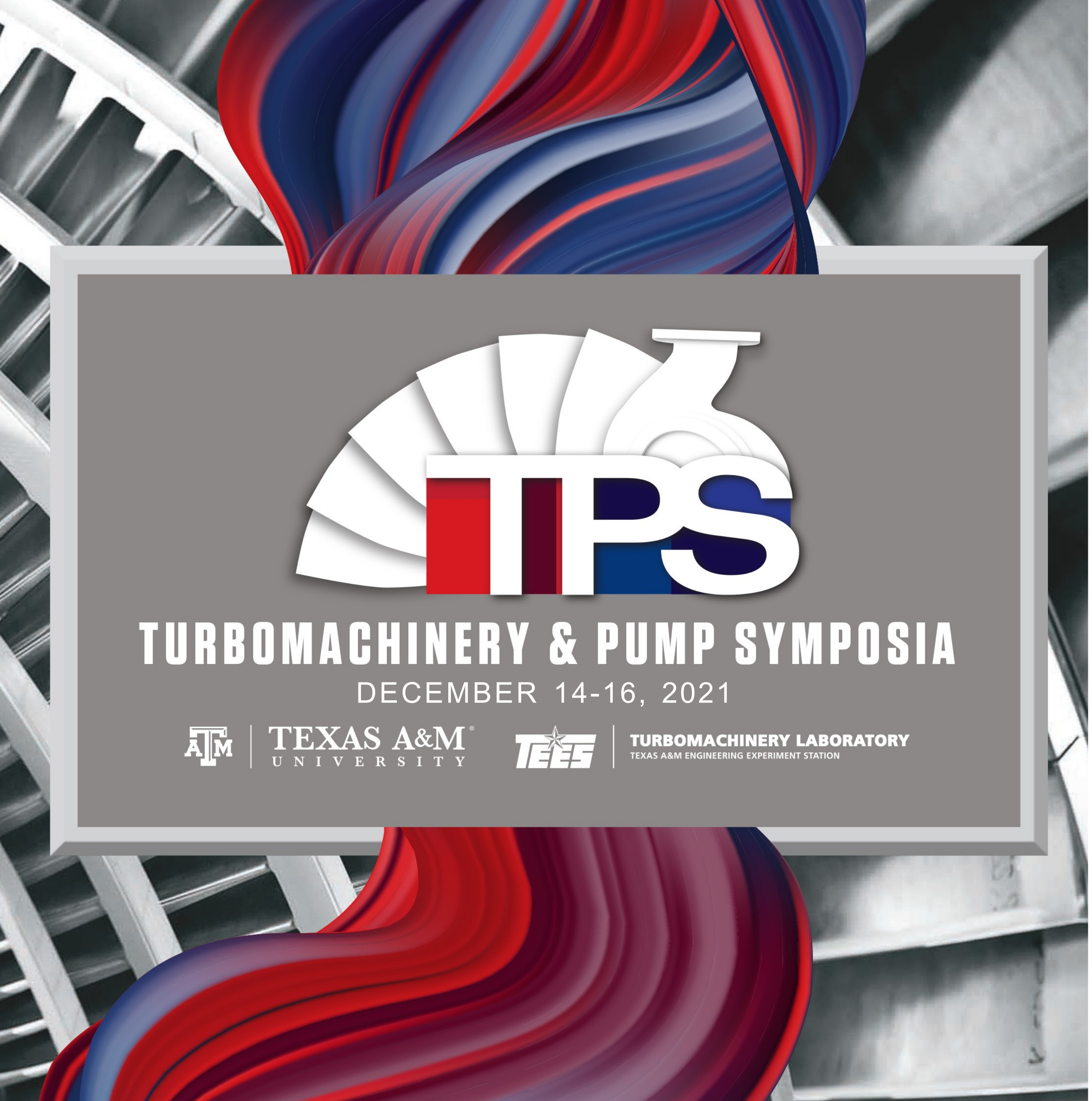


NEW ANALYTICS TO IMPROVE PUMP PERFORMANCE

BY: Juan Gamarra, PE [Specific Energy] & Rodney Seaver [Kempner Water Supply Corporation]

SPECIFIC ENERGY

BIOS:

Juan Gamarra, PE

- Director of Business Development
- Licensed Professional Engineer in the State of NJ
- 14+ years of experience in the pump industry

Rodney Seaver

- Distribution Manager
- Specific Energy customer since 2009
- Found Specific Energy as Field Service Supervisor

Abstract

Kempner Water Supply Corp. in Central Texas serves a population of 20,000. After installing VFDs, they experienced high pressure spikes which strained their pipe network as well as their staff. Line breaks became a common issue. After installation of a Dynamic Pump Optimizer (DPO), the pressure transients decreased and the VFDs were used to their full potential. In the end, KWSC was able to reduce peak transients by 77%, cut their energy costs by 20%, and better manage their assets.

