

Return Activated Sludge Pumping System: From Conceptual Design To Daily Operation

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THE CITY OF
COLUMBUS
MICHAEL B. COLEMAN, MAYOR
DEPARTMENT OF
PUBLIC UTILITIES

BURGESS & NIPLE
Engineers ■ Architects ■ Planners

CELEBRATING
100
YEARS
1912 ~ 2012

Project 'Driver'

Jackson Pike Wastewater Treatment Plant

- **Two (2) Consent Orders (2002 & 2004)**
- **Signed with Ohio EPA to eliminate SSOs and reduce CSOs**
- **Development of Wet Weather Management Plan as a response**



Project Background

Jackson Pike Wastewater Treatment Plant

Contract J210 included:

- **Rehabilitation of Secondary Clarifiers**
 - **Replacement of Sludge Collection Mechanisms**
 - **Replacement of Inlet Structures**
 - **Addition of Scum Collection Systems**
 - **Upgrade of all clarifiers electrical and controls**



Project Background

Jackson Pike Wastewater Treatment Plant

Contract J210 included:

- **Modifications to Pumping Systems**
 - Upgrade of Influent Pumps' electrical/controls
 - Increase capacity of flushing water system



Project Background

Jackson Pike Wastewater Treatment Plant

Contract J210 included:

- **Wet Weather Management Improvements**
 - **Increase RAS pumping capacity**
 - **Addition of step feed aeration capabilities**
 - **Replacement of aeration diffuser systems**
 - **Elimination of various plant hydraulic restrictions**
 - **Addition of flocculation baffles in secondary clarifiers**

