Using PI Vision to Optimize Wastewater Treatment

Josh Goldman-Torres and Johnny Tran

METRO WASTEWATER RECLAMATION DISTRICT

Denver, CO

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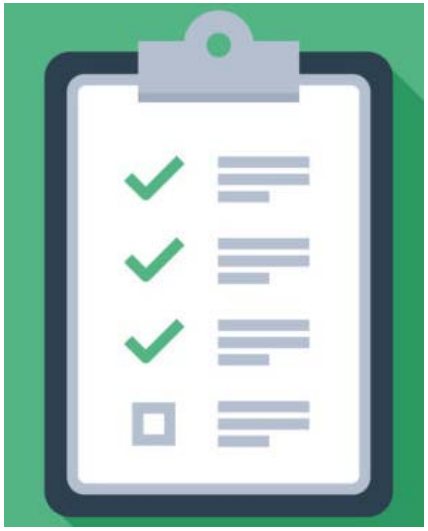
Agenda

- About Metro Wastewater Reclamation District
- Data Usage Challenge
- PI Vision Use Cases
  - Permit Tracking
  - Power Tracking
  - Process Area Detail
- Business Impact
- New Initiatives
- Conclusion



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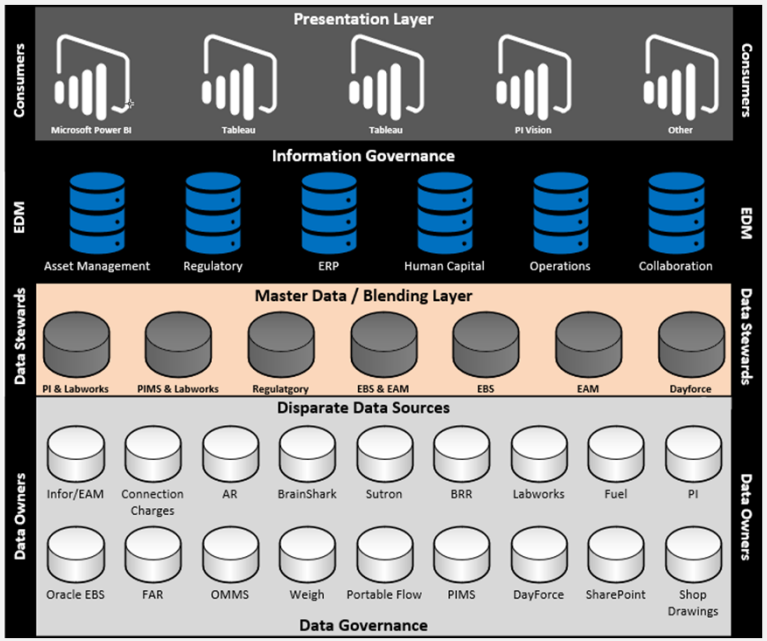
- Large public wastewater utility serving Denver and surrounding suburbs (2M population)
- Average daily flow is 130 mgd
- Secondary treatment with biological nitrogen and phosphorus removal
- Large on-site laboratory
- More than 400 empoloyees
- PI serves as historical and analytical data archiving service
- PI system components
  - PI Archive servers: over 30K tags
  - PI Software: AF, Analysis, Notifications, PI Vision, Datalink, Processbook, Manual Logger
- PI AF developed as an analytical repository
  - Operational data, lab data, financial data

Metro Wastewater Reclamation District

How PI Vision fits into Metro's world



Data Sources and Organization

- Metro Data Store concept
  - How do we evolve from a system of disparate data silos throughout the plant?
  - Common repository of data for all users to access
    - Don't need to know how to access different systems anymore
  - Master data layer extracted from different sources

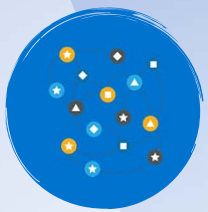
The Problem

Operational Culture

Operations staff reliance on weekly updated spreadsheet calculations

Knowledge Gap

It's hard to ask for changes when you don't know what's possible.



Disparate Systems

Many data sources that weren't integrated.

Expertise

Who has the right skill set to determine the best use of data and to develop solutions?

Buy-In

How to convince incorporate new visualizations into our process?

