Better Plants
U.S. DEPARTMENT OF ENERGY

WATER VIRTUAL IN-PLANT (VINPLT) TRAINING

Session 4

U.S. DEPARTMENT OF ENERGY

Session 4: The 5 L's and Treasure Hunts

Thank You!

Sponsor:

Better Plants
U.S. DEPARTMENT OF ENERGY

Today’s Agenda

	Homework Recap
	Leaking
	Losing
	Break
	Loading
	Treasure Hunts
	Kahoot!
	Q&A

HOMEWORK RECAP

POLL

The 5 L's: Common Water System Inefficiencies

- Leaping
- Looping
- Leaking
- Losing
- Loading

LEAKING

Leaking – Problem

High-Pressure Leak

Low-Pressure Leak

WATER LOSS IS ENERGY LOSS!

Tim Waldron, "Success Techniques in Applying Water Loss Strategies for Financial Benefits," Workshop on Water and Energy/Water Loss (International Water Association, 2014)

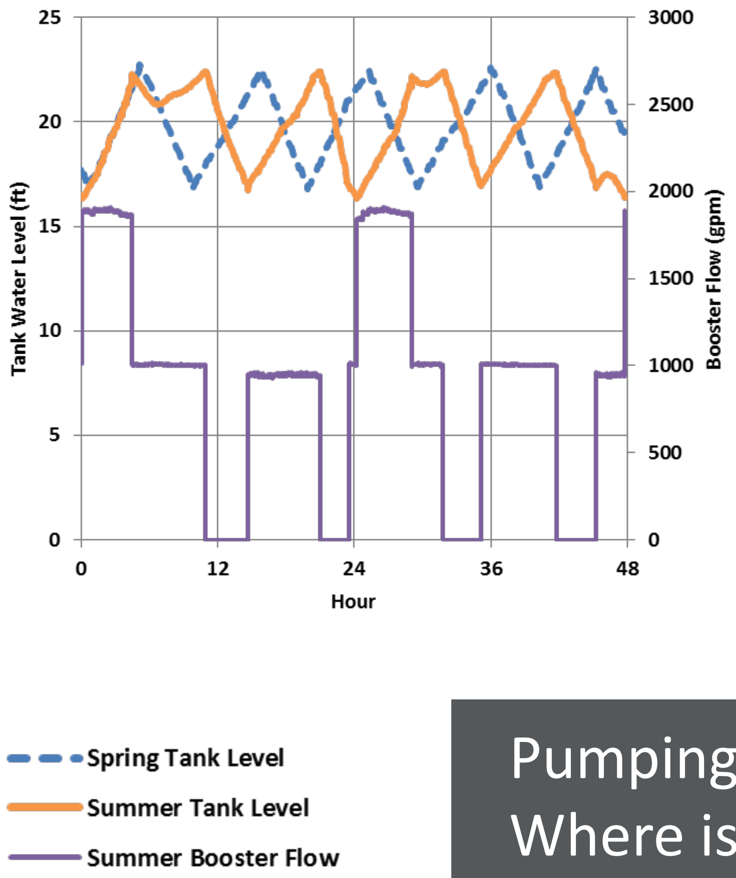
Water Loss Audit

<table>
<tr><td rowspan="8">Volume from Own Sources (corrected for known errors)</td><td rowspan="11">System Input Volume</td><td>Water Exported (corrected for known errors)</td><td colspan="3">Billed Water Exported</td><td>Revenue Water</td></tr>
<tr><td rowspan="10">Water Supplied</td><td rowspan="4">Authorized Consumption</td><td rowspan="2">Billed Authorized Consumption</td><td>Billed Metered Consumption</td><td rowspan="2">Revenue Water</td></tr>
<tr><td>Billed Unmetered Consumption</td></tr>
<tr><td rowspan="2">Unbilled Authorized Consumption</td><td>Unbilled Unmetered Consumption</td><td rowspan="8">Non-revenue Water</td></tr>
<tr><td>Unbilled Metered Consumption</td></tr>
<tr><td rowspan="6">Water Losses</td><td rowspan="3">Apparent Losses</td><td>Customer Metering Inaccuracies</td></tr>
<tr><td>Unauthorized Consumption</td></tr>
<tr><td>Systematic Data Handling Errors</td></tr>
<tr><td rowspan="3">Water Imported (corrected for known errors)</td><td rowspan="3">Real Losses</td><td>Leakage on Transmission and Distribution Mains</td></tr>
<tr><td>Leakage and Overflows at Utility's Storage Tanks</td></tr>
<tr><td>Leakage on Service Connections up to the point of Customer Metering</td></tr>
</table>

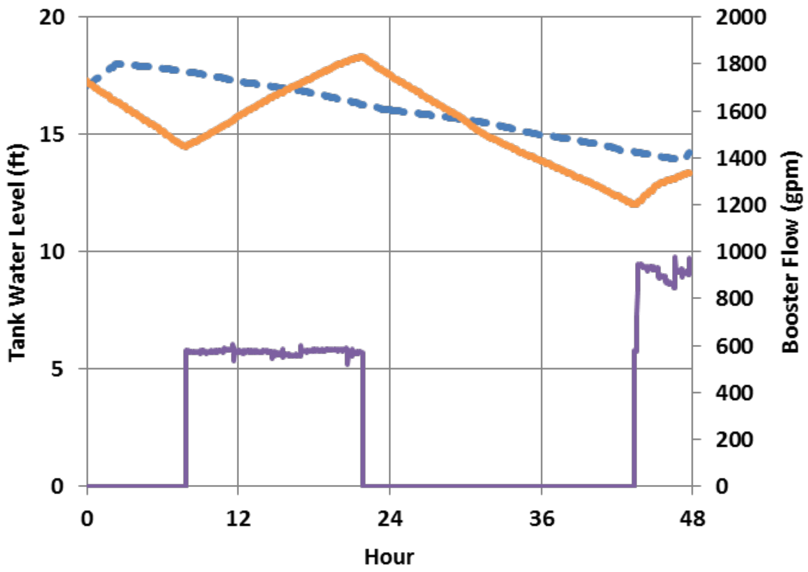
AWWA/IWA

Leaking – Example

Probable Leak



Normal



Pumping a lot, using a little.
Where is all the water going?

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Leaking – Example

Leaking – Diagnosis

How to detect:

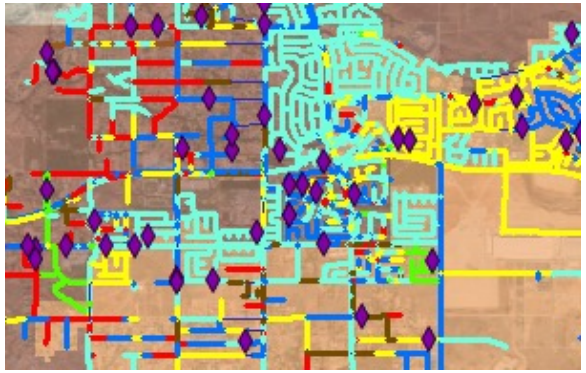
- Water production exceeds water use
- Pumping, but no demand
- Leak detection equipment
- You see it!

How to resolve:

- Replace leaky pipes
- Fix leaky storage tanks
- Lower the pressure

Leaking – Where to Focus

- Old pipes
- High pressures
- Hot spots



Leak on 12" main. Photo courtesy of Harold Hargaves, City of Pocatello, ID.

