



# Central Davis Sewer District Nutrient Removal Project

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Doug Barber  
Associate Engineer





# Study Objectives

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1. Develop conceptual level alternatives for nutrient removal

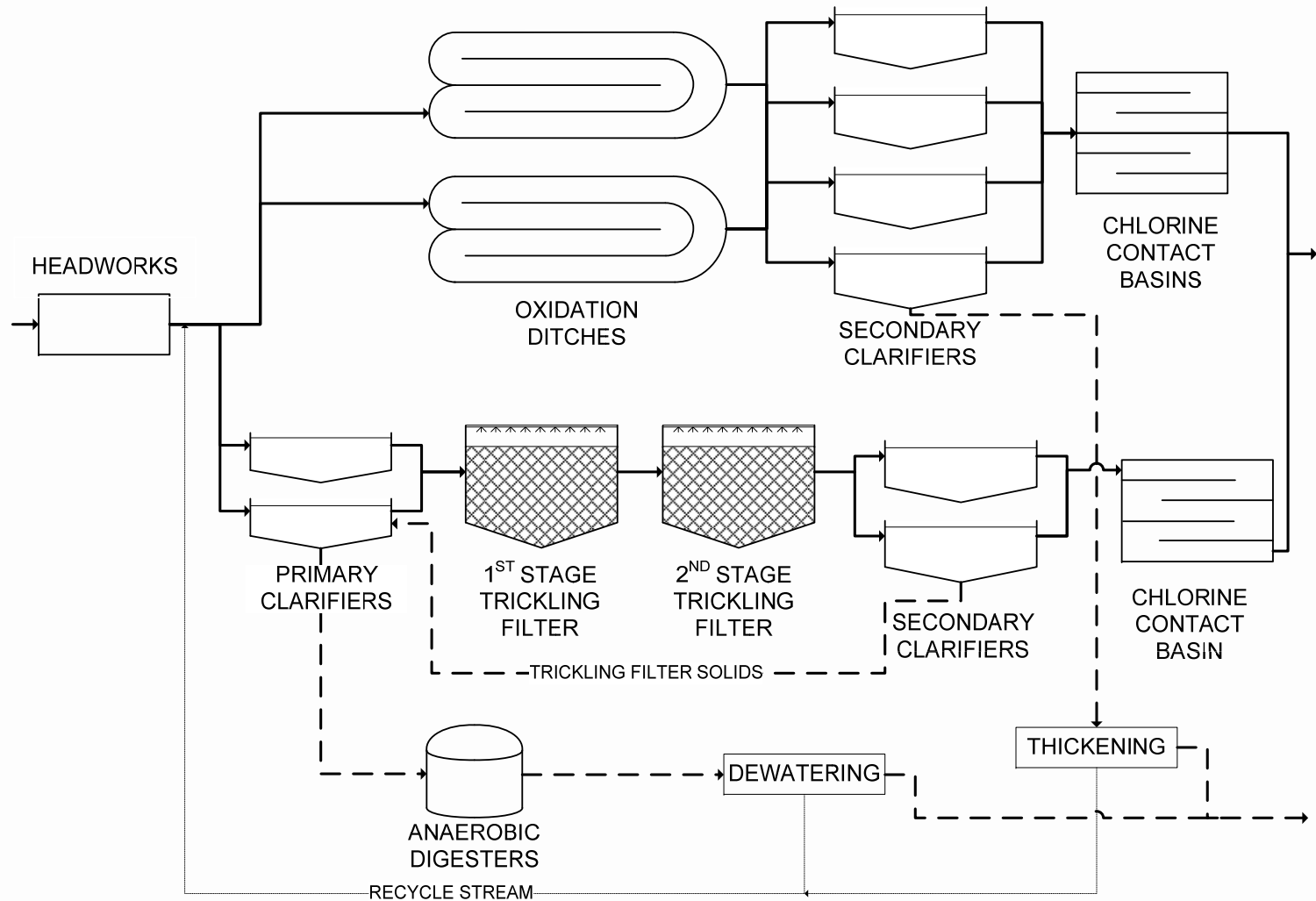
High: TN = 20 mg/L      TP = 1.0 mg/L

Low : TN = 10 mg/L      TP = 0.3 mg/L

2. Determine process performance of alternatives (mass balance)
3. Develop conceptual level construction costs and O&M costs

