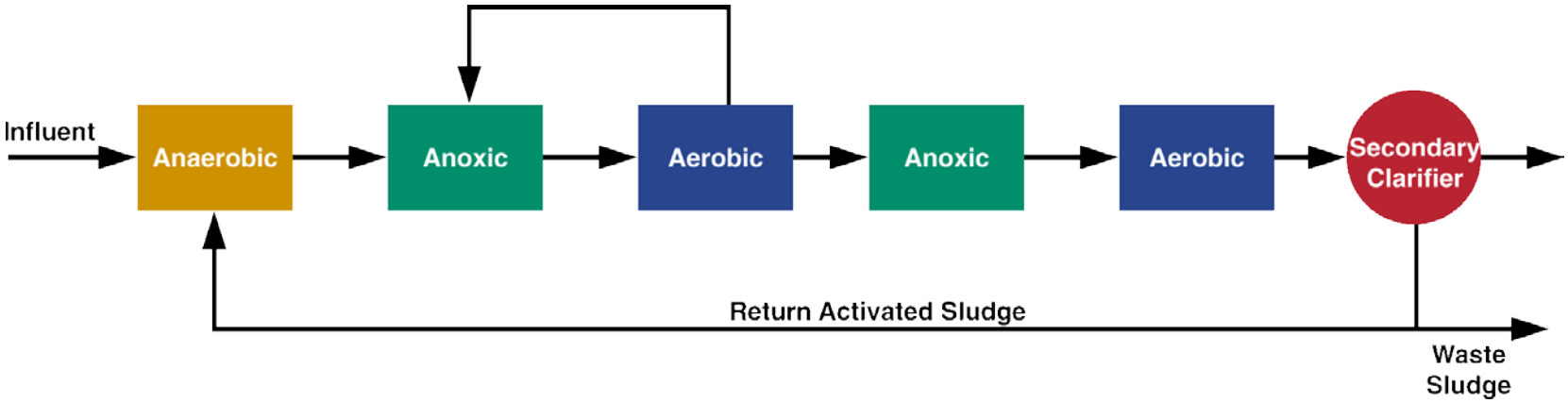


COMBINING NITROGEN AND PHOSPHORUS REMOVAL

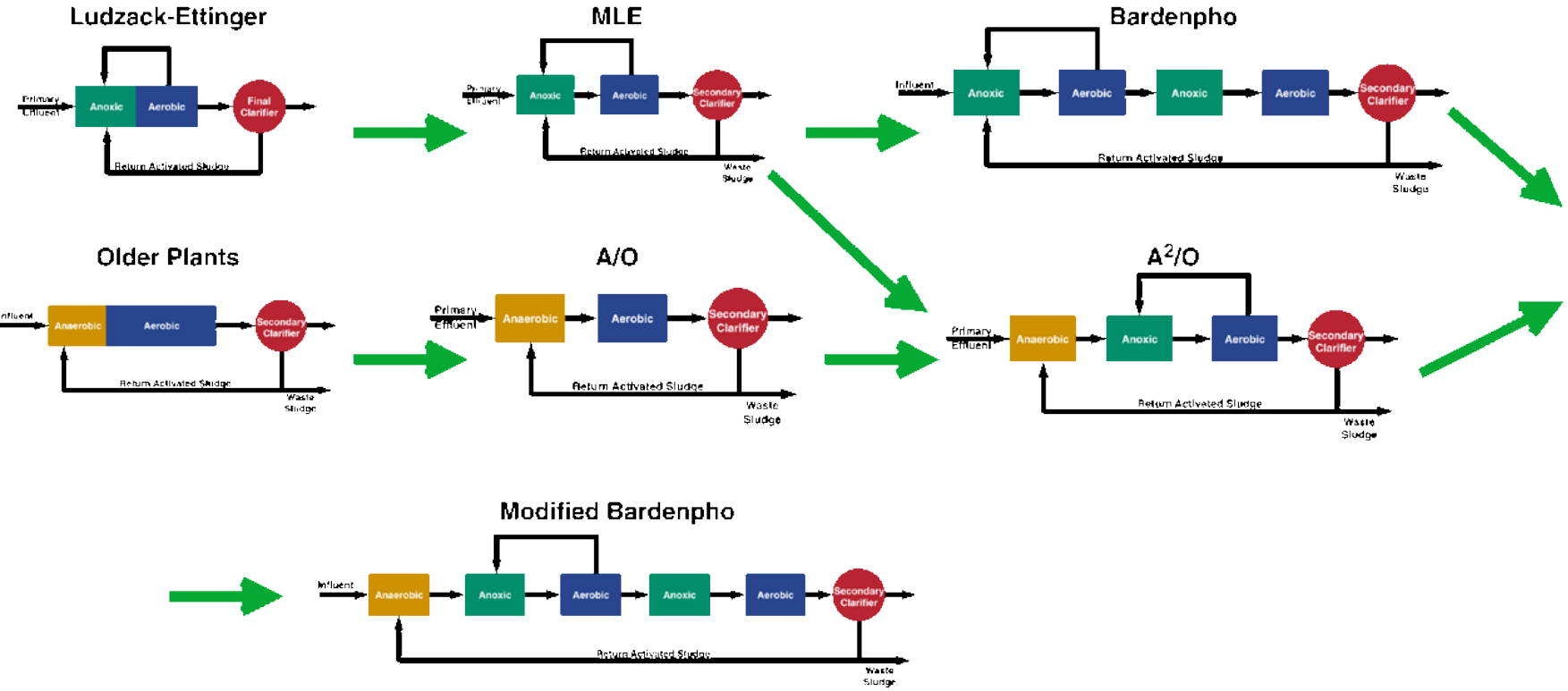
The A^2O Process Combines A/O and MLE Processes