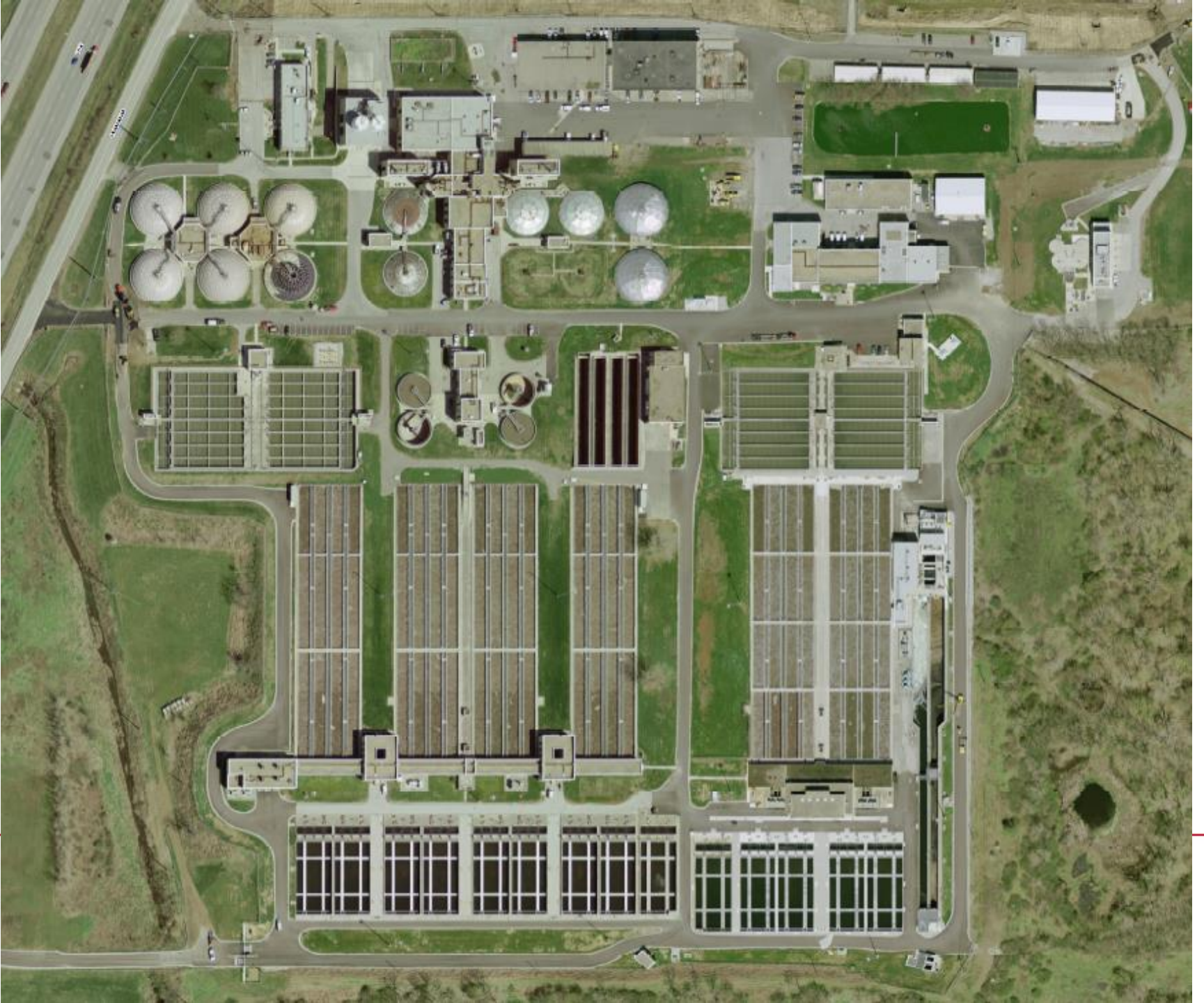


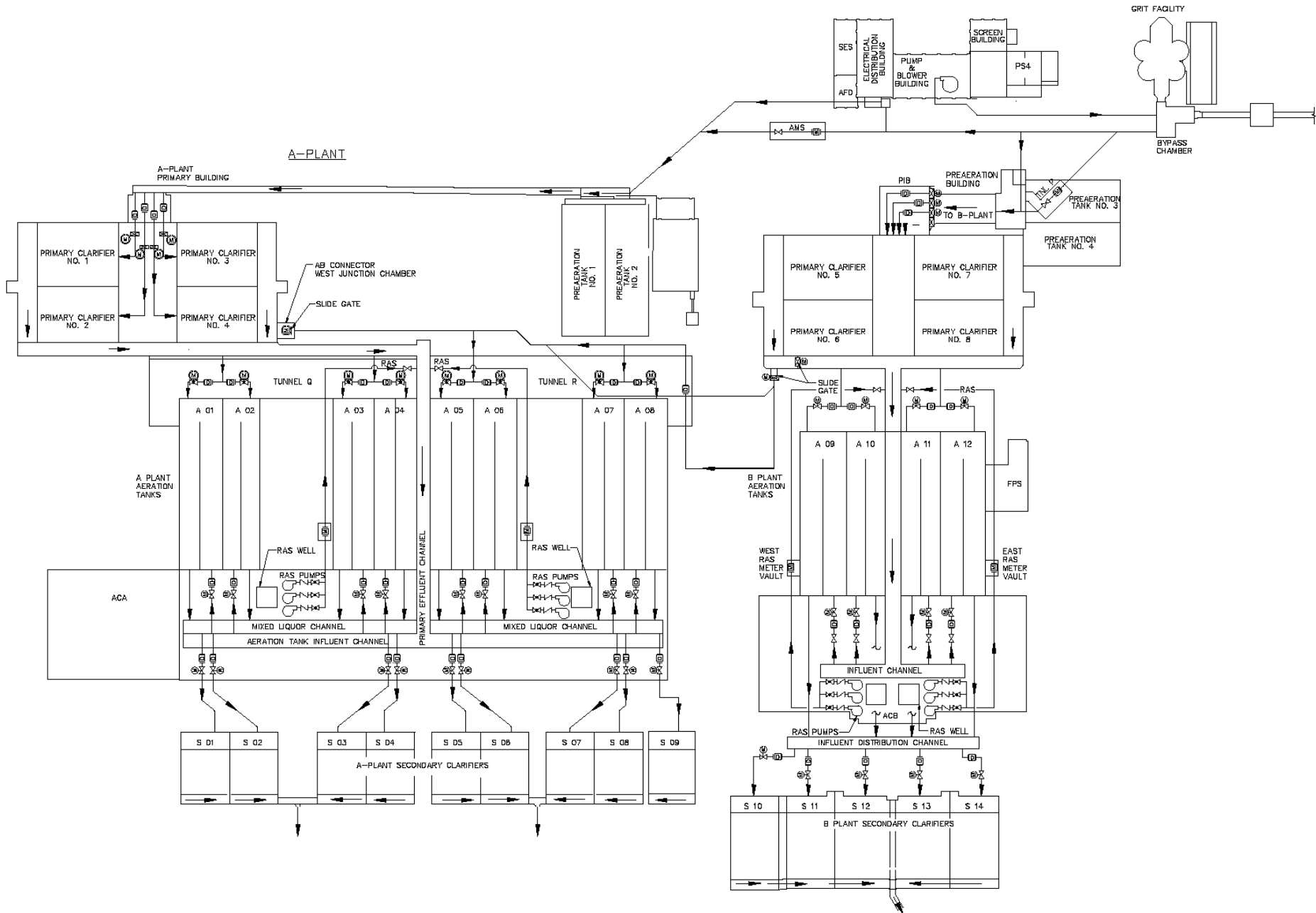
Facility Background

Jackson Pike Wastewater Treatment Plant

- **Peak Hourly Design Flow: 165 MGD**
- **Total Average Daily Design Flow: 68.0 MGD**
- **A-Plant ADDF: 45.3 MGD**
- **B-Plant ADDF: 22.7 MGD**
- **Design RAS Rates: 30% Min. & 75% Max.**
- **A-Plant RAS Range: 14-34 MGD**
- **B-Plant RAS Range: 7-17 MGD**







Design Objectives

Jackson Pike Wastewater Treatment Plant

- Increase RAS pumping capacity/capability to 75% of ADDF
- Provide a minimum RAS rate of 30% ADDF
- Maintain an equal RAS flow distribution
- ‘Draw-off’ equal volumes from each secondary clarifier
- Provide all components for a complete automated RAS system



