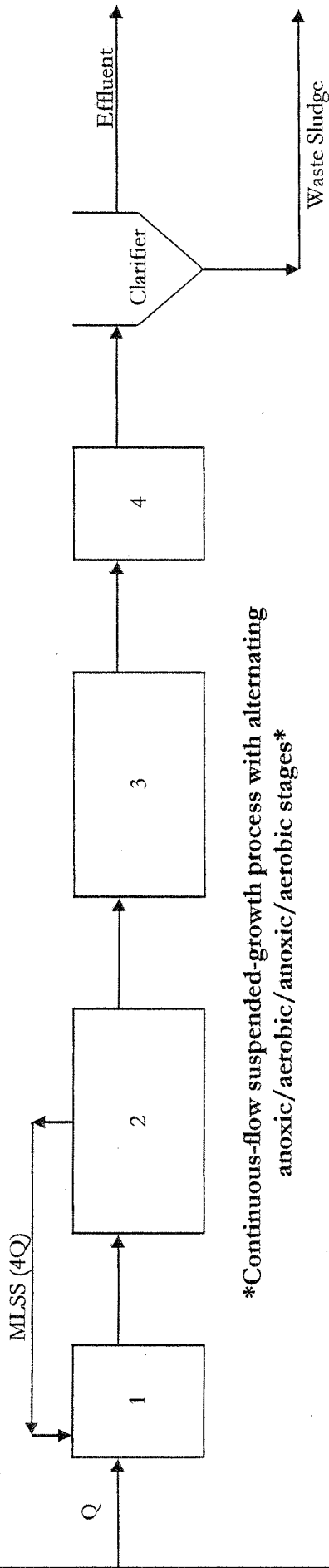


ATTACHMENT A

PROCESS FLOW SCHEMATICS

4-STAGE BARDENPHO PROCESS

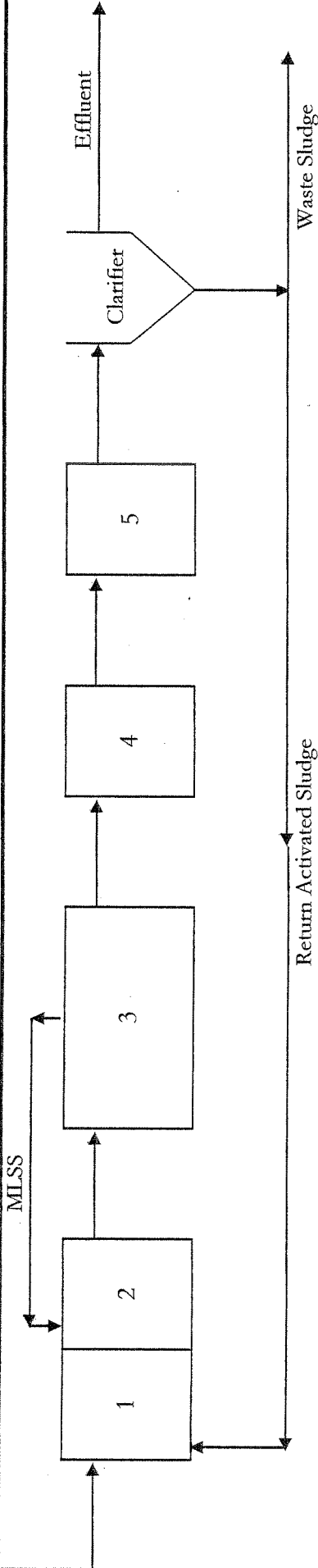


Continuous-flow suspended-growth process with alternating anoxic/aerobic/anoxic/aerobic stages

- Stage 1** First anoxic stage (De-nitrification)
 Mix only, D.O. = 0 mg/L
 Nitrate rich MLSS from stage 2 mixes with influent flow.
 Nitrate reduced to gaseous nitrogen and released to atmosphere.
- Stage 2** Fully aerobic stage (Nitrification)
 Mix and air, D.O. > 2.0 mg/L
 Oxygen oxidizes BOD and converts ammonia to nitrate.
- Stage 3** Second anoxic stage (De-nitrification)
 Nitrate reduced to gaseous nitrogen and released to atmosphere.
- Stage 4** Re-aeration stage (Nitrification)
 Mix and air, D.O. > 1.5 mg/L
 Creates and maintains aerobic condition for final clarification.
 Strip nitrogen gas formed in second anoxic zone.

