Innovative New Media with Advanced Deep Bed Primary Filtration Makes Significant Strides

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Tomorrow Water

29 January 2025
Boston, MA

History of Biologically Active Filters (BAF) Development

	Technology	Media	Flow	Aeration	Application
1950s	**Trickling Filter**	Rock (sunken)	Down	None (usually)	Secondary, Tertiary
1970s	**Flopac™**	Chamotte (sunken)	Down	Pre-filtration	Tertiary
1980s	**Biofor®, Biocarbone®**	Biolite, Exp. Shale (sunken)	Up	Buried Diffusers	Secondary, Tertiary
	Dynasand™	Sand (sunken)	Up	Airlift Pump	Tertiary
1990s	**Biostyr®**	EPS spherical (float)	Up	Diffusers	Secondary, Tertiary
	BBF™	EPP ovoid (float)	Up	Diffusers	Secondary, Tertiary
2010s	**Proteus™**	EPP cross (float)	Up	Diffusers	Primary, Secondary, Tertiary, Wet Weather

APPLICATIONS

1. Primary Filtration
2. Wet Weather Flow (WWF) Treatment
3. Secondary BOD Removal
4. Secondary BNR
5. Tertiary Nitrogen Control
6. Split Bed DN & Reuse Polishing
7. Partial deNitrification Anammox (PdNA)

Primary Treatment Technologies

Conventional Primary Treatment

Clarification / Sedimentation

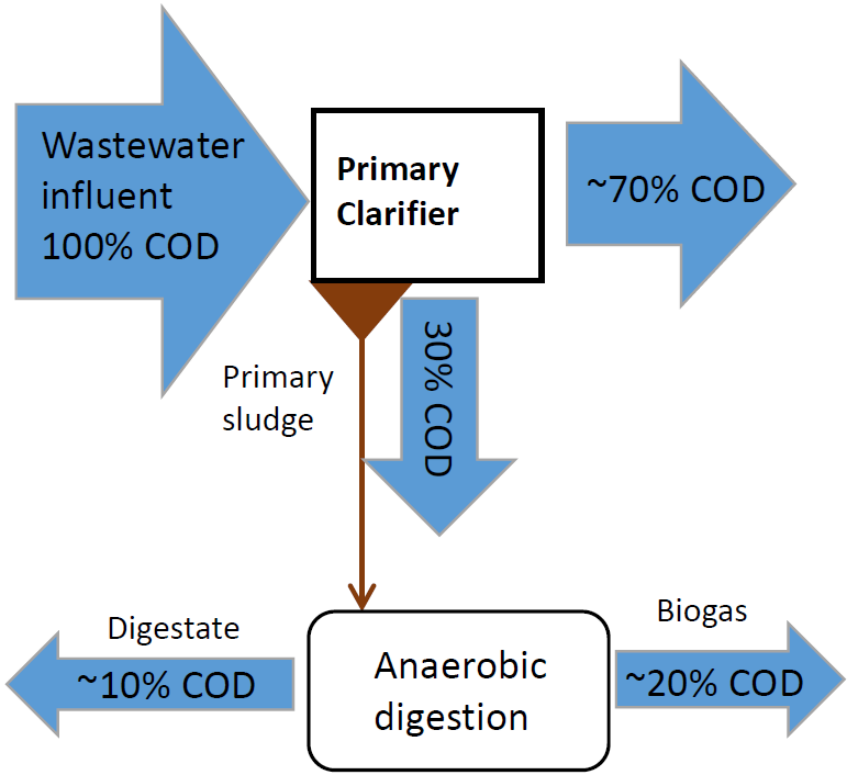
Caliskaner et al, WEFTEC 2023

Advanced Primary Treatment (APT)

- Chemically Enhanced Primary Treatment (CEPT)
- Filtration Technologies
  - Primary Filtration (PF)
  - Primary Biofiltration (PBF)
  - Primary Effluent Filtration (PEF)
- Microscreens
- Rotating Belt Screens/Filters
- Other Emerging Technologies

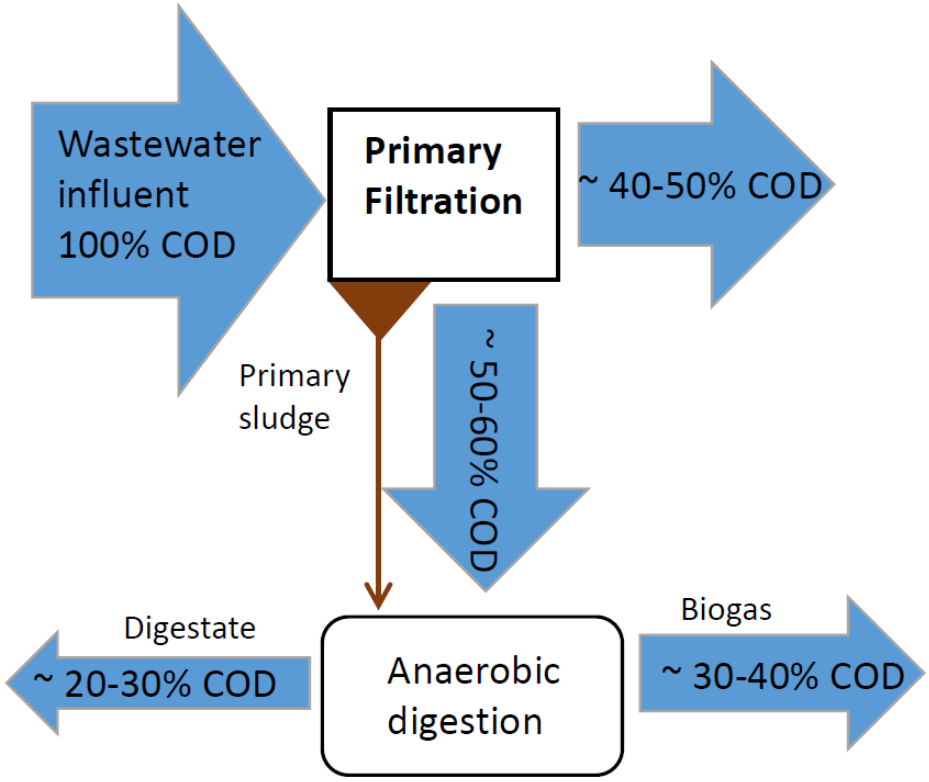
Primary Treatment Technologies

Conventional Primary Treatment



Adapted from Shewa and Dagnew (2020)

Advanced Primary Treatment *Filtration*



Drivers for Advanced Primary Filtration

Primary Clarifier	Advanced Primary Filtration
Slow - settling *by gravity* force	Fast - filtration by *hydraulic force*
Controllable ? No. relies on gravity	*Controllable? Yes. With media size and bed depth*
Range of operation – limited, <1.5Q	Range of operation – broad, 3-5 Q
Average settling time: 60 to 90 minutes	*Average filtration time: 7 to 15 minutes*
Foot print – Large	*Foot print – smaller, ~20% of clarifier*

WHY ADVANCED PRIMARY FILTRATION?