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Current Procedures

Several steps, increased chance of errors, limited data availability

Weekly Target Data Gathering

- Legacy system text-based reporting (cut and paste)
- Process books
- Excel calculations
- Print and post

Targets for:	Dec 1 - Dec 8											December 2, 2019
Area	Parameter	Data Source	Permit Limit 30 day	Permit Limit 7 day	Dailey Max	Target	Do Not Exceed - DNE	7 day Avg	Month to Date	% of Permit	Baseline	Action
NPDES TSS, CBOD, E.coli, NH_3, NO_3 TIN	TSS, mg/L	NSFEQ	30	45		16.5	30	14.8	15.2	50.7%		DAILY - Monitor NSFEQ ODS Report: daily & week-to-date averages
	CBOD, mg/L	NSFEQ	17	25		10	17	4.8	4.8	28.2%		
	E coli	NSFEQ	126	252		50	80	60.2	60.2	47.8%		
	Ammonia, mg/L	NSFEQ	5.10			1.0		0.76	0.86	16.9%	30D: <89% of Target - Month to Date	
	Ammonia Dailey Max, mg/L	NSFEQ			9.20			0.94	0.94	10.2%		December 2019: Combined NH3 Effluent Limit: 30D: 5.10 mg/L: Daily Max 9.20 mg/L
	Nitrate + nitrite, mg/L	NSFEQ			9.80	6.94		4.60	4.60	46.9%	Max Daily 7d & Max Daily MTD	December 2019: Combined NO5 Effluent Limit: Daily Max 9.8 mg/L
	TIN	NSFEQ						5.20	5.20			
NH_3	NSEC NH3, mg/L	NIT				<1.0		0.50	0.70			
	NSEC NH3 Daily Max, mg/L	NFEQ						1.27	1.28			
	SSEC NH3, mg/L	SFEQ				<1.0		0.42	0.46			
	SSEC NH3 Daily Max, mg/L	SFEQ						0.62	0.62			

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Collaboration:
Technology and Innovation
IT Operations

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Optimization Improvement Example 1 – Permit Tracking

Must meet permitted discharge limits of several water quality parameters

Legacy Process

- Legacy system text based reporting (cut and paste)
- Cut/Paste
- Excel calculations
- Print and post

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Add a new variable

Name	Expression	Output Attribute
endTime	`TimeStamp(TagVal('Ecoli Daily','*'))`	Map
startTime7d	`bod(endTime)-(Weekday(endTime)-1)*86400`	Map
dataArray7d	`RecordedValues('Ecoli Daily',startTime7d,endTime)`	Map
product7d	`Exp(Total(MapData(dataArray7d,Log($val))))`	Map

geomean7d	`// ln(a) + ln(b) +... = ln(a*b*...)`
	`// e^(ln(a*b*...) = a*b*...`
	`if (ArrayLength(dataArray7d) = 0) then NoOutput() else product7d^(1/ArrayLength(dataArray7d))`
		Ecoli 7d Week-To-Date

startTime30d	`Bom(endTime)`	Map
dataArray30d	`RecordedValues('Ecoli Daily',startTime30d,endTime)`	Map
product30d	`Exp(Total(MapData(dataArray30d,Log($val))))`	Map
geomean30d	`if (ArrayLength(dataArray30d) = 0) then NoOutput() else product30d^(1/ArrayLength(dataArray30d))`	Ecoli 30d Month-To-Date

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Optimization Improvement Example 1 – Permit Tracking

Must meet permitted discharge limits of several water quality parameters

Legacy Process

- Legacy system text-based reporting (cut and paste)
- Cut/Paste
- Excel calculations
- Print and post

Development

- Technology and innovation worked closely with operations to determine **what data** is most useful and in **what format**
- Creation of **real-time** visualizations to convey information in **more intuitive format**
  - Required use of lab data and online instrumentation data
  - Analyses developed in PI System Explorer
  - Visualization developed in PI Vision

