Better Plants
U.S. DEPARTMENT OF ENERGY

WATER VIRTUAL IN-PLANT (VINPLT) TRAINING

Session 6

U.S. DEPARTMENT OF ENERGY

Session 6: Hydraulic Modeling and Energy Efficient Design

Thank You!

Sponsor:

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Today's Agenda

	Homework Recap
	Hydraulic Modeling
	Break
	Energy-Efficient Design
	Capital Project Incentives
	Kahoot!
	Q&A

HOMEWORK RECAP

POLL

HYDRAULIC MODELING

Hydraulic Model Demos...

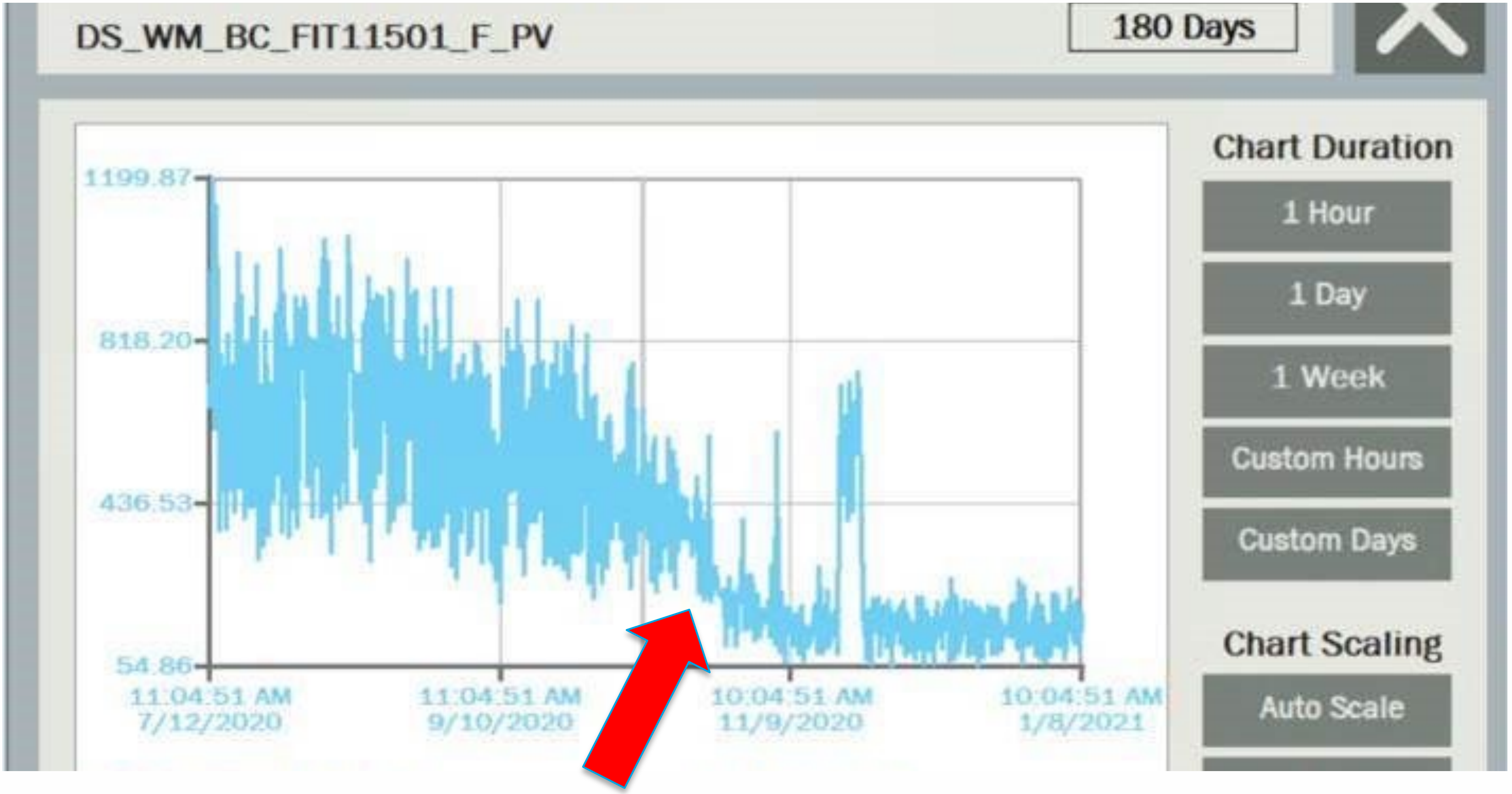
- High Pressure Areas
- Low Pressure Areas
- Broken PRV
- Pump Power
- WTP Trace
- Tank Levels

Broken PRV: How much does it cost?

- 642 gpm
- 4858 ft upstream – 4706 ft downstream = 152 ft
- Assume 75% efficiency for upstream pump

Power = (642)(152)/(3960*0.75) = 32.9 HP

(32.9 HP)(0.746 kW/HP)(24 h/d)(30 d/mo)($0.085/kWh) = **$1,502/mo**


DS_WM_BC_FIT11501_F_PV
180 Days
Chart Duration
1 Hour
1 Day
1 Week
Custom Hours
Custom Days
Chart Scaling
Auto Scale
1199.87
818.20
436.53
54.86
11:04:51 AM 7/12/2020
11:04:51 AM 9/10/2020
10:04:51 AM 11/9/2020
10:04:51 AM 1/8/2021

BREAK

ENERGY-EFFICIENT DESIGN

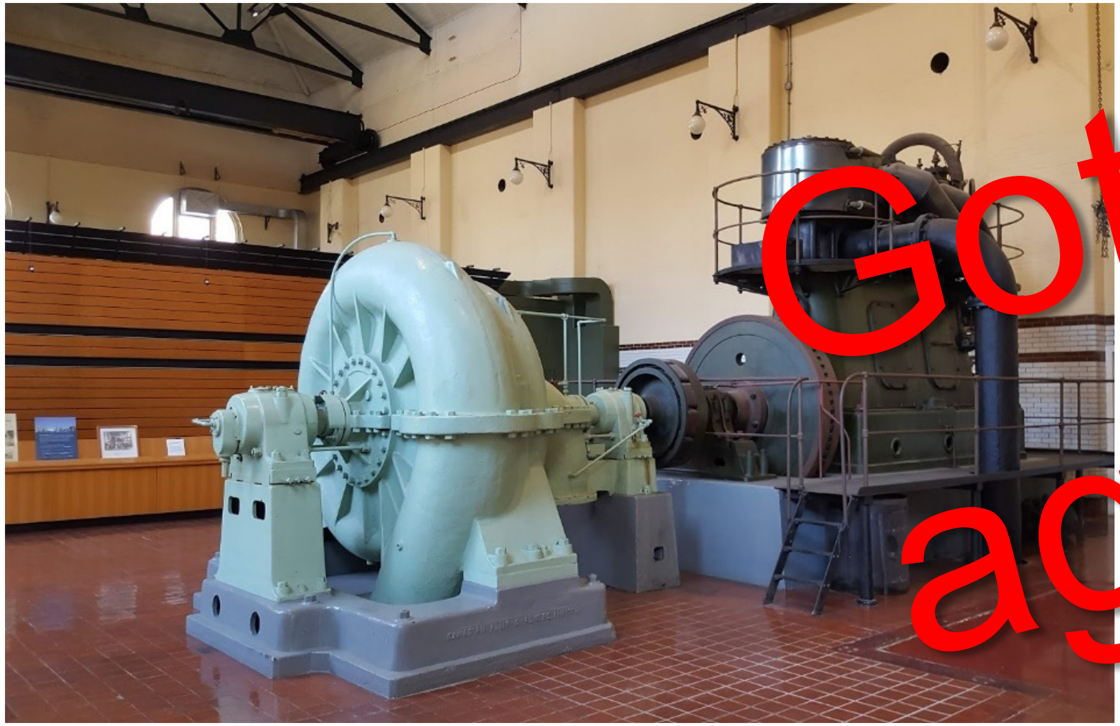
Which pump station is more efficient?

A

Gotcha!

B

Which pump station is more efficient?



