Brainstorming Nutrient Optimization Opportunities with Tennessee Volunteers

Webinar for Tennessee Wastewater Operators
March 24, 2021

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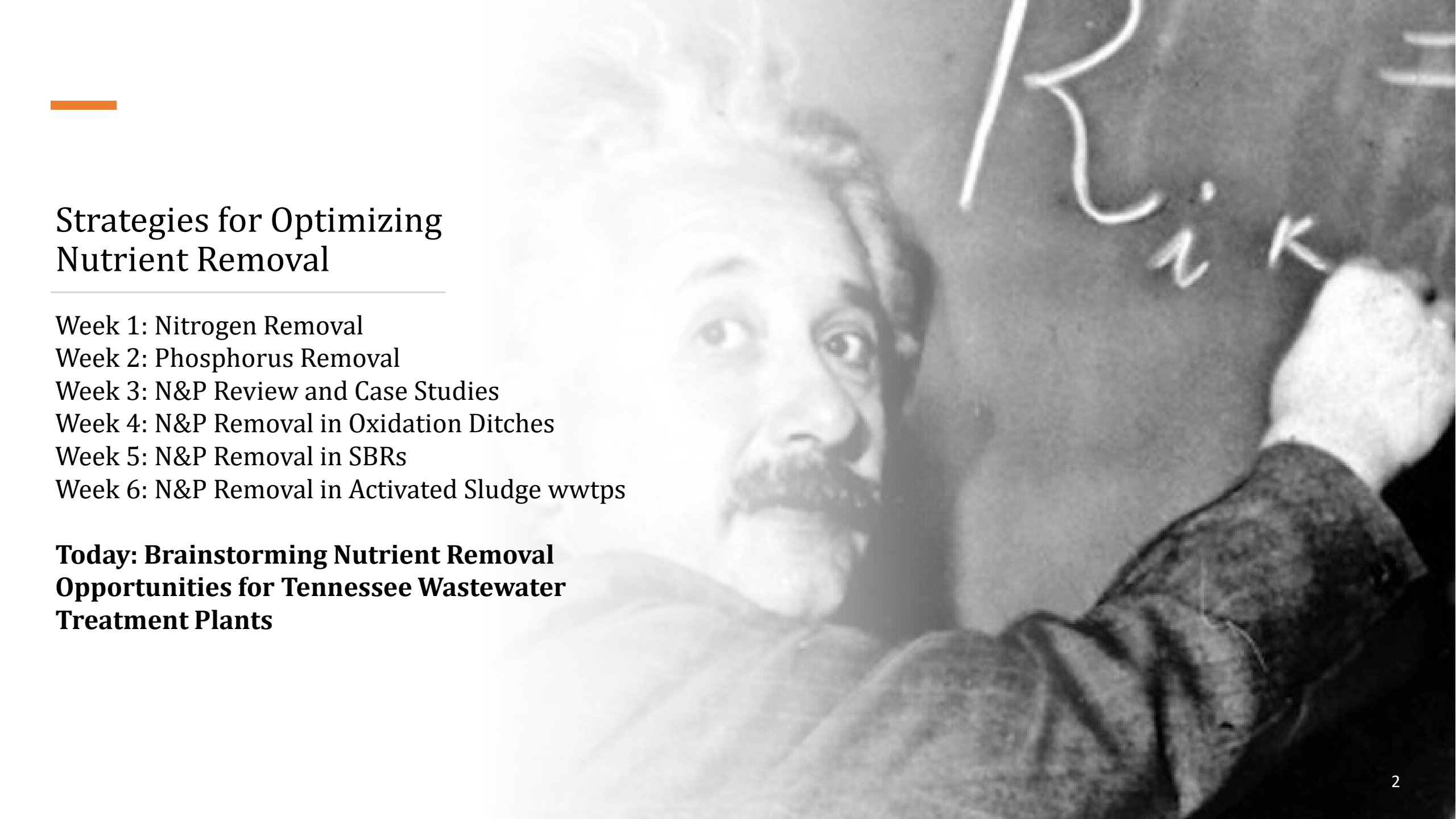
President

CleanWaterOps
G.Weaver@CleanWaterOps.com

Strategies for Optimizing Nutrient Removal

Week 1: Nitrogen Removal
Week 2: Phosphorus Removal
Week 3: N&P Review and Case Studies
Week 4: N&P Removal in Oxidation Ditches
Week 5: N&P Removal in SBRs
Week 6: N&P Removal in Activated Sludge wwtps

Today: Brainstorming Nutrient Removal Opportunities for Tennessee Wastewater Treatment Plants



Dickson County:

White Bluff wwtp
Jones Creek wwtp

WATER AUTHORITY
OF DICKSON COUNTY

White Bluff WastewaterTreatment Plant
347 Shady Oak Dr.
White Bluff, Tennessee 37187
NPDES# TN0020460
Design Capacity: 0.5 MGD

WATER AUTHORITY
OF DICKSON COUNTY

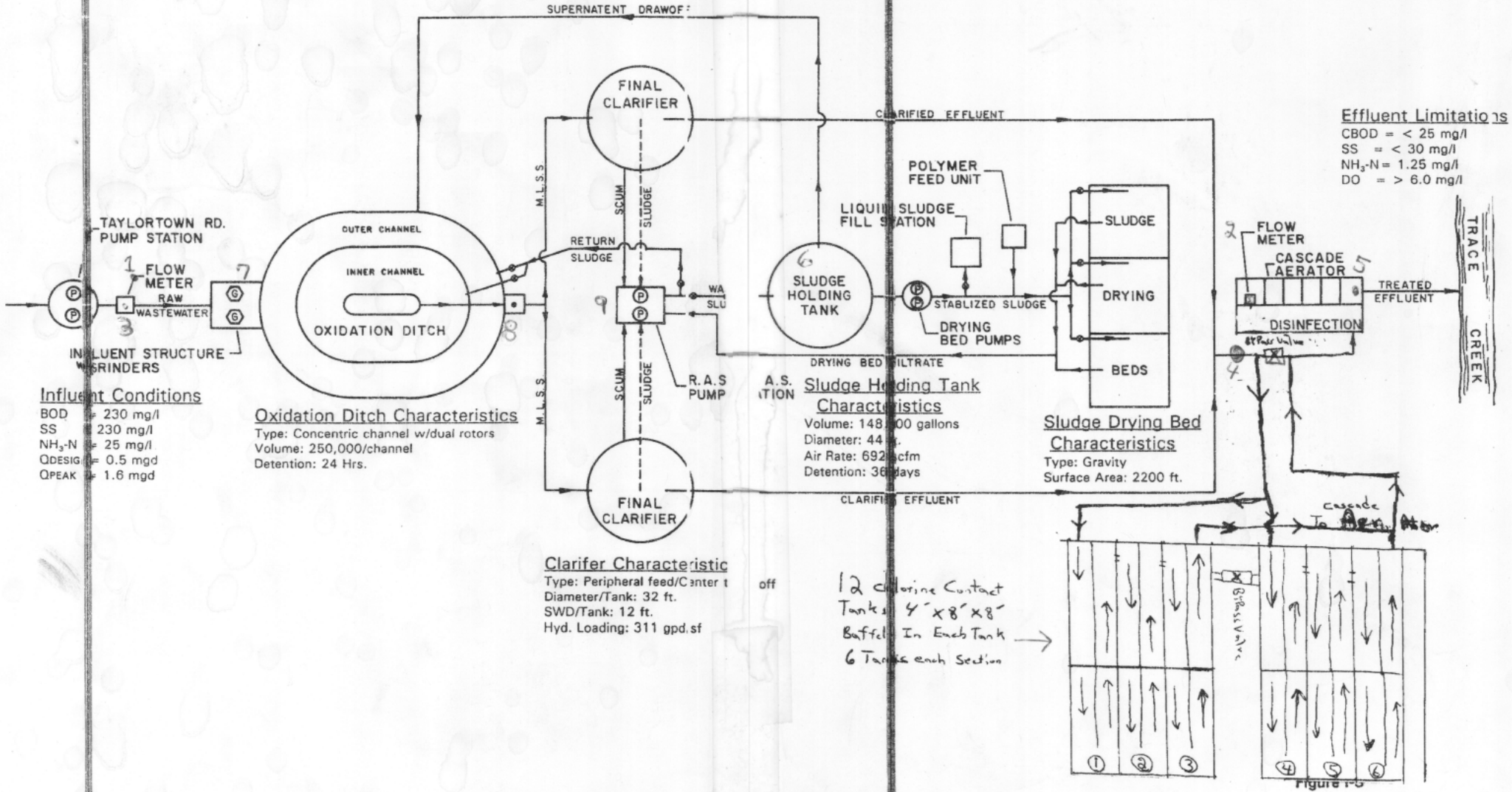
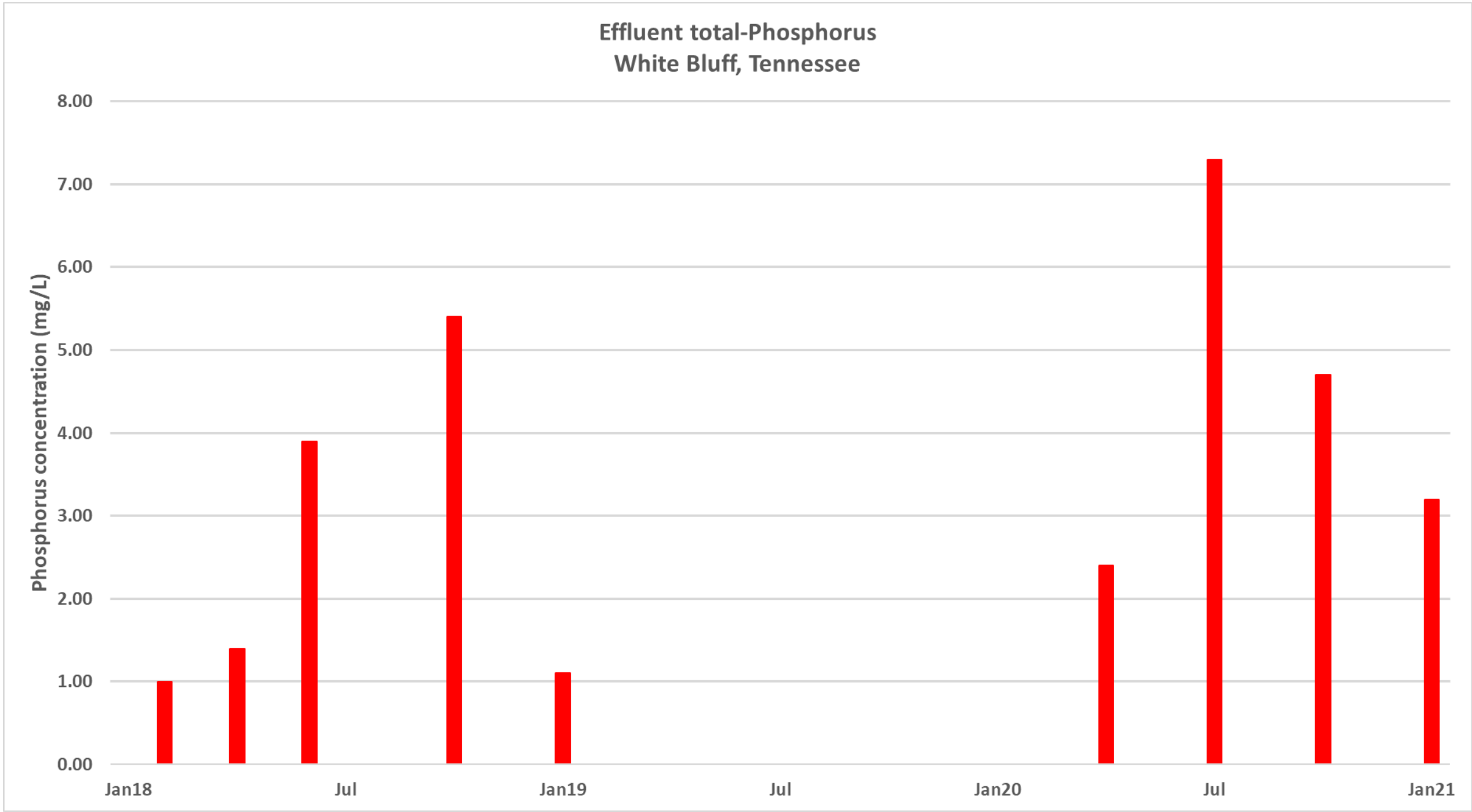
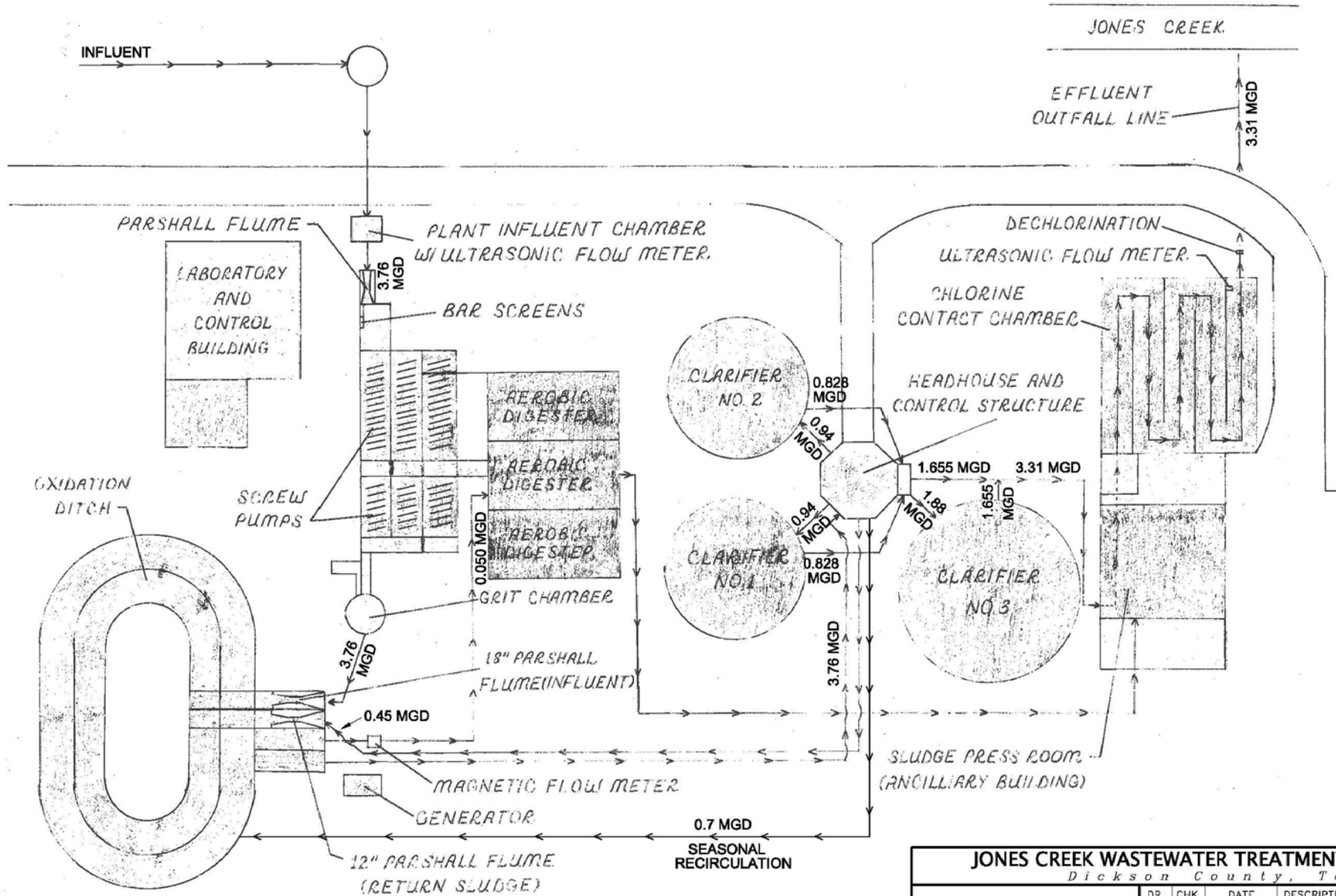


