

# BUILDING A WORLD OF DIFFERENCE

**A NEW TOOL TO ENHANCE BIOLOGICAL  
PHOSPHORUS REMOVAL –  
MIXED LIQUOR FERMENTATION**

STEVE ARANT, P.E. – PROJECT MANAGER  
JAMES BARNARD PH.D. WEF FELLOW – GLOBAL PRACTICE LEADER  
ED KOBYLINSKI, P.E. – SENIOR PROCESS SPECIALIST  
HEATHER PHILLIPS, P.E. – CITY OF OLATHA, KS

 **CSWEA** Member **WEF**  
COUNCIL OF STATE WATER POLLUTION CONTROL AGENCIES

 **BLACK & VEATCH**  
Building a world of difference.

## AGENDA

Phosphorus Removal Basics  
Traditional Technology  
Fermentation of Mixed Liquor



# PHOSPHORUS REMOVAL



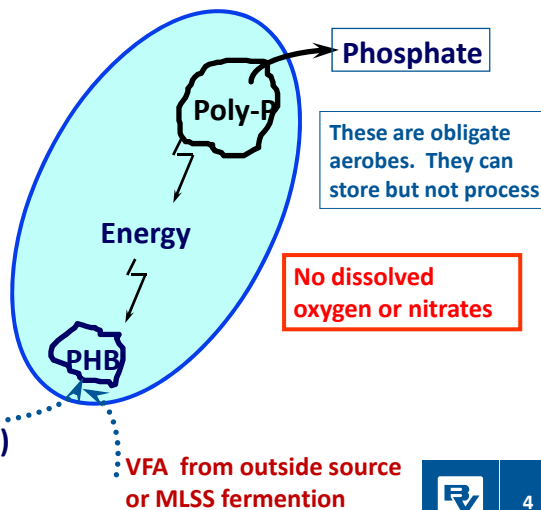
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## BIO-P ORGANISMS STORE PHB AND RELEASE P IN THE ANAEROBIC ZONE

Readily Biodegradable COD (rbCOD) Influent

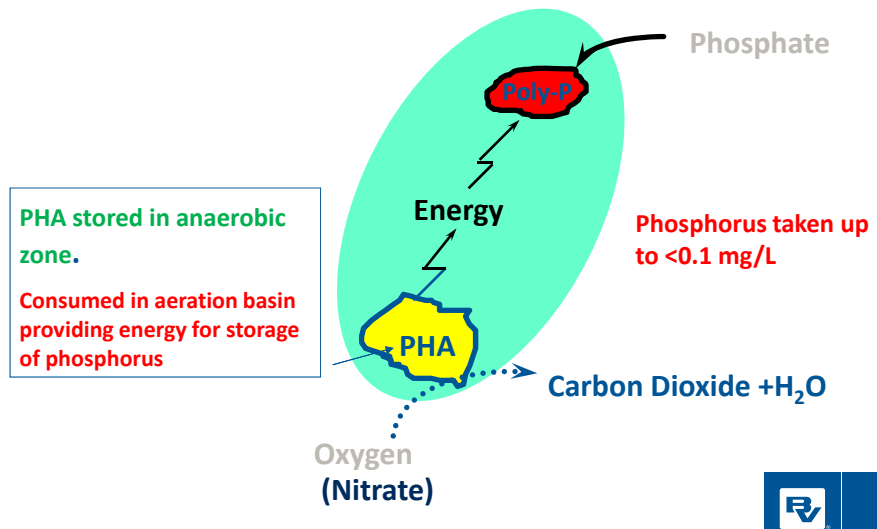
Facultative heterotrophs

Influent → Volatile Fatty Acids (VFA)