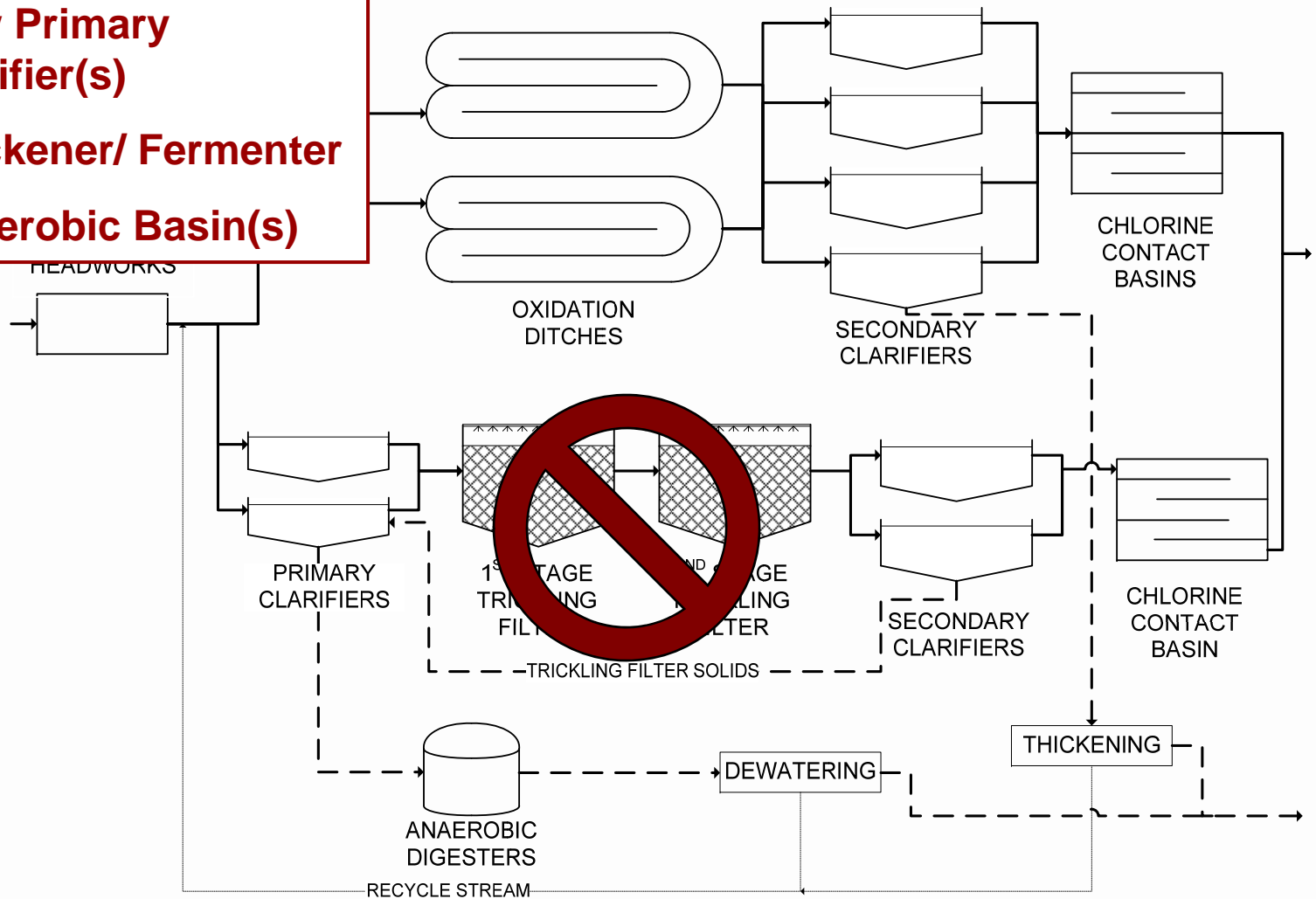


# Existing Process Flow Diagram



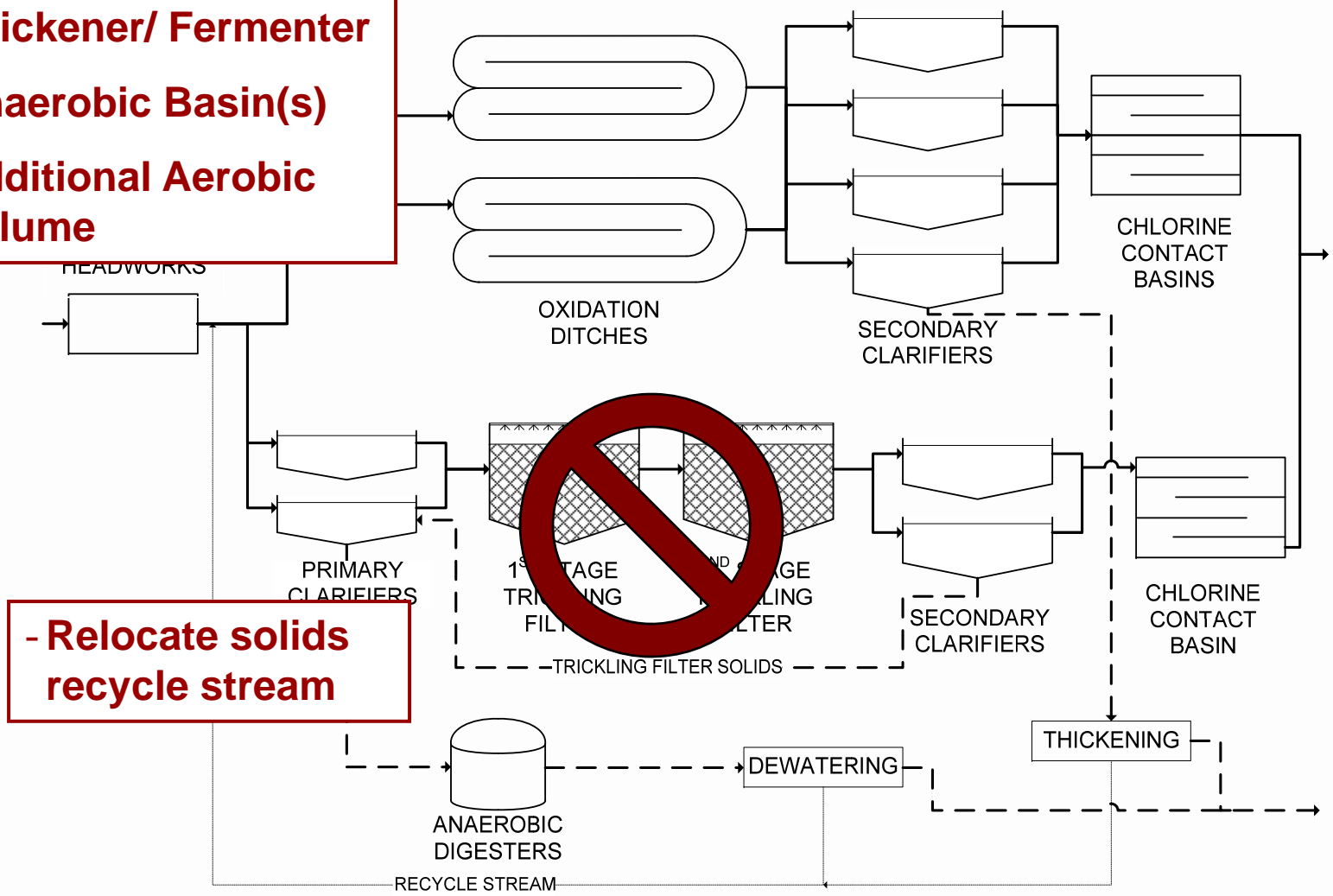
# Development of Alternative 1

- New Primary Clarifier(s)
- Thickener/ Fermenter
- Anaerobic Basin(s)