Modified Bardenpho Process

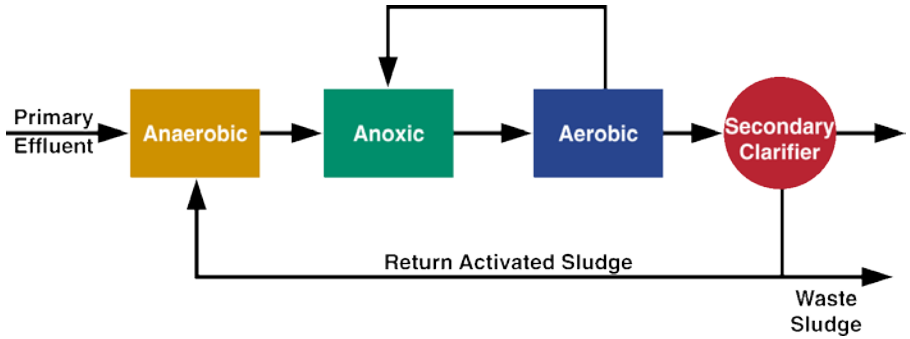


Progression of BNR Options

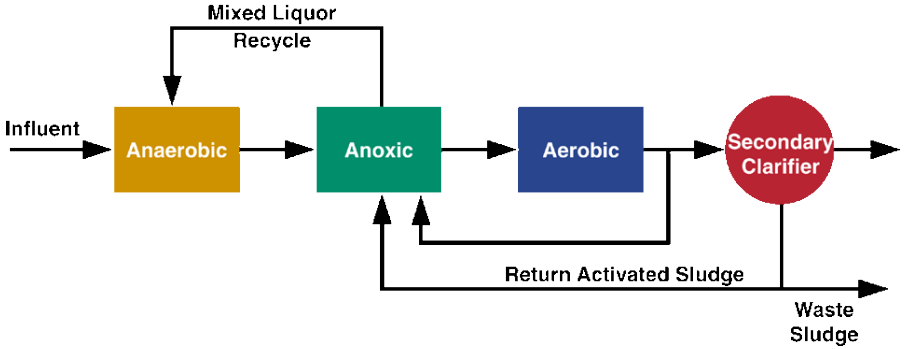


A^2O to UCT

A^2O

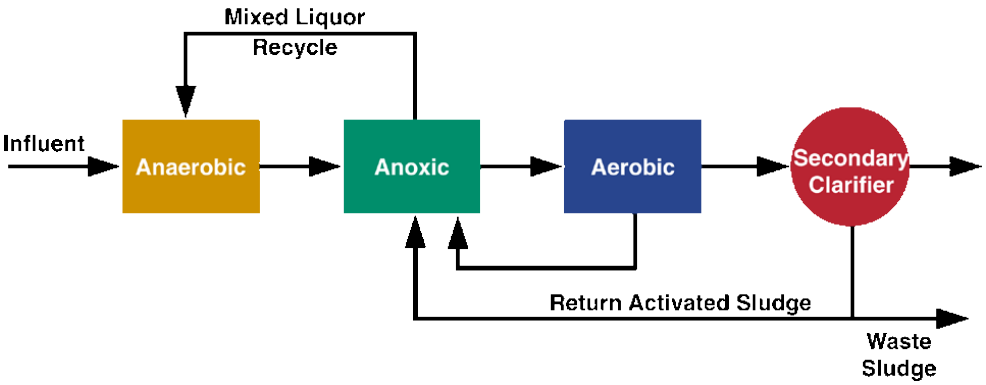


UCT

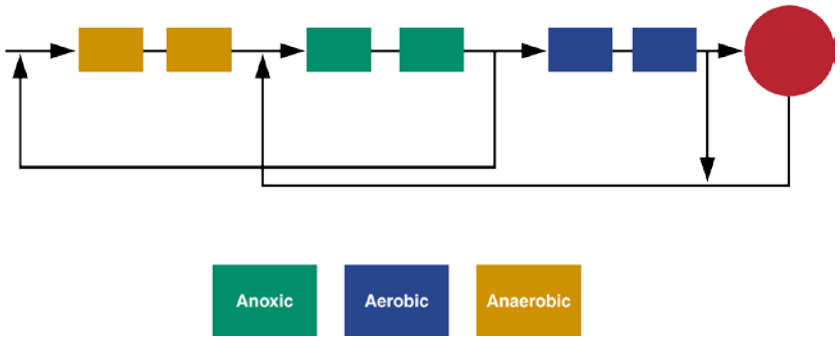


From UCT to VIP

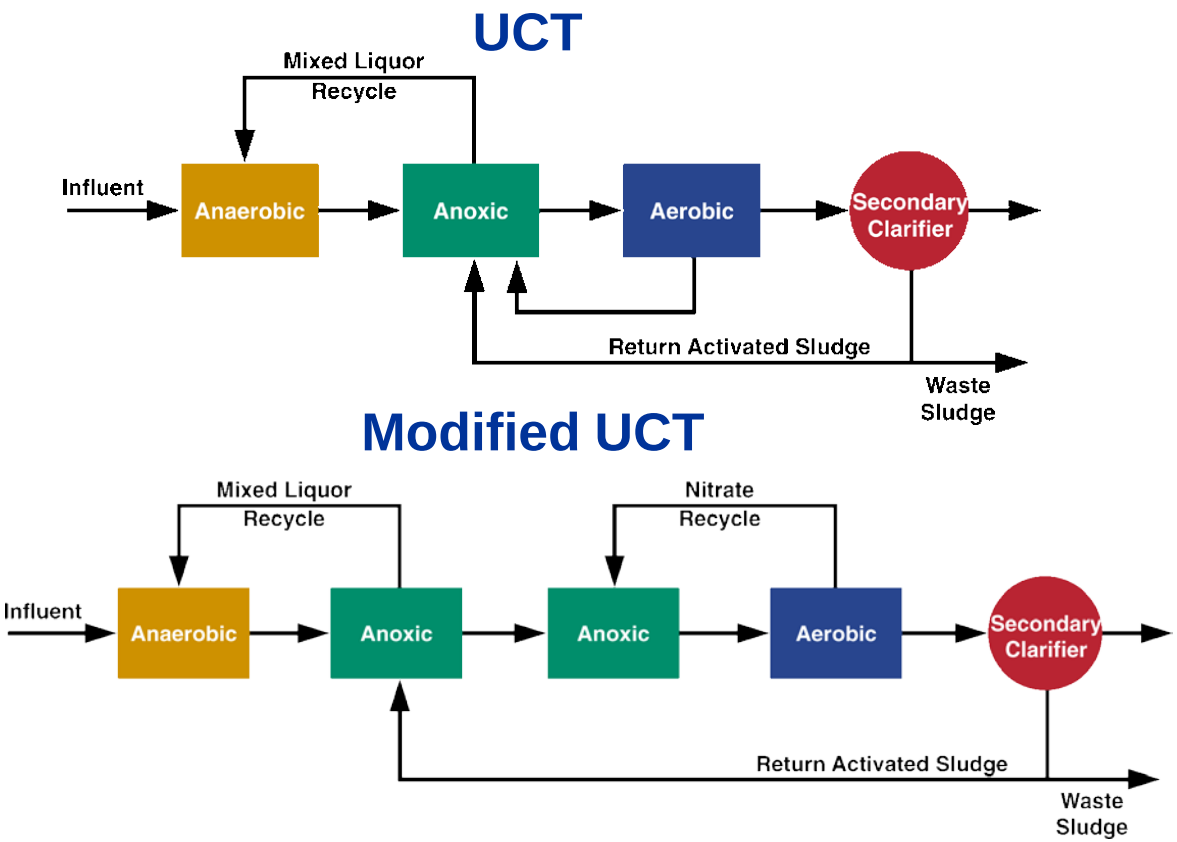
UCT



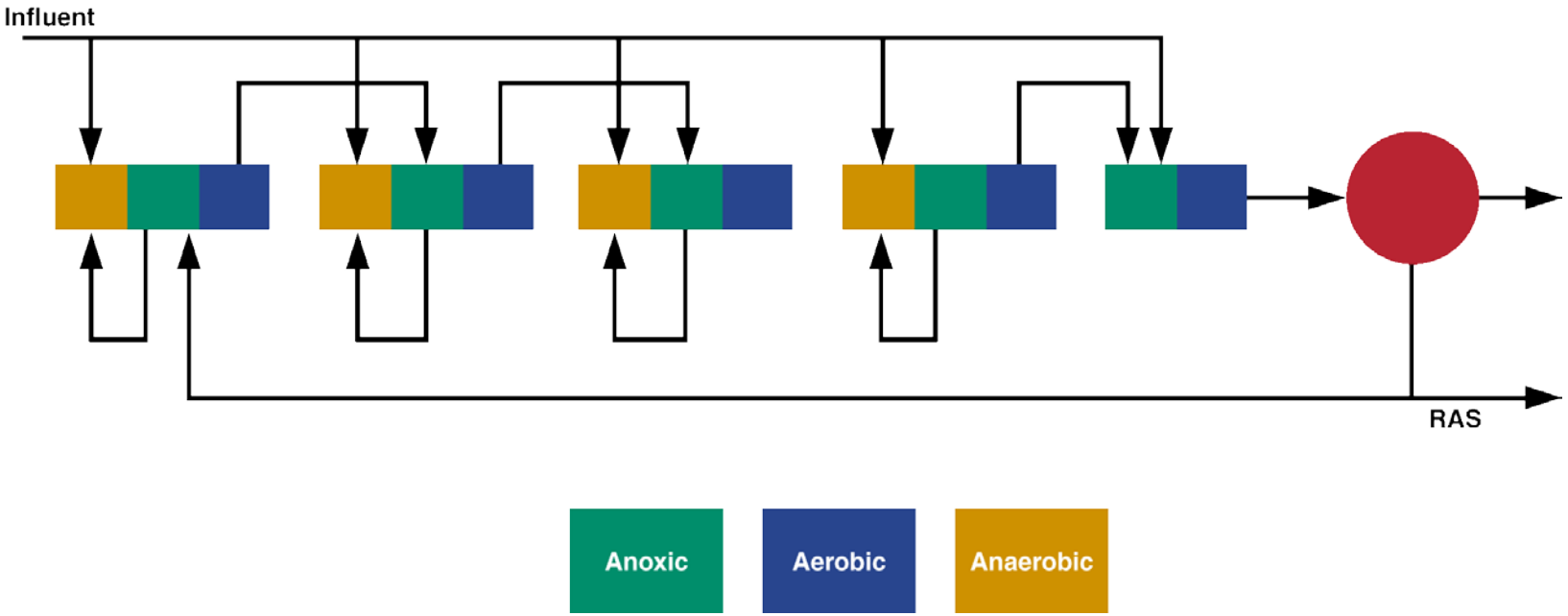
