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Excellence in Engineering Since 1946

Strand Associates, Inc.®

Case Studies in Finding the Biological Sweet Spot

OTCO Class III & IV Workshop July 26, 2018

Kevin R. Earnest, PE (OH, IN)

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Goals

- Share training and workshops designed to develop adequate monitoring plans
- Review of databases and spreadsheet tools that can assist in turning the data into information
- Development of unique protocols to meet site specific needs

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Case Studies

- Utilizing SCADA and Database Tools
- Example: Bensenville, IL – Startup Training
- Example: Waterloo, IA – Data to Information
- Other Operational Conversations (as time allows)

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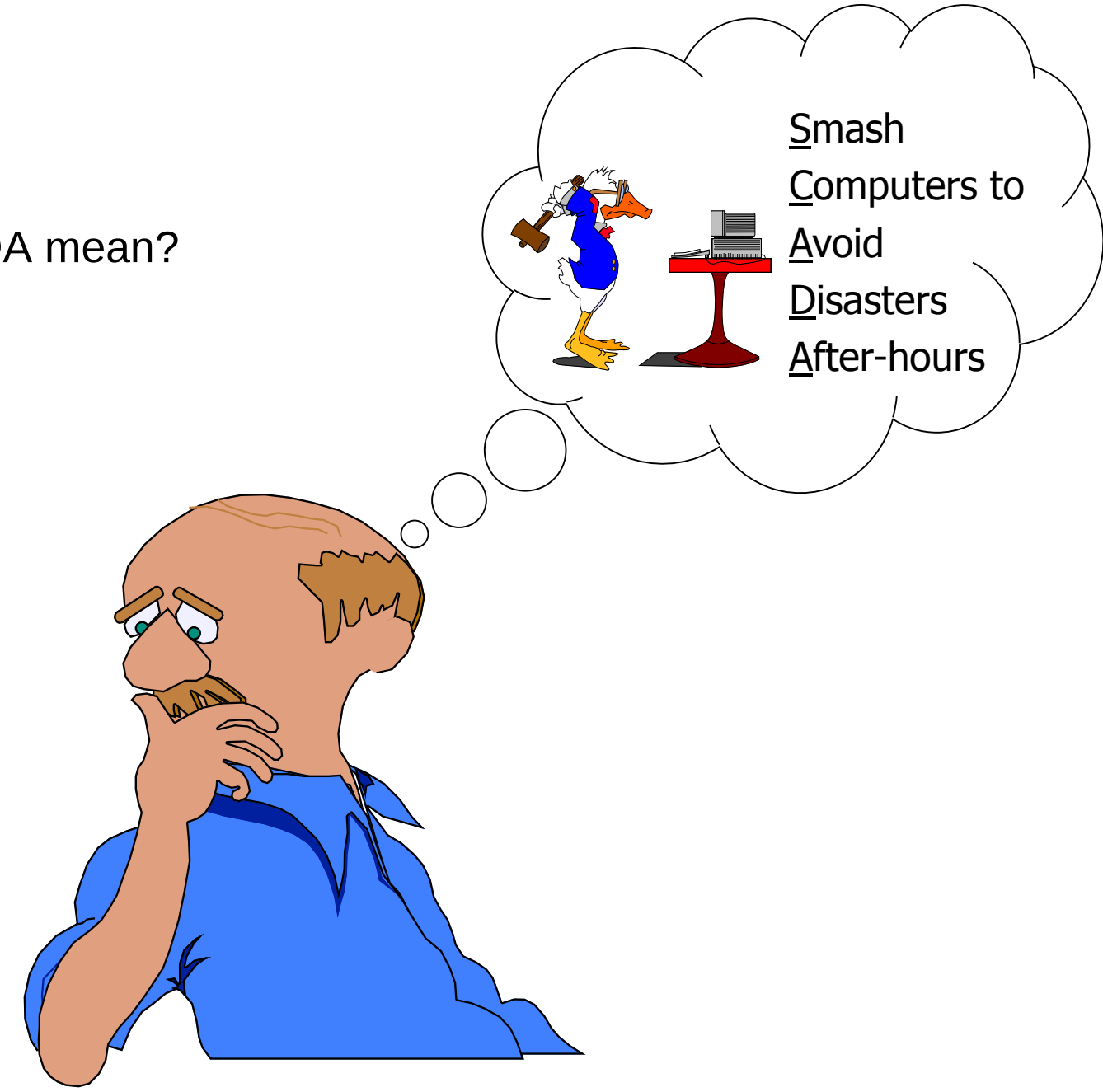
SCADA Basics

- What does SCADA mean?
  - Supervisory
  - Control
  - And
  - Data
  - Acquisition



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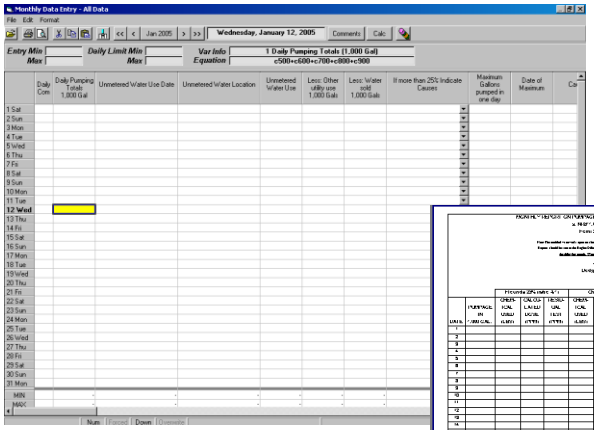
SCADA Basics

- How large/small can a SCADA System be?
  - Single pump station and master computer
  - Wastewater Treatment Plant
  - Regional water/wastewater systems

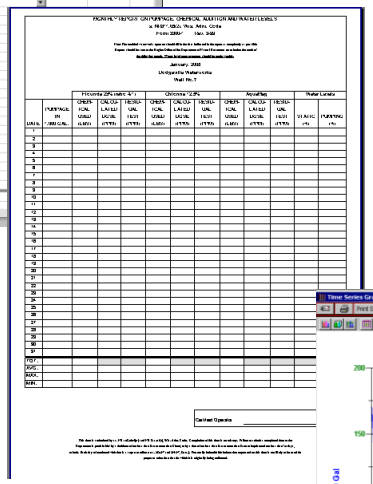
Reporting Basics

- What does a Reporting System do?

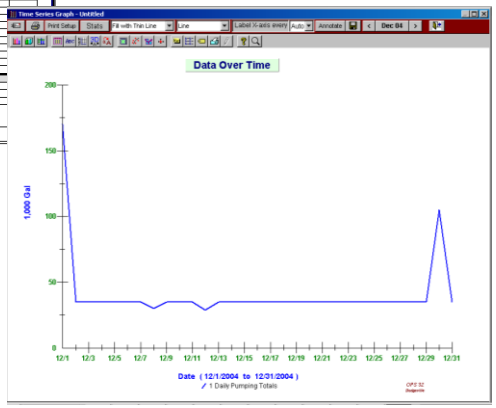
Collect Data



Report Data



Trend Data



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Reporting Basics

- What can a Reporting System be used for?
  - Long-term data storage
  - Operator logs/entry
  - OEPA-required reports
  - Lab analysis
    - Data manager
    - QA/QC
  - Billing
  - Process optimization and troubleshooting
  - Future planning/trends

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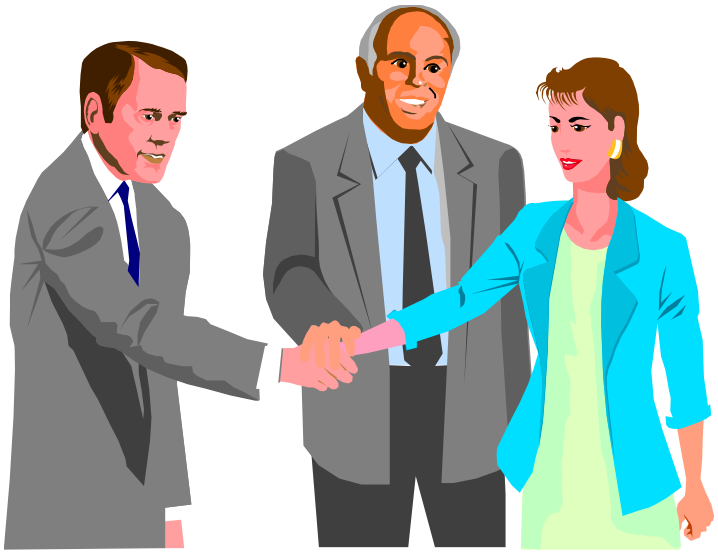
Optimizing Your Reporting Program

- Planning, Communication, and Teamwork are Necessary to Develop a Relevant - User Friendly System.



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Optimizing Your Reporting Program

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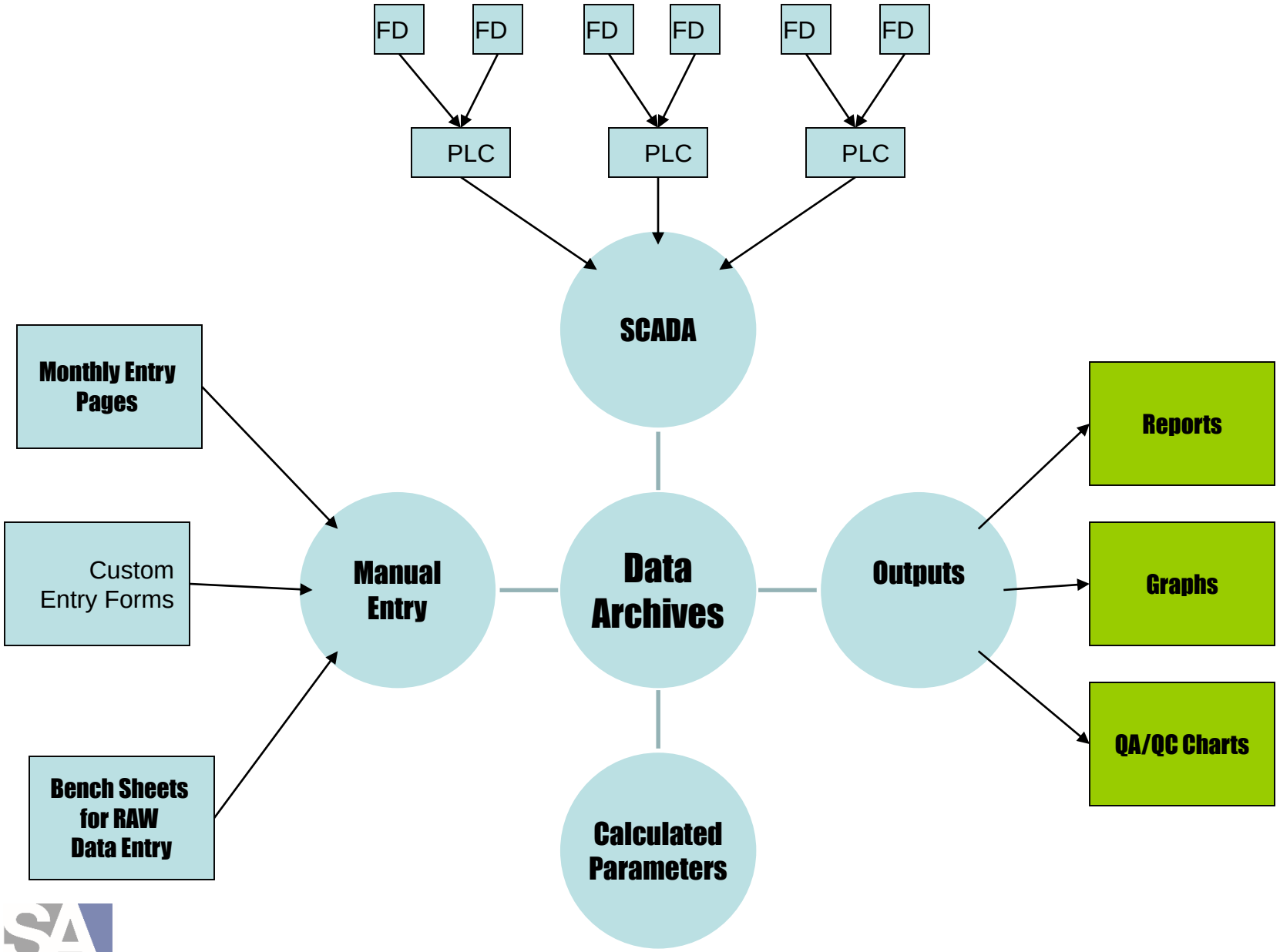

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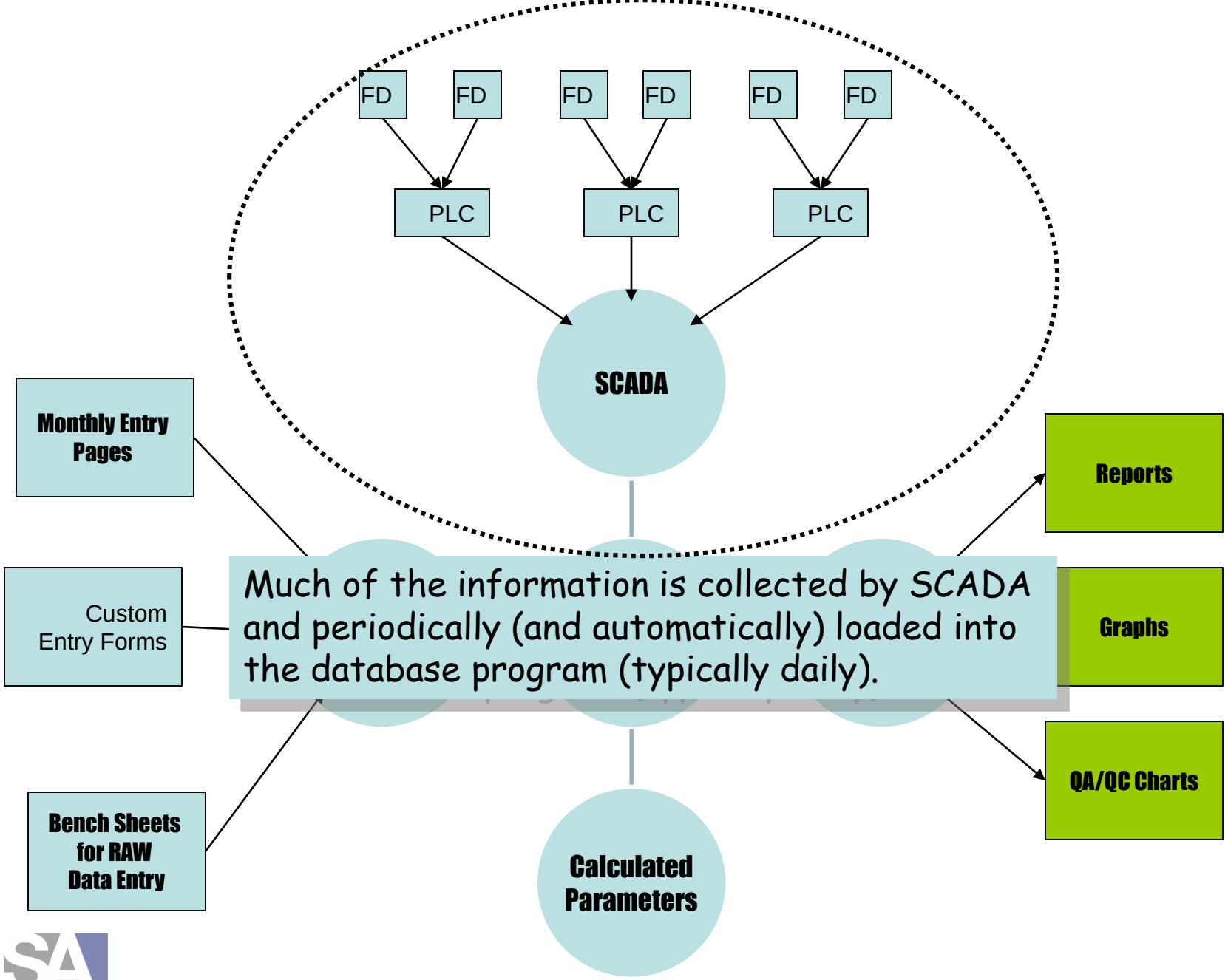

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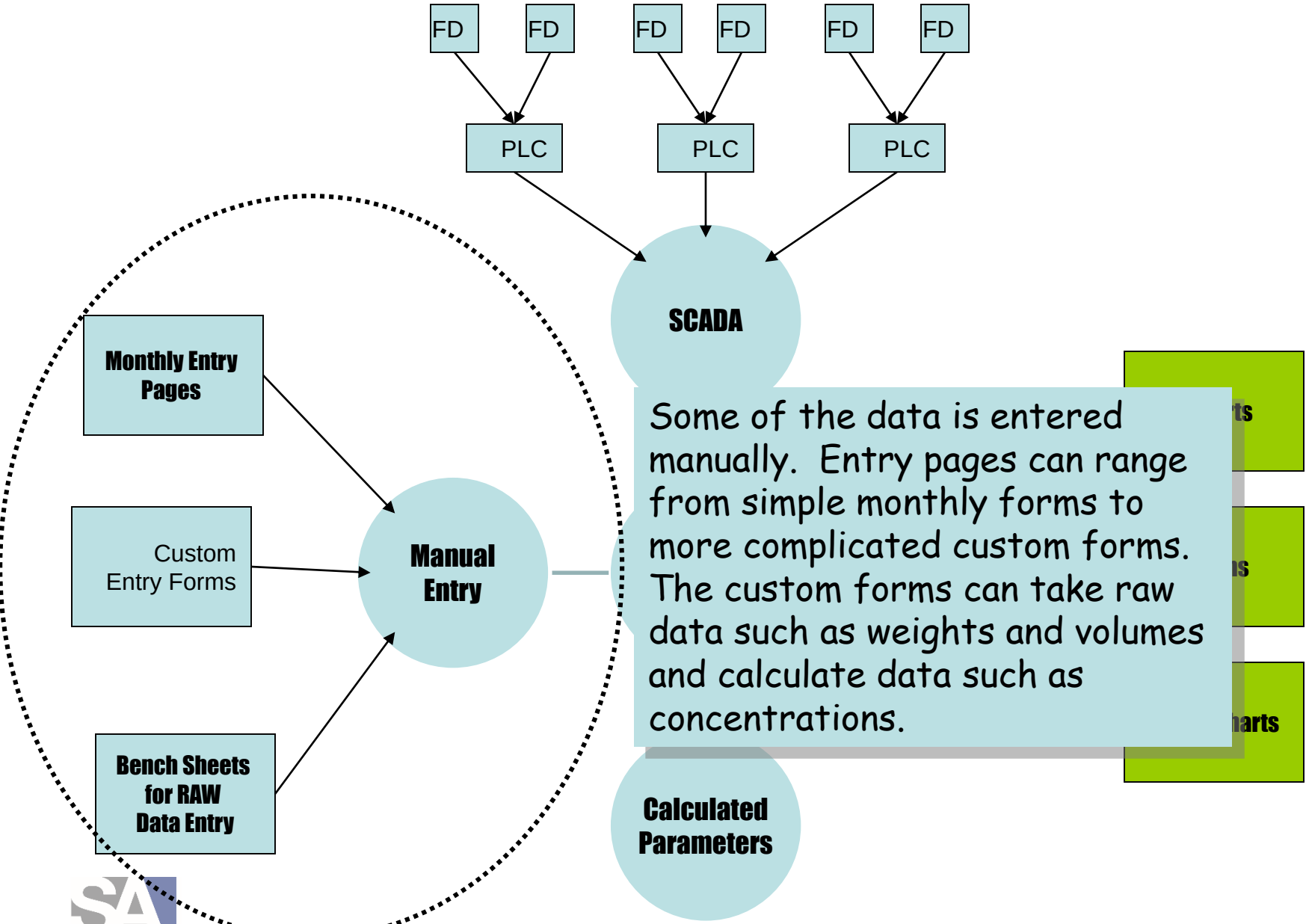

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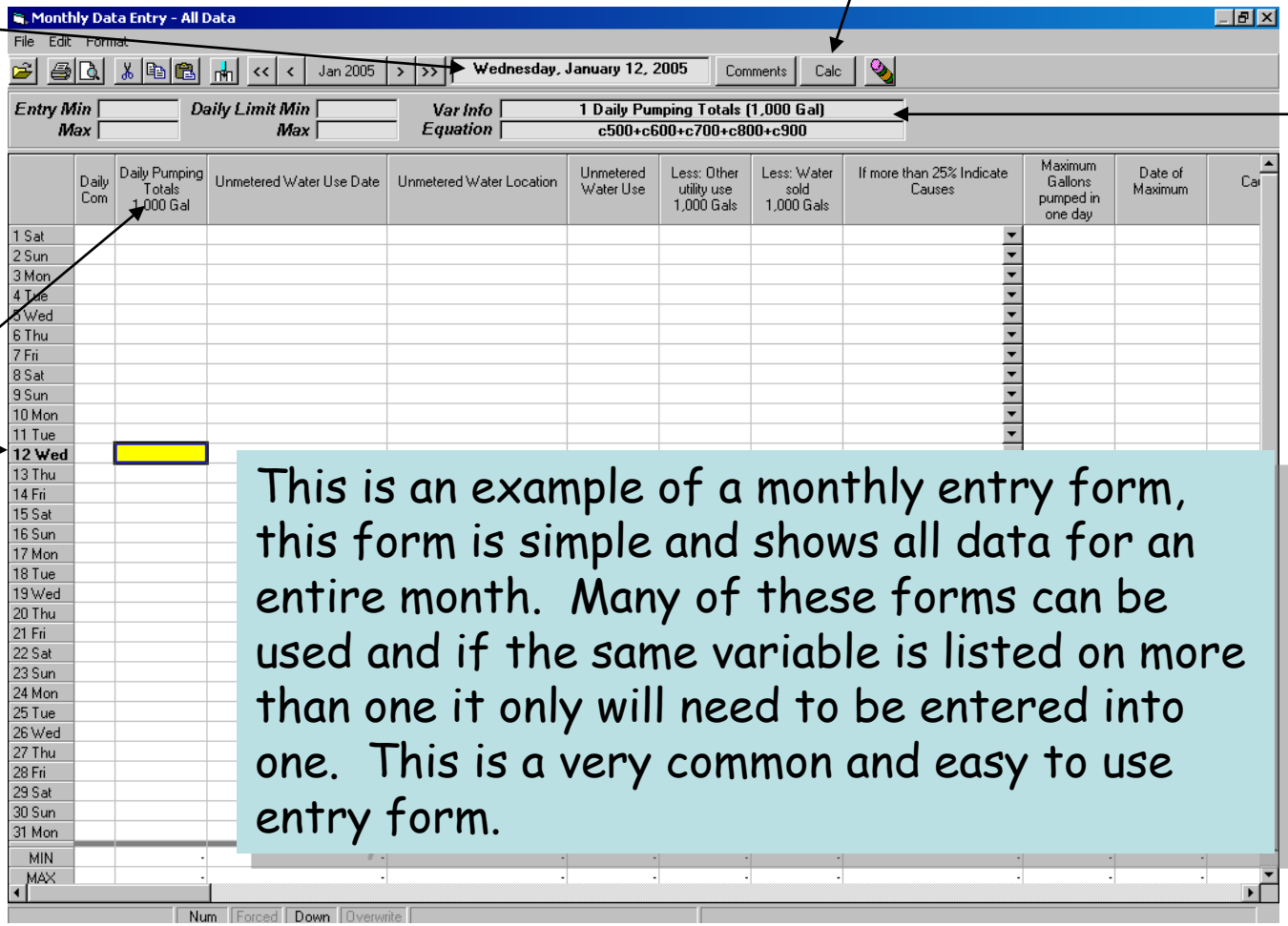
Data Entry

The “Calc” should be selected to inform Ops to perform the various calculations.

Date (Curser)



Variable (curser)

On a “Monthly Entry Form” the entries are arranged by day-of-month and variable.

This is an example of a monthly entry form, this form is simple and shows all data for an entire month. Many of these forms can be used and if the same variable is listed on more than one it only will need to be entered into one. This is a very common and easy to use entry form.

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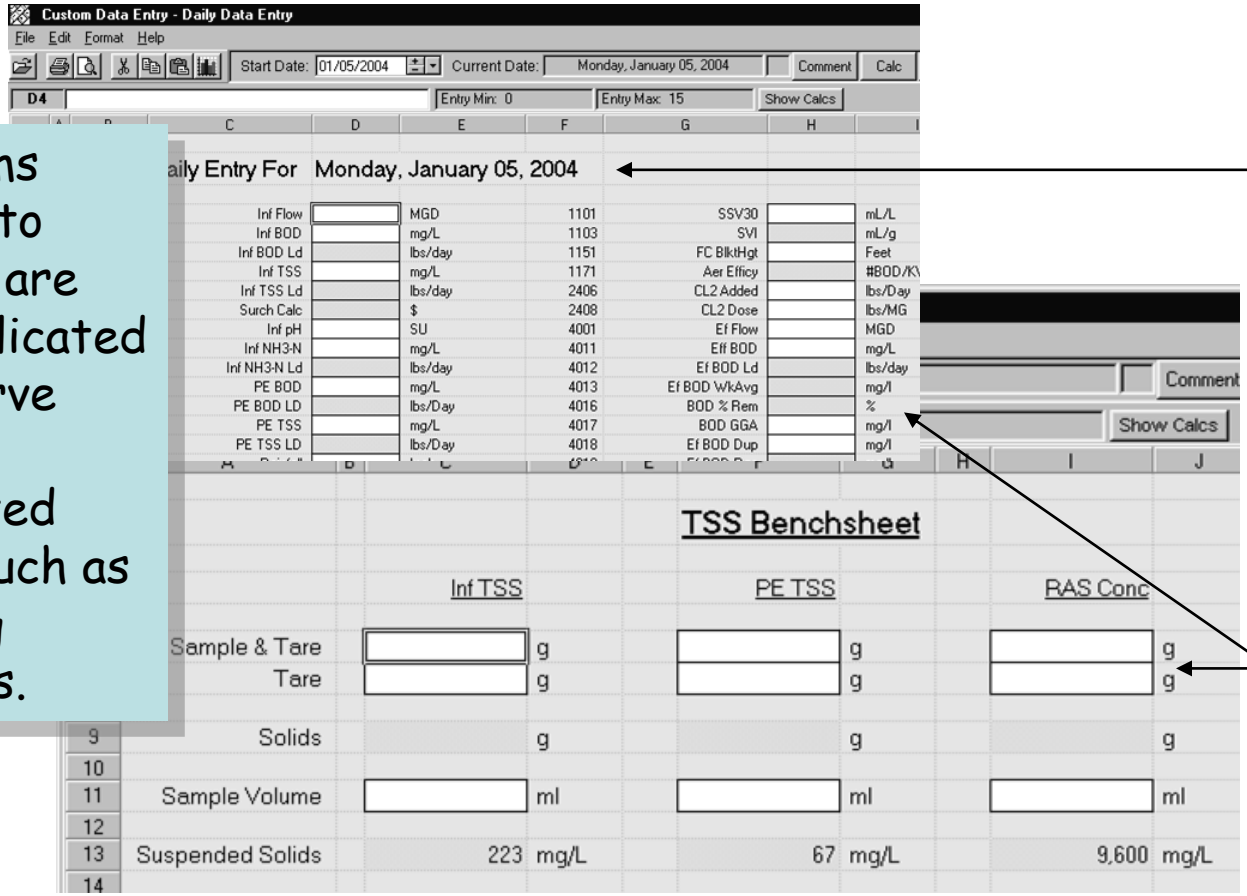
Data Entry

These forms take more to set-up and are more complicated but can serve more sophisticated purposes such as performing calculations.



All for the same date.

Variables could be arranged to match field sheets or other personalized needs.