# Development of Alternative 2

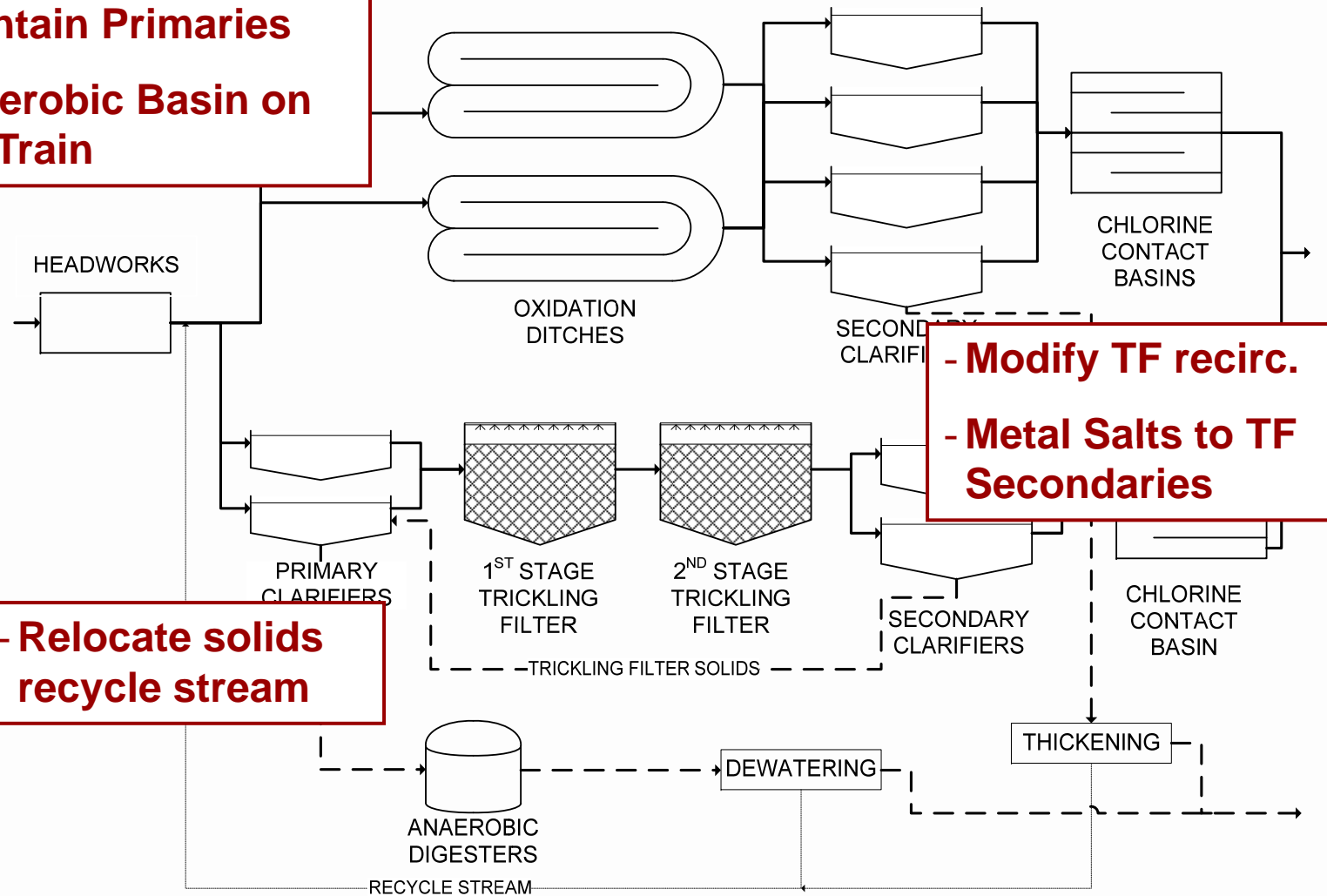
- Thickener/ Fermenter
- Anaerobic Basin(s)
- Additional Aerobic Volume



- Relocate solids recycle stream

# Development of Alternative 3

- Maintain Primaries
- Anaerobic Basin on OD Train



- Modify TF recirc.
- Metal Salts to TF Secondaries

- Relocate solids recycle stream



## Development of Alternative 4

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- Chemical Polishing added to Previous Alternatives
- Effluent Goal = 10 mg/L TN and 0.3 mg/L TP
- Several Approaches Analyzed
  - Metal Salt Addition to Primaries
  - Metal Salt Addition to Secondaries
  - Tertiary Clarification with chemical coagulants
  - Filtration with chemical coagulants

# Process Modeling Criteria (Truncated)

Parameter	Value	Source
AAF	7 mgd	Historical Data
PMF	9.9 mgd	Historical Data
TSS PM Loading	14,600 lbs/day	Historical Data
VSS:TSS Ratio	75%	Literature Value
BOD <sub>5</sub> PM Loading	11,820 lbs/day	Historical Data
NH <sub>3</sub> -N PM Loading	1,100 lbs/day	Historical Data
TKN PM Loading	1,700 lbs/day	Literature PF
TP PM Loading	410 lbs/day	Literature PF
Primary Solids Conc.	2.7 % TS	Historical Data
Anaerobic HRT	1 hour	CH2M HILL Design Basis
OD Channel Velocity	1 fps	Typical Operation
OD Aerator Horsepower	300 hp, Total	Plant Design Criteria