FILTER PRIMARY SOLIDS INSTEAD OF SETTLING

Huge 80% Footprint Reduction
Over Primary Clarifiers

CAPTURE MORE TSS

70-90% Removal
Instead of 30-60% in Clarifiers

ALLOWS FOR CARBON DIVERSION

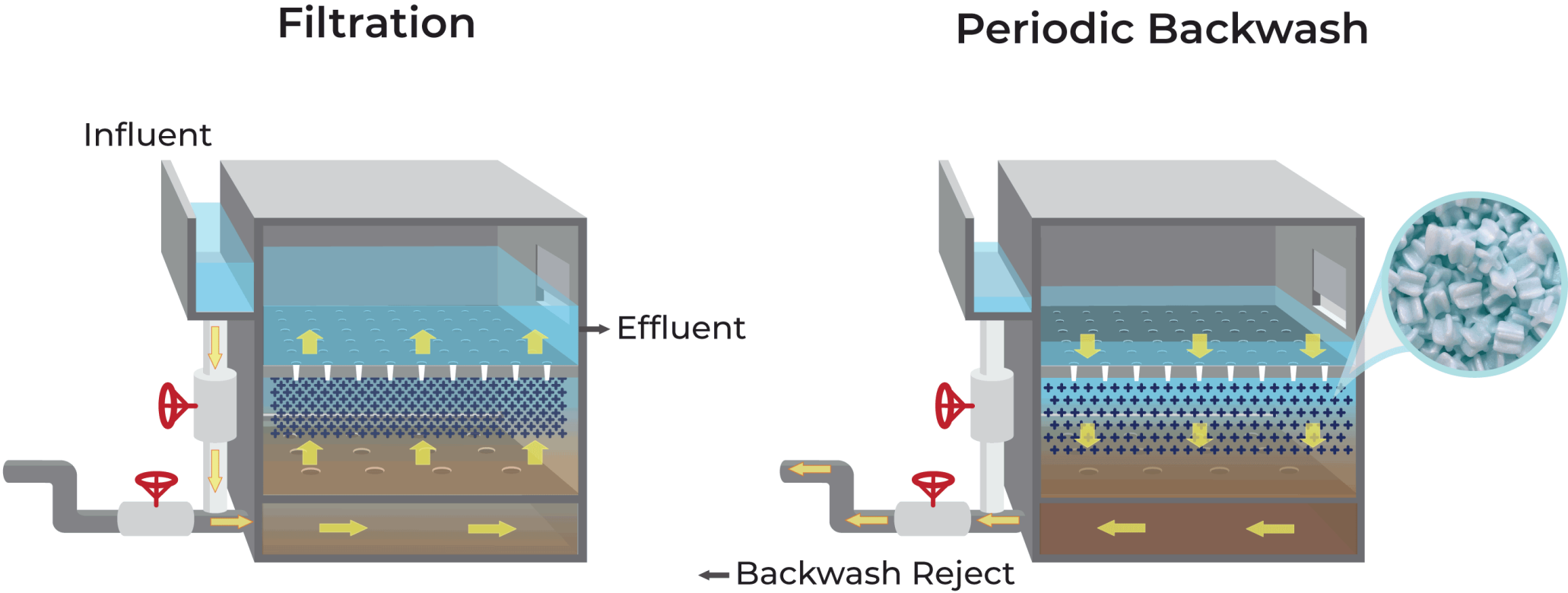
Grab More BOD Upstream of Aeration
& Send To Digestors

10-25% Aeration Energy Reduction

10-25% More Secondary Treatment Capacity

20-30% Increase In Gas Production

Advanced Primary Filtration



Two Major Innovations

1. NEW MEDIA

Handles High Solids

Low Head Loss

More Effective Backwash

2. SPLIT-BED AERATION

Oxic on top, Anoxic below

High SSA means intensification

LEGACY MEDIA

Expanded Polypropylene (EPP)

- Long lifespan

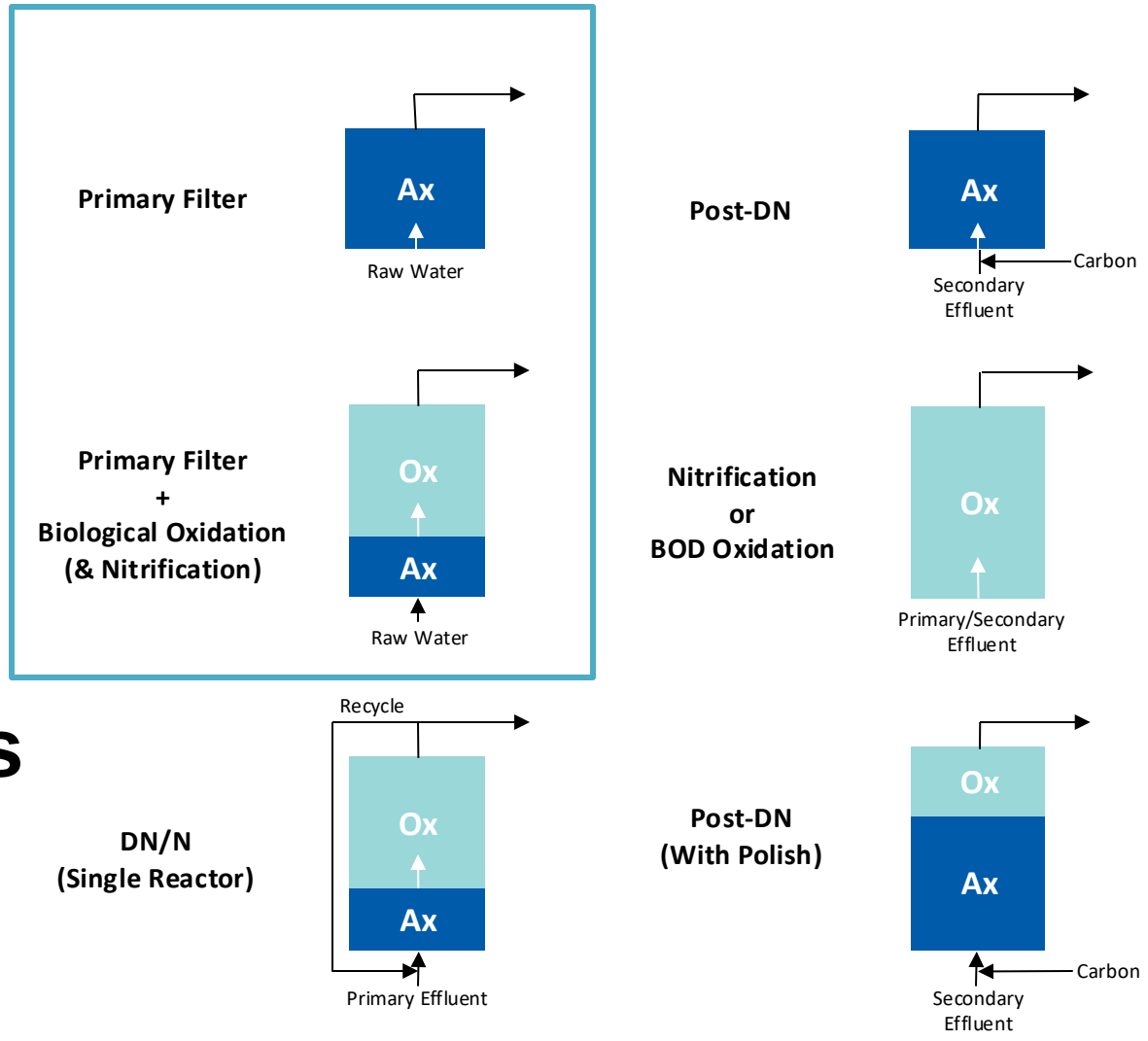
Ovoid Shape

GREAT for Tertiary Biofiltration

New Floating Media

1	**50% MORE specific surface area**: 2100 m^2/m^3 - 3x HIGHER than K5 (IFAS) - 50% > other BAFs
2	**High Void Fraction:** 0.4~0.5 - Low head loss @ high solids
3	**High SS Loading:** >3 kg/m^3 (216lb/1000 ft^3) - Minimizes backwash rate
4	**High O2 Transfer:** SOTE 35-45% - With only coarse-bubble aeration
5	**Made With Expanded Polypropylene** - Cost-effective - Long lifespan (>35 years)