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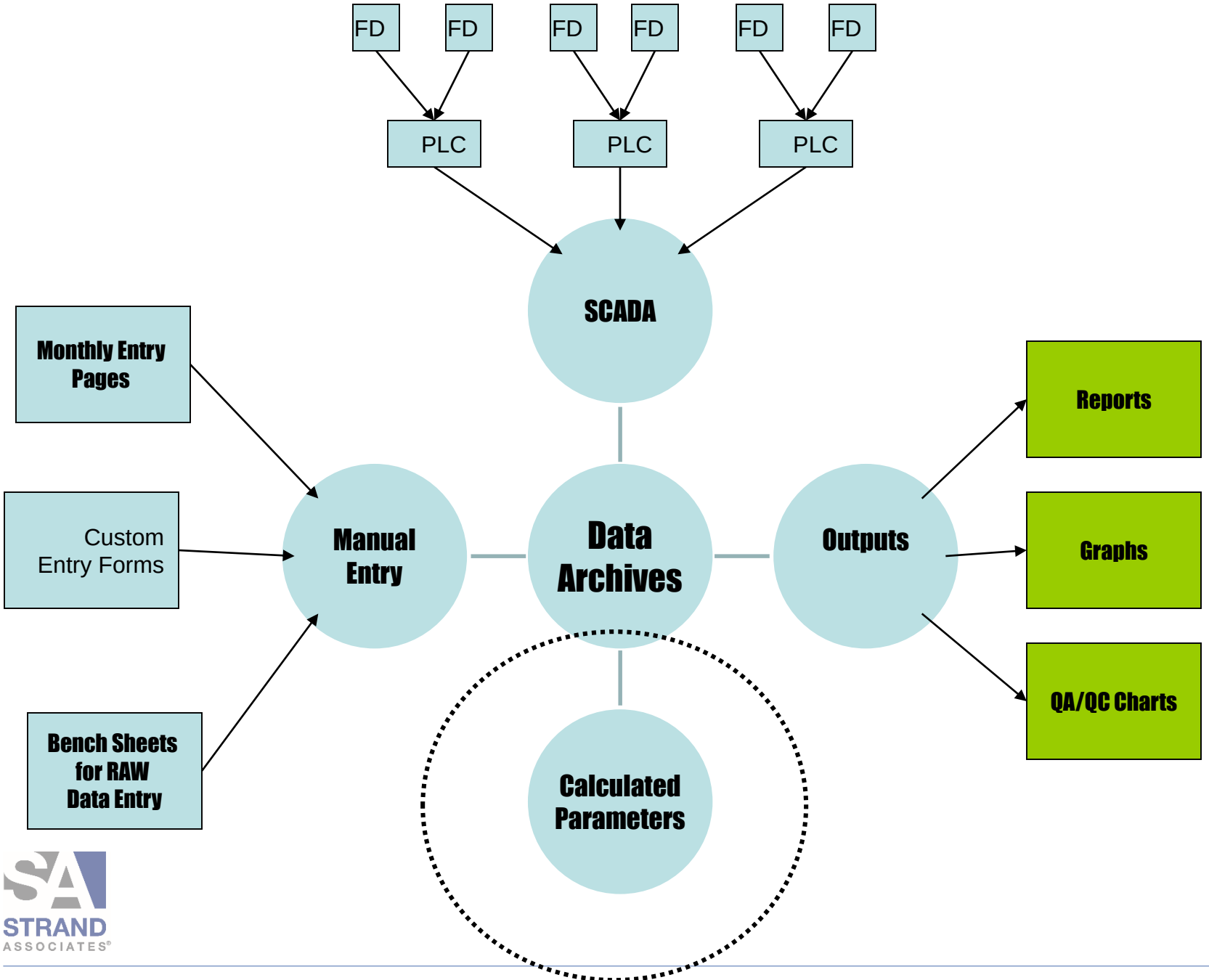

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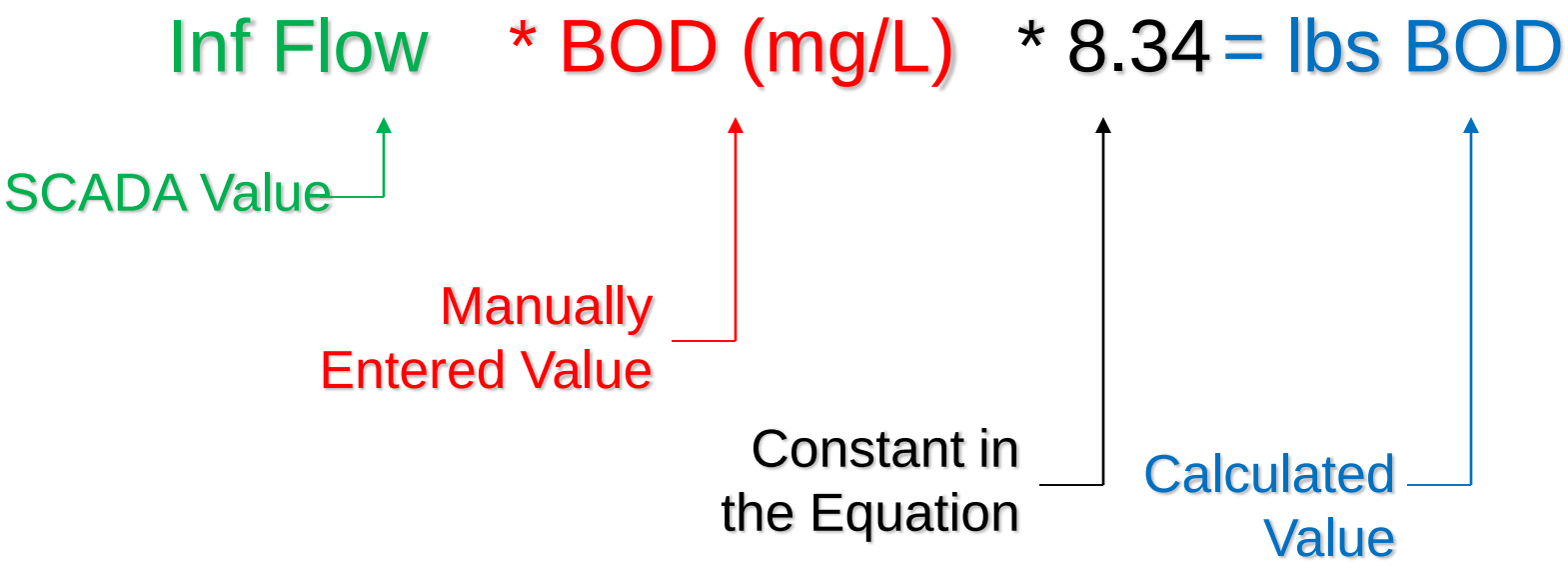
Optimizing Your Reporting Program

Calculations



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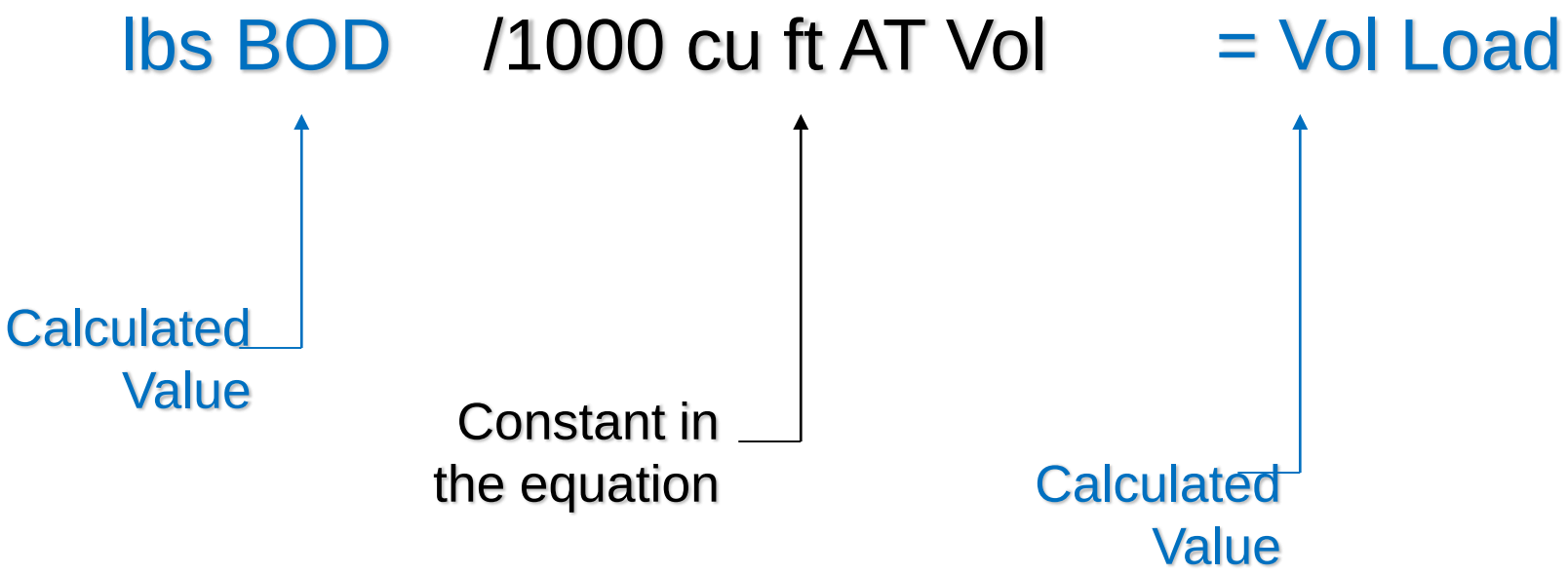
Optimizing Your Reporting Program

Calculations



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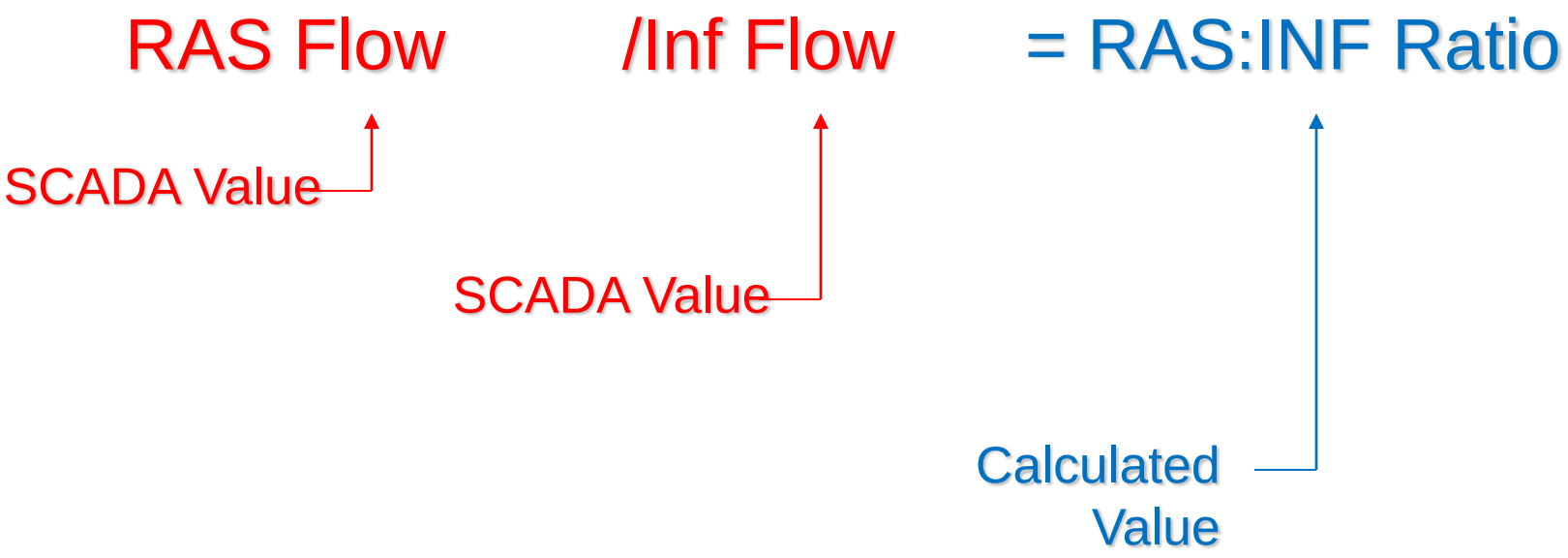
Optimizing Your Reporting Program

Calculations



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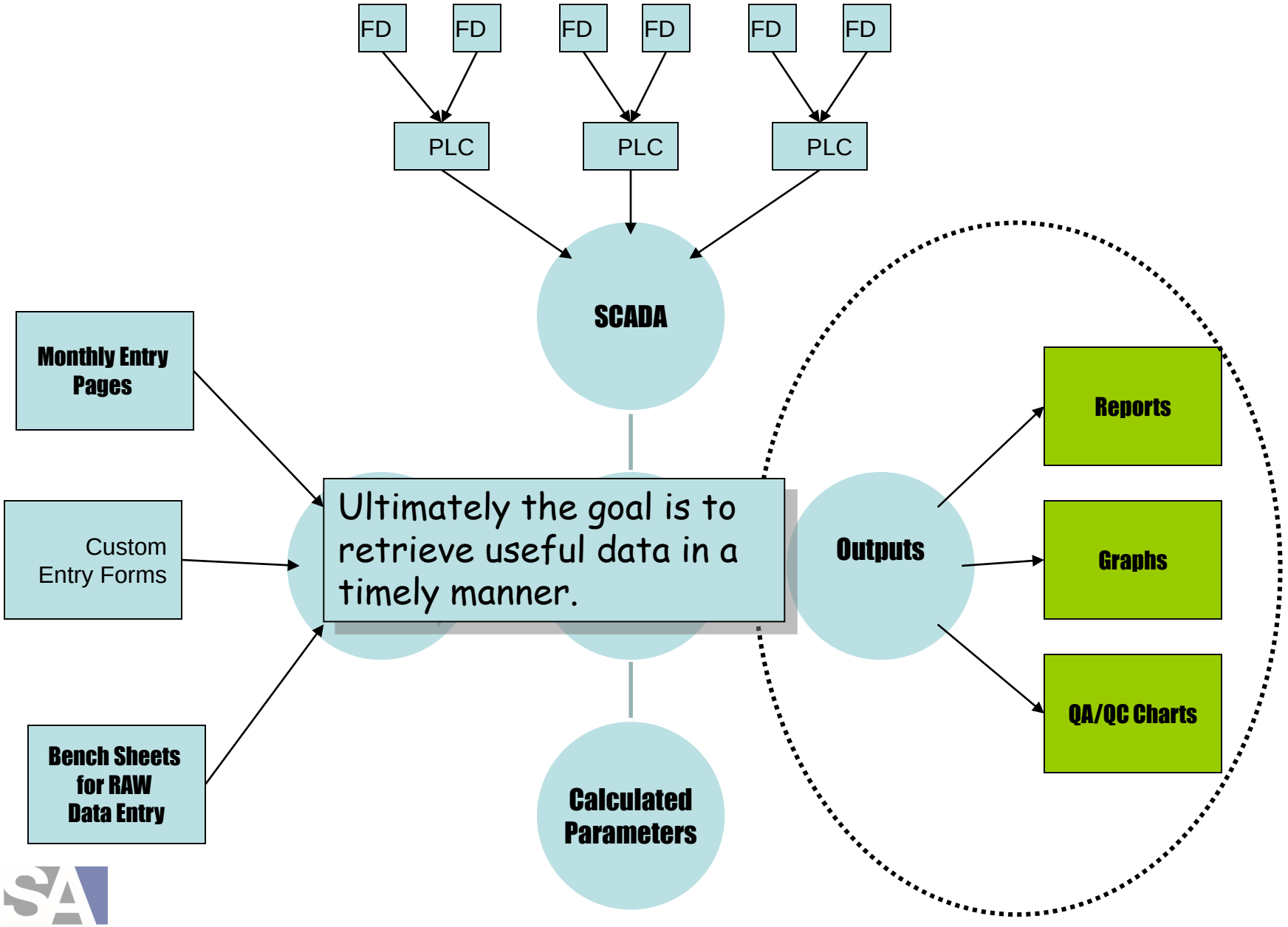

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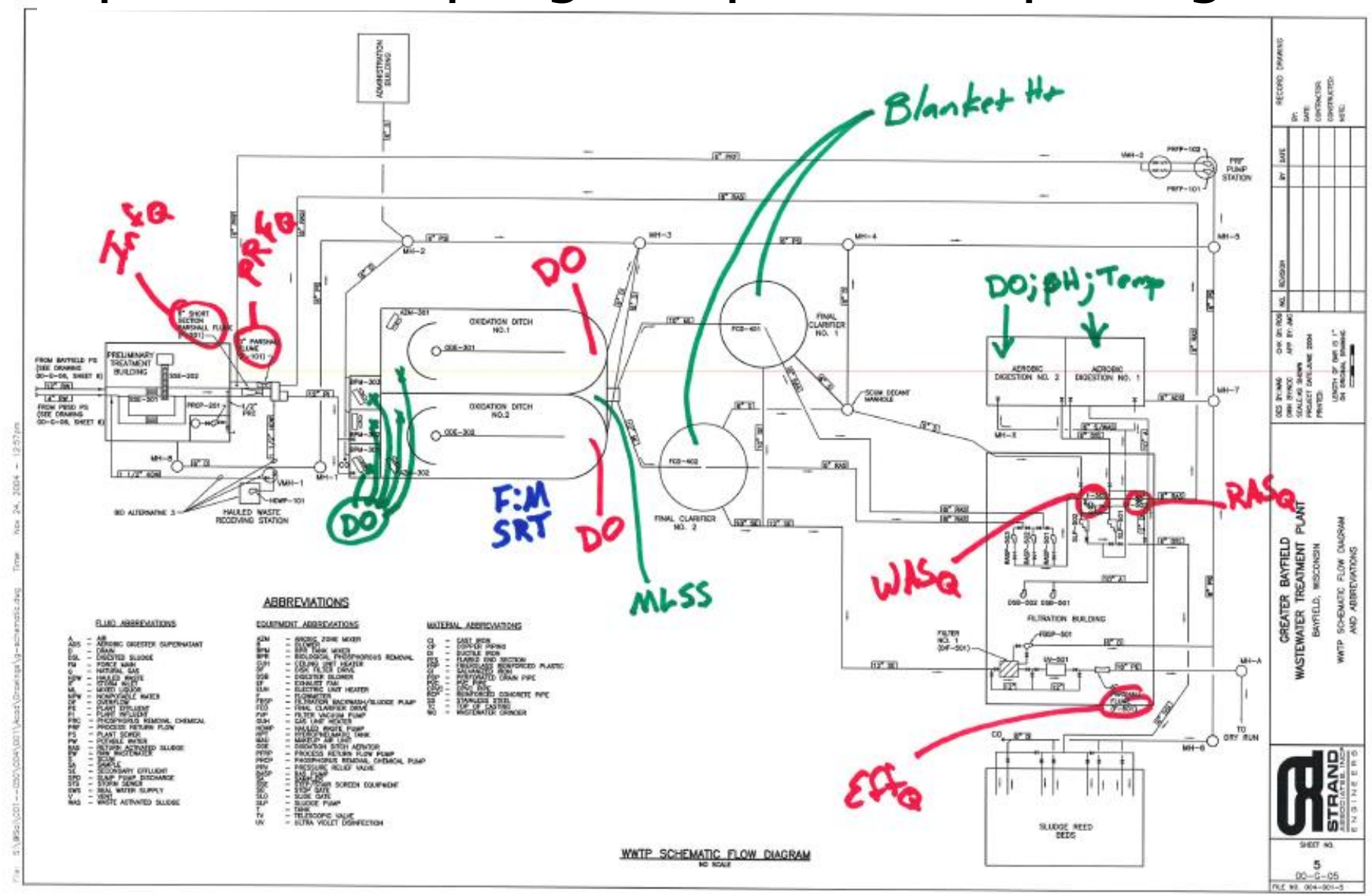
Optimizing Your Reporting Program

- A variable list should:
  - include information that has a purpose
  - avoid overwhelming those collecting the data
  - be reviewed periodically
  - be clean and well organized (like items should be grouped together e.g. *influent data*)

Optimize Sampling to Optimize Reporting



Optimizing Your Reporting Program

Begin With The End In Mind

The eventual users need to develop a concept of what they want to do with the reports so that they can provide direction to the programmer. To do this the user will need to be or become familiar with his/her options.

Some Common Uses Include:

- Regulatory Reporting
- Process Control Reporting
- Run Time Reporting
- Lab Data Entry
- Field Data Entry
- Trending

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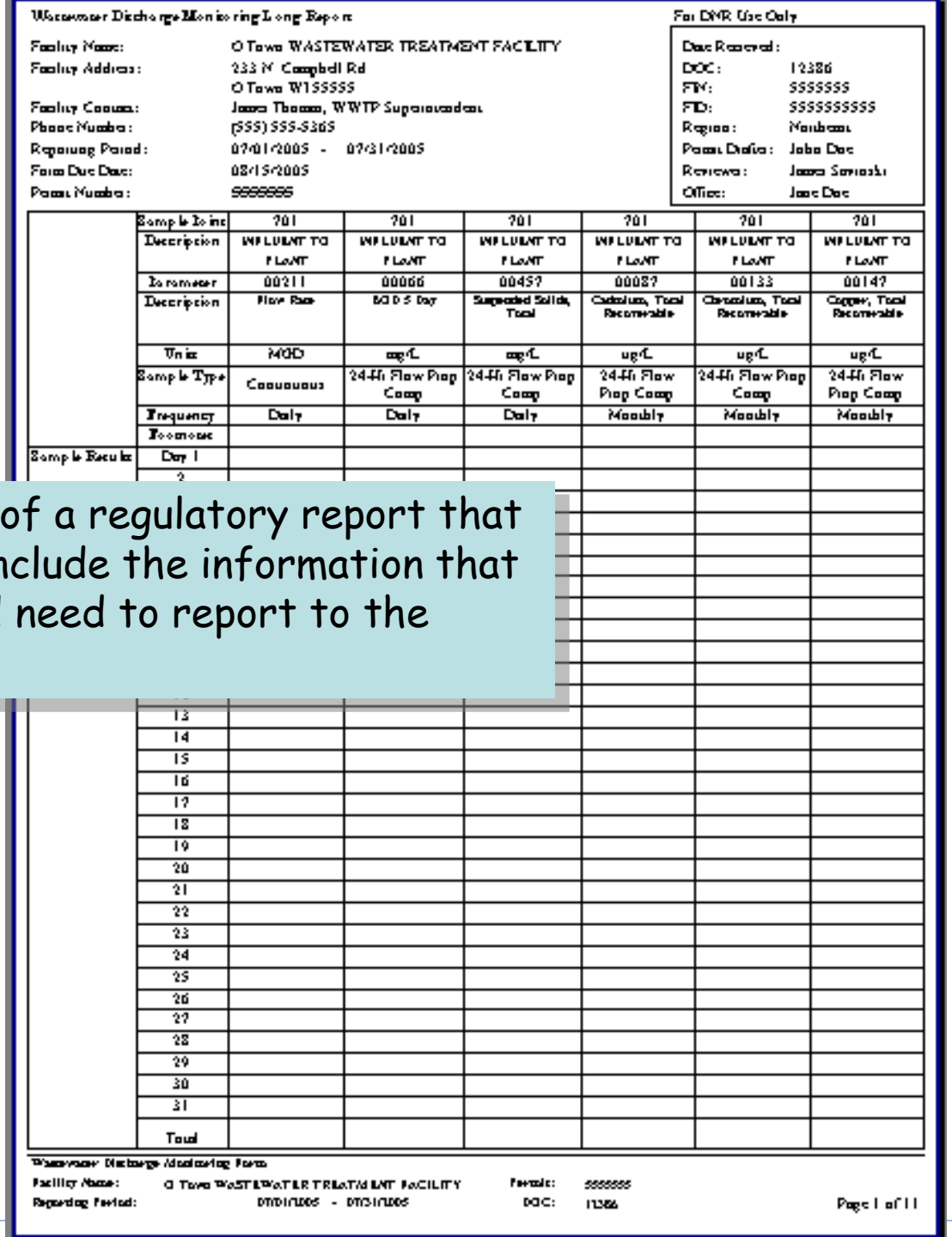

Wastewater Discharge Monitoring Long Report

For DNR Use Only

Facility Name: O Town WASTEWATER TREATMENT FACILITY
Facility Address: 233 N Campbell Rd
O Town WI55555
Facility Contact: Jane Thomas, WWTP Superintendent
Phone Number: (555) 555-5365
Reporting Period: 07/01/2005 - 07/31/2005
Form Due Date: 08/15/2005
Permit Number: 5555555

Date Received:
DOC: 12386
FIN: 5555555
FID: 5555555555
Region: Northeast
Permit Data: John Doe
Reviewed: Jane Smith
Office: Jane Doe

	Sample Point	701	701	701	701	701	701
	Description	INFLUENT TO PLANT	INFLUENT TO PLANT	INFLUENT TO PLANT	INFLUENT TO PLANT	INFLUENT TO PLANT	INFLUENT TO PLANT
	Parameter	00211	00666	00452	00927	00133	00147
	Description	Flow Rate	BOD 5 Day	Suspended Solids, Total	Cadmium, Total Recoverable	Chromium, Total Recoverable	Copper, Total Recoverable
	Units	MGD	mg/L	mg/L	ug/L	ug/L	ug/L
	Sample Type	Continuous	24-Hr Flow Prop Comp	24-Hr Flow Prop Comp	24-Hr Flow Prop Comp	24-Hr Flow Prop Comp	24-Hr Flow Prop Comp
	Frequency	Daily	Daily	Daily	Monthly	Monthly	Monthly
	Footnotes						
Sample Results	Day 1						
	2						
	3						
	4						
	5						
	6						
	7						
	8						
	9						
	10						
	11						
	12						
	13						
	14						
	15						
	16						
	17						
	18						
	19						
	20						
	21						
	22						
	23						
	24						
	25						
	26						
	27						
	28						
	29						
	30						
	31						
	Total						

Wastewater Discharge Monitoring Form
Facility Name: O Town WASTEWATER TREATMENT FACILITY Permit: 5555555
Reporting Period: 07/01/2005 - 07/31/2005 DOC: 12386

Page 1 of 11

This is an example of a regulatory report that was developed to include the information that the operator would need to report to the state.

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Phosphorus

Date	In Phos Ld lbs/day	MLVSS Avg mg/l	RAS Flow KGAL	RASQ:InfQ Ratio	Recycle Speed %	Ef Phos Ld lbs/day	FeCl3 daily gal/day	Fe:P ratio	BPR SS ratio Anoxic:Anaerobic	Eff P mg/l
3/1/2002			805	0.42	60		41.85		1.09	
3/2/2002			791	0.42	60		41.85		1.09	
3/3/2002	64	2,280	769	0.42	60	5	41.85	1.13	0.92	0.30
3/4/2002			801	0.42	60	5	41.85		1.03	0.30
3/5/2002	69	1,993	792	0.42	60		30.44		1.08	
3/6/2002			786	0.42	60		30.44		1.07	
3/7/2002	65	2,020	812	0.43	60	5	30.44	0.77	0.92	0.30
3/8/2002			825	0.43	60		30.44		1.09	
3/9/2002			1,318	0.43	60		30.44		0.75	
3/10/2002	67	2,473	909	0.43	60	5	30.44	0.84	1.02	0.30
3/11/2002			892	0.43	60	5	30.44		0.99	0.30
3/12/2002	65	3,260	928	0.43	58		30.44		1.02	
3/13/2002									1.06	
3/14/2002								.78	1.74	0.30
3/15/2002									1.54	
3/16/2002									1.62	
3/17/2002								.00	1.45	0.30
3/18/2002								.00	1.81	0.30
3/19/2002									1.56	0.30
3/20/2002									1.68	0.30
3/21/2002								.00	1.49	0.30
3/22/2002			914	0.43	49		0.00		1.61	
3/23/2002			925	0.43	49		0.00		1.82	
3/24/2002	63	2,920	893	0.43	49	5	0.00	0.00	1.56	0.30
3/25/2002			878	0.43	49	7	0.00		1.59	0.40
3/26/2002	62	2,687	876	0.43	49		0.00		1.64	
3/27/2002			898	0.43	49		0.00		1.69	
3/28/2002	68	3,153	888	0.43	49	7	0.00	0.00	1.66	0.40
3/29/2002			912	0.43	49				1.55	
3/30/2002			926	0.43	49		0.00		1.64	
3/31/2002	62	2,660	837	0.43	49	7	0.00	0.00	1.82	0.40
Minimum	62	1,993	769	0.40	49	5	0.00	0.00	0.75	0.30
Maximum	69	3,360	1,318	0.43	60	7	41.85	1.13	1.82	0.40
Total	839	33,047	27,619	13.17	1,657	82	498.39	3.52	42.59	4.80
Average	65	2,754	891	0.43	53	5	17.19	0.35	1.37	0.32

This is an example of a process control report that was developed to include the information that the operator would want to know related to a specific process.