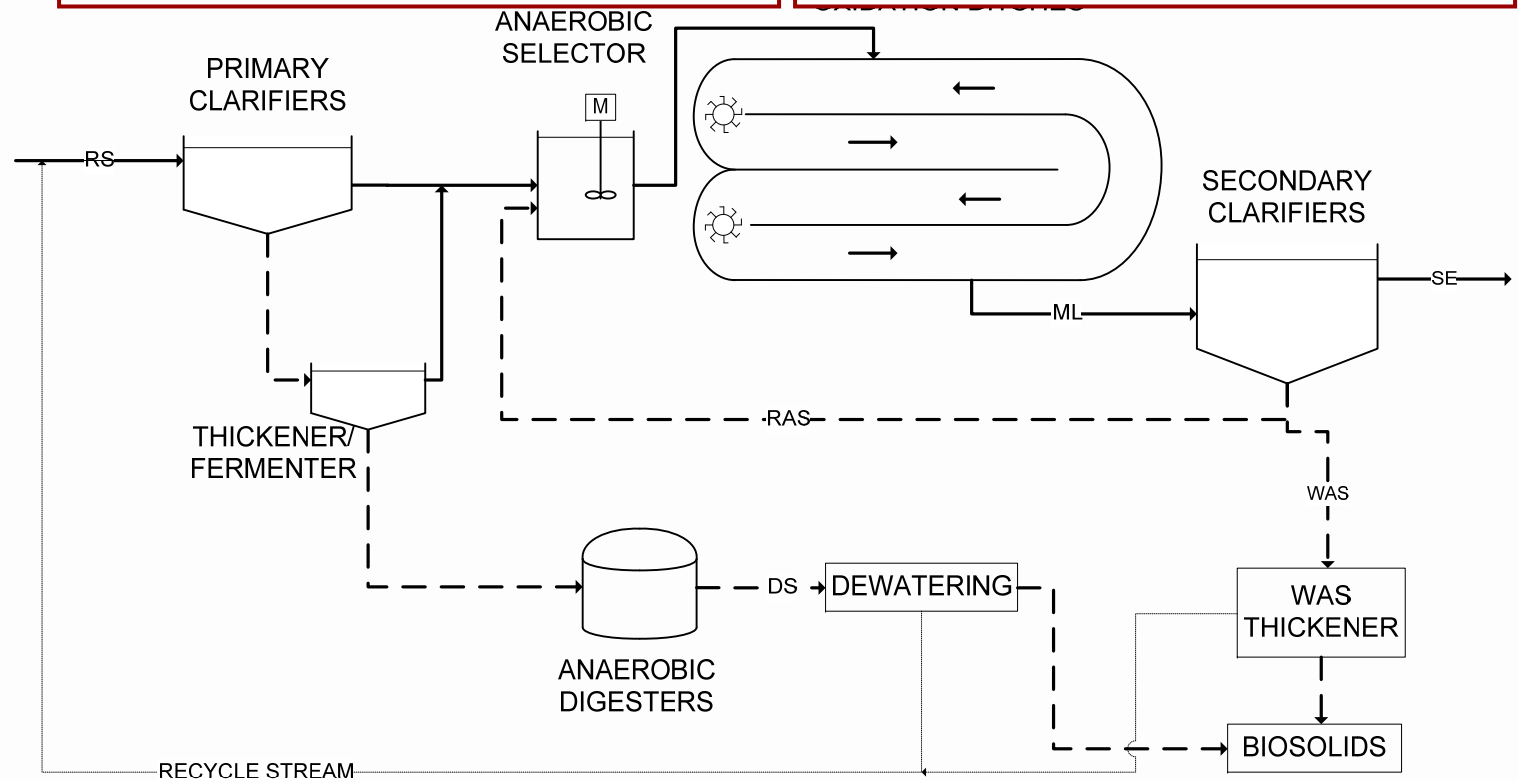
# Alternative 1

## Scenario 1-B

- Additional Aeration
- Additional 2° Clarifier Area

## Scenario 1-C

- Third Oxidation Ditch
- Additional 2° Clarifier Area





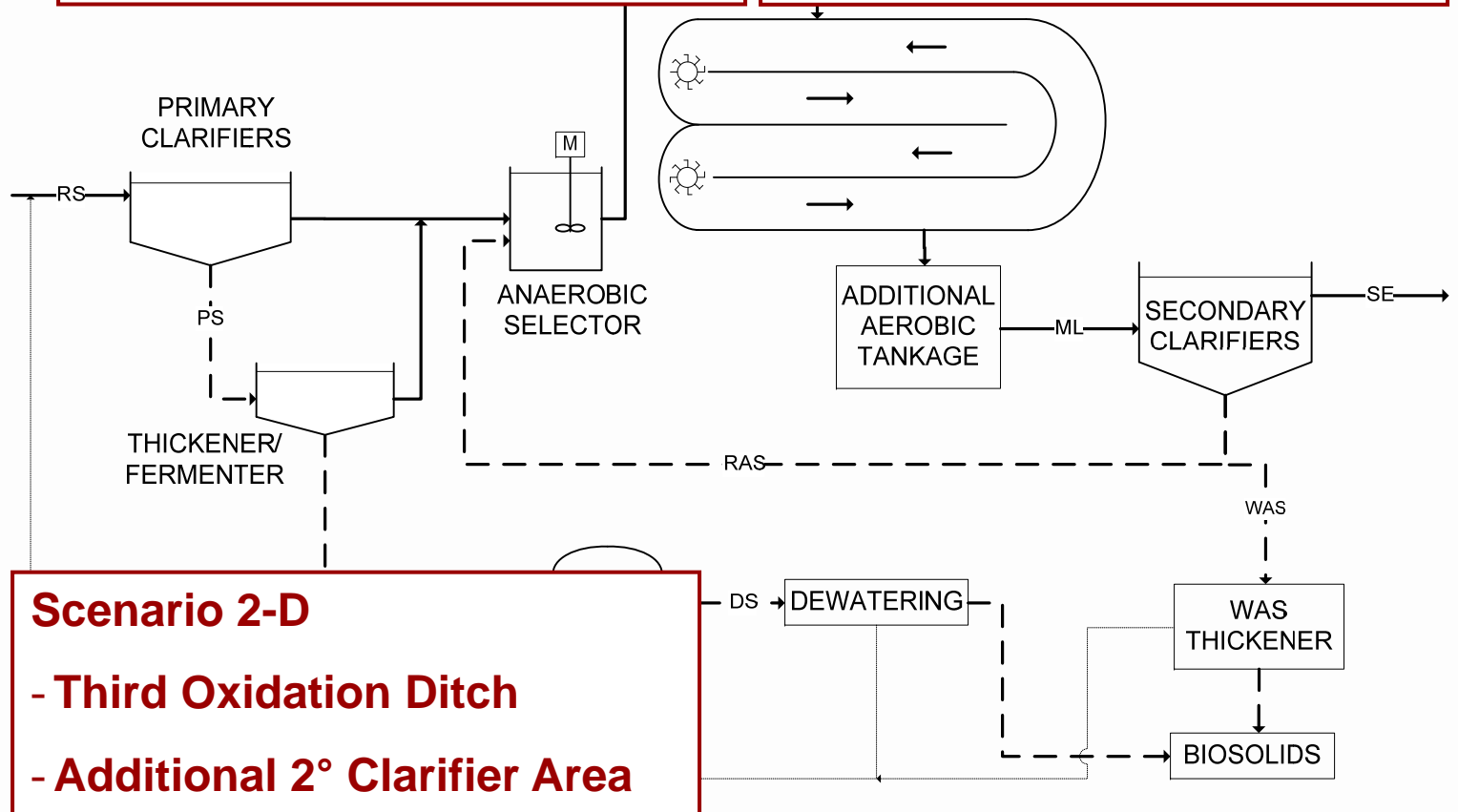
# Alternative 2

## Scenario 2-B

- Supplemental Aeration
- Additional 2° Clarifier Area

## Scenario 2-C

- Supplemental Aeration
- Additional 2° Clarifier Area
- Internal NRCY from Aerobic Basins