BNR CAPABILITIES	
Nitrogen Removal	Good
Phosphorus Removal	Minimal

5-STAGE BARDENPHO PROCESS



Bardenpho process with the addition of an initial anaerobic zone for phosphorus removal

Stage 1

Fermentation Stage

Mix only, no air, D.O. < 0 mg/L

Activated sludge from the clarifier mixes with influent wastewater.

Produces necessary organic stress conditions for biological phosphorus removal in following aerobic stages.

Organic stress occurs in absence of DO and Nitrate.

Stage 2

First anoxic stage (De-nitrification)

Mix only, no air, D.O. = 0 mg/L

Nitrate rich MLSS from Stage 2 mixes with flow from fermentation stage.

Nitrate reduced to gaseous nitrogen and released to atmosphere.

Luxury phosphorus uptake by organisms.

Stage 3

Aerobic stage (Nitrification)

Mix and air, D.O. > 2.0 mg/L

Oxygen oxidizes BOD and converts ammonia to nitrate.

Stage 4

Second anoxic stage (De-nitrification)

Mix only, no air, D.O. = 0 mg/L

Nitrate reduced to gaseous nitrogen and released to atmosphere.

Results in low effluent nitrogen concentration.

Stage 5

Aerobic stage (Nitrification)

Mix and air, D.O. > 1.5 mg/L

Creates and maintains aerobic condition for final clarification.

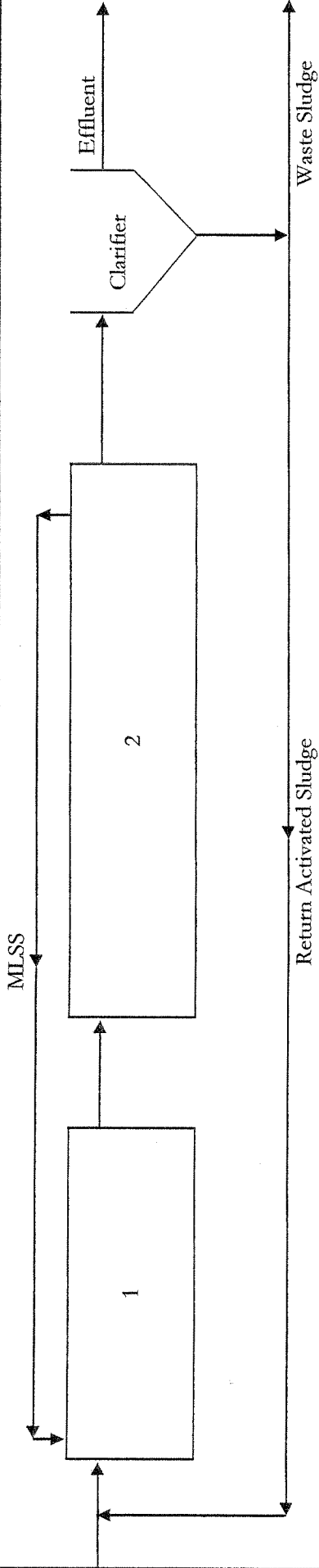
Prevents sludge from becoming septic and releasing phosphorus in the clarifier.

Additional oxygen ensures that sludge remains aerobic, retaining phosphorus for use in Stage 1.

BNR CAPABILITIES

Nitrogen Removal	Excellent
Phosphorus Removal	Excellent

Modified Ludzack-Ettinger Process (MLE)



Continuous-flow suspended-growth process with an initial anoxic stage, followed by an aerobic stage

Stage 1 Anoxic Stage (De-nitrification)

Mix only, D.O. = 0 mg/L

Combination of influent wastewater, return activated sludge from the clarifiers & nitrate rich mixed liquor from Stage 2. Nitrate reduced to gaseous nitrogen and released to atmosphere.