Phosphorus

Date	In Phos Ld lbs/day	MLVSS Avg mg/l	RAS Flow KGAL	RASQ:InfQ Ratio	Recycle Speed %	Eff Phos Ld lbs/day	FeCl3 daily gal/day	Fe:P ratio	BPR SS ratio Anoxic:Anaerobic	Eff P mg/l
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3/8/2002			825	0.43	60		30.44		1.09	
3/9/2002			1,318	0.43	60		30.44		0.75	
3/10/2002	67	2,473	909	0.43	60	5	30.44	0.84	1.02	0.30
3/11/2002			892	0.43	60	5	30.44		0.99	0.30
3/12/2002	65	3,260	928	0.43	58		30.44		1.02	
3/13/2002			1,016	0.43	53		30.44		1.06	
3/14/2002	63	3,360	899	0.43	51	5	30.44	0.78	1.74	0.30
3/15/2002			904	0.42	51		26.63		1.54	
3/16/2002			936	0.43	49		0.00		1.62	
3/17/2002	67	3,100	922	0.43	49	5	0.00	0.00	1.45	0.30
3/18/2002	62		910	0.42	49	5	0.00	0.00	1.81	0.30
3/19/2002			843	0.40	49	5			1.56	0.30
3/20/2002			904	0.43	49	5	0.00		1.68	0.30
3/21/2002	62	3,140	904	0.42	49	5	0.00	0.00	1.49	0.30
3/22/2002			914	0.43	49		0.00		1.61	
3/23/2002			925	0.43	49		0.00		1.82	
3/24/2002	63	2,920	893	0.43	49	5	0.00	0.00	1.56	0.30
3/25/2002			878	0.43	49	7	0.00		1.59	0.40
3/26/2002	62	2,687	876	0.43	49		0.00		1.64	
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3/28/2002	68	3,153	888	0.43	49	7	0.00	0.00	1.66	0.40
3/29/2002			912	0.43	49				1.55	
3/30/2002			926	0.43	49		0.00		1.64	
3/31/2002	62	2,660	837	0.43	49	7	0.00	0.00	1.82	0.40
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Average	65	2,754	891	0.43	53	5	17.19	0.35	1.37	0.32

Area B & C Primary Clarifiers Monthly Run Times Page 1

For Date: July, 2006

	Primary Clarifier 1 Run Time	Primary Clarifier 2 Run Time	Primary Clarifier 3 Run Time	Primary Clarifier 4 Run Time	Primary Sludge Pump 1 Run Time	Primary Sludge Pump 2 Run Time	Primary Sludge Pump 3 Run Time	Primary Sludge Pump 4 Run Time
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								
26								
27								
28								
29								
30								
31								
TOTAL								
AVERAGE								
MAXIMUM								
MINIMUM								

This is an example of a report that was developed to allow SCADA information (run times) to be reviewed by the operators.

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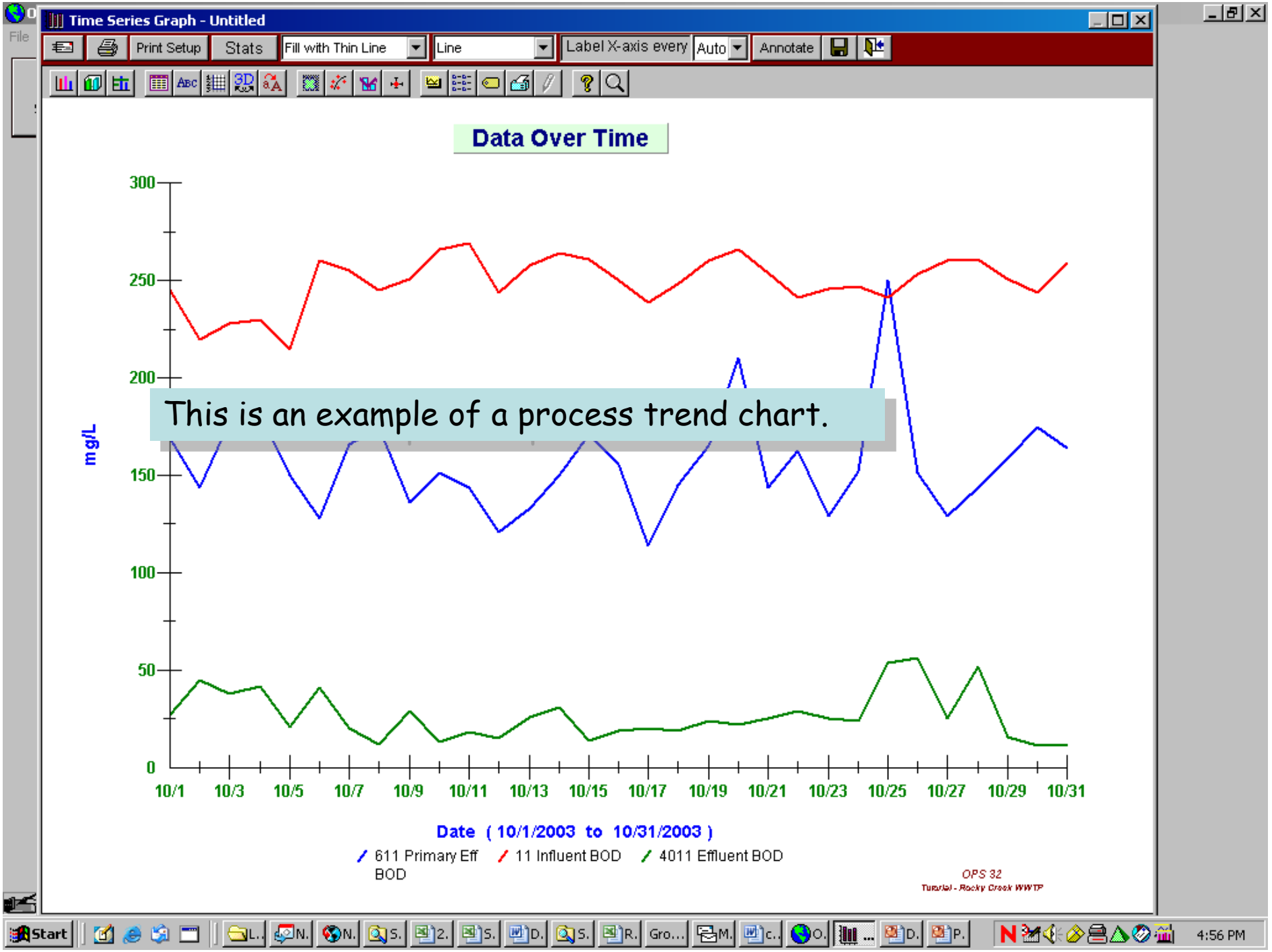
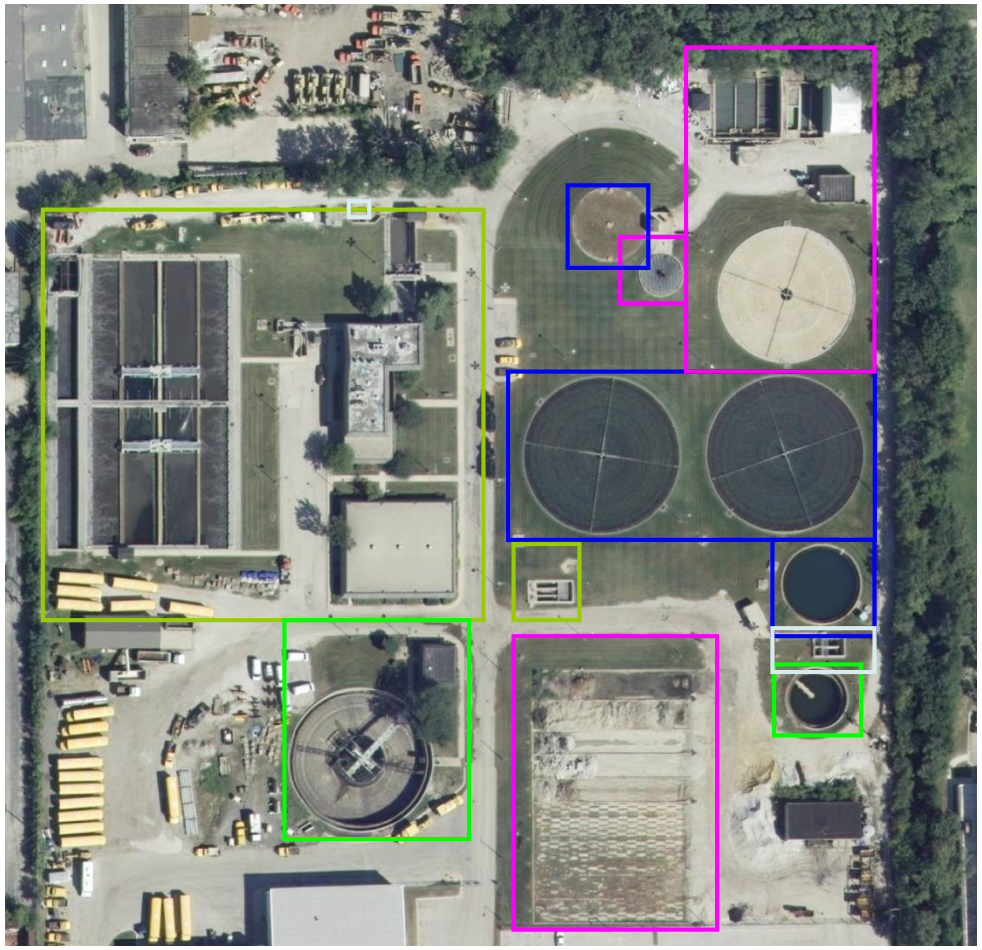

Time Series Graph - Untitled
Print Setup
Stats
Fill with Thin Line
Line
Label X-axis every
Auto
Annotate
Data Over Time
This is an example of a process trend chart.
mg/L
300
250
200
150
100
50
0
10/1
10/3
10/5
10/7
10/9
10/11
10/13
10/15
10/17
10/19
10/21
10/23
10/25
10/27
10/29
10/31
Date (10/1/2003 to 10/31/2003)
611 Primary Eff BOD
11 Influent BOD
4011 Effluent BOD
OPS 32
Tutorial - Rocky Creek WWTP
Start
4:56 PM

Philosophy

- Create a Comprehensive Parameter List
  - Do not collect data that you do not know how you will use, it only complicates things
  - Do set the computer up to do math to eliminate opportunities for error and to get data fast
- Maintain Good Communication With All Involved (especially between programmer and operator)
- Get The Most Out Of Training
- Develop An Understanding Of What You Intend To Do With The Program Early In The Process

Bensenville, IL Wastewater Treatment Facility
History of Construction



1940s

1960s

1970s

1980s

1990s

Most of the plant was more than 40 – 50 years old

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Project Need and Drivers

- Plant age and deficiencies
- Controls/automation
- Regulatory changes (P-removal)
- Sanitary Sewer Overflows/Surcharging

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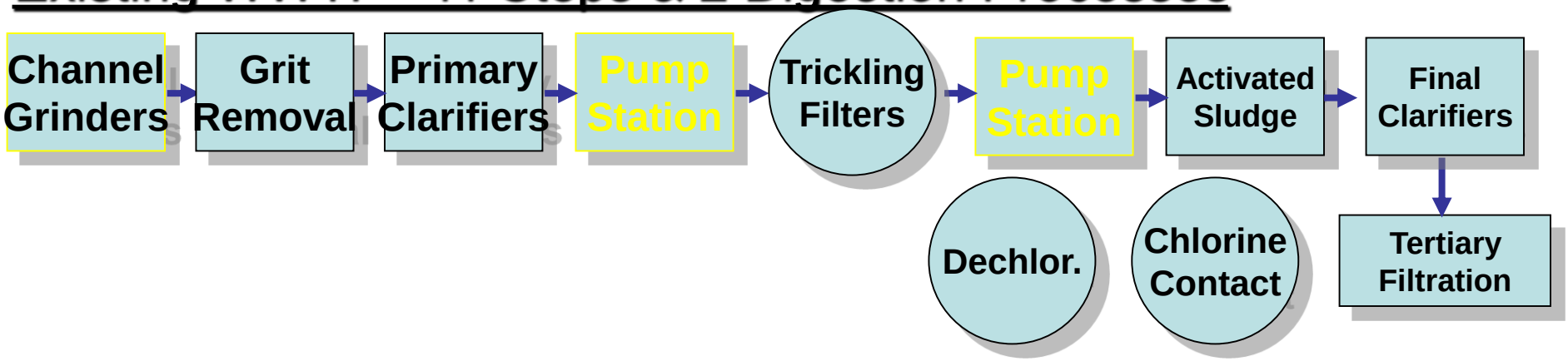
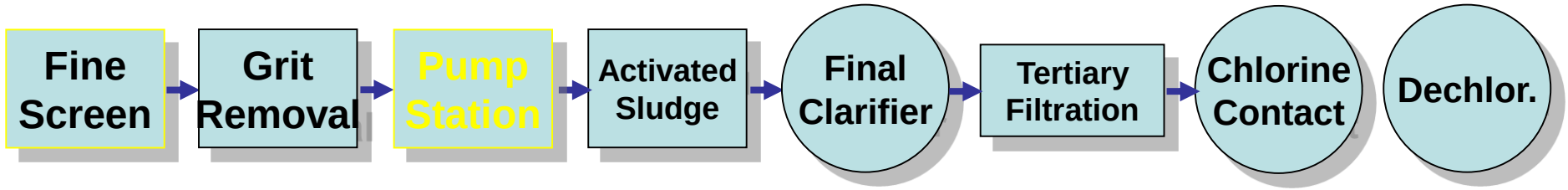
Key Considerations - Simplify the WWTF

Existing WWTF - 11 Steps & 2 Digestion Processes



Simplified WWTF - 8 Steps & 1 Digestion Process



- *Lower Capital $*
- *Lower Operating $*
- *Lower Maintenance $*

- *Easier to Operate*
- *Easier to Maintain*
- *Improved Flexibility*

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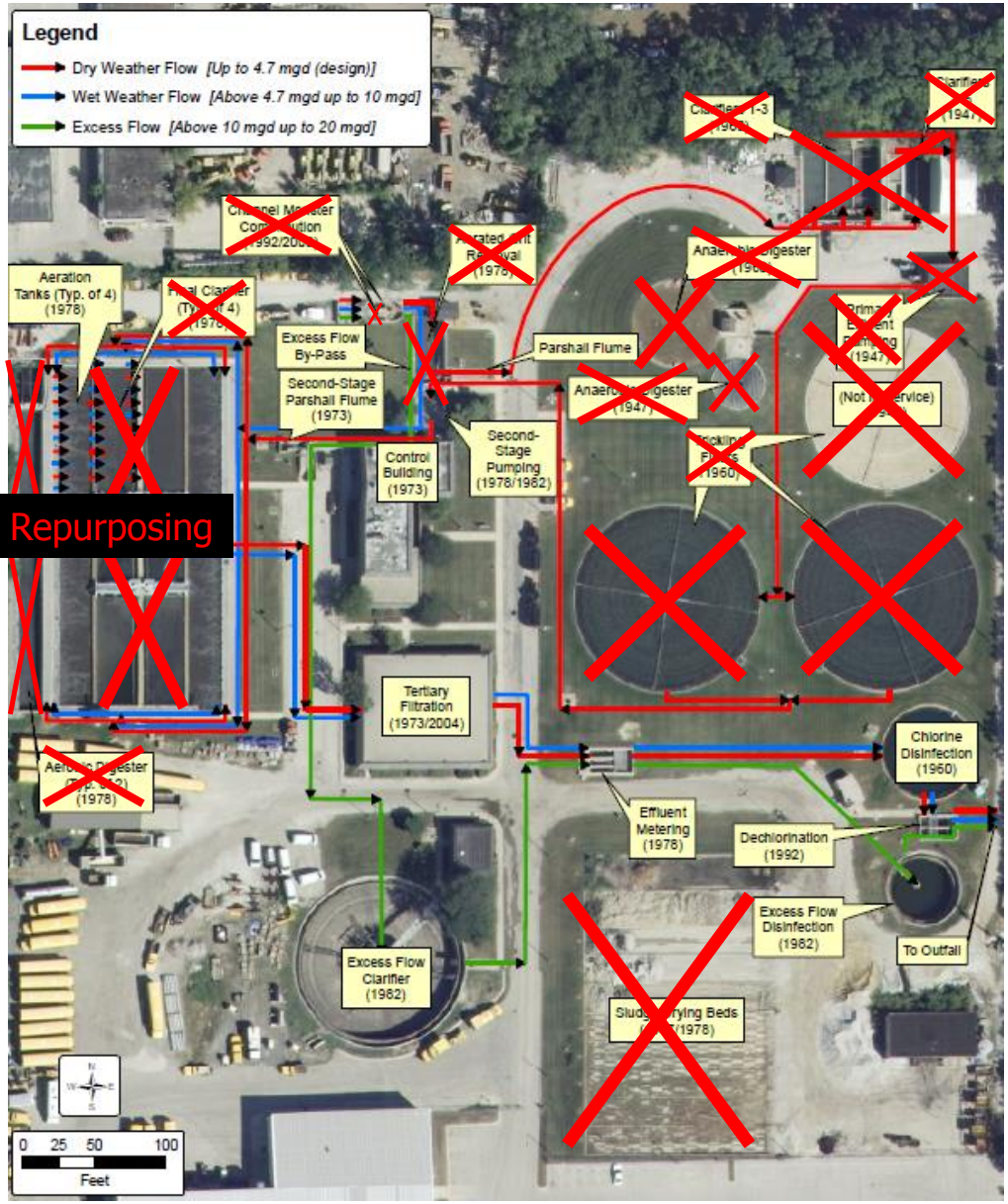
Major Challenges Overcome During Construction

- Taking Existing Processes Out of Service While Meeting Effluent Limits
- Extremely Tight Site
- Aeration Tank Modifications in Multiple Stages
- Underground Utilities/Site Piping
- Influent Pumping Modifications

Existing Site Layout



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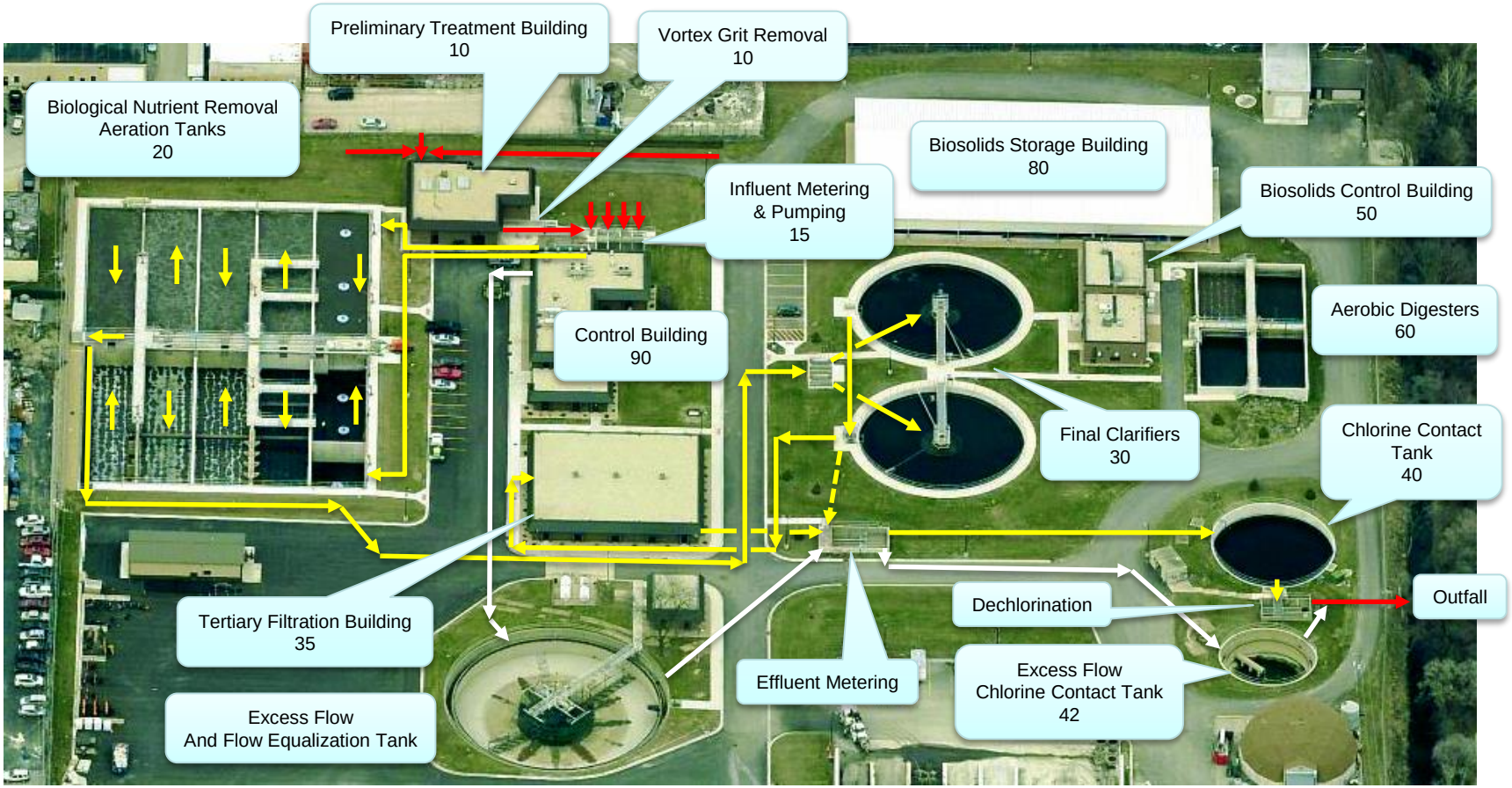
Bensenville WWTF Flow Schematic



Legend:
Total Flow (Normal and Excess Flows)
Normal Flows up to 12.0 MGD
Wet Weather Flows Above 12.0 MGD up to 30.0 MGD

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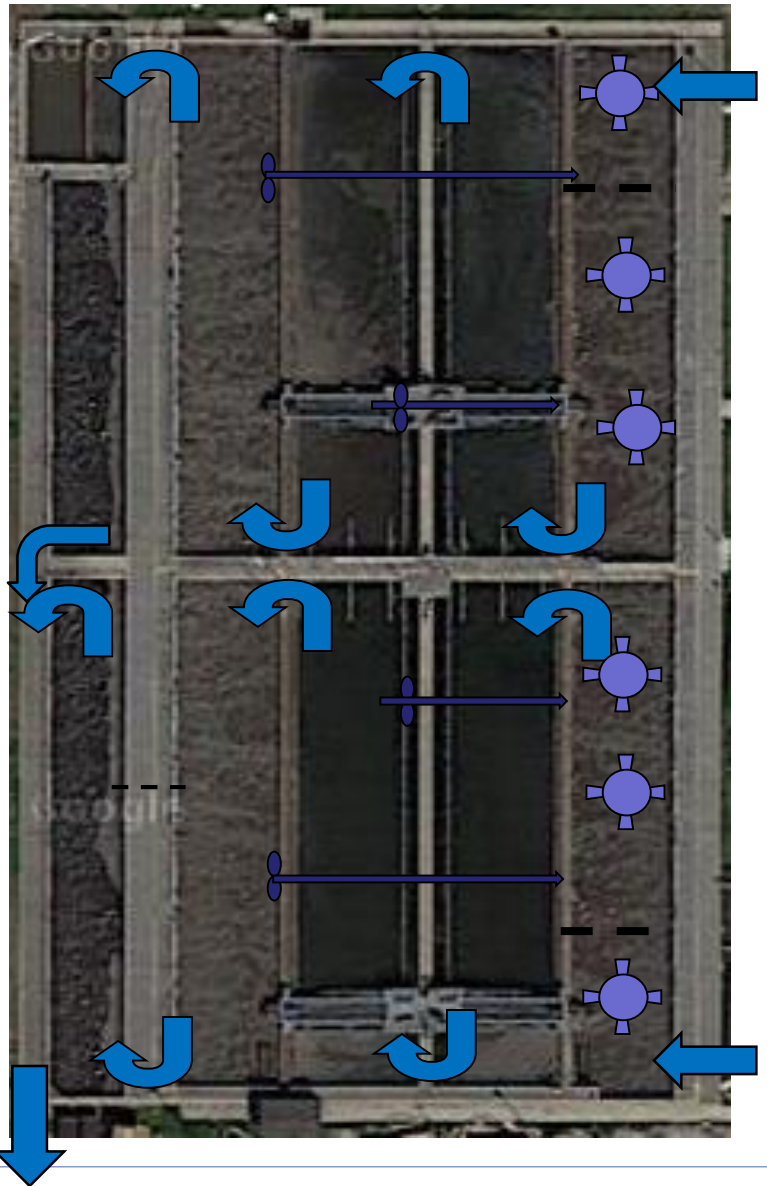
BNR Upgrades

- Biological Phosphorus Removal
  - AO or A2O Process
- Remove BOD and Ammonia
  - Plug Flow Operation
  - Fine Bubble Aeration/Turbo Blowers/DO/ORP Control
- Provide Flexibility
  - Take Tanks out of Service
  - Multiple Nitrate Recycle Pumping Locations
- Remove Nitrate
  - Energy Savings
  - Settling Characteristics
  - Nitrogen Removal
  - Alkalinity Restoration



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Start-up Training Timing

- Timing
  - Too Early = Limited Urgency
  - Too Late = Too Much Burden on Operator

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Start-up Operator Involvement

- Involvement
  - Too Much = Too Much Burden on Operator
  - Too Little = Lost Learning Opportunity

- Roles
  - Contractor
    - Construct
    - Coordinate
  - Engineer
    - Big Picture Training
    - Advocate for Owner
  - Manufacturer
    - Small Detail Training
  - Owner/Operator
    - Participation
    - Operation

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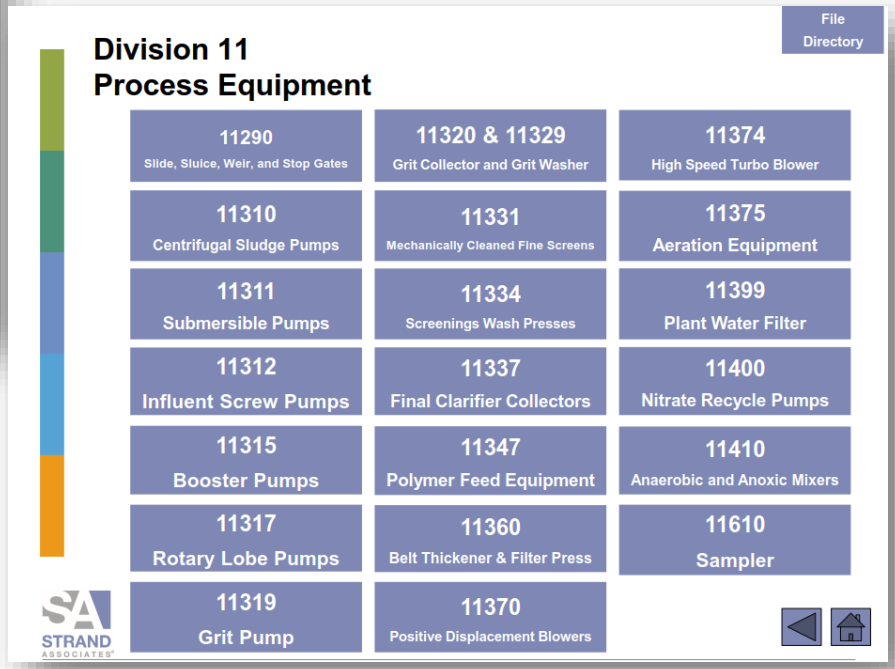
Contract Information Organized and Searchable