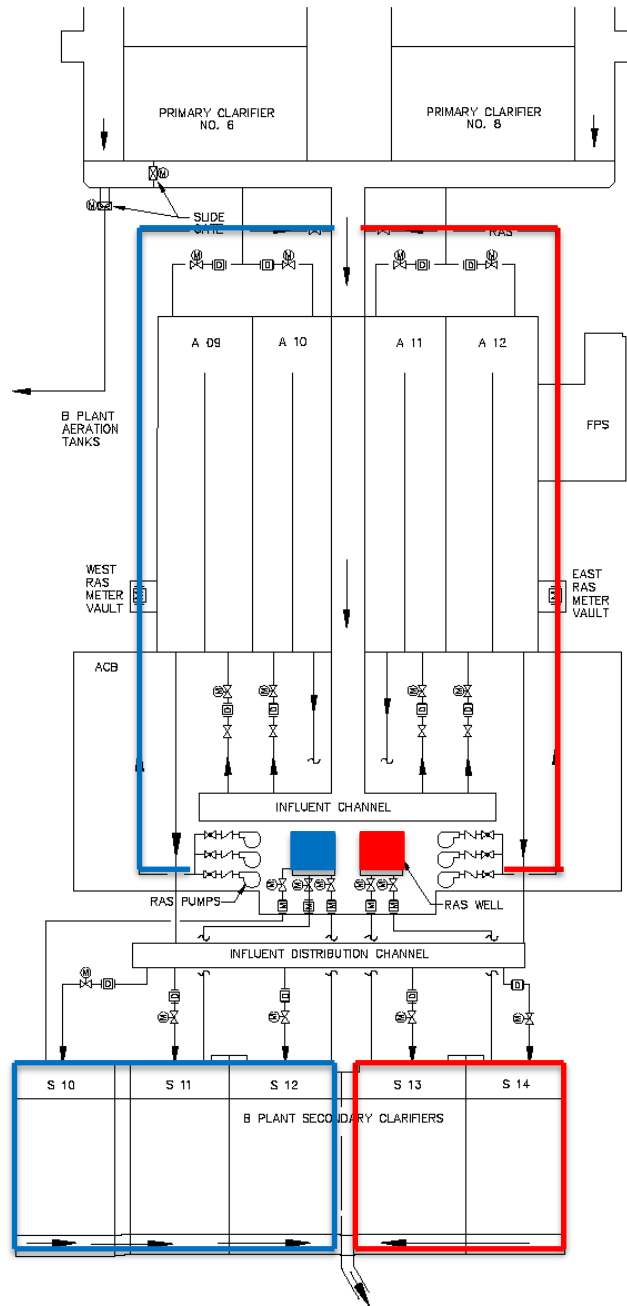
Design Challenges

Jackson Pike Wastewater Treatment Plant

“Skewed Geometry”

- Four (4) Aeration Tanks (A-09 to A-12)
- Two (2) RAS Pumping Wells (B-Plant East & West)
- Five (5) Secondary Clarifiers (S-10 to S14)





West RAS Well
3 Clarifiers
10.2 MGD Firm

East RAS Well
2 Clarifiers
6.8 MGD Firm

The Design Process

Jackson Pike Wastewater Treatment Plant

- Evaluate clarifier ‘underflow’ to RAS Wells
- Consider Valve Modulation vs. Most-Open-Valve concepts for ‘underflow’
- Evaluate flow metering options
 - RAS Pumps’ Discharge to Aeration Tanks
 - Clarifier Underflow Piping to RAS Wells
- Consider AFDs for each pumping unit
- Develop an effective control strategy

The Design Process

Jackson Pike Wastewater Treatment Plant

- Select appropriate pumps that can meet RAS return rates (30 to 75% of ADFD)
- Determine range of flows for the various pump operating combinations by varying speeds
- Evaluate RAS underflow hydraulics to ensure equal 'draw-off' can be achieved
- Evaluate all existing piping and valves suitable for increased flow rates – upsize as necessary



The Design Process

Jackson Pike Wastewater Treatment Plant

Pump Design

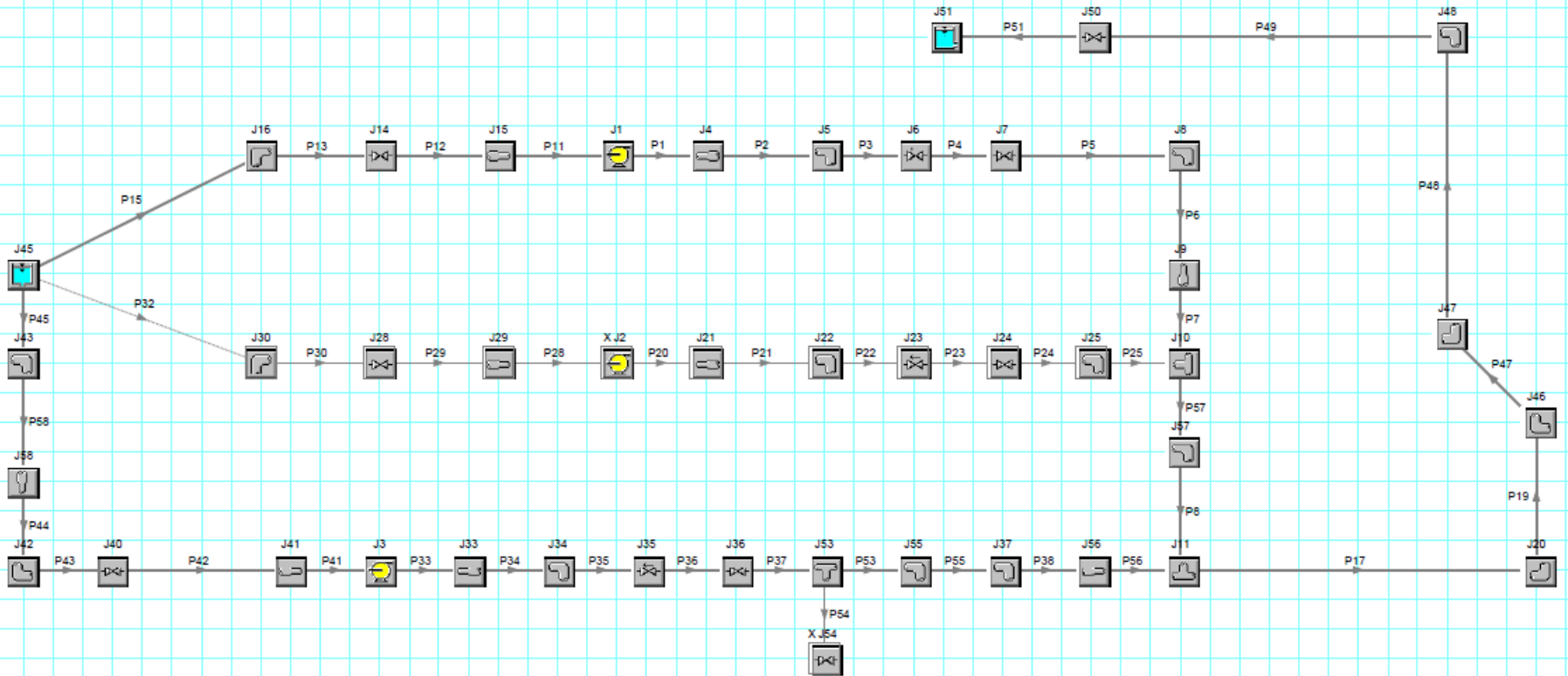
- **Size pump for max condition: two pumps operating at full speed, i.e. $10.2 \text{ MGD}/2 = 5.1 \text{ MGD} = 3,550 \text{ gpm}$ (60 Hz)**
- **Determine system pumping head (TDH) at this condition**
- **Select pump/impeller based on this design point**
- **Determine minimum speed turndown for pumps**
- **Check one pump operation for NPSH and reduced speeds**
- **Evaluate the effect of a clarifier out of service**