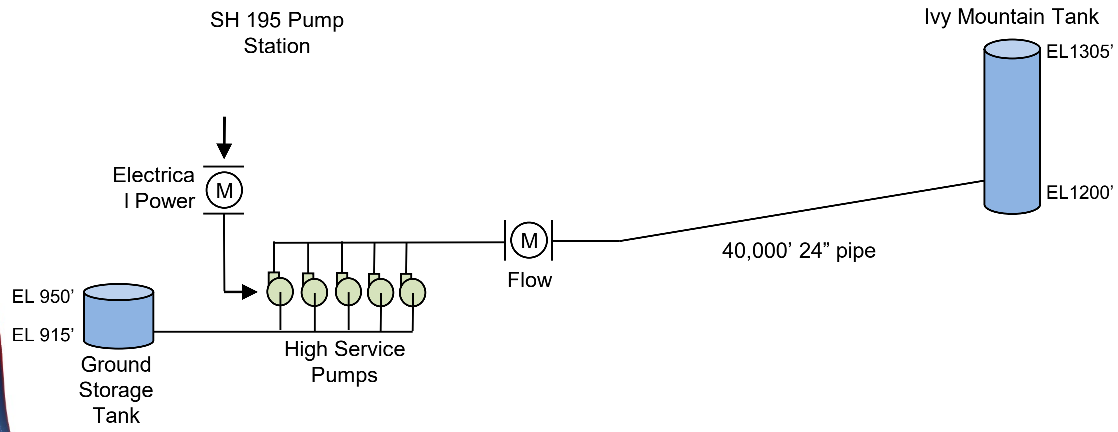
TURBOMACHINERY & PUMP SYMPOSIA

Problem Statement

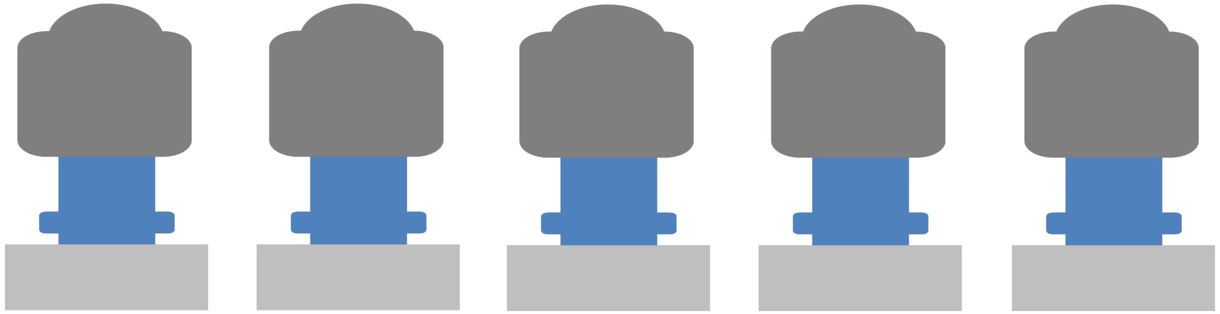
"After installing VFDs, my team was fixing suction and discharge pipe ruptures once a week. I was about to lose my guys because they grew frustrated of having to perform the same urgent repairs, working lo

System Overview

- State Highway 195 Pump Station
- (5) 250 HP Vertical Turbine Pump
- Pump water to Ivy Mountain tank
- KWSC's largest energy consumer
- Installed VFDs to reduce energy



Operators' Challenge



Constant Speed Control ON / OFF

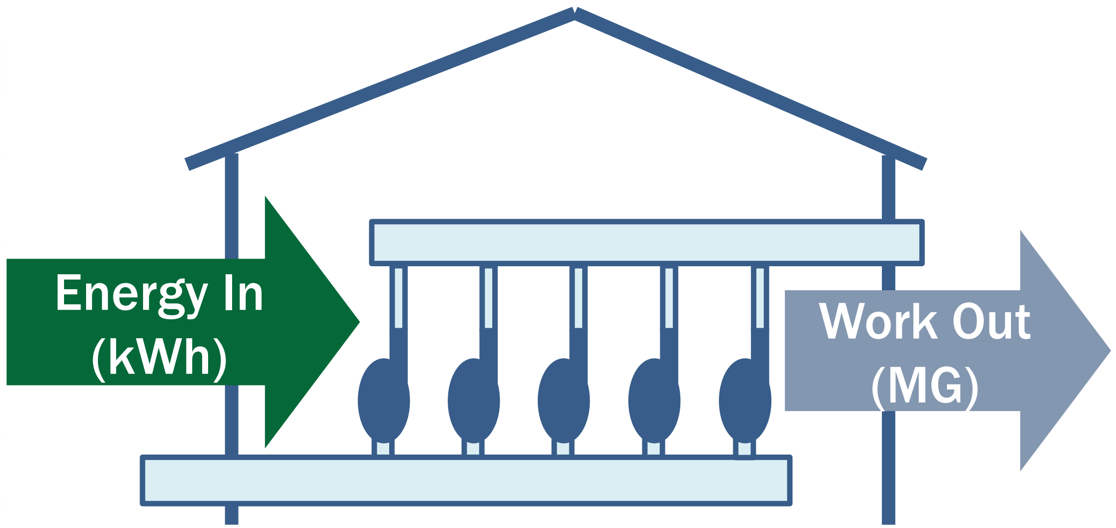
2 x 2 x 2 x 2 x 2 = 32 combinations

31 x 31 x 31 x 31 x 31 > 28 million combinations

VFD Speed Control (0.5 Hz res.)

45 60 45 60 45 60 45 60 45 60

Specific Energy - Defined



$$\text{Specific Energy} = \frac{Energy\ [kWh]}{Volume\ [MG]} = \frac{Power\ [kW]}{Flow\ [MG/h]}$$

EXAMPLE

Pump station power: P = 1,125 kW

Flow rate: Q = 15,000 gpm

SE = *k* (*P* / *Q*)

SE = 1,125 kW / 15,000 gal / min
* (1,000,000 gal / MG)
* (1 hour / 60 minutes)

