

Evaluation of Wet Weather Auxiliary Treatment Alternatives to Increase Plant Capacity

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BLACK & VEATCH

Project Background/Goals

- **2020 Facilities Plan**

- Increase wet weather treatment capacity from 300 to 450 mgd
- SSO Level of Protection >5 year
- Ballasted flocculation pilot tested
- Bio-ballasted flocculation – Bench tested

- **Project Goals**

- Demonstrate other “non-proprietary” processes:
 - Chemically Enhanced Sedimentation (CES)
 - Biological Contact Treatment (BC)
 - Compressible Media Filtration (CMF)

Milwaukee MSD South Shore Water Reclamation Facility

24 Final Settling Tanks

28 Aeration Basins

16 Primary Settling Tanks

Aerated Grit

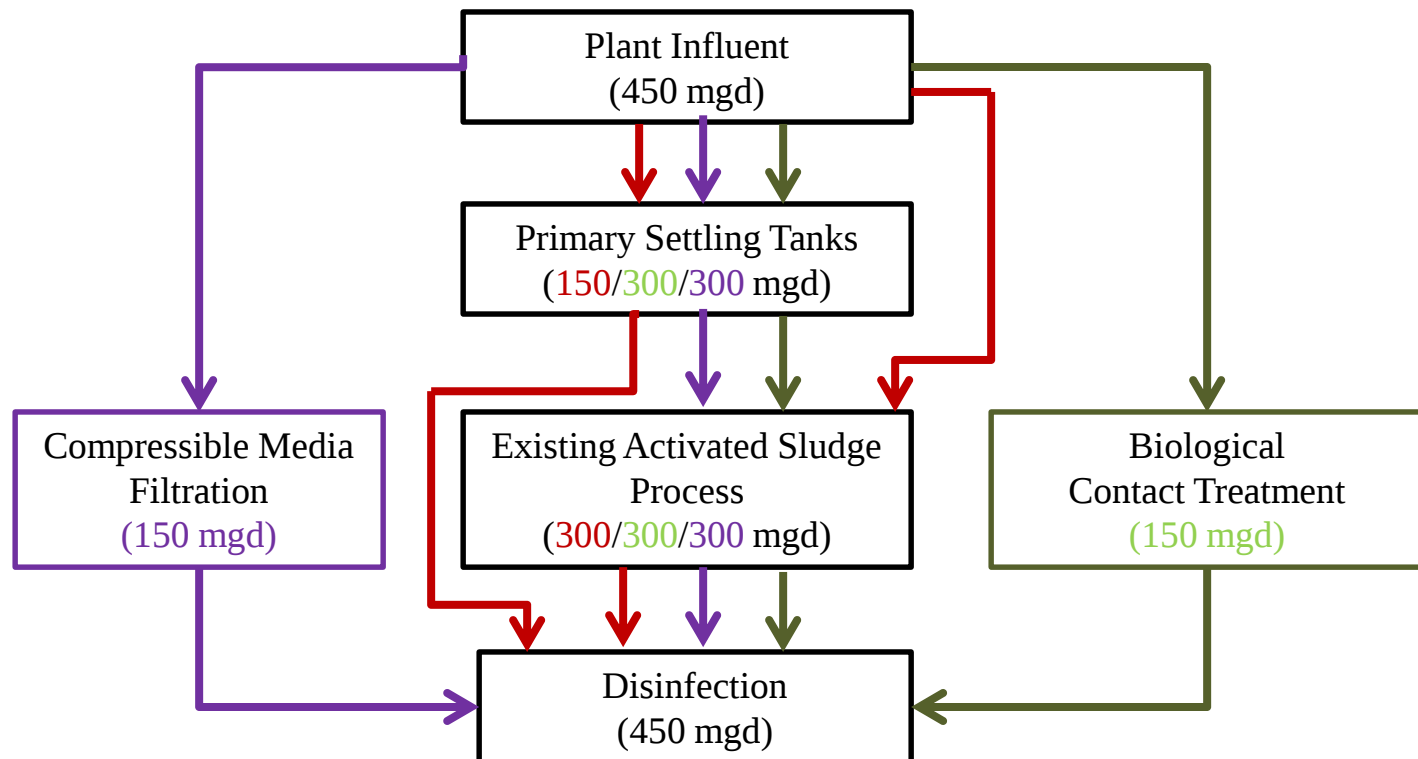
1" screens



Outline

- Concept/Demonstration Facilities
- Testing Results
- Alternative Analysis
- Conclusions

Treatment Flow Routing



Flow routing and flow rates

Compressible Media Filtration/Biological Contact /
Chemically Enhanced Sedimentation