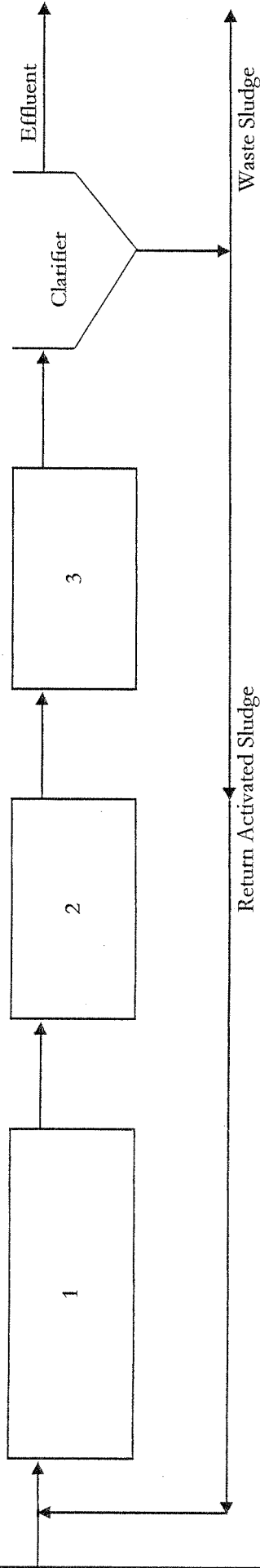
Stage 2 Aerobic Stage (Nitrification)

Mix and air, D.O. > 2.0 mg/L

Oxygen oxidizes BOD and converts ammonia to nitrate.

BNR CAPABILITIES	
Nitrogen Removal	Good
Phosphorus Removal	None

Wuhrman Process

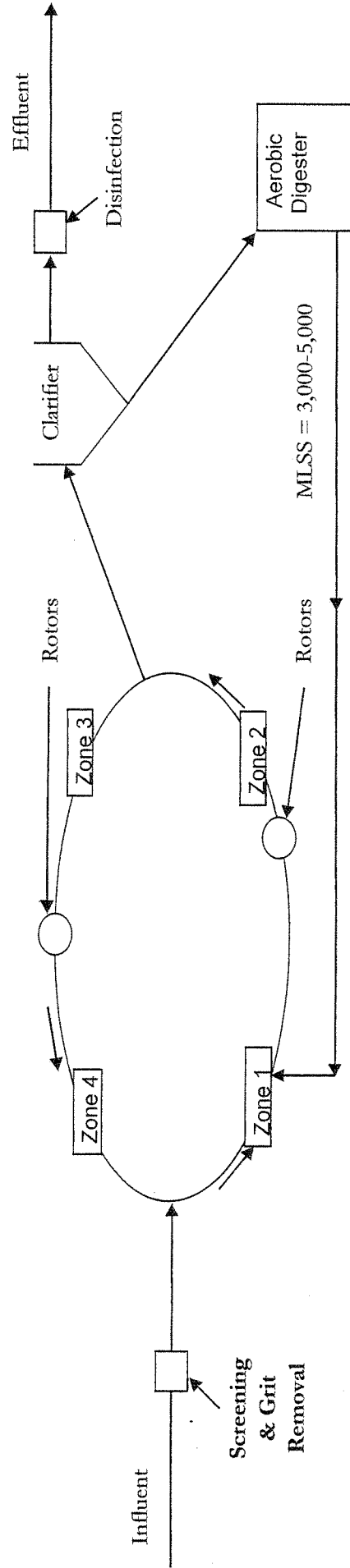


Continuous-flow suspended-growth process which places an anoxic basin after the nitrification zone

- Stage 1 Aerobic Stage (Nitrification)
 Mix and air, D.O. > 2.0 mg/L
 Oxygen oxidizes BOD and converts ammonia to nitrate.
 Combination of influent wastewater and return activated sludge from the clarifiers.
- Stage 2 Anoxic Stage (De-nitrification) ◀
 Mix only, D.O. = 0 mg/L
 Nitrate reduced to gaseous nitrogen and released to atmosphere.
- Stage 3 Re-aeration stage (Nitrification)
 Mix and air, D.O. > 1.5 mg/L
 Releases nitrogen gas bound in sludge prior to final clarification.