The Design Process

Jackson Pike Wastewater Treatment Plant

Utilized a Pump Hydraulics Program with AFD analysis
(Fathom by Applied Flow Technologies)



The Design Process

Jackson Pike Wastewater Treatment Plant

The screenshot displays the AFT Fathom software interface for a hydraulic network design. The main workspace shows a complex network of pipes, pumps, and junctions. A 'Pump Specifications' dialog box is open, providing detailed settings for a pump.

Pump Specifications Dialog:

- Number: 2
- Name: Pump
- Upstream Pipe: 28
- Downstream Pipe: 20
- Elevation: (blank)
- Inlet: 692.17 feet
- Outlet: (blank)
- Same as Inlet:
- NPSH Reference: (blank)

Pump Model: Variable Speed (selected), Optional (checked), Cost, Notes, Status.

Pump Model Selection: Pump Curve (selected), Egler Curve Data...

Flow Rate Options: Volumetric Flow Rate Fixed, Mass Flow Rate Fixed, Head Rise Fixed, Pressure Rise Fixed.

Impeller Modifications: Ratio as Percent, Actual Impeller Trim.

Check Valve at Discharge (No Backflow Allowed):

Head Rise Graph: Max X-Axis Value: 3500. The graph plots dH (feet) on the y-axis (0 to 25) against Q (gal/min) on the x-axis (0 to 4,000). The curve shows a linear decrease in head rise as flow rate increases.

Hydraulic Network Diagram: The diagram shows a network of pipes (P1-P57) and junctions (J1-J54). A pump (P2) is highlighted with a red box, corresponding to the 'Pump Specifications' dialog. The network includes various components like pumps, valves, and junctions, connected in a complex layout.

Taskbar: The Windows taskbar at the bottom shows the following applications: Microsoft PowerPoint, My Documents, RAS System (Not Res...), AFT Fathom - RAS..., and Microsoft Excel - Book1. The system tray shows the time as 8:59 PM.

The Design Solution

Jackson Pike Wastewater Treatment Plant

Pump Selection

- **Three (3) horizontal centrifugal, solids handling pumps for each RAS Well - identical in size**
- **Two (2) pumps operating at full speed achieve maximum RAS return rate; one standby**
- **Capability to run all three (3) pumps if desired**
- **Turndown limit established for the pumps = 37 Hz (62%)**



The Design Solution

Jackson Pike Wastewater Treatment Plant

Design Features For Automated RAS Control

- **Modulating valves and flow meters on each underflow pipe from the secondary clarifiers**
- **AFD for each RAS pump to vary speed and expand range of RAS return rate**
- **Flow meters on pump discharge from each RAS Well**
- **Level instrumentation provided for each RAS Well**
- **All required electrical panels and inputs/outputs for complete automated control of clarifier draw-off and return pumping**

The Design Solution

Jackson Pike Wastewater Treatment Plant

- **Manual and Automatic Control Modes**
- **Design provided components for complete automated control and flexibility**
- **Control narratives, algorithms, programming, and screen shots developed with DOSD input**
- **“Automatic” = Prompt User to manually change settings (start/stop RAS pumps)**
- **Programming could be modified in future to revise operating strategies**

The Design Solution

Jackson Pike Wastewater Treatment Plant

Manual Control

- Human Machine Interface
- Area Operator Interface Terminal
- AFD Panel
- Pumps' Local Control Station