Figure 1-5

PROCESS FLOW SCHEMATIC


Effluent total-Phosphorus
White Bluff, Tennessee
Phosphorus concentration (mg/L)
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Jan18
Jul
Jan19
Jul
Jan20
Jul
Jan21

Jones Creek wwtp: Dickson, TN Population: 15,500 4.0 MGD design flow



JCWWTP - FLOW SCHEMATIC

Plan Scale: Not To Scale

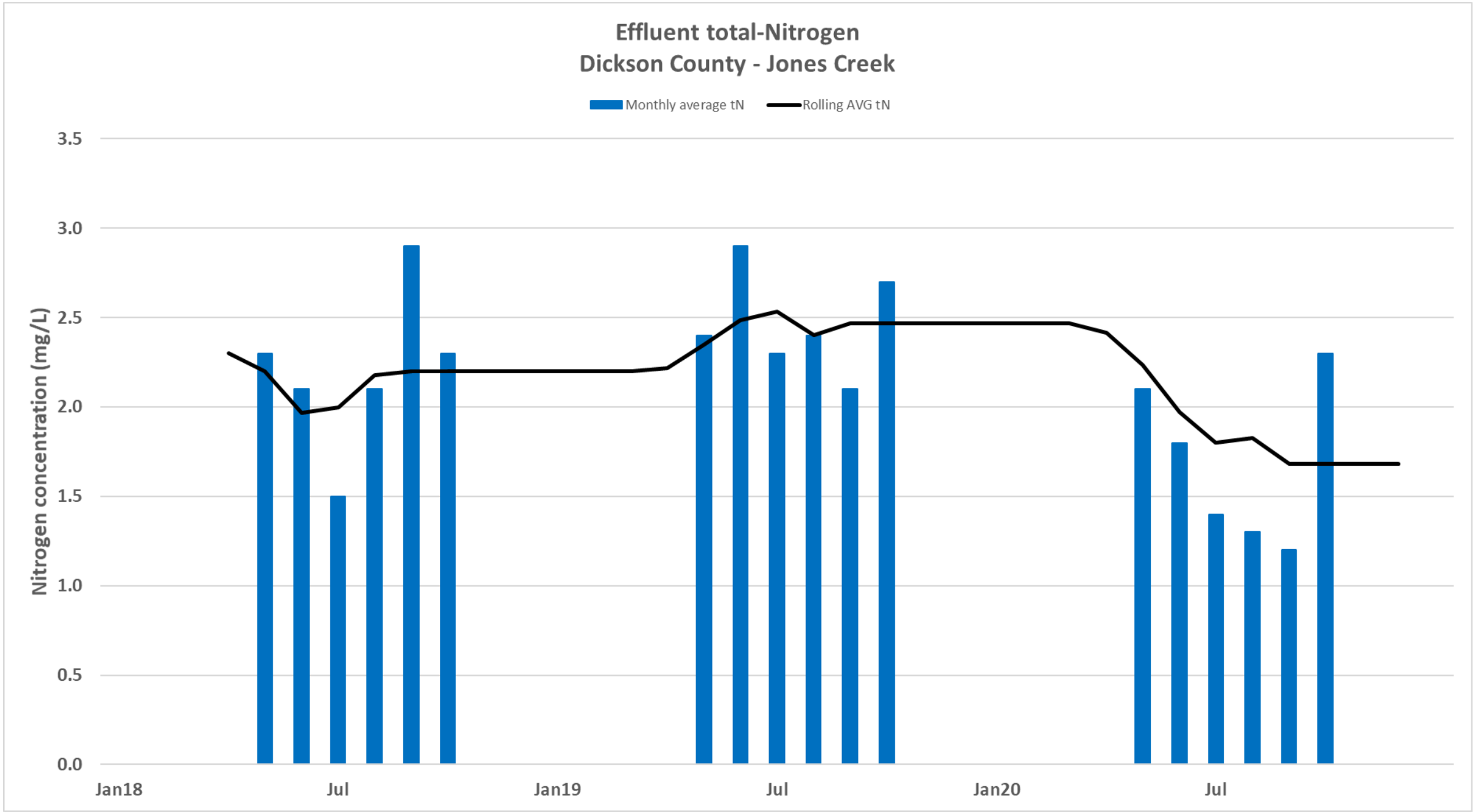
JONES CREEK WASTEWATER TREATMENT PLANT - TN0066958

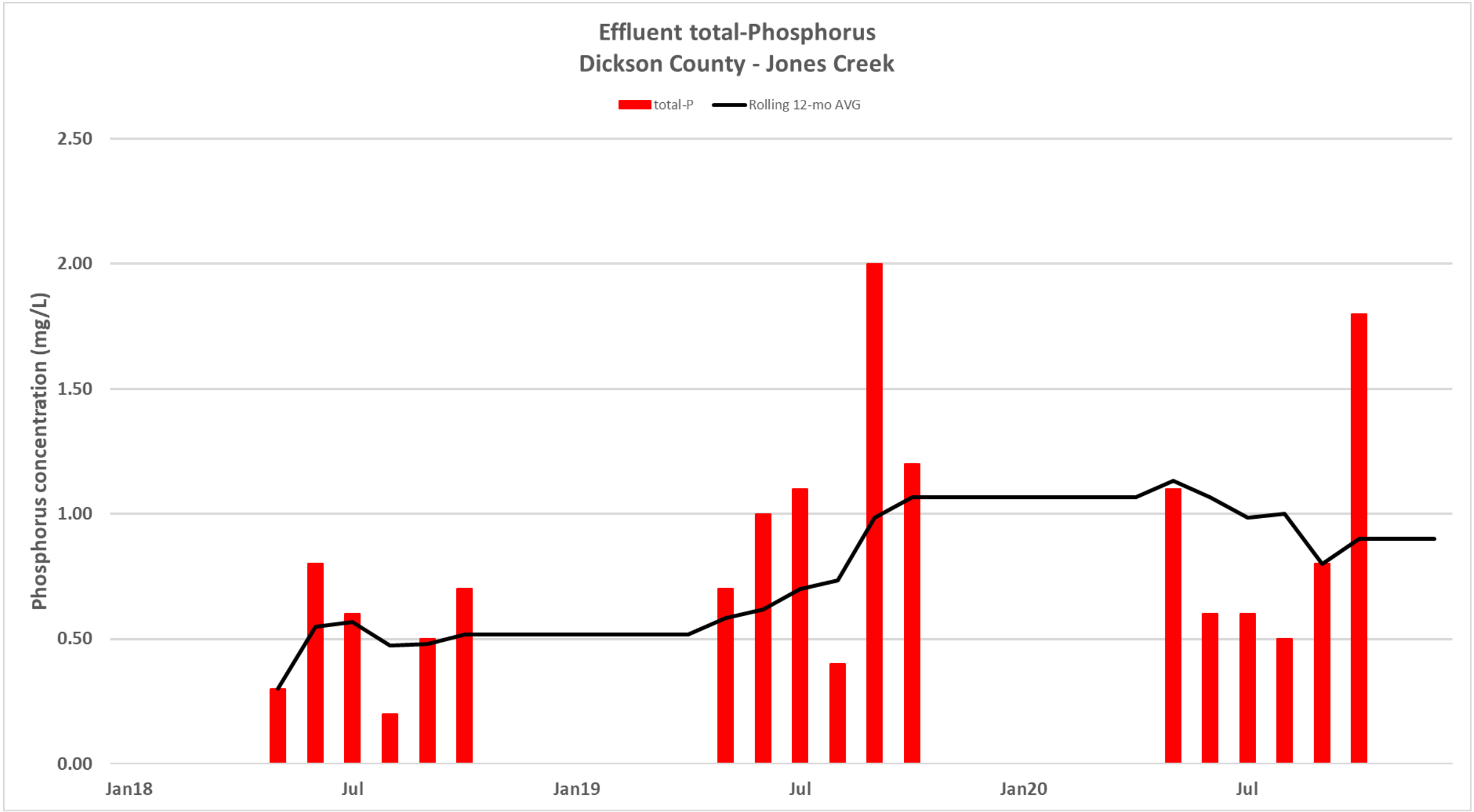
Dickson County, Tennessee

DR.	CHK.	DATE	DESCRIPTION
SBM	SKD	02-22-11	JCWWTP SCHEMATIC

WADC
Water Authority of Dickson County
101 Cowan Road • Dickson, Tennessee 37055
phone: (615) 441-4188 • www.wadc.us

SCALE: N.T.S. | PROJ. No. S11-002 | DWG. No. X-01


Effluent total-Nitrogen
Dickson County - Jones Creek
Monthly average tN
Rolling AVG tN
Nitrogen concentration (mg/L)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Jan18
Jul
Jan19
Jul
Jan20
Jul


Effluent total-Phosphorus
Dickson County - Jones Creek
total-P
Rolling 12-mo AVG
Phosphorus concentration (mg/L)
2.50
2.00
1.50
1.00
0.50
0.00
Jan18
Jul
Jan19
Jul
Jan20
Jul

Nick Tatum
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Mike Brown
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Kevin Petty
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Norris, Tennessee Population: 1,450 0.2 MGD design flow