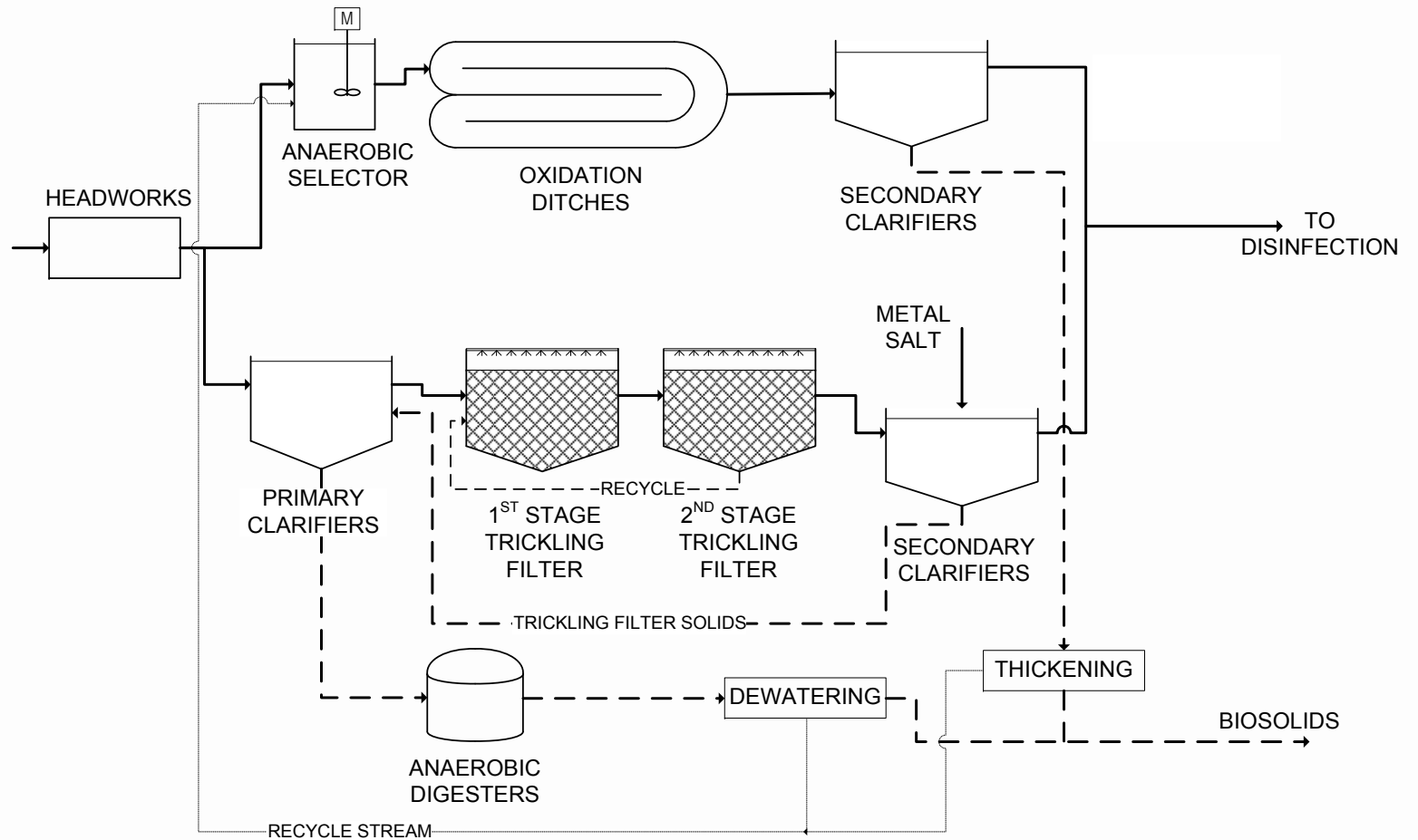


## Scenario 2-D

- Third Oxidation Ditch
- Additional 2° Clarifier Area

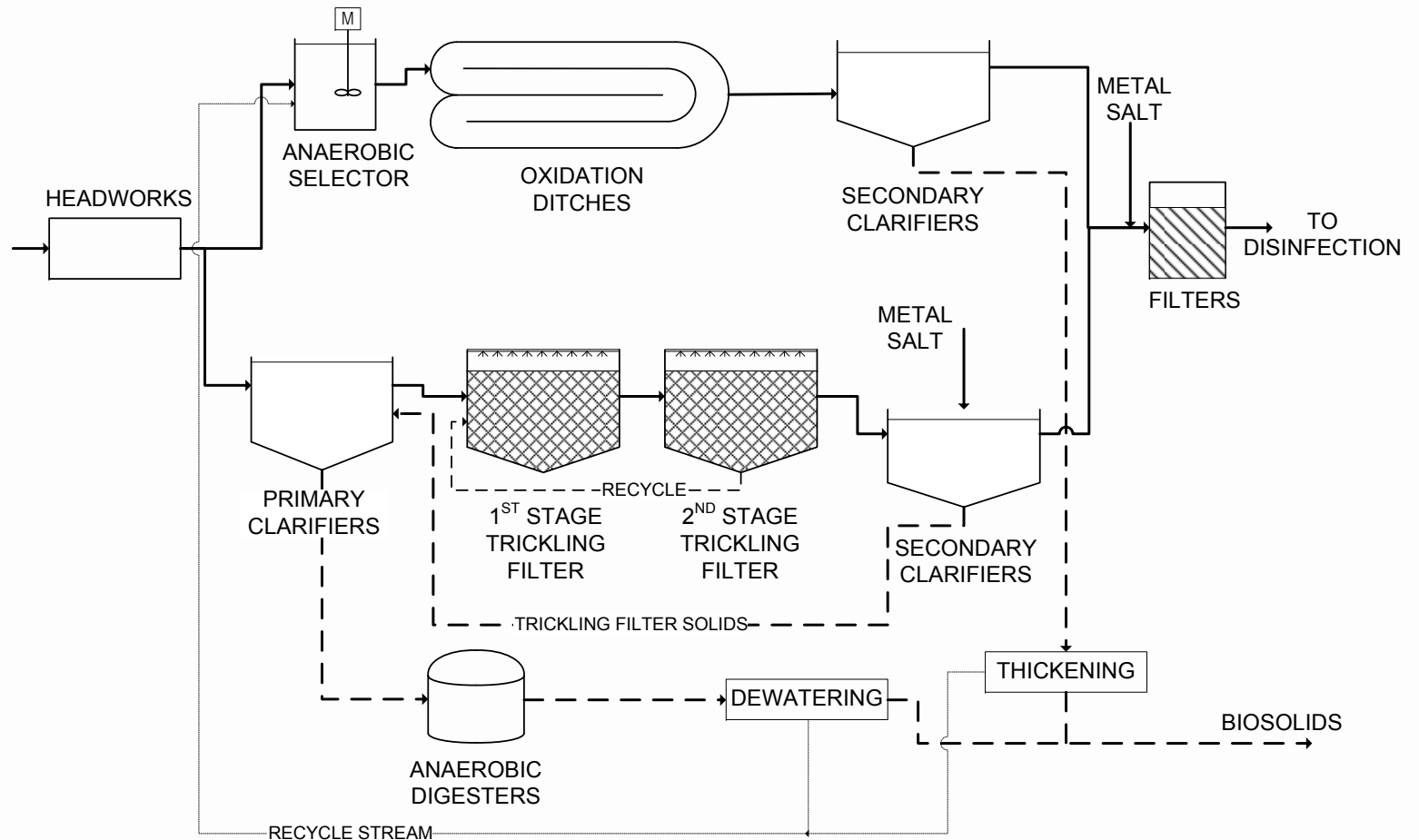


# Alternative 3





# Alternative 4



Based on Alternative 3 as Shown



# Conceptual Design

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## Nutrient Removal Alternatives (Effluent Criteria TN = 20 mg/L and TP = 1.0 mg/L)

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### BNR Alternative 1-B

- Abandon trickling filters
- New 76-ft diameter Primary clarifier
- New 30-ft diameter PS thickener
- New 0.4 MG anaerobic basin
- 2 new 25 hp aerators
- 2 new 110-ft diameter secondary clarifiers

### BNR Alternative 2-D

- Abandon trickling filters
- New 30-ft diameter PS thickener
- New 0.4 MG anaerobic basin
- Third 1.54 MG oxidation ditch
- New 110-ft diameter secondary clarifier

### BNR Alternative 3-A

- New 0.3MG anaerobic basin
- Modify trickling filter recycle piping
- Ferric chloride feed and storage facility



# Conceptual Design

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## Nutrient Removal Alternatives (Effluent Criteria TN = 10 mg/L and TP = 0.3 mg/L)

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### Chemical Polishing Alternative 1-B

- Abandon Trickling Filters
- New 76-ft Diameter Primary Clarifier
- New 30-ft diameter PS thickener
- New 0.4 MG anaerobic basin
- 2 new 25 hp aerators
- 2 new 120-ft diameter secondary clarifiers
- 1,350 ft<sup>2</sup> Gravity media filter
- Ferric Chloride feed and storage system

### Chemical Polishing Alternative 2-D

- Abandon Trickling Filters