SE = 1,250 kW h / MG

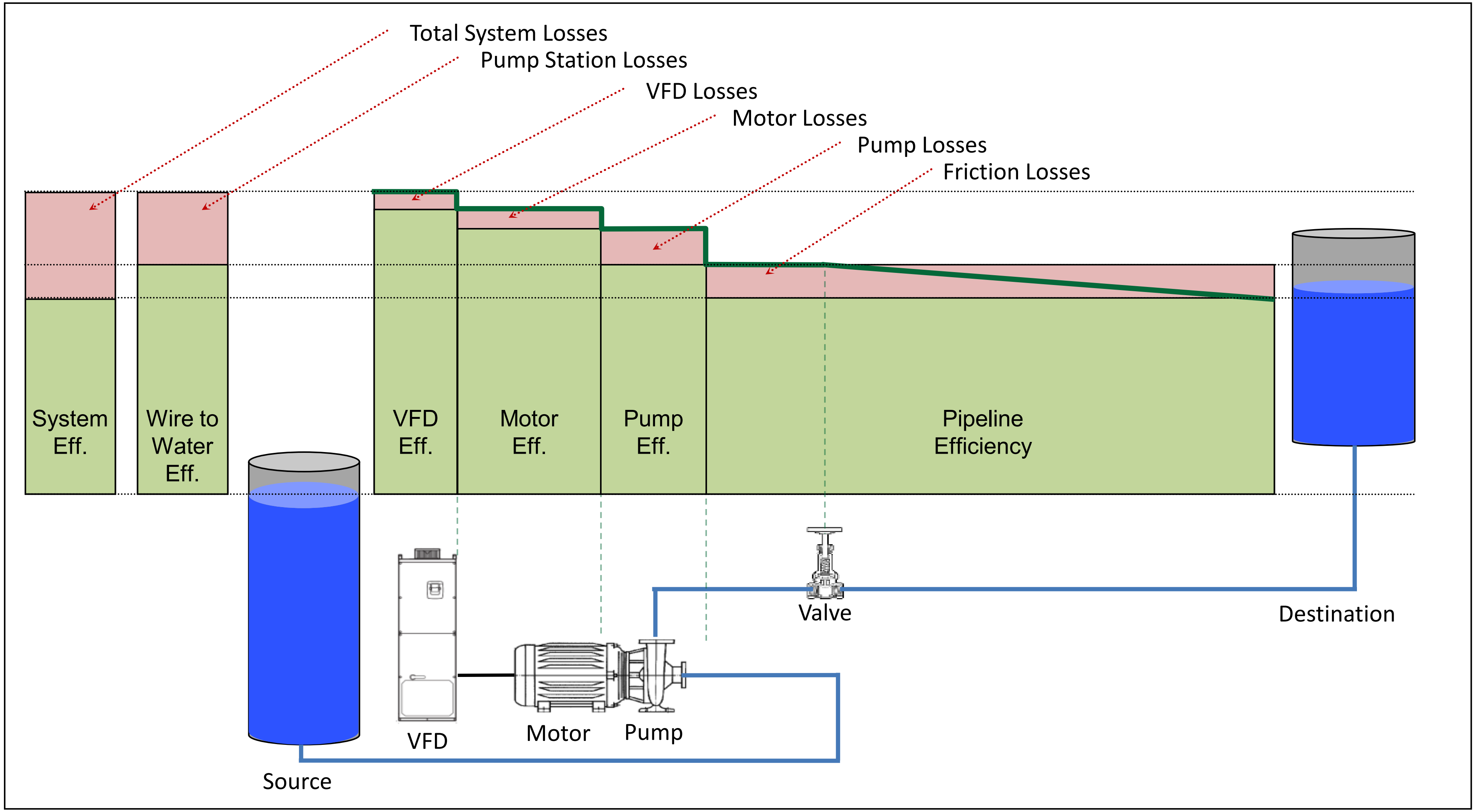
100% efficient system: 3.14 kilowatt-hours per million gallons per foot of elevation gain.

SE Efficiency =

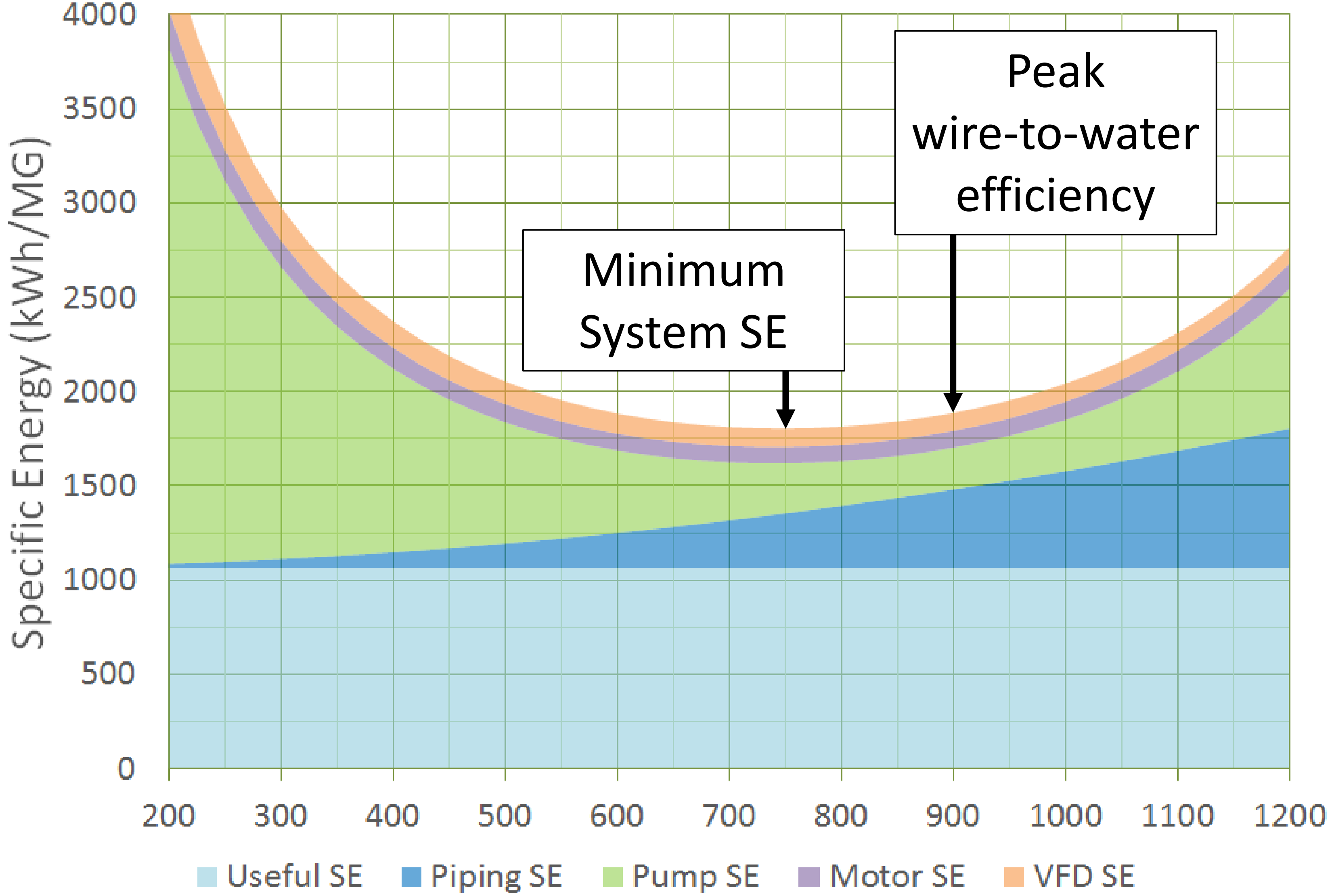
$$\frac{3.14 \cdot (\text{elevation gain in ft})}{(\text{measured SE})}$$

Typical efficiency for public water pumping and distribution systems: 50% to 75%.