Simple Menus Navigate Information Categories

Links to Searchable PDFs Allow Quick Access



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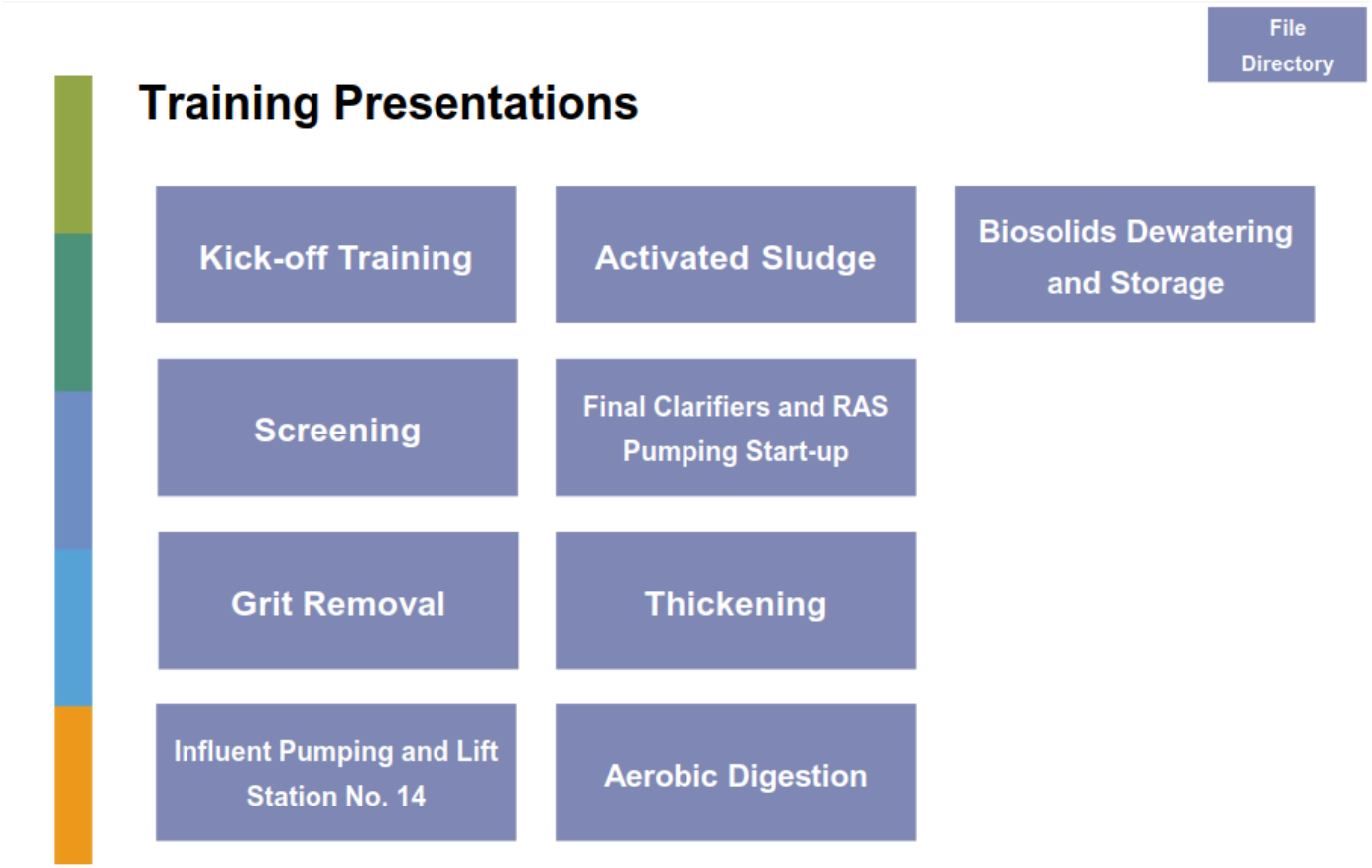
Training Modules Consistent with O&M Manuals



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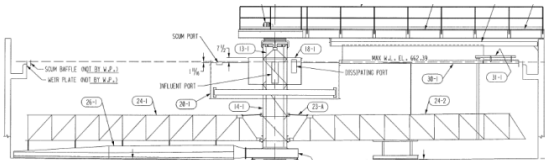
Kick-off Training

Outline

1. Strand Training/Startup Team
2. Contractor's Schedule
3. Process Overviews
4. Resources

Final Clarification – Manufacturer Conversations



Source – Walker Process Shop Drawing

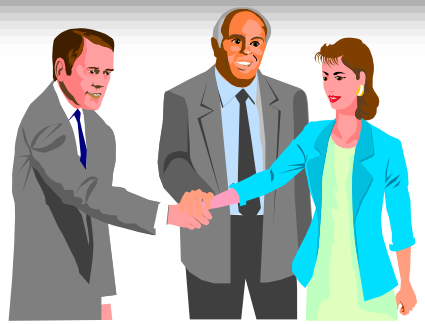
1. Lubrication
2. Preventive Maintenance
3. Clearances
   - Scum
   - Header
4. Manifold
5. Inspection
6. Winter Considerations

Database Development Provides Training Value

- Parameters
  - From Lab
  - From Field
  - From SCADA
  - Calculated
- Reports
  - Compliance
  - Operations
- Trends

Parameter List Development Prior to Building Database

	A	B	C	D	E	F
1		Variable Information				
2	Parameter Name	Process - Location	Parameter	Units	Equipment	Decimals TRD
3	Aeration Blower 1	Secondary Treatment	Run Time	hours	B-90-01	1
4	Aeration Blower 1	Secondary Treatment	Starts	Count	B-90-01	0
5	Aeration Blower 2	Secondary Treatment	Run Time	hours	B-90-02	1
6	Aeration Blower 2	Secondary Treatment	Starts	Count	B-90-02	0
7	Aeration Blower 3	Secondary Treatment	Run Time	hours	B-90-03	1
8	Aeration Blower 3	Secondary Treatment	Starts	Count	B-90-03	0
9	Aeration Combined ML 30 min SSV	Secondary Treatment				0
10	Aeration Combined ML 5 min SSV	Secondary Treatment				0
11	Aeration Combined F/M	Secondary Treatment	F/M	lbs BOD:lb MLVSS	CALCULATE	2
12	Aeration Combined Filament Abundance	Secondary Treatment				0
13	Aeration Combined MLSS	Secondary Treatment				0
14	Aeration Combined MLSS % Volatile	Secondary Treatment				2
15	Aeration Combined SRT (MCRT)	Secondary Treatment	SRT	Days	CALCULATE	1
16	Aeration North Anoxic 1 ORP	Secondary Treatment	ORP Average	mV	AIT-20-01	0
17	Aeration North Anoxic 1 ORP	Secondary Treatment	ORP Maximum	mV	AIT-20-01	0
18	Aeration North Anoxic 1 ORP	Secondary Treatment	ORP Minimum	mV	AIT-20-01	0
19	Aeration North F/M	Secondary Treatment				3
20	Aeration North Influent Flow	Secondary Treatment	Total	MG	CALCULATE	3
21	Aeration North Influent Flow	Secondary Treatment	Min	MGD	CALCULATE	3
22	Aeration North Influent Flow	Secondary Treatment	Max	MGD	CALCULATE	3
23	Aeration North ML 30 min SSV	Secondary Treatment		mls		0



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Operator Training Designed to Challenge Operators

Quiz Prior to Training Creates Challenge and Provides Feedback to Trainers

Pre-Quiz
Activated Sludge

1. Describe anaerobic conditions, anoxic conditions, and aerobic conditions.
   Anaerobic:
   Anoxic:
   Aerobic:

2. Describe biochemical oxygen demand (BOD) and how it's removed in the activated sludge process.
   BOD:

   Activated Sludge Process:

3. What is the purpose of biological nutrient removal (BNR) and nitrate recycle pumping?
   BNR:

   Nitrate Recycle Pumping:

4. During ideal biological nutrient removal, in which tank(s) should microorganisms release phosphorus (P) and which tanks(s) should phosphorus uptake by microorganisms occur?
   a. Release P in Anoxic Tank; uptake P in Anaerobic Tank
   b. Release P in Anaerobic Tank and Aerobic Tank; uptake P in Anoxic Tank
   c. Release P in Aerobic Tank; uptake P in Anaerobic Tank and in Anoxic Tank
   d. Release P in Anaerobic Tank; uptake P in Aerobic Tank

5. Circle True or False for each statement regarding nitrifying bacteria.
   T F - Nitrifiers reproduce at a rate faster than heterotrophic bacteria
   T F - Loss of alkalinity may inhibit complete nitrification
   T F - At lower temps, nitrifiers reproduce slower
   T F - Nitrifiers in the anoxic tank do not require oxygen for the nitrification process

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Operator Training Covered Details from Theory to Implementation

Blend of Theory and Site Specific Information

Denitrification Theory

- Denitrification

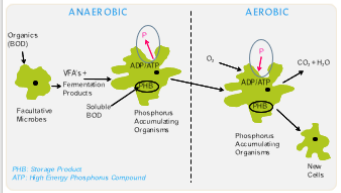
NO_3-N → Facultative Bacteria → N_2-N (to the atmosphere) + BOD_5

= + 2.9 lb O_2 /lb NO_3 - N

- Oxygen/Energy Recovery
  - Allowing denitrification to occur in controlled environments allows a facility to recover some of the aeration expense incurred during nitrification.

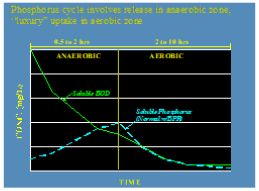
16

Biological Phosphorus Treatment



17

Biological P Removal - Theory

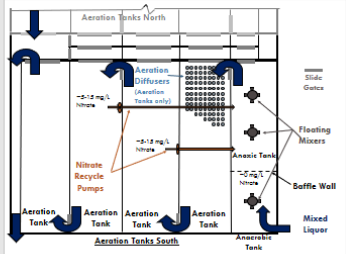


18

Biological P Removal - Principles

- Key Wastewater Characteristics
  - Influent Phosphorus Concentration
  - Influent BOD_5 Concentration
    - Fraction of Readily Biodegradable
  - BOD_5 to P Ratio
  - Influent TKN
  - Influent Volatile Fatty Acids (VFAs)

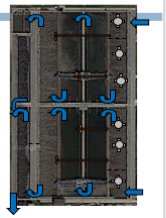
19



20

Aeration Tanks

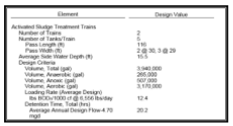
- Remove Phosphorus
  - Perform Biological Phosphorus Removal
- Remove Ammonia
  - Plug Flow: Serpentine Pattern
- Remove Nitrate
  - Energy Savings
  - Settling Characteristics
  - Nitrogen Removal
  - Alkalinity Restoration



21

Design Criteria

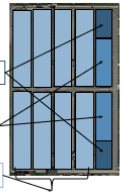
- See Table 5.2-2 of O&M Manual for all design criteria



22

Aeration Basin

- Number of Trains: 2
- Passes per Train: 5
- Total Volume: 3,940,000 gal
- Loading Rate
  - Daily Average:
    - 12.4 lb BOD/1000 cf at 6,556 lbs/day



23

Major Components

- Floating Mixers
  - Provides mixing to Anaerobic Tanks and Anoxic Tanks

Design Criteria	
Type	Floating
Number	Anaerobic Tank - 1 Anoxic Tank - 2
Motor	5 hp each

24

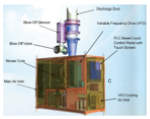
Major Components

- Nitrate Recycle Pump
  - Transfers ML from Aeration Tanks to Anoxic Tanks

Design Criteria	
Type	Propeller
Number	4
Motor	20 hp
Capacity	16,300 gpm

25

Major Components

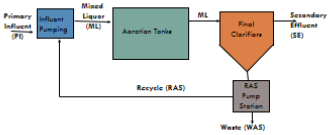


- Blowers
  - Provide air to aeration tanks

Design Criteria	
Type	High Speed Centrifugal
Number	2 + 1 standby
Motor	200 hp
Capacity	16,300 gpm
Minimum Air	

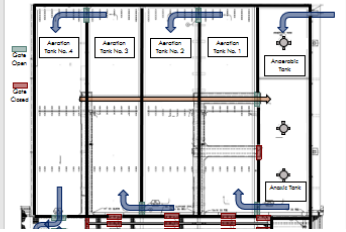
Operation

Routine Process Schematic



Routine Operation

- Influent Splitter Box and RAS Splitter Box
  - The RAS and PI flows are divided in their respective splitter boxes
  - The RAS and PI combine to form ML
    - RAS flow to combine to ML – controlled by Stop gates
    - PI flow to combine to ML – controlled by DOW gates
- During normal operation, flow should be evenly split to each treatment train from the influent splitter box



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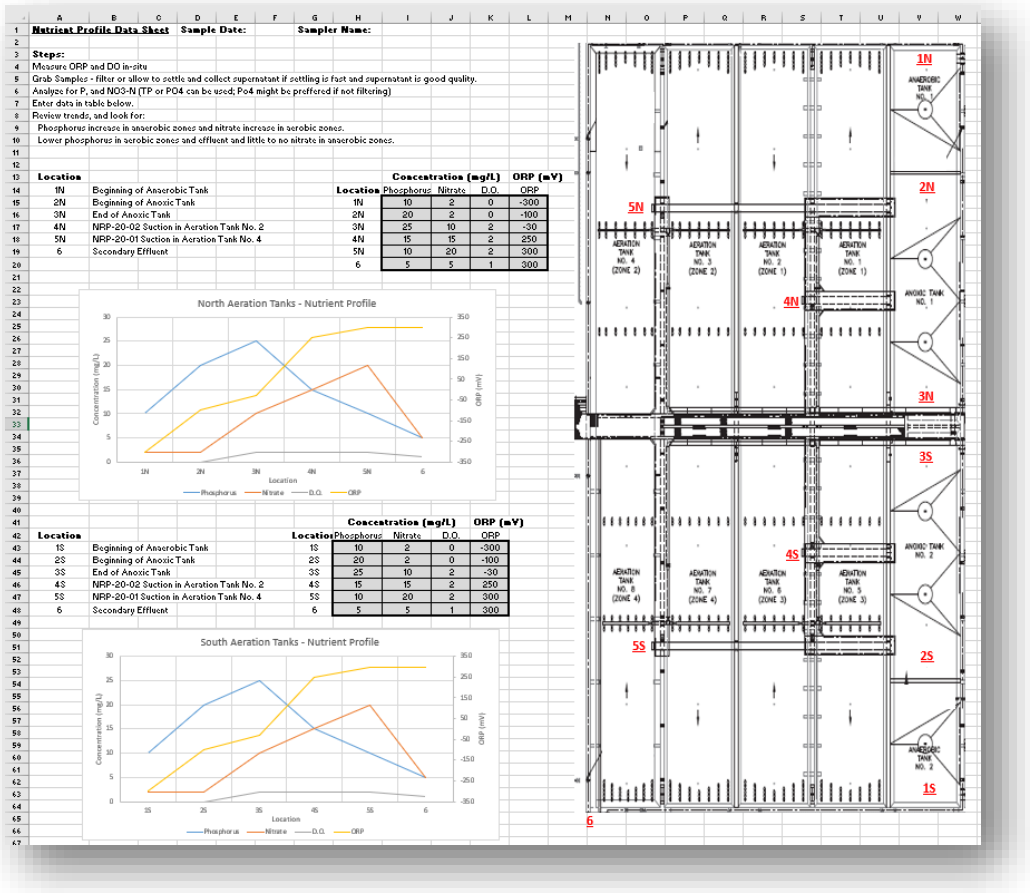
Operator Training Continues During Operations

- Parameters
  - Phosphorus
  - Nitrate
  - Dissolved Oxygen
  - Oxidation Reduction Potential

Image of Tool Built to "Profile" BNR System to Characterize Each Intended Environment



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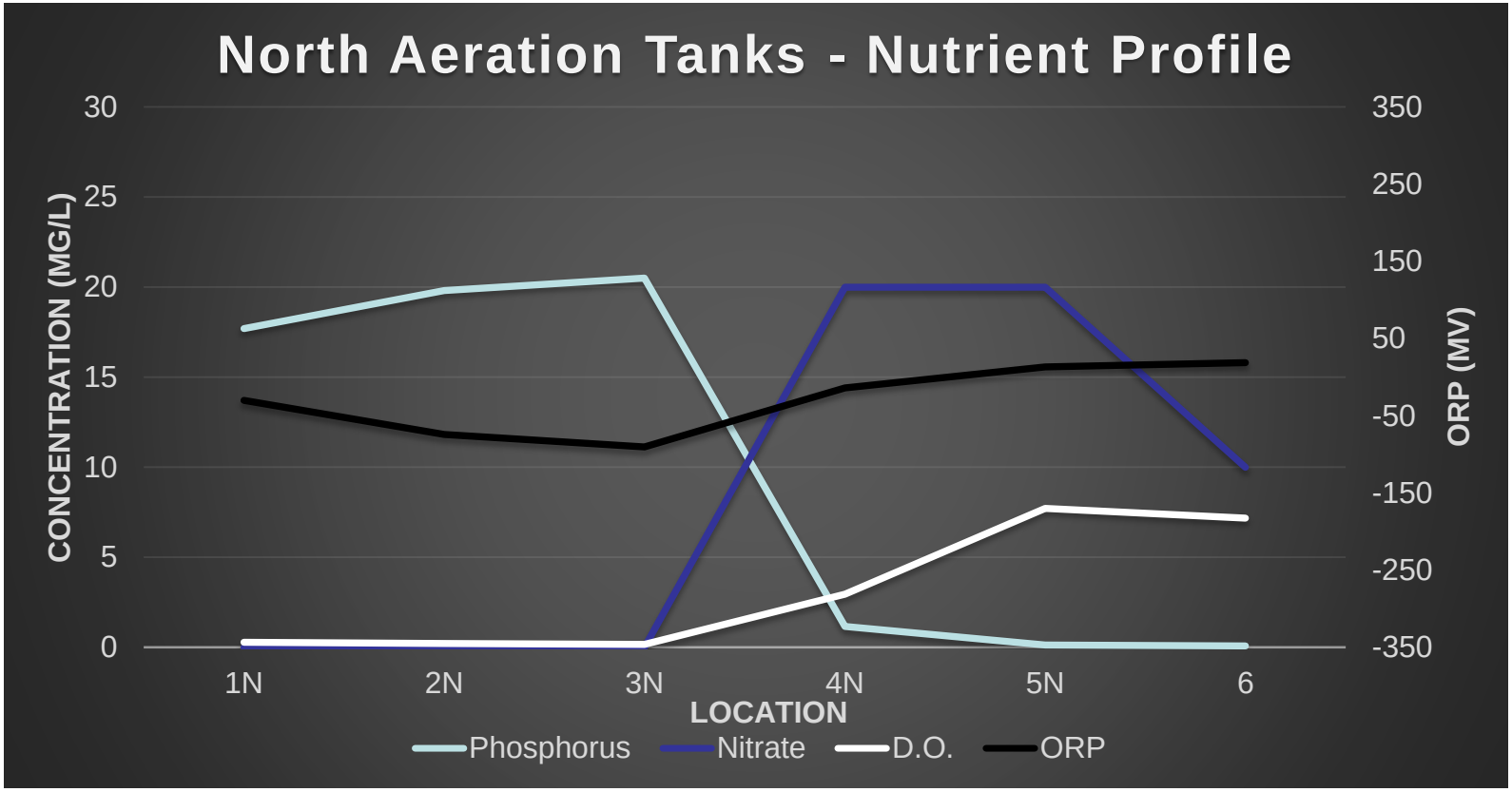
Operator Training and Optimization Continues During Operations



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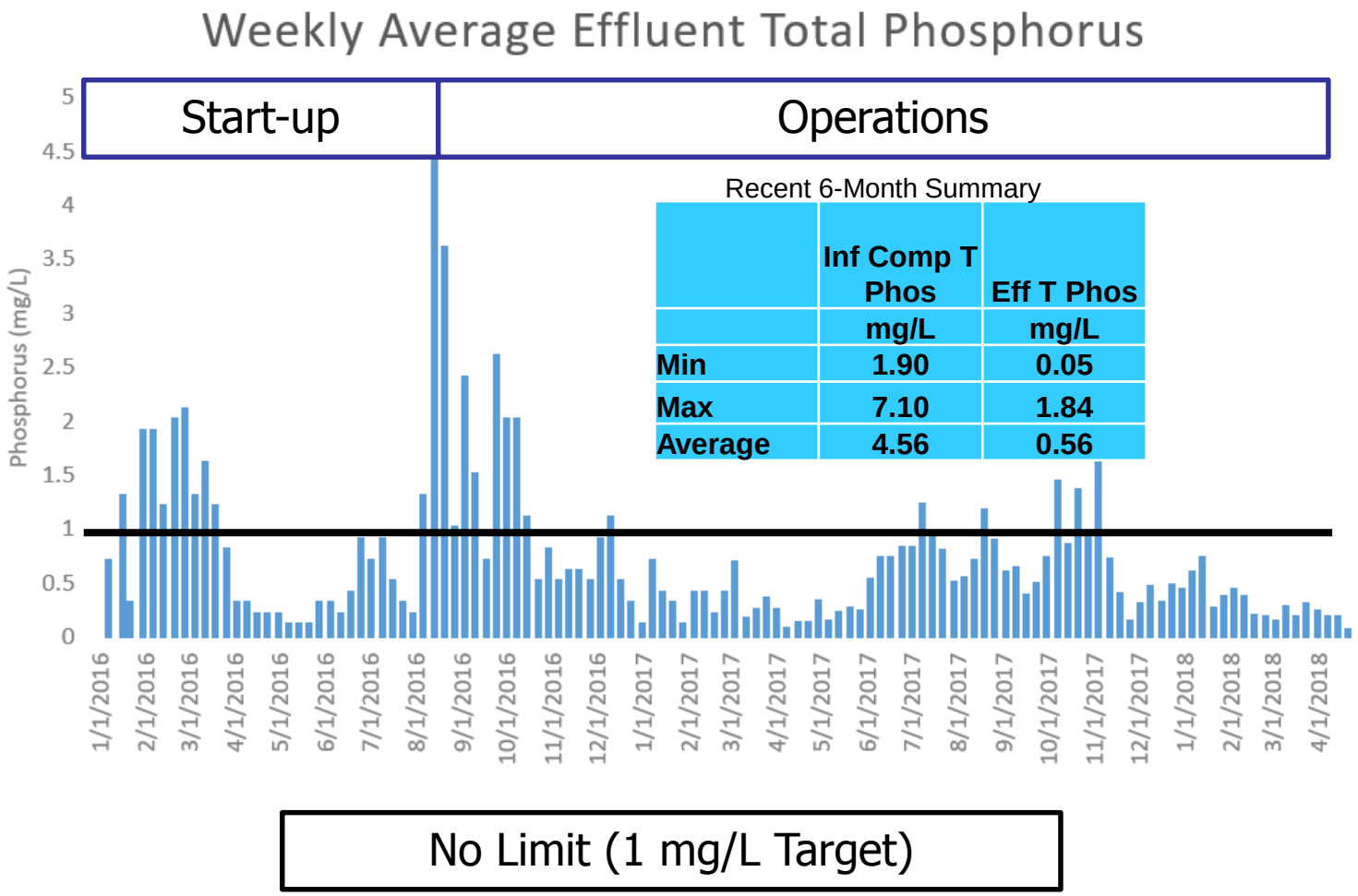
Early Operation Learning Opportunities



Recent 6-Month Summary

	Inf Comp T Phos	Eff T Phos
	mg/L	mg/L
Min	1.90	0.05
Max	7.10	1.84
Average	4.56	0.56

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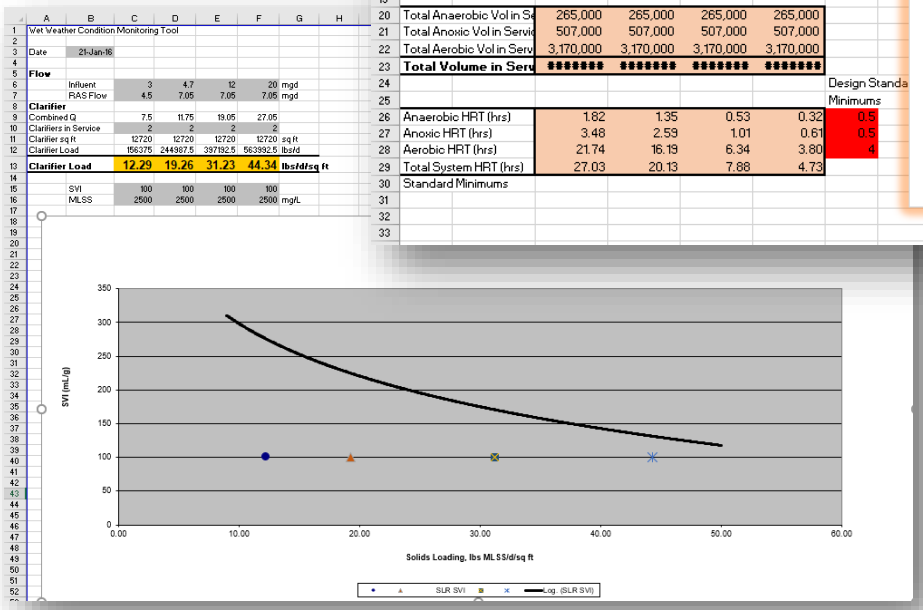
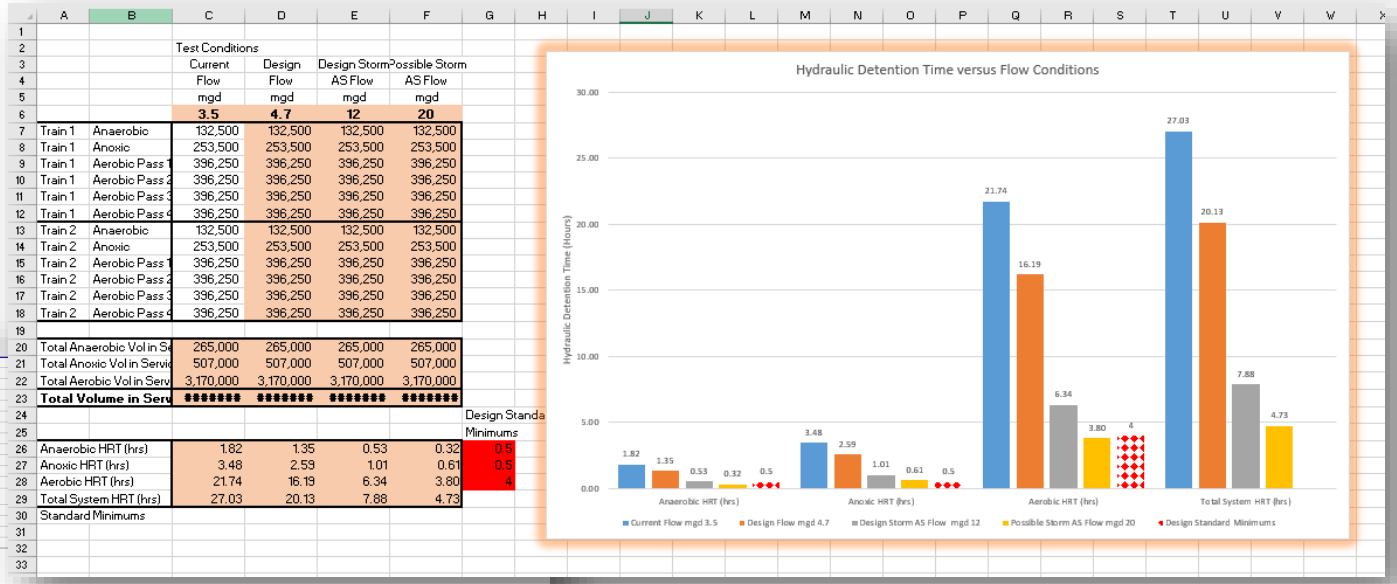
Wet Weather Workshops Developed Strategies Based on Capacity Fundamentals