BNR CAPABILITIES	
Nitrogen Removal	Good
Phosphorus Removal	None

Oxidation Ditch Process

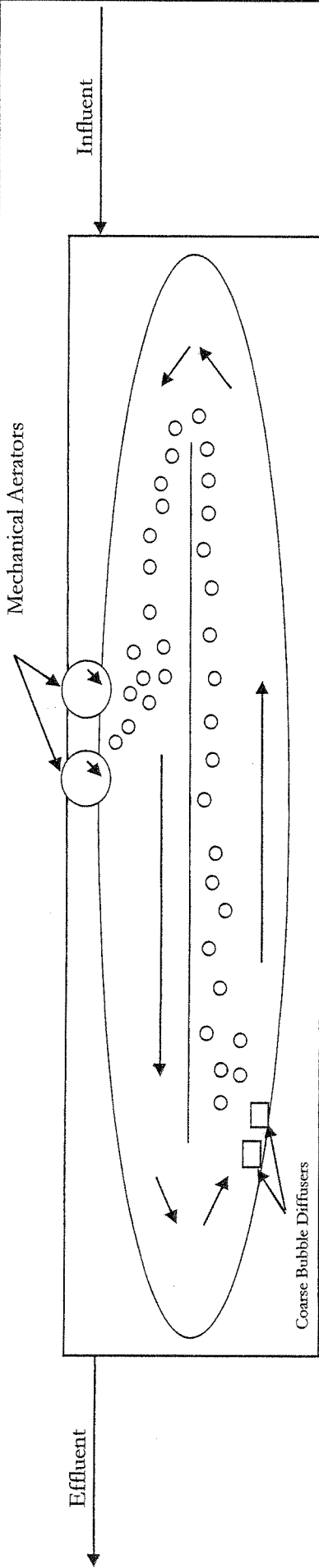


Continuous-flow process using looped channels to create time sequenced anoxic/aerobic/and anaerobic zones

- Zone 1 Anoxic zone
D.O. = 0 mg/L
Nitrate reduced to gaseous nitrogen and released to atmosphere.
Return activated sludge from digester introduced to provides necessary micro-organisms.
- ▲ Zone 2 Aerobic Zone
Air supplied through mechanical rotors.
Oxygen oxidizes BOD and converts ammonia to nitrate.
- Zone 3 Second Anoxic Zone
D.O. = 0 mg/L
Nitrate reduced to gaseous nitrogen and released to atmosphere.
- Zone 4 Second Aerobic Zone
Air supplied through mechanical rotors.
Oxygen oxidizes BOD and converts ammonia to nitrate.

BNR CAPABILITIES	
Nitrogen Removal	Excellent
Phosphorus Removal	Limited

Vertical Loop Reactor

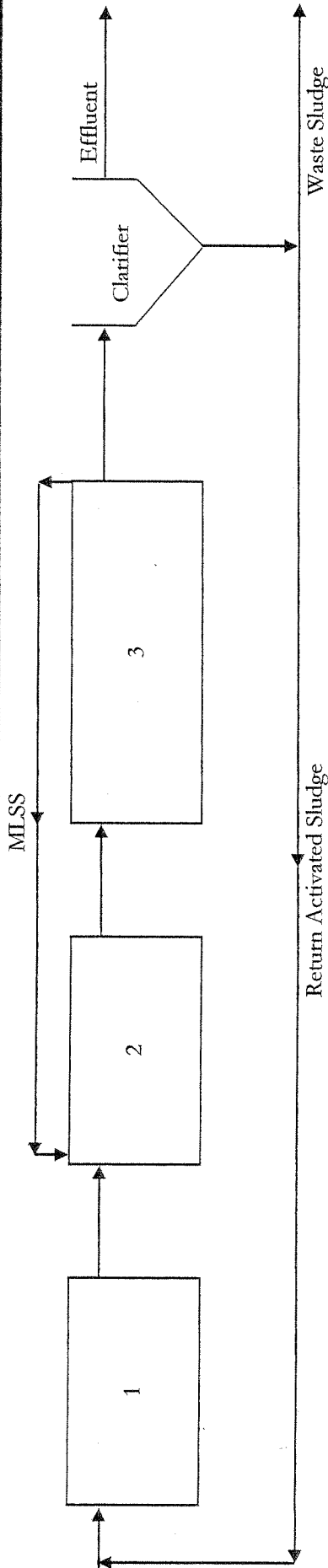


Continuous-flow process using looped channels to create time sequenced anoxic/aerobic/and anaerobic zones

- 1 Flow enters reactor in anoxic zone, denitrification begins.
- 2 Mechanical Aerators provide complete mixing and deliver oxygen for nitrification.
- 3 Flow continues into anaerobic zones for further de-nitrification.
- 4 Coarse bubble diffusers supply additional oxygen as needed for additional nitrification.
- 5 Flow returns to anoxic zone, where influent is introduced and de-nitrification occurs.

BNR CAPABILITIES	
Nitrogen Removal	Excellent
Phosphorus Removal	Limited

3-Stage Phoredox Process (A2O Process)



Continuous-flow suspended-growth process with an initial anaerobic stage, followed by an anoxic stage, then by an aerobic stage

Stage 1

Anaerobic stage.