Process Configurations



PROTEUS FULL-SCALE INSTALLATION

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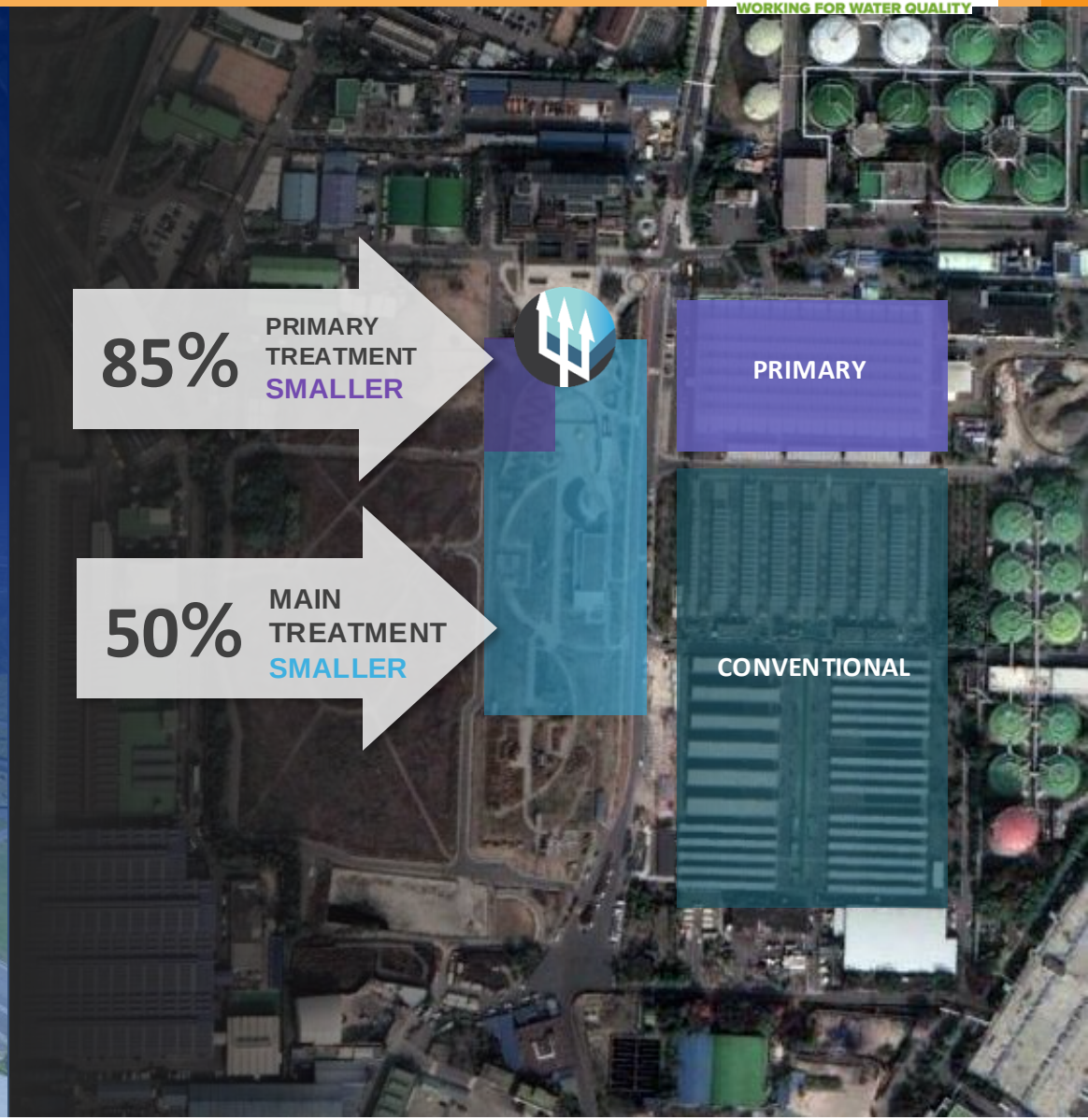
WORKING FOR WATER QUALITY