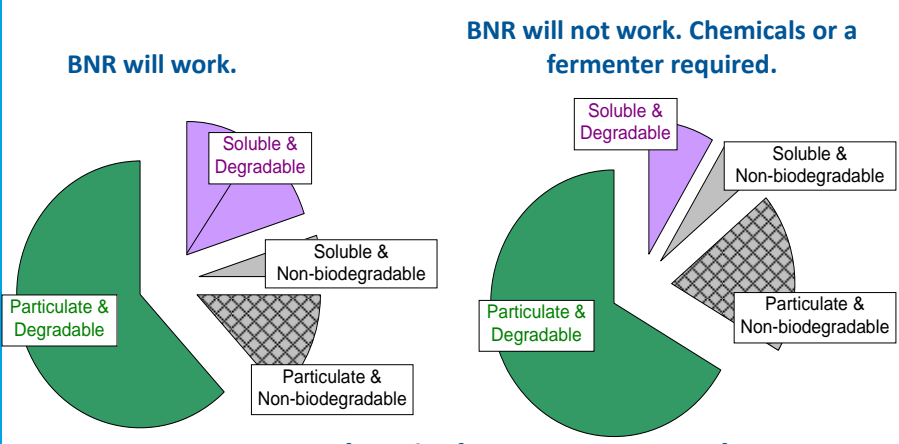


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## BIO-P ORGANISMS OXIDIZE PHA AND REMOVE P IN THE AEROBIC ZONE



## THE IMPORTANCE OF INFLUENT SAMPLING

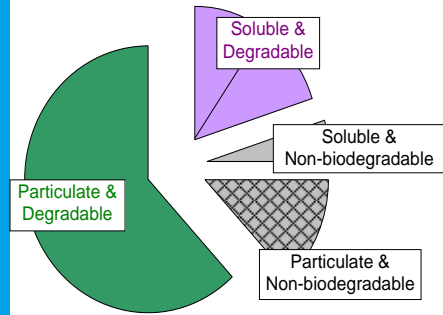


### Wastewater Chemical Oxygen Demand

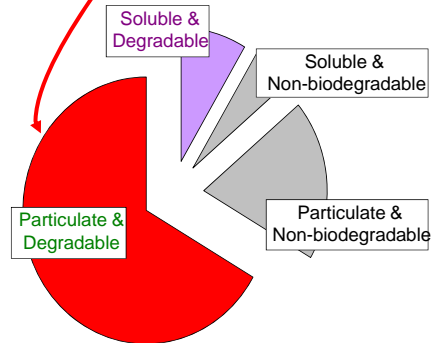
Methods for Wastewater Characterization in Activated Sludge Modeling (Metcalf et al. 2003)

# THE IMPORTANCE OF INFLUENT SAMPLING

BNR will work.



BNR will not work. Chemicals or a fermenter required.

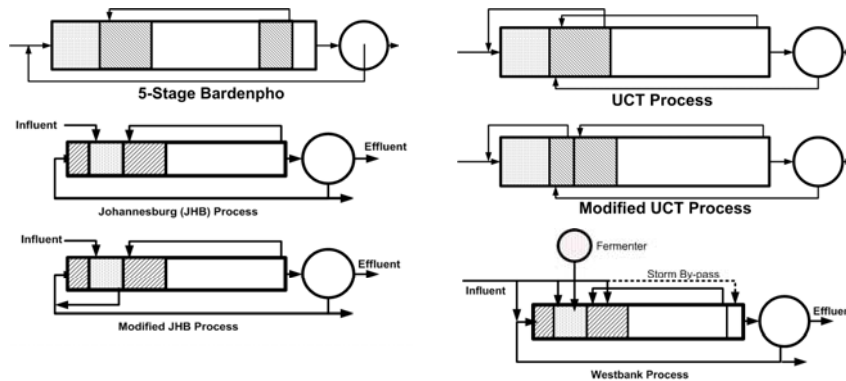


## Wastewater Chemical Oxygen Demand

Methods for Wastewater Characterization in Activated Sludge Modeling (Melcer et al 2003)