Specific Energy - Illustrated



Specific Energy - Graphed



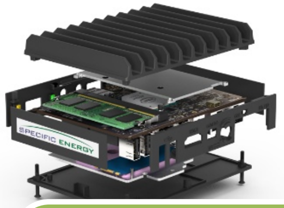
Single Pump Flowrate (gpm)

Specific Energy - Solution Architecture

Physical System ⟷ Digital Twin

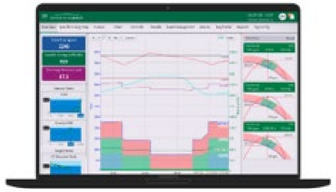
Plant Data

- Pressure
- Flow
- Level
- Pump power/speed
- PLC/Controller (inputs/outputs)



Dynamic Pump Optimizer - Edge Device

- Physics based model analytics
- Compute Pump Curves
- Optimize in real-time
- Model ROI
- Dynamic modeling



Cloud

- Operating visibility and recommendations
- Pump health reports
- Monitor from anywhere
- Unlimited data storage/historian

Operations

- Text message alerts
- Recommendations
- Real-time pump performance
- Flexible operations
- Dashboards

Advisory Mode [Passive]

DPO Control [Active]

Model-based Control

Optimized Performance

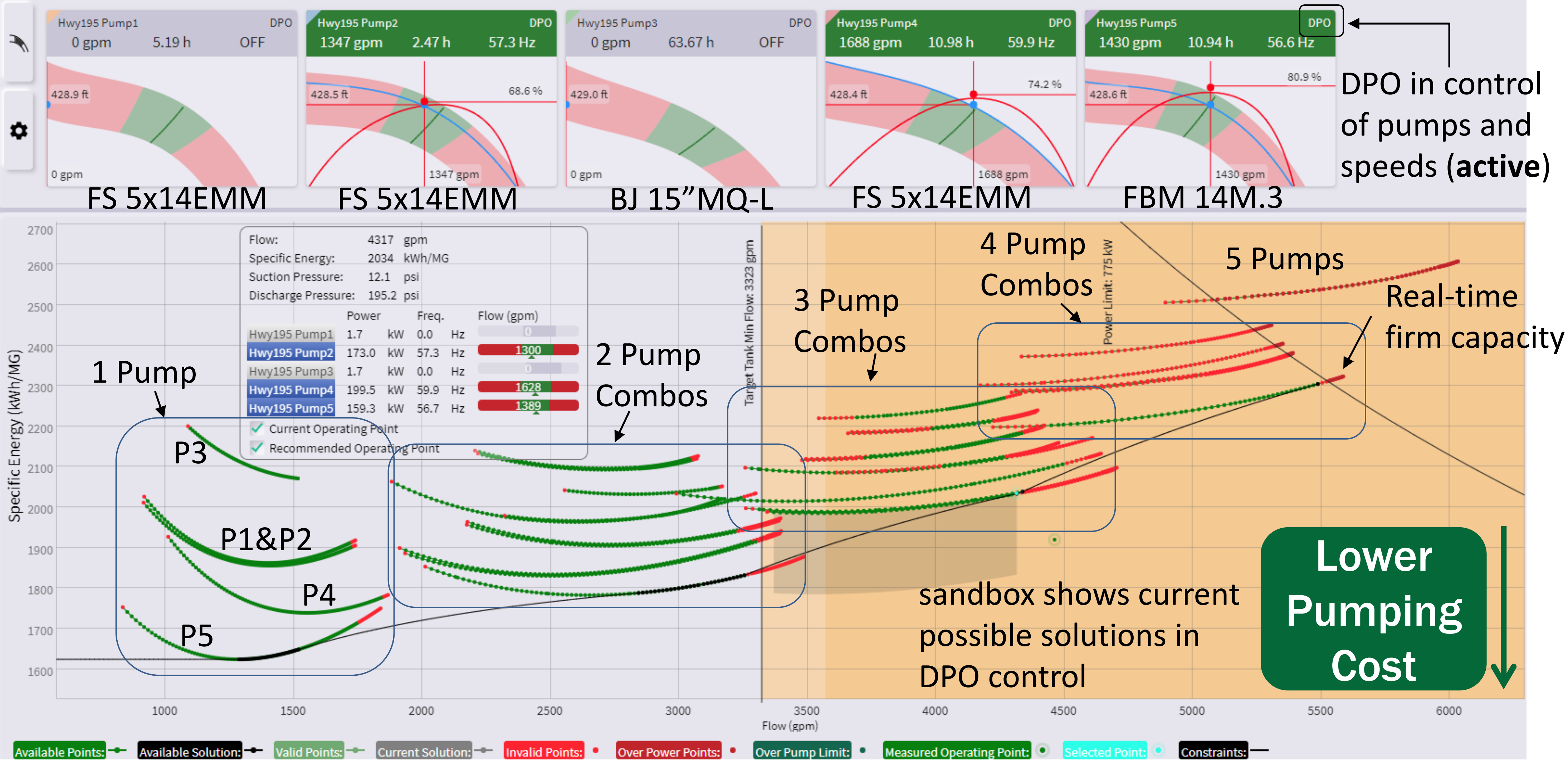
Informed Decisions

Actionable Results

Specific Energy – Map

Green = In POR

Red = Out of POR



Map shows all possible ways to run the pump station. The lower the point, the lower the SE.