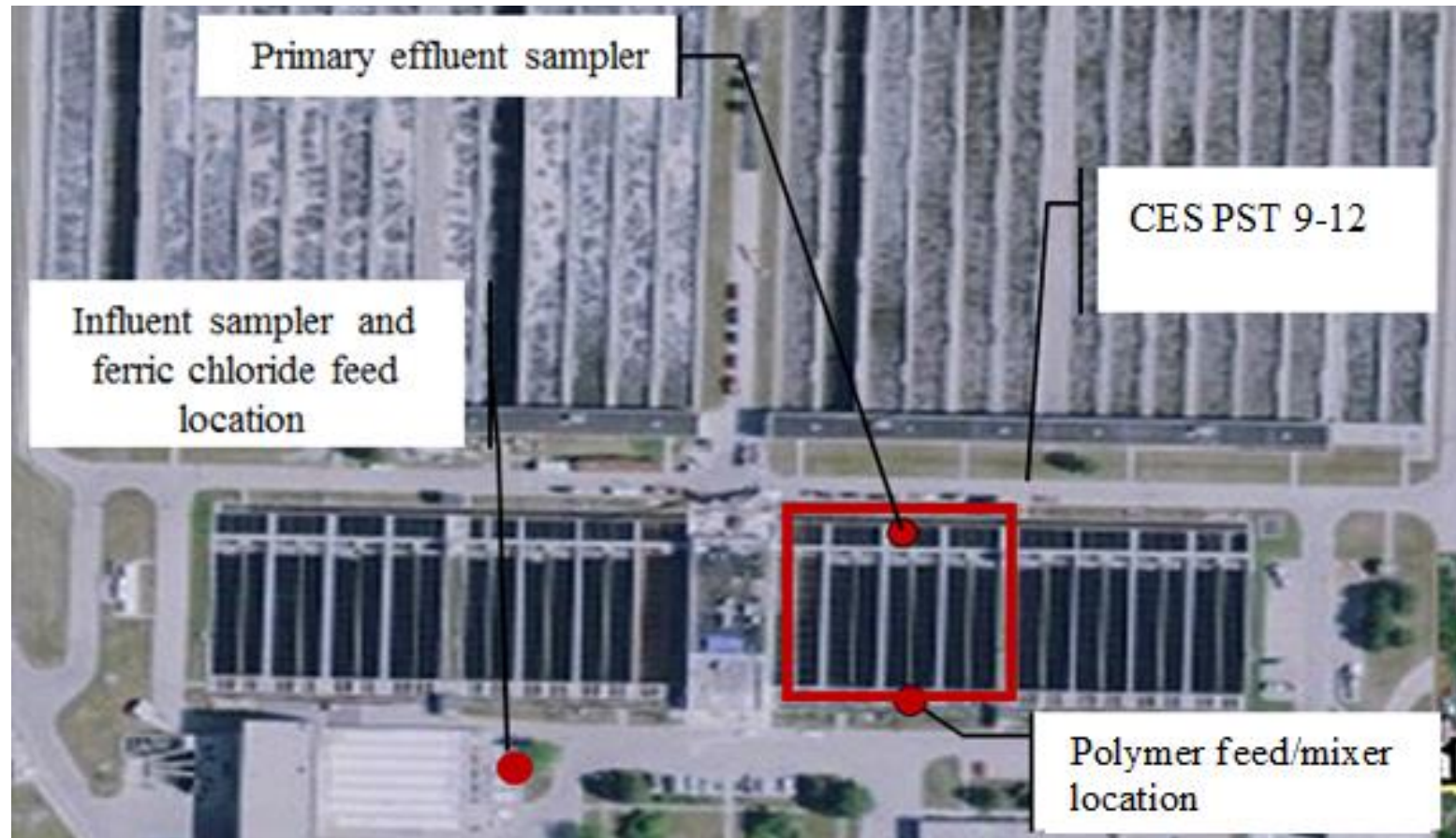
Demonstration Study Effluent Goals

Item	Units	NPDES Permit	Operations Contract	Demonstration Study Daily Goals
Total BOD ₅	mg/L	30 ^a /45 ^b	15 ^a	35
Total Suspended Solids	mg/L	30 ^a /45 ^b	15 ^a	35
Total Phosphorus	mg P/L	1.0 ^a	1.0 ^a	1
Ammonia-Nitrogen	mg N/L	Seasonal	5 ^a	5
Fecal Coliform ^c	(no./100 mL)	200	100	--