Leaking – Activity

In Zone 4, there is a serious leak that consumes approximately 100 MG per year. The pressure in the pipe is currently 100 psi. Your energy team has identified this leak as well as recognized that the pressure can be reduced to 60 psi. The pump that serves this zone uses 1,200 kWh/MG.

1a. How much energy (kWh) is currently lost by the leak each year?

$$\frac{100\ \cancel{MG}}{year} * \frac{1{,}200\ kWh}{\cancel{MG}} = 120{,}000\ kWh/year$$

1b. At $0.05 per kWh, how much does this leak cost in terms of energy?

$$\frac{120{,}000\ \cancel{kWh}}{year} * \frac{\$0.05}{\cancel{kWh}} = \$6{,}000\ year$$

Leaking – Activity

2. How much water (MG) can be saved by reducing the pressure to 60 psi? Assume the % water savings = half of the % pressure reduction.

Pressure reduction = 100 psi – 60 psi = 40 psi

40 psi/100 psi = 40%

Percent water savings = 0.5 * 40% = 20%

Water saved = 20% * 100 MG = 20 MG

Leaking – Activity

3a. How much energy (kWh) can be saved by reducing the pressure?

$$\frac{20\ \cancel{MG}}{year} * \frac{1{,}200\ kWh}{\cancel{MG}} = 24{,}000\ kWh/year$$

3b. At $0.05 per kWh, how much money would this save?

$$\frac{24{,}000\ \cancel{kWh}}{year} * \frac{\$0.05}{\cancel{kWh}} = \$1{,}200$$

4a. If the leak can be repaired (new pipe), how much energy can be saved?

$$\frac{100\ \cancel{MG}}{year} * \frac{1{,}200\ kWh}{\cancel{MG}} = 120{,}000\ kWh/year$$

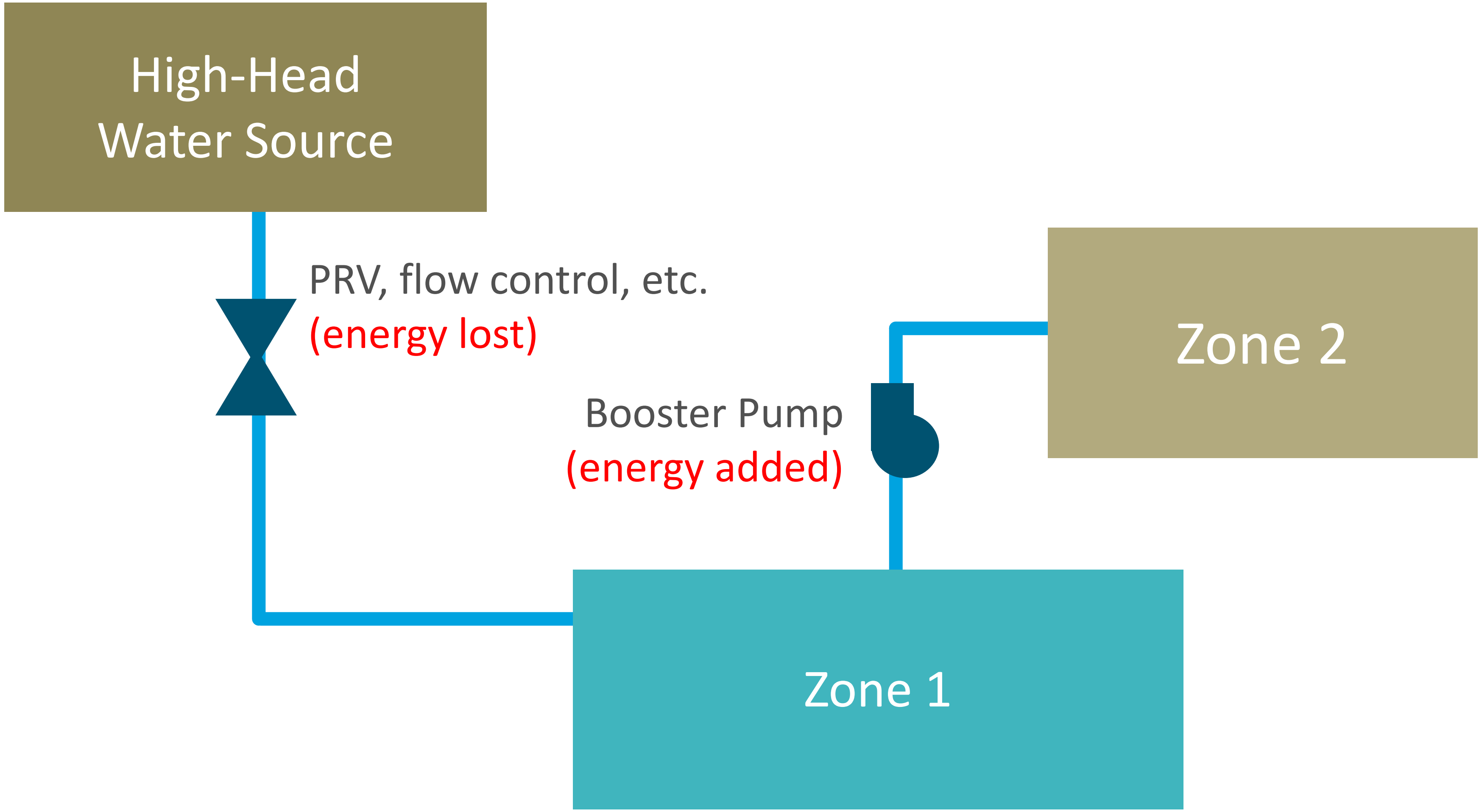
4b. At $0.05 per kWh, how much would this repair save?

$$\frac{120{,}000\ \cancel{kWh}}{year} * \frac{\$0.05}{\cancel{kWh}} = \$6{,}000/year$$