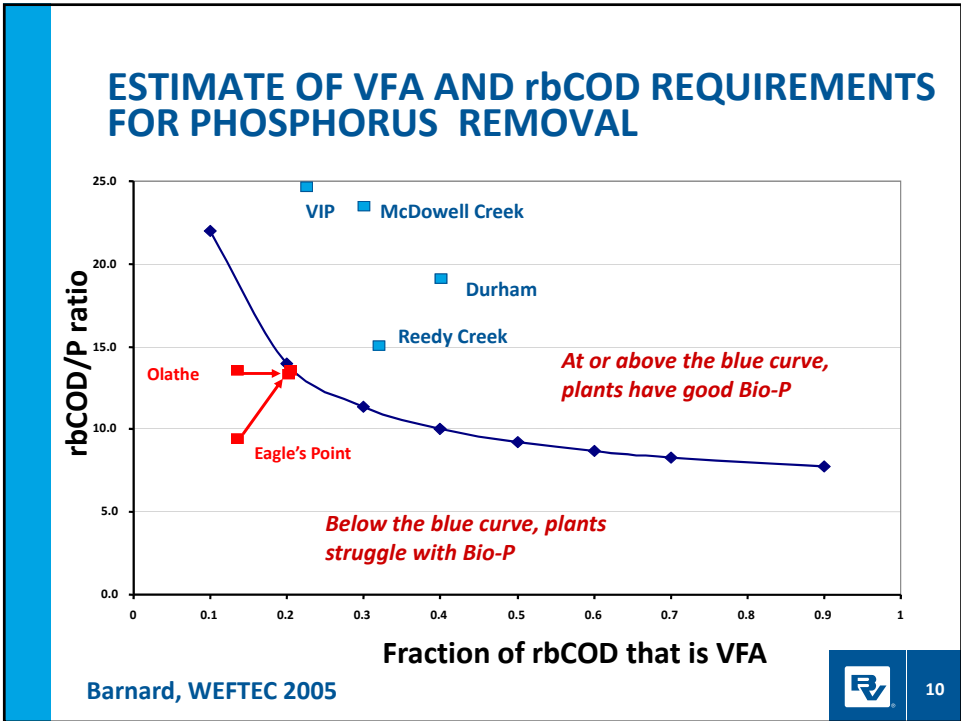
# SOME TRADITIONAL FLOW DIAGRAMS



Anaerobic    
 Anoxic    
 Aerobic



# FERMENTATION



## NEED FOR FERMENTATION

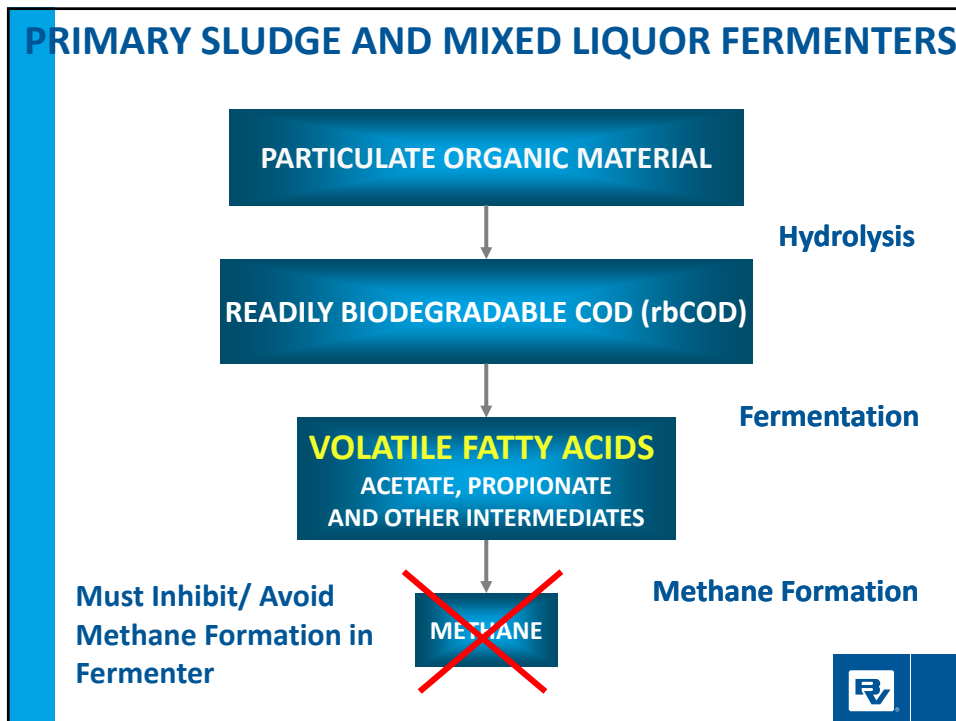
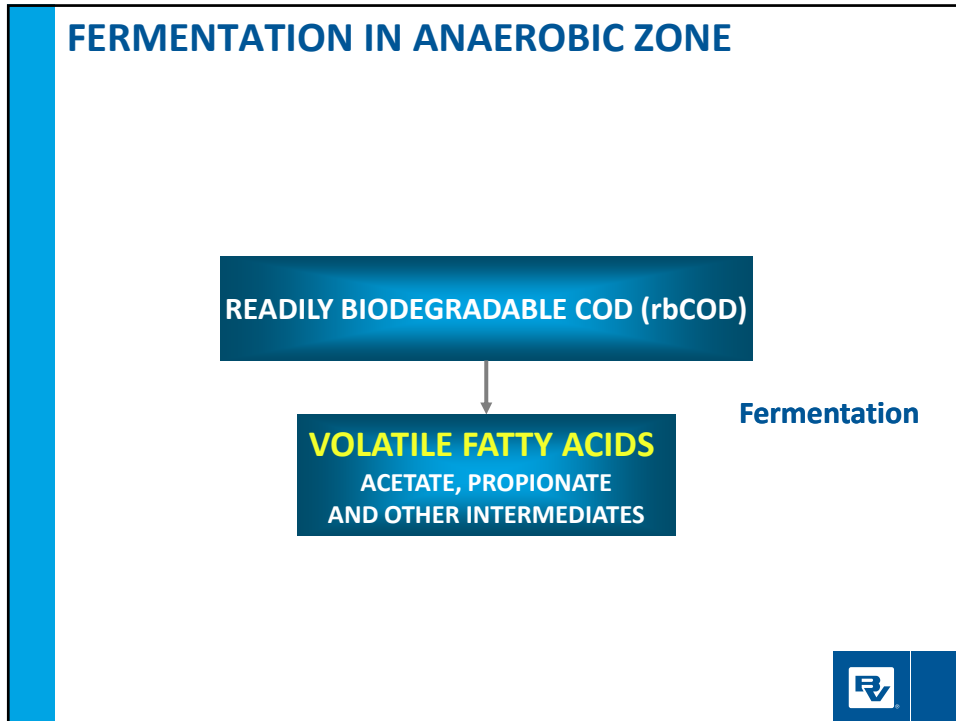
- BioP organisms need acetate or propionate as feedstock
- About 4 to 6 g VFA as COD for 1g P
- Surplus VFA means greater reliability
- Shorter overall retention time in anaerobic zone