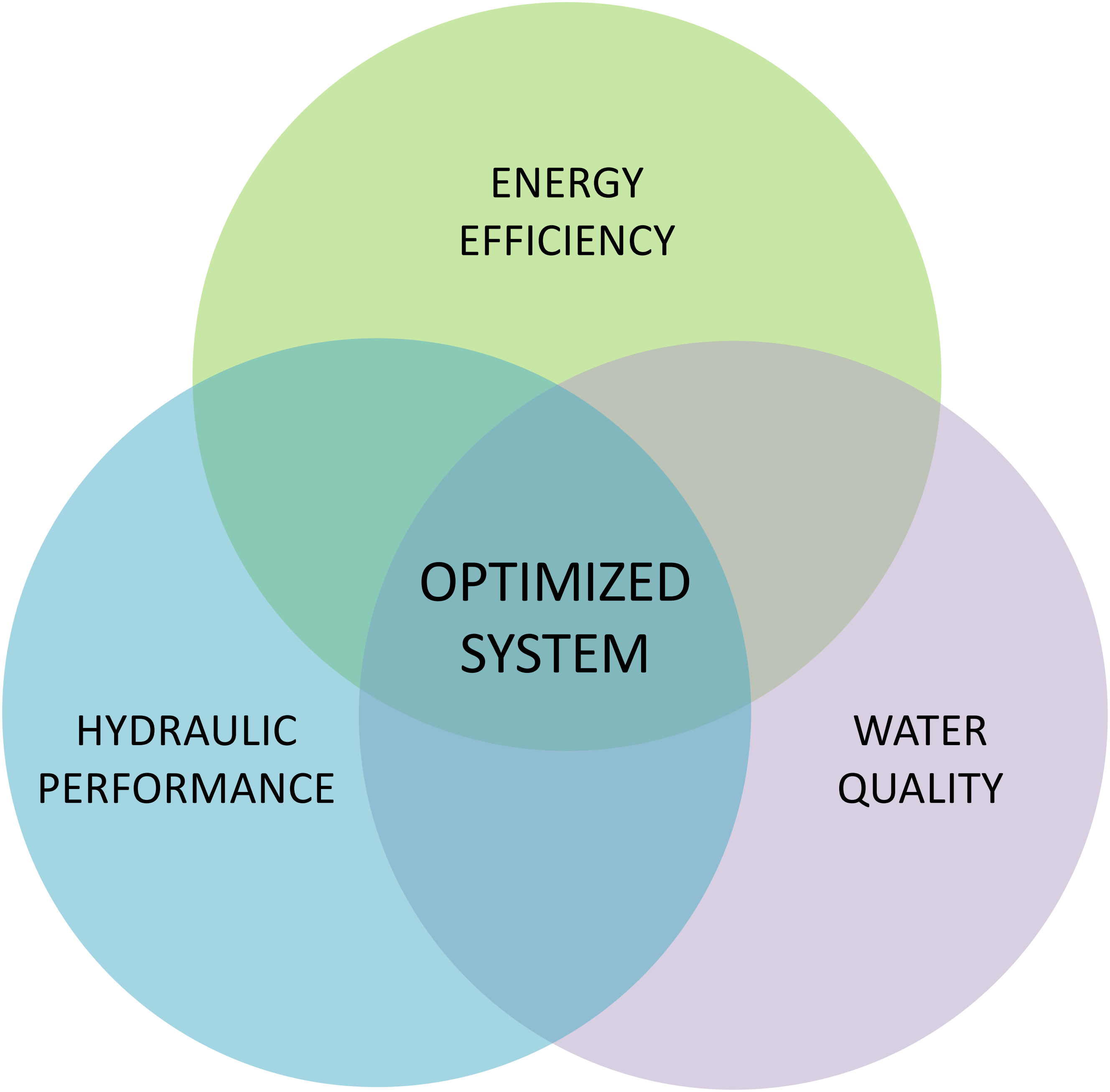
Gotcha again!

A

B

You can't always SEE energy efficiency

- Much occurs before construction
- Much depends on how the facility is used, not what's in it
- Facility is just a piece of the system puzzle
- Conditions (e.g., hydraulics, climate) vary



Jones and Sowby, “Water System Optimization” (*Journal AWWA*, June 2014)

Overview

- Planning
- Energy analysis
- Layout
- Equipment
- Monitoring

Planning

- Evaluate master planned projects
  - Typically developed with historic system function
  - Not developed with energy efficiency in mind
  - May modify or eliminate master planned projects
- Is this the right project?

Planning

- What's the range of operating conditions?
  - Existing, future
  - Peak day, winter
- Consider energy efficiency
  - Does an alternative minimize energy cost?
  - Or reduce/eliminate other capital projects?
- Extended-period simulation (EPS) hydraulic model

Case Study: Logan City, Utah

LOGAN
CITY UNITED IN SERVICE

Logan City Water System

- Population 50,000
- Utah State University
- >10,000 metered connections
- 190 miles of mainline
- 1 spring and 4 deep wells

Problems

- Deteriorating infrastructure
- Many mainline breaks: over 300 per year
- High pressures: over 220 psi
- Water shortage in summer
- High pumping costs
- Reactionary, rather than proactive, operations

Specific System Performance Goals

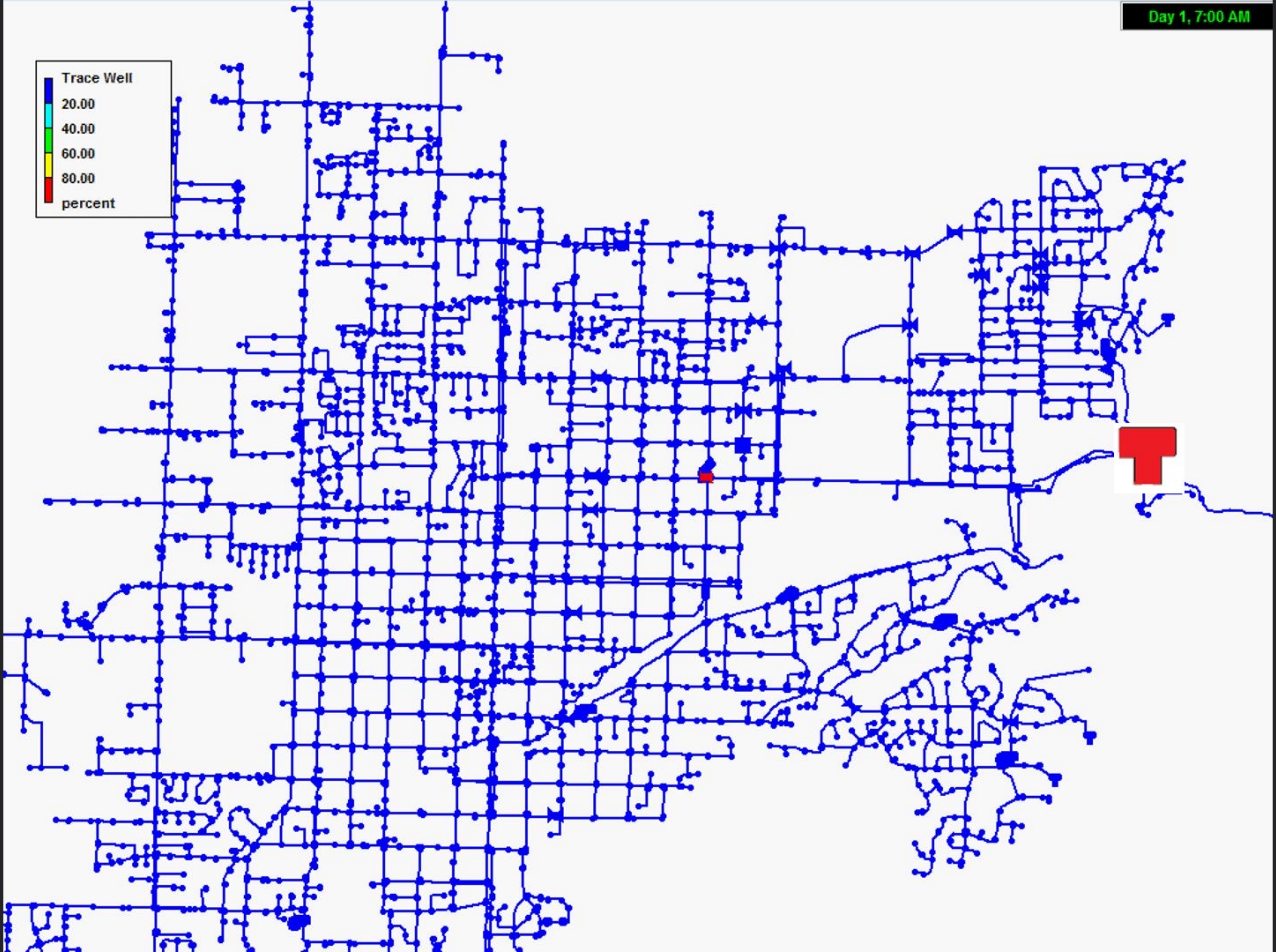
- Minimize pressure fluctuations
- Maximize storage use
- Eliminate unnecessary pumping
- Eliminate unnecessary PRV flow
- Improve water quality
- Minimize pumping costs