Mix only, D.O. < 0 mg/L (ORP = 80)

Combination of influent wastewater and return activated sludge from the clarifiers.

Acts as fermentation stage, where biological phosphorus removal occurs.

Stage 2

Anoxic Stage (De-nitrification)

Mix only, D.O. = 0 mg/L

Combination of influent from stage 1 with nitrate rich mixed liquor from Stage 3.

Nitrate reduced to gaseous nitrogen and released to atmosphere.

Stage 3

Oxic Stage (Nitrification)

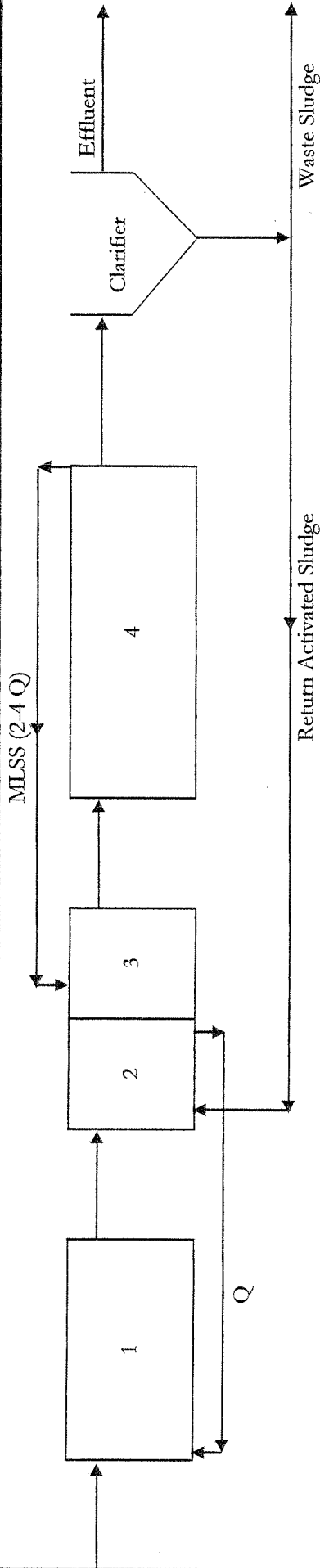
Mix and air, D.O. > 2.0 mg/L

Oxygen oxidizes BOD and converts ammonia to nitrate.

Re-aeration of sludge to maintain phosphorus and improve sludge settling in clarifiers.

BNR CAPABILITIES	
Nitrogen Removal	Good
Phosphorus Removal	Minimal

Modified University of Cape Town Process (MUCT)

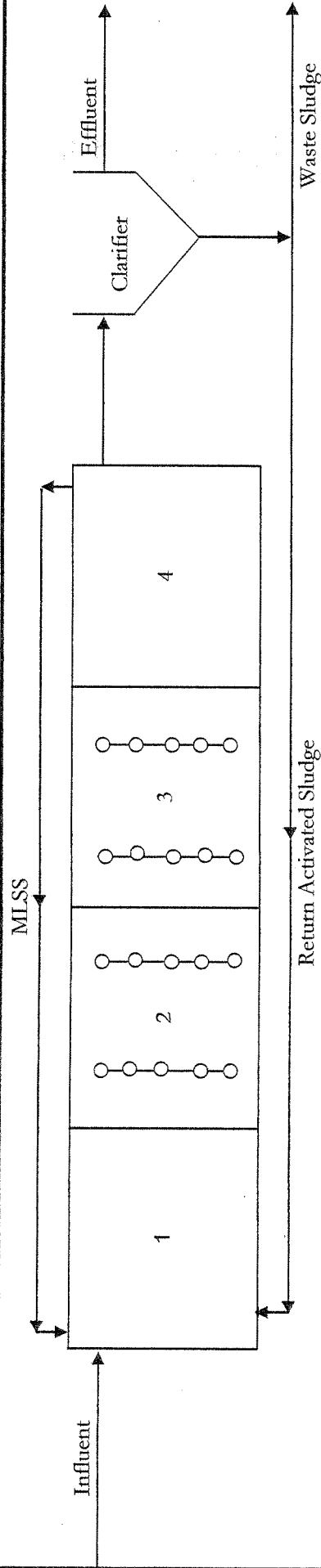


Continuous-flow suspended-growth process. Modified A2O process which incorporates second anoxic stage where internal nitrate recycle is returned.