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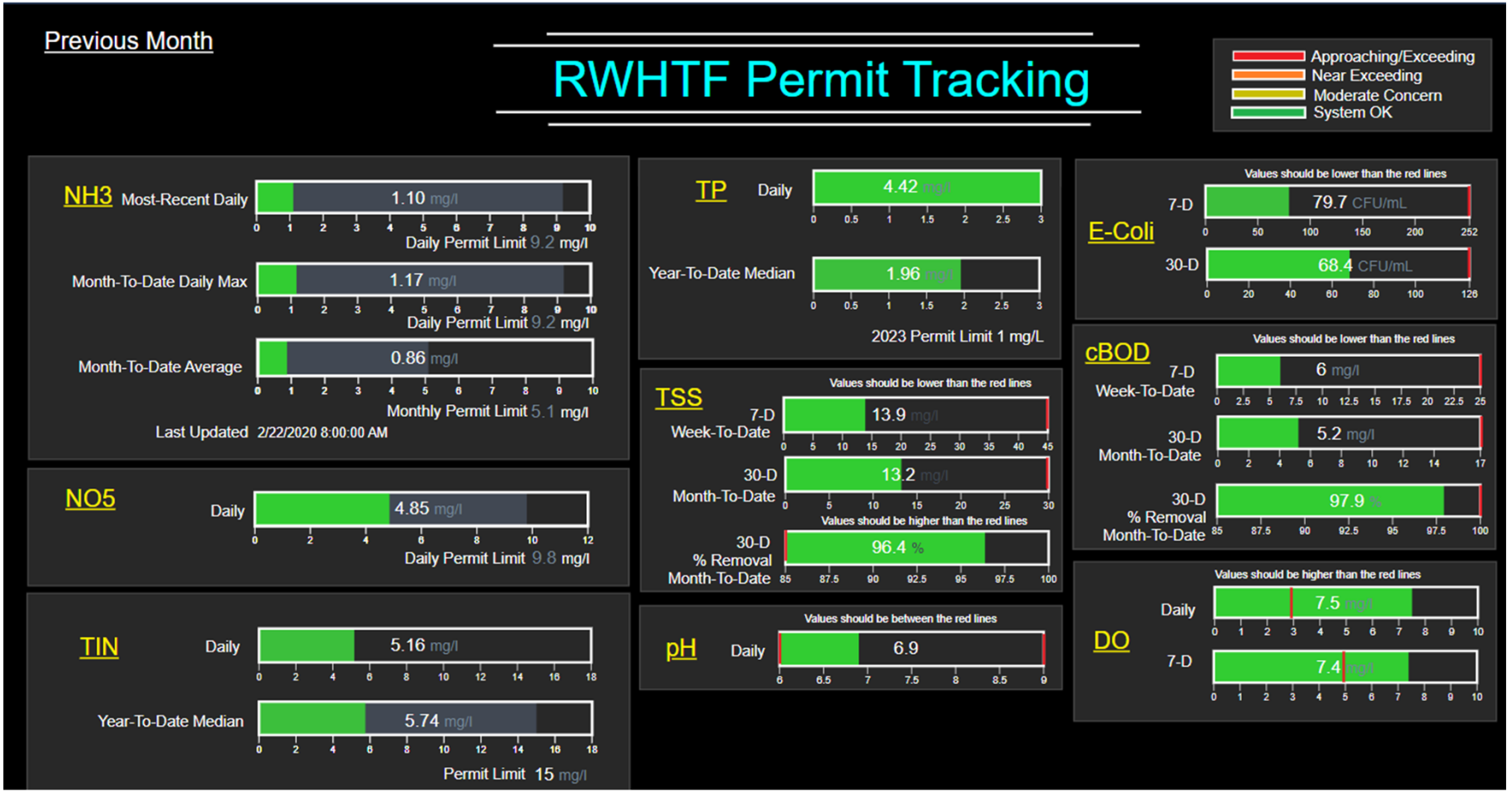