VIP



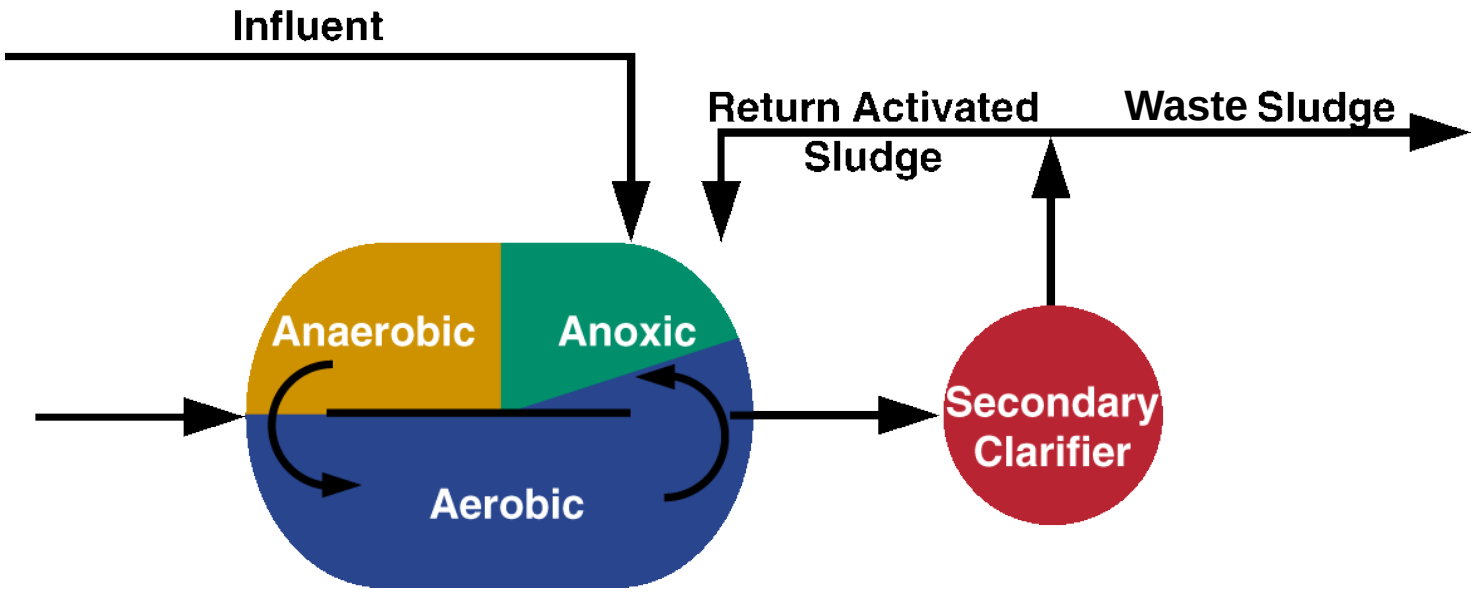
UCT and Modified UCT



Step BioP Process



N & P Removal in Oxidation Ditch



BNR Process Performance

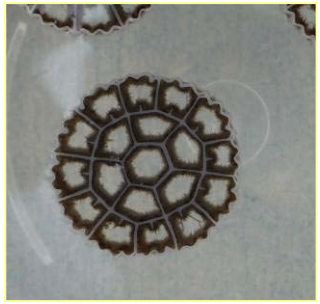
Process	Nitrogen Removal	Phosphorus Removal
MLE	Good (7-9 TN)	None
Step Feed DN	Good (7-9 TN)	None
AO	None	Moderate (< 2 TP)
A^2O	Good (7-9 TN)	Good (< 1 TP)
Step Feed DN & bio P	Good (7-9 TN)	Good (< 1 TP)
UCT & VIP	Good (7-9 TN)	Good (< 1 TP)
4 Stage Bardenpho	Excellent (3 – 6 TN)	None
5 Stage Bardenpho	Excellent (3 – 6 TN)	Good (< 1 TP)
Denitrification Filter w/C feed	Excellent (3 – 4 TN)	None
Chemical Addition	None	Excellent (< 0.5 TP)
Advanced Processes	Excellent (1 TN)	Excellent (< 0.1 TP)

BNR Process Enhancements

Enhancement	Nitrogen Removal	Phosphorous Removal
IFAS	Reduces needed volume w/o increasing clarifier load	None
MBR	Reduces needed volume, no sec clarifiers required	Enhanced P solids removal
Media Filters	None	Enhanced P Solids removal
Cloth Filters	None	Enhanced P solids removal
Ballasted Clarification	None	Enhanced P solids removal

What is IFAS?