- Stage 1** Anaerobic stage.
 Mix only, D.O. = 0 mg/L
 Combination of influent wastewater and anoxic mixed liquor from Stage 2.
 Acts as fermentation stage, where phosphorus release occurs.
- Stage 2** Anoxic Stage (De-nitrification) ◀
 Mix only, D.O. = 0 mg/L
 Combination of influent from Stage 1 with return activated sludge from clarifier.
 Rapid phosphorus uptake by organisms.
- Stage 3** Second Anoxic Stage (De-nitrification)
 Mix only, D.O. = 0 mg/L
 Combination of influent from Stage 2 with nitrate rich mixed liquor from Stage 4.
 Nitrate reduced to gaseous nitrogen and released to atmosphere.
- Stage 4** Oxic Stage (Nitrification)
 Mix and air, D.O. > 2.0 mg/L
 Oxygen oxidizes BOD and converts ammonia to nitrate.
 Re-aeration of sludge to maintain phosphorus and improve sludge settling in clarifiers.

BNR CAPABILITIES	
Nitrogen Removal	Good
Phosphorus Removal	Good

Integrated Fixed Film Activated Sludge (IFAS)

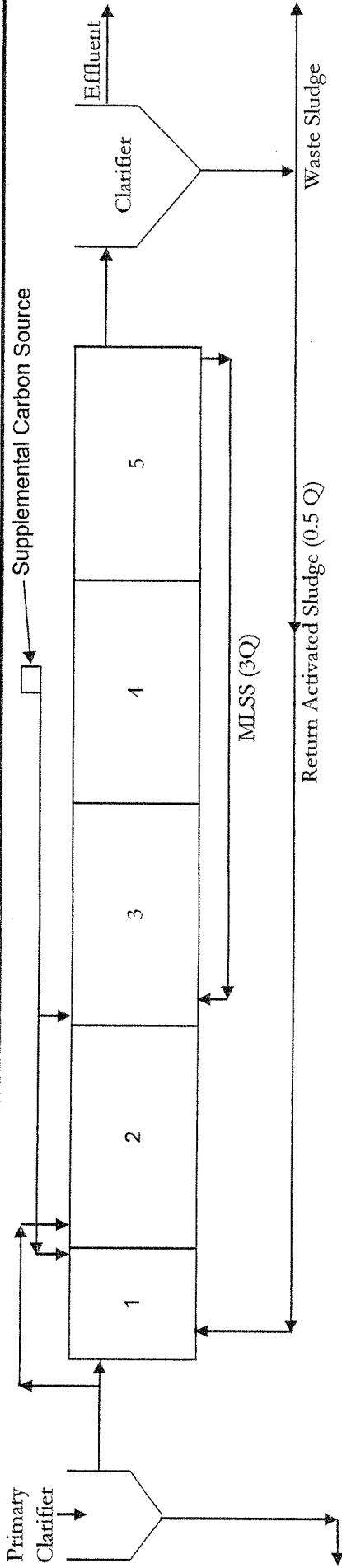


Hybrid approach combining attached biological growth with suspended biological growth.

- Stage 1 Anaerobic stage.**
 Mix only, D.O. = 0 mg/L
 Combination of influent wastewater, return activated sludge from the clarifiers and nitrate rich mixed liquor from stage 4.
 Nitrate reduced to gaseous nitrogen and released to atmosphere.
- Stage 2 Oxic Stage (Nitrification)**
 Mix and air, D.O. > 2.0 mg/L
 Oxygen oxidizes BOD and converts ammonia to nitrate.
 Biological growth provides wastewater treatment.
- Stage 3 Oxic Stage (Nitrification)**
 Mix and air, D.O. > 2.0 mg/L
 Oxygen oxidizes BOD and converts ammonia to nitrate.
 Biological growth provides wastewater treatment.
- Stage 4 Oxic Stage (Nitrification)**
 Mix and air, D.O. > 2.0 mg/L
 Oxygen oxidizes BOD and converts ammonia to nitrate.
 Biological growth provides wastewater treatment.

BNR CAPABILITIES	
Nitrogen Removal	Good
Phosphorus Removal	Good

Westbank Process



Continuous-flow suspended-growth process consisting of numerous stages (cells).