Norris, Tennessee


Norris, TN

Norris, TN:
Nitrogen Removal

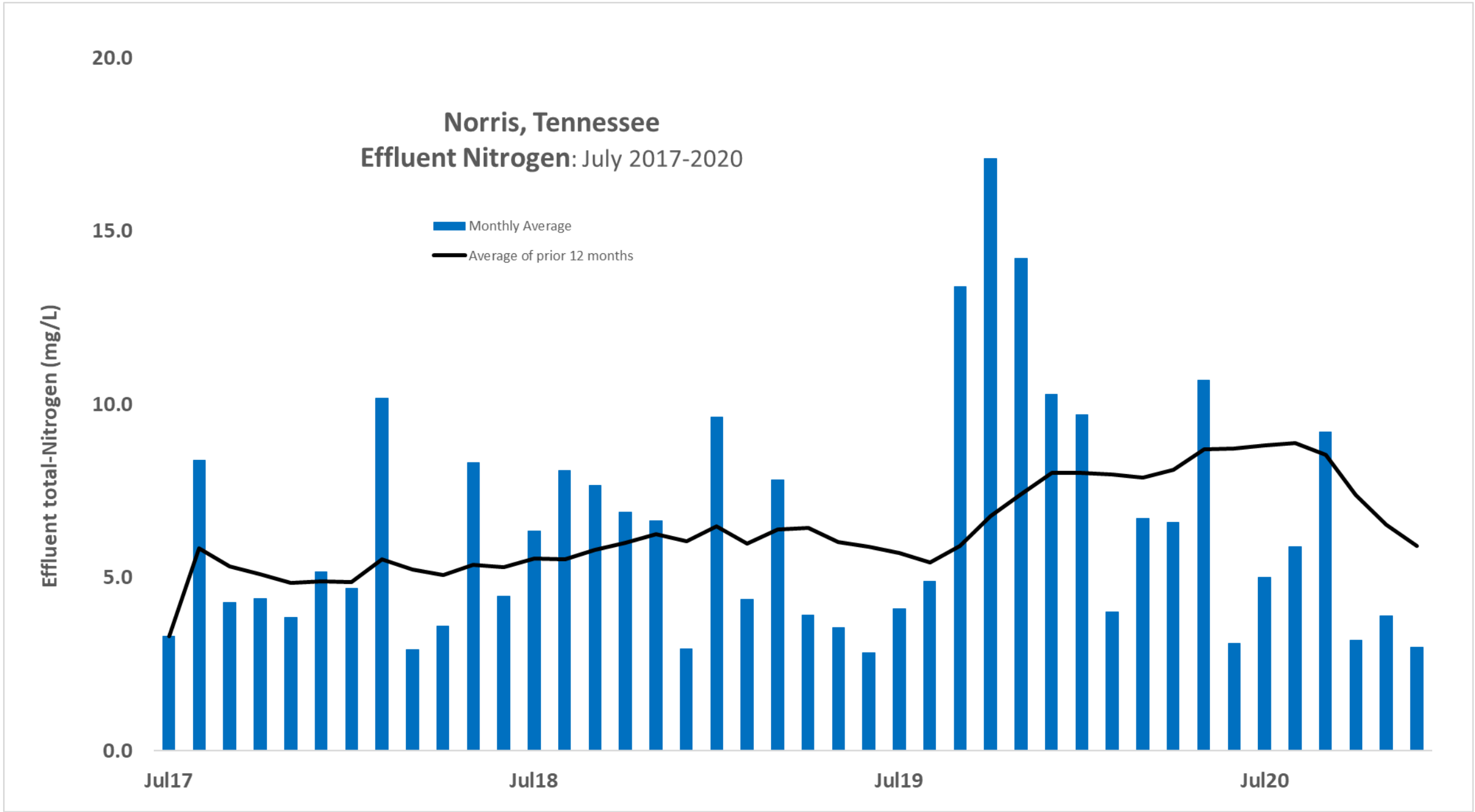
Nitrogen Removal

Raise MLSS concentration

Cycle aeration:

ON 2-3 hours

OFF 1½-2 hours


Norris, Tennessee
Effluent Nitrogen: July 2017-2020
Monthly Average
Average of prior 12 months
Effluent total-Nitrogen (mg/L)
20.0
15.0
10.0
5.0
0.0
Jul17
Jul18
Jul19
Jul20

Norris, TN: First try at Phosphorus Removal

Phosphorus Removal

Recycle RAS through fermenters

Norris, TN: Second try at Phosphorus Removal

Phosphorus Removal

Create Fermentation Zone in Aeration Tank …

Air off

70% RAS to aeration

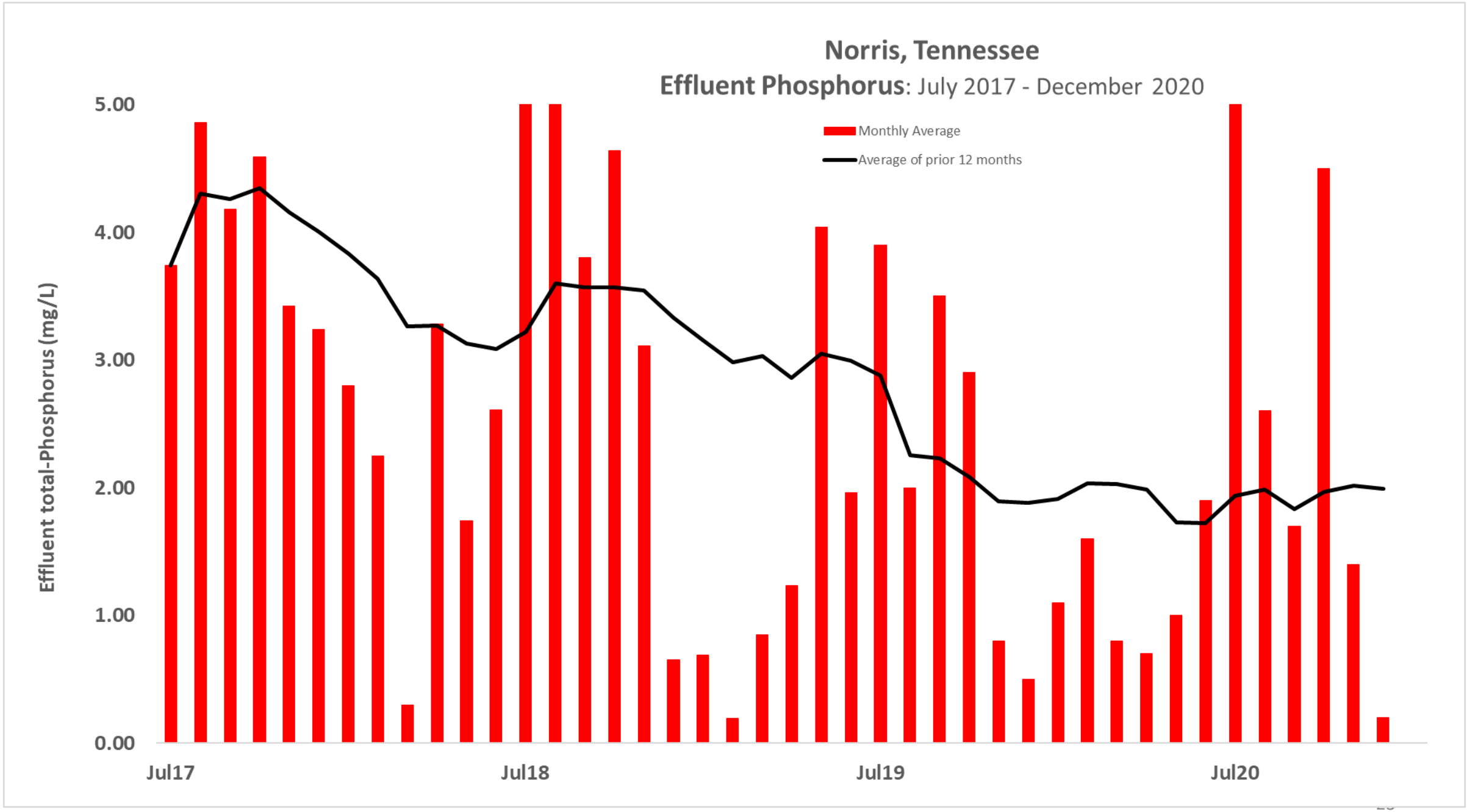
Norris, TN: Third try at Phosphorus Removal

Phosphorus Removal

Hold influent in tote fermenters

- and -

Create Fermentation Zone in Aeration Tank


Norris, Tennessee
Effluent Phosphorus: July 2017 - December 2020
Monthly Average
Average of prior 12 months
Effluent total-Phosphorus (mg/L)
5.00
4.00
3.00
2.00
1.00
0.00
Jul17
Jul18
Jul19
Jul20