Pump Health – Graph

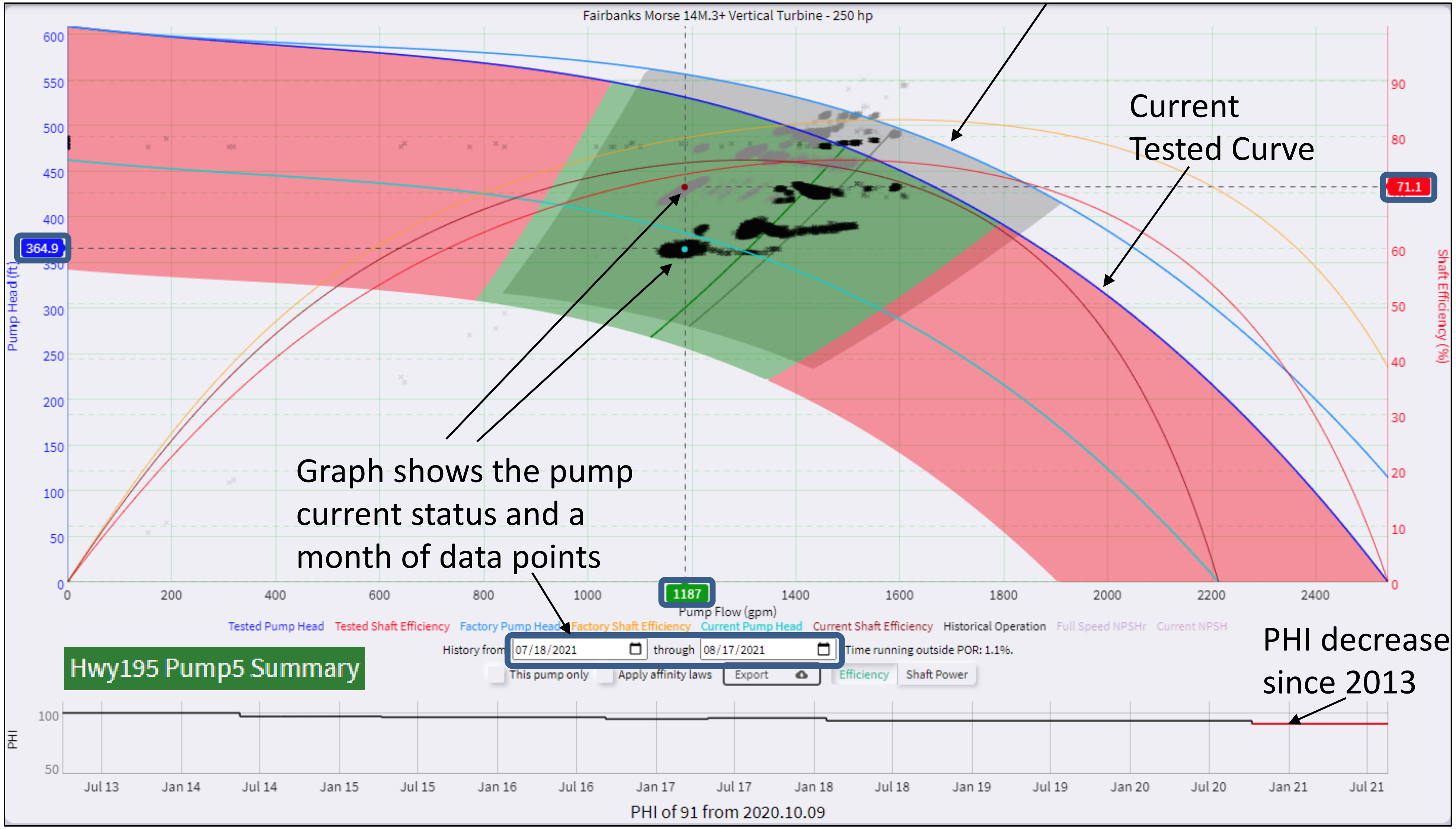
Pump Health Index (PHI) = Current BEP Efficiency vs. Factory BEP Efficiency

Factory Curve

Current Tested Curve

Graph shows the pump current status and a month of data points

PHI decrease since 2013



TURBOMACHINERY & PUMP SYMPOSIA

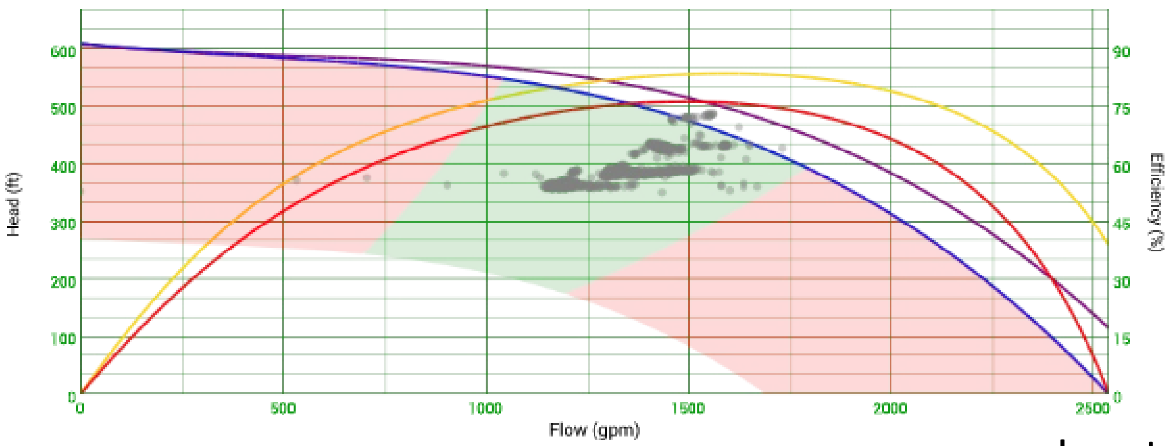
Pump Health – Report

SH 195 Pump Station - Hwy195Pump5

July, 2021 | Fairbanks Morse 14M.3+ Vertical Turbine | Page 6 of 6

Pump Health Index (PHI)	Reduced Capacity	Days Since Last Test	Repair Net Present Value	Repair ROI
91	8.7%	296	$78,757	167.5%

Factory and Tested Pump Curves

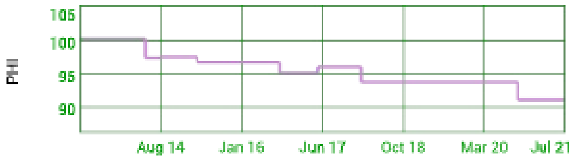


Inputs

Operating Summary	
Month Run Time	355.5 hours
Month Time Outside of POR	1.6 hours
Total Run Time	30,422 hours
Total Run Time Outside of POR	1,086 hours

Pump Repair Financial Factors	
Pump Repair Cost	$47,018
Annual Discount Rate	3%
Expected Pump Life	10 years
Predicted Energy Reduction*	$14,745/yr