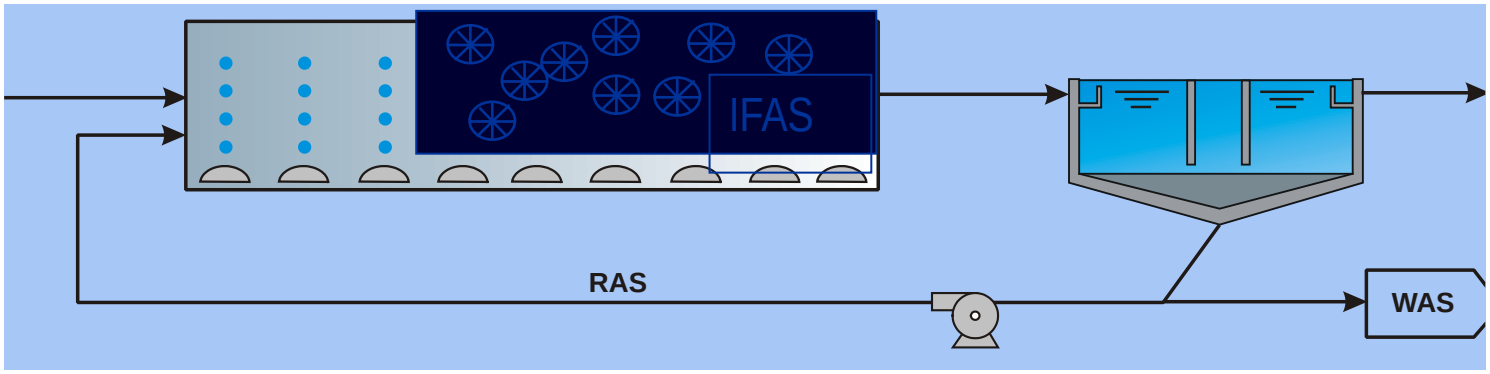
AS + TF(RBC) = IFAS



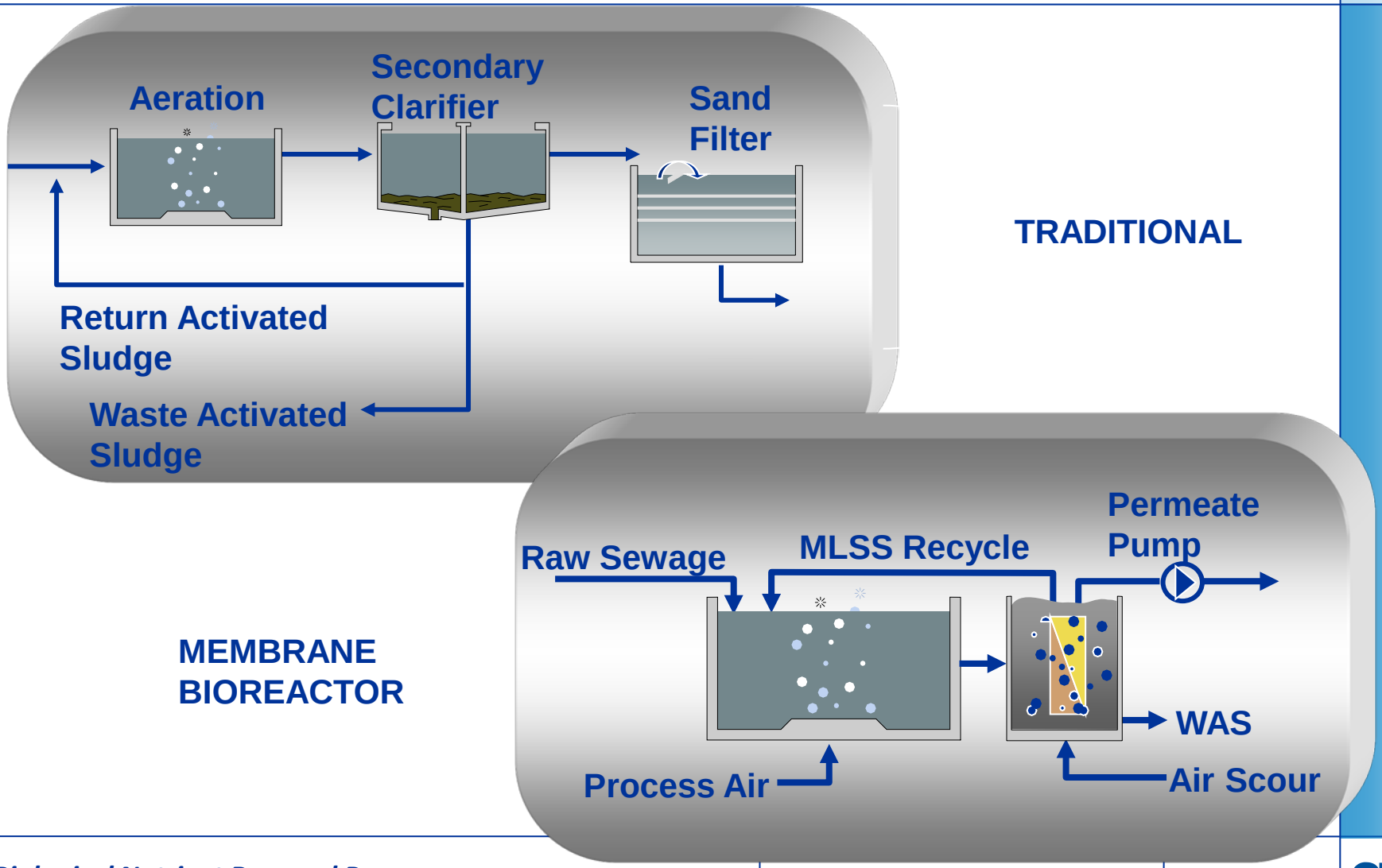
Integrated Fixed Film Activated Sludge

The Advantages….

- Higher capacity in same volume
- Increased biomass w/o increased clarifier loading
- Re-seeding of suspended phase
- “Self correcting”