Doug Snelson
Dsnelson.nwc@gmail.com


BREAK TIME
memegenerator.net

Harpeth Valley, Tennessee Population: 25,000 10 MGD design flow

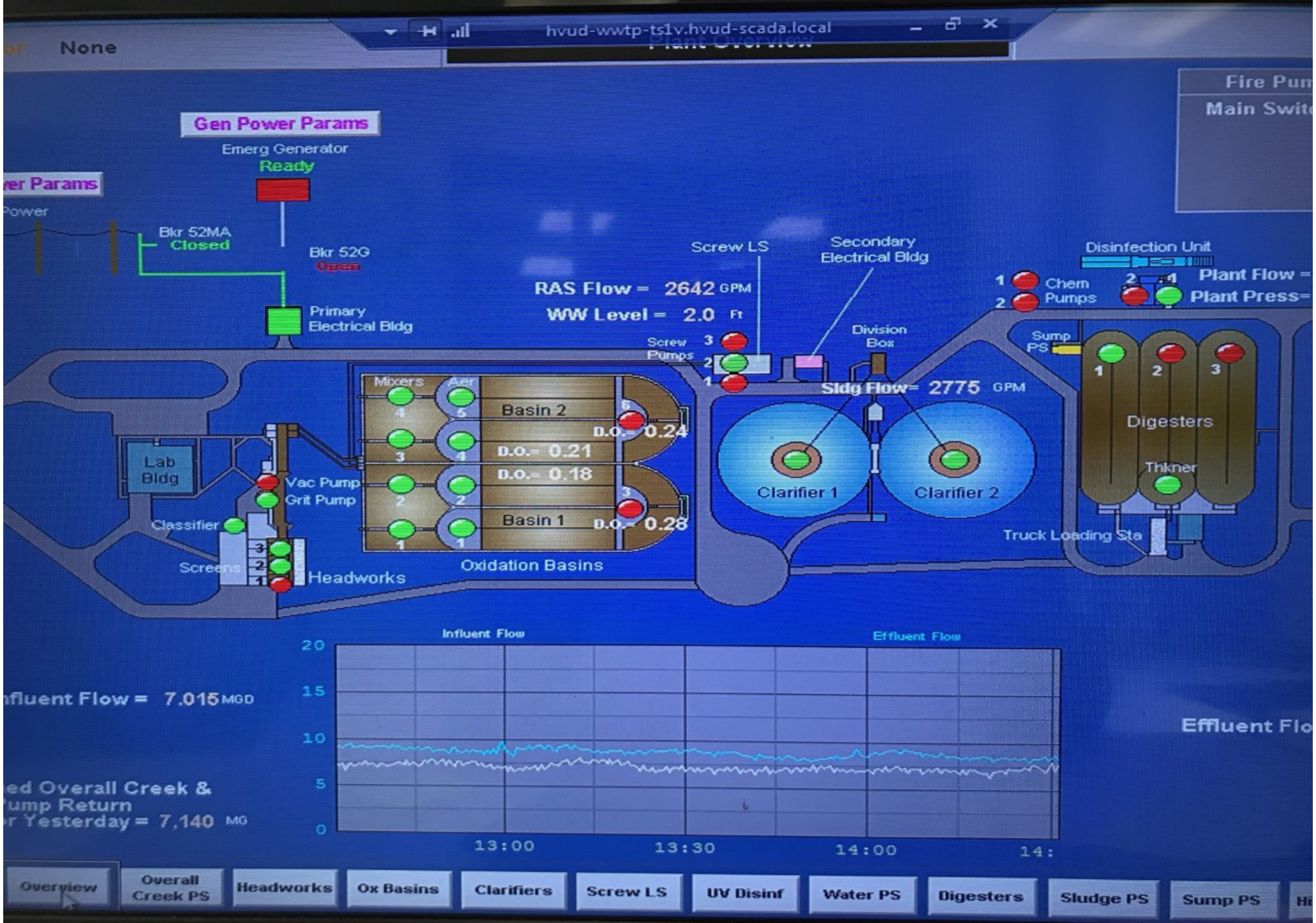
HVUD WWTP

4063 Old Hickory Blvd

Nashville, TN 37218

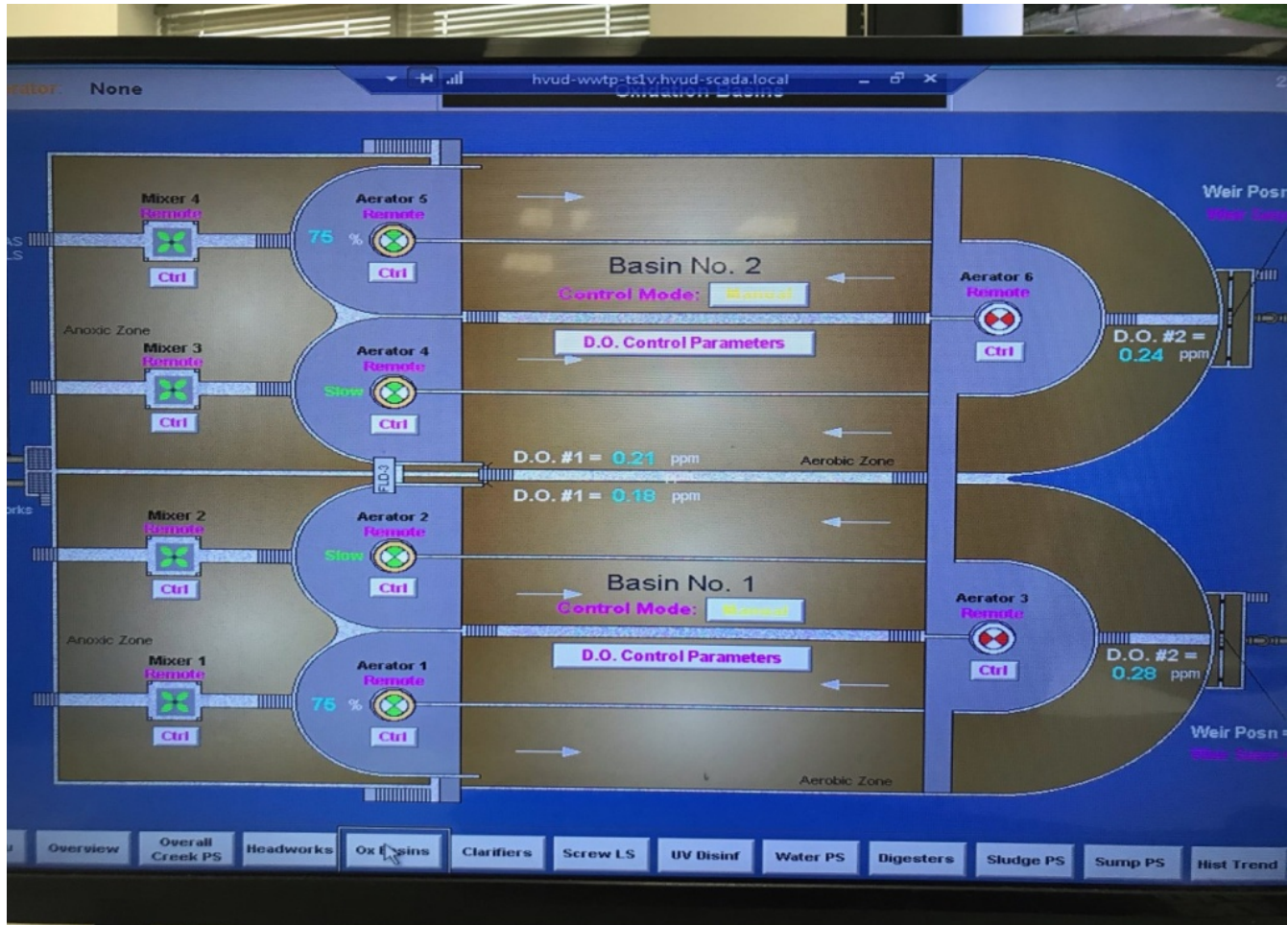
HVUD Plant Design

- Design Flow 10 MGD
- Average Flow ~5 MGD
- Peak Flow 25 MGD
- Hydraulic Retention Time 20 Hours
- Extended Aeration Capacity
  - Anoxic 1.4 MGD
  - Aerobic 6.93 MGD
- Serving over 13,800 Sewer Customer


hvud-wwtp-ts1v.hvud-scada.local
None
Plant Overview
Fire Pun
Main Swit
Gen Power Params
Emerg Generator
Ready
Bkr 52MA
Closed
Bkr 52G
Open
Primary
Electrical Bldg
Screw LS
Secondary
Electrical Bldg
RAS Flow = 2642 GPM
WW Level = 2.0 Ft
Screw
Pumps
Division
Box
Disinfection Unit
Chem
Pumps
Plant Flow =
Plant Press=
Sump
PS
Sldg Flow= 2775 GPM
Digesters
Thkner
Truck Loading Sta
Mixers
Aer
Basin 2
D.O.= 0.24
D.O.= 0.21
D.O.= 0.18
Basin 1
D.O.= 0.28
Oxidation Basins
Lab
Bldg
Vac Pump
Grit Pump
Classifier
Screens
Headworks
Clarifier 1
Clarifier 2
Influent Flow
Effluent Flow
20
15
10
5
0
13:00
13:30
14:00
14:
fluent Flow = 7.015 MGD
Effluent Flo
ed Overall Creek &
ump Return
r Yesterday = 7.140 MG
Overview
Overall
Creek PS
Headworks
Ox Basins
Clarifiers
Screw LS
UV Disinf
Water PS
Digesters
Sludge PS
Sump PS

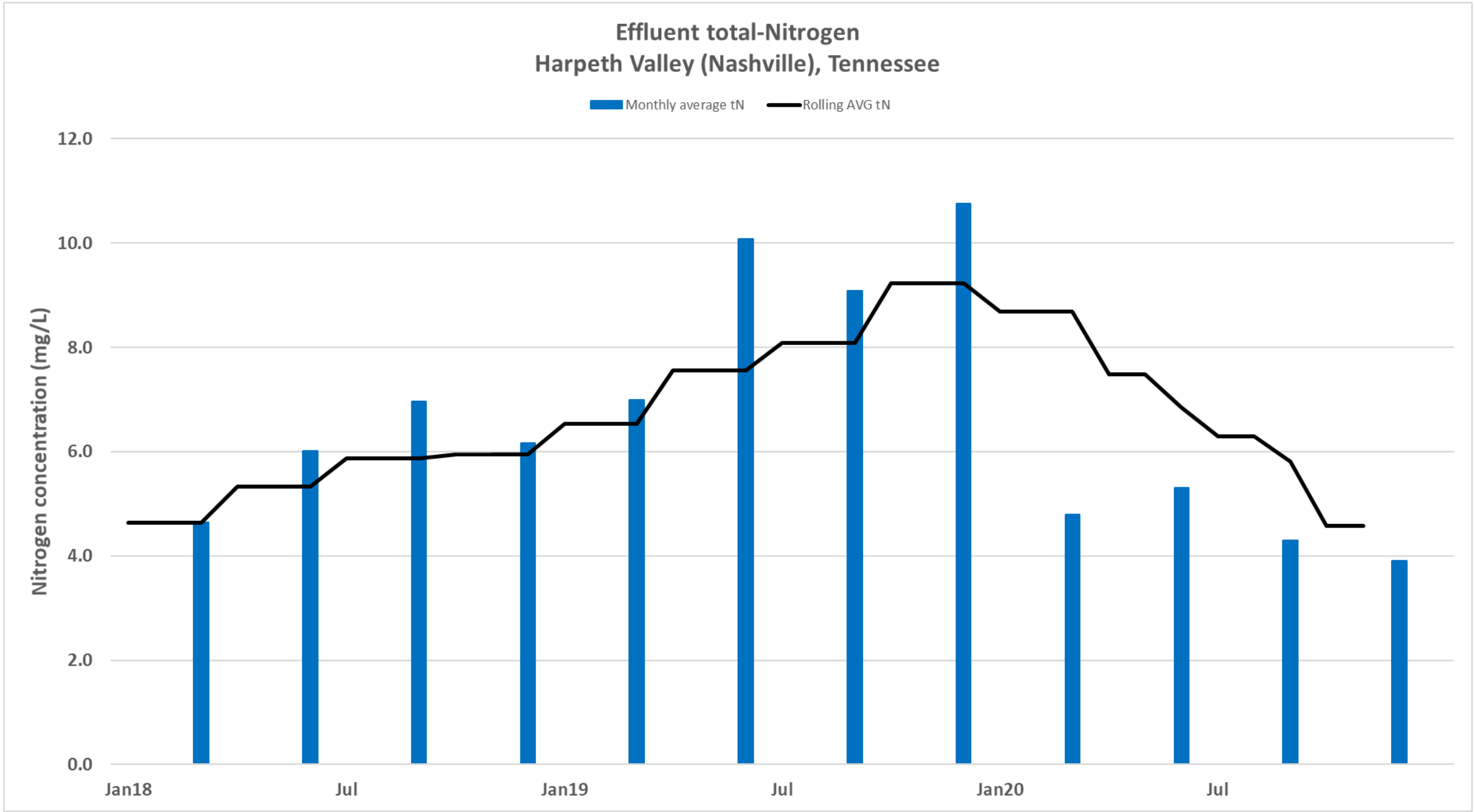
Extended Aeration Operation

- Maintain a D.O. of 0.2-0.9 mg/L
- Limit Aerators in Operation
- On/Off Aeration



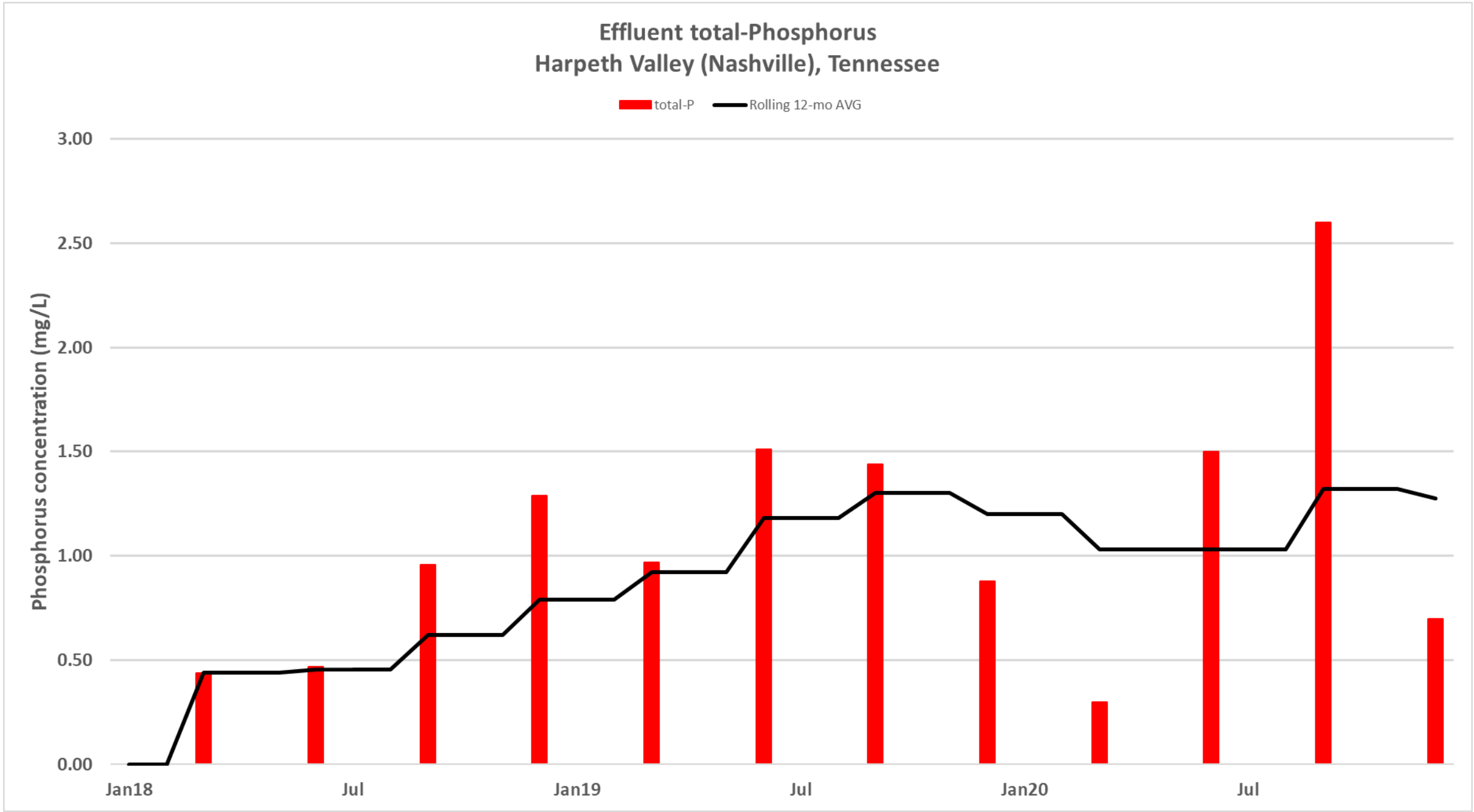
Nitrogen

- Influent 31.6 mg/L
- Effluent 4.2 mg/L
- Approximately 87% Removal rate


Effluent total-Nitrogen
Harpeth Valley (Nashville), Tennessee
Monthly average tN
Rolling AVG tN
Nitrogen concentration (mg/L)
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Jan18
Jul
Jan19
Jul
Jan20
Jul

Phosphorus

- Influent Average 3.4 mg/L
- Effluent Average 1.5 mg/L
- Approximate 56% Removal


Effluent total-Phosphorus
Harpeth Valley (Nashville), Tennessee
total-P
Rolling 12-mo AVG
Phosphorus concentration (mg/L)
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Jan18
Jul
Jan19
Jul
Jan20
Jul

Objectives

- Find ways to save energy
  - On/Off Air
  - Minimize Aerators in Operation
- Through saving energy, nutrient removal was increased