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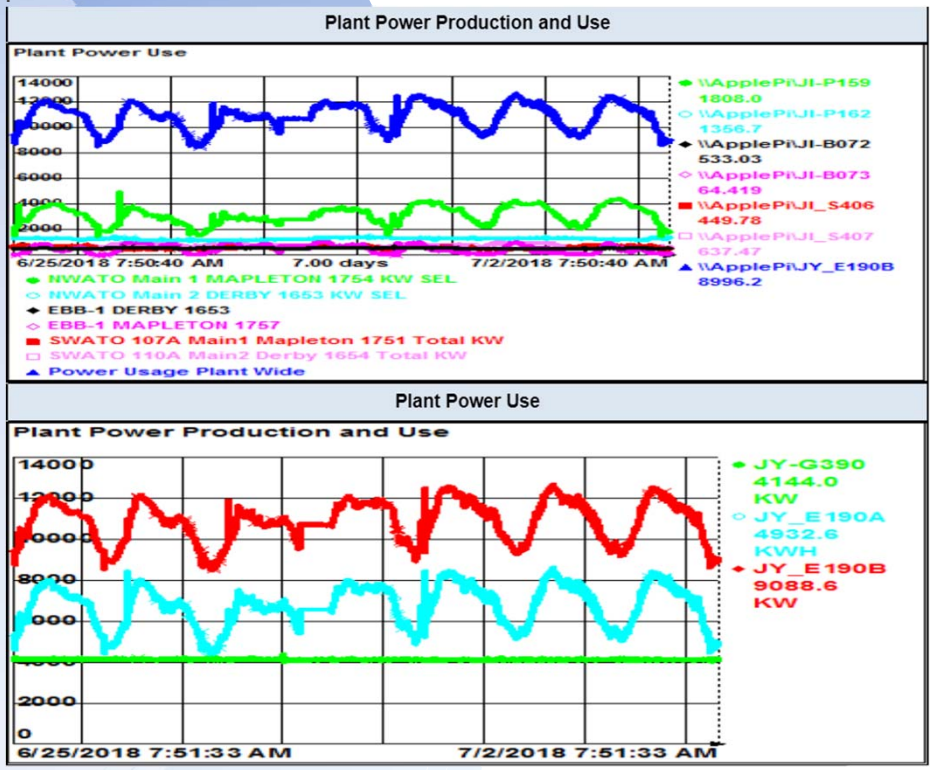
Optimization Improvement Example 1 – Power Tracking

Power usage data can be used to reduce overall power costs

Legacy Process

- PI Process Book
- Screen Shot



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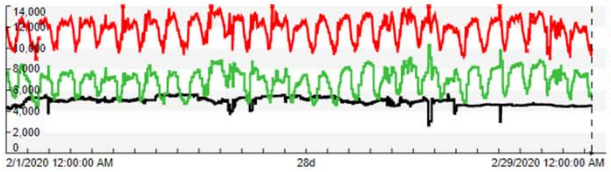
Current Month
Last Month
Two Months Ago

Hite Energy and Power Overview

Power by Process Area
Electricity Costs Page
How does the electricity bill work?
What is Energy?
What is Demand?

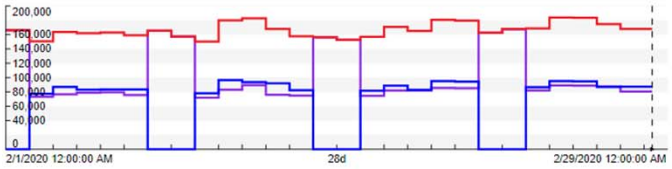
Total Power Usage (Kilowatts)



Total Power
9,972 kW
Total Power Purchased
5,463 kW
15 min Avg Cogen Power
4,569 kW

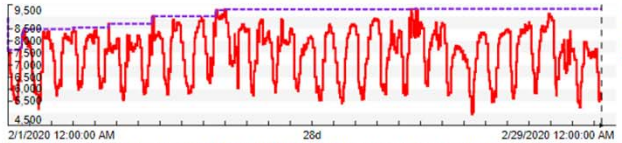
Power From Cogen
46 %

Energy Use (Kilowatt-Hours)



Daily Energy
167,918 kWh
On Peak 87,419 kWh 0.042 $/kWh
Off Peak 80,513 kWh 0.030 $/kWh

Peak Power - Distribution

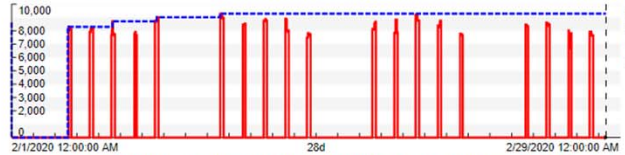


Peak Distribution Demand
9,321 kW
Demand
5,632 kW

The Distribution Demand service charge is applied to the monthly maximum power peak; minimize this monthly peak to keep operational costs down.

Demand (kW) = XcelPower (kW) + CogenPower (kW) - StandbyNomination (kW)

Peak Power - Generation and Transmission



Peak Gen and Trans Demand
9,272 kW
Gen Trans Demand
0 kW

The Generation and Transmission Demand is the monthly maximum power peak we create weekdays between 2:00pm and 6:00pm.

Gap: Demand to Peak

3,688 kW

Ok to start?

North West Blower	1,100 kW
North East Blower	1,900 kW
South Blower	1,500 kW
Primary Effluent Pump	336 kW
Centrifuge	300 kW

Green means go!