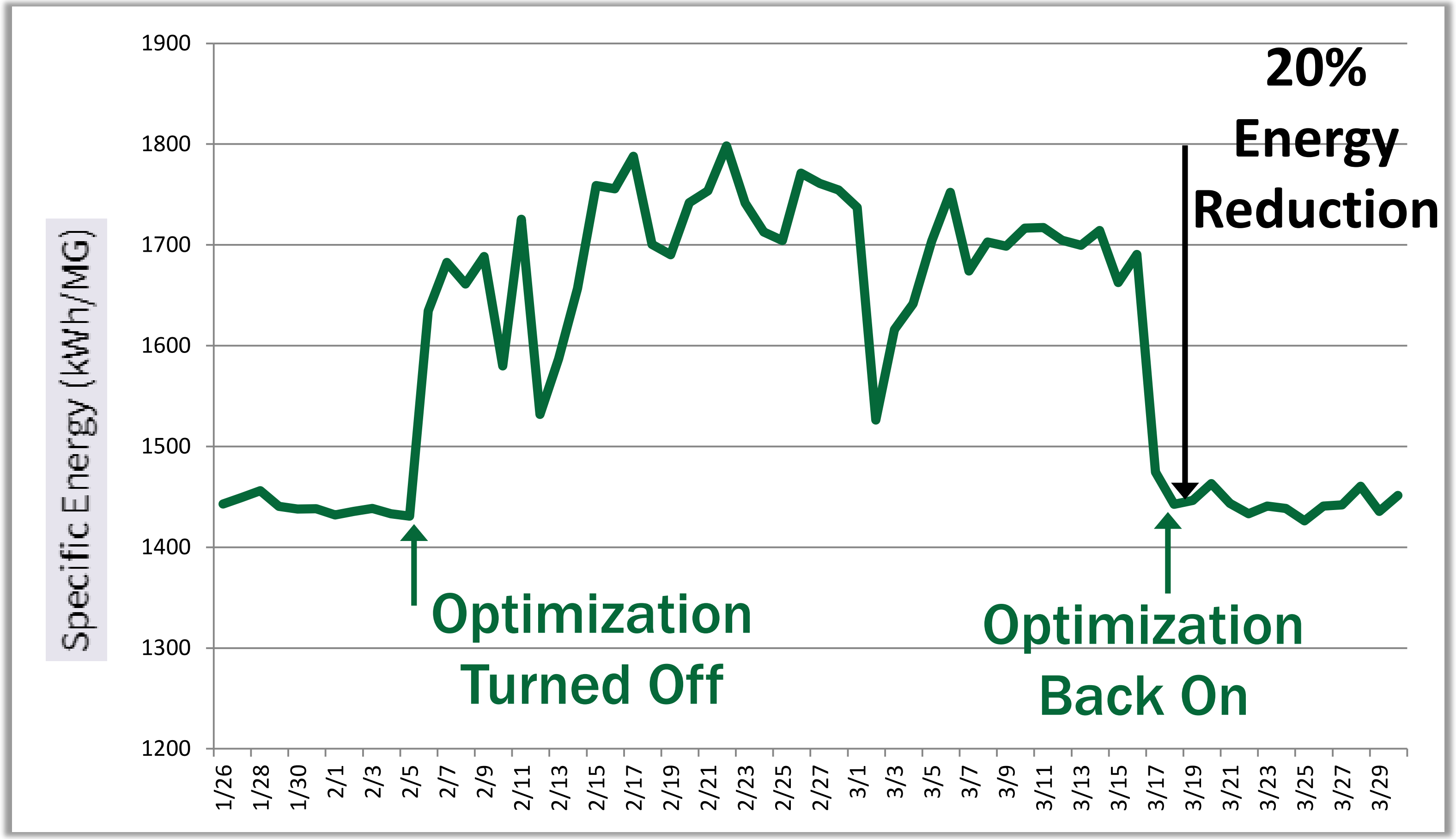
Historical Pump Health Index (PHI)



Pump Repair Financial Analysis	
Present Value of Energy Reduction	$125,775
Pump Repair Cost	$47,018
Net Present Value (NPV)	$78,757
Return on Investment (ROI)	167.5%
Internal Rate of Return (IRR)	28.9%

The <u>monthly health report</u> shows how the pump has worn to date. The goal is to quickly show managers information on deciding to refurbish a unit when the <u>Net Present Value (NPV)</u> turns positive. It takes the total run time and calculates the energy reduction based on using a refurbished unit (more efficient). <u>No more running pumps to failure</u> or past their energy efficient lifespans. In some cases, capacity reduction is king.

Results - Energy Reduction



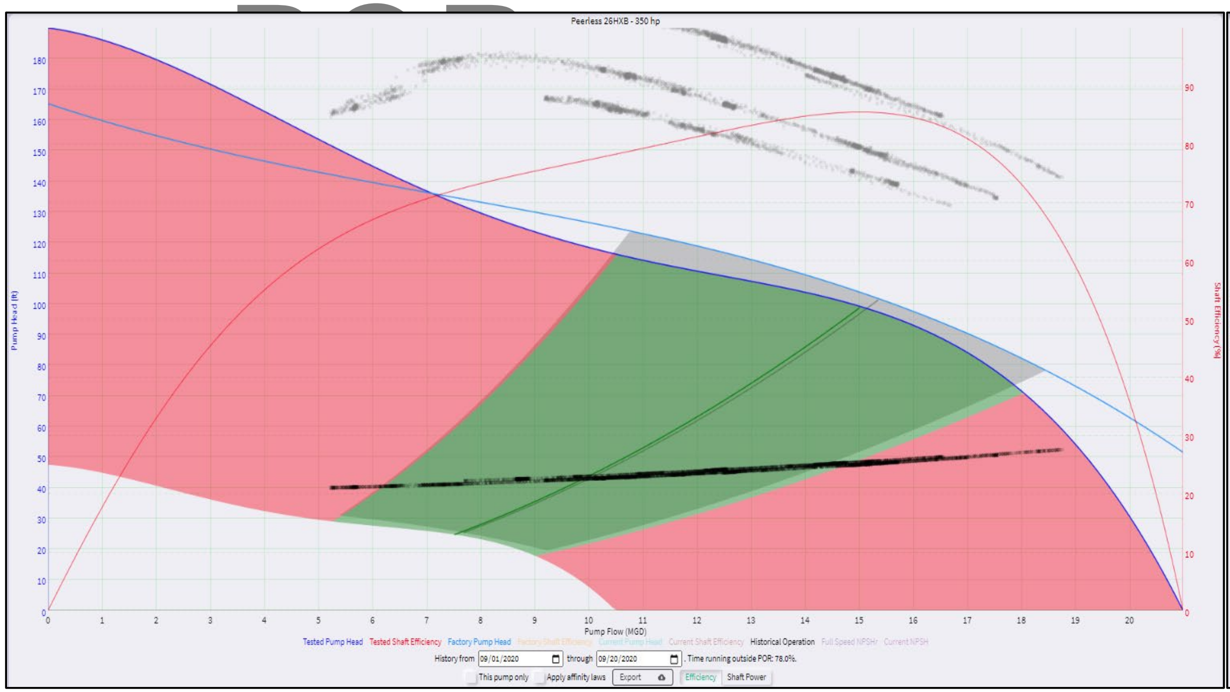
Daily Specific Energy (1/26/2014 – 3/30/2014)