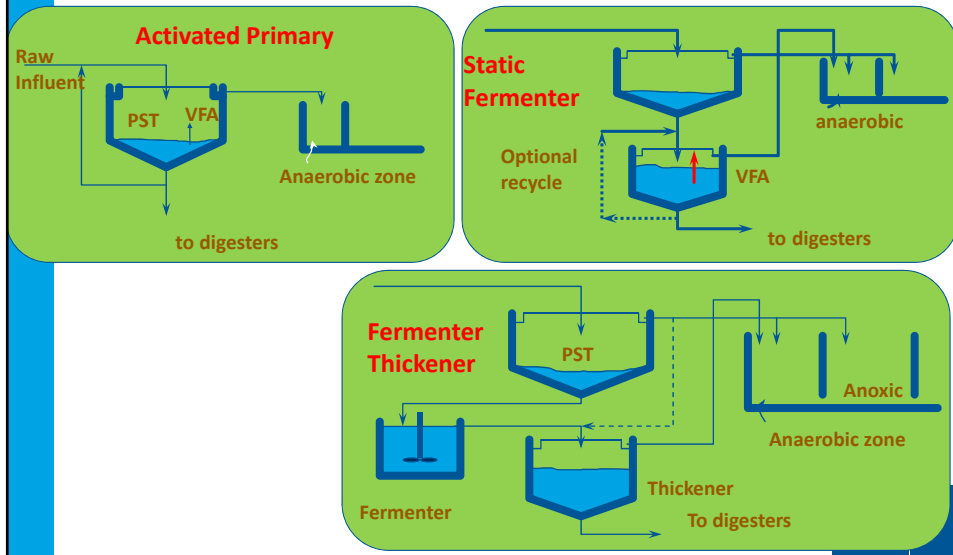
## POTENTIAL SCENARIOS FOR VFA

- Plenty of VFA in influent wastewater means *fermentation not needed* – it has already occurred in the sewer
- Plenty of rbCOD (not much VFA) in influent means that *fermentation in the anaerobic zone*
- Not enough VFA or rbCOD means VFA must be made elsewhere on site or added as supplemental carbon – *Fermenter needed*