Jungnang WRF
Seoul, Korea

66 MGD
Complete Wastewater
Treatment Process

132 MGD WWF Filter
in parallel with Primary Filter

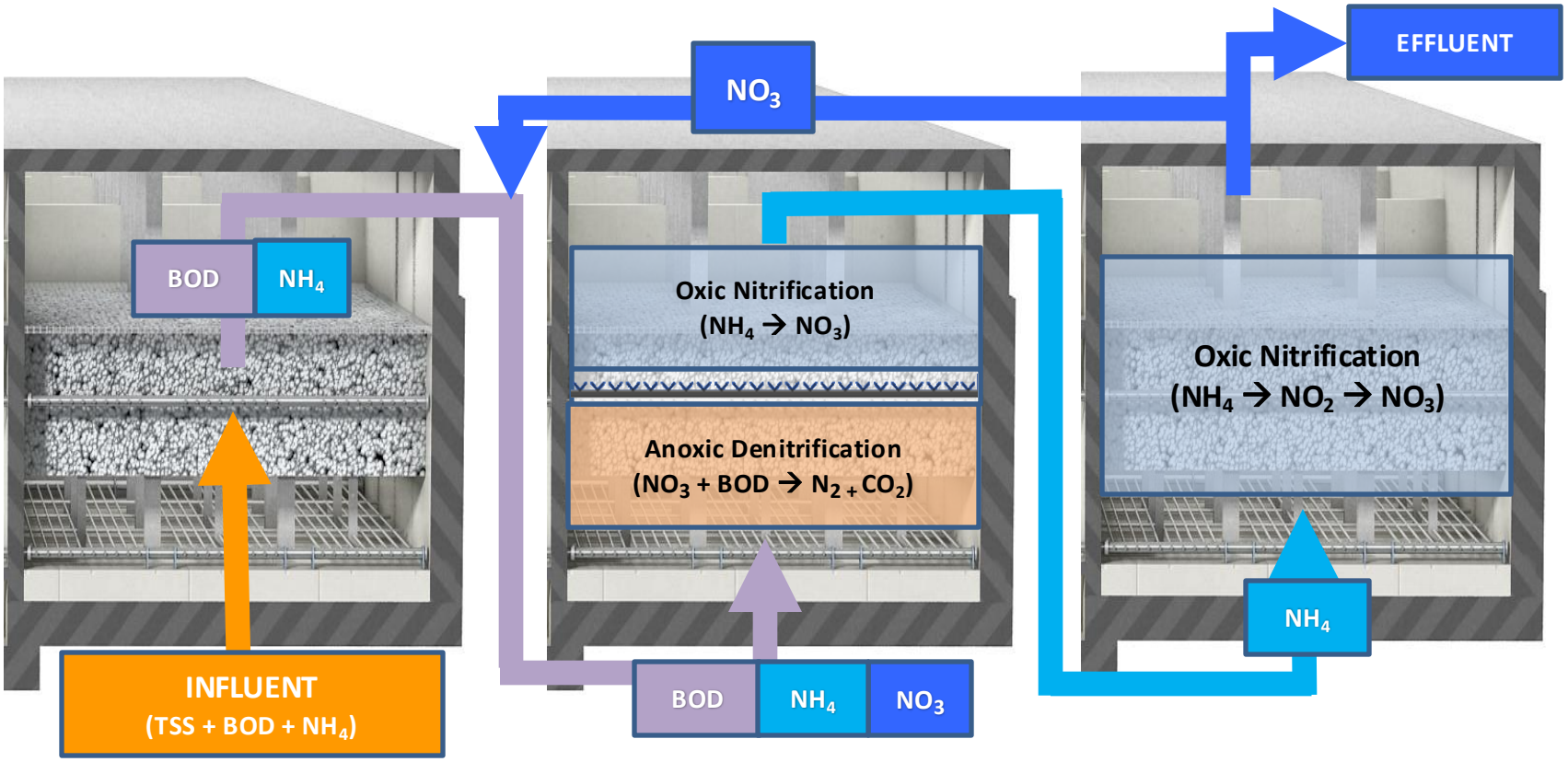
Commissioned 2017



Proteus Primary™
Primary Filtration
(No Aeration, No Recycle)
TSS Capture Only

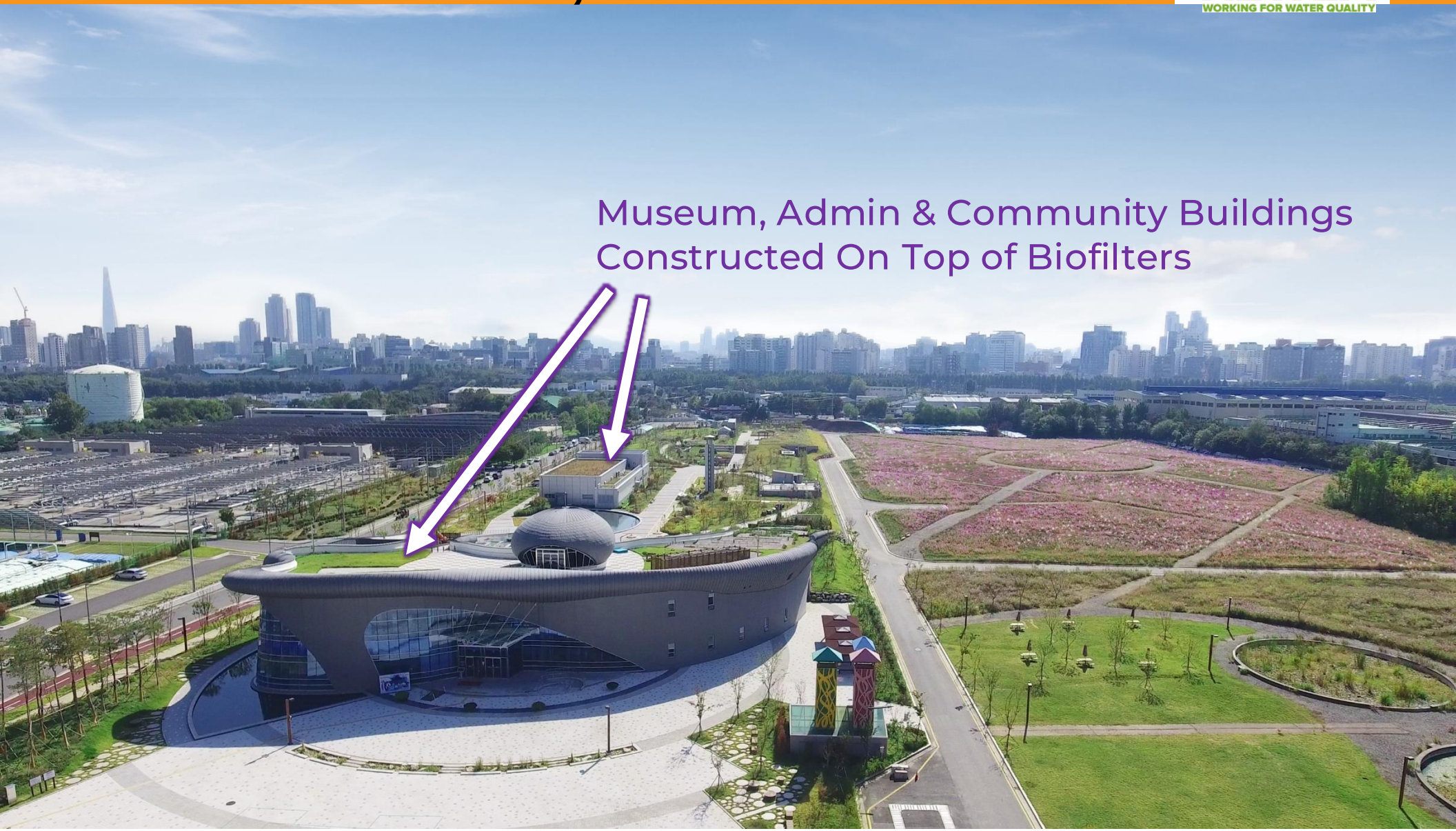
Proteus™-DN/N
DN/O Stage
(Aeration Bisects Media Layer)

Proteus-N™
N Stage (Full Aeration)
Recycle NO_3 to DN stage



JUNGNANG WRF
Seoul, Korea

NEWEA
WORKING FOR WATER QUALITY



JUNGNANG WRRF
PERFORMANCE DATA

Operating with zero permit violations over 7 years

Actual HRT: 3.4 Hrs (excluding MDF)

Design HRT: 2.1 Hrs

Data from March-October 2018

Chemical P Removal (Alum + Filter)

Parameter		Influent	Permit	BBF Effluent	Plant Effluent
BOD5	Ave	**120**	**10**	**9.1**	**1.4**
	Max	192		17	3.2
	Min	42		2.4	0.5
SS	Ave	**102**	**10**	**4.9**	**2.5**
	Max	236		11	6
	Min	38		1.5	0.4
TN	Ave	**33**	**20**	**15**	**13**
	Max	44		20	19
	Min	8		7	6.0
TP	Ave	**3.1**	**0.5**	**1.6**	**0.23**
	Max	4.2		2.6	0.56
	Min	0.8		0.2	0.05

Wet Weather Flow Treatment Strategies

Traditional

1. Increase Plant Capacity

2. Storage & Equalization (Tunnels/Interceptor)

   Big CAPEX, useless in dry weather, needs cleaning

   Presumes predictability of max flows

3. Divert & Blend
   - Risk violating permit without auxiliary treatment
   - Blending permits may be hard to get

New(er)

1. Auxiliary High-Rate Treatment
   - Physical filtration or biological treatment?
   - A lot of infrastructure just for rare WWF events

2. Dual-Use Systems: The best of both worlds
   - Provides treatment for dry weather flow
   - Switch feed or ramp up loading rate to manage WWF