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Albert Solberg
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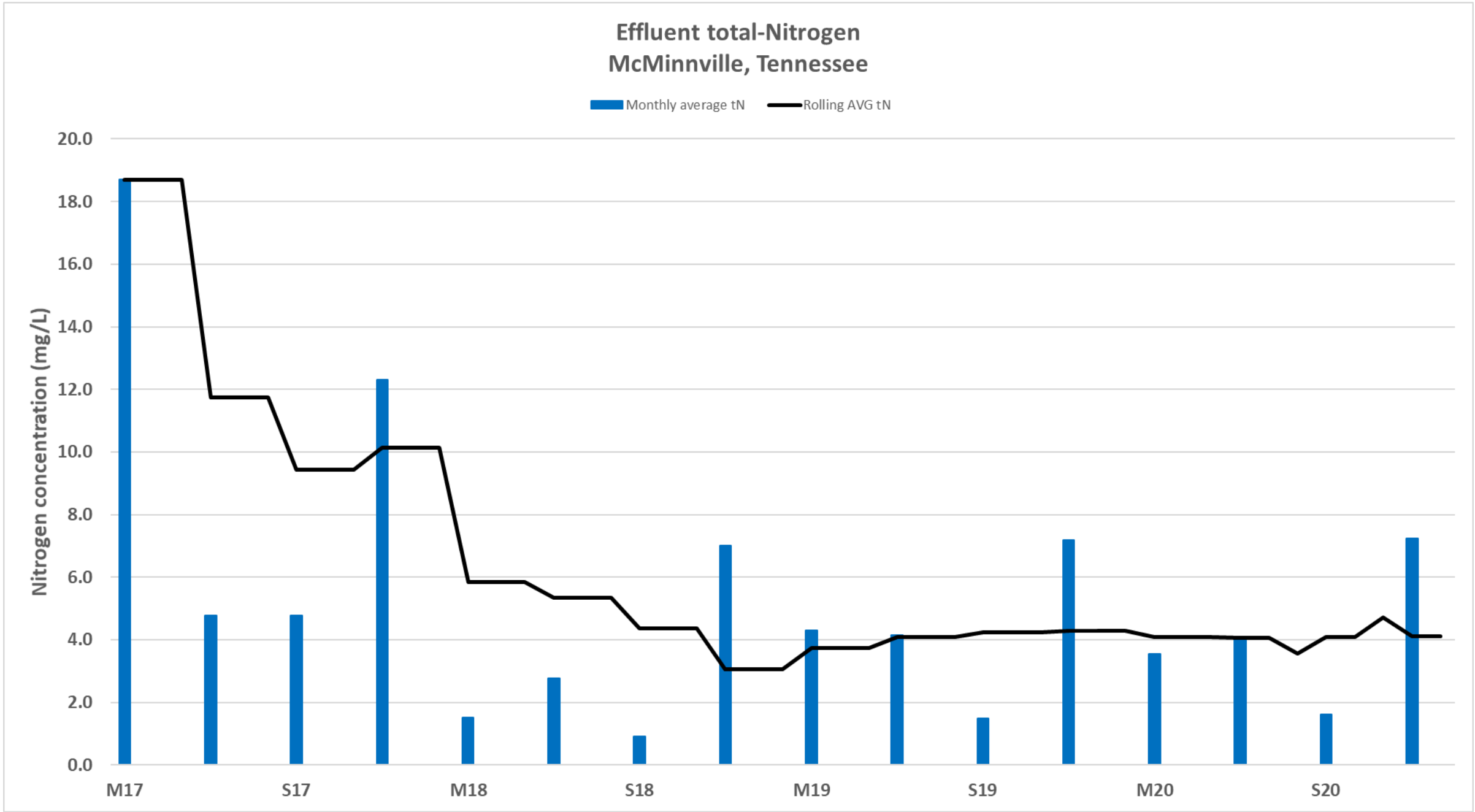
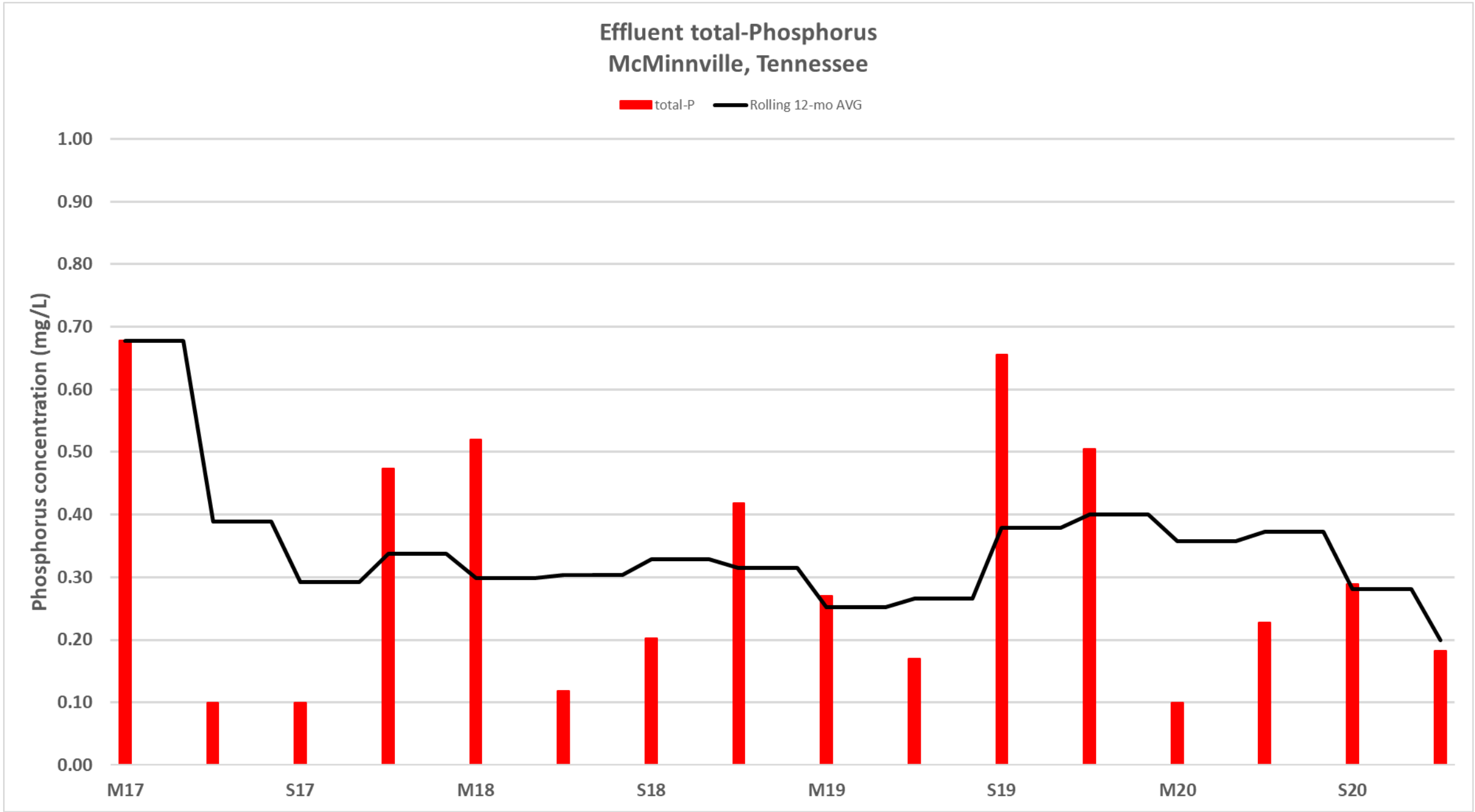
McMinnville, Tennessee Population: 13,700 4.0 MGD design flow


Clark Creek


Effluent total-Nitrogen
McMinnville, Tennessee
Monthly average tN
Rolling AVG tN
Nitrogen concentration (mg/L)
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
M17
S17
M18
S18
M19
S19
M20
S20


Effluent total-Phosphorus
McMinnville, Tennessee
total-P
Rolling 12-mo AVG
Phosphorus concentration (mg/L)
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
M17
S17
M18
S18
M19
S19
M20
S20

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Acknowledgements

TENNESSEE DEPARTMENT OF ENVIRONMENT & CONSERVATION (TDEC)
Karina Bynum, Sherry Wang, George Garden, Jenny Dodd, Jason Benton, Eddie Bouzied, Bryan Carter, David Duhl, Jordan Fey, Oakley Hall, Michael Murphy, Steve Owens, Rob Ramsey, Sherwin Smith, Robert Tipton, Sandra Vance, John West, Ariel Wessel-Fuss …

HARRIMAN
Ray Freeman

NASHVILLE
Johnnie MacDonald & David Tucker

NORRIS
Tony Wilkerson & Doug Snelson

Brett Ward (UT-MTAS), Dewayne Culpepper (TAUD), Greg Hayes (Athens), Larry Gamblin (Bartlett), Danny Neely (Baileyton), David Harrison (Collierville), Nic Willis (Cowan), Ray Freeman (Harriman), Darryl Green (Henderson), Jack Hauskins & Rocky Hudson (Lafayette), Johnnie MacDonald (Nashville) …

… and, many more!

Acknowledgements, continued

KANSAS Tom Stiles, Rod Geisler (retired), Shelly Shores-Miller, Nick Reams & Ryan Eldredge (**KDHE**), Jamie Belden & Becky Lewis (**Wichita**)

MONTANA Paul LaVigne (retired), Pete Boettcher, Josh Viall, Ryan Weiss, Bill Bahr (retired), Dave Frickey (retired) & Mike Abrahamson (**DEQ**), Keith Thaut (**Conrad**), Mark Fitzwater & entire staff (**Helena**)

EPA Paul Shriner & Tony Tripp (**HQ**), Tina Laidlaw (**R8**), Brendon Held & Craig Hesterlee (**R4**), Sydney Weiss (**R5**)

… and, many more!

Comments & Questions

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REVIEW

Change day-to-day operations to
create ideal habitats for bacteria to remove phosphorus


7
N
Nitrogen

Step 1: Convert Ammonia (NH_4) to Nitrate (NO_3)

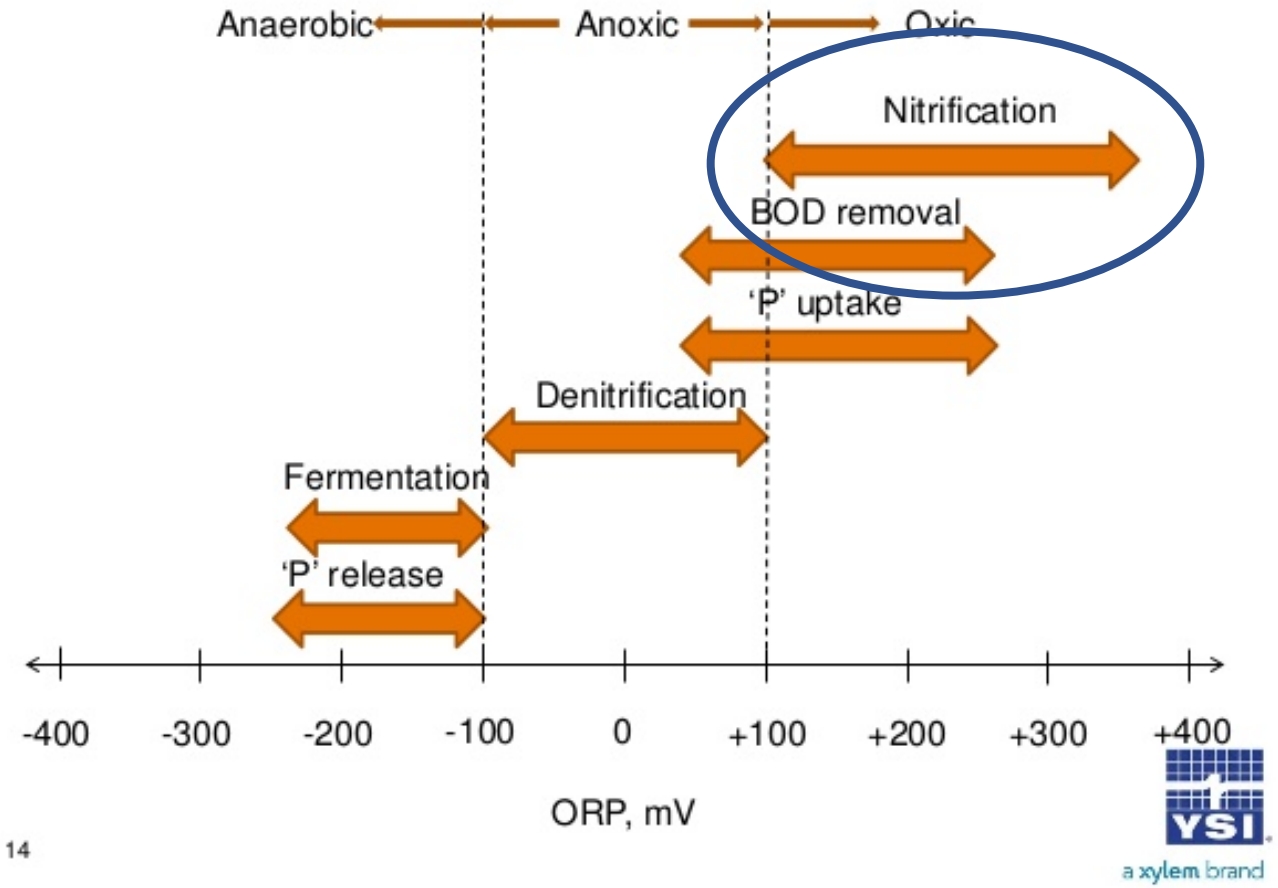
Oxygen-rich Aerobic Process
Don't need BOD for bacteria to grow
Bacteria are sensitive to pH and temperature

Step 2: Convert Nitrate (NO_3) to Nitrogen Gas (N_2)

Oxygen-poor Anoxic Process
Do need BOD for bacteria to grow
Bacteria are hardy

Ammonia Removal - 1st Step of N Removal

What Does ORP Tell Us About Our Process?