The Design Solution

Jackson Pike Wastewater Treatment Plant

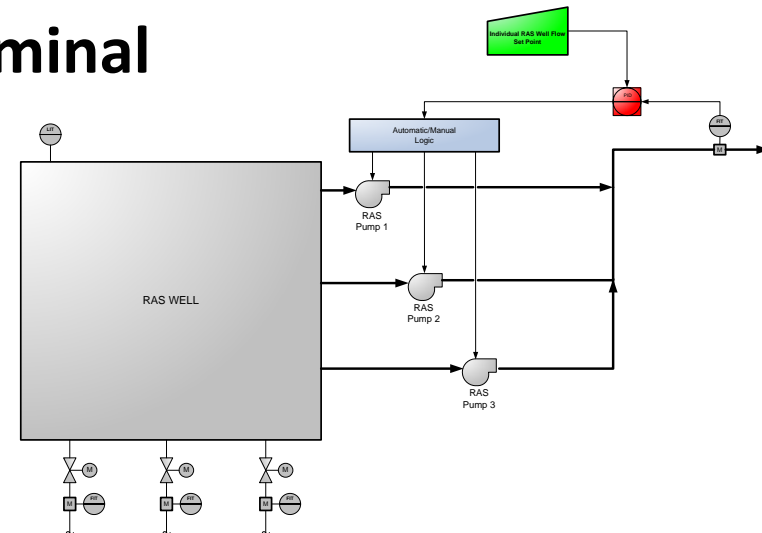
Automatic Control Modes

RAS Flow Setpoint Control

- Human Machine Interface
- Area Operator Interface Terminal

Plant Flow-Pace Control

- Human Machine Interface
- Area Interface Terminal



The Design Solution

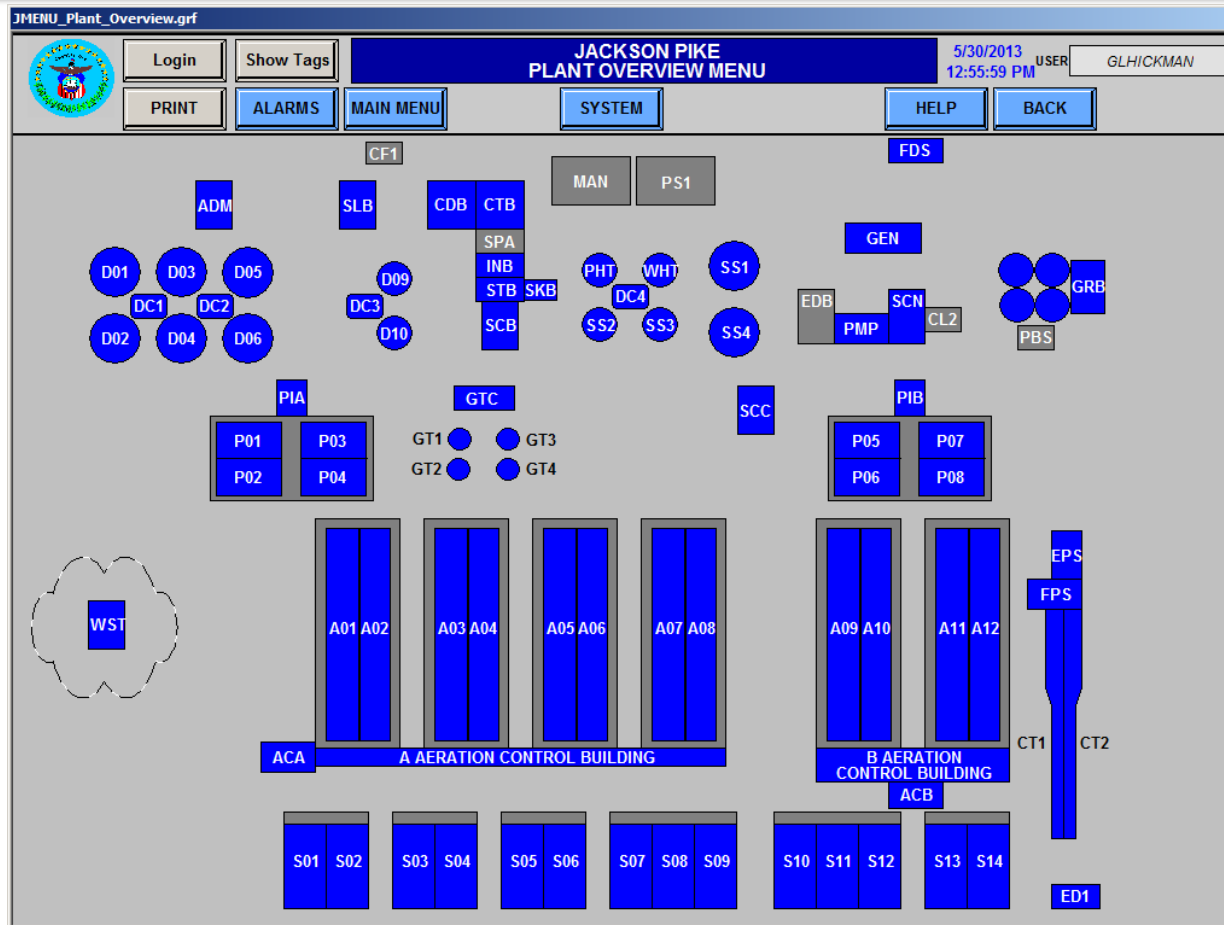
Jackson Pike Wastewater Treatment Plant

RAS Control – “Cheat Sheet”

B-Plant West RAS Well Flow Setpoints	# of Pumps Needed
>12.8 MGD	Not Recommended
10.3 to 12.8 MGD	3
6.2 to 10.2 MGD	2
3.5 to 6.1 MGD	1
0.1 to 3.4 MGD	Not Recommended
0 MGD	0