Stage 1 RAS DE-nitrification Stage. De-nitrification of return activated sludge.
Mix only, D.O. = 0 mg/L

Stage 2 Anaerobic cell. Minor phosphorus release through assimilation.
Mix only, D.O. = 0 mg/L

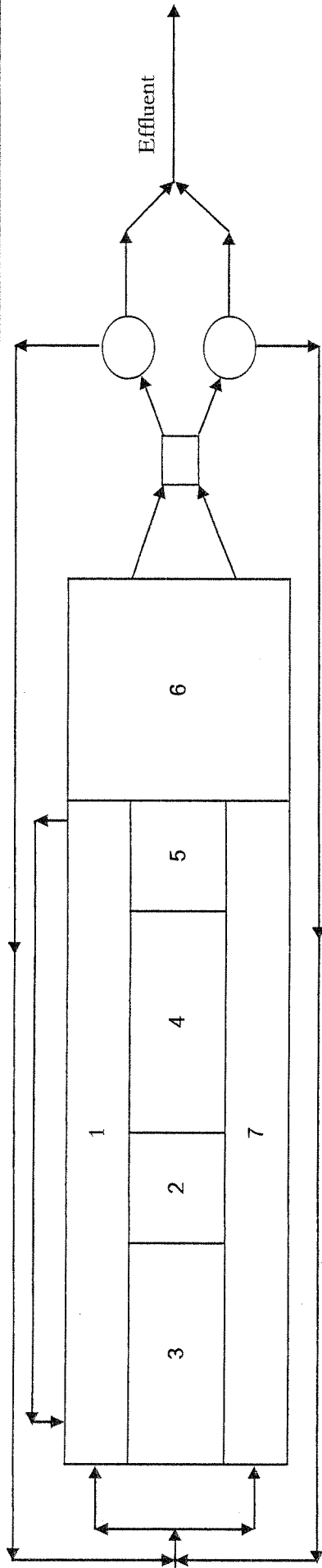
Stage 3 Anoxic Stage 1. Nitrate in MLSS is de-nitrified.
Mix only, D.O. = 0 mg/L

Stage 4 Anoxic Stage 2. Nitrate in MLSS continues de-nitrification.
Mix only, D.O. = 0 mg/L

Stage 4 Oxic Stage (Nitrification)
Mix and air, D.O. > 2.0 mg/L
Oxygen oxidizes BOD and converts ammonia to nitrate.
Re-aeration of sludge to maintain phosphorus and improve sludge settling in clarifiers.

BNR CAPABILITIES	
Nitrogen Removal	Good
Phosphorus Removal	Minimal

Modified Sequencing Batch Reactor (MSBR)



Fill and Draw suspended-growth process with an initial anaerobic stage, followed by an anoxic stage, then by an aerobic stage

Cell 1 Sequencing Cell-alternation of 4 phases (anoxic mixing/aerobic mixing/pre-settle/clarification)

Cell 2 Phase separator cell to concentrate recycled mixed liquor solids & promote environment for phosphorus release.

Cell 3 Fermentation cell to increase concentration of VRA's

Cell 4 Anaerobic cell designed to promote phosphorus release.

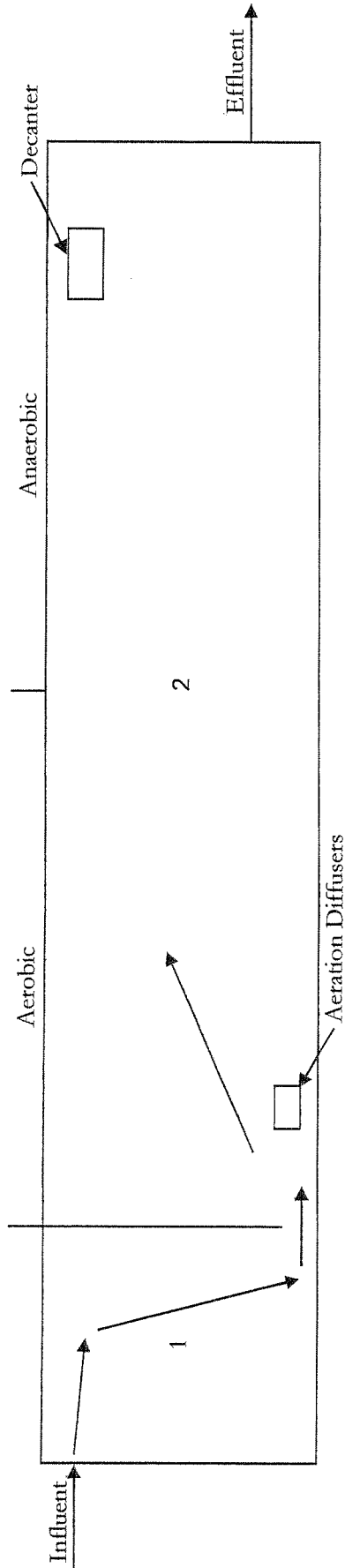
Cell 5 Anoxic mixing for de-nitrification.