Initial Scope (RFQ)

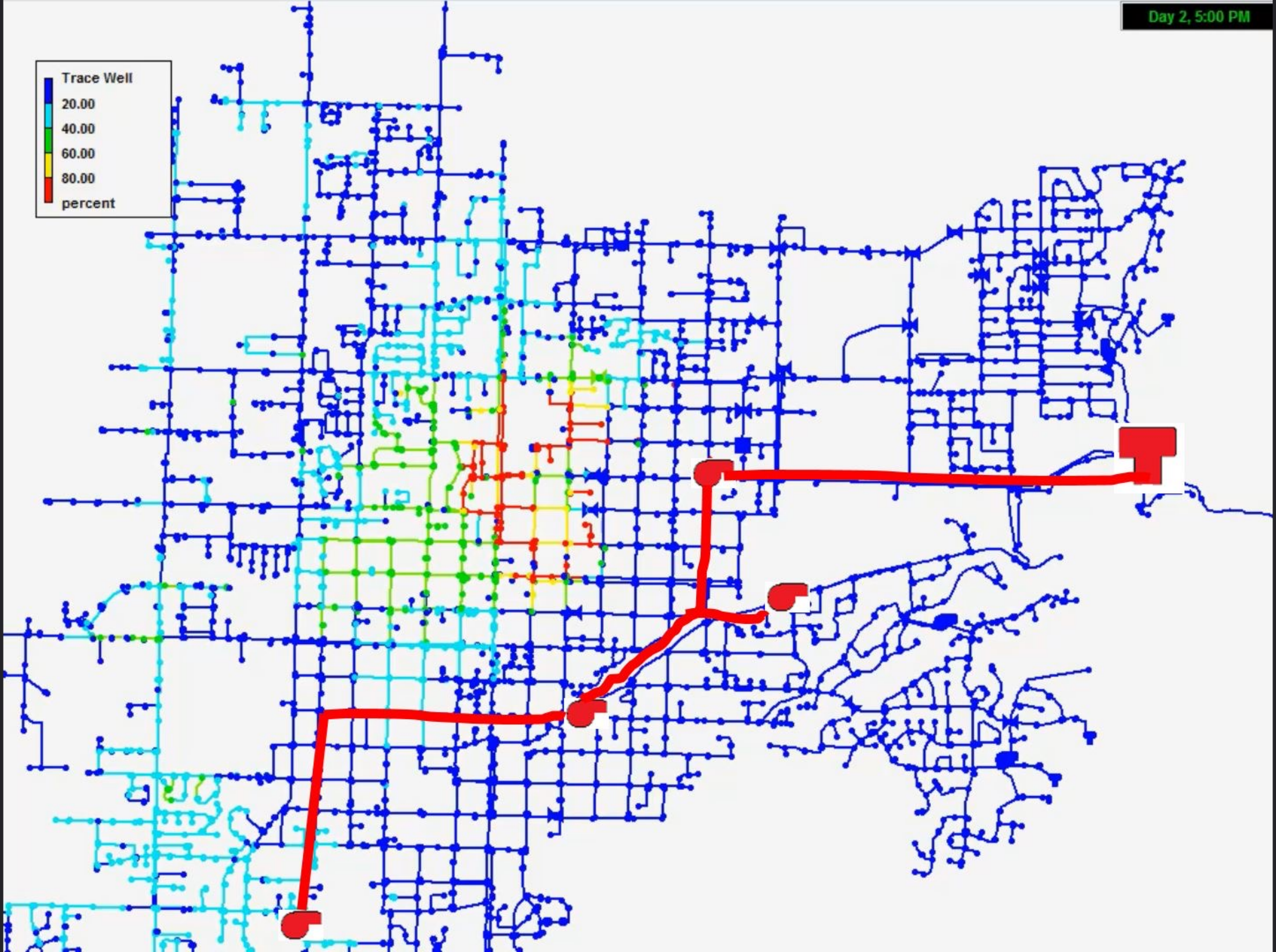
- Well
- Transmission line

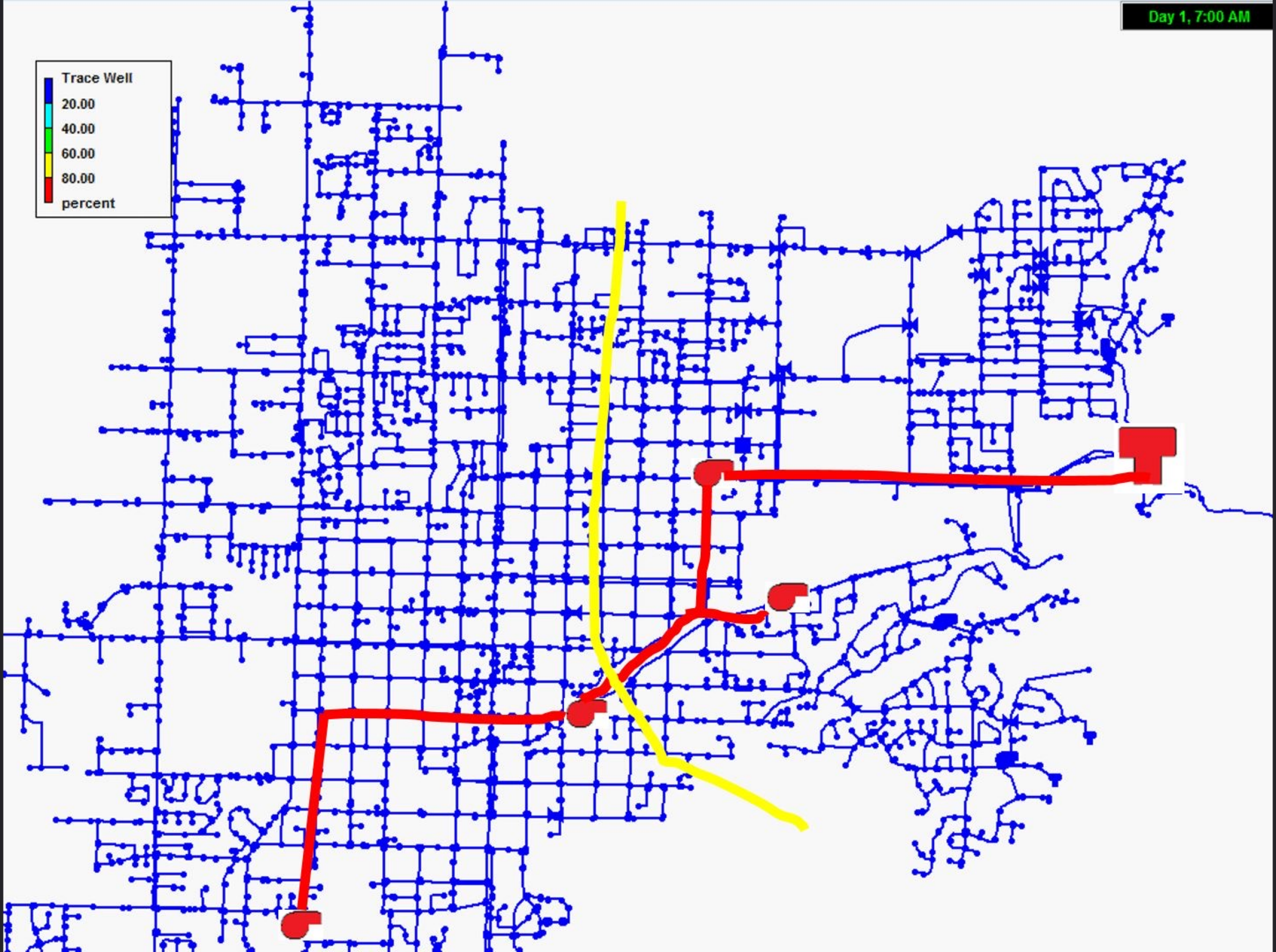
Actual Scope

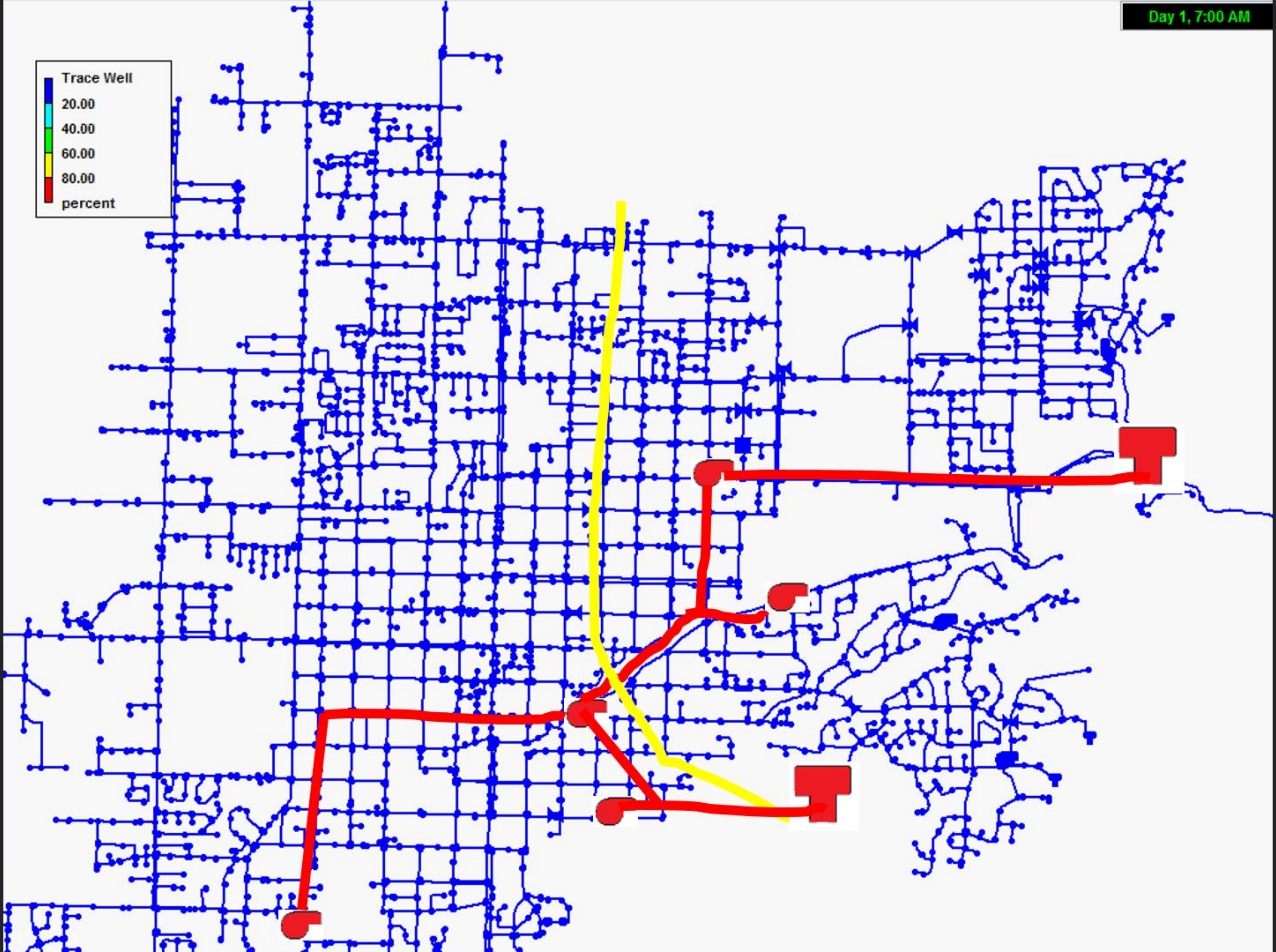
- ~~Well~~
- ~~Transmission line~~
- Hydraulic modeling
- Audit of water & energy use
- New pressure zone
- Well pump station retrofits
- Minor transmission upsizing
- Efficient operation



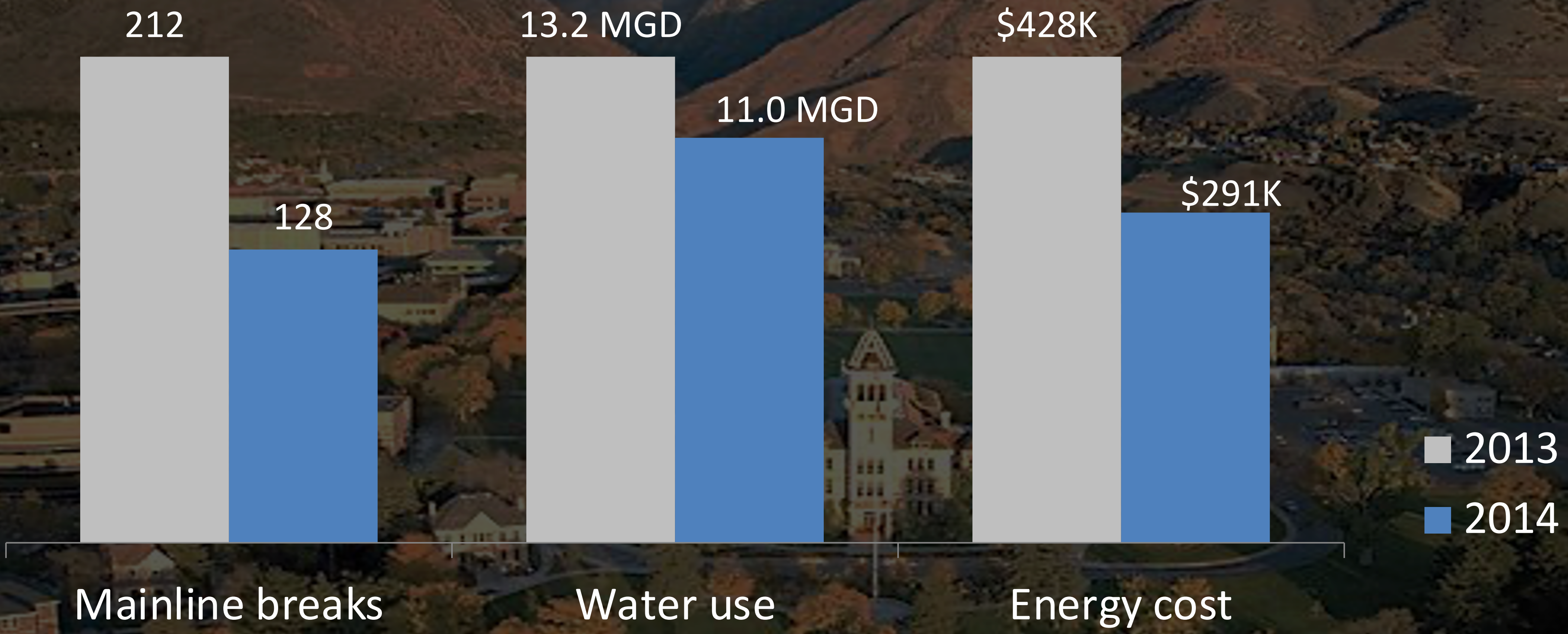
Day 1, 7:00 AM
Trace Well
20.00
40.00
60.00
80.00
percent


Day 2, 5:00 PM
Trace Well
20.00
40.00
60.00
80.00
percent


Day 1, 7:00 AM
Trace Well
20.00
40.00
60.00
80.00
percent


Day 1, 7:00 AM
Trace Well
20.00
40.00
60.00
80.00
percent

Project Results



↓ 40% **↓ 17%** **↓ 32%**

City-Identified Benefits

- Less water wasted = Less energy and money wasted
- Fewer pressure complaints
- Preventive maintenance occurring
- Crew attitudes improved
- Safer working environment – lower pressures
- Eliminated the need for a $3 million transmission project
- Postponed construction of new water source