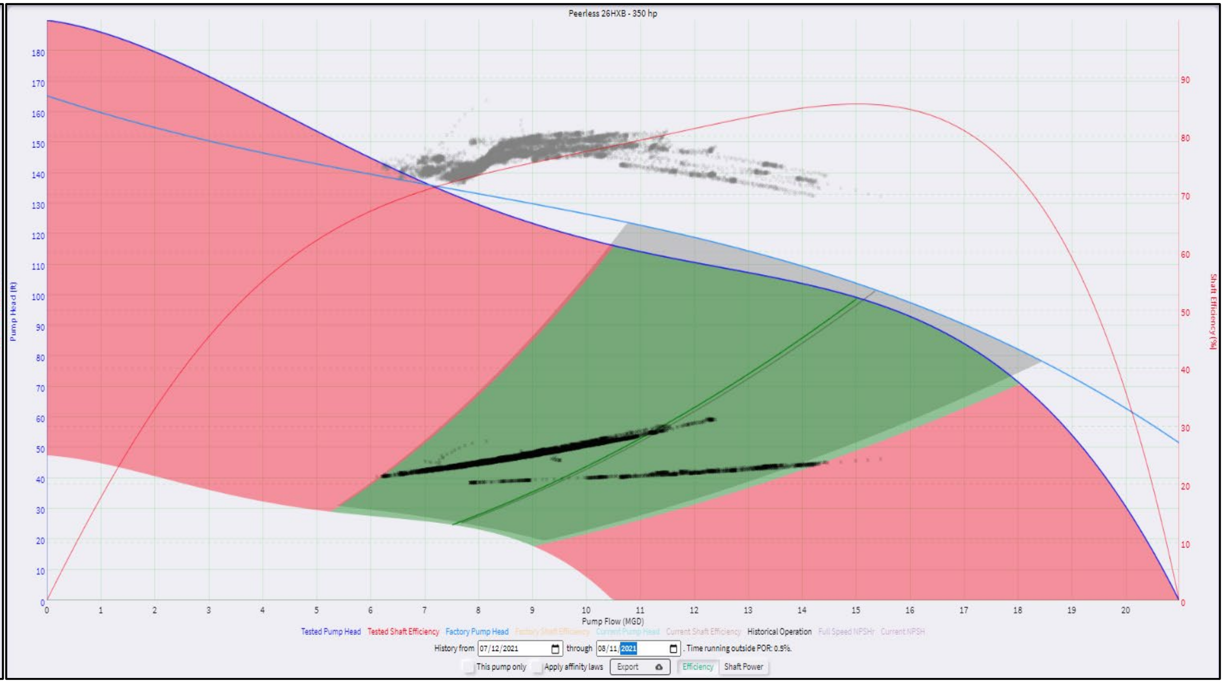
Annual Energy Savings:
$37,000
431,052 kWh

Optimization period involved all pumps. The DPO system was controlling the combination of pumps and speeds (**active**) to meet the demand at minimum SE.

TURBOMACHINERY & PUMP SYMPOSIA

Results – Operation within POR





20 days of operation

Operators without dashboard access

"Flying Blind" =78% out of POR

Green = In POR

Red = Out of POR

Operators are controlling the pumps and speeds following DPO recommendations in Advisory Mode(**passive**).