			Test Conditions			
			Current Flow	Design Flow	Design Storm AS Flow	Possible Storm AS Flow
			mgd	mgd	mgd	mgd
			3.5	4.7	12	20
Train 1	Anaerobic		132,500	132,500	132,500	132,500
Train 1	Anoxic		253,500	253,500	253,500	253,500
Train 1	Aerobic	Pass 1	396,250	396,250	396,250	396,250
Train 1	Aerobic	Pass 2	396,250	396,250	396,250	396,250
Train 1	Aerobic	Pass 3	396,250	396,250	396,250	396,250
Train 1	Aerobic	Pass 4	396,250	396,250	396,250	396,250
Train 2	Anaerobic		132,500	132,500	132,500	132,500
Train 2	Anoxic		253,500	253,500	253,500	253,500
Train 2	Aerobic	Pass 1	396,250	396,250	396,250	396,250
Train 2	Aerobic	Pass 2	396,250	396,250	396,250	396,250
Train 2	Aerobic	Pass 3	396,250	396,250	396,250	396,250
Train 2	Aerobic	Pass 4	396,250	396,250	396,250	396,250
Total Anaerobic Vol in Se			265,000	265,000	265,000	265,000
Total Anoxic Vol in Servi			507,000	507,000	507,000	507,000
Total Aerobic Vol in Serv			3,170,000	3,170,000	3,170,000	3,170,000
Total Volume in Seru			*******	*******	*******	*******
Anaerobic HRT (hrs)			1.82	1.35	0.53	0.32
Anoxic HRT (hrs)			3.48	2.59	1.01	0.61
Aerobic HRT (hrs)			21.74	16.19	6.34	3.80
Total System HRT (hrs)			27.03	20.13	7.88	4.73
Standard Minimums						

Design Standa
Minimums
0.5
0.5
4

Tools Developed to Review Wet Weather Impacts On Fundamental Control Indices Such as Detention Times and Solids Loading Rates

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Operator Standard of Care Added Great Value to Project

Staff Implemented Labels and Communication Tools

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Open House Ideas

Held Duck Races in Final Clarifier

Highlighted Other Public Works Departments

Invited Other Organizations

Staged Smaller Tour Groups

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Waterloo, Iowa

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Microthrix parvicella:

the bête noire (black beast) of filaments

"Microthrix parvicella, a gram positive, unbranched filament, can confidently be said to be the most troublesome filamentous bacterium in activated sludge"

- Elizabeth Seviour and Robert Seviour Australian microbiologists with the Biotechnology Research Centre at La Trobe University, Bendigo

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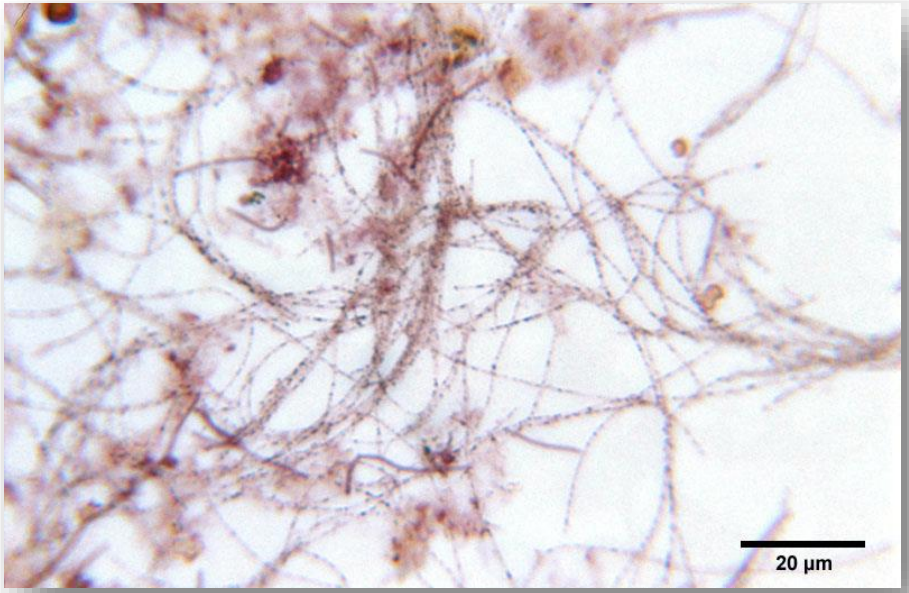
M. Parvicella Characteristics

- Associated with
  - Low F:M Ratios
  - High Fat and Grease
  - Low Temperatures
  - Selectors



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Aesthetics

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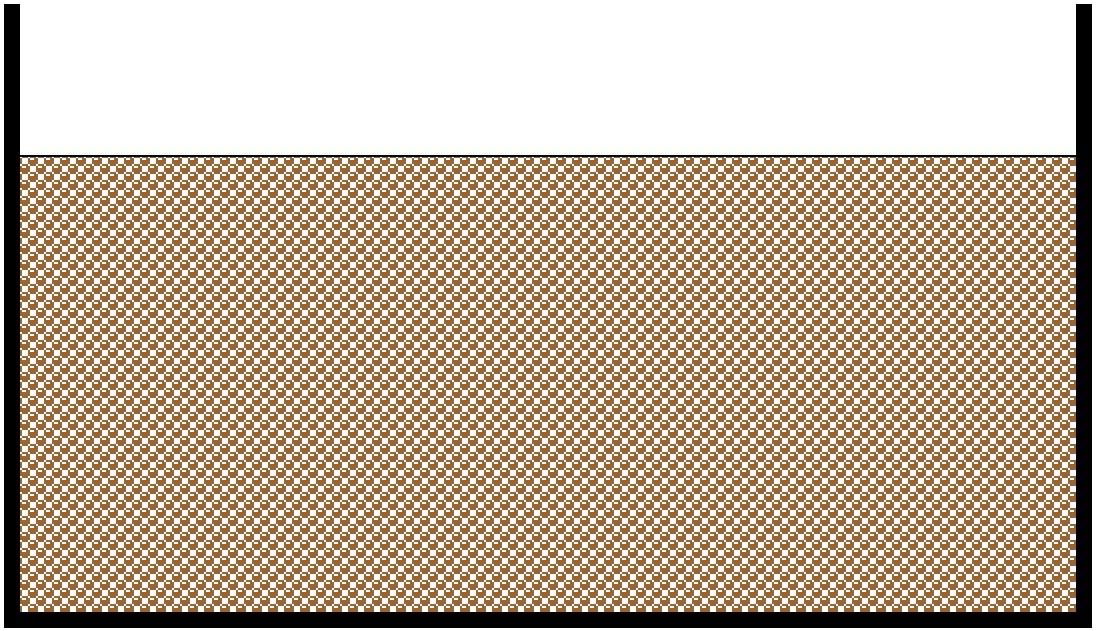
Inventory Management



Aeration Tank

Profile View

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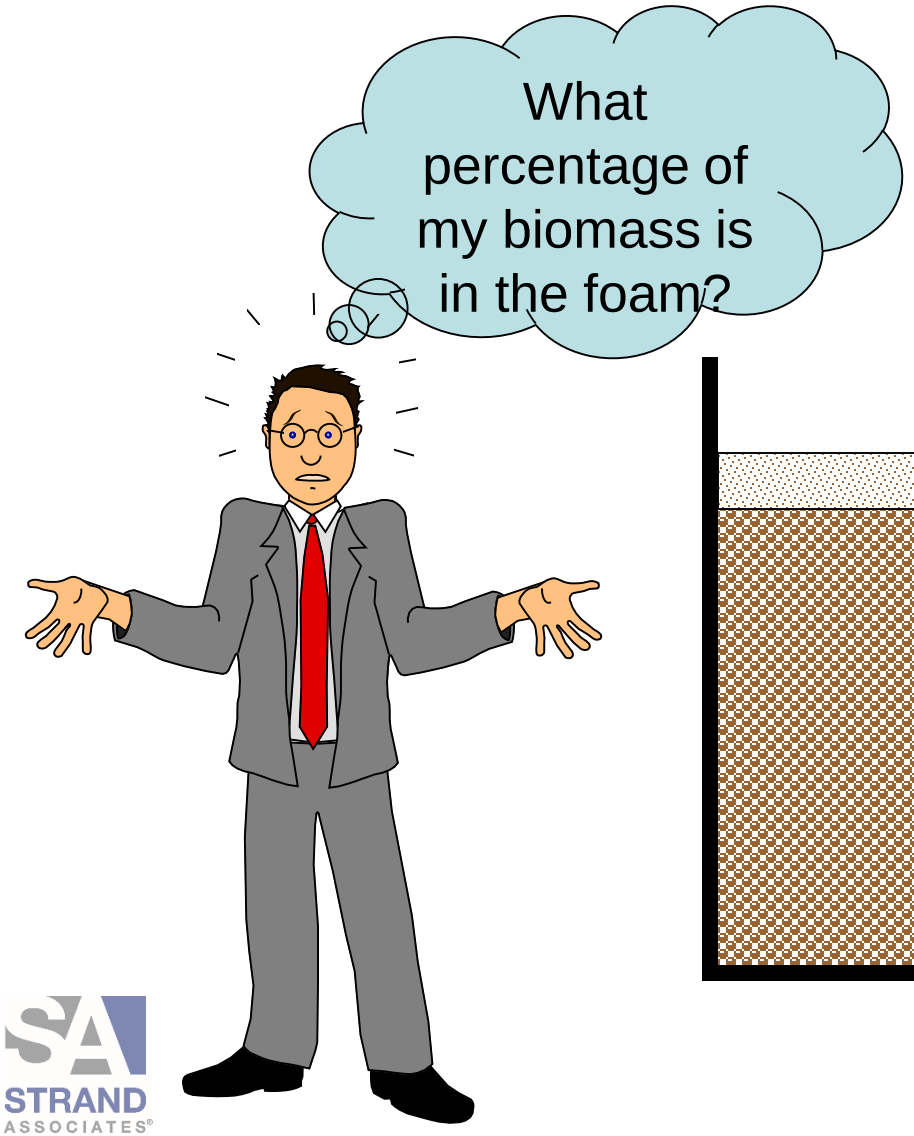
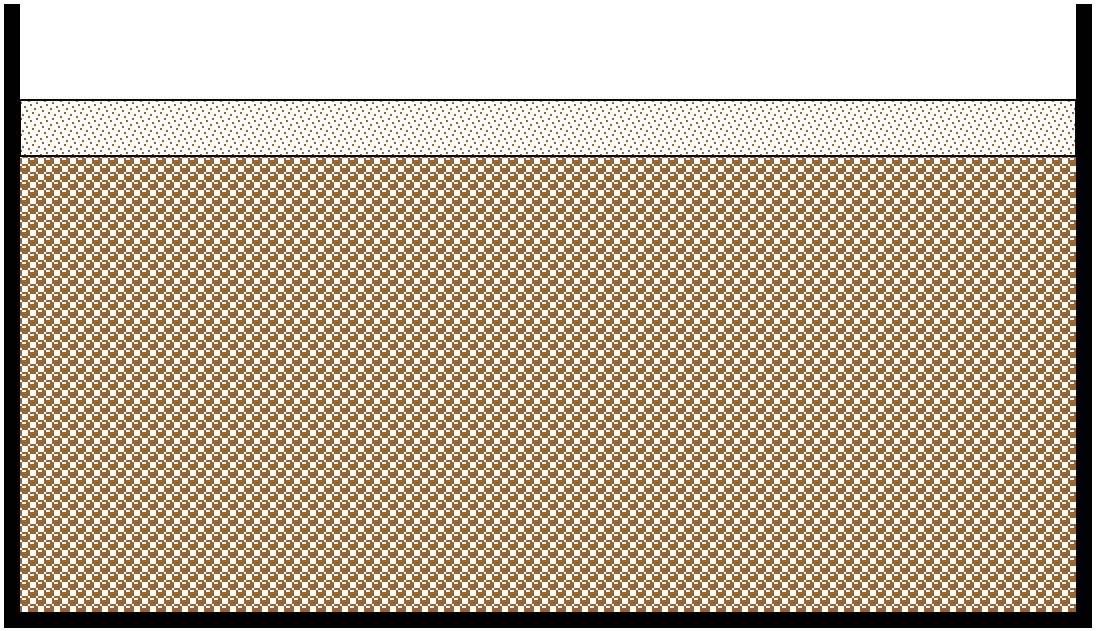
Inventory Management





Aeration Tank

Profile View

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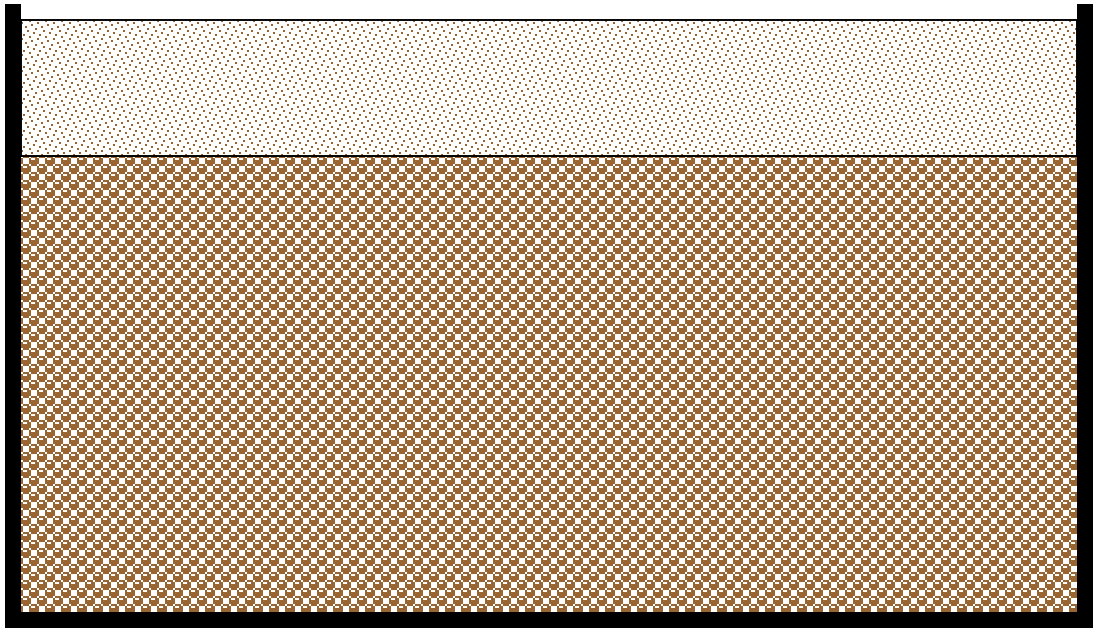
Inventory Management



Aeration Tank

Profile View

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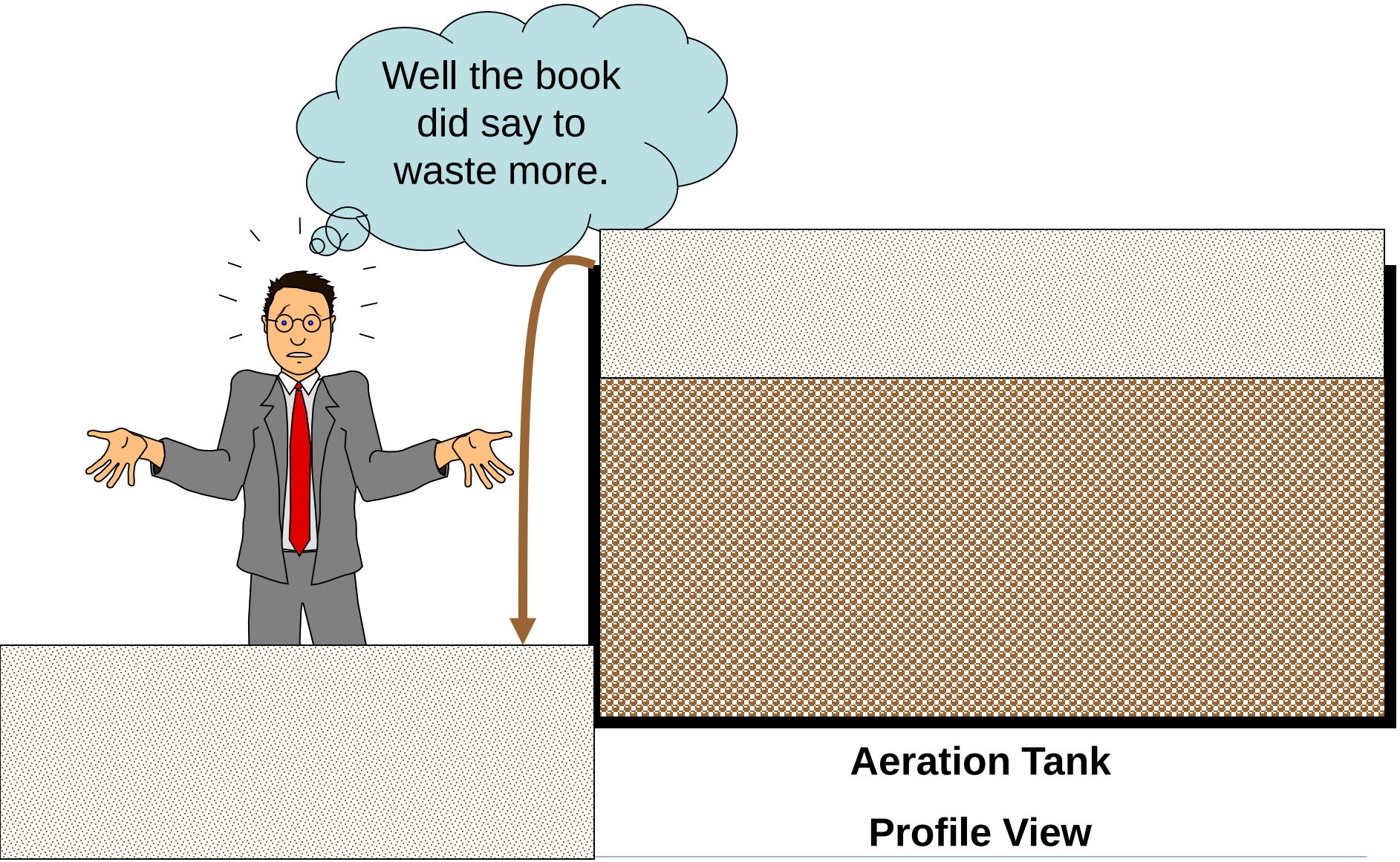
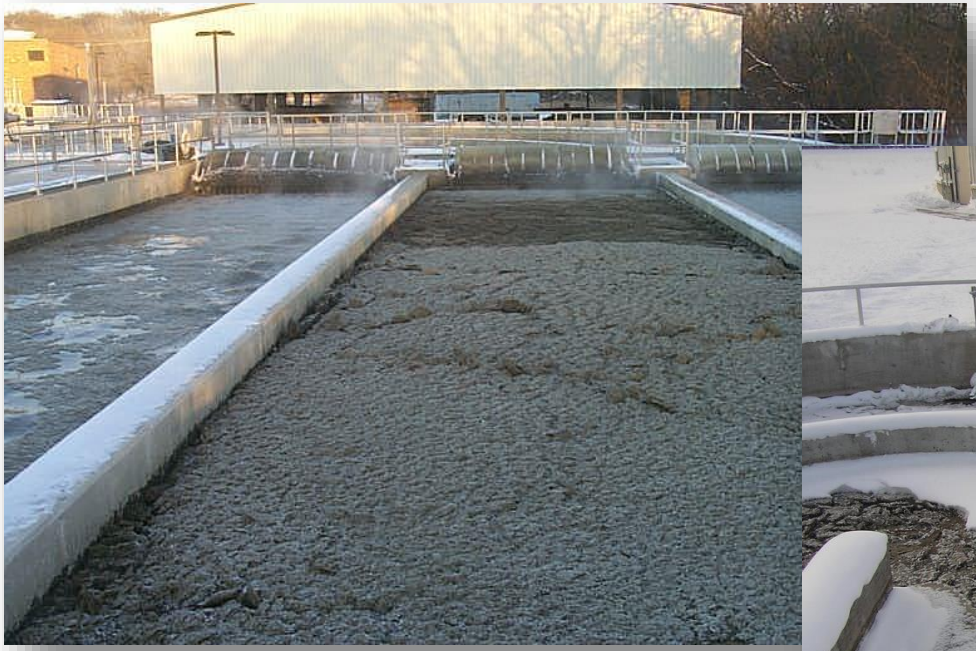
Inventory Management



Freezing Concerns



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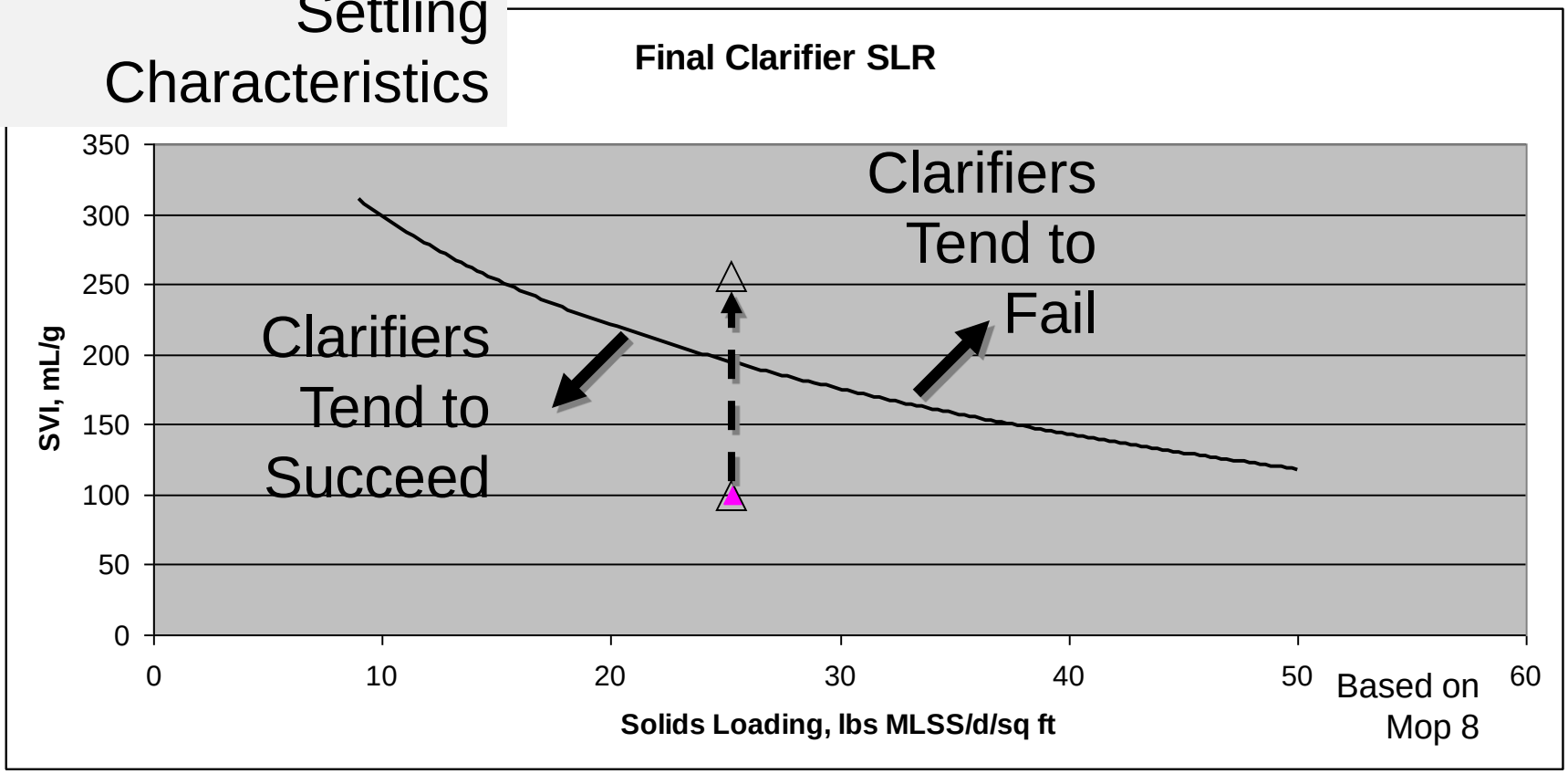
Settleability/Capacity Limitation

Clarifier Capacity is Impacted by Settling Characteristics



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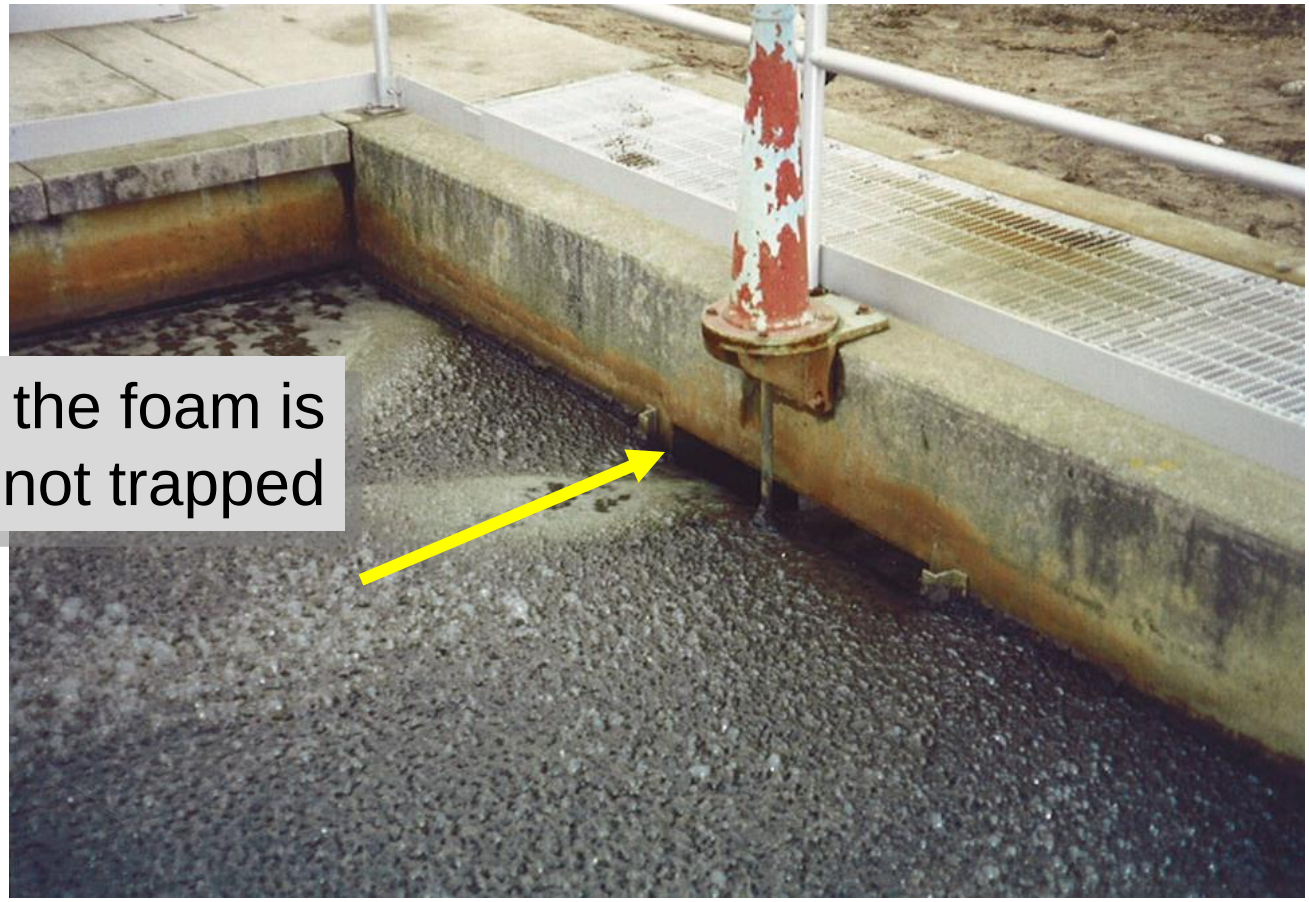
Foam Trapping