- New 30-ft diameter PS thickener
- New 0.4 MG anaerobic basin
- Third 1.54 MG oxidation ditch
- New 110-ft diameter secondary clarifier
- 1,350 ft<sup>2</sup> Gravity media filter
- Ferric Chloride feed and storage system

### Chemical Polishing Alternative 3-A

- New 0.3MG anaerobic basin
- Modify trickling filter recycle piping
- Ferric Chloride feed and storage facility
- 1,350 ft<sup>2</sup> Gravity media filter



## Present-Worth Cost Summary

Process Alternative	Capital Costs	Initial O&M Costs	20-year NPV*
BNR Alternative 1-B	9,460,000	80,000	10,250,000
BNR Alternative 2-D	11,400,000	110,000	12,430,000
BNR Alternative 3-A	7,400,000	120,000	8,830,000
Chemical Polishing Alternative 1-B	23,570,000	130,000	24,230,000
Chemical Polishing Alternative 2-D	25,820,000	150,000	26,720,000
Chemical Polishing Alternative 3-A	20,490,000	150,000	21,780,000

\* Assumes a 4.0% rate of inflation and a 6.0% discount rate

Note: All values presented in 2008 dollars



## Summary

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- Three biological nutrient removal alternatives were evaluated to achieve an effluent with  $TN \leq 20$  mg/L and  $TP \leq 1.0$  mg/L
- Three chemical polishing alternatives were evaluated to obtain plant effluent with  $TN \leq 10$  mg/L and  $TP \leq 0.3$  mg/L
- Cost estimates show that a modified two train system results in the lowest net present-worth for the higher discharge limits.
- Cost estimates show that a modified two train system combined with filtration results in the lowest net present-worth for the lower discharge limits.