a. Monthly average b. Weekly average c. Geometric mean

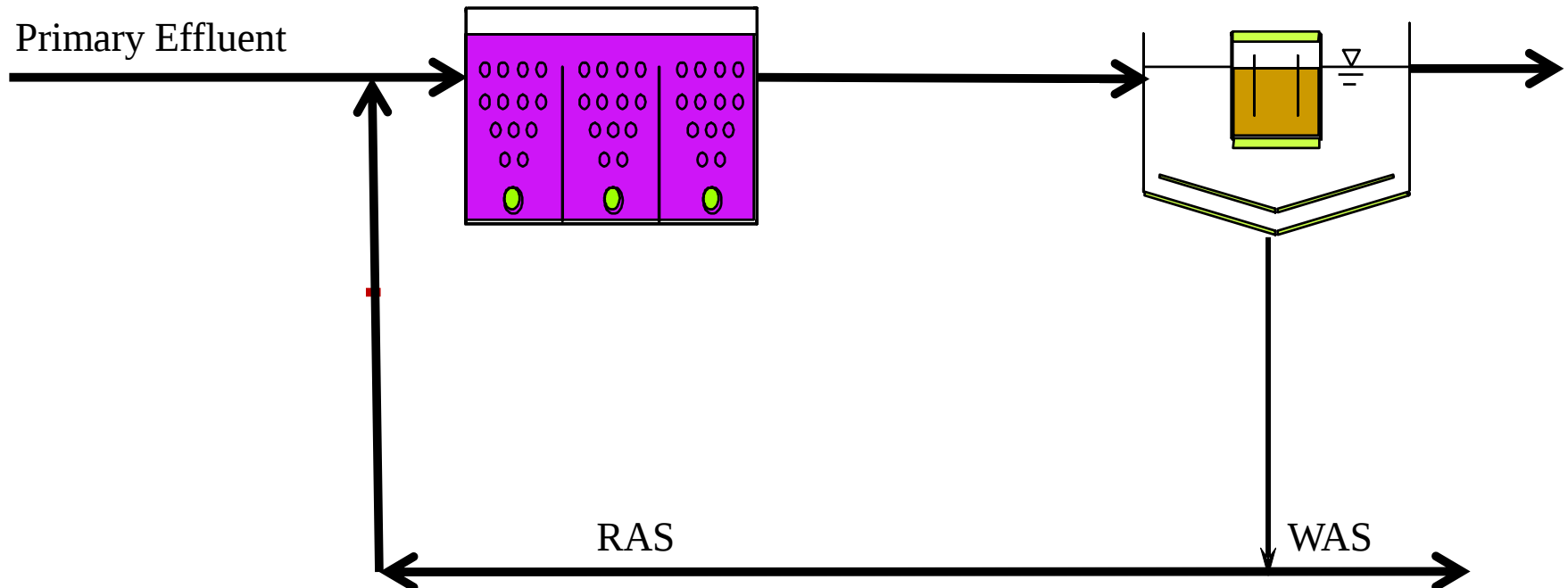
CES Demonstration – Full Scale

- ¼ Existing Primary Settling Tanks
- Wet weather SOR: 1500 gpd/sf
- Bench Testing: 40 mg/L FeCl_3 and 0.5 mg/L anionic polymer



Biological Contact Treatment

- High rate biological process which relies on biological flocculation for colloidal & particulate removal
- No chemical addition required
- Effluent meets secondary treatment requirements



Biological Contact Demonstration- Pilot

- 4000 gallon aerated plug flow reactor
- Bench Scale Settling Tests
 - MLSS: 1500 to 2000 mg/L
 - HRT: 20 to 15 minutes
- Bench tests to simulate final clarifiers



CMF Demonstration – Pilot/Trailer

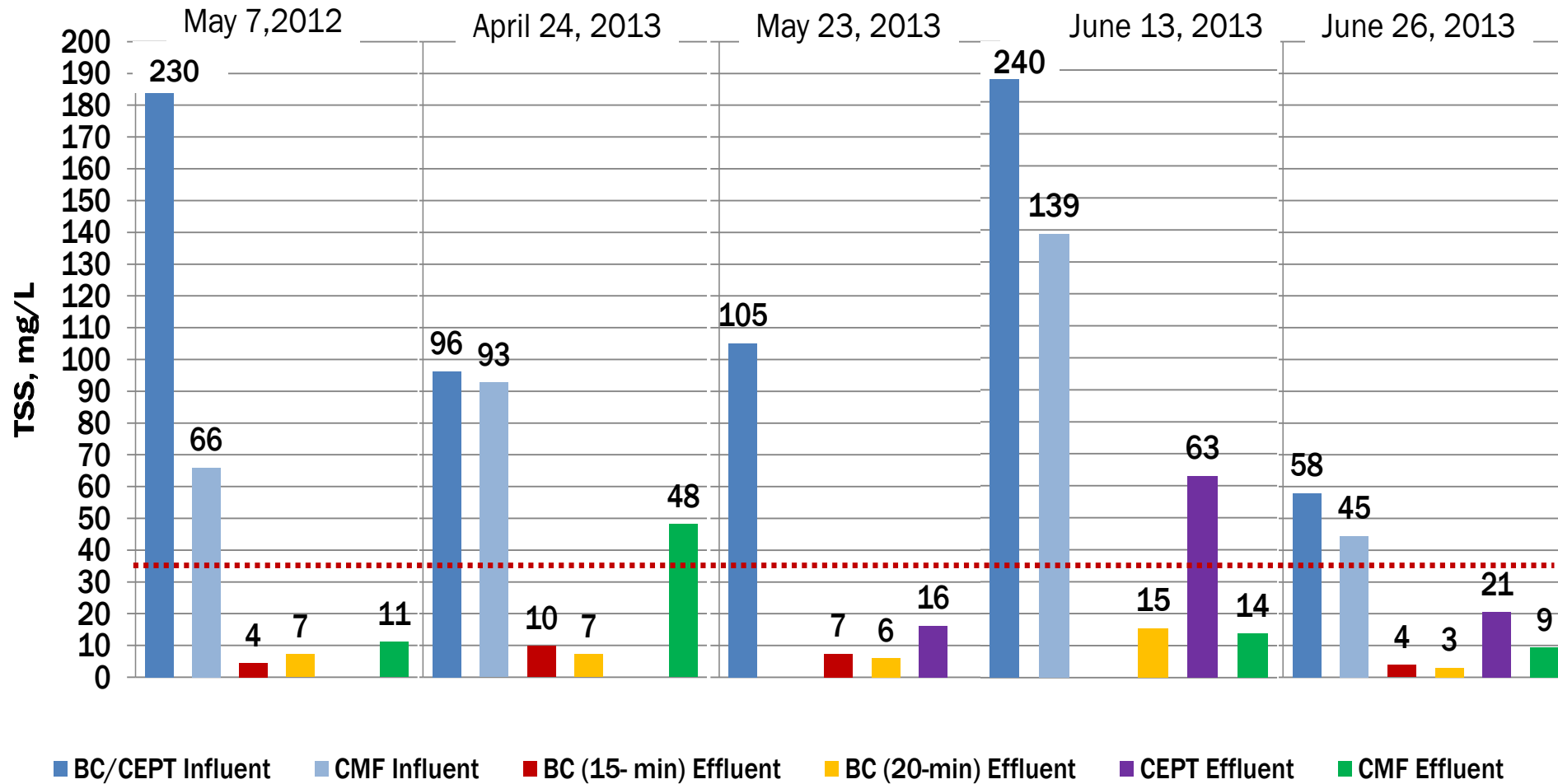
- WWETCO Rental
- Filtration rate 5-7.5 gpm/sf
- 2011 - Primary effluent and secondary effluent
- 2012/13 - Primary influent