Paul Lindhardt, W/WW Manager

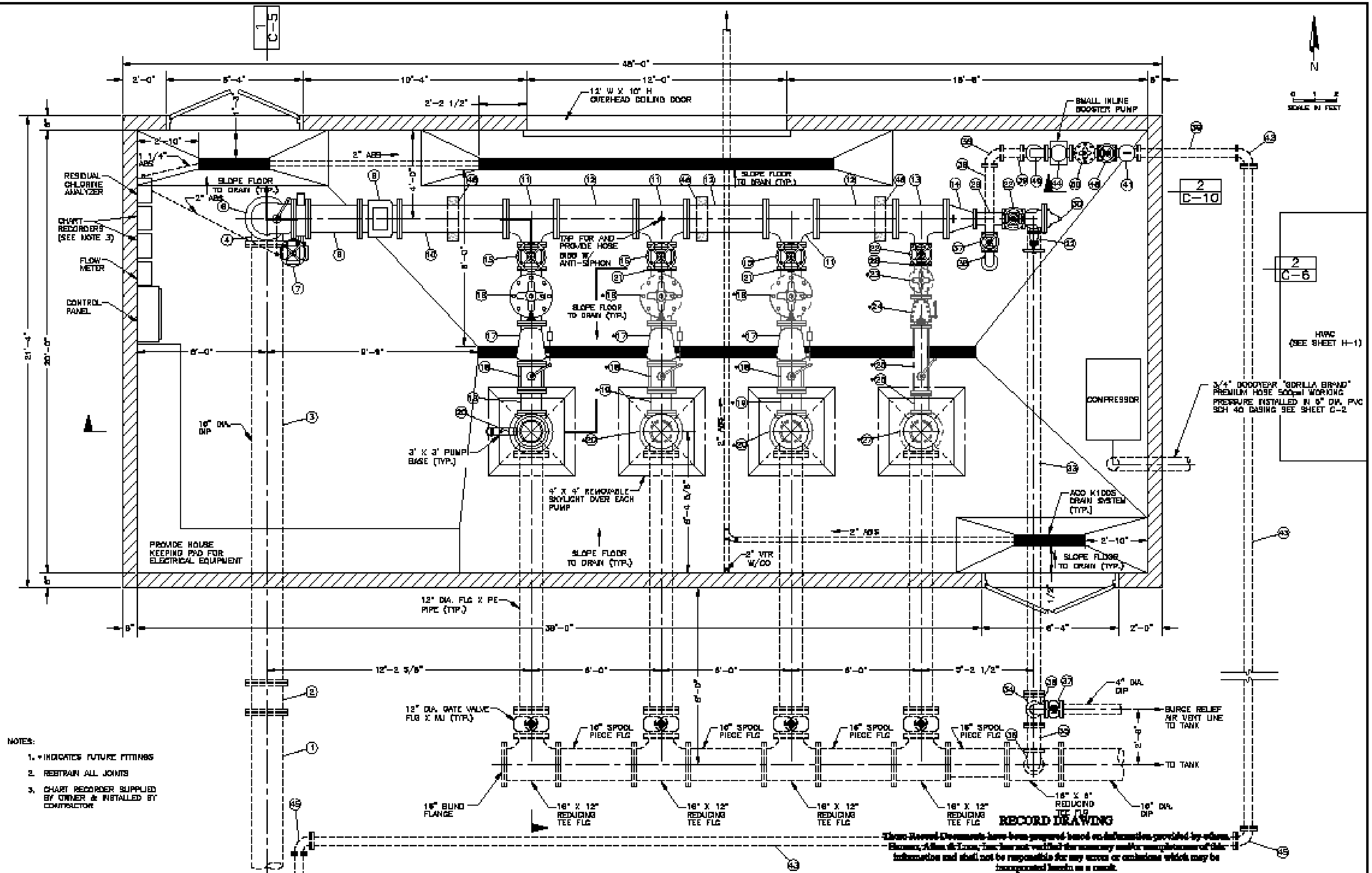
The savings and operational efficiency have continued each year since 2013. … The payback period for this project will be shorter than projected.

Energy Analysis

- Include energy analysis in engineer's scope!
  - Otherwise it won't happen
  - How much will it cost to operate?
  - Look beyond capital costs
- Pumping components
- Building components

Layout

- Pump array of different sizes
  - Efficiently handle range of water demands
  - Jockey pump—small, efficient, constant
- Bays for future pumps
- Space for VFD and other controls



NOTES:

1. * INDICATES FUTURE FITTINGS
2. RESTRAIN ALL JOINTS
3. CHART RECORDER SUPPLIED BY OWNER & INSTALLED BY CONTRACTOR

RECORD DRAWING

These Record Documents have been prepared based on information provided by others. Hansen, Allen & Luce, Inc. has not verified the accuracy and/or completeness of this information and shall not be responsible for any errors or omissions which may be incorporated herein as a result.

DESIGNED VGC	3		
DRAFTED SDN	2		
CHECKED MEA	1	04/2008	RECORD DRAWING
DATE SEPTEMBER 2006	NO.	DATE	REVISIONS

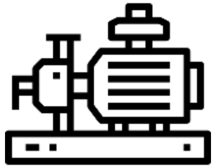
PROJECT ENGINEER

SCALE: AS SHOWN

ANDRA BOOSTER PUMP STATION
CIVIL
FLOOR PLAN

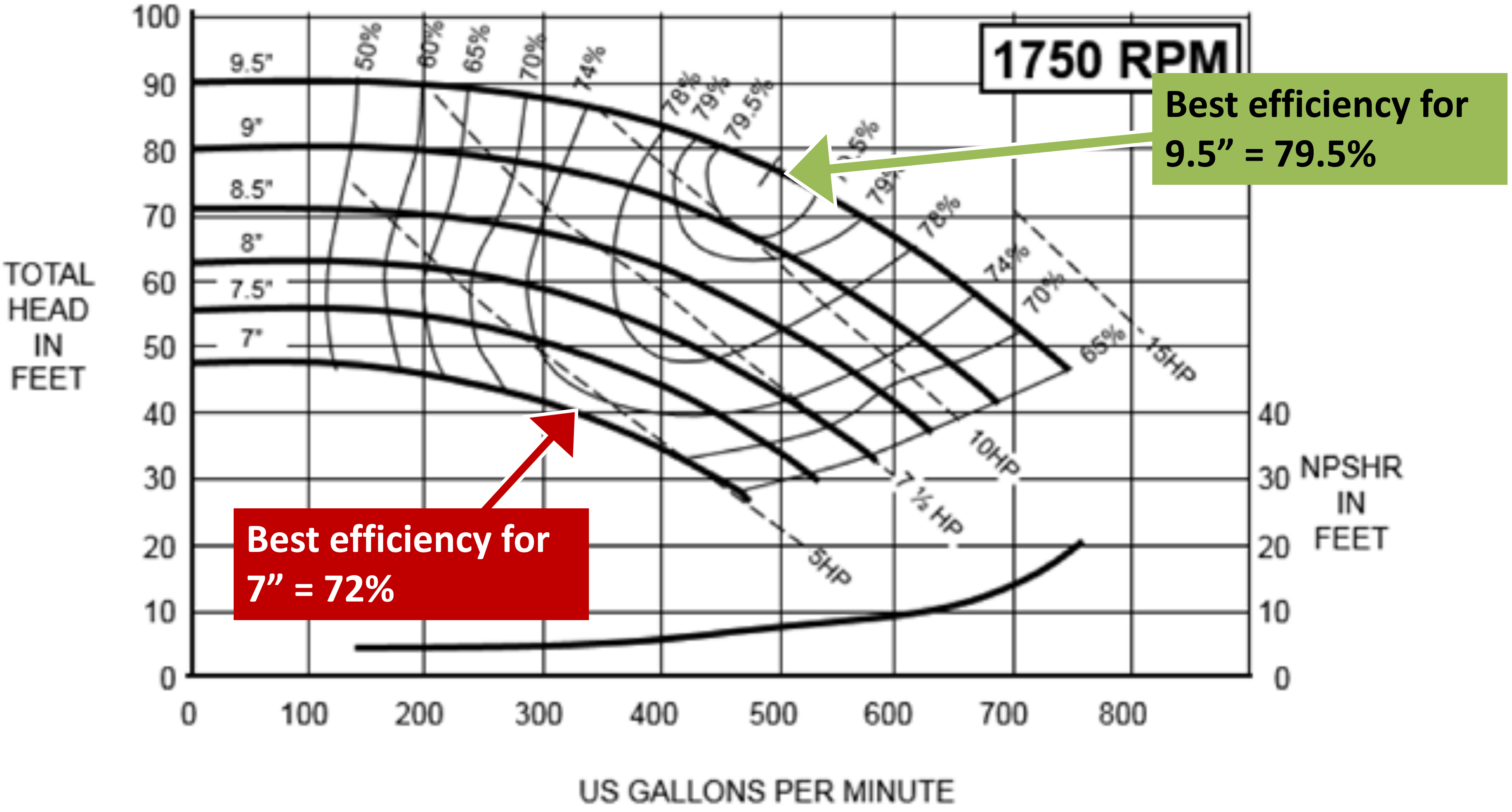
SHEET C-4

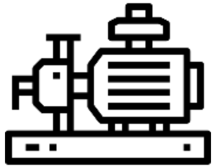
019.32.200



Equipment

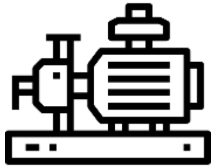
- Premium high-efficiency motors
- Avoid oversizing pumps and motors
  - Worst-case condition?
  - Safety factor applied at every step?
- Largest impeller for given pump casing
  - Smaller gap between casing and impeller
  - More power applied to fluid
  - Higher efficiency