1st DUAL-USE INSTALLATION

Seonam WRF, Seoul, Korea

- **95 MGD Primary Filter**

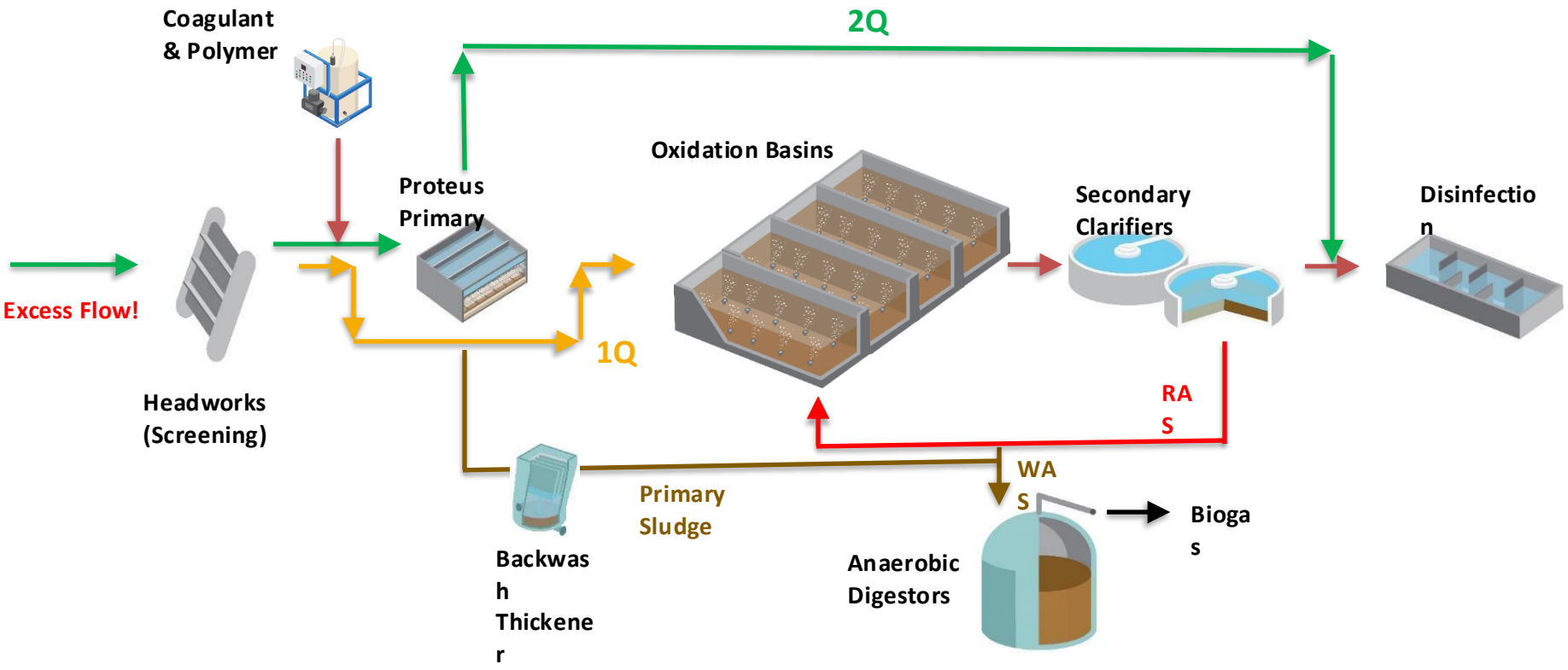
  Converts to

- ***190 MGD WWF Filter***

  Flow velocity increased

- **Commissioned 2020**

Seonam WRC – 190 MGD (Dual-Use)



SEONAM WRRF

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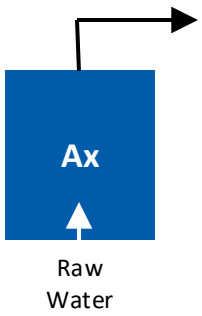
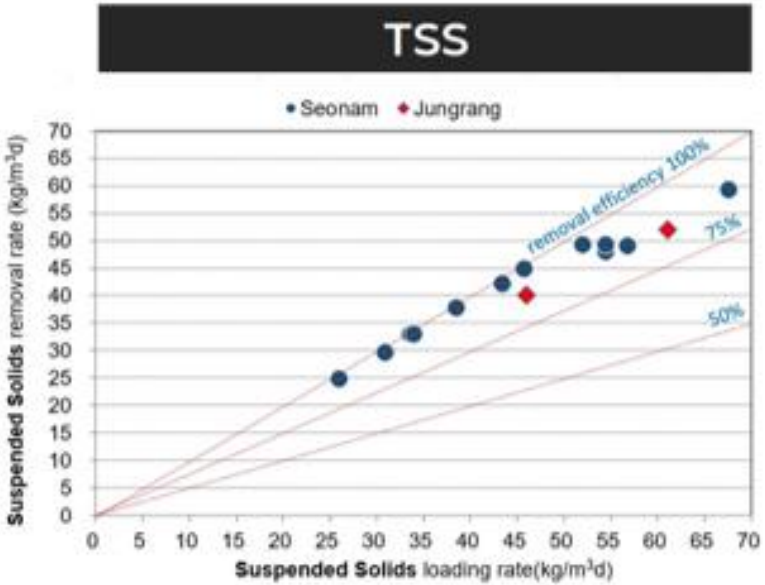
2020 WET WEATHER FILTER PERFORMANCE: Seonam (190 MGD)

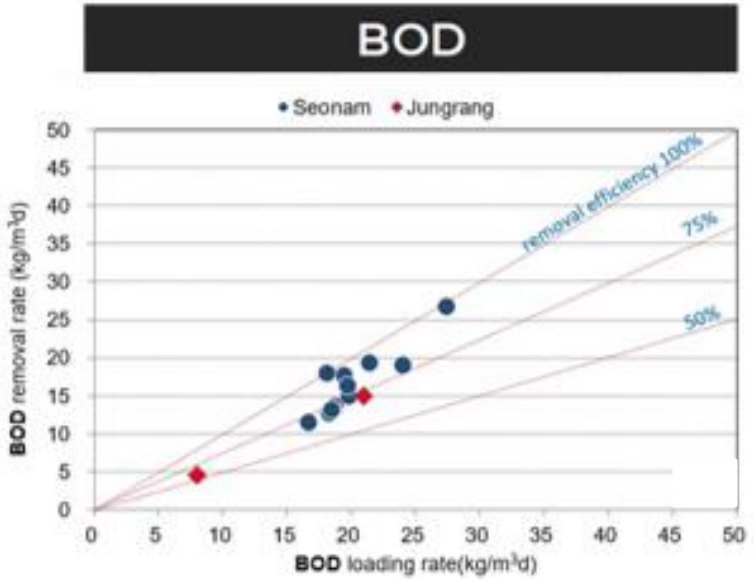


Event	Q (m3/d)	Influent		Effluent		Removal Efficiency	
		BOD_5 (mg/L)	SS (mg/L)	BOD_5 (mg/L)	SS (mg/L)	BOD	SS
1	720,000	79.8	288.0	21.6	34.8	73%	88%
2	720,000	102.3	242.0	20.7	32.8	80%	86%
3	720,000	116.7	232.0	2.8	27.2	98%	88%
4	720,000	91.5	232.0	9.2	22.0	90%	91%
5	720,000	84.4	222.0	20.6	11.4	76%	95%
6	720,000	78.0	195.0	23.9	3.6	69%	98%
7	720,000	82.8	185.0	7.5	5.4	91%	97%
8	720,000	79.2	164.0	23.2	3.0	71%	98%
9	720,000	77.1	143.0	0.4	2.4	99%	98%
10	720,000	71.1	145.0	21.8	4.1	69%	97%
11	720,000	78.9	111.0	22.4	5.3	72%	95%
12	720,000	84.0	132.0	14.4	5.4	83%	96%
Average		85.5	190.9	15.7	13.1	81%	94%
Max		116.7	288.0	23.9	34.8	99%	98%
Min		71.1	111.0	0.4	2.4	69%	86%

Full-scale Plants – Jungnang (132 MGD) and Seonam (190 MGD)

PROTEUS PERFORMANCE



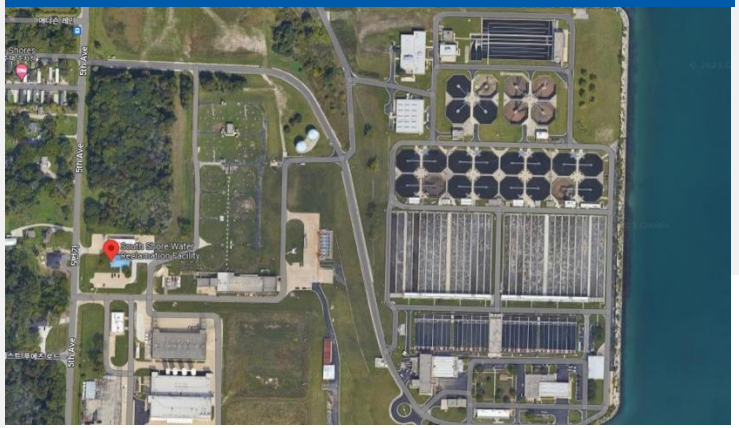


Pilot Testing in North America

GCDC, Michigan
April, 2019 - May, 2020: 13 Month

Testing by Plant Lab and outside lab for special tests. Operation by TW (daily) and Plant staff (backup, daily)
Paper at WEFTEC 2020

MMSD, Wisconsin
Jan – June, 2022: 6 Month



Testing by Plant Lab and outside lab for special tests. Operation by Veolia staff (daily) and TW staff (monthly)
Paper at WEFTEC 2023

Additional Pilots

- **Bridgeport, CT 2023 (WEFTEC 2024)**
- **Linda County, CA 2024 (WEFTEC 2024)**
- **Los Angeles County, CA 2025**
- **City of Cincinnati, OH 2025 BAF**