# CDSD Nutrient Removal Project

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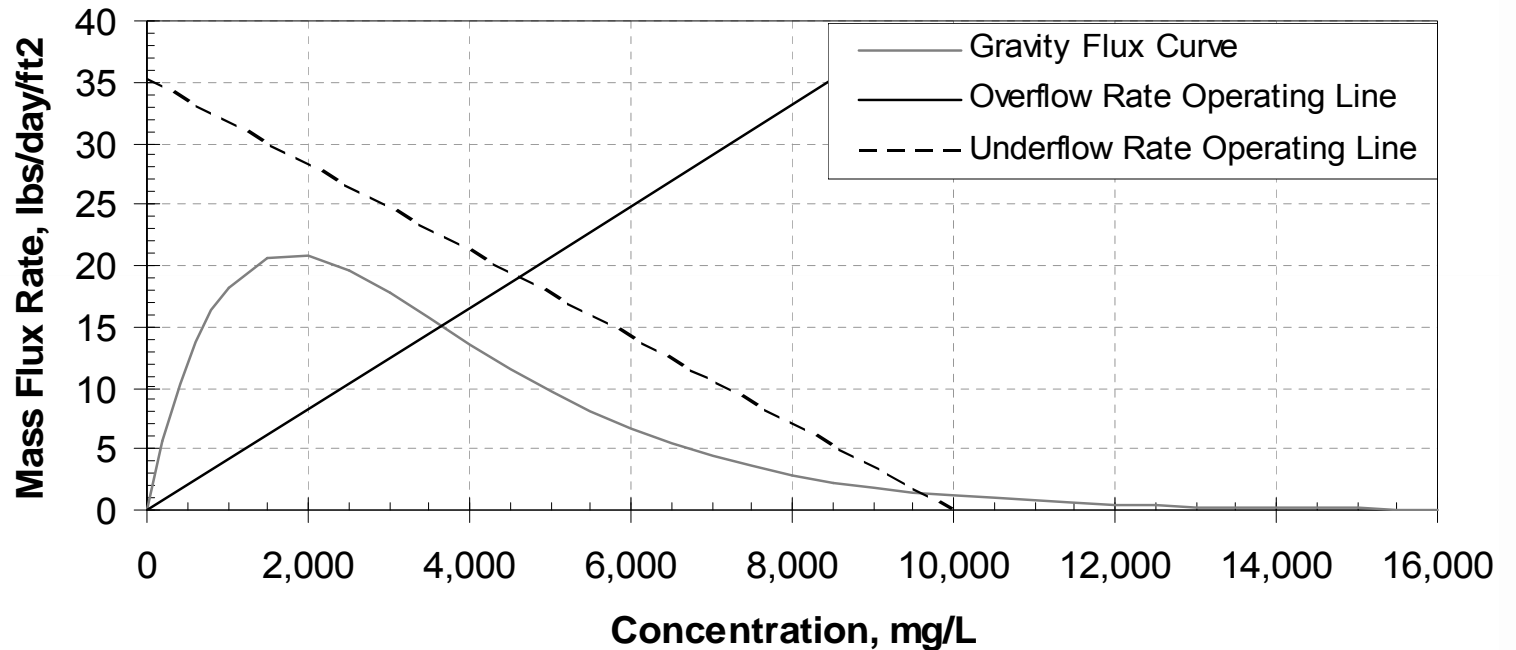
Jim McQuarrie, P.E.  
Senior Technologist

Doug Barber  
Associate Engineer





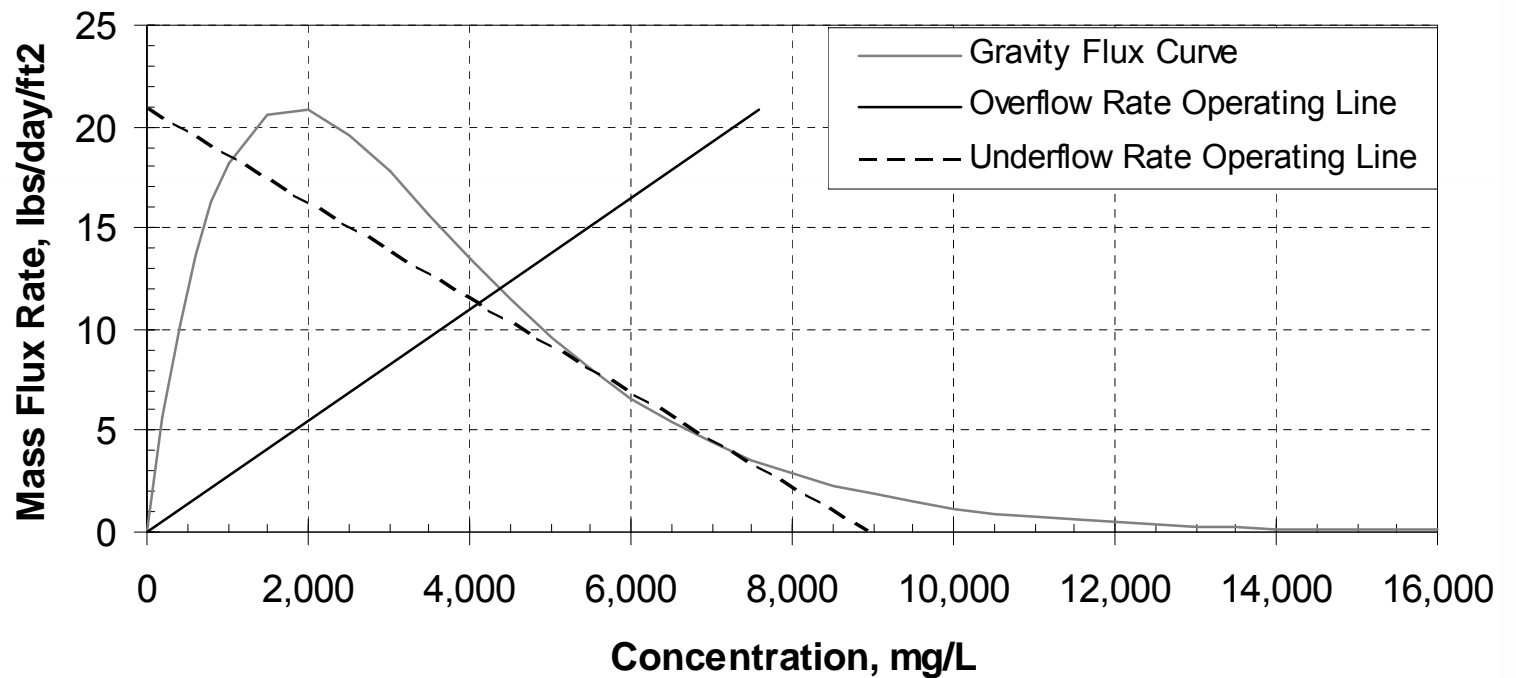
# State Point Analysis for Alt. 1-A



(Area = 20,100 ft<sup>2</sup>, SRT = 18 days, MLSS = 4600 mg/L, RAS rate = 85%Q)