1750 RPM
Best efficiency for 9.5” = 79.5%
Best efficiency for 7” = 72%
TOTAL HEAD IN FEET
NPSHR IN FEET
US GALLONS PER MINUTE
9.5"
9"
8.5"
8"
7.5"
7"
50%
60%
65%
70%
74%
78%
79%
79.5%
5HP
7 ½ HP
10HP
15HP
0
10
20
30
40
50
60
70
80
90
100
200
300
400
500
600
700
800



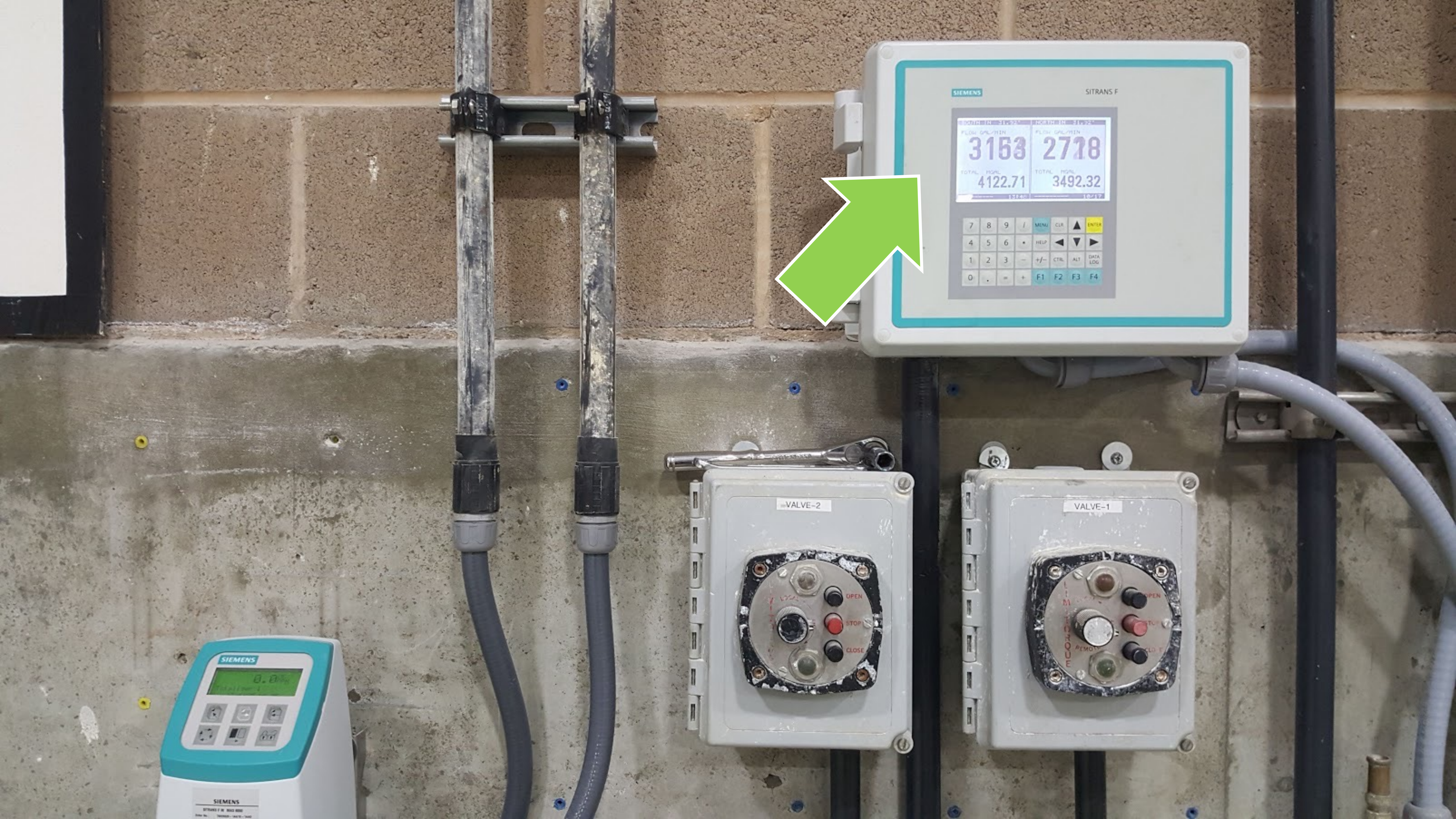
Equipment

- Variable Frequency Drive (VFD)
  - Control flow rate
  - Respond to varying water demands
  - Maintain high efficiency
  - Bypass at full speed
  - Also for mixers and other treatment equipment



Equipment

- Flow meter
  - Please!
- Suction and discharge pressure gages
  - Total dynamic head when pump is running
- Power submeter for major components
  - E.g., well + booster

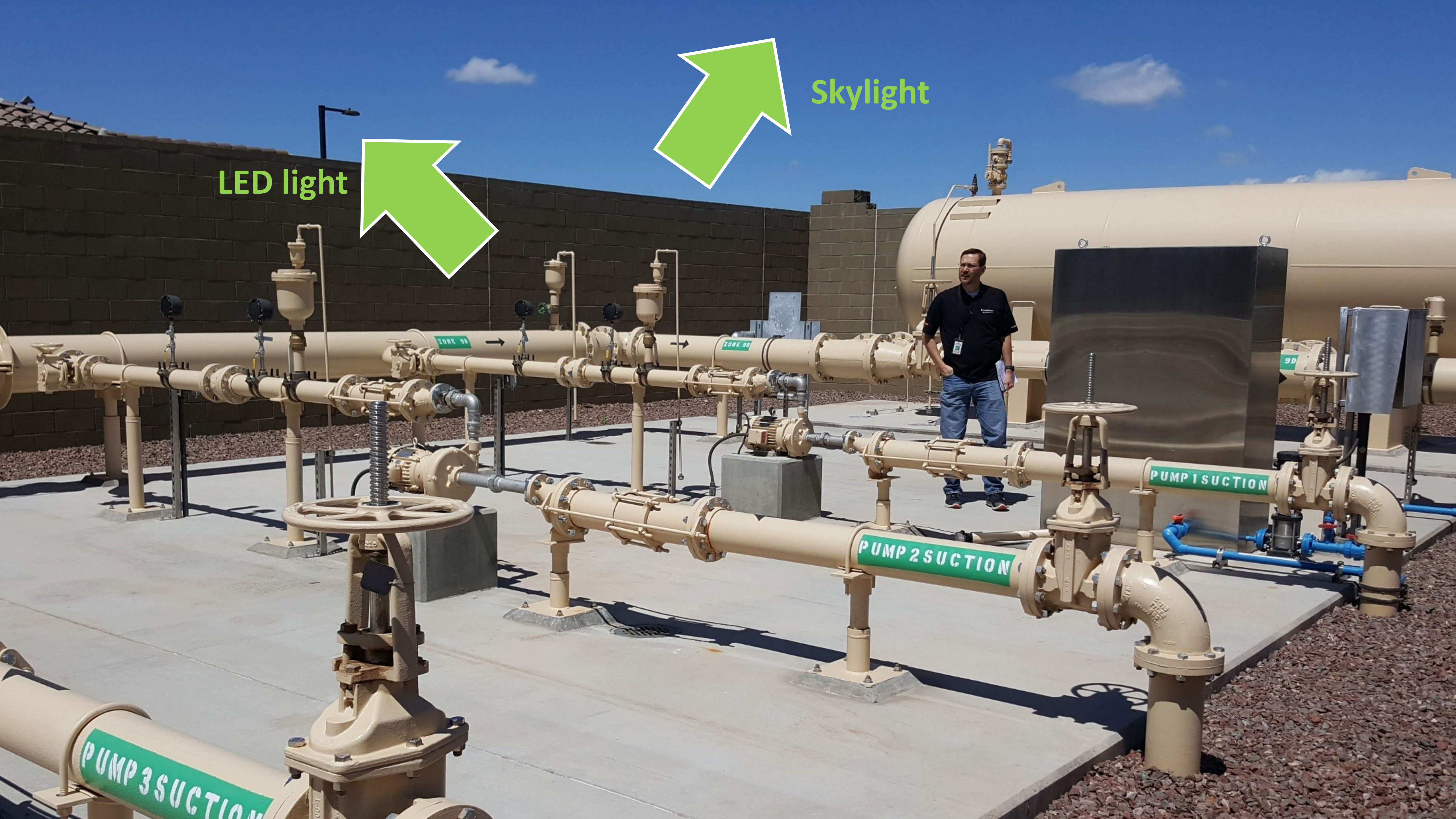

SIEMENS
SITRANS F
3163
2718
4122.71
3492.32
VALVE-2
VALVE-1
OPEN
STOP
CLOSE
SIEMENS


kV2c
Multifunction Meter
PACIFICORP
55 317 094
Mult by 40
CL 20 120-480V 4W FM9S Kt 1.8
50/60Hz CA 0.2 TA 2.5 Kh 1.8 TV 120
DANGER
Do NOT Remove Meter-
Current Transformers in Circu
CAUTION
480