PRIMARY & WWF 13-MONTH PILOT

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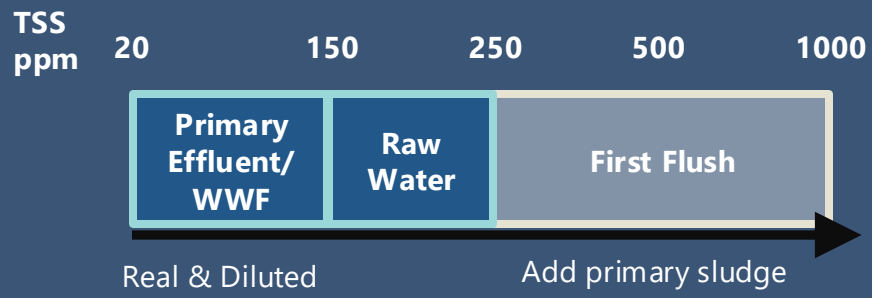
GENESEE COUNTY MICHIGAN

PHASE 1: Wide range of influents (up to133gpm), simulate wet weather flows

PHASE 2: Stable performance with dilute Primary Effluent

PLUS: Catch a real wet weather event



3rd Party Reviewer: Dr. Glen Daigger
Paper at WEFTEC 2020

Results Summary

Removal	Phase 1 (Raw) **Influent** (mg/L)	Phase 2 (PE) **Influent** (mg/L)	**Primary Filter Removal**		**Biological Filter Removal**	
			Raw Water	Primary Effluent	Raw Water	Primary Effluent
TSS	185	76	**78%**	**71%**	**84%**	**84%**
BOD	161	64	**69%**	**51%**	**81%**	**60%**
Total P	5.1	3.2	45%	37%	54%	51%
Fecal Coliform	7.5 CFU/mL	2.3 CFU/mL	51%	NA	79%	45%
Chlorine Demand	0.67	NA	70%	NA	88%	NA

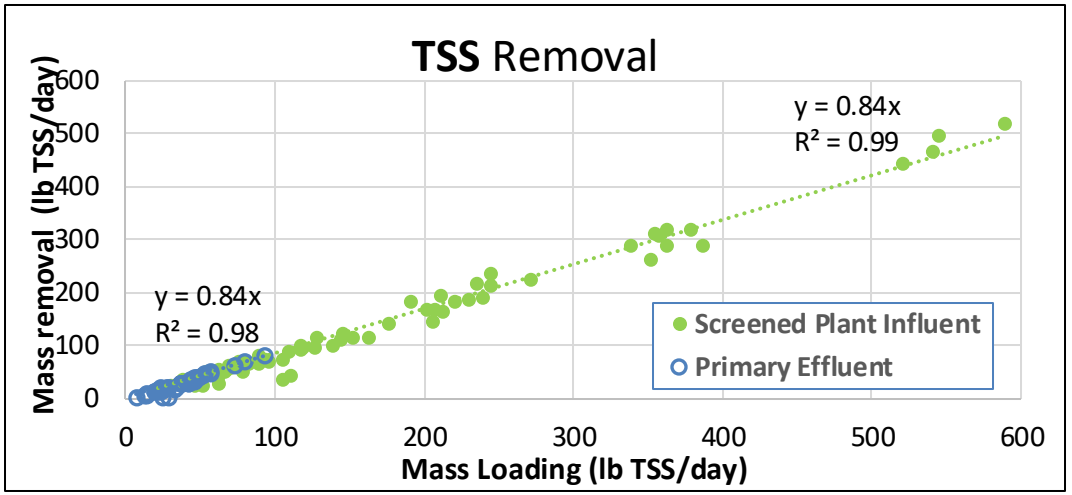
OPTIMUM VALUES FOR THIS PLANT:

Primary Filter: **15-20 m/hr (5-8 min EBCT)**

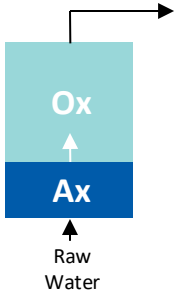
Biological Filter: **15-20 min EBCT**

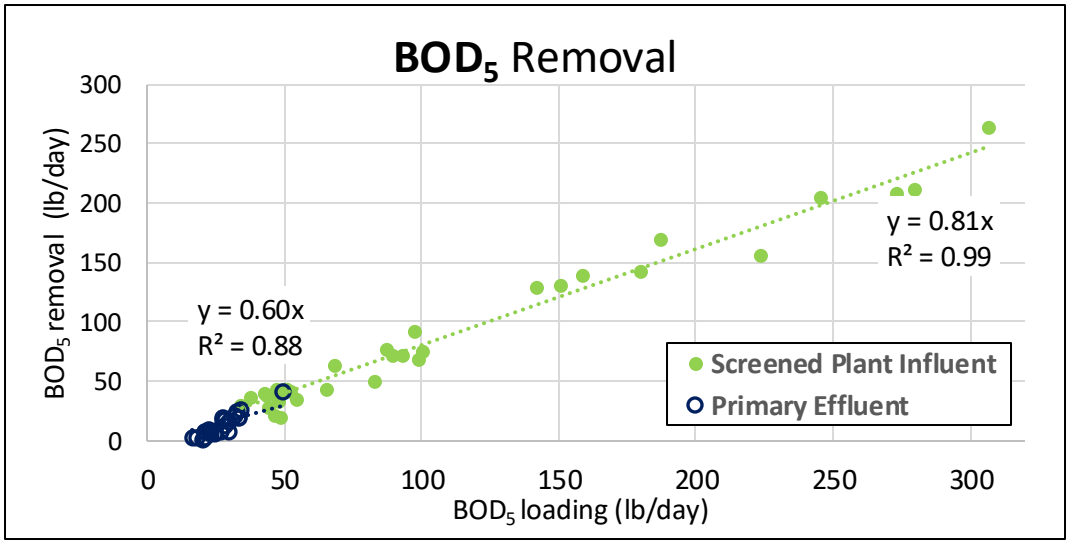
Proteus+ Biological Filter

13-Month Pilot in Michigan



84% TSS removal
Higher removal than primary filter (78%)

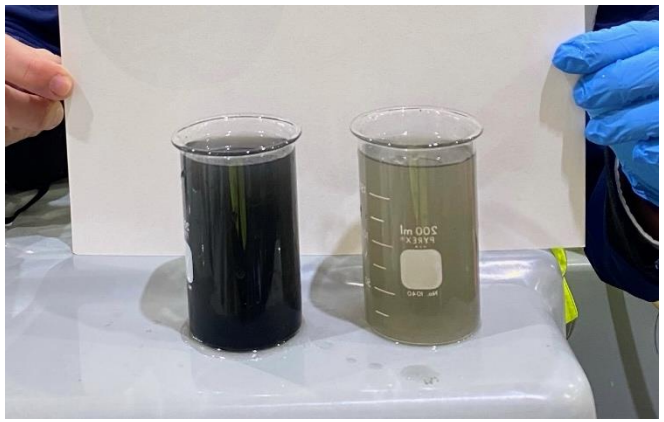




81% BOD Removal at 15-20min EBCT
in plant influent
60% for PE

2022 Dual-Use Pilot for Milwaukee Metro Sewerage District

- 5-month pilot at South Shore WRF
- Operated by MMSD, validation by Black & Veatch
- Tested Primary and Bio Filter Retrofit Designs
- Tested 6 different SLRs of 0.9-8.7 gpm/sf (equiv. 40 – 572 MGD)
- TSS up to 1200 ppm, plus low-flow slugs
- Shallow bed to fit to hydraulic profile at MMSD SSWRF