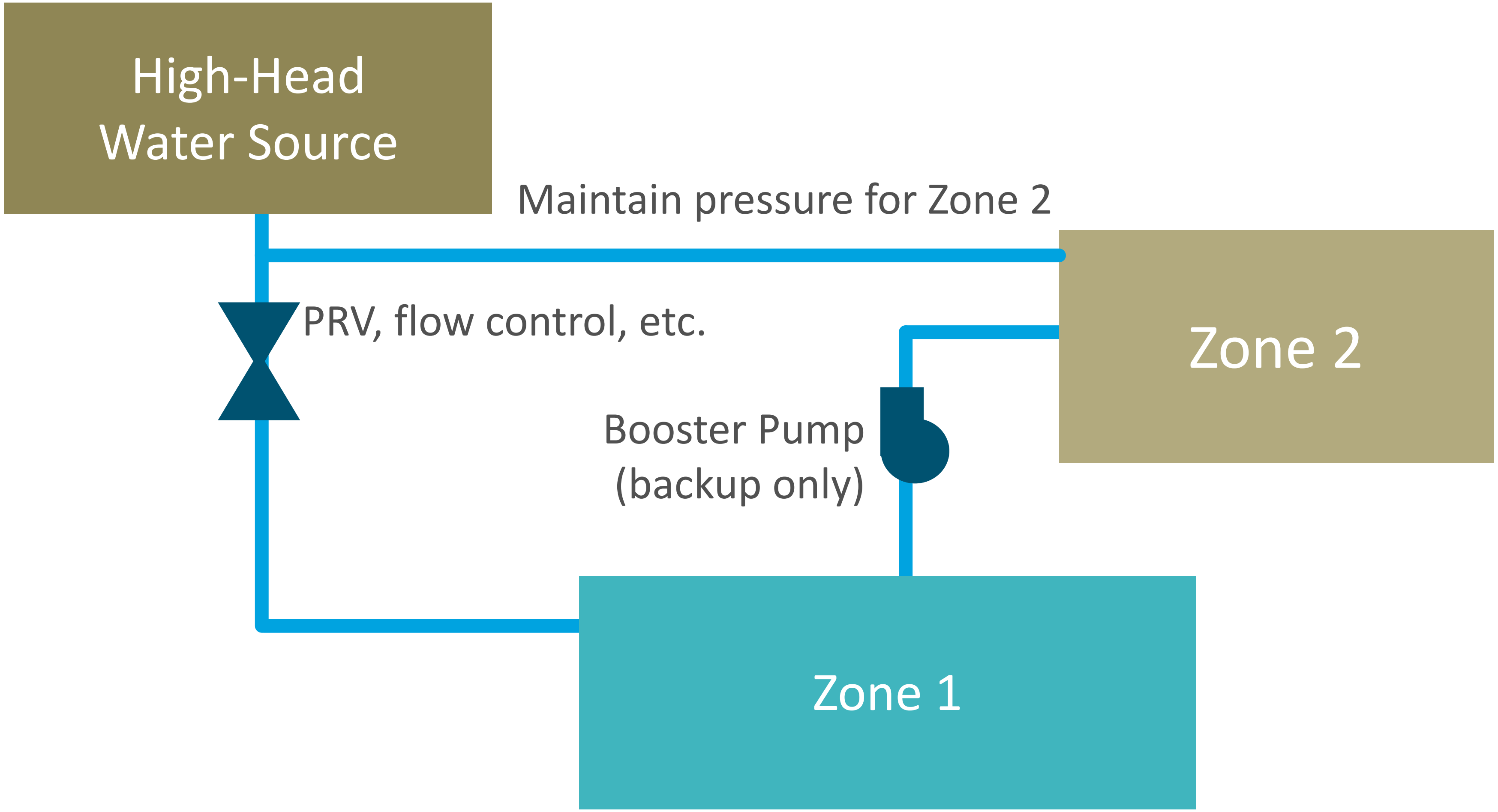
LOSING

Losing – Problem

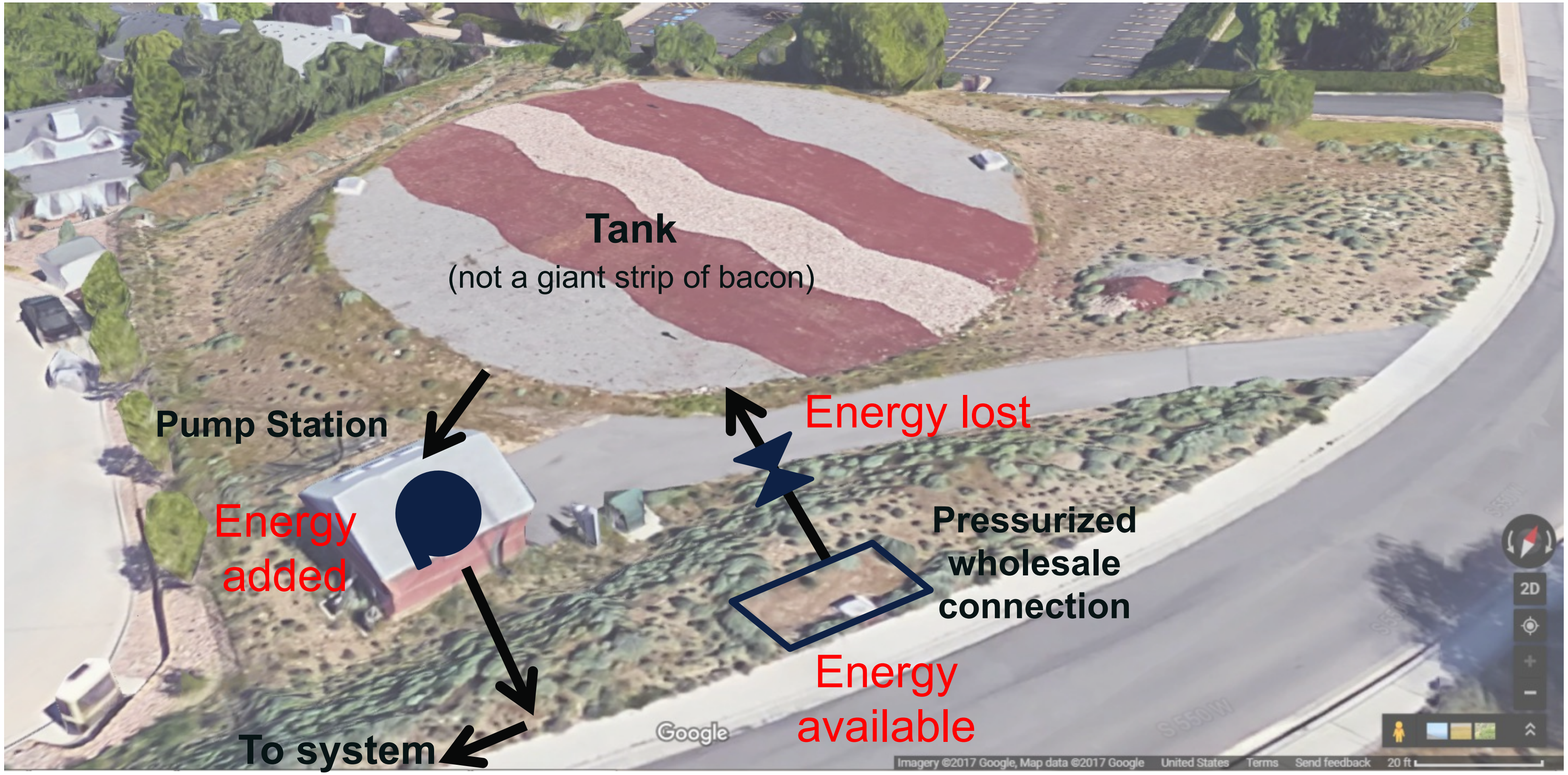
"Breaking pressure prematurely"