Peak Demand Tracking

	Distribution	Gen. and Trans
Time of Peak	2/19/2020 6:45:01 PM	2/10/2020 2:15:01 PM
Days Since Peak	9 d	18 d
Current Peak	9,321 kW 4.1 %	9,272 kW 7.6 %
November Peak	8,957 kW	8,621 kW

This is a % of last month's peak. Keep it negative to save money!

What's the difference between the two Power Peaks?

Gen and Trans: Very Expensive, up to 4x Distribution

Distribution Price: 3.77 $/kW
Transmission Price: 12.64 $/kW

To save $, avoid starting machinery on weekdays between 2-6pm when possible!

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Power by Process Area

Energy Home

North

NSEC POWER
3,387 kW

North kWh/MG
55

NSEC % of Plant Load
45 %

South

SSEC POWER
2,659 kW

South kWh/MG
62

SSEC % of Plant Load
36 %

Solids Processing

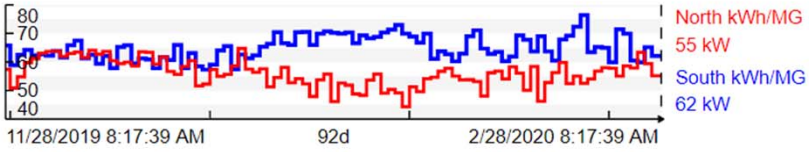
Total Solids Processing Power
918 kW

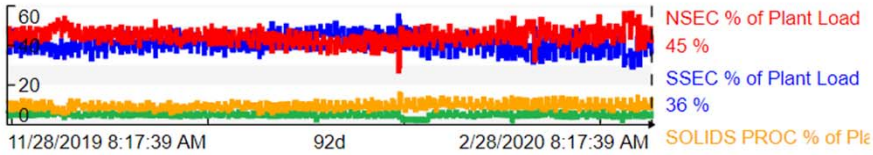
SOLIDS PROC % of Plant Load
12 %

HVAC

Total HVAC Power
505 kW

HVAC % of Plant Load
7 %





Blowers

SOUTH BLOWER POWER
1,290 kW

NORTH BLOWER POWER
2,103 kW

Total Blower Power
3,393 kW

Centrifuges

Total Centrifuge Power
439 kW

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Digesters	Temperature, F	ANDIG P3	99	95	<97>101	100.0	100.0	101%		Digester 12 in Acid Phase
	SRT CMPLX, days	ANDIG P4		15	<16	14.0	12.0	80%	ODS SRT 7D Average: 8D: 16 & MTD 16	Current Lab FECAL for MTD: 620,000 with a high value of 620,000 for MTD
	Dig TS Feed, TPD	ANDIG P1				224.0	266.0			
	Dig VS Feed, TPD	ANDIG P1				192.0	228.0			
	VS destruction, %	ANDIG P4		38	<40	53.5	54.1	142%		
	VS destruction, tpd	ANDIG P4				102.5	123.6			12/26/2018: Digester 8 Non Op
	Dig Effluent, TPD	ANDIG P3				110.6	137.4			
	Centrate NH_3-N, mg/L	CentDAF				1103.0	1114.0			2/26/2018: Digester 5 Non Op
	Units in/s	ANDIG P4				9.0	9.0			
	Gas production, kcfd	ADGAS				2991.4	2907.0			
	Electrical production, kw	JY-G390				4660	4259		Electrical production to offset Xcel costs	
	H2S, ppm	ADGAS	1050	1680 ppm/ 3 hr avg	1100	939.0	916.0	87%	H2S ppm must stay under 1680 as a 3-hr moving average for Title V Air Permit compliance	Ensure that only 3 Digester Flares are enabled, 4th flare must be keyed OFF - for Title V Air Permit compliance
		CNTSU								