Influent vs Effluent during low-flow solids slug

RESULTS: Influent Quality & Flow

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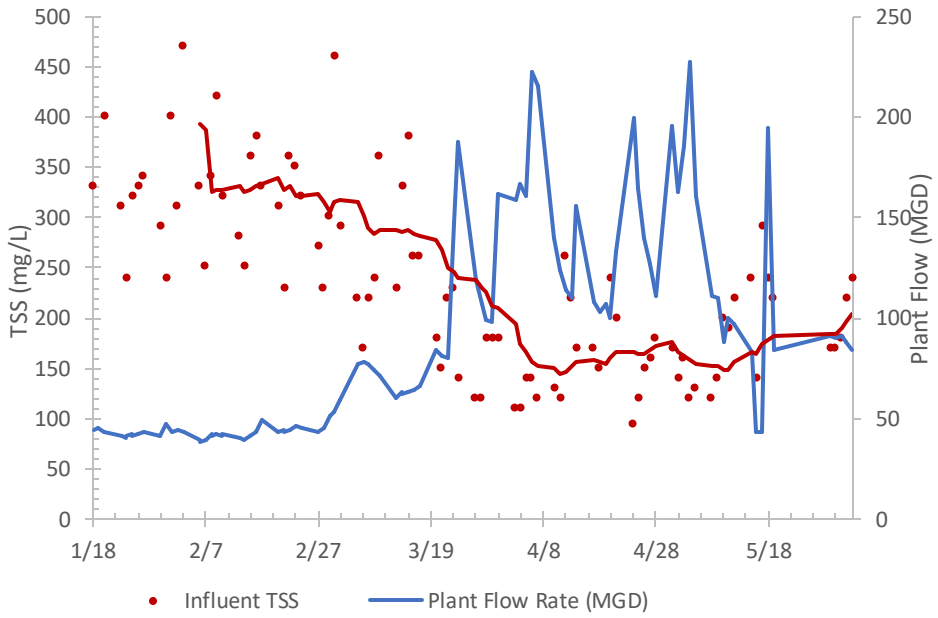
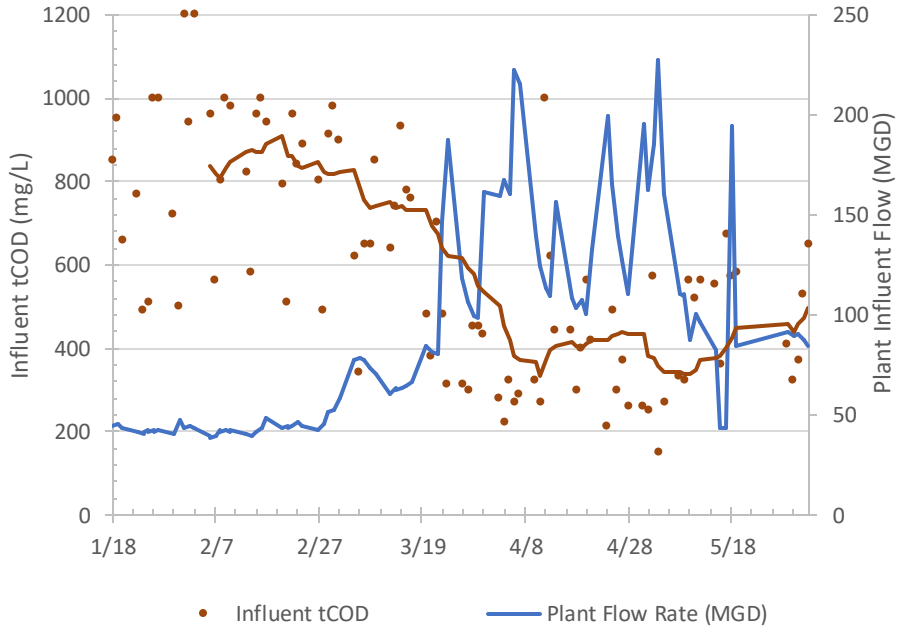
Influent TSS



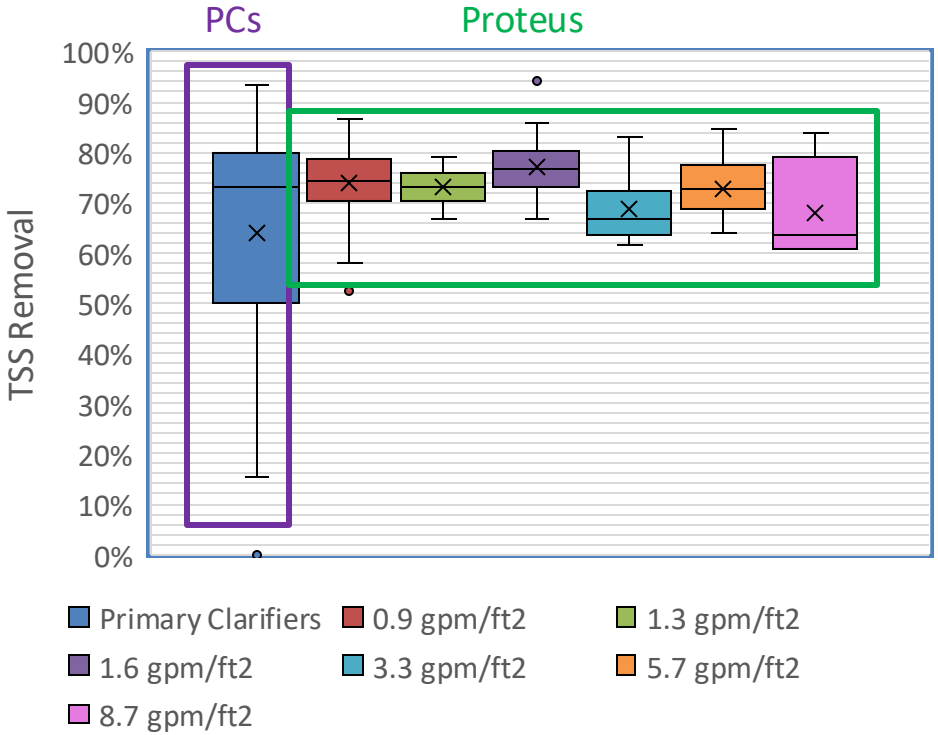
Influent Total COD

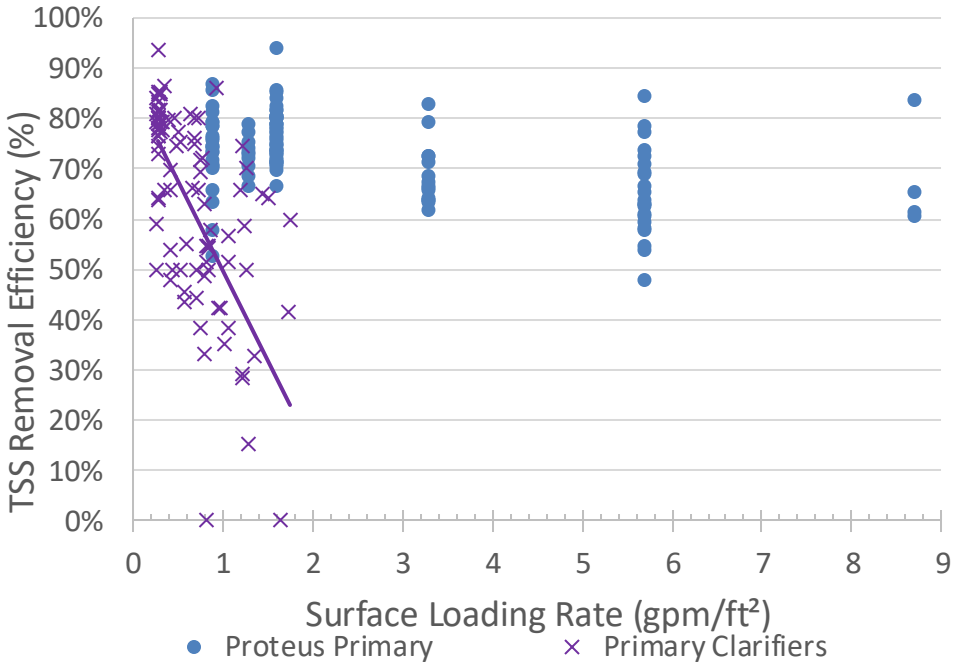


Parameter	Low Flow Period (1/18-3/20)		Average Flow Period (3/21-6/2)	
	Average (mg/L)	Range (mg/L)	Average (mg/L)	Range (mg/L)
TSS	**328**	170-1200	**171**	93-290
tCOD	**793**	340-1200	**416**	150-1000
$cBOD_5$	**376**	300-460	**192**	95-280
sCOD	**393**	172-754	**185**	77-757