## TRADITIONAL PRIMARY SLUDGE FERMENTERS



## FERMENTER THICKENER



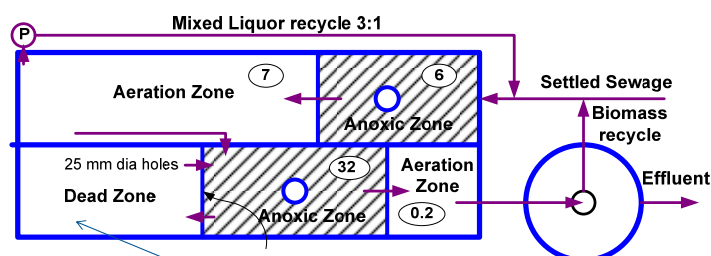


# PHOSPHORUS REMOVAL USING MLSS FERMENTATION



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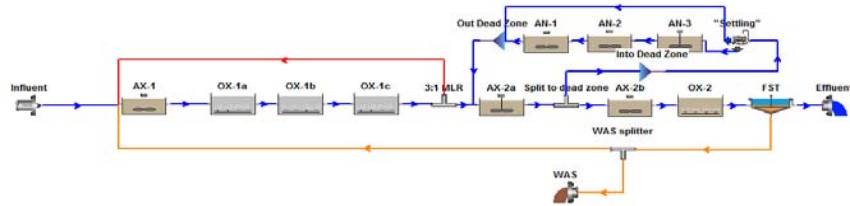
## BARDENPHO PILOT PLANT (25,000 GPD)



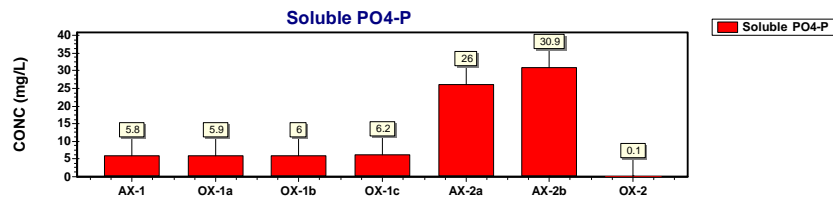
The purpose of the dead zone was to allow relative adjustments to the other zones.



## MODEL BASED ANALYSIS



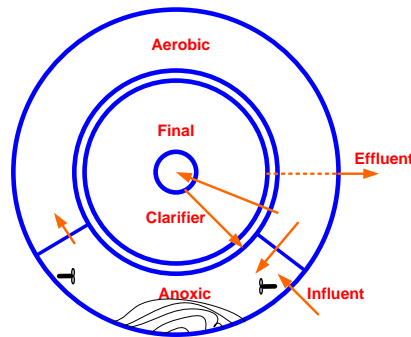
### Bardenpho Pilot Plant Barnard (1974)



Houweling, D. Dold, P. and Barnard, J.L. (2010) Theoretical limits to biological phosphorus removal: rethinking the influent COD:N:P ratio. *Proceedings of the 83rd Annual Technical Exhibition and Conference of the Water Environment Federation, New Orleans, LA.*



## JOPPATOWNE MD USA



- No anaerobic zone
- Large anoxic zone with bad mixing
- Operators noticed sludge accumulation in the anoxic zone
- Phosphorus reduced from 8 mg/l to 1 mg/l

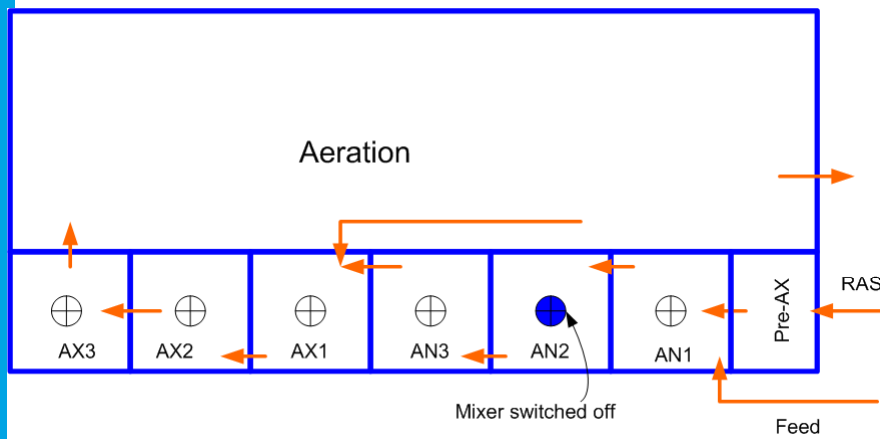
Source – Black & Veatch design report to Harford Co MD