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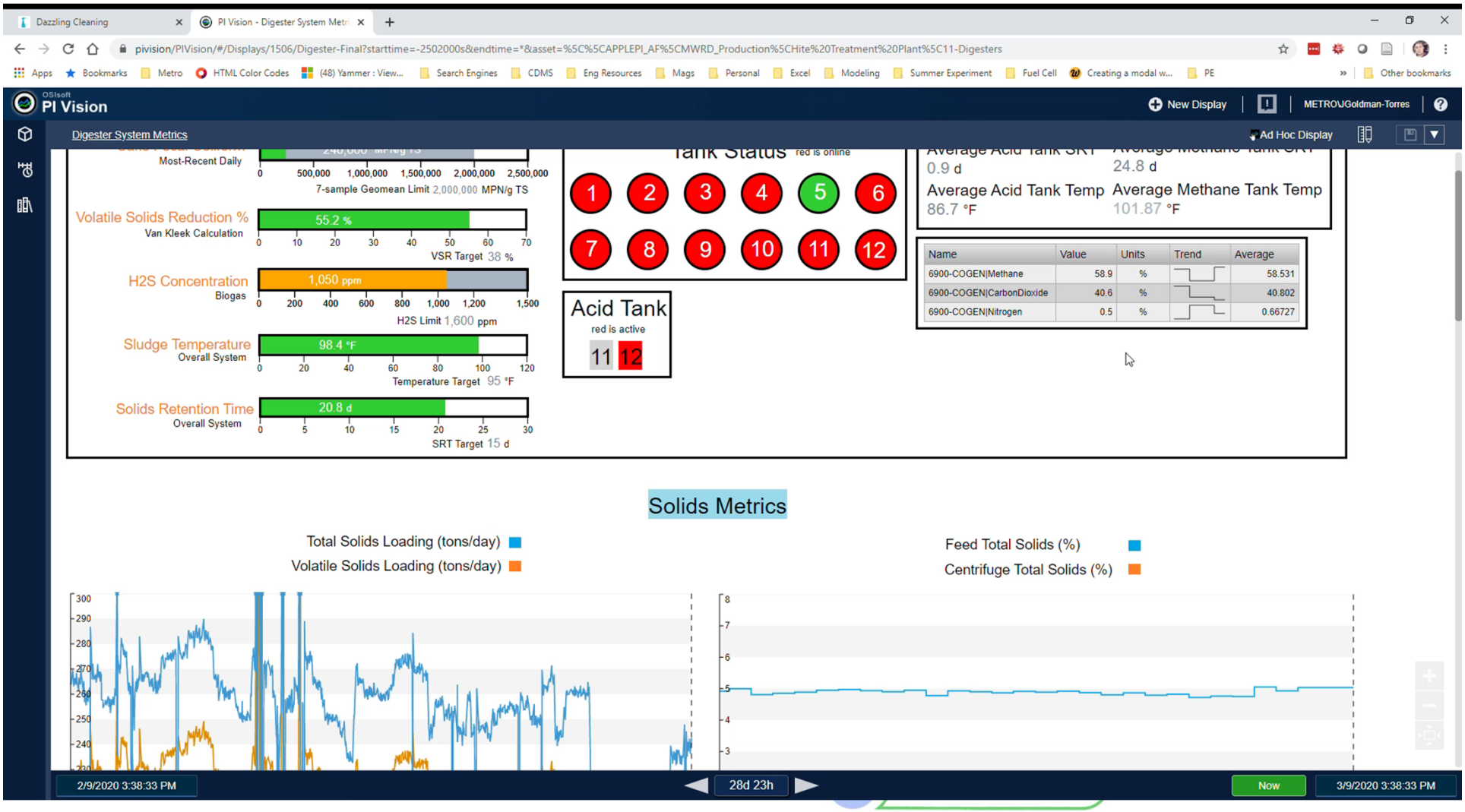
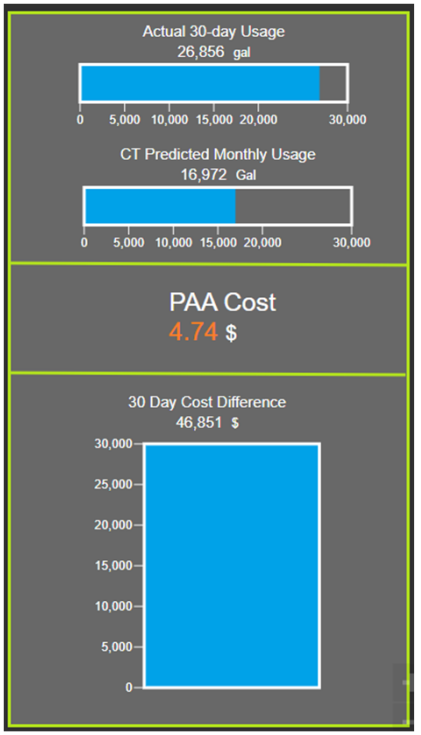