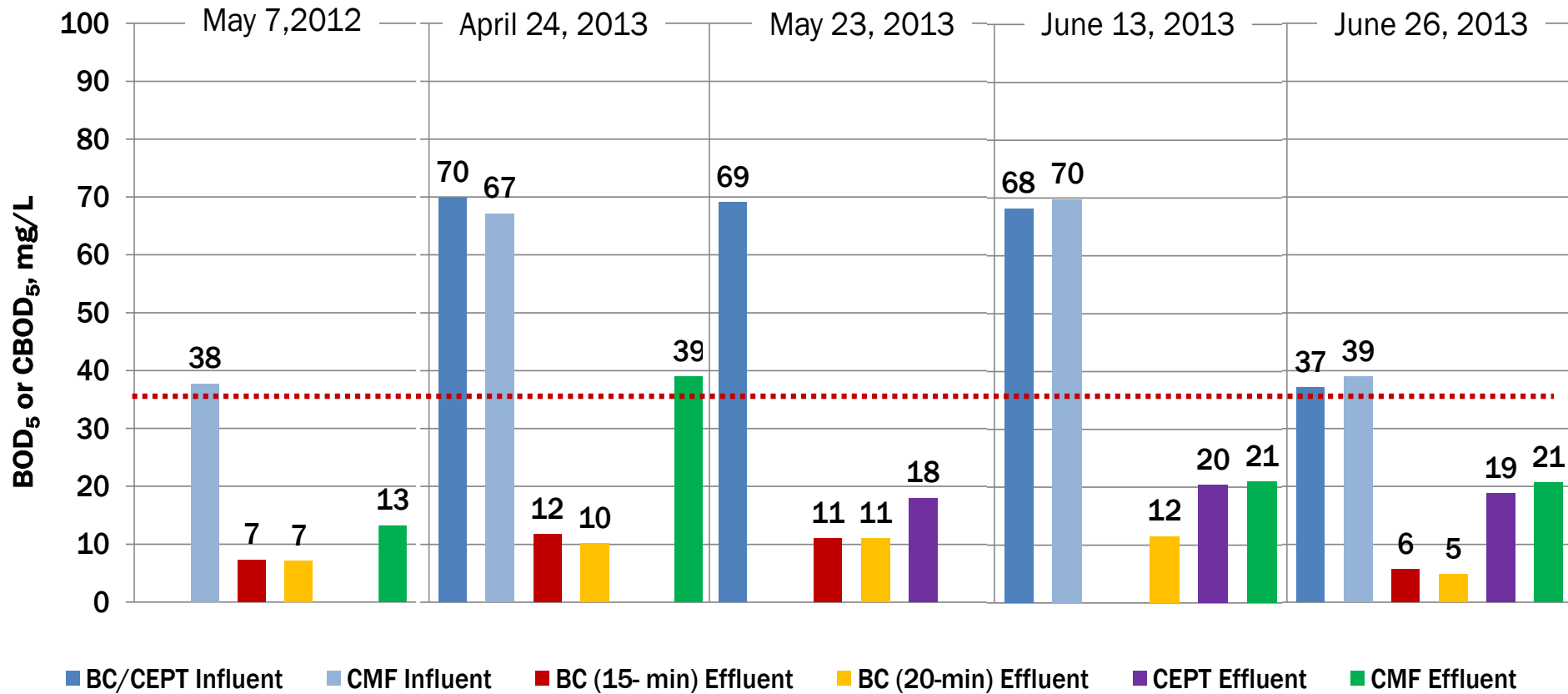
Demonstration Wet Weather Testing Events

Date	Influent Flow during Test, mg	Influent T, degrees C	CES	Biological Contact	CMF
May 7, 2012	275 → 250	15		✓	✓
April 24, 2013	172 → 180	10.5		✓	✓
May 23, 2013	215 → 200	13.5	✓	✓	
June 13, 2013	179	15.2	✓	✓	✓
June 26, 2013	218	15.8	✓	✓	✓