At least the foam is not trapped

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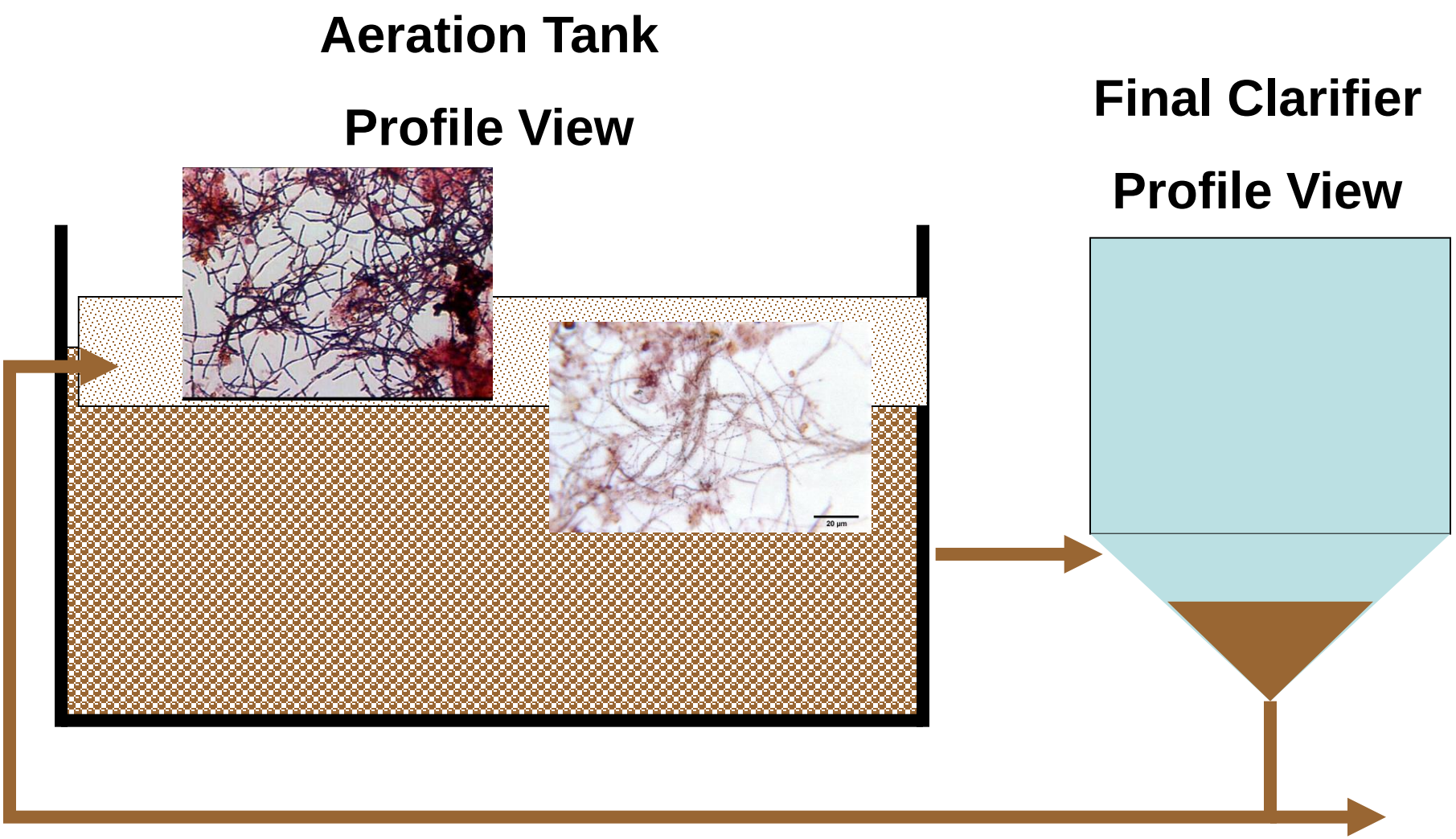
Foam Trapping



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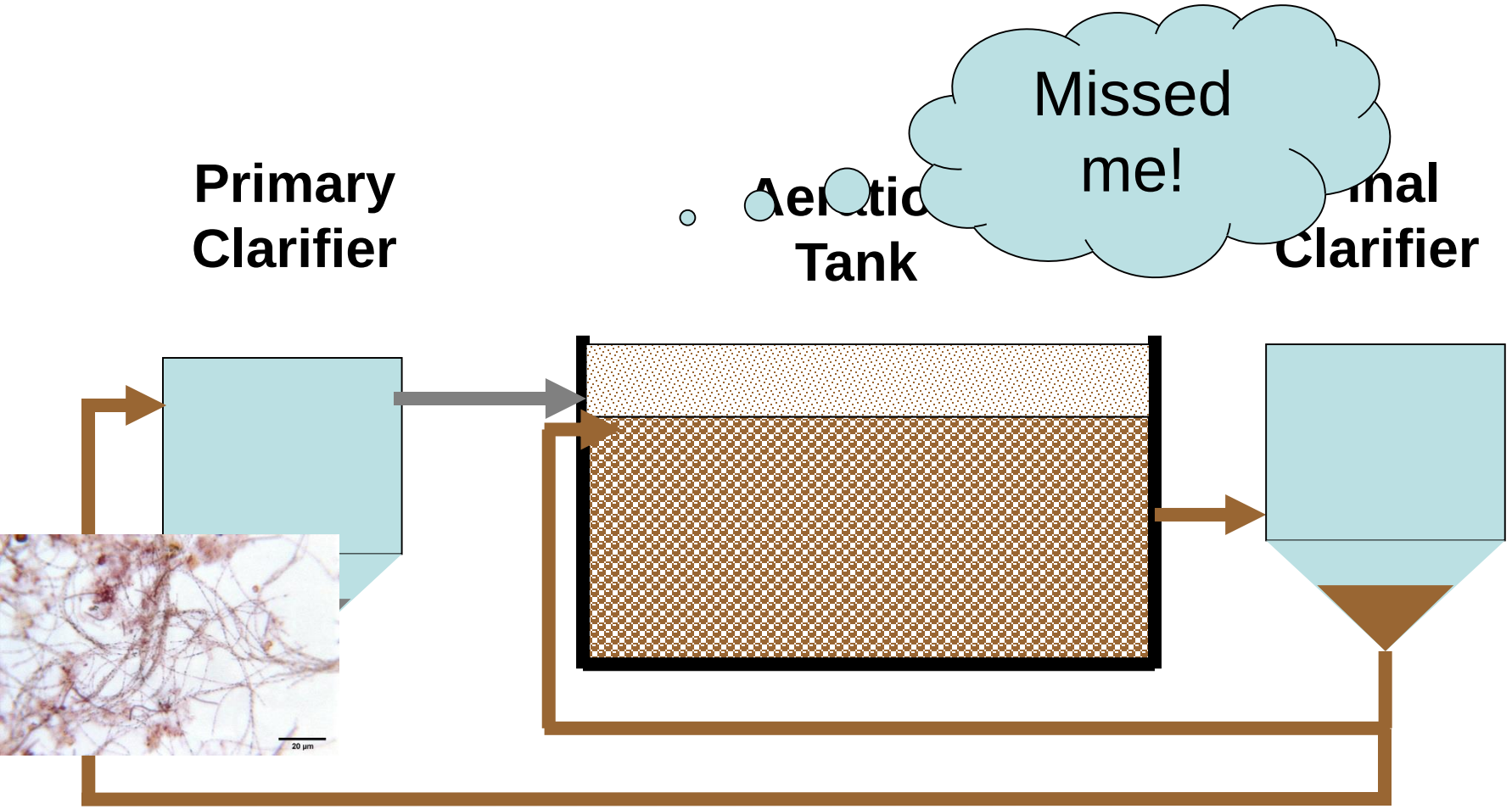
Foam Trapping – Co-Thickening



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Inventory Control and Sludge Age Impacts Foaming Filaments

- Conventional Wisdom and Experience Indicate Sludge Age to be a Factor
  - Higher sludge ages allow slower growing filaments to compete
    - 12 days is a divide at some facilities

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Countering the Triggers

- Eliminate Foam Trapping
- Control F.O.G.
- Reduce Sludge Age
- Provide Plug Flow Features for all zones
- Avoid low D.O. Zones
- Consider Chemical Treatment

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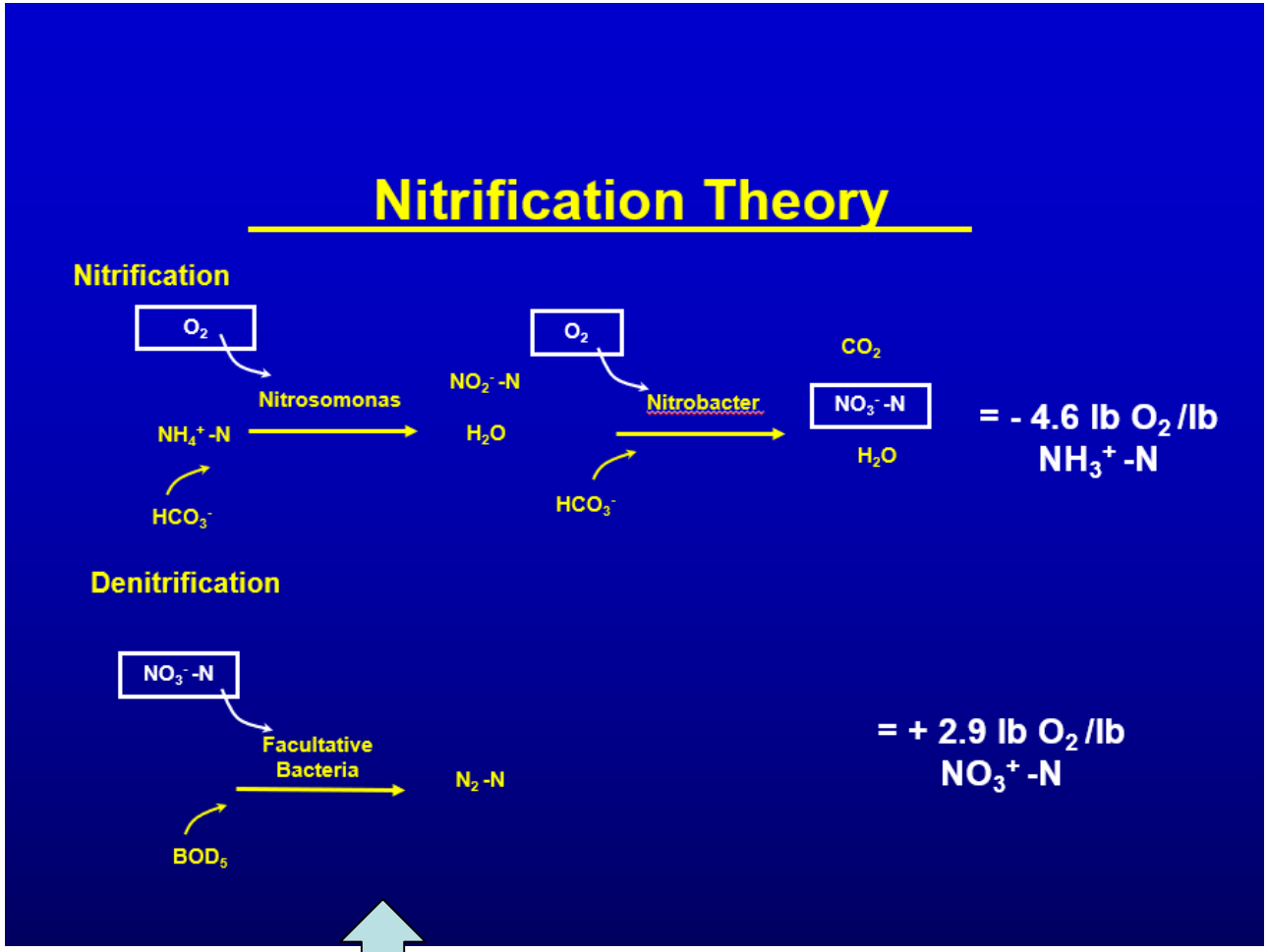
Fundamental: Alkalinity Impacts Nitrification

- pH/ Alkalinity
  - Nitrifiers are pH sensitive (best 7.5 - 9, can nitrify down to 4.5)
  - Bicarbonate alkalinity is needed for a carbon source (7.14 mg Alk./ mg NH_3 nitrified)
  - Significant changes in pH can be toxic to nitrifiers or inhibit their ability to completely nitrify
  - Loss of alkalinity may inhibit complete nitrification

Fundamental: Nitrification and Denitrification – Historical Theory



Air Mixing Hinders Denitrification

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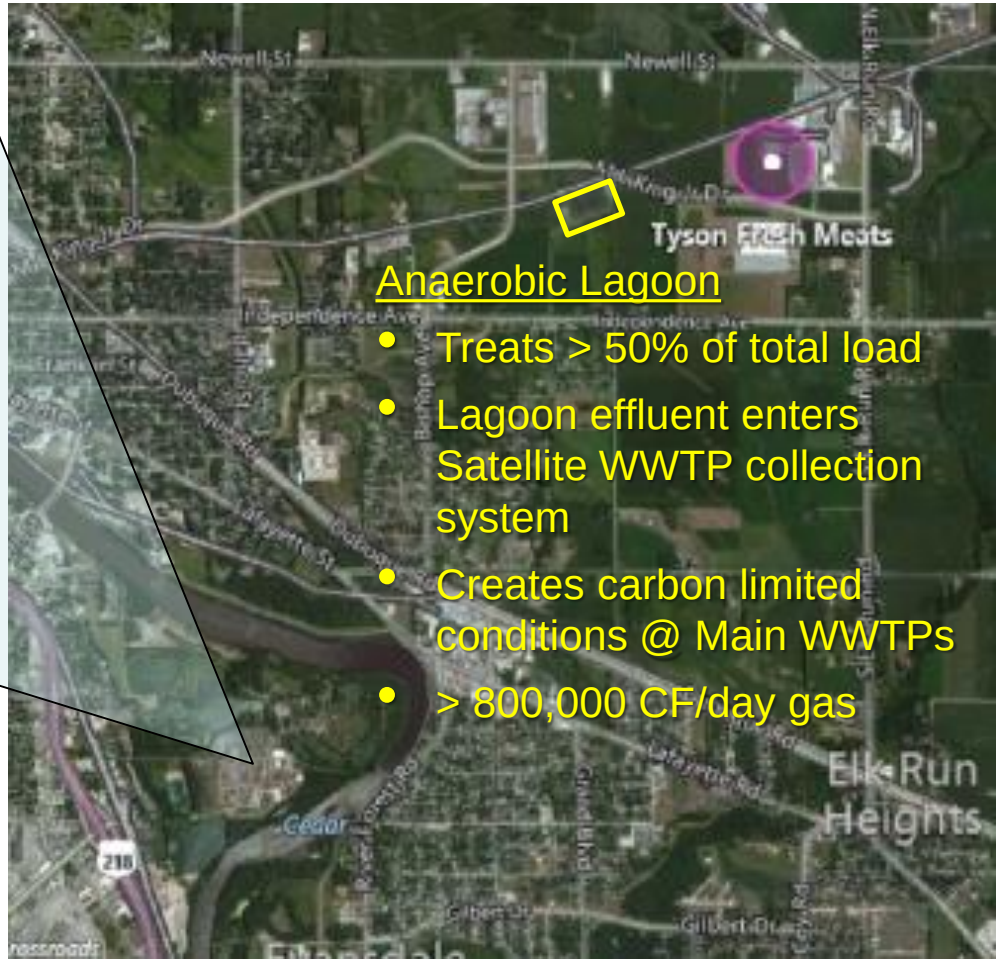
Waterloo Wastewater Facilities Includes Two Main WWTPs and Off-site Anaerobic Lagoon

Main WWTFs

- Easton WWTP (domestic)
- Satellite WWTP (industrial)



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Two Separate Biological Units
Easton & Satellite

Satellite Facility
Designed to Accept
Designated Industrial
Waste only

Easton Facility
Designed to Accept
Domestic and Minor
Industrial Waste only

Current Mode of Operation was
To Combine the Waste and Treat
Only Thru the Easton Facility

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Existing WWTP Design Criteria

	Easton	Satellite	Combined
Design Flow			
Annual Average	20.4	6.7	27.1
Average Wet Weather	26.7	8.1	34.8
Peak Flow to Biological Treatment	36.0	11.1	47.1
BOD Loading			
Average Day	24,000	38,800	62,800
Maximum Month	30,000	58,000	88,000
TKN Loading			
Average Day	4,500	7,025	11,525
Maximum Month	7,500	13,550	21,050

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Treatment Capacity with Current Operation

	Current Value	Easton Plant Design	% of Easton Design Capacity
Combined Influent Flow, mgd			
Average Day	17.2	20.4	84%
Combined Influent Loads, lbs/day			
BOD_5	28,645	24,000	119%
TSS	33,114	18,000	184%
TKN	8,241	4,500	183%

Satellite influent contribution:

35% of BOD, 30% of TSS, and 60% of TKN

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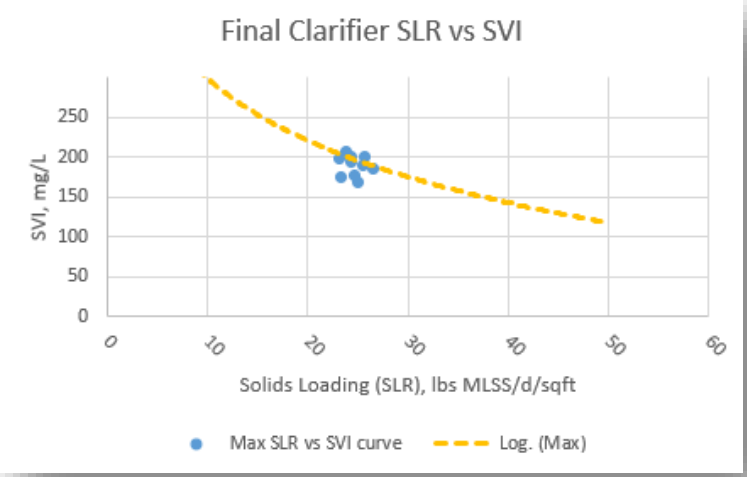
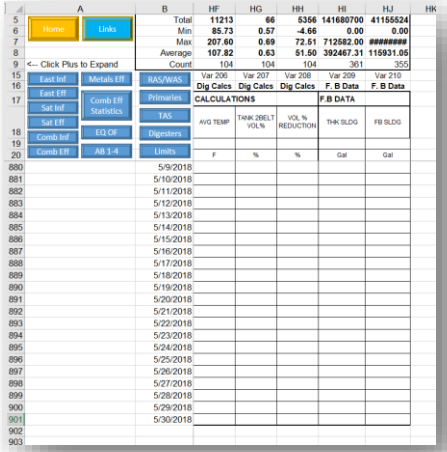
Challenges and Operational Responses





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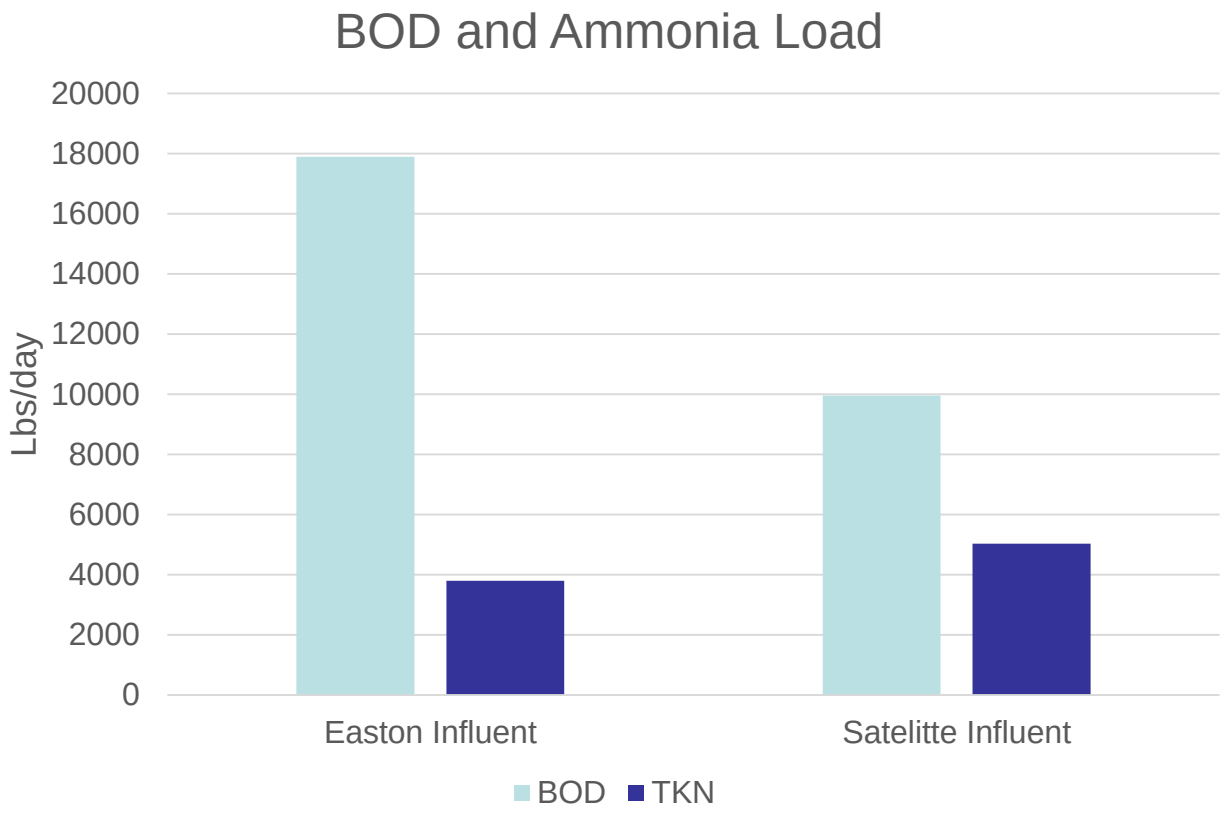
Challenge: Nitrogen Load Ratio High From Industrial Sector



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Challenge: Nitrification Alkalinity Demands Are Significant

- Nitrogen Load – Alkalinity Balance Fragile
- Denitrification Rate Impacted by:
  - BOD:N Ratio
  - Aerated anoxic zone
- SOP to monitor alkalinity and supplement magnesium hydroxide necessary at times
  - pH <6.6 Add Magnesium Hydroxide
  - Alkalinity Minimums

	Alkalinity
Units	mg/L
5/15/2017	250
5/16/2017	225
5/18/2017	175
5/21/2017	200
5/23/2017	160
5/25/2017	165
6/5/2017	115
6/6/2017	165
6/8/2017	100

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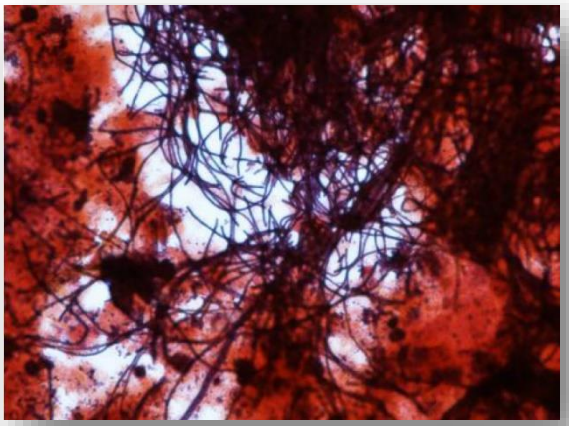
Challenge – Filaments: Microthrix



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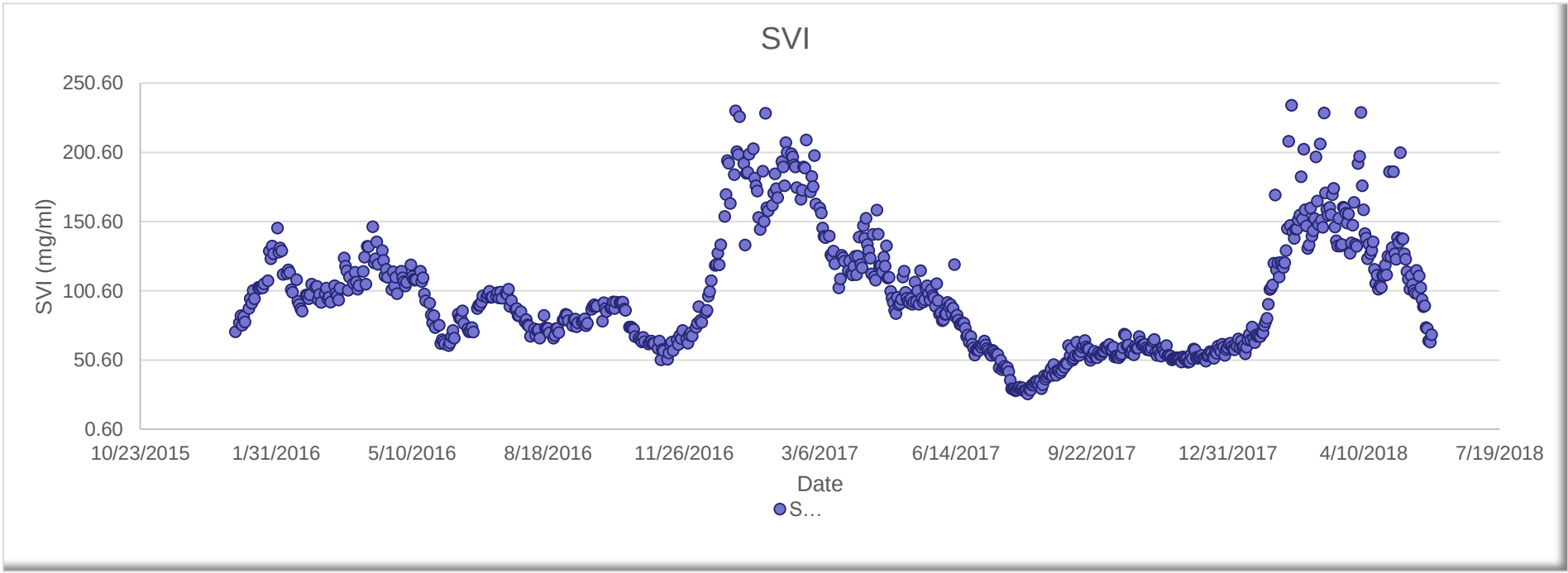
Settling Issues Occur in Winter



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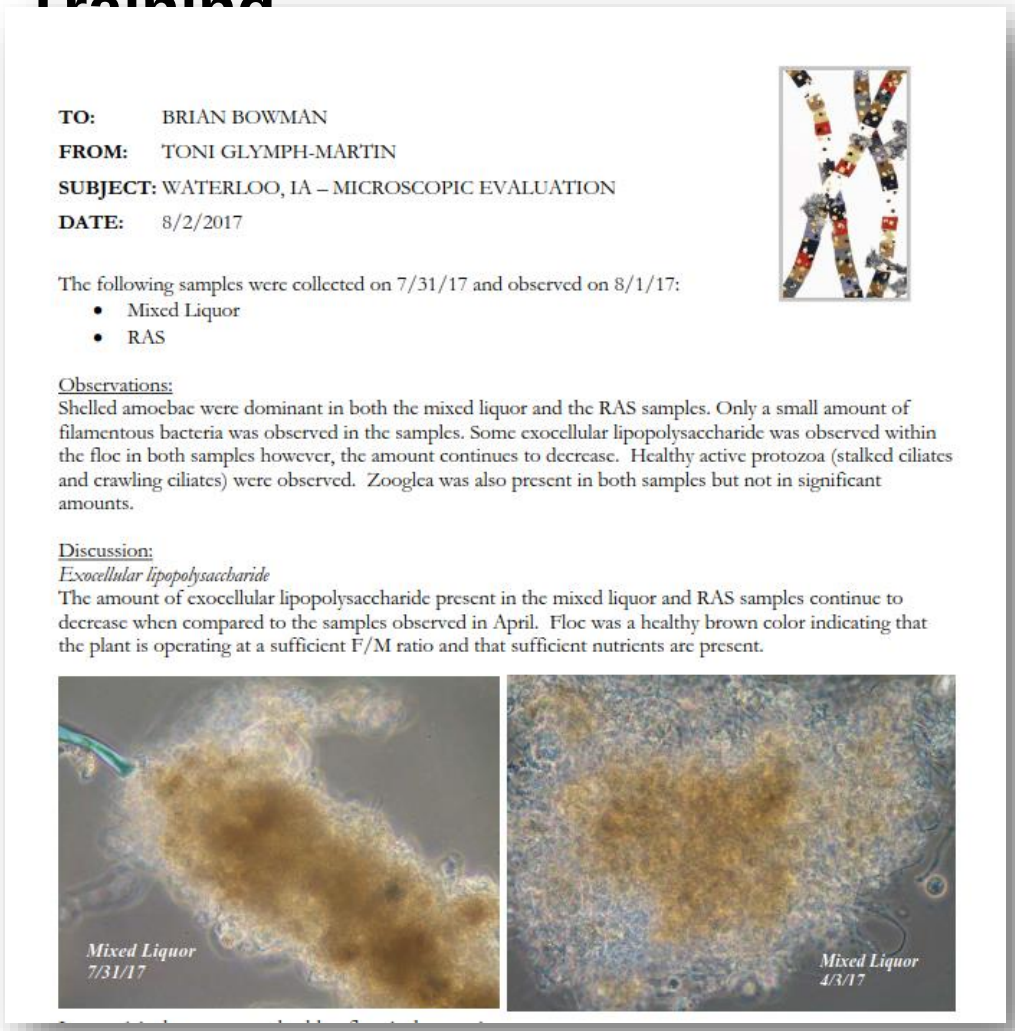
Operational Responses – Microscopy Assistance and Training



TO: BRIAN BOWMAN

FROM: TONI GLYMPH-MARTIN

SUBJECT: WATERLOO, IA – MICROSCOPIC EVALUATION

DATE: 8/2/2017

The following samples were collected on 7/31/17 and observed on 8/1/17:

- Mixed Liquor
- RAS

Observations:
Shelled amoebae were dominant in both the mixed liquor and the RAS samples. Only a small amount of filamentous bacteria was observed in the samples. Some exocellular lipopolysaccharide was observed within the floc in both samples however, the amount continues to decrease. Healthy active protozoa (stalked ciliates and crawling ciliates) were observed. Zooglea was also present in both samples but not in significant amounts.