### CAROUSEL PLANT HENDERSON NV



### MIXED LIQUOR FERMENTATION AT HENDERSON NV



## SURFACE APPEARANCE OF HENDERSON PLANT



Mixer off

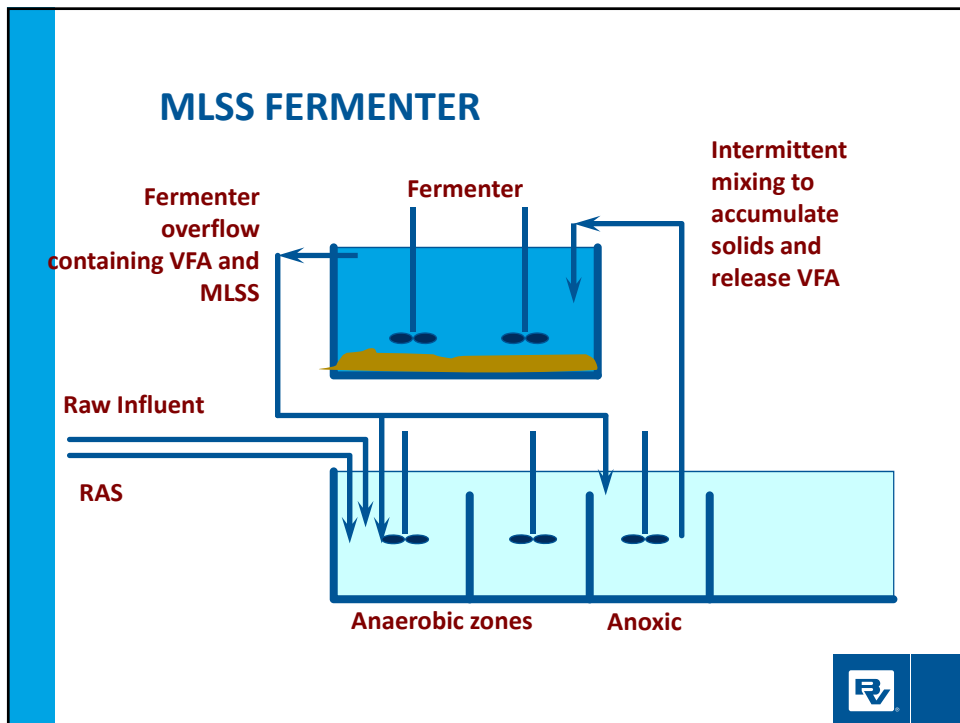
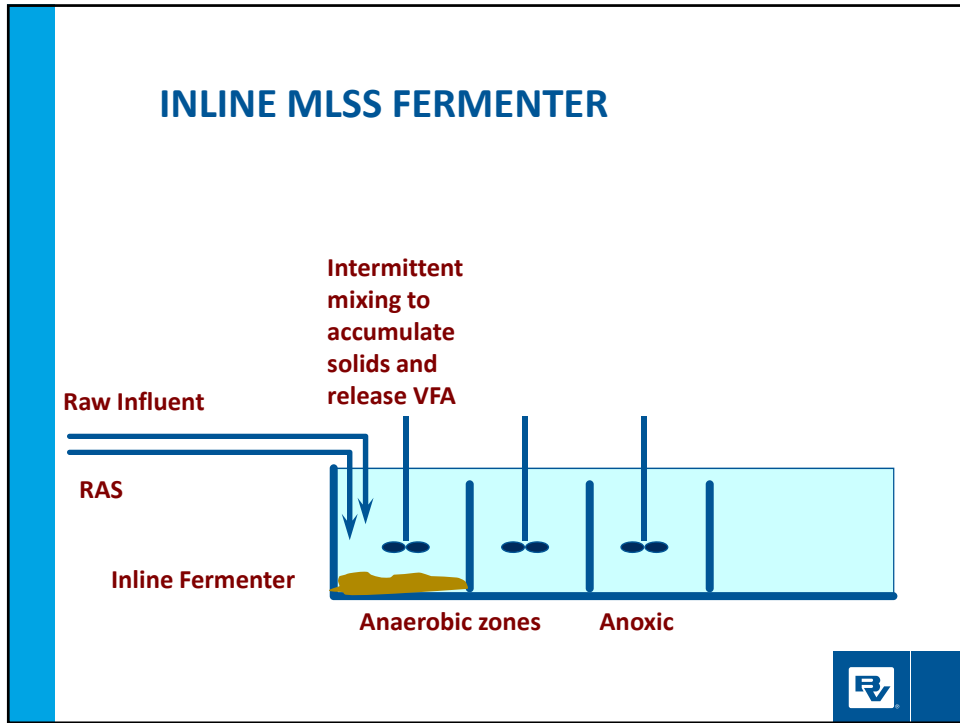
During mixing