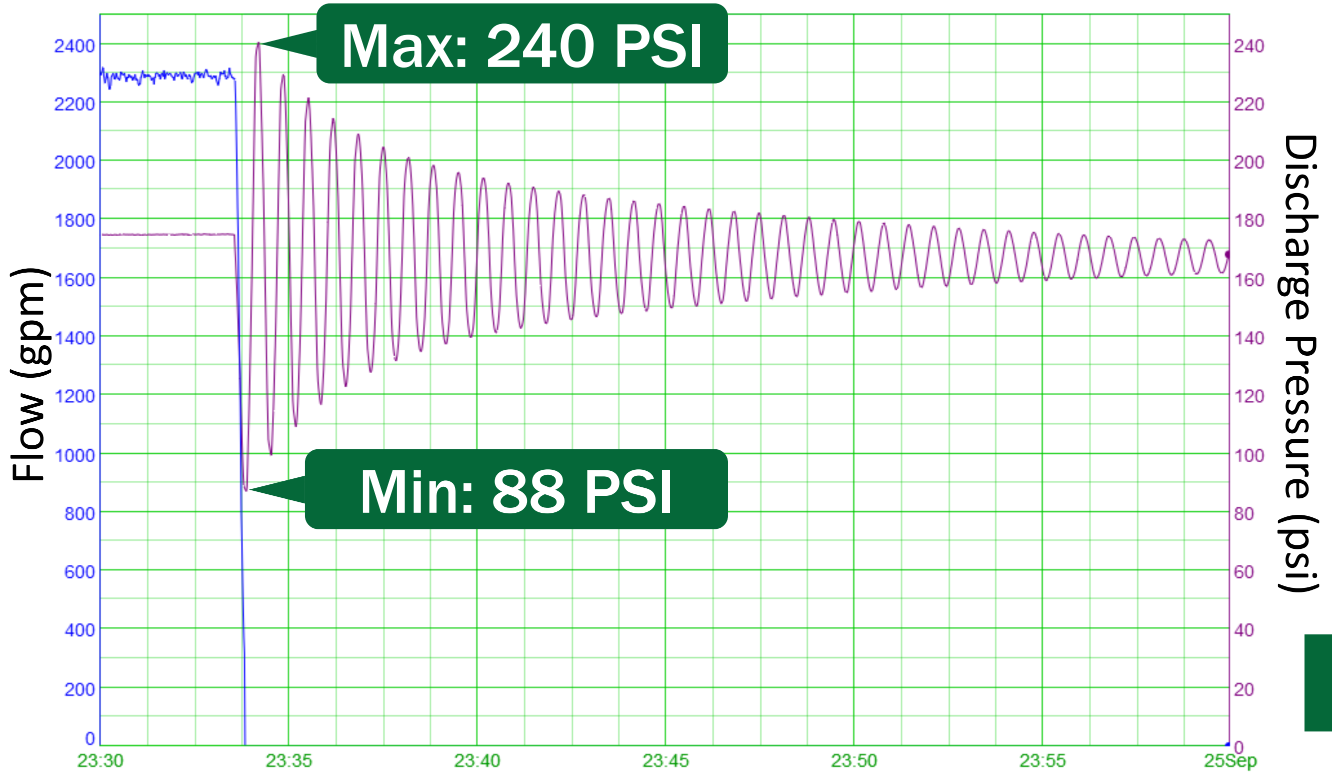
Operators following recommendations

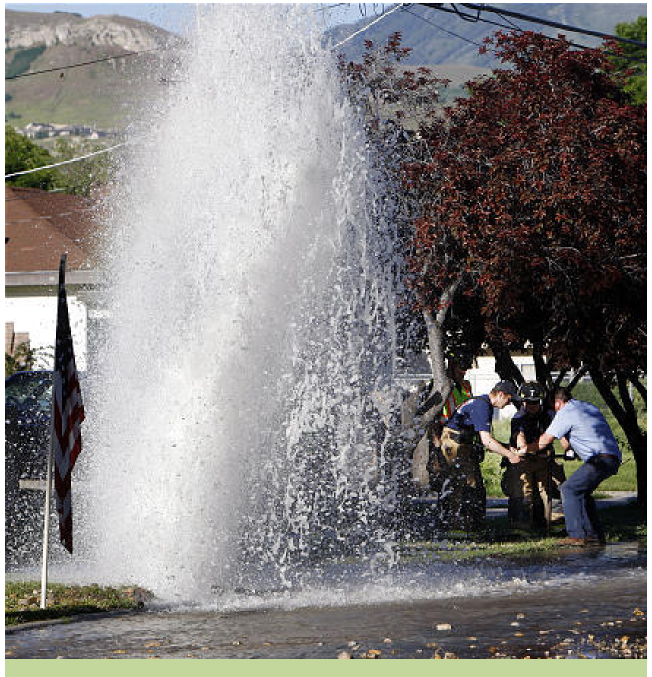
Advisory Mode <1% out of POR

30 days of operation

TURBOMACHINERY & PUMP SYMPOSIA

Water Hammer - Before





PID control made changes too quickly
[no flow rate-of-change control]
controlled via pump speed

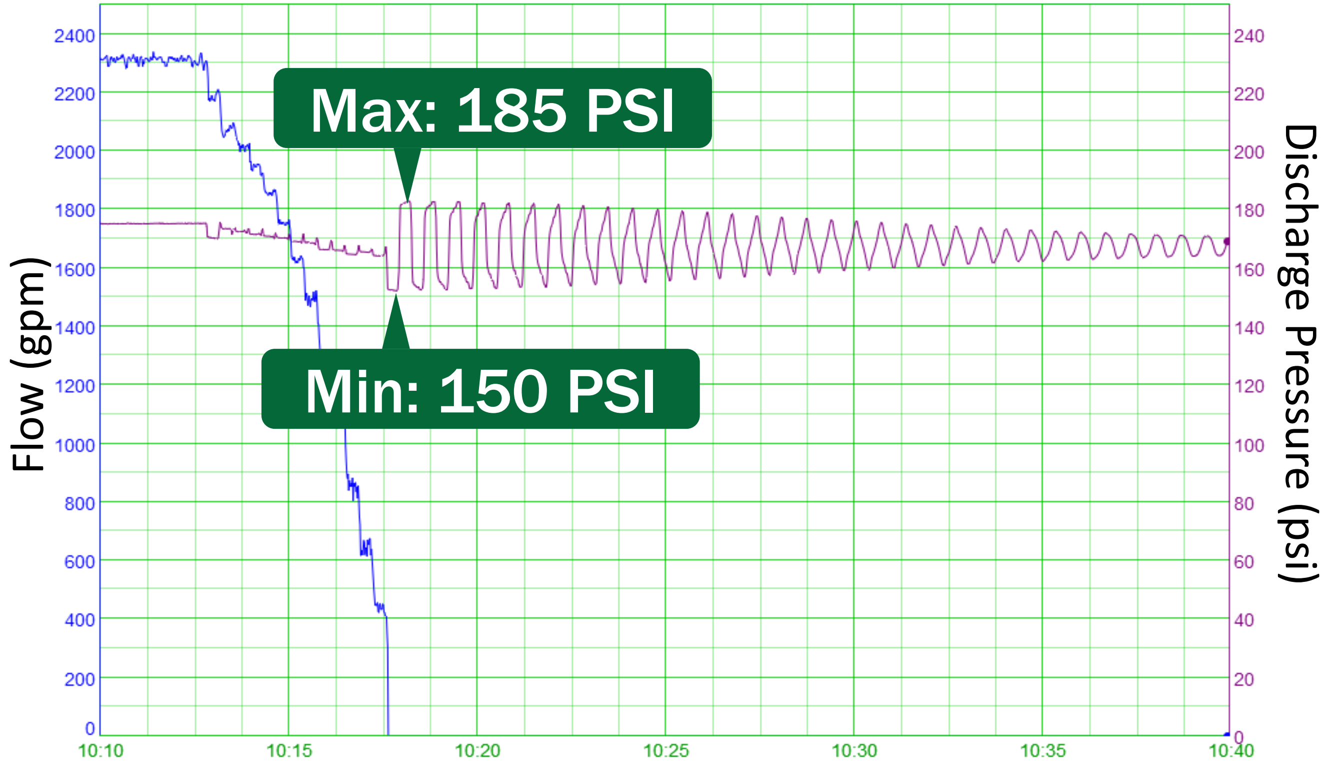
Without Digital Transient Control

Max Pressure: 240 PSI

Min Pressure: 88 PSI

Δ Pressure: 152 PSI

Digital Transient Control -



Edge analytics determined appropriate response interval for flow rate-of-change (Dynamic Pump Optimizer in control)

With Digital Transient Control

Max Pressure: 185 PSI

Min Pressure: 150 PSI

Δ Pressure: 35 PSI

TURBOMACHINERY & PUMP SYMPOSIA

Lessons Learned

- Kempner WSC learned that their lead pump was severely worn and operating at a peak efficiency of 57% - almost 30% lower than the peak efficiency of a new pump
- Software recommended a pump repair project with a NPV of $12,488 and a ROI of 50%
- An average of 23% energy savings realized by operating at minimum specific energy
- Digital Transient Control functionality reduced peak pressure transients during pump starts and stops by 77%, from 152 to

Customer Feedback

"The DPO has made it much easier to run our pump station and allowed us to get the full benefit out of our VFDs." – Rodney Seaver

TURBOMACHINERY & PUMP SYMPOSIA