RESULTS: Proteus vs Primary Clarifiers

- Proteus outperformed South Shore's primary clarifiers ***at all flow rates*** for median TSS removal
  - Despite iron salts dosed in primary clarifiers (vs. no chemical dose in Proteus)
- Proteus removal ***more consistent than clarifiers.*** *Removal efficiency decreased only ~10%* as SLRs increase





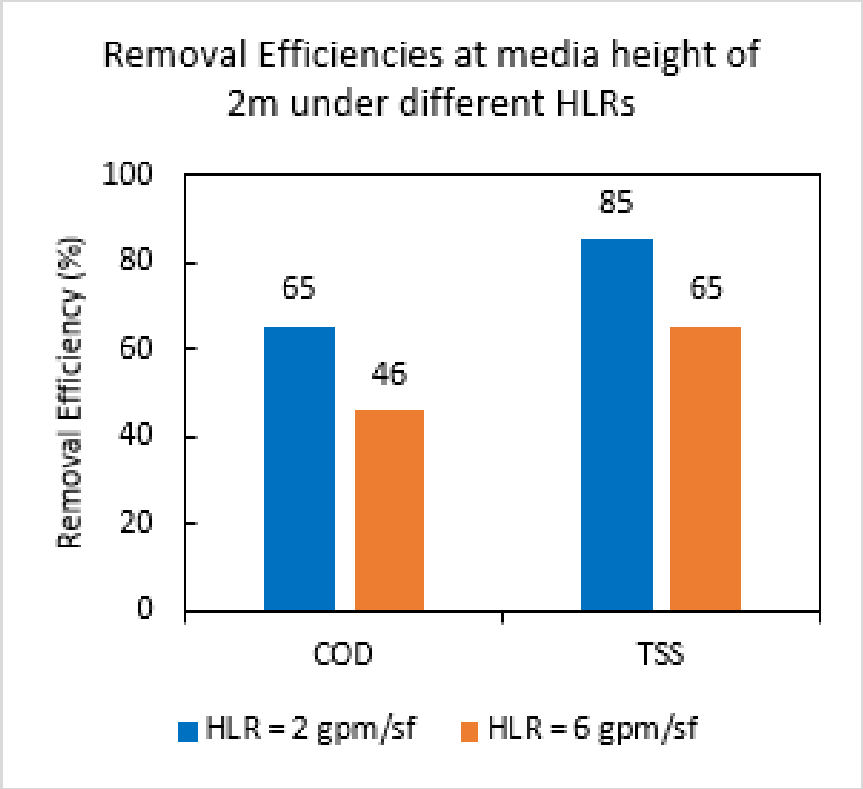
California Energy Commission Project at Linda County Water District, CA

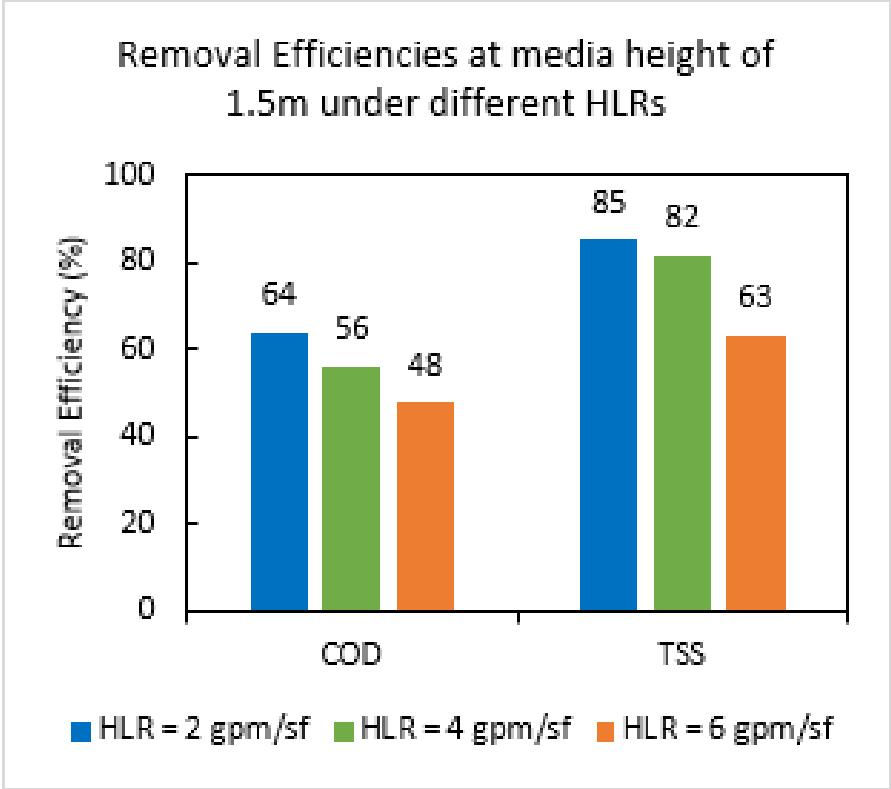
Overall Treatment Performance[1]					
TSS			**Total COD**		
Avg. Influent	471	mg/L	Avg. Influent	1097	mg/L
Avg. Effluent	62	mg/L	Avg. Effluent	360	mg/L
Removal Efficiency	85	%	Removal Efficiency	65	%
PC Removal Efficiency[2]	62	%	PC Removal Efficiency	37	%
VSS/TSS Ratio	Influent	0.83	COD/TSS Ratio	Influent	2.12
	Effluent	0.74		Effluent	5.77
Carbonaceous BOD			**Soluble COD**		
Avg. Influent	315	mg/L	Avg. Influent	202	mg/L
Avg. Effluent	186	mg/L	Avg. Effluent	206	mg/L

[1] Performance under ADF (2gpm/ft^2) and media height of 2m is presented in TSS and tCOD removal efficiency.
[2] PCs at Linda WWTP are typically operated at surface overflow rates between 400 and 1000 gal/day/ft^2.

Program Manager: Caliskaner Water Technologies

TSS Removal at Different Media Heights and HLRs





Comparative loading and performance of full-scale plants and pilot plants

Site	Flow (m^3/d)	Surface Loading Rate (m^3/m^2d)	Surface Loading Rate (gpm/sf)	Solids Loading Rate (kg SS/m^3 per cycle)	TSS Removal (Mean)	BOD Removal (Mean)
Jungnang Primary	250,000	41-408	0.7-8.2	0.05—2.12	52%	33%
Jungnang WWF *chems added	500,000	480	8.2	4.2	87%	63%
Seonam Primary *Larger Media	360,000	250	4.3	1.3—9.2	32%	25%
Seaonam WWF *chems added	720,000	468	8.6	1.7—4.0	94%	81%
Michigan Primary	725	360—480	6.1—8.2	1.5—7.3	75%	60%
Michigan BEPT	349	144—192	2.5—3.3		84%	81%
Milwaukee Primary	27	52—510	0.9—8.7	1.5—4.3	75%	46%
Milwaukee BEPT	27	52—76	0.9—1.3	1.4—2.3	77%	64%
Bridgeport Primary	119	64—867	1.1—14.8	0.3—13.1	69%	44%

THANK YOU

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