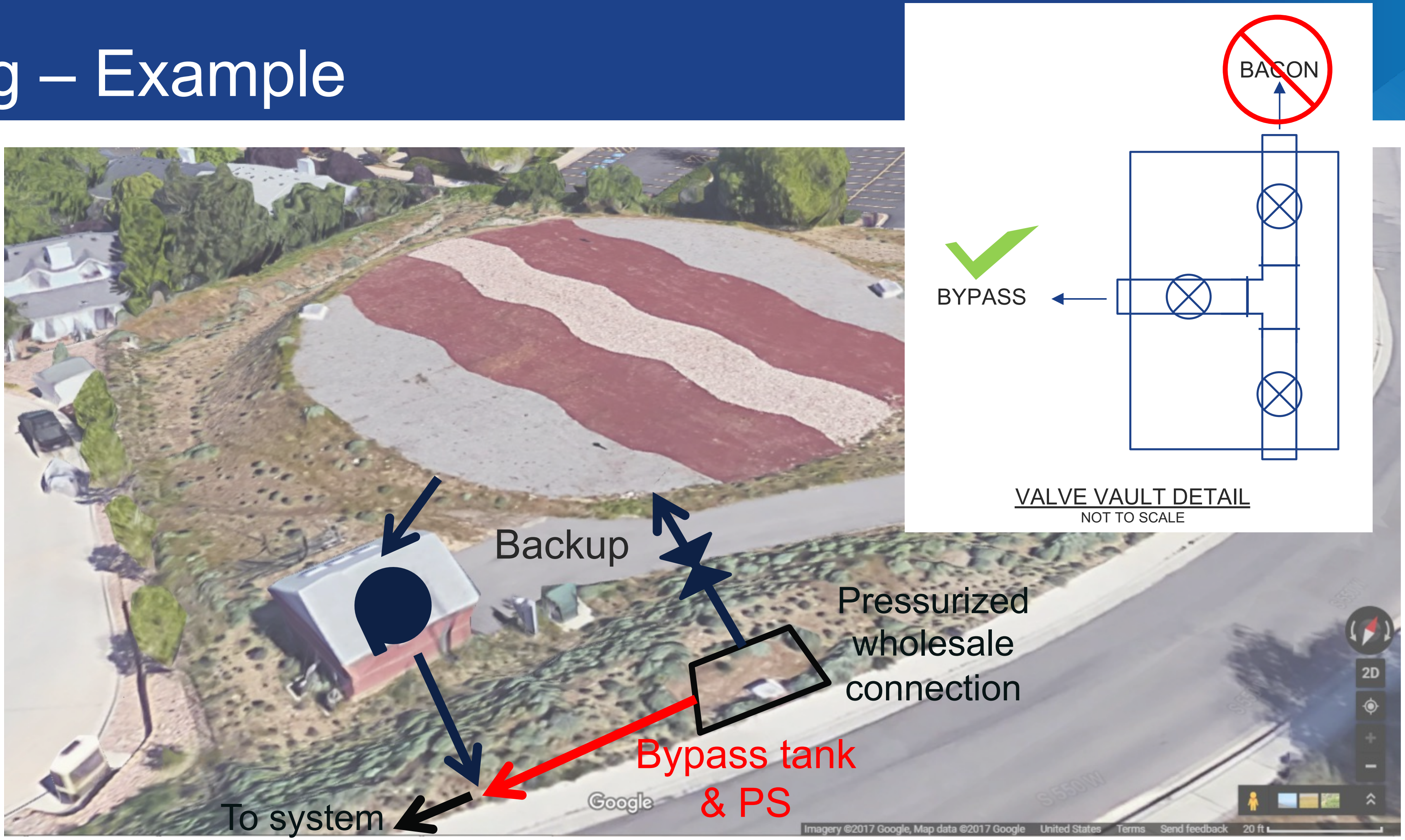
Losing – Solution



Losing – Example



Losing – Example



Losing – Diagnosis

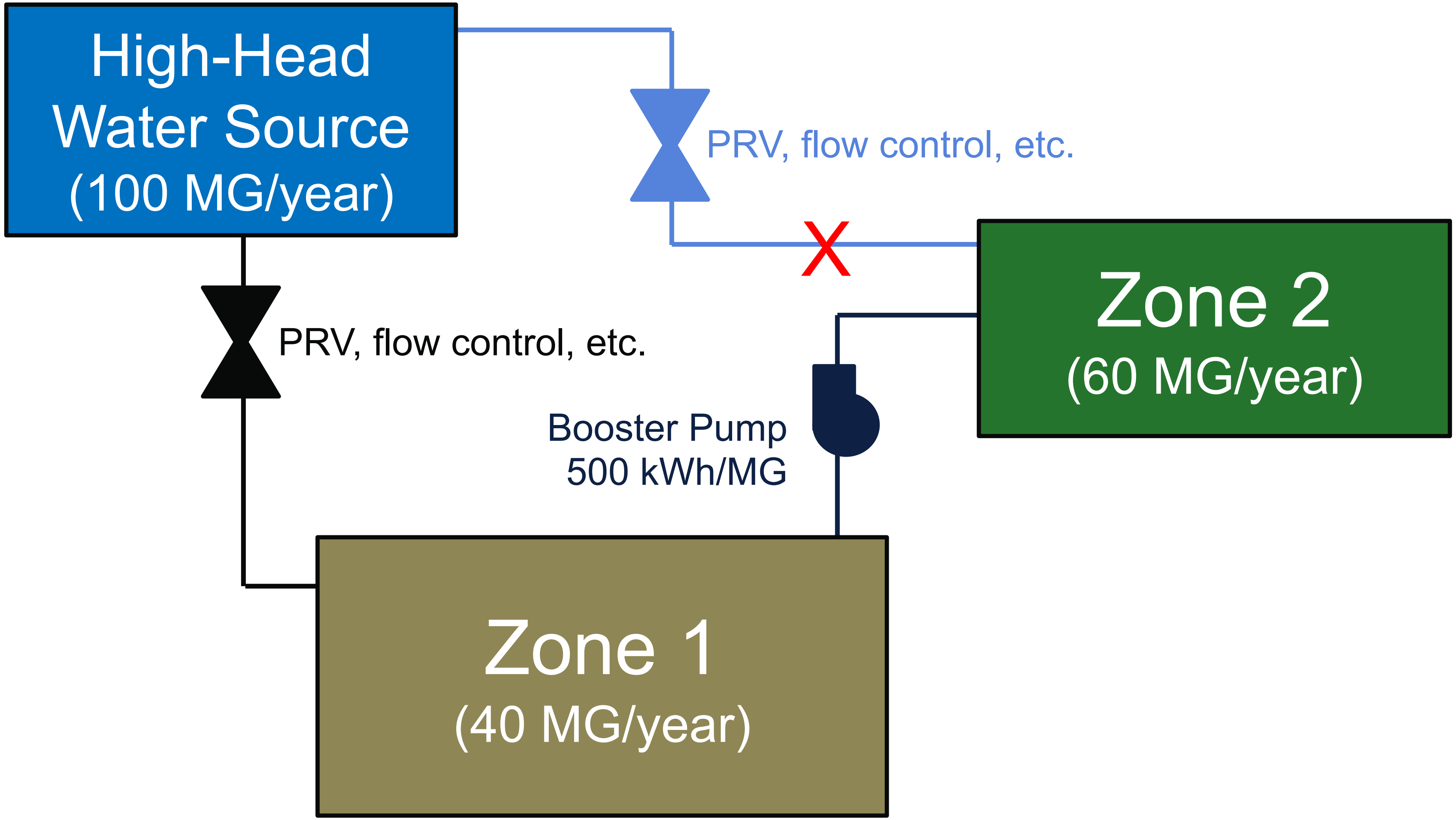
How to detect:

- A water source's head is higher than a pumped zone
- Hydraulic modeling

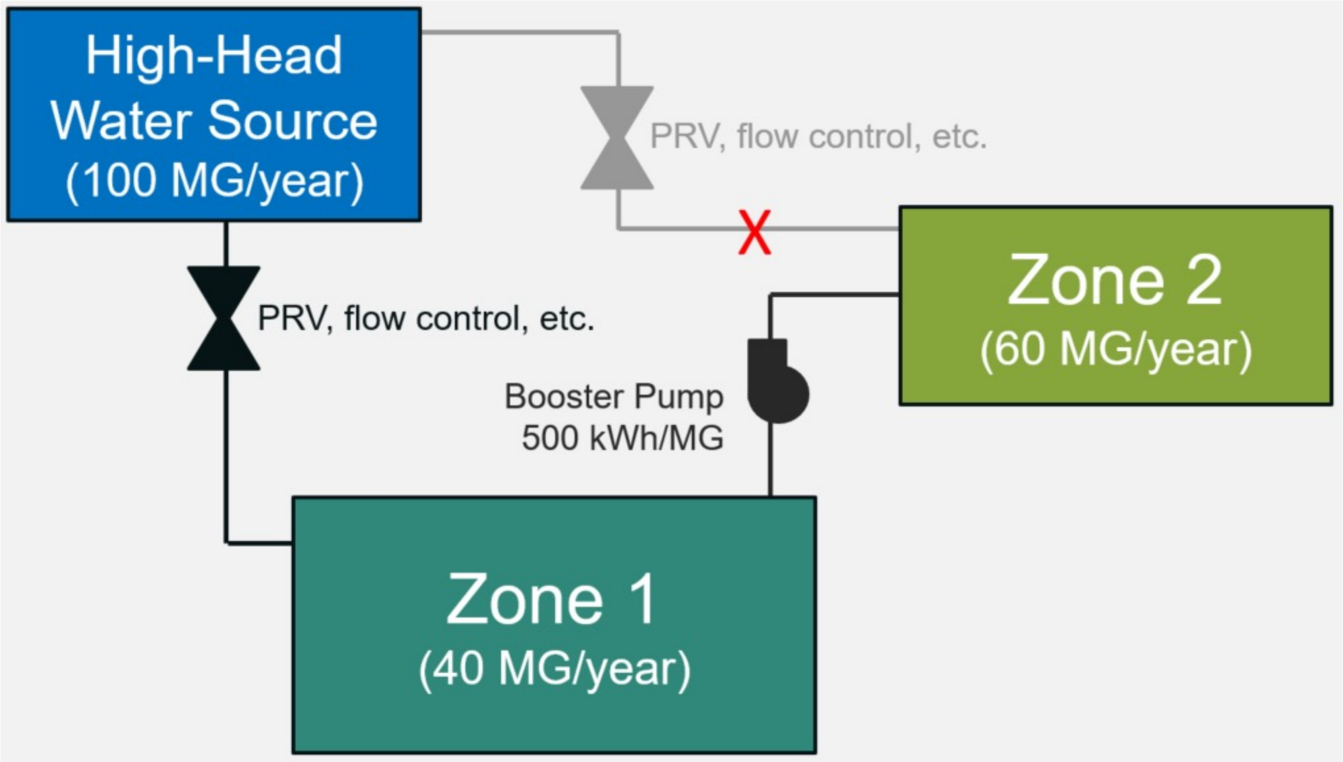
How to resolve:

- Bypass pressure break and serve zone directly
- Maintain booster backup if needed

Losing – Activity



Losing – Activity



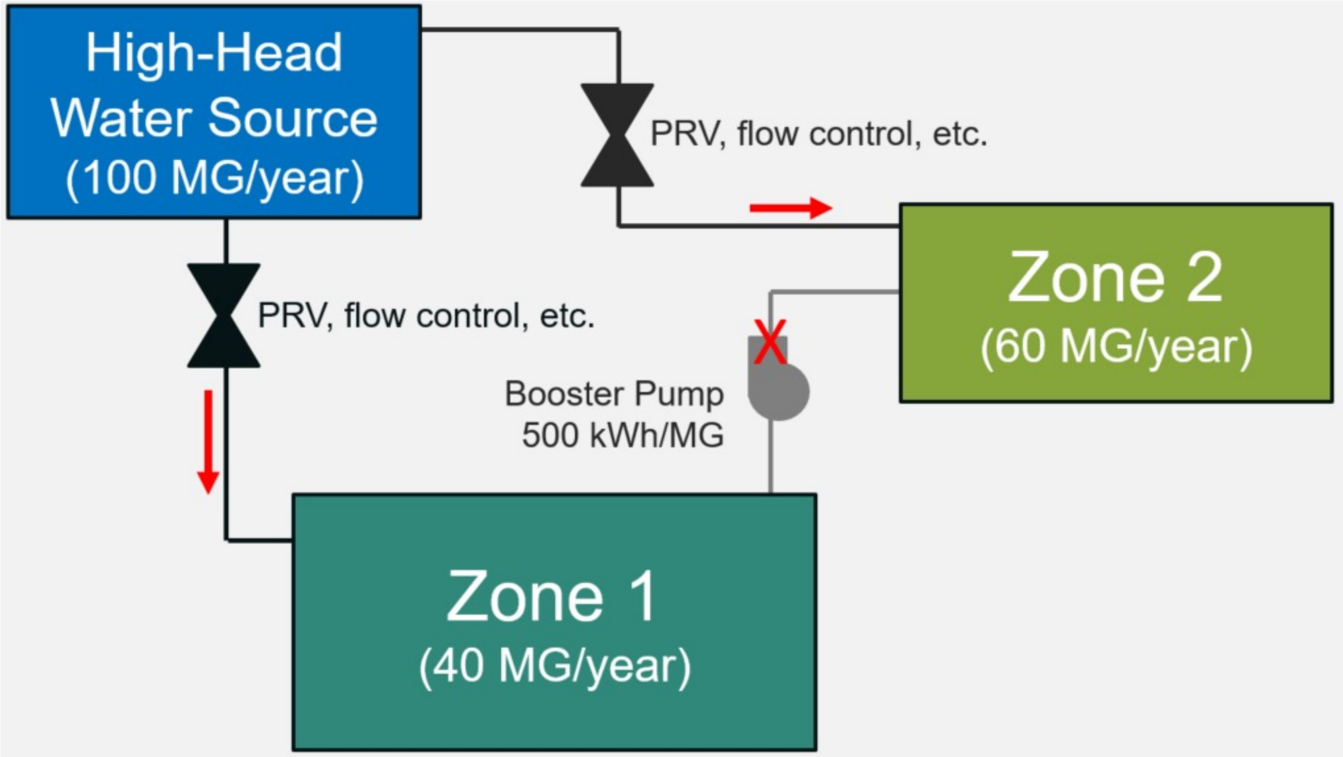
$$\frac{60\ \cancel{MG}}{year} * \frac{500\ kWh}{\cancel{MG}} = \frac{30{,}000\ kWh}{year}$$

$$\frac{30{,}000\ \cancel{kWh}}{year} * \frac{\$0.05}{\cancel{kWh}} = \frac{\$1{,}500}{year}$$

1. How much energy (kWh) is currently consumed by flowing to Zone 1 and boosting to Zone 2 to meet demands?

2. At $0.05 per kWh, what is the energy cost to flow to Zone 1 and boost to Zone 2?

Losing – Activity



$$\frac{60\ \cancel{MG}}{year} * \frac{500\ kWh}{\cancel{MG}} = 30{,}000\ \frac{kWh}{year}$$

$$30{,}000\ \frac{\cancel{kWh}}{year} * \frac{\$0.05}{\cancel{kWh}} = \frac{\$1{,}500}{year}$$