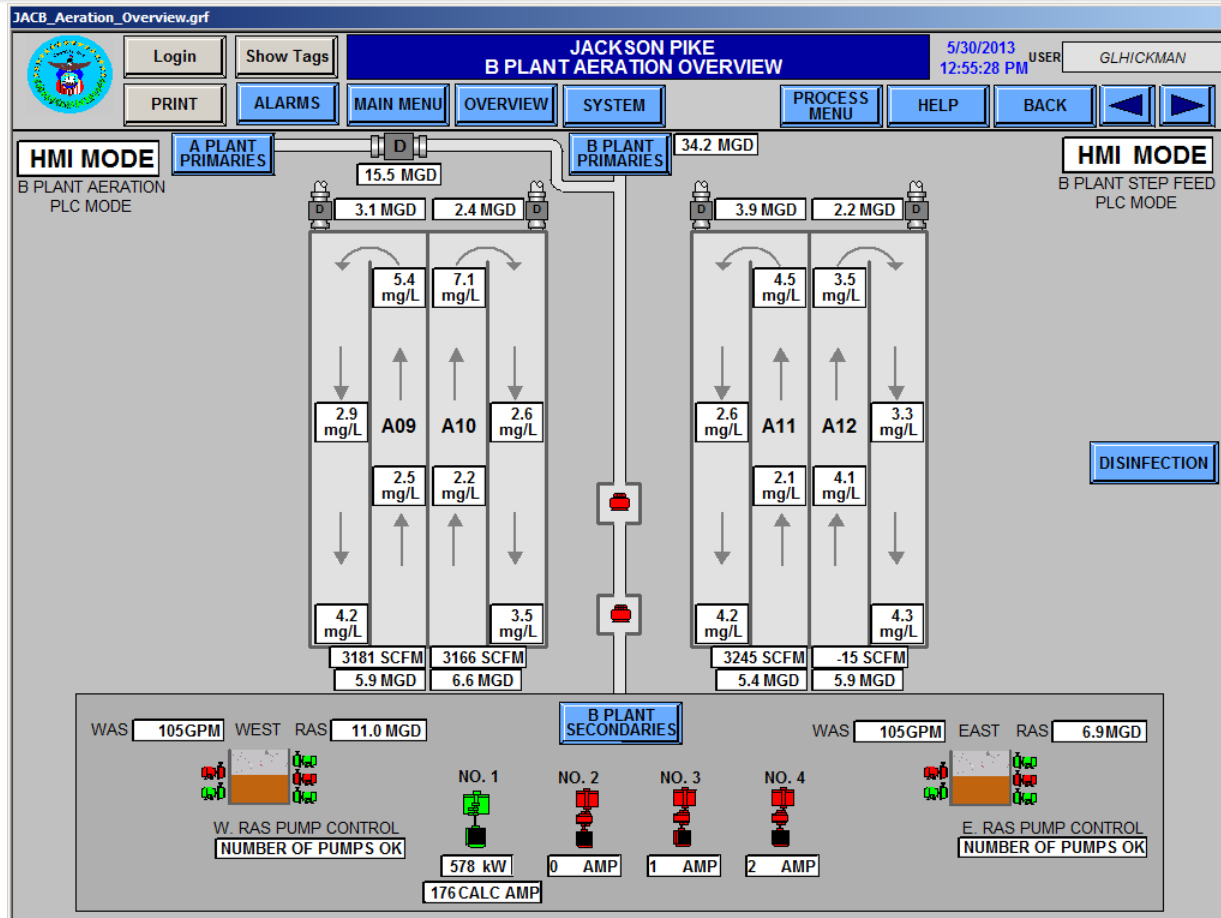
RAS Control Operation

Jackson Pike Wastewater Treatment Plant



RAS Control Operation

Jackson Pike Wastewater Treatment Plant



RAS Control Operation

Jackson Pike Wastewater Treatment Plant

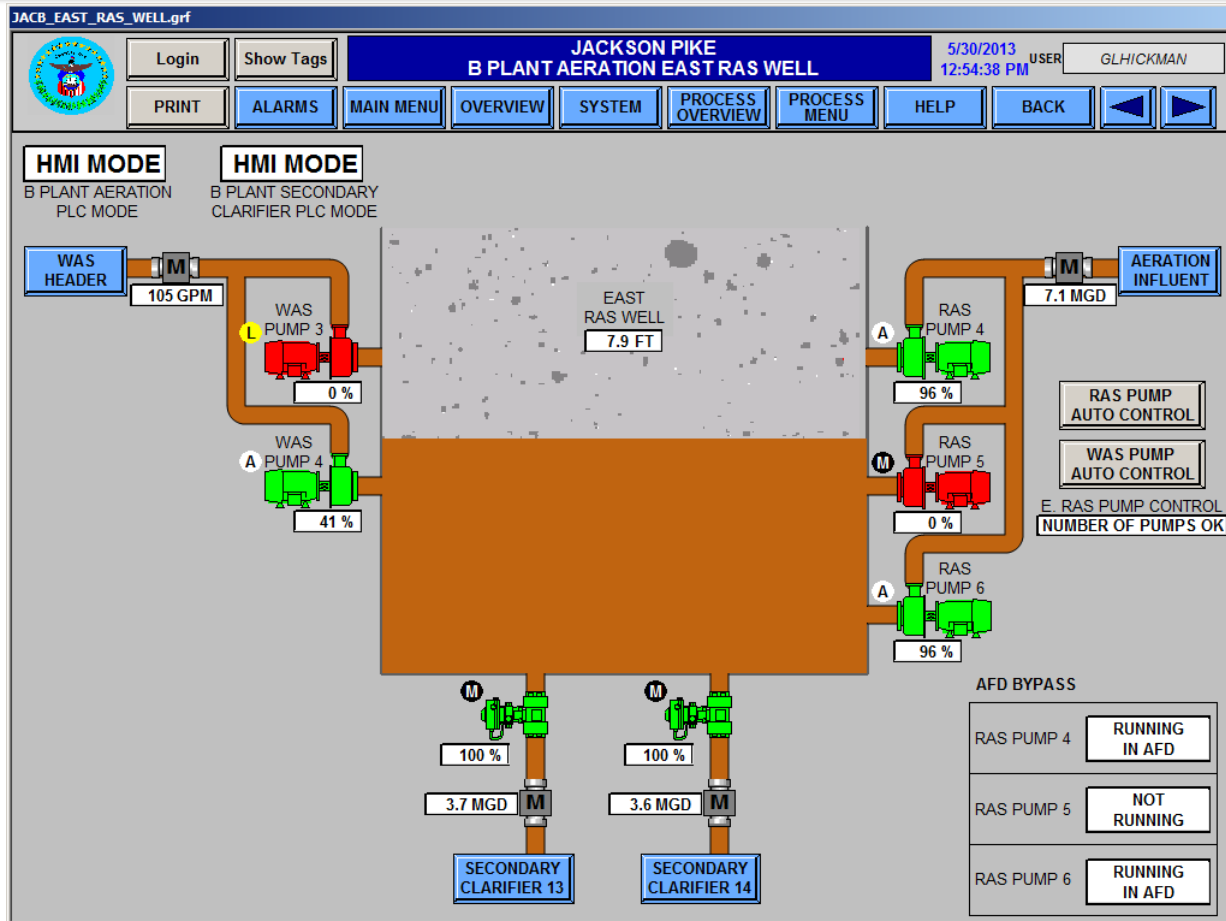
JACB_POP_RAS_PUMP_CONTROL.grf

**JACKSON PIKE
B PLANT RAS FLOW
CONTROL**

HMI MODE	B PLANT FLOW TOTAL 33.0 MGD	B PLANT RAS FLOW TOTAL 18.1 MGD	CONTROL MODE SELECTION	FLOW SETPOINT PACE SELECTED	
WEST WET WELL RAS FLOW SETPOINT 11.0 MGD	WEST RAS FLOW 11.0 MGD	EAST WET WELL RAS FLOW SETPOINT 7.0 MGD	EAST RAS FLOW 7.0 MGD		
RAS FLOW SET POINT CALCULATOR	WEST RAS WELL LEVEL 7.7 FT	RAS FLOW SET POINT CALCULATOR	EAST RAS WELL LEVEL 7.9 FT		