14

YSI
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7

Step 1: Ammonia Removal

N

pH of 6.5+

Plenty of D /L

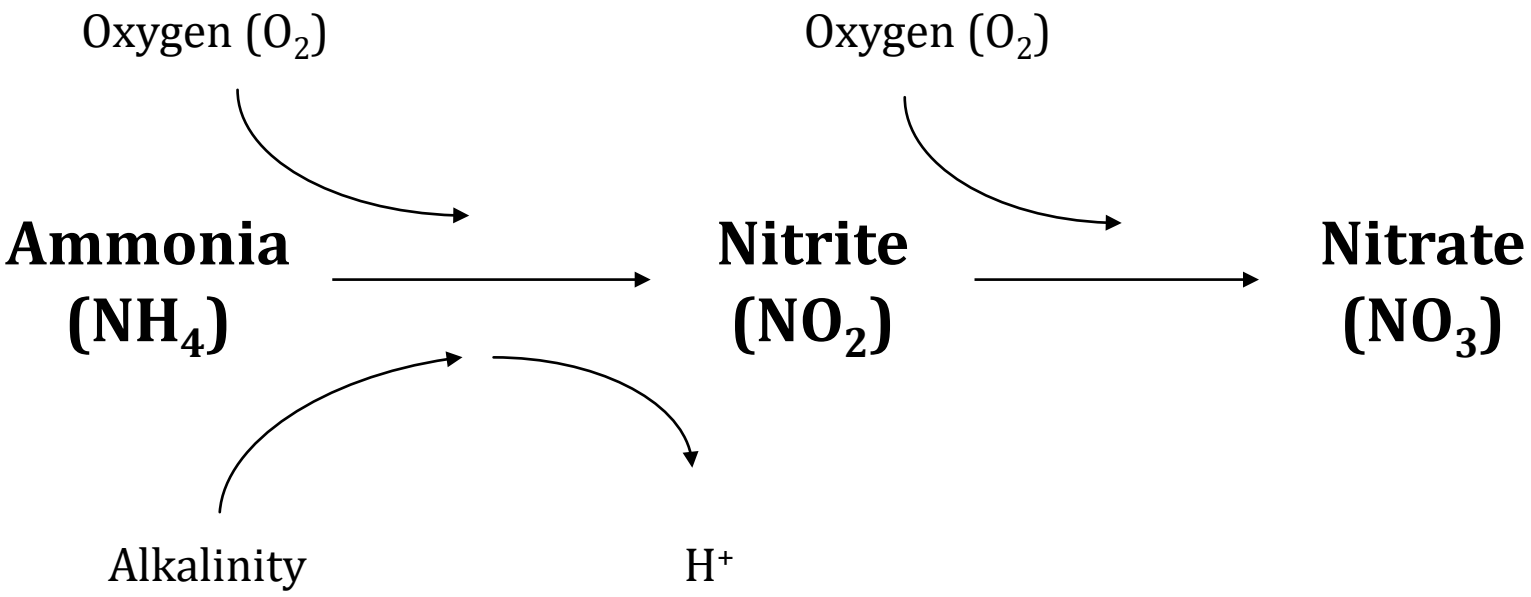
ORP of +15 V

Little to no D

4+ hours retention time

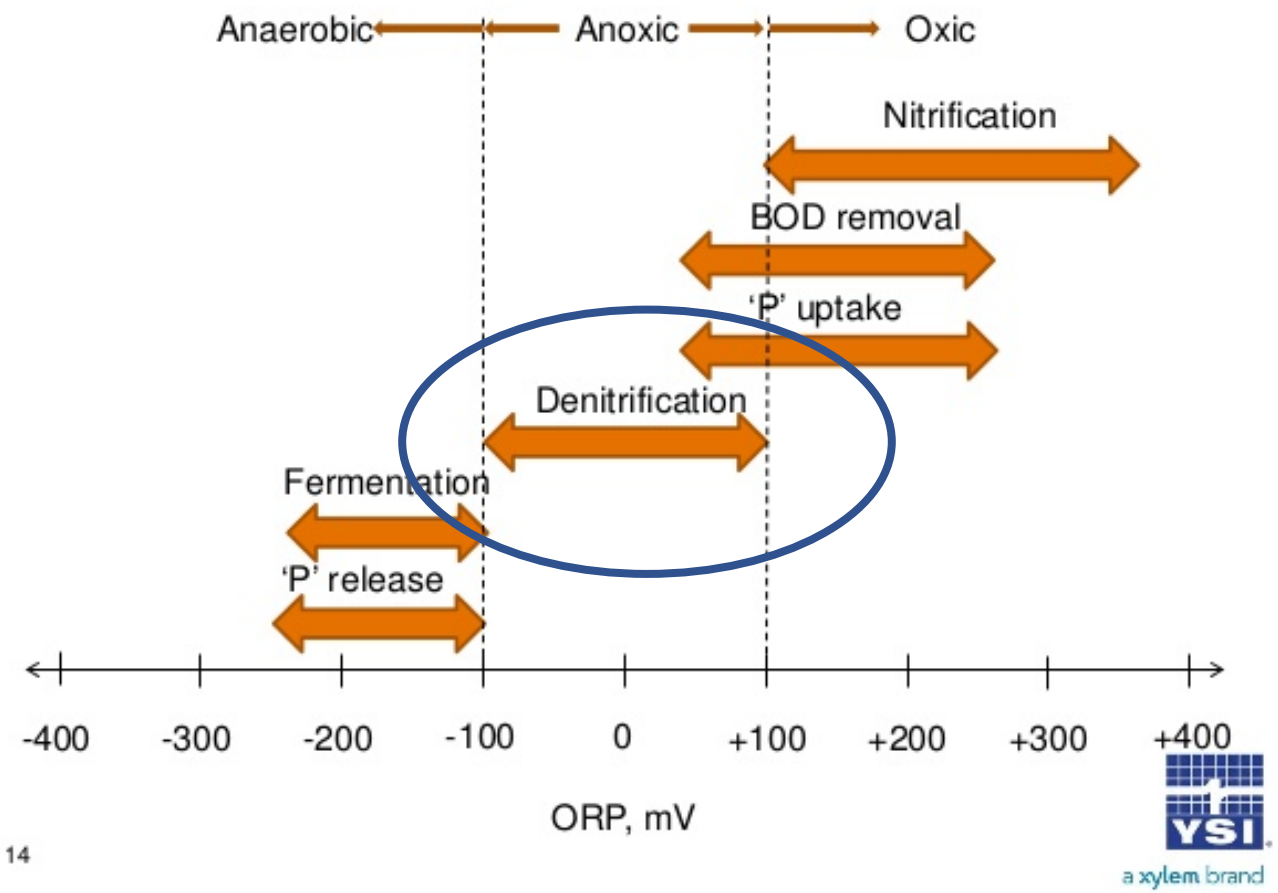
Nitrogen

Ammonia Removal



Nitrate Removal - 2nd Step of N removal

What Does ORP Tell Us About Our Process?



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Step 2: Nit e Remo

Little to no rable

ORP of -10 V

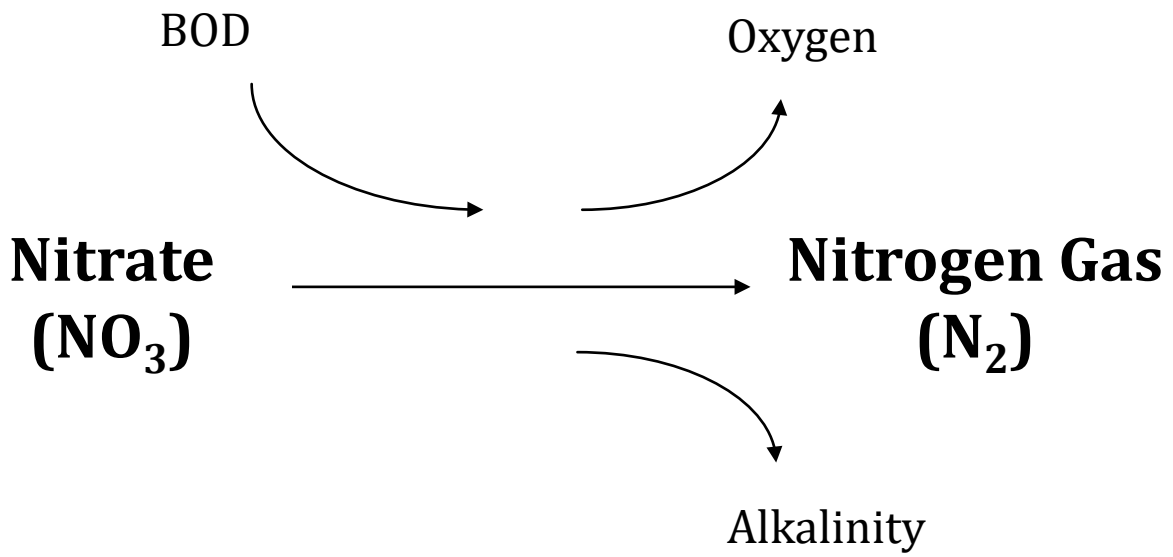
5-10 times much s Nitrate

2+ hours re tion tim

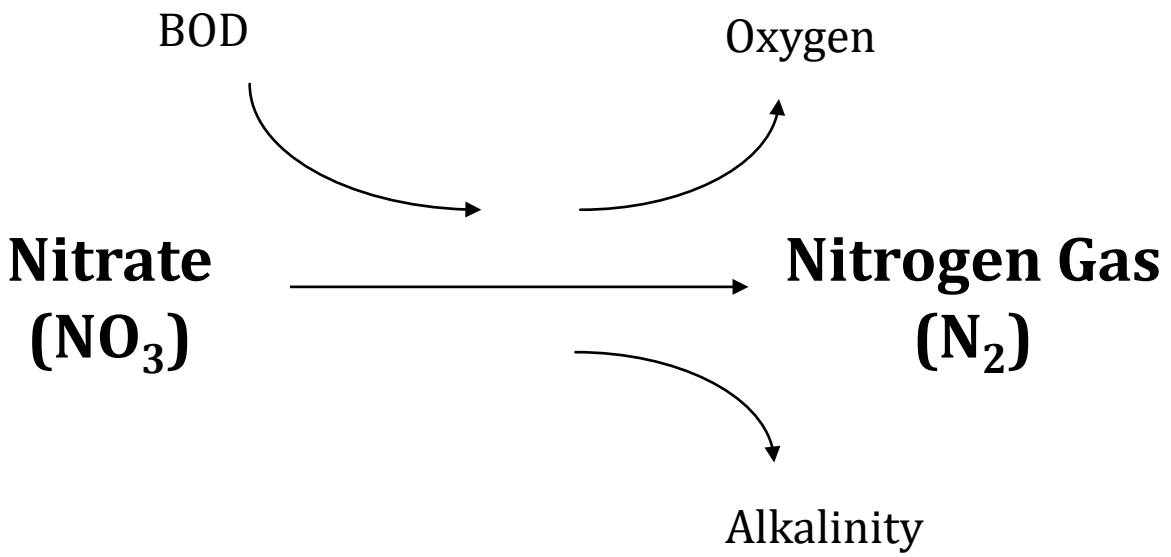
N

Nitrogen

Nitrate Removal



Nitrate Removal



Adds DO (dissolved oxygen)

Consumes BOD … Denitrifiers out compete bio-P bugs for VFAs!