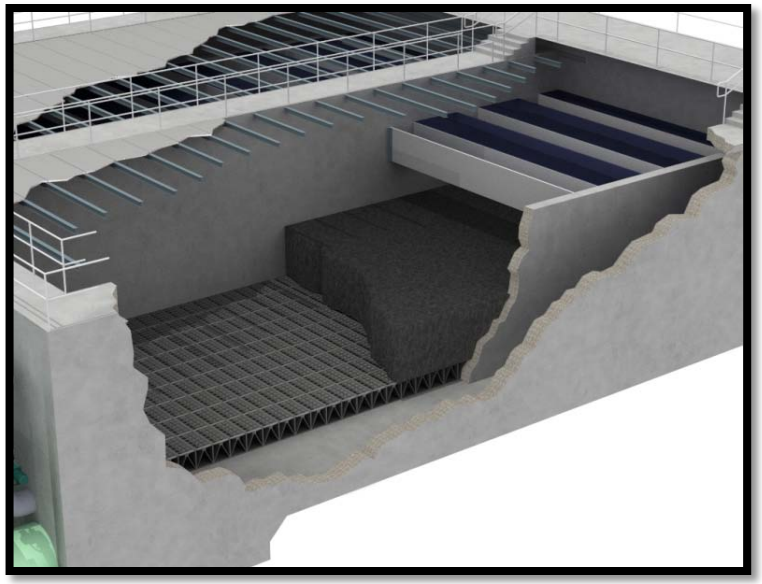


Wastewater Treatment Traditional vs Membrane Bioreactor (MBR)



Denite Filters

- Removes biosolids
  - (contain N & P)
- Removes P solids
- Denitrification mode
  - Add carbon source
    - Methanol
    - Acetate
  - Nitrate to Nitrogen gas



QUESTIONS?