Equipment

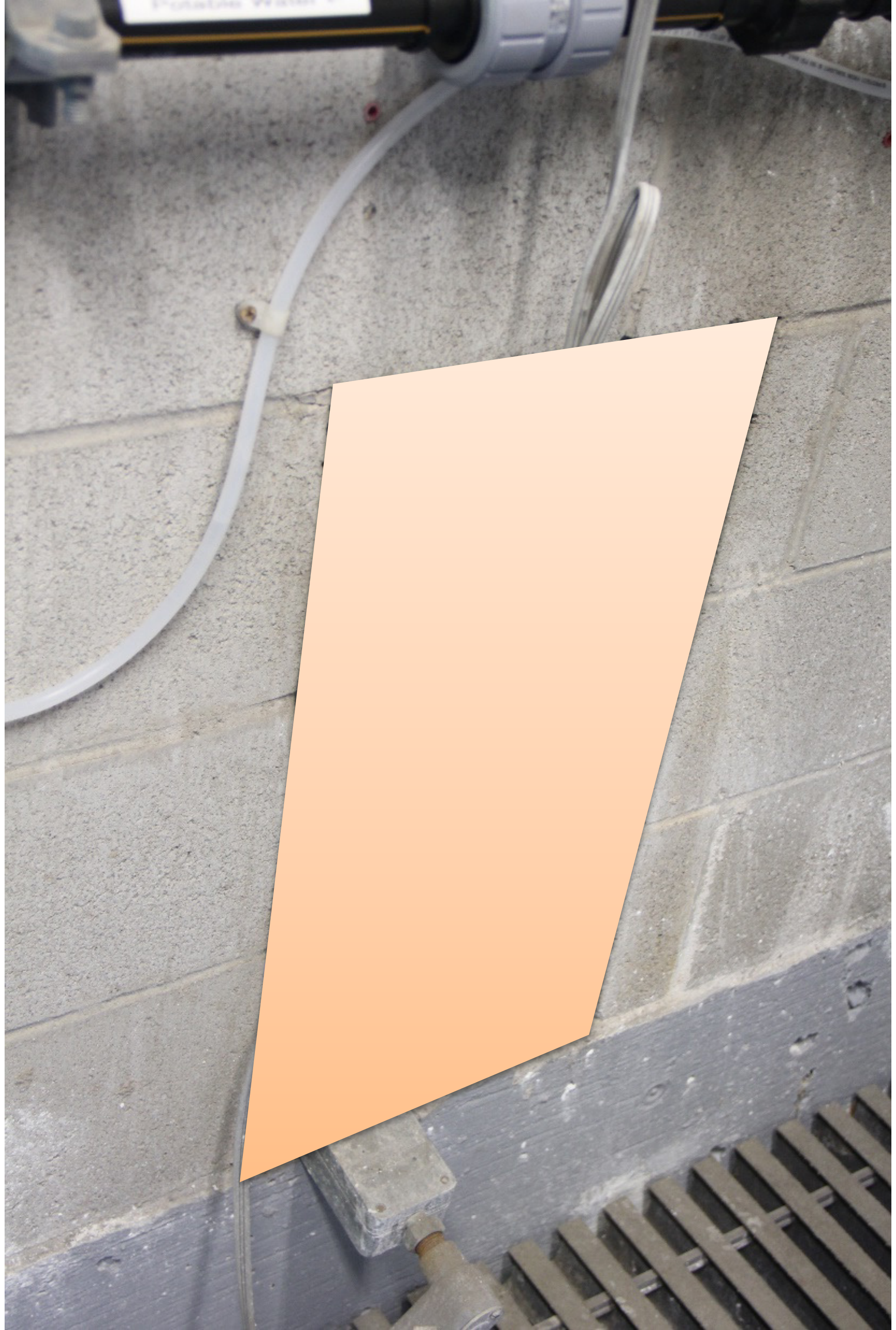
- Other
  - Skylights
  - LED lights
  - Occupancy sensors or timers
  - Programmable HVAC
  - Fans (high volume, low speed)
  - Insulation over vents and hatches when winterized


Creepy old light
← with spider webs


LED light
Skylight
ZONE 9D
ZONE 9D
PUMP 1 SUCTION
PUMP 2 SUCTION
PUMP 3 SUCTION

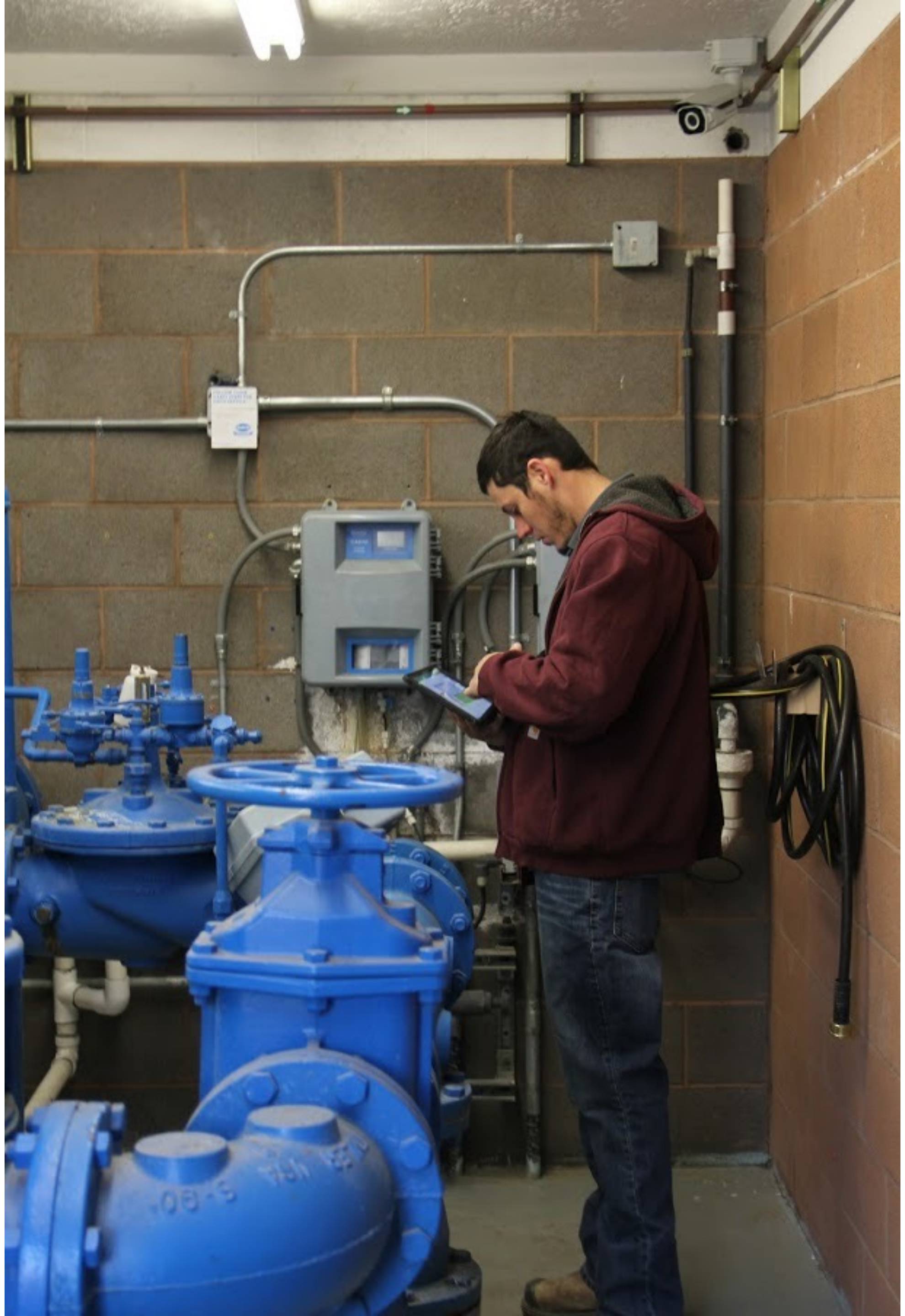

LO


TRANE
74
6:30
76



Monitoring

- Pump curves (or at least make and model)
  - Pump and motor inventory
- Power meter number/account
  - Match to facility
  - Facilitate customer service and engineering