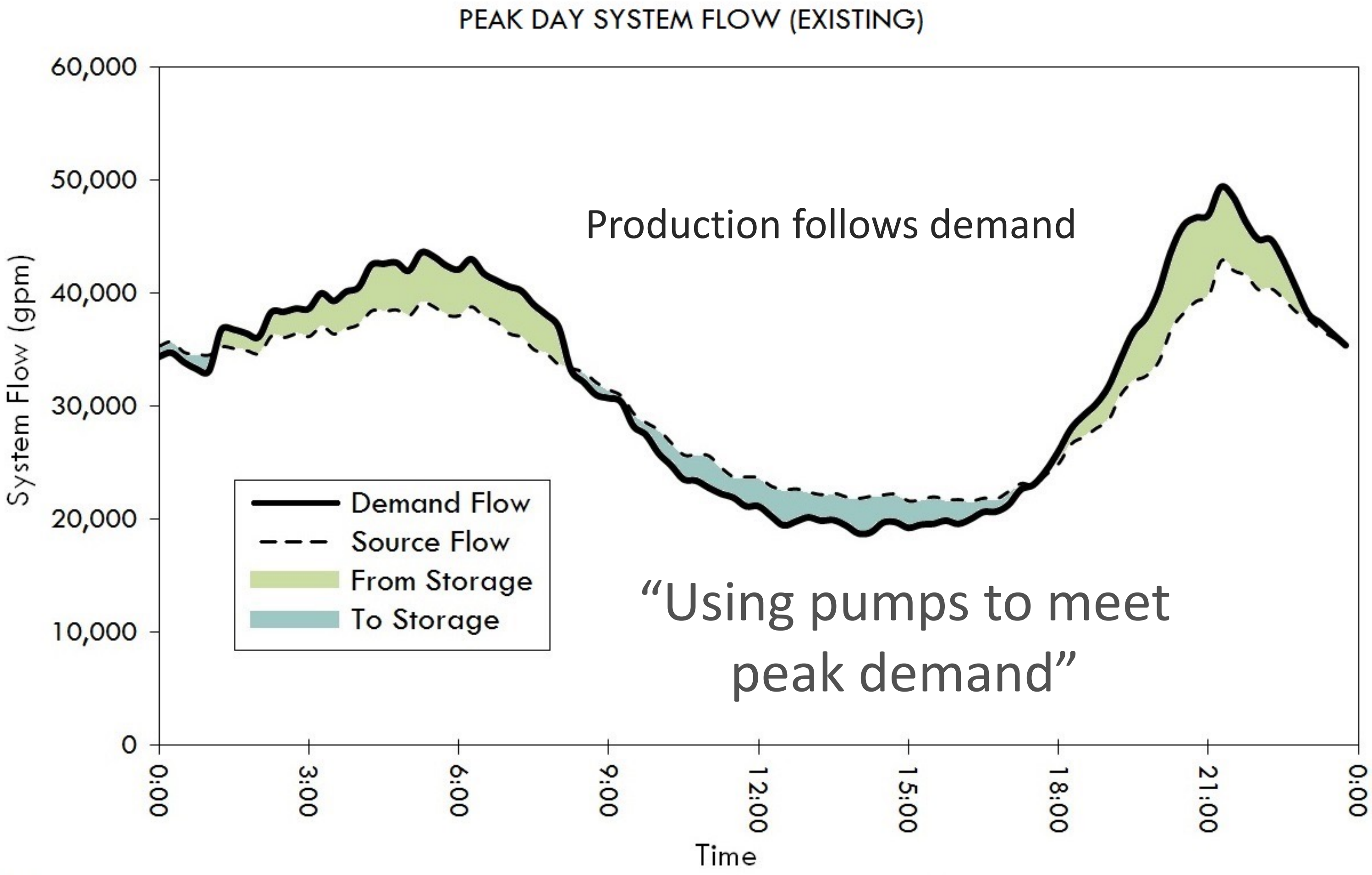
3a. How much energy (kWh) can be saved by fixing the valve and supplying the appropriate amounts to each zone without using the booster pump?

3b. At $0.05 per kWh, how much money would this adjustment save?