Gives back alkalinity … beneficially raises pH

Nitrogen Removal

	Step 1: Nitrification (Ammonia Removal)	**Step 1: Denitrification** (Nitrate Removal)
DO: Dissolved Oxygen	1 mg/L or more	Less than 0.2 mg/L
ORP: Oxygen Reduction Potential	+150 mV	-100 mV
MLSS: Mixed Liquor Suspended Solids	2500 mg/L or more	Same
HRT: Hydraulic Retention Time	6 or more hours	1 or more hours
BOD: Biochemical Oxygen Demand	less than 20 mg/L	**100 mg/L or more … VFAs preferred!**
Alkalinity	60 mg/L or more	
	Alkalinity is lost	***Alkalinity is gained***

Note: All numbers are approximations, “rules of thumb”

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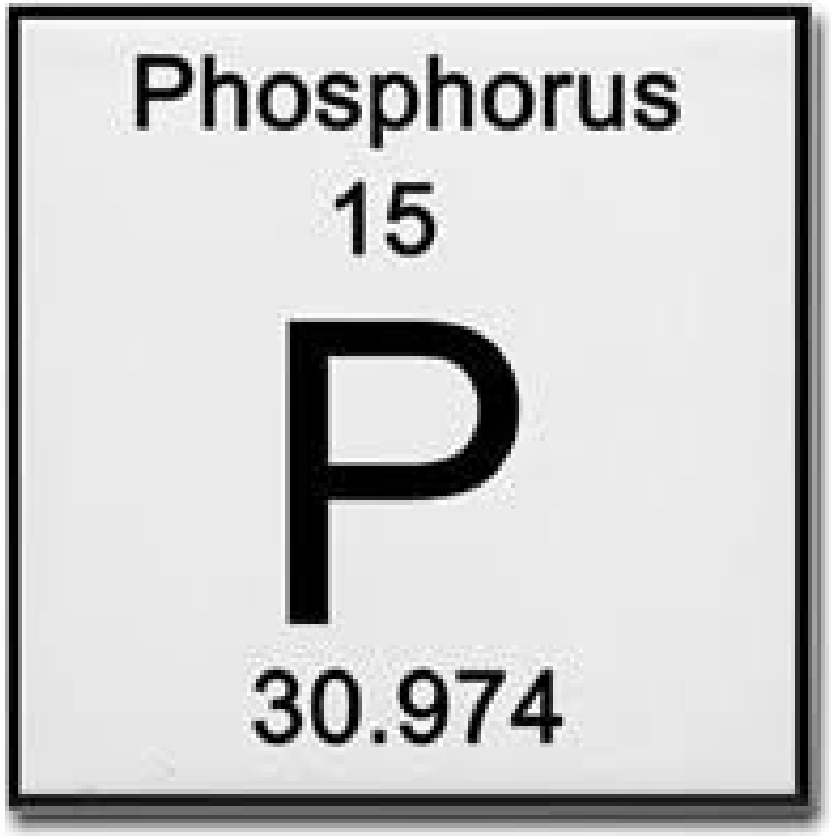
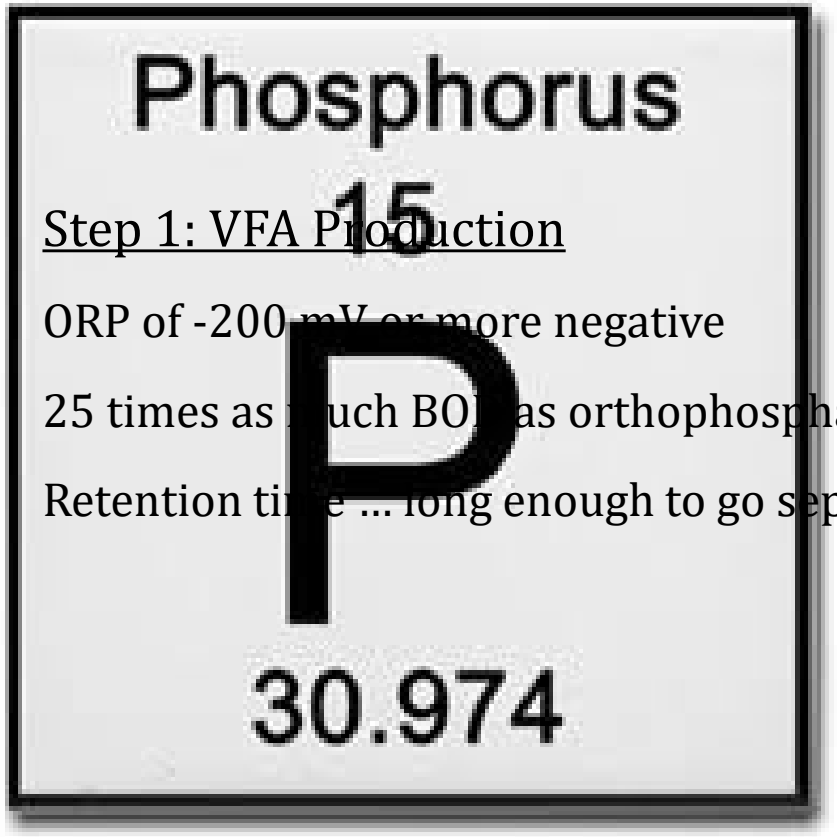

Phosphorus
15
P
30.974


THREE
steps

Biological Phosphorus Removal

Step 1: prepare “dinner”

VFA (volatile fatty acids) production in anaerobic/fermentive conditions

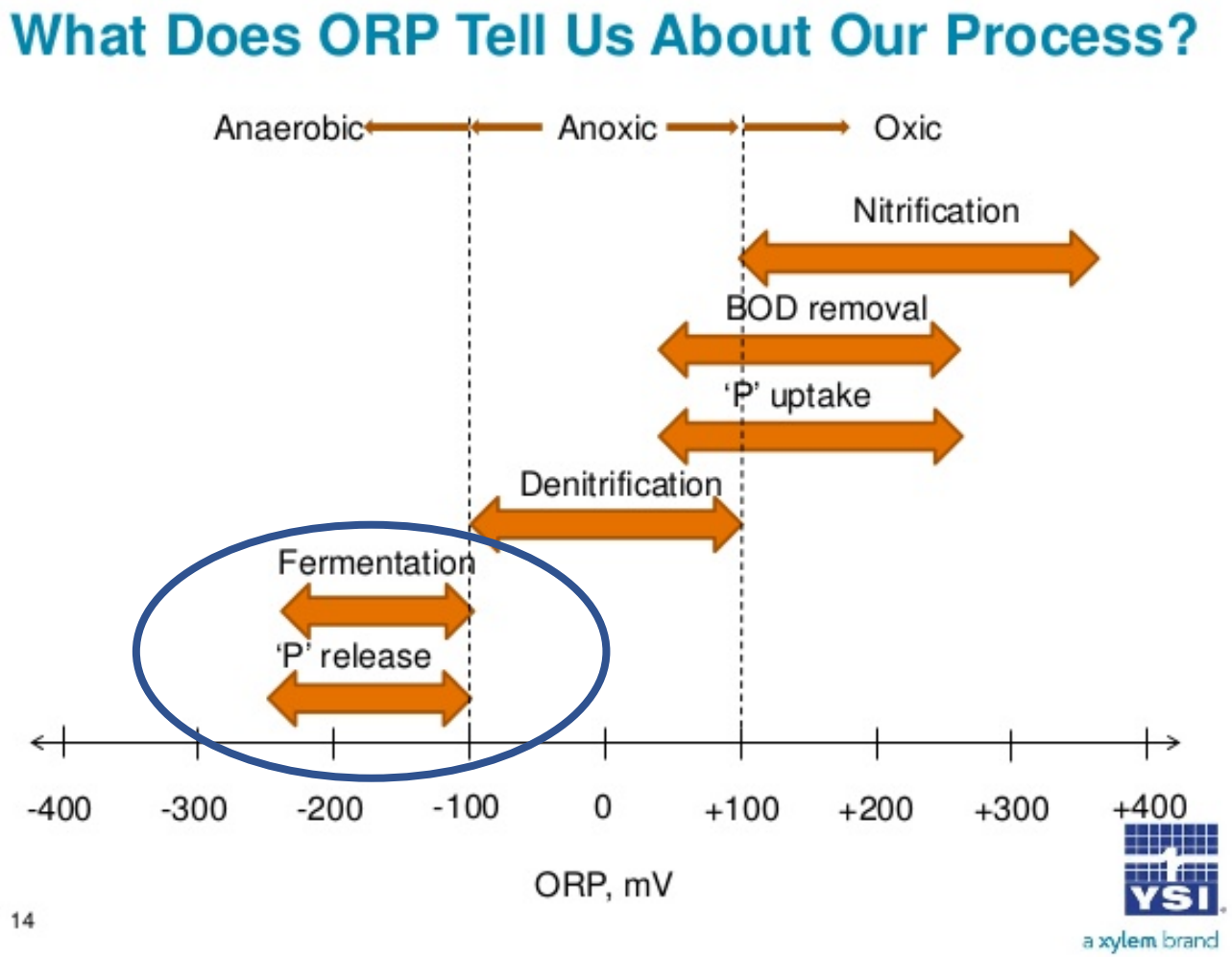


Step 1: VFA Production

ORP of -200 mV or more negative

25 times as much BOD as orthophosphate

Retention time … long enough to go septic



Biological Phosphorus Removal

Step 1: prepare “dinner”

VFA (volatile fatty acids) production in anaerobic/fermentive conditions

Step 2: “eat”

Bio-P bugs (PAOs, “phosphate accumulating organisms”) eat VFAs in anaerobic/fermentive conditions … temporarily releasing more P into the water

Phosphorus

15

P

30.974

Step 2: VFA uptake / P-release

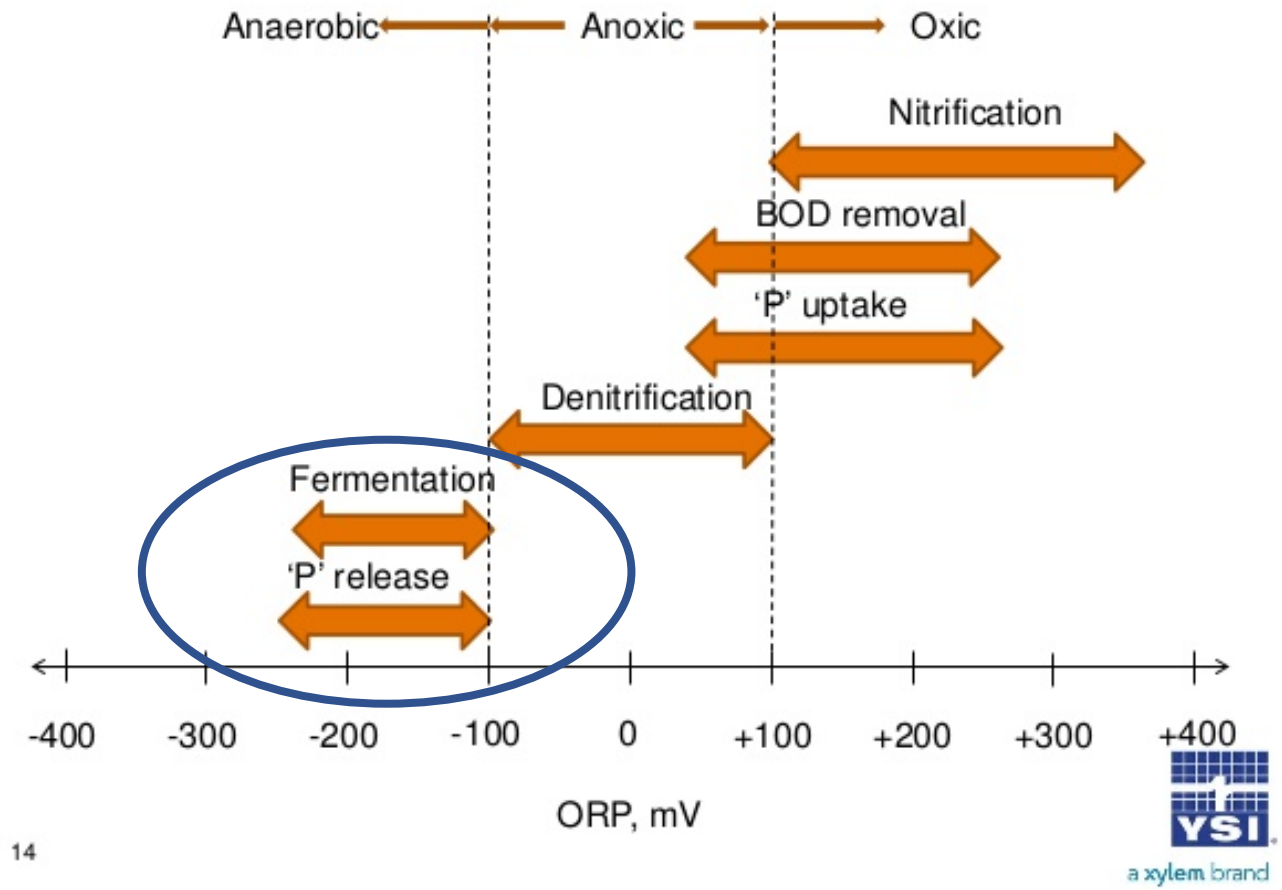
MLSS and VFAs in same tank

ORP of -200 mV or more negative

Nitrate control

Process control tool: 3 times as much ortho-P leaving tank as coming in

What Does ORP Tell Us About Our Process?