Discussion:
Exocellular lipopolysaccharide
The amount of exocellular lipopolysaccharide present in the mixed liquor and RAS samples continue to decrease when compared to the samples observed in April. Floc was a healthy brown color indicating that the plant is operating at a sufficient F/M ratio and that sufficient nutrients are present.

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Operational Responses – Operational Adjustments

- Capacity in service
- Wasting rate sludge age based on filament elimination
- WAS decant
- FOG program continues to be a point of emphasis
- Lagoon management to equalize flows/loads as practical
- DO control an operator emphasis

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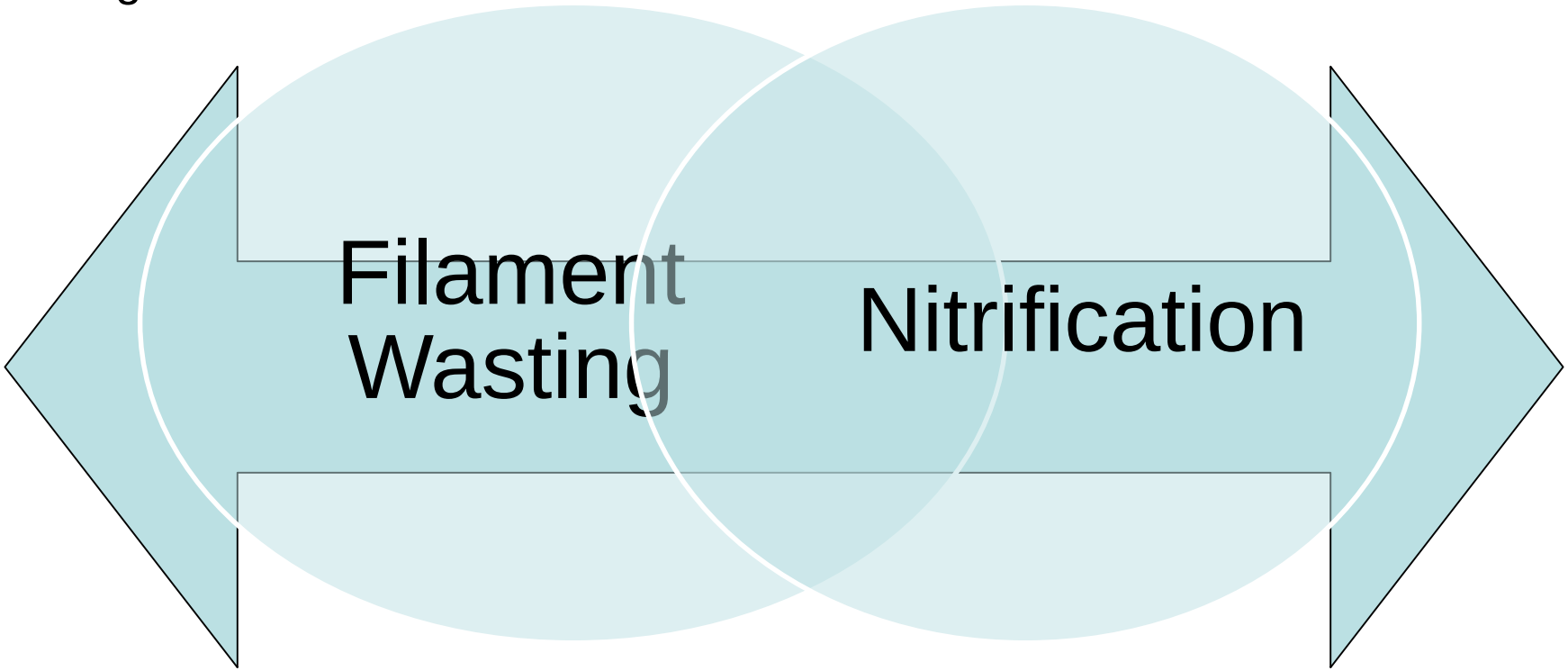
Nitrification and Filament Reduction have Different Ideal Sludge Ages

- Lower Benefits Filament Removal
- Higher Benefits Nitrification



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Nitrification and Filament Reduction have Different Ideal Sludge Ages

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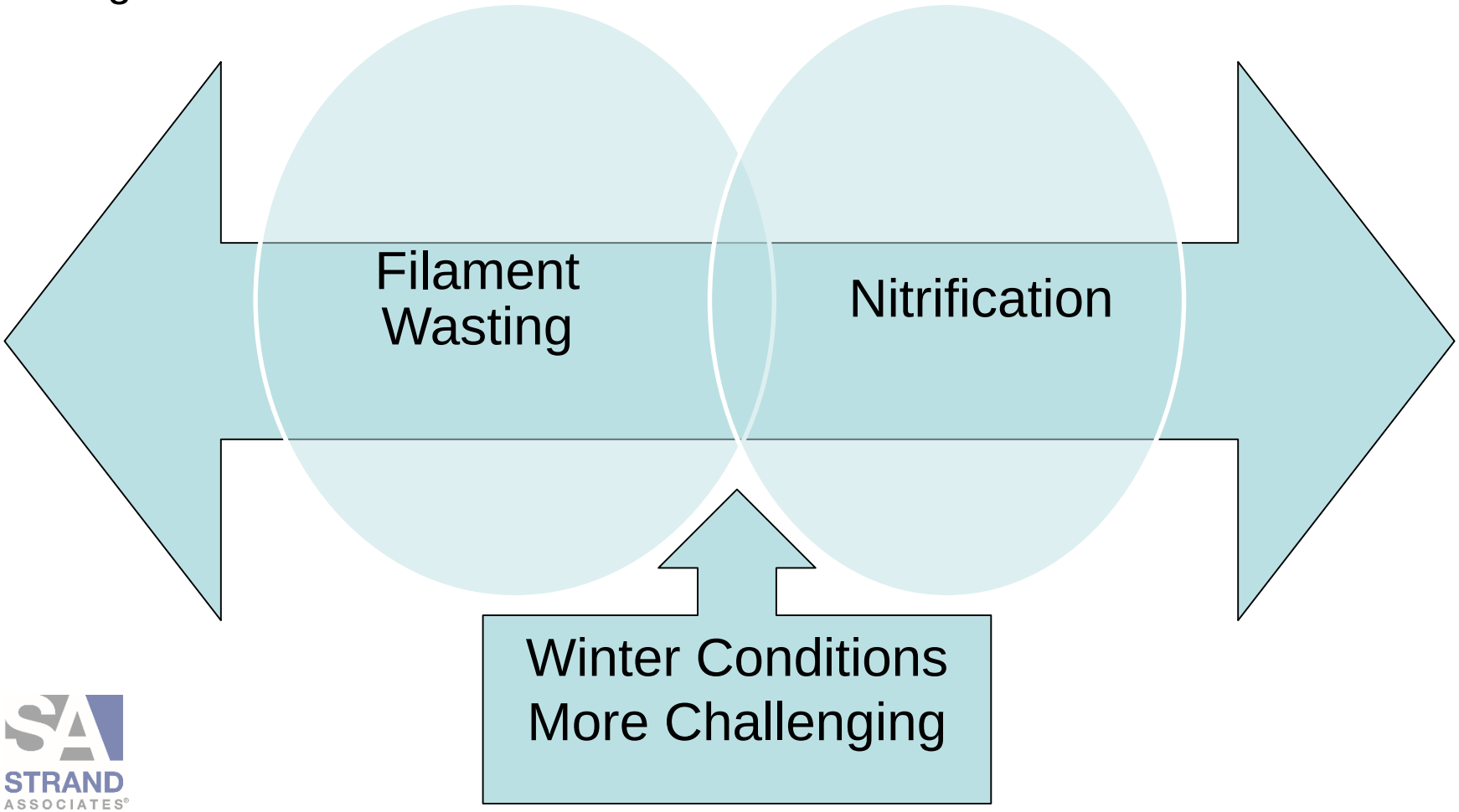

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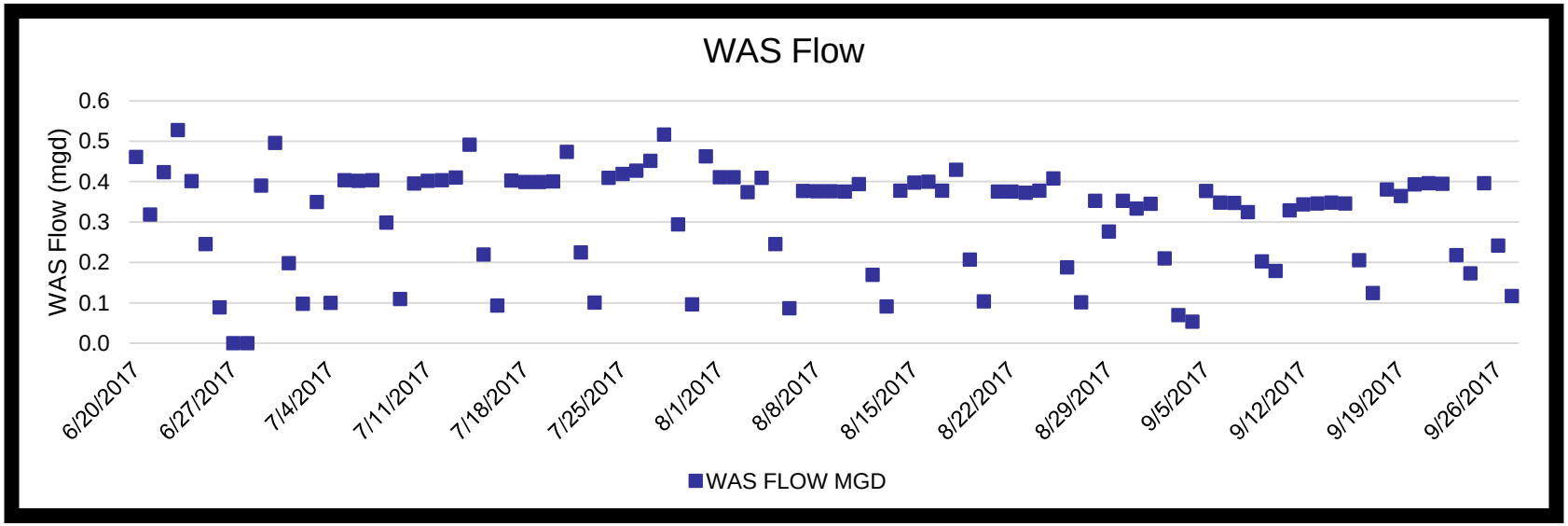
Challenge – Wasting Limitations



Current WAS Storage Limits Operations

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Operational Response: WAS Storage Tank Decant Automation

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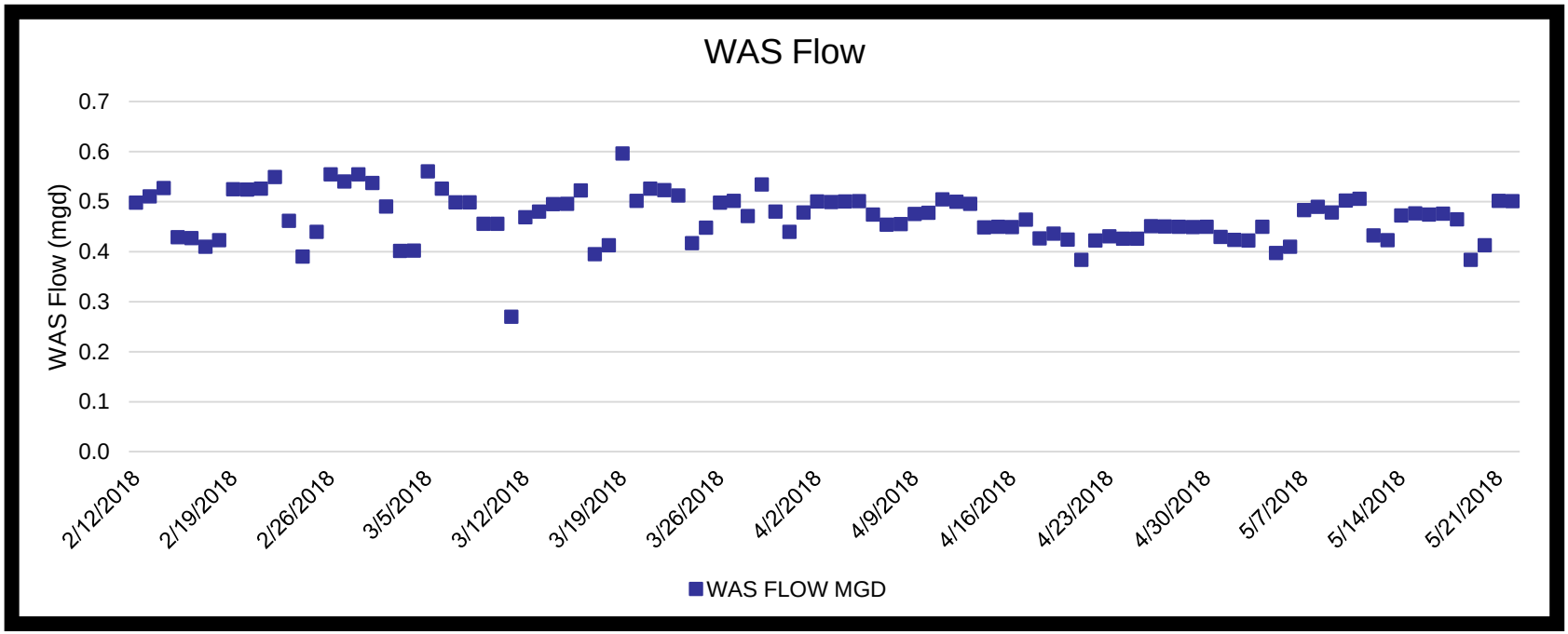
Operational Response: Weekend Wasting a Priority



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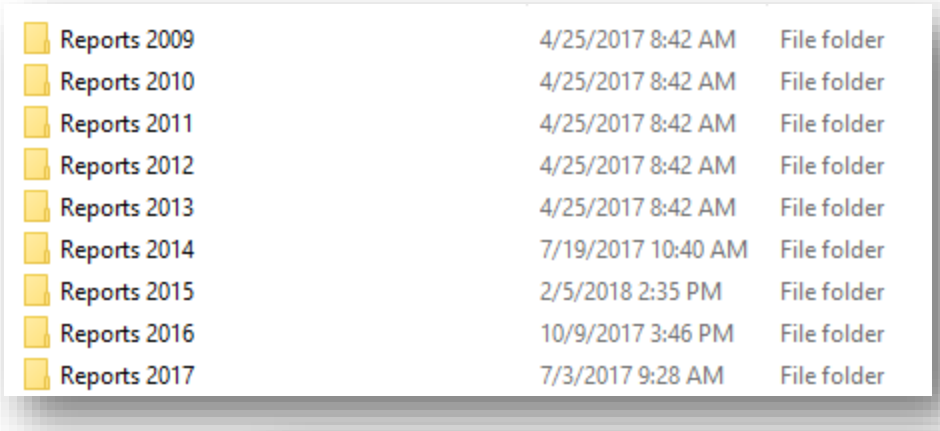
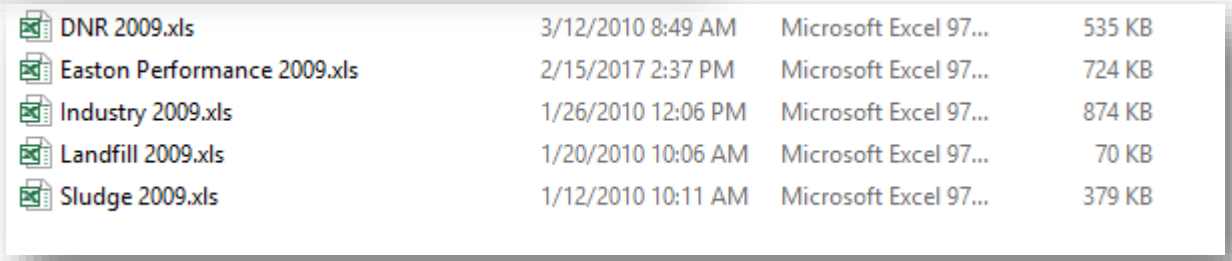
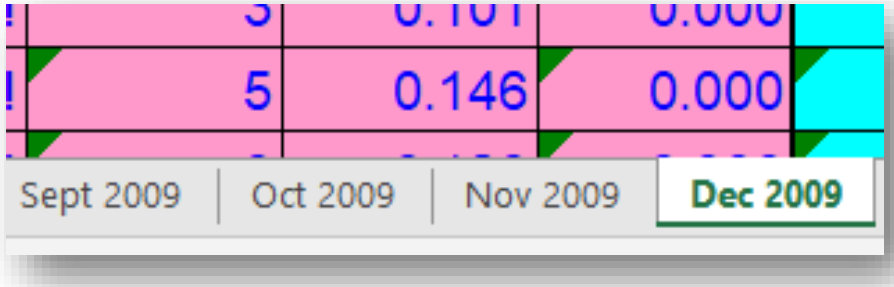
Challenge - Data Collected In Monthly Sheets







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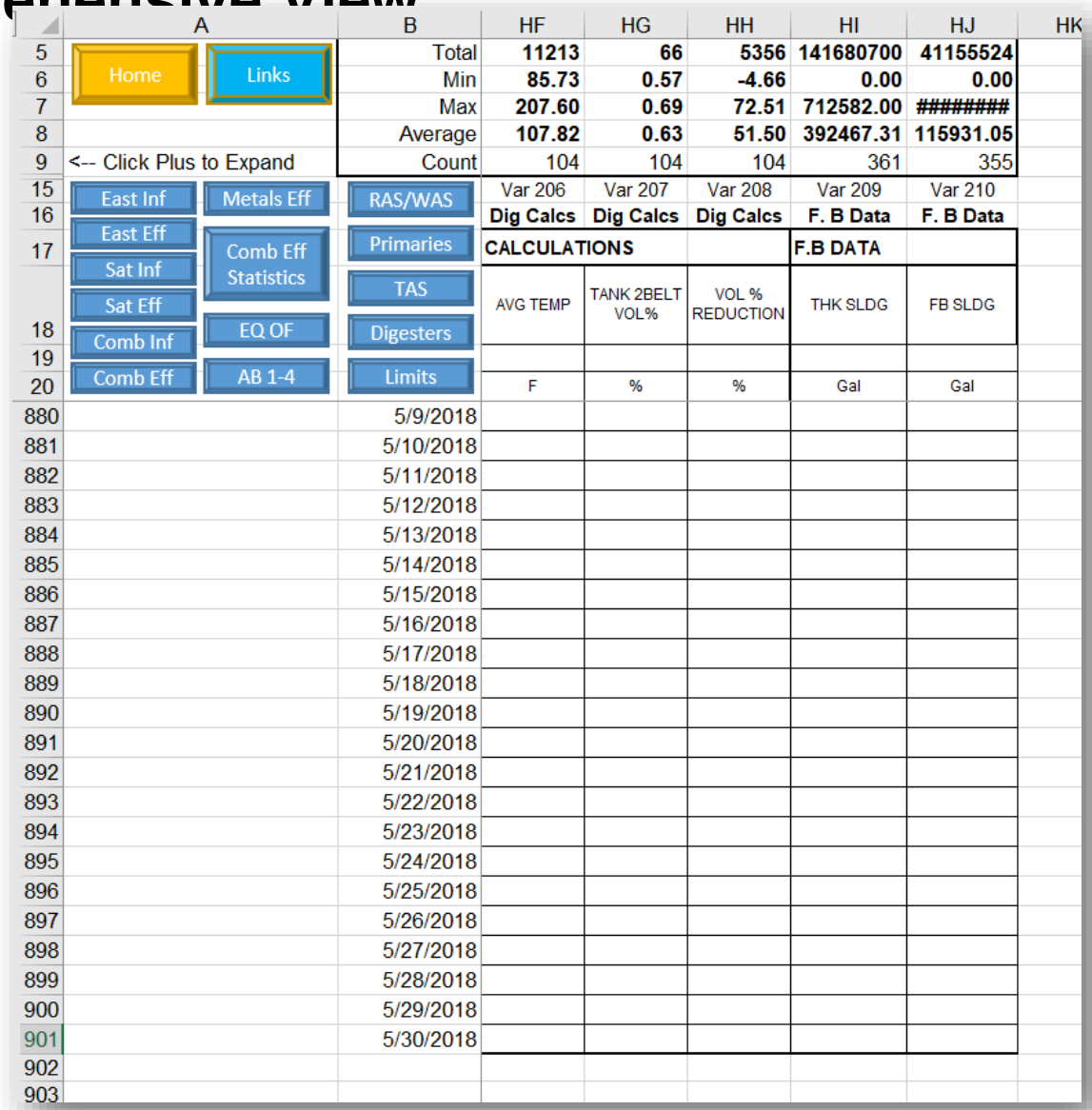
Operational Responses - Existing Spreadsheets Combined for Comprehensive View

- ~200 Variables
- Buttons to minimize random searching for information.



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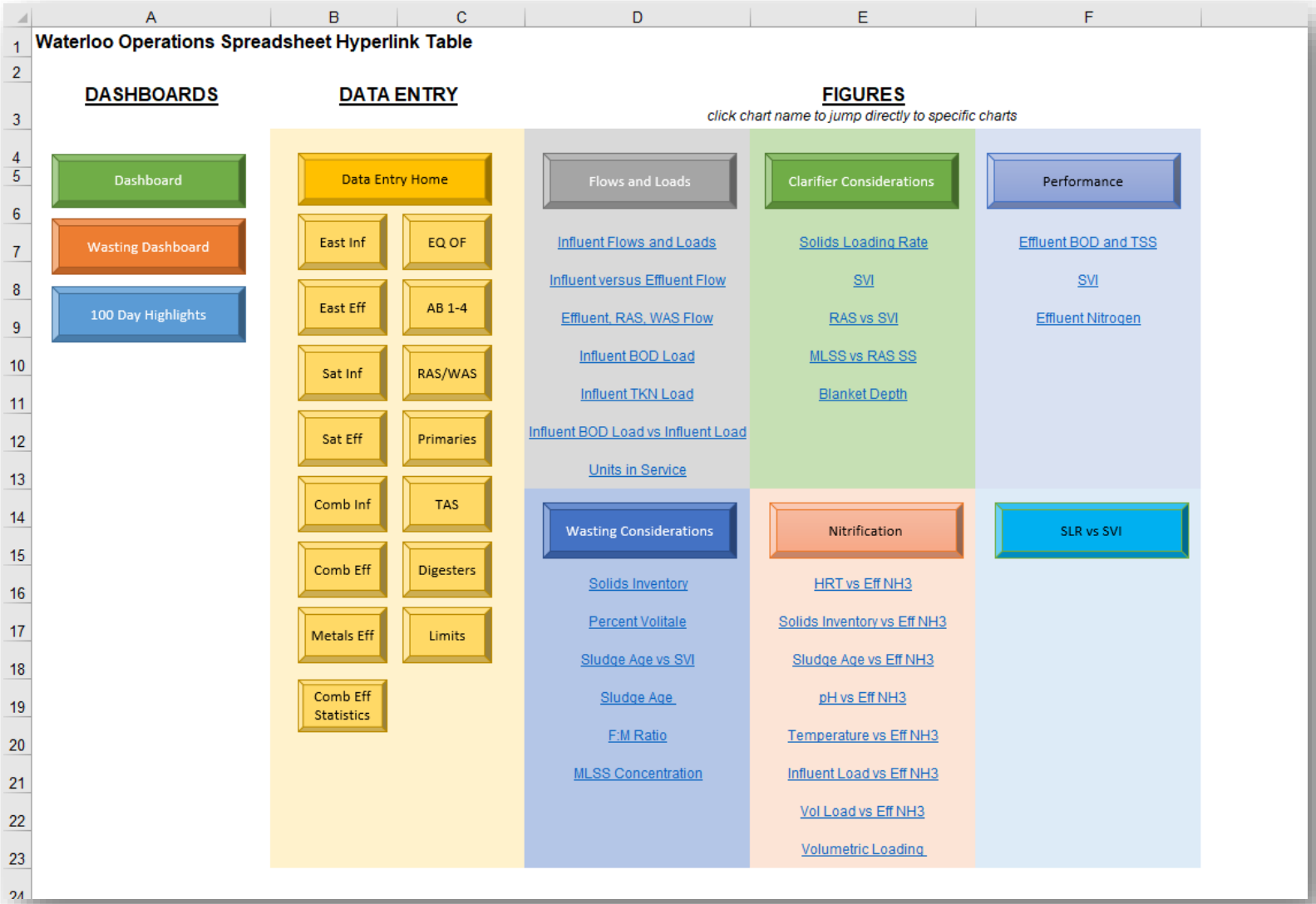
Spreadsheet Hyperlinks Limit Issues with Spreadsheet Size