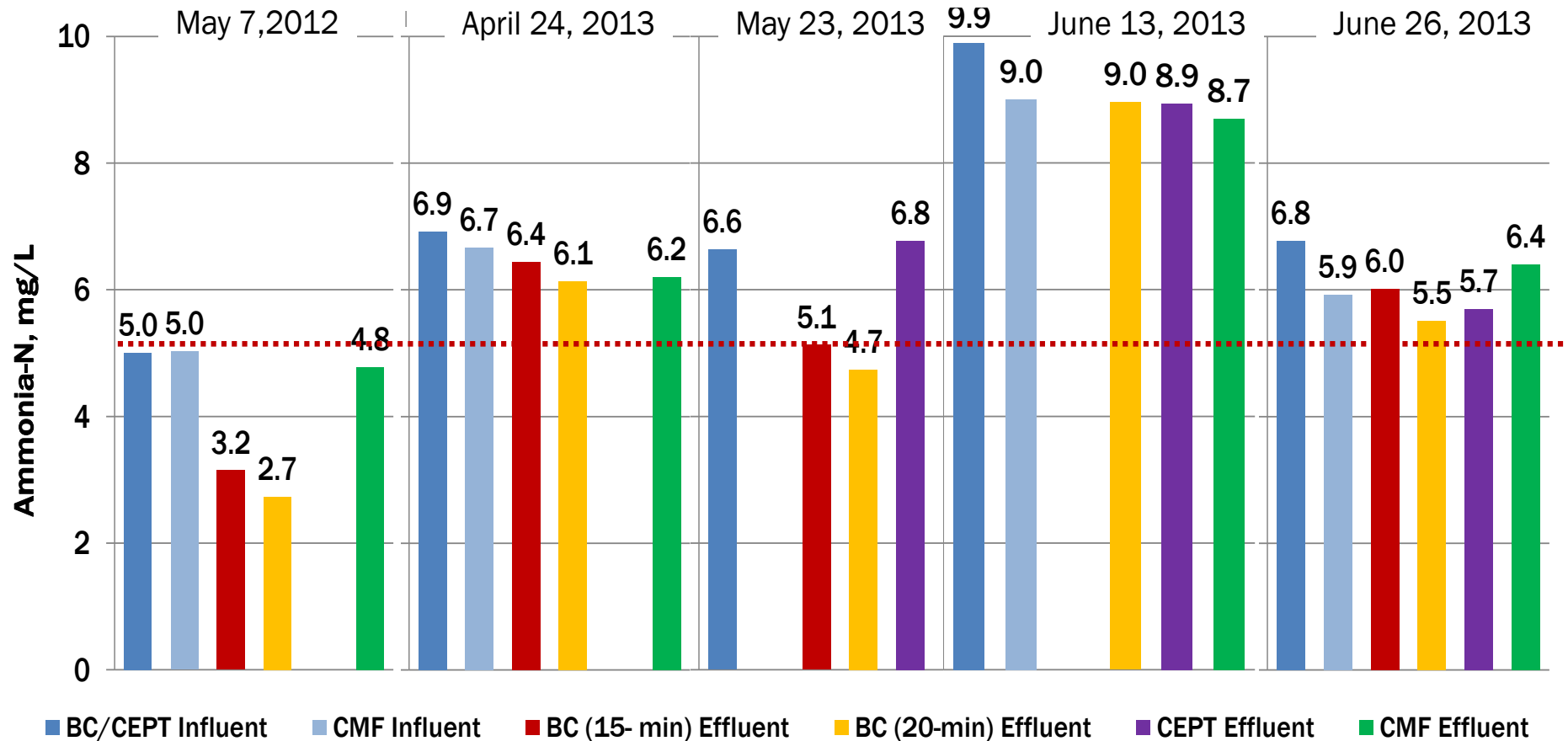
Test Results- TSS



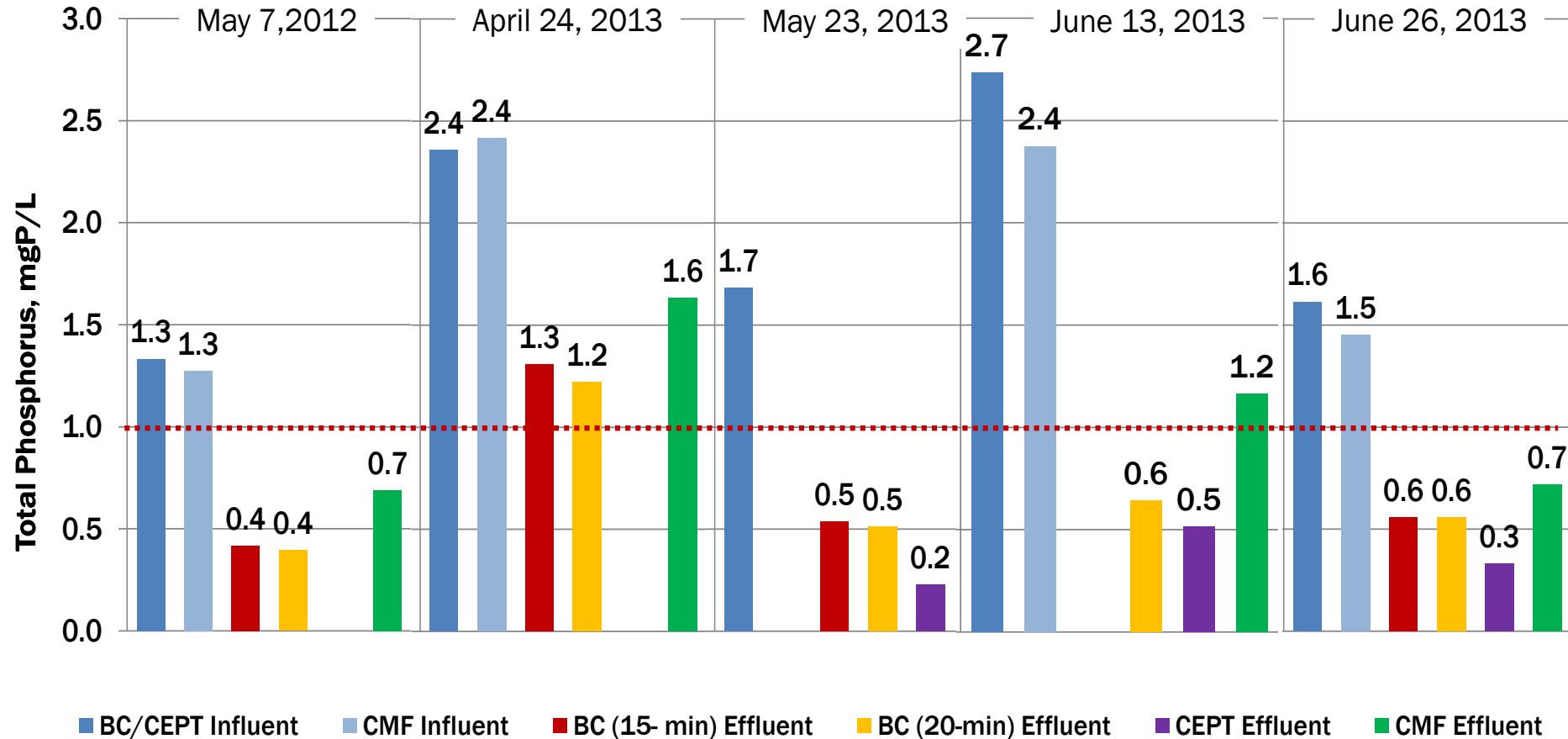
Test Results-BOD



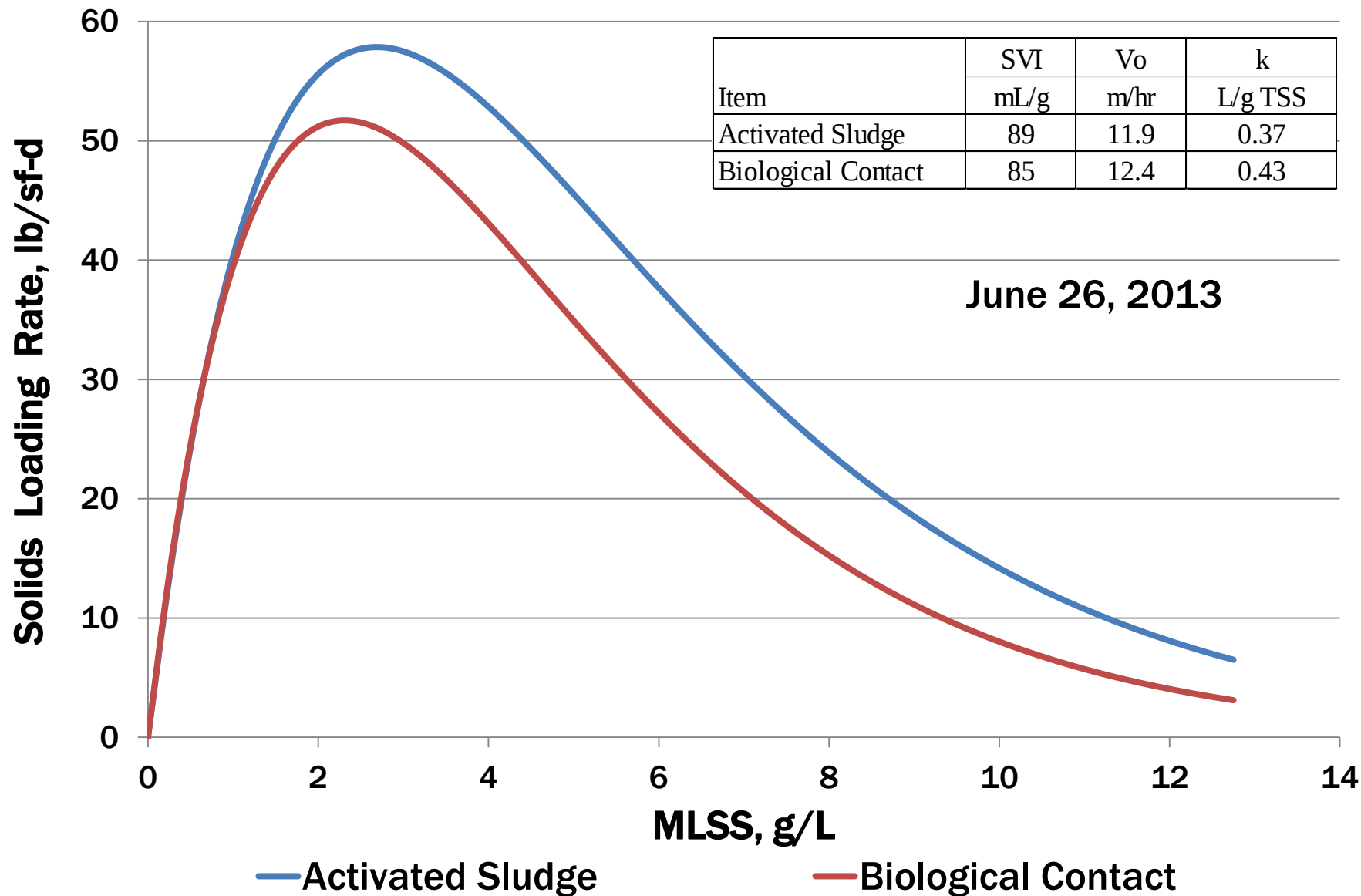
Test Results- Ammonia



Test Results - TP



Biological Contact Sludge Quality



Predicted Biological Contact ESS at Different Loading Conditions

Item	Units	Existing Chemical Phosphorus Removal	Chemical Phosphorus Removal with Polymer Addition	EBPR	Average SVI (all and wet weather)
SVI	mL/g	165	150	135	100
Predicted Effluent Suspended Solids					
SOR = 1200 gal/sf-d	mg/L	10	9	8	6
SOR = 1750 gal/sf-d	mg/L	60	23	17	10

Predicted ESS based upon 2Dc clarifier modeling using non-calibrated model. Steady state model runs conducted with 135-foot diameter clarifiers (18-foot SWD, flocculation baffle, in-board launders, hydraulic sludge removal), MLSS of 1600 mg/L, and 50% RAS rate.