Dazzling Cleaning
PI Vision - Digester System Metri
pivision/PIVision/#/Displays/1506/Digester-Final?starttime=-2502000s&endtime=*&asset=%5C%5CAPPLEPI_AF%5CMWRD_Production%5CHite%20Treatment%20Plant%5C11-Digesters
Apps
Bookmarks
Metro
HTML Color Codes
(48) Yammer : View...
Search Engines
CDMS
Eng Resources
Mags
Personal
Excel
Modeling
Summer Experiment
Fuel Cell
Creating a modal w...
PE
Other bookmarks
OSIsoft
PI Vision
New Display
METRO\Goldman-Torres
Digester System Metrics
Ad Hoc Display
Most-Recent Daily
0
500,000
1,000,000
1,500,000
2,000,000
2,500,000
7-sample Geomean Limit 2,000,000 MPN/g TS
Volatile Solids Reduction %
55.2 %
Van Kleek Calculation
0
10
20
30
40
50
60
70
VSR Target 38 %
H2S Concentration
1,050 ppm
Biogas
0
200
400
600
800
1,000
1,200
1,500
H2S Limit 1,600 ppm
Sludge Temperature
98.4 °F
Overall System
0
20
40
60
80
100
120
Temperature Target 95 °F
Solids Retention Time
20.8 d
Overall System
0
5
10
15
20
25
30
SRT Target 15 d
Tank Status
red is online
1
2
3
4
5
6
7
8
9
10
11
12
Acid Tank
red is active
11
12
0.9 d
24.8 d
Average Acid Tank Temp
86.7 °F
Average Methane Tank Temp
101.87 °F
Name
Value
Units
Trend
Average
6900-COGEN|Methane
58.9
%
58.531
6900-COGEN|CarbonDioxide
40.6
%
40.802
6900-COGEN|Nitrogen
0.5
%
0.66727
Solids Metrics
Total Solids Loading (tons/day)
Volatile Solids Loading (tons/day)
Feed Total Solids (%)
Centrifuge Total Solids (%)
300
290
280
270
260
250
240
8
7
6
5
4
3
2/9/2020 3:38:33 PM
28d 23h
Now
3/9/2020 3:38:33 PM

Business Impact
Smarter operations

- **Time Savings**
  - Several hours per week required to generate and physically post Weekly Target spreadsheets
  - Time required to digest information and make decisions
- **Cost Savings**
  - Still being quantified
  - Working on real-time quantification of cost savings
- **Intangibles**
  - All staff gain better understanding of how data analytics can be used to optimize processes
  - Bridge the gap between operators and plant data



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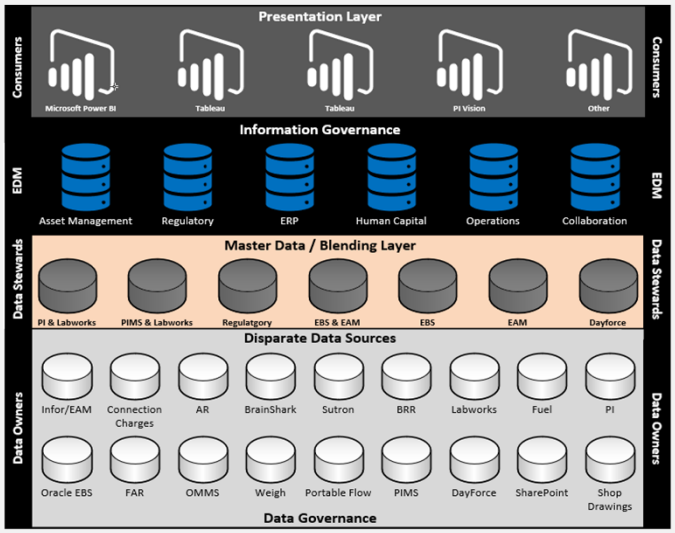

New Initiatives

- Advanced analytics for prediction of performance
- Pull data from AF through PI Web API using Alteryx, R
- Run statistical models, neural network models
- Write predictive data back to PI AF through PI Web API using Alteryx and R

Conclusions

- **MWRD invested in data optimization**
  - Created Technology and Innovation Division
  - Purchased PI Vision
- **Collaboration between teams**
  - TID, IT, Operations
- **Conversion of Weekly Target Process**
- **Advanced Data Analytics**
- **Benefits**
  - Time
  - Money
  - Intangibles

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Questions?

Please wait for
the **microphone**

State your
name & company

Save the Date...

AMSTERDAM
October 26-29, 2020

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