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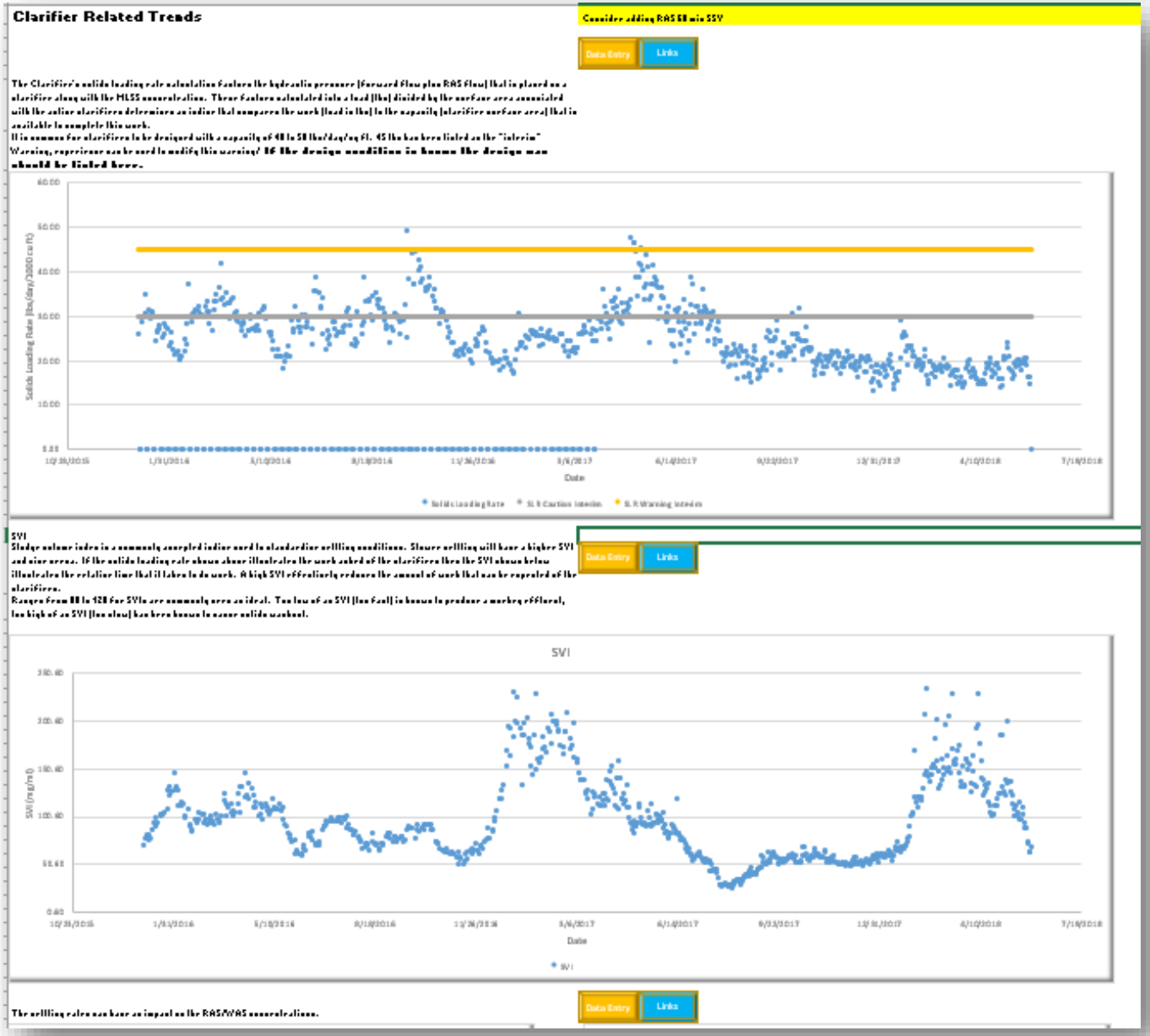
Spreadsheet Develops Correlation



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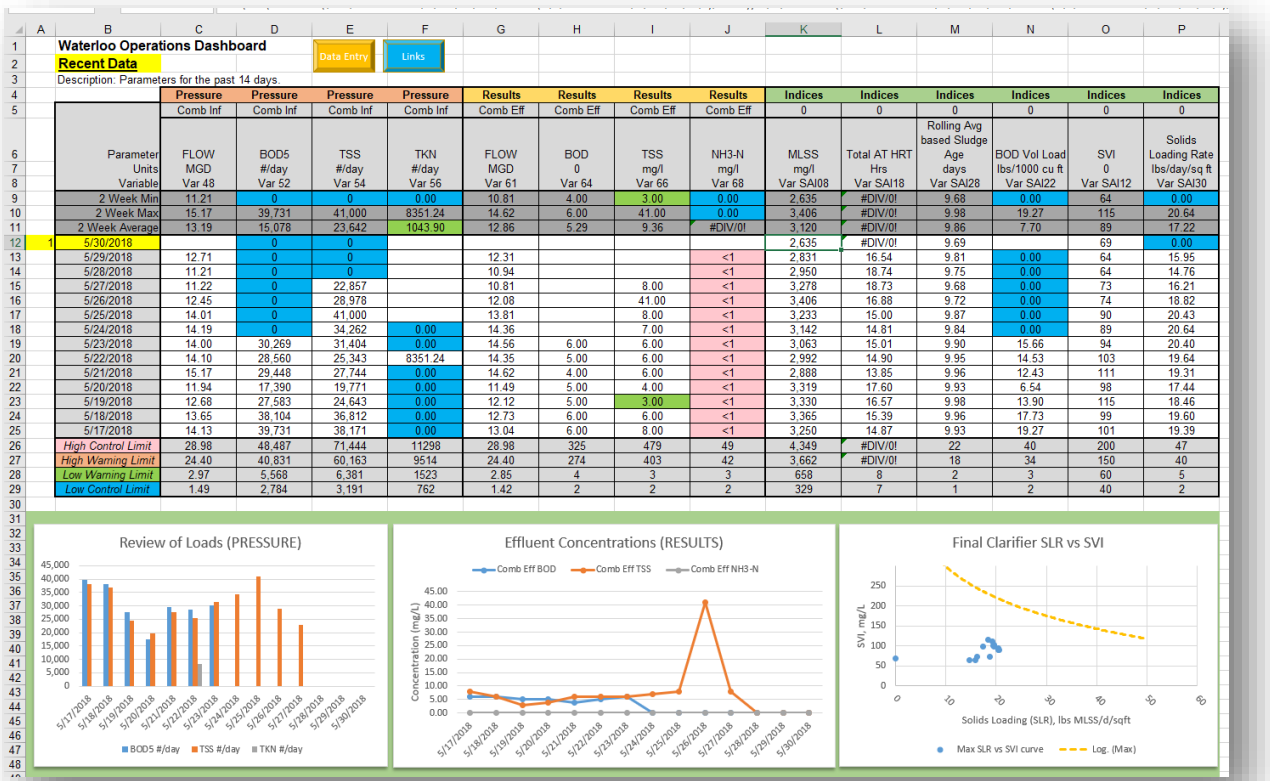
Dashboards Allow Quick Reference

- Key Indices
  - Performance
  - Wasting
  - 100 Day Troubleshooter
- Date Adjustable



Waterloo Operations Dashboard

Data Entry | Links

Recent Data

Description: Parameters for the past 14 days.

	Pressure	Pressure	Pressure	Pressure	Results	Results	Results	Results	Indices	Indices	Indices	Indices	Indices	Indices
	Comb Inf	Comb Inf	Comb Inf	Comb Inf	Comb Eff	Comb Eff	Comb Eff	Comb Eff	0	0	0	0	0	0
Parameter	FLOW	BOD5	TSS	TKN	FLOW	BOD	TSS	NH3-N	MLSS	Total AT HRT	Rolling Avg based Sludge Age	BOD Vol Load	SVI	Solids Loading Rate
Units	MGD	#/day	#/day	#/day	MGD	0	mg/l	mg/l	mg/l	Hrs	days	lbs/1000 cu ft	0	lbs/day/sq ft
Variable	Var 48	Var 52	Var 54	Var 56	Var 61	Var 64	Var 66	Var 68	Var SAI08	Var SAI18	Var SAI28	Var SAI22	Var SAI12	Var SAI30
2 Week Min	11.21	0	0	0.00	10.81	4.00	3.00	0.00	2,635	#DIV/0!	9.68	0.00	64	0.00
2 Week Max	15.17	39,731	41,000	8351.24	14.62	6.00	41.00	0.00	3,406	#DIV/0!	9.98	19.27	115	20.64
2 Week Average	13.19	15,078	23,642	1043.90	12.86	5.29	9.36	#DIV/0!	3,120	#DIV/0!	9.86	7.70	89	17.22
1 5/30/2018		0	0						2,635	#DIV/0!	9.69		69	0.00
5/29/2018	12.71	0	0		12.31			<1	2,831		16.54	9.81	0.00	64	15.95
5/28/2018	11.21	0	0		10.94			<1	2,950		18.74	9.75	0.00	64	14.76
5/27/2018	11.22	0	22,857		10.81		8.00	<1	3,278		18.73	9.68	0.00	73	16.21
5/26/2018	12.45	0	28,978		12.08		41.00	<1	3,406		16.88	9.72	0.00	74	18.82
5/25/2018	14.01	0	41,000		13.81		8.00	<1	3,233		15.00	9.87	0.00	90	20.43
5/24/2018	14.19	0	34,262	0.00	14.36		7.00	<1	3,142		14.81	9.84	0.00	89	20.64
5/23/2018	14.00	30,269	31,404	0.00	14.56	6.00	6.00	<1	3,063		15.01	9.90	15.66	94	20.40
5/22/2018	14.10	28,560	25,343	8351.24	14.35	5.00	6.00	<1	2,992		14.90	9.95	14.53	103	19.64
5/21/2018	15.17	29,448	27,744	0.00	14.62	4.00	6.00	<1	2,888		13.85	9.96	12.43	111	19.31
5/20/2018	11.94	17,390	19,771	0.00	11.49	5.00	4.00	<1	3,319		17.60	9.93	6.54	98	17.44
5/19/2018	12.68	27,583	24,643	0.00	12.12	5.00	3.00	<1	3,330		16.57	9.98	13.90	115	18.46
5/18/2018	13.65	38,104	36,812	0.00	12.73	6.00	6.00	<1	3,365		15.39	9.96	17.73	99	19.60
5/17/2018	14.13	39,731	38,171	0.00	13.04	6.00	8.00	<1	3,250		14.87	9.93	19.27	101	19.39
High Control Limit	28.98	48,487	71,444	11298	28.98	325	479	49	4,349	#DIV/0!	22	40	200	47
High Warning Limit	24.40	40,831	60,163	9514	24.40	274	403	42	3,662	#DIV/0!	18	34	150	40
Low Warning Limit	2.97	5,568	6,381	1523	2.85	4	3	3	658	8	2	3	60	5
Low Control Limit	1.49	2,784	3,191	762	1.42	2	2	2	329	7	1	2	40	2

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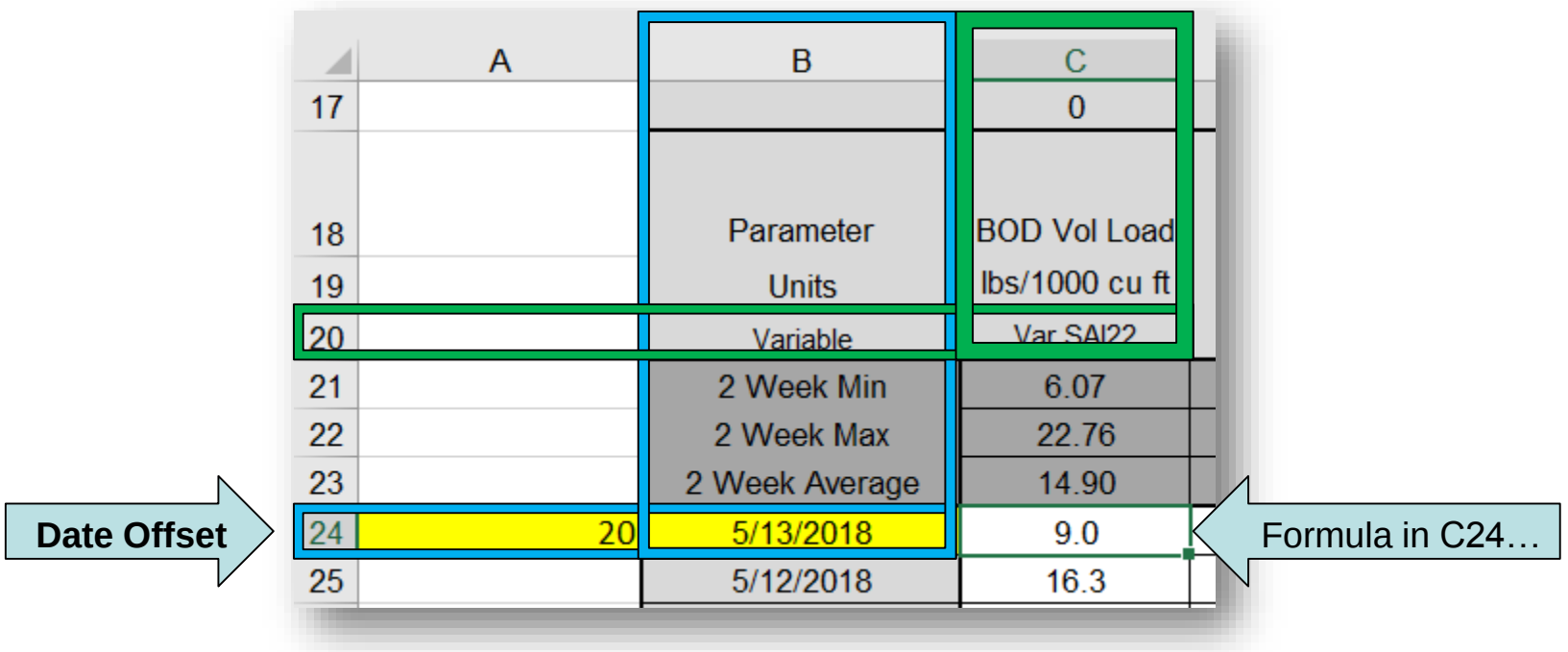
Use of Functions Allows “Dashboard” Functionality



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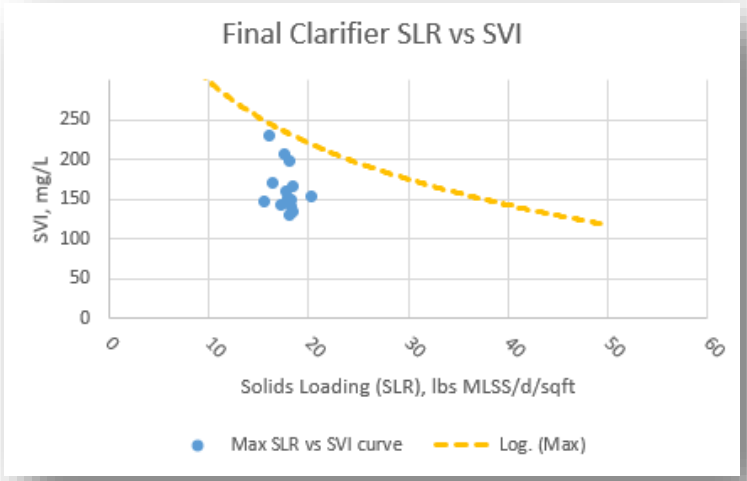
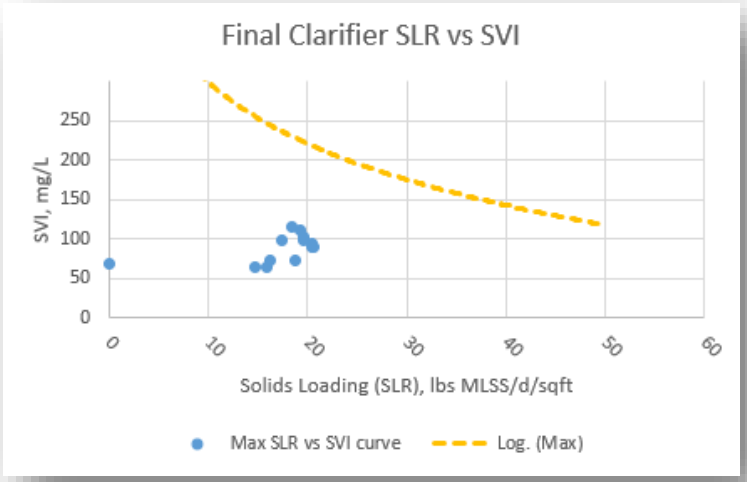
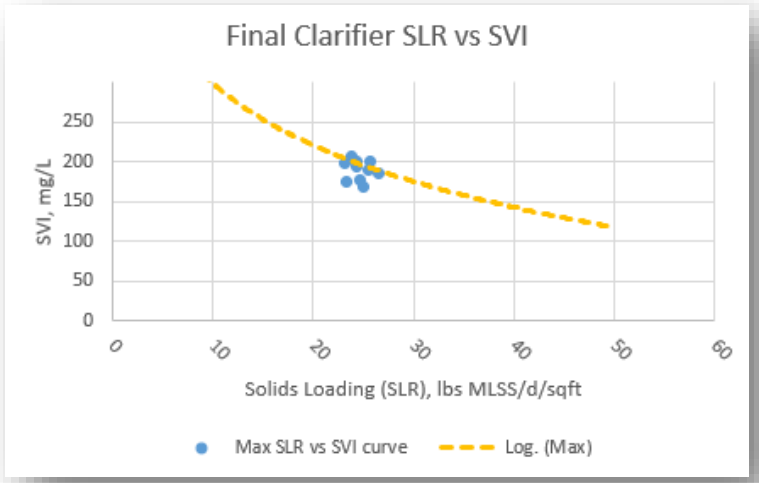
Dashboards Provide Quick Reference to Stress



March 2018



May 2018



February 2017

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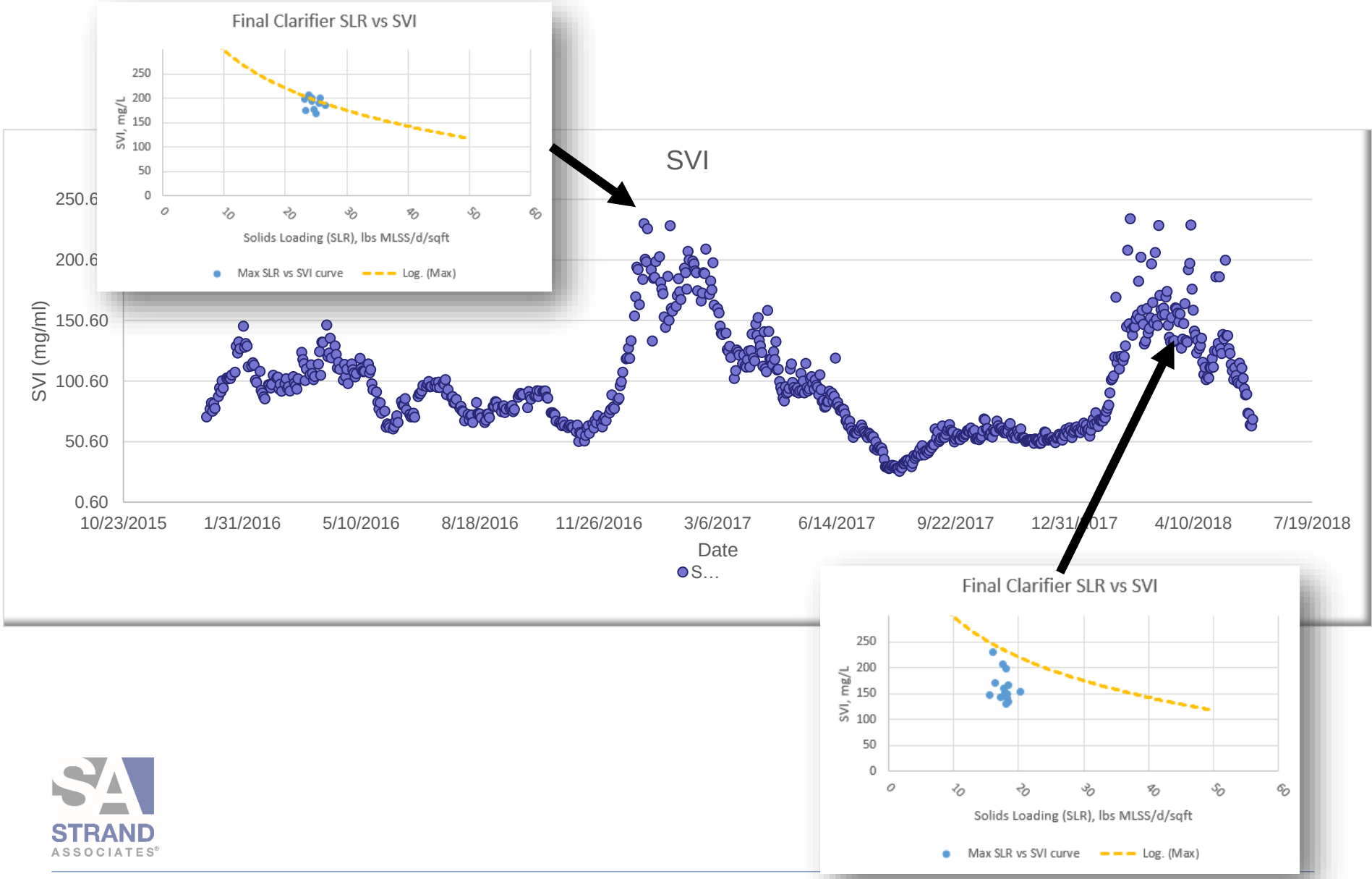
Spreadsheet Develops Correlation



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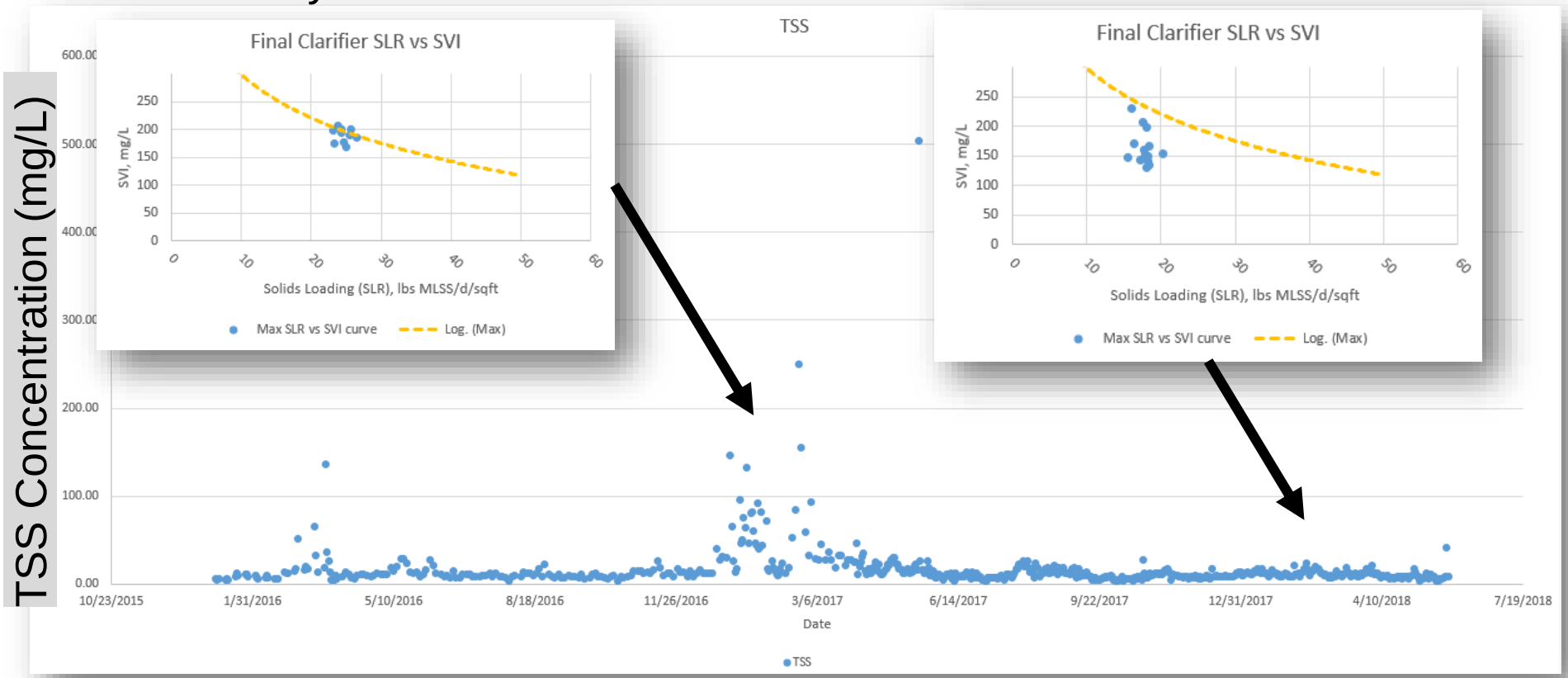
Spreadsheet Develops Correlation

February 2017

March 2018



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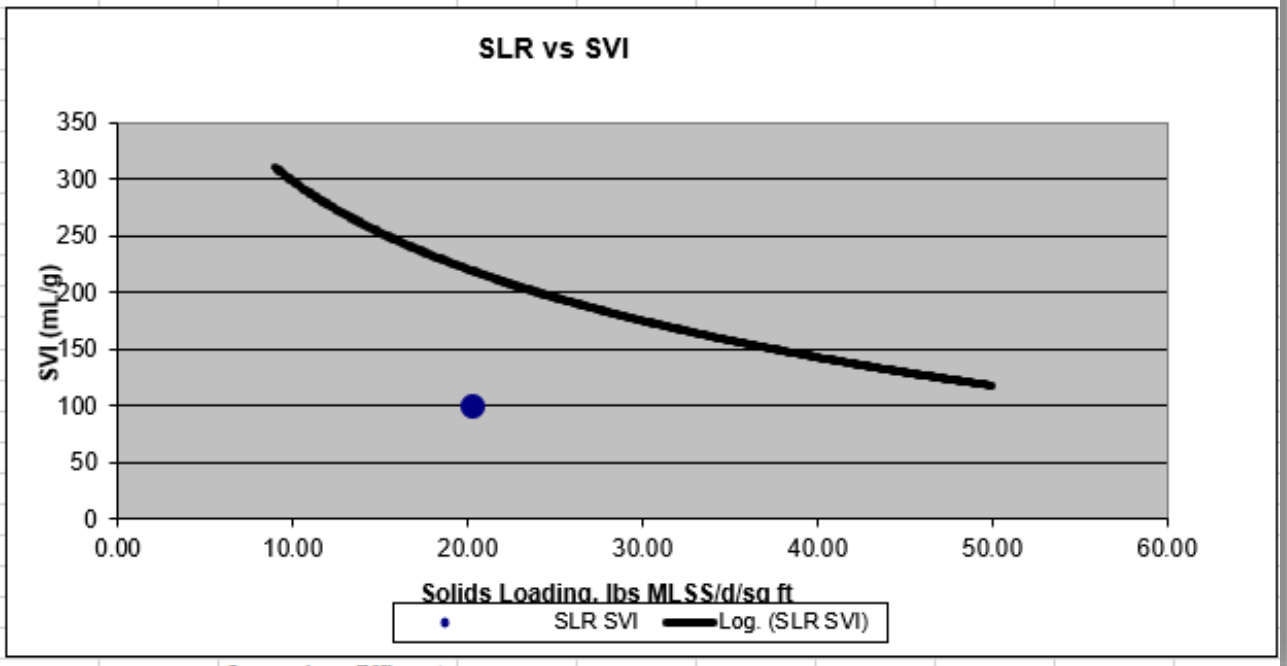
Spreadsheet Allows for “What If” Scenarios

	A	B	C	D	E	F	G	H	I	J	K
1	Wet Weather Condition Monitoring Tool										
2							Data Entry	Links			
3	Date										
4											
5	**Flow**										
6		Influent	14	mgd	Enter instantaneous rate			**Mixed Liquor**			
7		RAS Flow	14	mgd	Enter instantaneous rate						
8	**Clarifier**								SVI	100	
9	Combined Q		28					30 Min Settling		300	
10	Clarifiers in Service		4						MLSS	3000	mg/L
11	Clarifier sq ft		34640	sq ft							
12	Clarifier Load		700560	lbs/d							
13	**Clarifier Load**		**20.22**	**lbs/d/sq ft**							



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Questions and Answers

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