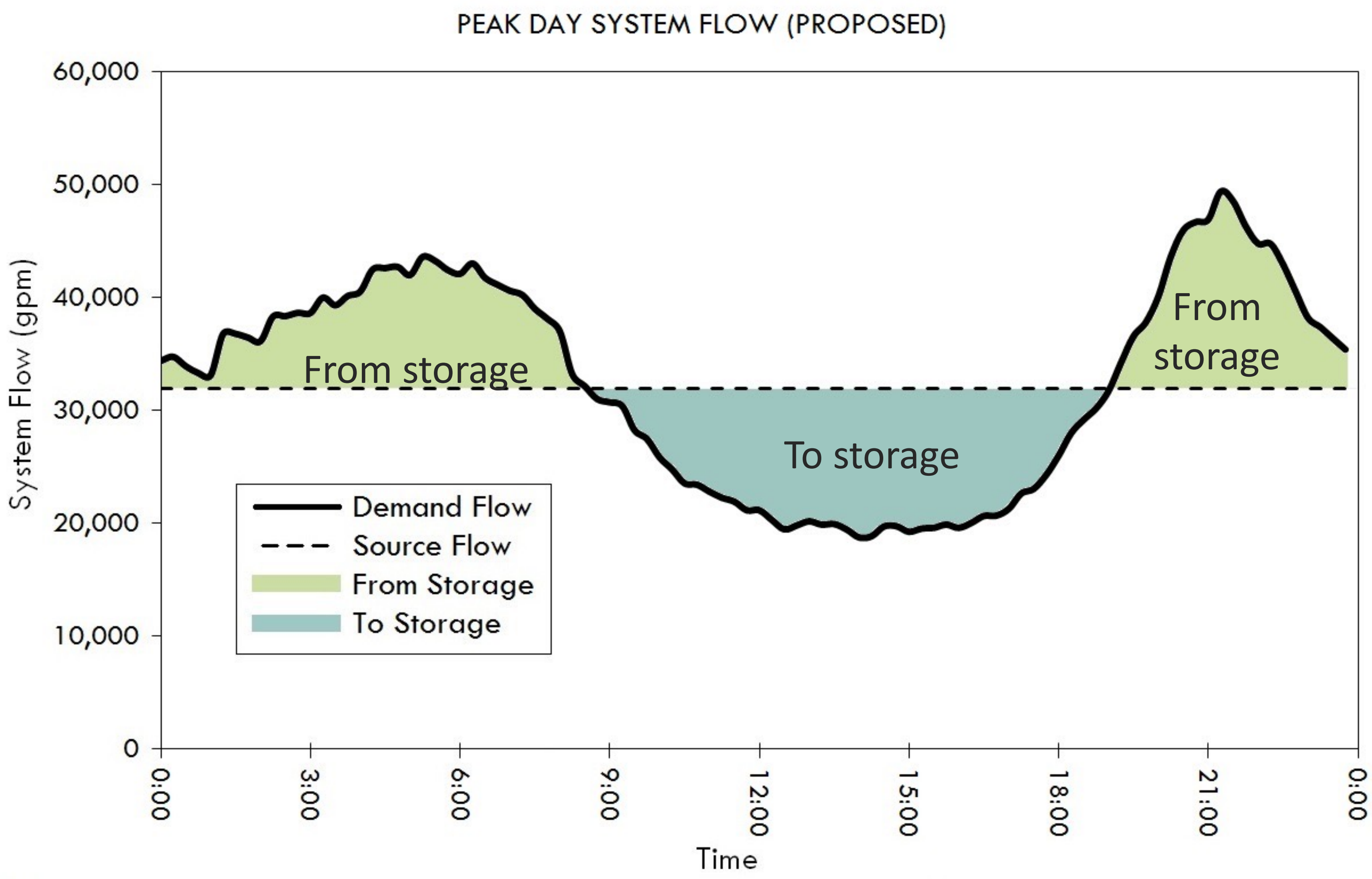
BREAK

LOADING

Loading

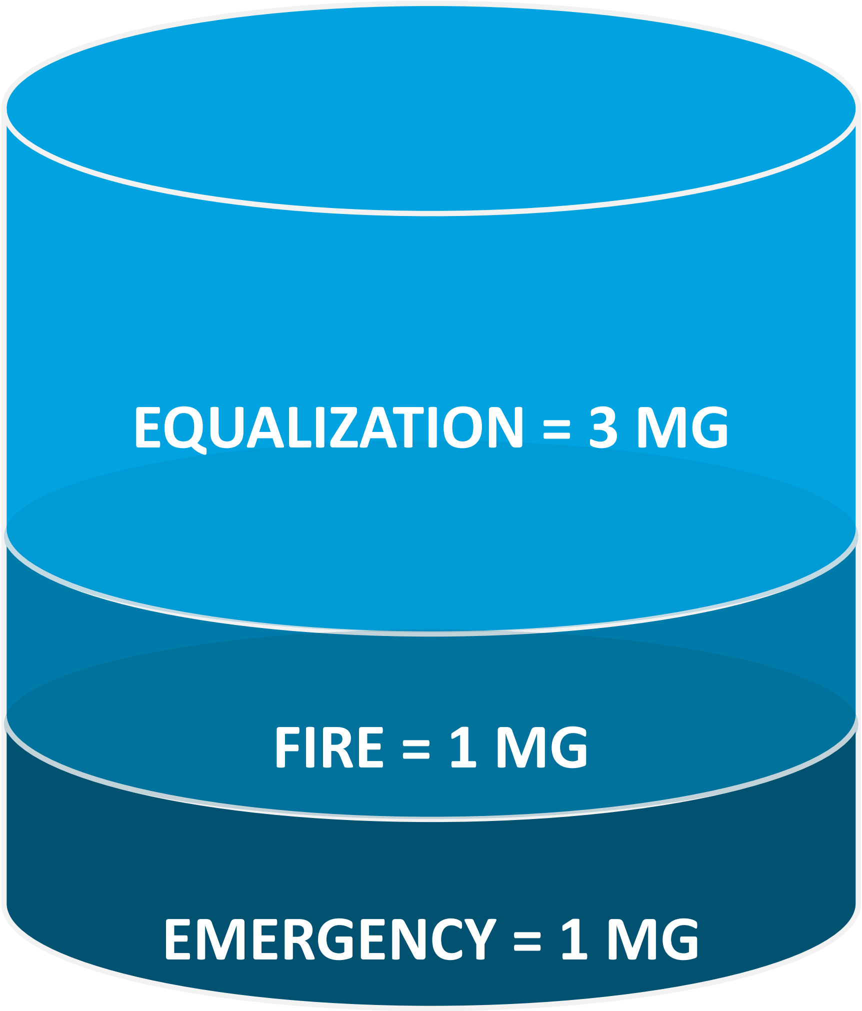

PEAK DAY SYSTEM FLOW (EXISTING)
System Flow (gpm)
60,000
50,000
40,000
30,000
20,000
10,000
0
0:00
3:00
6:00
9:00
12:00
15:00
18:00
21:00
0:00
Time
Demand Flow
Source Flow
From Storage
To Storage
Production follows demand
"Using pumps to meet peak demand"

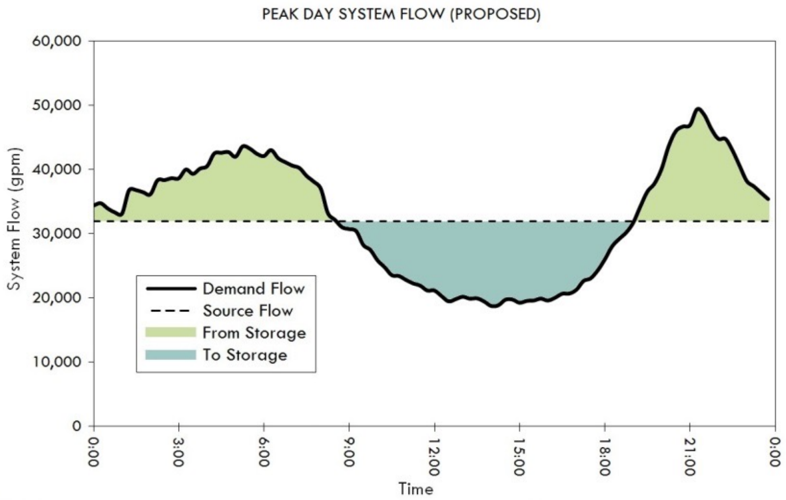
Loading



PEAK DAY SYSTEM FLOW (PROPOSED)
System Flow (gpm)
60,000
50,000
40,000
30,000
20,000
10,000
0
0:00
3:00
6:00
9:00
12:00
15:00
18:00
21:00
0:00
Time
From storage
To storage
From storage
Demand Flow
Source Flow
From Storage
To Storage