Monitoring

- Annual performance review
  - "How do you know if your pumps are stealing from you?"
  - Use flow, pressure, and energy data to evaluate performance
  - Does it match design?
  - Informs action

Monitoring: Efficiency vs. Intensity

- Energy Efficiency
  - Equipment
  - 0%–100%
  - High value good
- Energy Intensity
  - Facility or system
  - kWh/MG
  - Low value good

Example: Performing as Expected?

Favorite Greek letter

- Design: 79% wire-to-water efficiency
  - 84% pump efficiency
  - 94% motor efficiency
- Actual:
  - 1,000 gpm
  - 210 ft TDH
  - 75 kW = 100 HP

$$\eta = \frac{Qh}{3960P}$$

$$\eta = \frac{(1000)(210)}{3960(100)}$$

$$\boldsymbol{\eta = 53\%}$$

Which water well will want what watts when working?

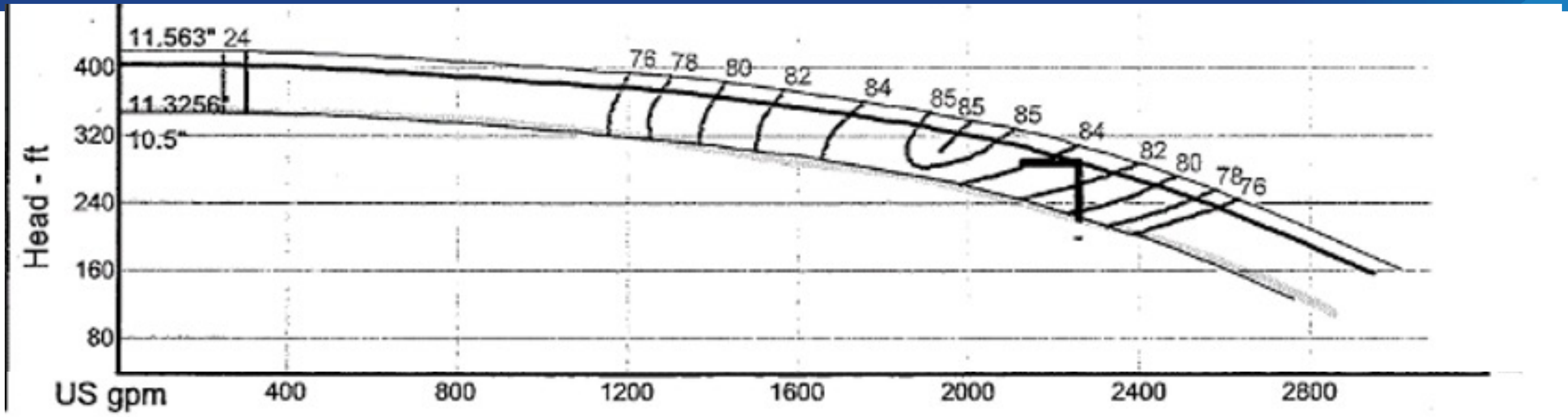
Well 1
750,000 kWh
300 MG

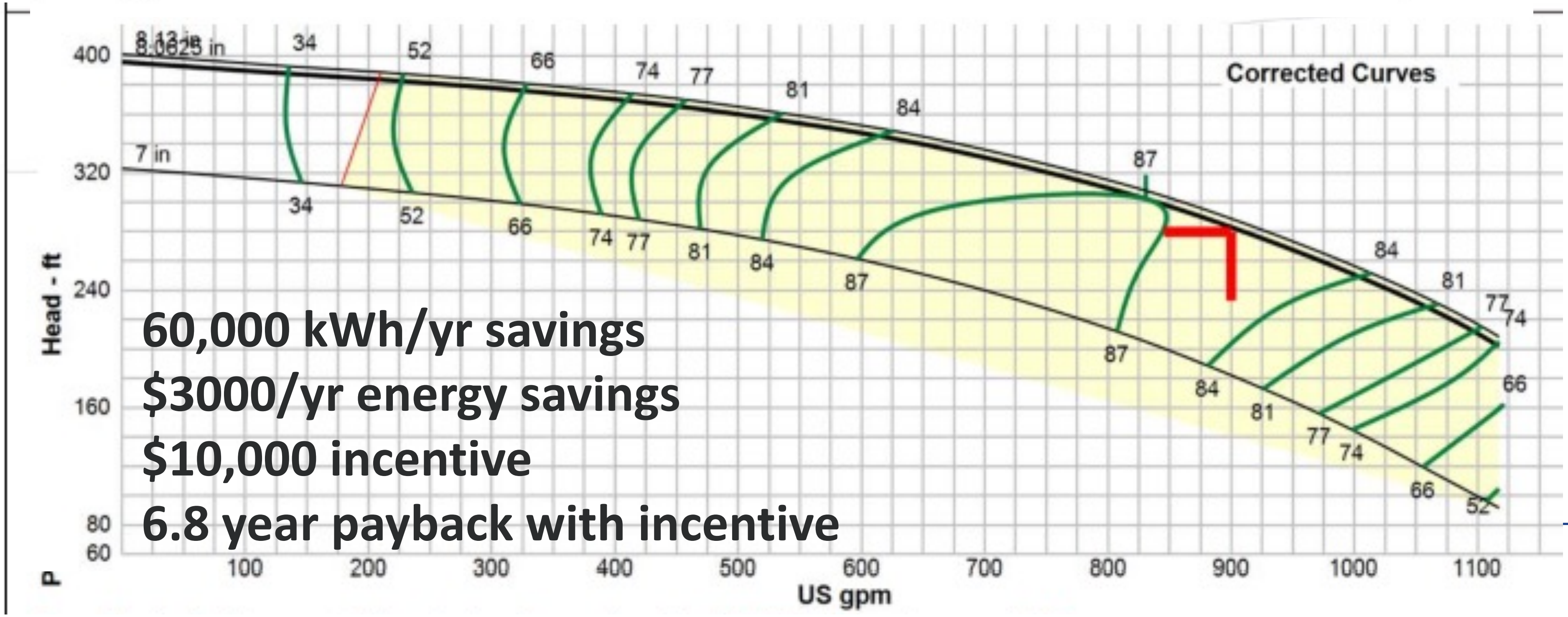
Well 2
345,000 kWh
230 MG

Well 3
252,000 kWh
120 MG

CAPITAL PROJECT INCENTIVES

Well Pump Retrofit Incentive





60,000 kWh/yr savings

$3000/yr energy savings

$10,000 incentive

6.8 year payback with incentive

City of Fruitland Water Treatment Plant

- Baseline – Existing
  - 40 hp screw compressor with inlet modulation and non-cycling dryer
- Energy Efficient Upgrade
  - 30 hp screw air compressor with VFD with cycling dryer
    - 97,790 kWh savings
    - $17,000 incentive
    - Payback without incentive 5.6 years
    - Payback with incentive 2 years

Hazelton Pumphouse Retrofit Incentive

- 10 hp pump w/VFD operates instead of a 20 hp & 50 hp
- $27,000 estimated incentive
- $7,700 estimated electrical cost savings per year

Plan for efficient operation

On your smart phone
Go to: https://kahoot.it/
Game PIN:

KAHOOT!

Takeaways

- If you have a hydraulic model – use it
- Design and plan for upgrades/replacements with energy efficiency in mind
- Reach out to your power provider about incentives when you are considering new equipment

Closing

Questions
Comments
Discussion

SEE YOU TUESDAY!

aquafficiency

Saving energy, one gallon at a time