# State Point Analysis for Alt. 3-B



**OD Clarifiers**  
(SRT = 15 days, MLSS = 4,100 mg/L, RAS rate = 85%Q)



# Alternative 1 Simulation Results

Parameter	Scenario A	Scenario B	Scenario C
Primary Clarifier Area (ft <sup>2</sup> )	12,100	12,100	12,100
PM Primary Clarifier Overflow Rate (gal/ft <sup>2</sup> -day)	820	820	820
Anaerobic Basin Volume (MG)	0.4	0.4	0.4
Total Oxidation ditch Volume (MG)	3.08	3.08	4.62
AOR (lbs O <sub>2</sub> /hour)	550	660	700
SRT (days)	18	18	18
MLSS Concentration (mg/L)	4,600	4,300	3,000
Total Bioreactor HRT (hours)	8	8	12
Net Yield (TSS/BOD <sub>5</sub> )	0.75	0.7	0.7
F/M (COD/MLSS)	0.12	0.13	0.13
RAS Flow (% of raw feed)	85%	85%	85%
Secondary Clarifier Area (ft <sup>2</sup> )	20,100	39,100	29,600
Solids Loading Rate (lbs/ft <sup>2</sup> -day)	35	17	16
Mass Limiting Flux (lbs/ft <sup>2</sup> -day)	27	17	21
Maximum Operating SVI (mL/g)	171	250	370
Plant Effluent NH <sub>3</sub> -N (mg/L)	13	0.8	0.2
Plant Effluent TN (mg/L)	14	3	7
Plant Effluent TP (mg/L)	0.6	0.7	1

# Alternative 2 Simulation Results

Parameter	Scenario 2-A	Scenario 2-B	Scenario 2-C	Scenario 2-D
Primary Clarifier Area (ft <sup>2</sup> )	7,536	7,536	7,536	7,536
Primary Clarifier Overflow Rate (gal/ft <sup>2</sup> -day)	1,320	1,320	1,320	1,320
Anaerobic Basin Volume (MG)	0.4	0.4	0.4	0.4
Total Oxidation ditch Volume (MG)	3.08	3.08	3.08	4.62
Additional Aerobic Basin (MG)	0.5	0.5	0.5	--
AOR (lbs O <sub>2</sub> /hour)	660	670	680	700
SRT (days)	18	18	18	18
MLSS Concentration (mg/L)	4,000	4,000	4,000	3,200
Total Bioreactor HRT (hours)	10	10	10	12
Net Yield (TSS/BOD <sub>5</sub> )	0.74	0.73	0.73	0.73
F/M (COD/MLSS)	0.12	0.13	0.13	0.13
RAS Flow (% of raw feed)	85	85	85	85
Secondary Clarifier Area (ft <sup>2</sup> )	20,100	39,100	39,100	29,600
Solids Loading Rate (lbs/ft <sup>2</sup> -day)	30	16	16	17
Mass Limiting Flux (lbs/ft <sup>2</sup> -day)	27	17	17	21
Maximum Operating SVI (mL/g)	210	280	280	340
Plant Effluent NH <sub>3</sub> N (mg/L)	0.9	0.3	0.2	0.2
Plant Effluent TN (mg/L)	3.4	2.8	3.1	7
Plant Effluent TP (mg/L)	0.6	0.6	0.6	1
Internal recycle	--	--	150%	--



# Alternative 3 Simulation Results

Parameter	Scenario 3-A	Scenario 3-B
Flow Split (OD Train:TF Train)	60:40	66:34
2nd Stage TF Effluent NH <sub>3</sub> -N/NO <sub>3</sub> -N	2/6	2/6
Ferric Chloride Dosage (mg/L)	27	27
TF Clarifier Effluent TP (mg/L)	0.2	0.2
TF Secondary Clarifier Overflow Rate (gal/ft <sup>2</sup> -day)	420	420
Oxidation Ditch SRT (days)	15	15
Net Yield (TSS/BOD <sub>5</sub> )	0.9	0.9
F/M (COD/MLSS)	0.13	0.13
AOR (lbs O <sub>2</sub> /hr)	540	540
Anaerobic Volume (MG)	0.3	0.3
Anaerobic HRT (hour)	1	1
MLSS Concentration (mg/L)	3,700	4,100
RAS flow (%raw feed)	85%	85%
OD Secondary Clarifier Solids Loading (lbs/ft <sup>2</sup> -day)	17	21
OD Limiting Mass Flux (lbs/ft <sup>2</sup> -day)	19	21
Maximum SVI (mL/g)	290	250
Plant Effluent NH <sub>3</sub> -N (mg/L)	1	1
Plant Effluent TN (mg/L)	9	7
Plant Effluent TP (mg/L)	1	0.6

# Alternative 4 Simulation Results

Parameter	Scenario 1-B	Scenario 2-D	Scenario 3-A
Primary Clarifier Area (ft <sup>2</sup> )	12,100	7,540	7,540
Oxidation Ditch SRT (days)	18	18	15
Anaerobic Basin Volume (MG)	0.4	0.4	0.3
Total Oxidation Ditch Volume (MG)	3.08	4.62	3.08
MLSS (mg/L)	4,500	3,400	4,000
Secondary Clarifier Area (ft <sup>2</sup> )	42,700	29,600	29,600
Ferric Chloride Dosage (mg/L)	10 mg/L	10 mg/L	10 mg/L
Plant Effluent NH <sub>3</sub> N (mg/L)	0.8	0.2	0.9
Plant Effluent TN (mg/L)	2.4	6.0	6.0
Plant Effluent TP (mg/L)	0.1	0.3	0.1