Cell 6 Aerobic cell for nitrification.

Cell 7 Sequencing Cell-alternation of 4 phases (anoxic mixing/aerobic mixing/pre-settle/clarification)

BNR CAPABILITIES	
Nitrogen Removal	Good
Phosphorus Removal	Good

Intermittent Cycle Extended Aeration System (ICEAS)

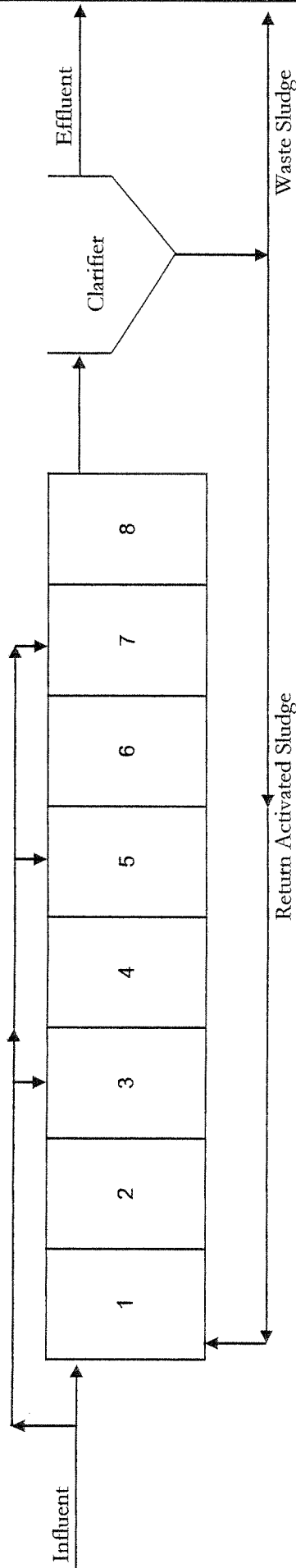


Continuous-flow suspended-growth SBR process.

- Cell 1 Pre-Reactor
Creates high F/M ratio, resulting in maximum biosorption of food.
Reactor acts as a biological selector for optimum organism proliferation
- Cell 2 Main Reactor Cell
Aerobic portion of cell promotes nitrification.
Anaerobic portion of cell promotes de-nitrification.

BNR CAPABILITIES	
Nitrogen Removal	Good
Phosphorus Removal	Limited

Step Feed Process



Continuous-flow suspended-growth process with alternating anoxic and aerobic stages, including influent flow introduction within multiple stages

- | | |
|---------|--|
| Stage 1 | Anoxic Stage (De-nitrification)
Combination of influent wastewater and return activated sludge from the clarifiers. Nitrate reduced to gaseous nitrogen and released to atmosphere. |
| Stage 2 | Oxic Stage (Nitrification)
Oxygen oxidizes BOD and converts ammonia to nitrate. |
| Stage 3 | Anoxic Stage (De-nitrification)
Combination of influent wastewater and effluent from Stage 2. Nitrate reduced to gaseous nitrogen and released to atmosphere. |
| Stage 4 | Oxic Stage (Nitrification)
Oxygen oxidizes BOD and converts ammonia to nitrate. |
| Stage 5 | Anoxic Stage (De-nitrification)
Combination of influent wastewater and effluent from Stage 4. Nitrate reduced to gaseous nitrogen and released to atmosphere. |
| Stage 6 | Oxic Stage (Nitrification)
Oxygen oxidizes BOD and converts ammonia to nitrate. |
| Stage 7 | Anoxic Stage (De-nitrification)
Combination of influent wastewater and effluent from Stage 6. Nitrate reduced to gaseous nitrogen and released to atmosphere. |
| Stage 8 | Re-aeration stage (Nitrification)
Releases nitrogen gas bound in sludge prior to final clarification. |

BNR CAPABILITIES	
Nitrogen Removal	Good
Phosphorus Removal	Limited