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Biological Phosphorus Removal

Step 1: prepare “dinner”

VFA (volatile fatty acids) production in anaerobic/fermentive conditions

Step 2: “eat”

Bio-P bugs (PAOs, “phosphate accumulating organisms”) eat VFAs in anaerobic/fermentive conditions … temporarily releasing more P into the water

Step 3: “breathe” and grow

Bio-P bugs (PAOs) take in almost all of the soluble P in aerobic conditions as they grow and reproduce

Phosphorus

15

P

30.974

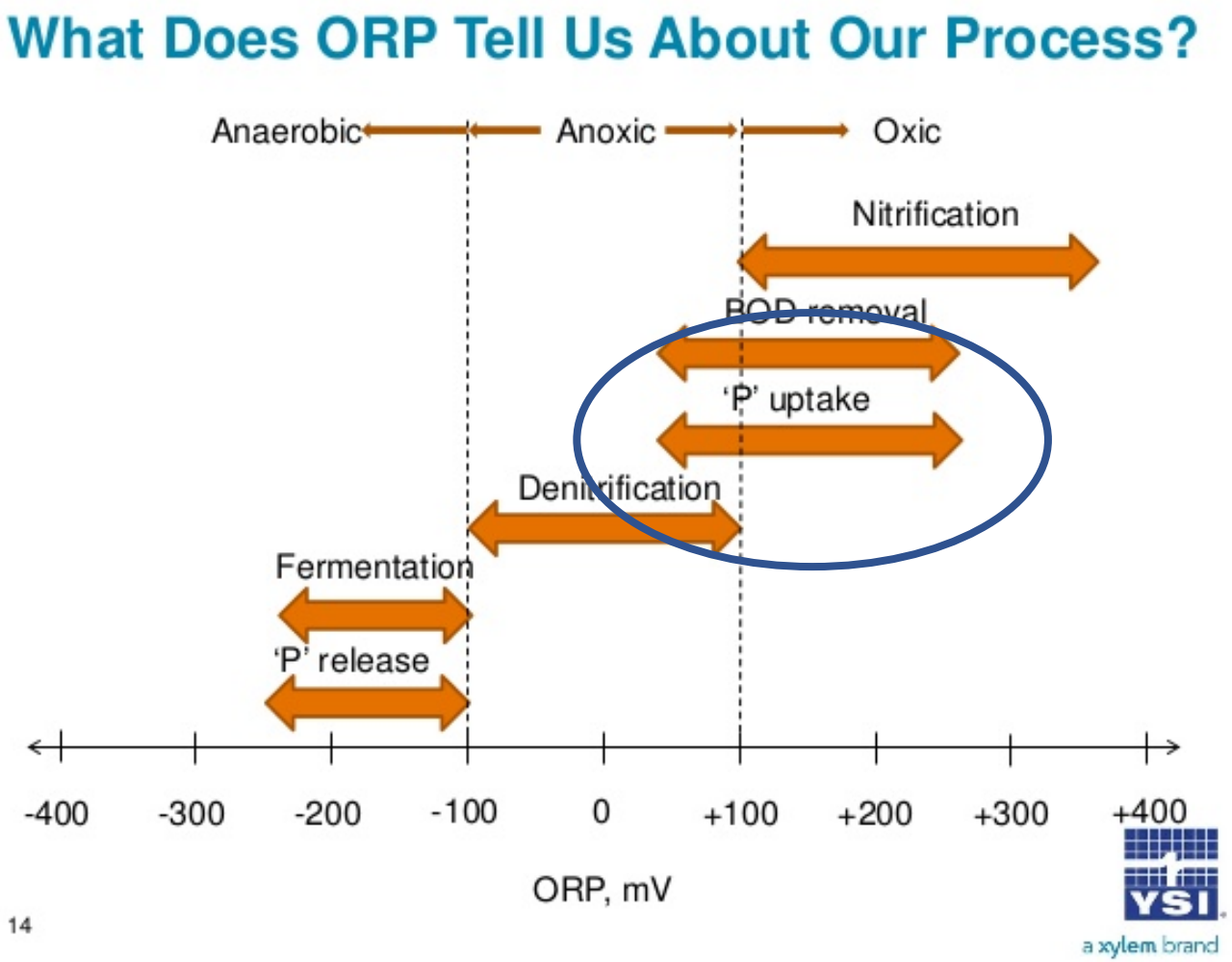
Step 3: P-uptake

ORP of +150 mV … no more DO than for ammonia removal

pH of 7.0+

Retention time … enough to remove ammonia

Enough BOD to support bacteria growth



Optimizing Bio-P Removal: Mainstream or Sidestream Fermentation

Anaerobic Tank

2 hour HRT (hydraulic retention time)*
ORP of -200 mV*
25 times as much BOD as influent ortho-P*
Ortho-P release (3 times influent ortho-P)*

Aeration Tank

DO of 2.0 mg/L
ORP of +150 mV
pH of 7.0+*
Ortho-P concentration of 0.05 mg/L*

*Approximate: Every Plant is Different

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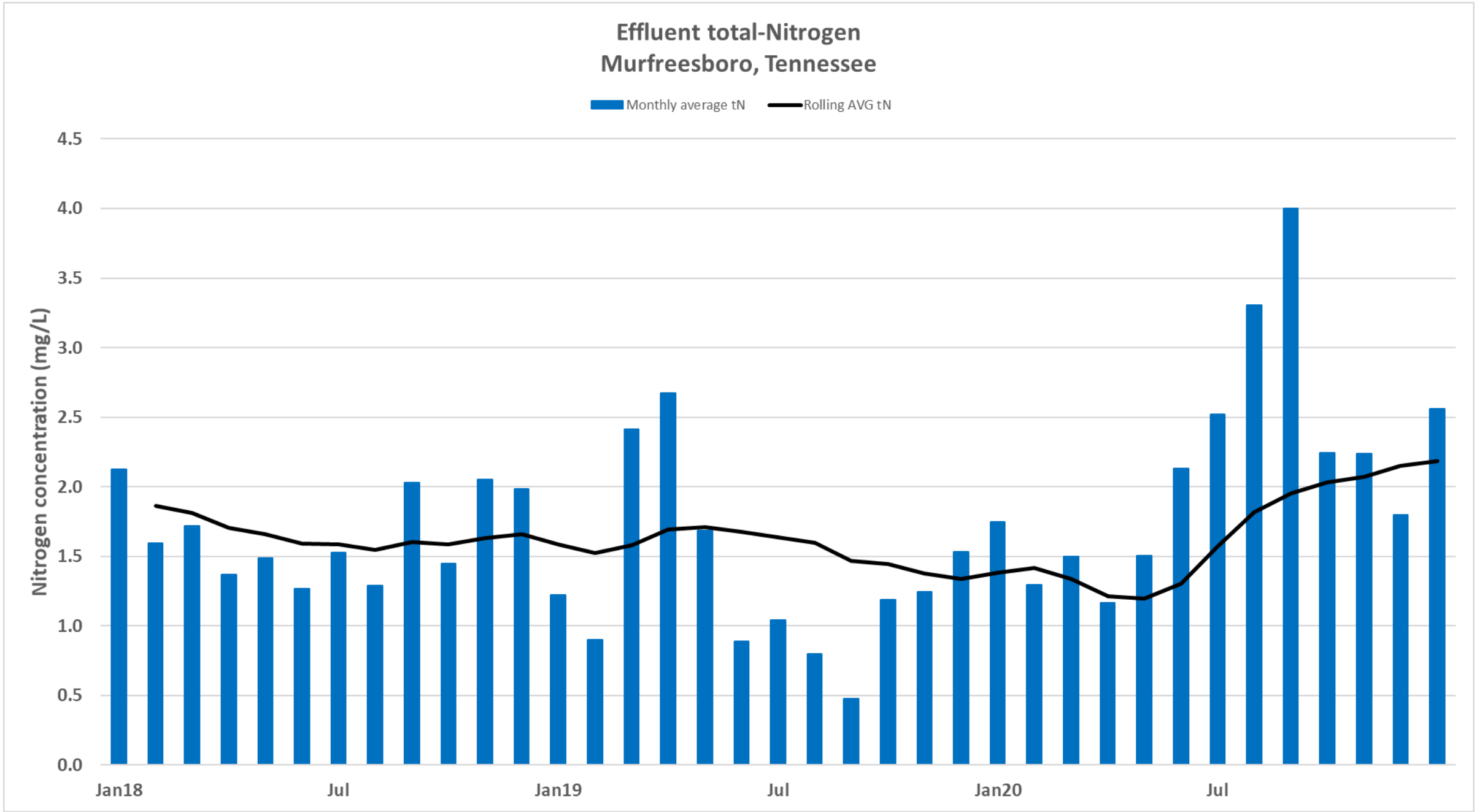
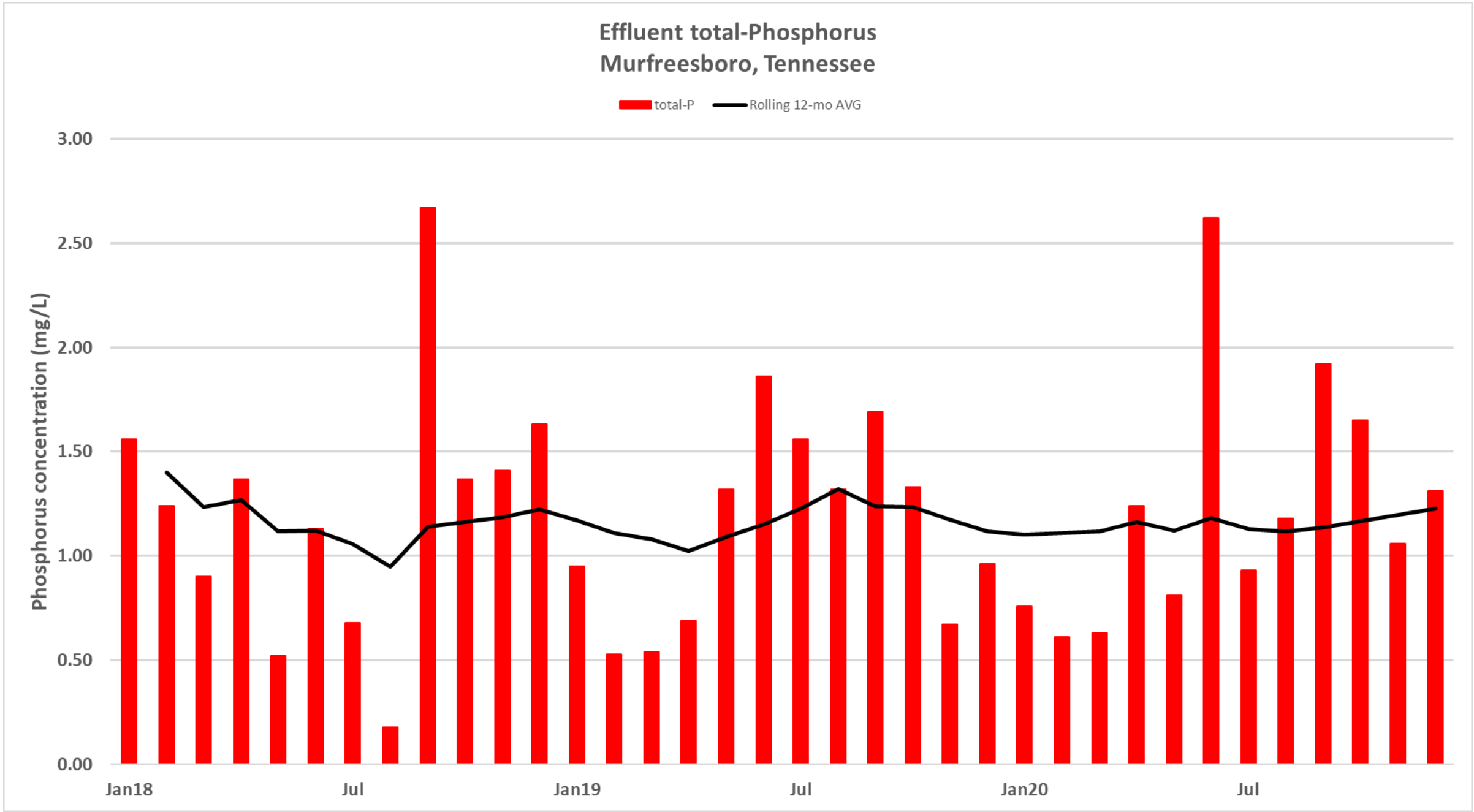
Murfreesboro, Tennessee Population: 136,000 20 MGD design flow


Fleming Training Center
Murfreesboro
Waste Water Plant
Blanton Dr
Blanton Dr
Google


Effluent total-Nitrogen
Murfreesboro, Tennessee
Monthly average tN
Rolling AVG tN
Nitrogen concentration (mg/L)
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Jan18
Jul
Jan19
Jul
Jan20
Jul


Effluent total-Phosphorus
Murfreesboro, Tennessee
total-P
Rolling 12-mo AVG
Phosphorus concentration (mg/L)
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Jan18
Jul
Jan19
Jul
Jan20
Jul

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