MMSD SSWRF Wet Weather Testing- Predicted Effluent Quality

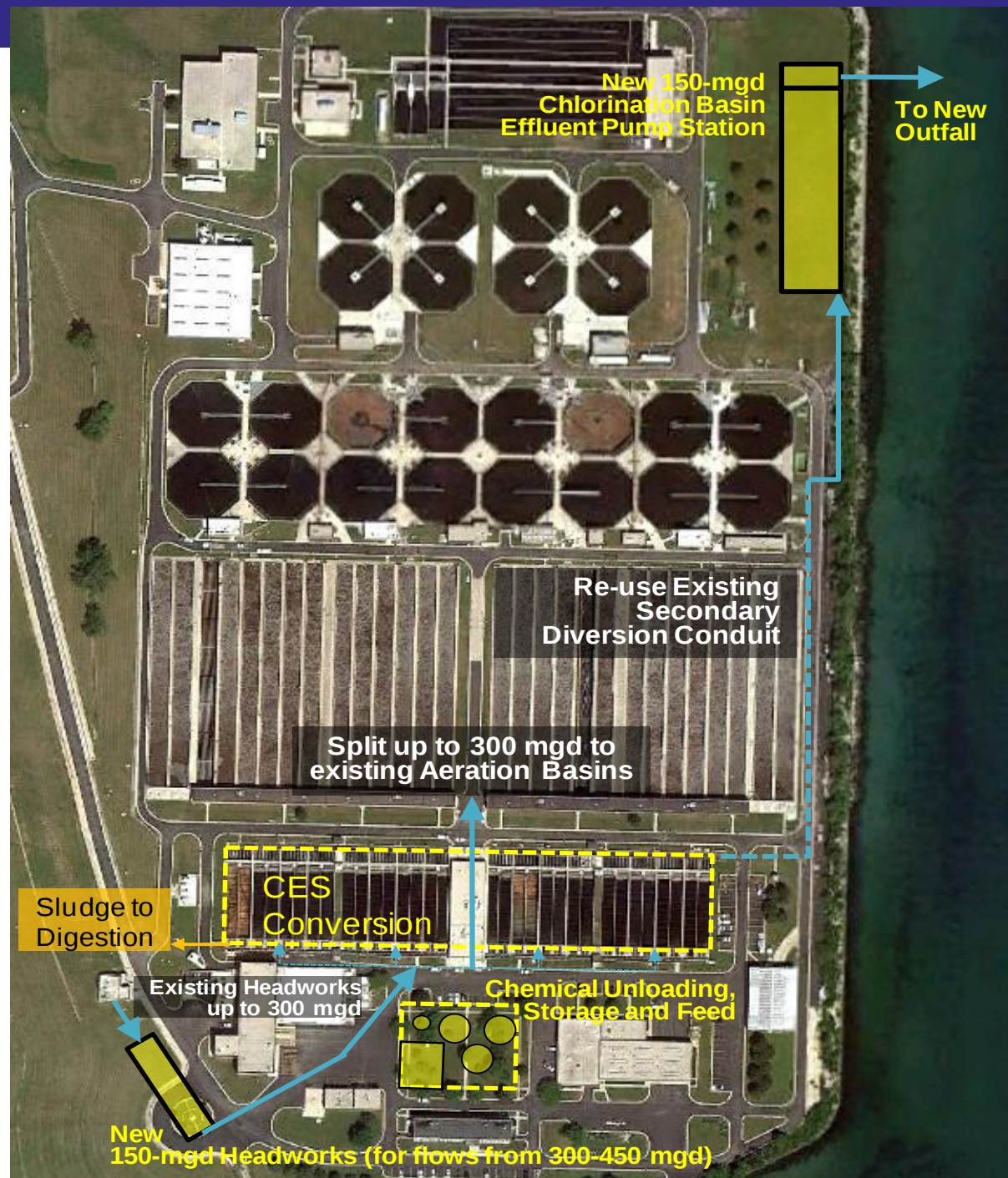
Item	Units	CES ¹	Biological Contact	CMF
cBOD ₅	mg/L	<20	≈ 10 at 1200 gal/sf-d ≈ 10-15 at 1750 gal/sf-d	20
TSS	mg/L	≈ 20	≈ 10 at 1200 gal/sf-d ≈ 10-20 at 1750 gal/sf-d	<15 - 20
NH3-N	mg N/L	In = Out	1-2 mg/L reduction	In = Out
TP	mg P/L	<0.5	< 1	≈ 1
Target Operating Parameters		50 mg/L FeCl ₃ Polymer = 2 mg/L	15 min HRT ² MLSS 1600 mg/L	7.5 gpm/sf

1. Performance impacted by SORs greater than design 1465 gpd/sf, tank flow short-circuiting and old polymer.
2. "Equal" 15- and 20- minute contact effluent quality. Assumes BC SVI of 150 mL/g or less at SOR of 1750 gal/sf-d. .