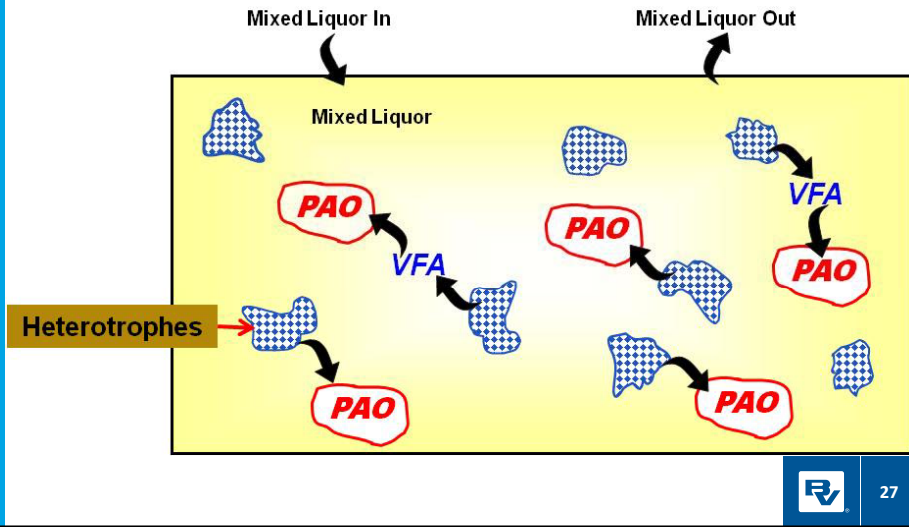
## MLSS FERMENTER

- Generally for facilities that have no primary sludge
- Using MLSS to ferment influent VSS and Non-BioP bacteria
- Recycle from anaerobic zone effluent to fermenter 10-20% of influent flow
- Intermittent mixing in fermenter to build up solids concentration and SRT; also releases VFA from solids to wash out to process