FLOW RATE OK	NUMBER OF PUMPS OK	FLOW RATE OK	NUMBER OF PUMPS OK		
WEST RAS PUMP NO. 1 RUNNING 87 % 22980.8 HRS 66 STARTS	WEST RAS PUMP NO. 2 STOPPED -0 % 14987.5 HRS 79 STARTS	WEST RAS PUMP NO. 3 RUNNING 87 % 18162.2 HRS 63 STARTS	EAST RAS PUMP NO. 4 RUNNING 96 % 19820.8 HRS 60 STARTS	EAST RAS PUMP NO. 5 STOPPED 0 % 18449.7 HRS 65 STARTS	EAST RAS PUMP NO. 6 RUNNING 96 % 20629.3 HRS 65 STARTS
RAS PUMP 1 AUTO MODE ACTIVE	SELECT AUTO MODE	RAS PUMP 3 AUTO MODE ACTIVE	RAS PUMP 4 AUTO MODE ACTIVE	SELECT AUTO MODE	RAS PUMP 6 AUTO MODE ACTIVE
START STOP	START STOP	START STOP	START STOP	START STOP	START STOP
SELECT MANUAL MODE	RAS PUMP 2 MANUAL MODE ACTIVE ADJUST SPEED	SELECT MANUAL MODE	SELECT MANUAL MODE	RAS PUMP 5 MANUAL MODE ACTIVE ADJUST SPEED	SELECT MANUAL MODE
EXIT					