Auxiliary Treatment Alternatives Considered

Alternative	Considered in Screening Process	Selected for Alternative Evaluation
Chemical		
CES	Yes	Yes
Ballasted Flocculation (Actiflo/DensaDeg)	Yes	Completed in Previous Analysis
CoMag	No	
Biological		
Biological Contact(BC)	Yes	Yes
Ballasted Biological Contact	Yes	Yes
Filtration		
Deep Bed Filters	No	
Cloth Media	No	
Compressible Media	Yes	

CES



Biological Contact

Contact Tanks

MLSS = 1600 mg/L

Dual function Bioreactors

HRT = 15 min

Clarifiers

6 – 135' clarifiers

Dry/wet weather

SOR = 1750 gal/sf-d



Ballasted Biological Contact

Contact Tanks

MLSS = 1600 mg/L

Single Purpose

HRT = 15 min

Ballasted Floc

Wet weather

SOR = 30 gpm/sf



Comparative Costs (\$ Millions)

Item	CES	Biological Contact	Ballasted Biological Contact	Ballasted Flocculation
Site work	\$ 0.4	\$ 11.0	\$ 2.7	\$ 2.7
Yard Piping	\$ 1.5	\$ 6.2	\$ 2.2	\$ 2.2
Chemical Flocculation	\$ 12.2	\$ -	\$ -	\$ -
Ballasted Flocculation	\$ -	\$ -	\$ 54.0	\$ 41.0
Biological Contact Tanks	\$ -	\$ 4.5	\$ 5.1	\$ -
Secondary Clarifiers	\$ -	\$ 15.9	\$ -	\$ -
Subtotal 1	\$ 14	\$ 38	\$ 64	\$ 46
Total Probable Project Cost	\$ 29	\$ 78	\$ 132	\$ 95
Annual O&M Cost	\$ 0.5	\$ 0.3	\$ 0.8	\$ 0.8
Net Present Value O&M	\$ 5.9	\$ 4.5	\$ 10.7	\$ 10.7
Total Present Value	\$ 35	\$ 82	\$ 143	\$ 105

1. Costs excludes common components such as preliminary treatment, disinfection, and effluent pumping

Conclusions

Bench Testing

- CES FeCl_3 dose under-estimated
- BC matched tested MLSS/HRT

Demonstration Testing

- Each alternative met performance criteria
- BC produced best effluent quality
- BC sludge settling characteristics different than main plant NAS.

Alternative Analysis

- CES recommended- lowest cost and least impact to site
- BC recommended for biological treatment

Thank you

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CES Testing

Date	Surface Overflow rate, gpd/sf	Ferric Chloride Dose, mg FeCl ₃ /L	Polymer Dose, mg/L	Pickle Liquor, mg Fe/L
May 7, 2012	-	-	-	-
April 24, 2013	-	-	-	-
May 23, 2013	2,050	45	2	--
June 13, 2013	1,760	60	2	--
June 26, 2013	2,130	50	5	4.3
Target values	1465	40	0.5 to 1	--

Biological Contact Demonstration Operating Conditions

Date	Median MLSS, mg/L	MLSS range mg/L	Tank 3 Contact Time ¹ minutes	Tank 4 Contact Time ¹ minutes
May 7, 2012	1,750	1,400 to 2,000	16	22
April 24, 2013	2,000	710 to 3,100	16	22
May 23, 2013	1,700	1,700 to 1,800	15	20
June 13, 2013	1,500	1,400 to 1,500	23	30
June 26, 2013	1,500	1,400 to 1,600	14	20

1. Contact time based upon combined forward flow of primary influent + return sludge flows.

Table 3-11. MMSD SSWRF Wet Weather Testing Summary.

Item		Units	Chemically Enhanced Sedimentation ¹	Biological Contact Treatment		Compressible Media Filtration
Sampling Events		--	3	5		4
Influent						
cBOD ₅	Median (Range)	mg/L	68 (37-69)	69 (37-70)		53 (38-70)
TSS	Median (Range)	mg/L	105 (58-202)	105 (58-230)		79 (45-139)
NH3-N	Median (Range)	mg N/L	6.8 (6.6-9.9)	6.8 (5.0-9.9)		6.3 (5.0-9.0)
TP	Median (Range)	mg P/L	1.7 (1.6-2.7)	1.7 (1.3-2.7)		1.9 (1.3-2.4)
Soluble P	Median (Range)	% TP mg P/L mg P/L	29 0.25 (0.04-0.47)	29 0.43 (0.04-0.69)		25 0.48 (0.25-0.56)
Alkalinity	Median (Range)	mg/L as CaCO3	240 (215-310)	273 (215-310)		298 (230-310)
Effluent				~ 15-Minute Contact Time	~ 20-Minute Contact Time	
cBOD ₅	Median (Range)	mg/L	19 (18-20)	9 (6-12)	10 (5-12)	21 (13-39)
TSS	Median (Range)	mg/L	21 (16-63)	6 (4-10)	7 (3-15)	12 (9-48)
NH3-N	Median (Range)	mg N/L	6.8 (5.7-8.9)	5.6 (3.2-6.4)	5.5 (2.7-9.0)	6.3 (4.8-8.7)
TP	Median (Range)	mg P/L	0.3 (0.23- 0.52)	0.5 (0.4-1.3)	0.6 (0.4-1.2)	0.94 (0.7-1.6)
Soluble P	Median (Range)	% TP mg P/L	3 0.14	73 0.40	66 0.34	37 0.49