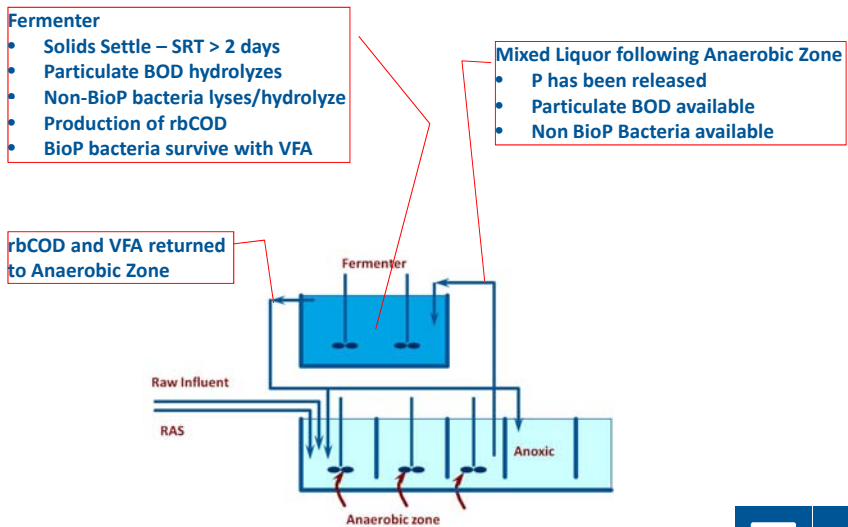




## MIXED LIQUOR FERMENTATION

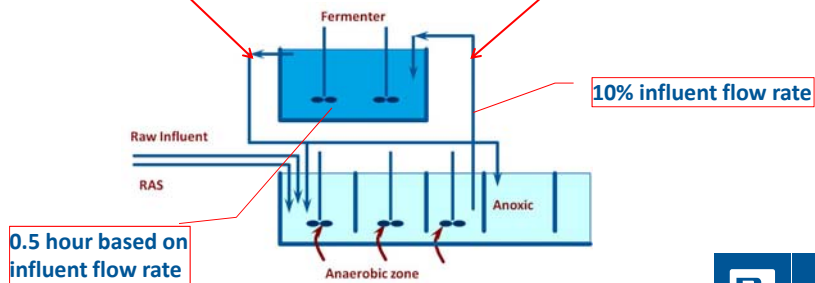


## HOW DOES IT WORK?

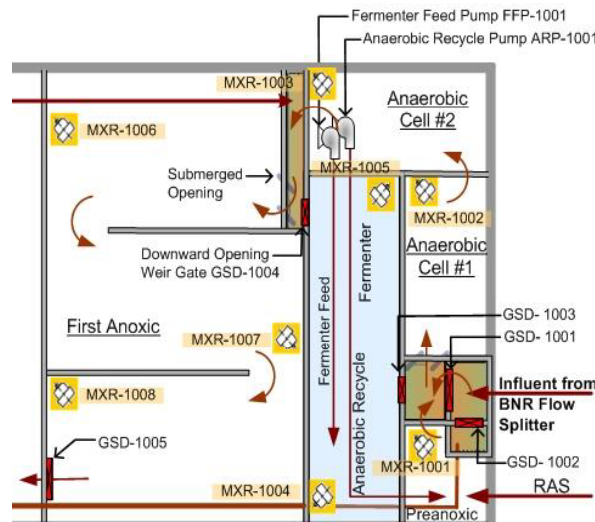


## HOW DOES IT WORK?

	mg/l as COD		mg/l as COD
Non-polyP heterotrophs	450	Non-polyP heterotrophs	675
PolyP heterotrophs	232	PolyP heterotrophs	251
PO4-P	67	PO4-P	26.5
Releasable stored polyP	0.1	Releasable stored polyP	30.9
Slowly bio. COD (part.)	19.5	Slowly bio. COD (part.)	225
Readily bio. COD	0.8	Readily bio. COD	6.2
Acetate	224	Acetate	6.8
Stored PHA	157	Stored PHA	114
Volatile suspended solids	1065	Volatile suspended solids	1312



## UNIQUE FERMENTER FLOW PATH



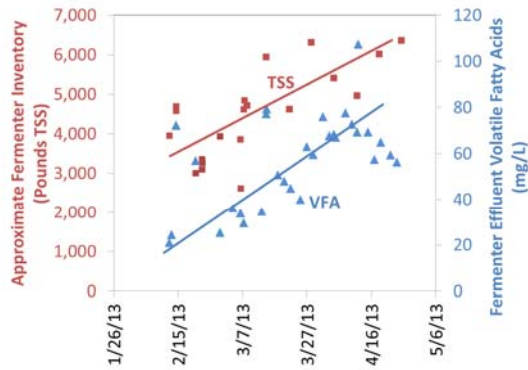
- Pump into Fermenter (from end of AN zone)
- Intermittent mixing
- Overflow out of Fermenter
  - To AN Zone
  - Or AX Zone



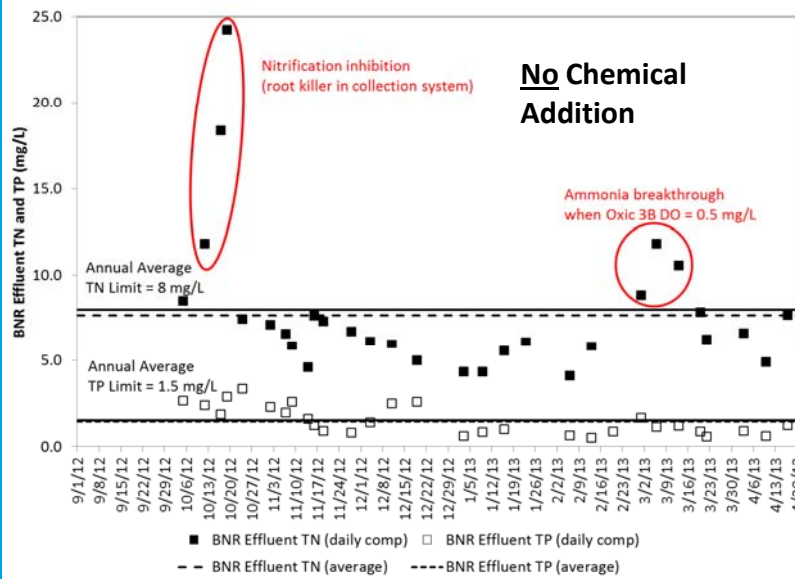
## FERMENTER STARTUP



- Weekly solids inventory
- Mixers control wasting and solids retention time
  - Mix 3 min/day
  - 2–5 days SRT



## BNR EFFLUENT SINCE STARTUP



Permit limits go into effect July 1, 2013





## FINAL MESSAGES

- Biological phosphorus removal is reliable and facilitates recovery
- Influent characterization necessary to determine the need for fermentation
- Fermentation facilitates biological phosphorus and nitrogen removal
- Mixed liquor fermentation available to enhance VFA production.



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# Together



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