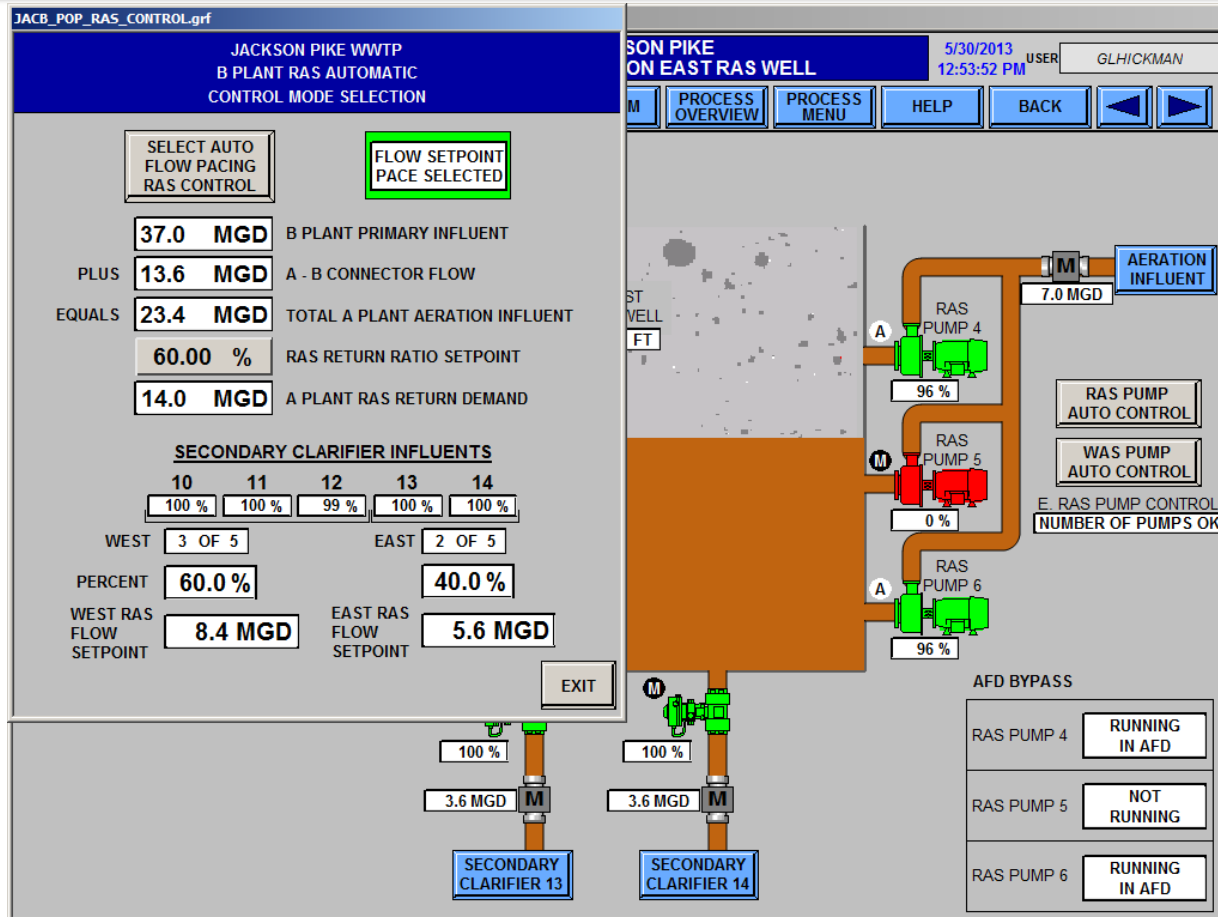
RAS Control Operation

Jackson Pike Wastewater Treatment Plant



RAS Control Operation

Jackson Pike Wastewater Treatment Plant



RAS Control Operation

Jackson Pike Wastewater Treatment Plant

JACB_WEST_RAS_WELL.grf

JACKSON PIKE
B PLANT AERATION WEST RAS WELL

4/26/2010 1:08:59 PM USER N/A

Login Hide Tags PRINT ALARMS MAIN MENU OVERVIEW SYSTEM PROCESS OVERVIEW PROCESS MENU HELP BACK

OIT MODE COMM

JACKSON PIKE
MTR 44110
B PLANT AERATION
RAS PUMP 1

AUTO/MANUAL MANUAL M

START STOP STOPPED

SPEED INDICATION: 0.00 %
SPEED SETPOINT: 95.0 %

FAIL TO START OK
FAIL TO RUN OK
FAULT OK
SPEED DEVIATION OK
HIGH TEMPERATURE OK

RE-ACK EXIT

JACKSON PIKE
MTR 44110
B PLANT AERATION
RAS PUMP 1

AUTO/MANUAL MANUAL M

START STOP STOPPED

SPEED INDICATION: 0.00 %
SPEED SETPOINT: 95.0 %

DETAILED STATUS EXIT

COMM VLV 42180 FIT 42170
COMM VLV 42280 FIT 42270
COMM VLV 42380 FIT 42370

SECONDARY CLARIFIER 10 SECONDARY CLARIFIER 11 SECONDARY CLARIFIER 12

RAS PUMP 1 18.0 MGD FIT 44150
RAS PUMP 2
RAS PUMP 3

RAS PUMP AUTO CONTROL
WAS PUMP AUTO CONTROL

AFD BYPASS

RAS PUMP 1 NOT RUNNING
RAS PUMP 2 NOT RUNNING
RAS PUMP 3 NOT RUNNING

RAS Control Operation

Jackson Pike Wastewater Treatment Plant

JACKSON PIKE
B PLANT RAS FLOW
CONTROL

5.0 MGD B PLANT RAS FLOW TOTAL -5.0 MGD

EAST WET WELL RAS FLOW SETPOINT 25.0 MGD EAST RAS FLOW -5.0 MGD

RAS FLOW SET POINT CALCULATOR EAST RAS WELL LEVEL 8.0 FT

FLOW RATE OK NUMBER OF PUMPS OK

EAST RAS PUMP NO.	STATUS
4	RUNNING
5	FAIL
6	FAIL

JACB_POP_CALC.grf

JACKSON PIKE WASTEWATER TREATMENT PLANT
B PLANT RAS FLOW
SETPOINT CALCULATOR

74 MGD RAW SEWAGE PUMP TOTAL FLOW

38.1 MGD B PLANT PRIMARY TANKS INFLUENT

MINUS 14.5 MGD A-B CONNECTOR FLOW TO A PLANT

EQUALS 23.5 MGD B PLANT AERATION INFLUENT

TIMES 60.0% RAS RETURN RATIO

EQUALS 14.1 MGD B PLANT RAS RETURN DEMAND

	WEST	EAST	TOTAL
NUMBER OF SECONDARY CLARIFIERS IN-SERVICE	3	2	5
PERCENT	60.0%	40.0%	

WEST RAS FLOW SETPOINT 8.5 MGD EAST RAS FLOW SETPOINT 5.7 MGD

REFRESH

EXIT

Calculator is **ONLY** a tool to establish RAS flow setpoints for the operator.

RAS Control Operation

Jackson Pike Wastewater Treatment Plant

JACKSON PIKE
RAS FLOW CONTROL

MGD

EAST WET WELL RAS FLOW SETPOINT 10.0 MGD EAST RAS FLOW 10.0 MGD

RAS FLOW SET POINT CALCULATOR EAST RAS WELL LEVEL 5.0 FT

OK

EAST RAS PUMP NO. 4	EAST RAS PUMP NO. 5	EAST RAS PUMP NO. 6
RUNNING	RUNNING	STOPPED
50 %	50 %	0 %
94.8 HRS	94.5 HRS	309.2 HRS
9STARTS	5STARTS	5STARTS
RAS PUMP 4 AUTO MODE ACTIVE	RAS PUMP 5 AUTO MODE ACTIVE	SELECT AUTO MODE
STOP	STOP	START STOP
SELECT MANUAL MODE	SELECT MANUAL MODE	RAS PUMP 6 MANUAL MODE ACTIVE
		ADJUST SPEED
		EXIT

When the pumps are running, but NOT achieving the flow setpoint this box will either indicate:

“Flow < Setpoint - Add a Pump”

OR

“Flow > Setpoint - Stop a Pump”

Operator must ‘manually’ start or stop a pump. Then, speeds will be adjusted automatically once the appropriate number of pumps are in operation.

RAS Control Operation

Jackson Pike Wastewater Treatment Plant

Why utilize such a 'manual' operating approach?

- Abrupt inflow variations experiences at plant
- Potential to divert flow to Southerly WWTP
- Informed staff influences positive reactions to plant variations
- Operator flexibility



Project Completion

Jackson Pike Wastewater Treatment Plant

Before



After



Project Completion

Jackson Pike Wastewater Treatment Plant

Before



After



Project Completion

Jackson Pike Wastewater Treatment Plant

Before



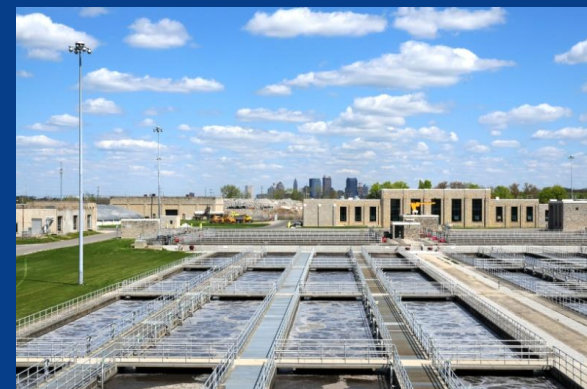
After



Questions?



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