Tank Utilization

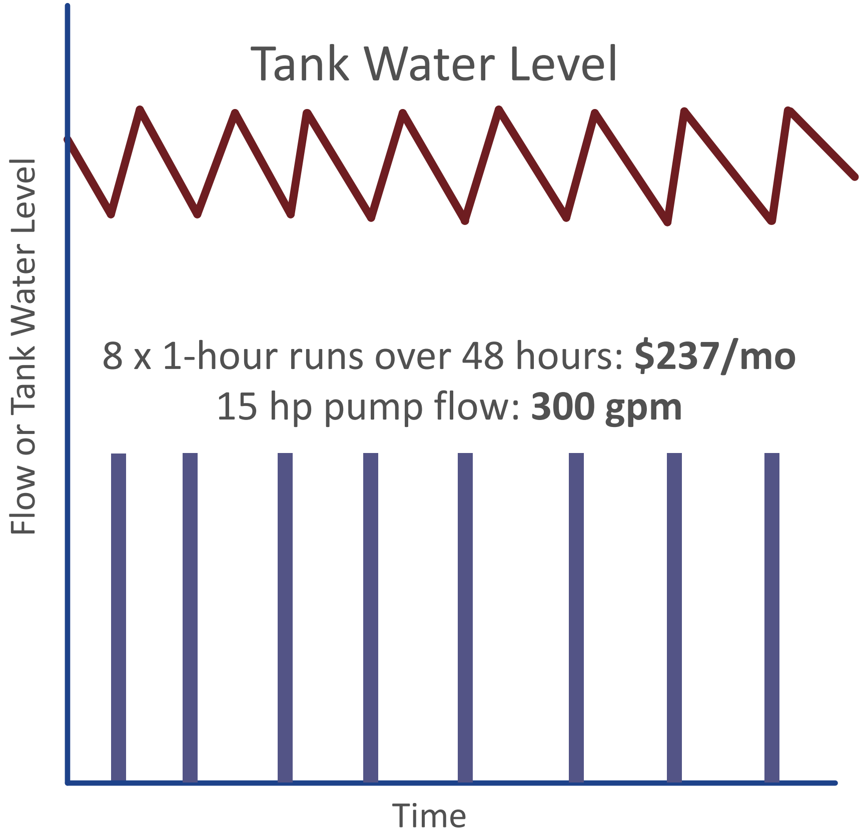




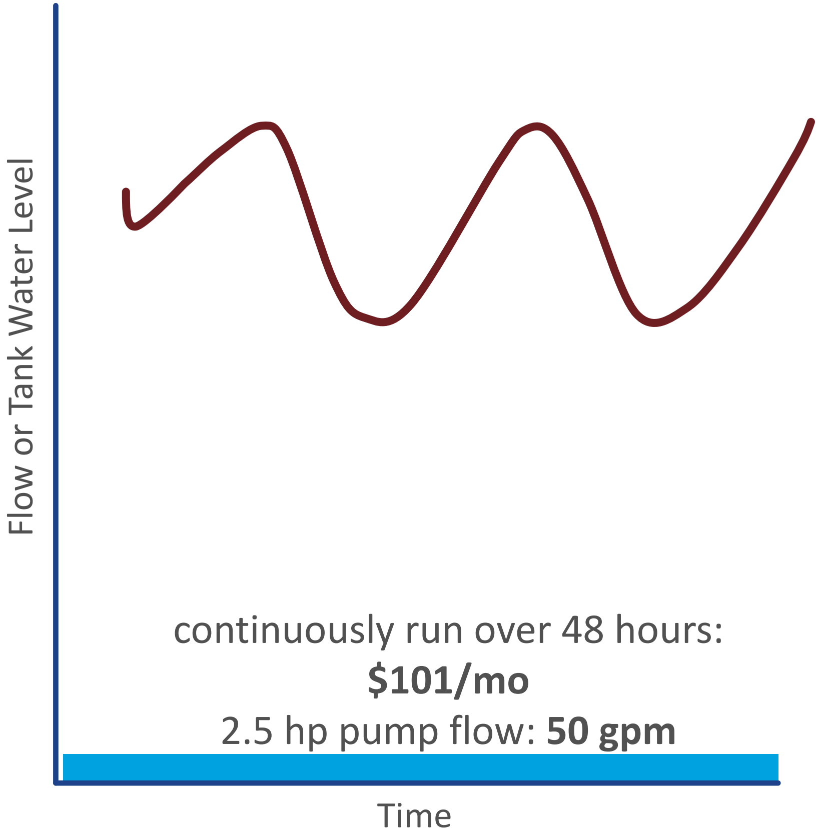
Tanks are batteries! Use storage to meet peak demand

Loading – Example

INEFFICIENT	EFFICIENT



8 x 1-hour runs over 48 hours: **$237/mo**
15 hp pump flow: **300 gpm**

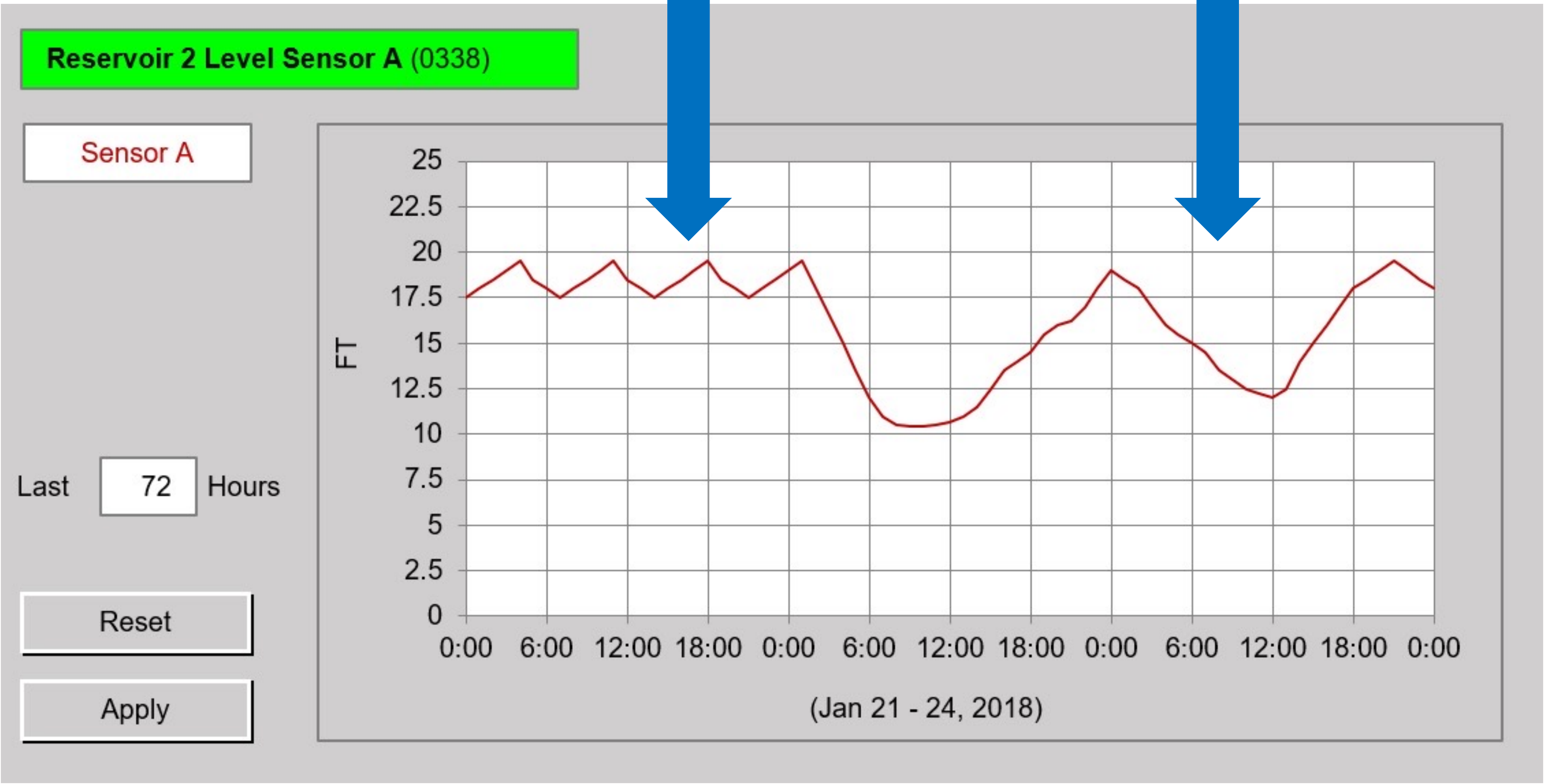


continuously run over 48 hours: **$101/mo**
2.5 hp pump flow: **50 gpm**

Loading

Inefficient

More efficient



Loading

How to detect:

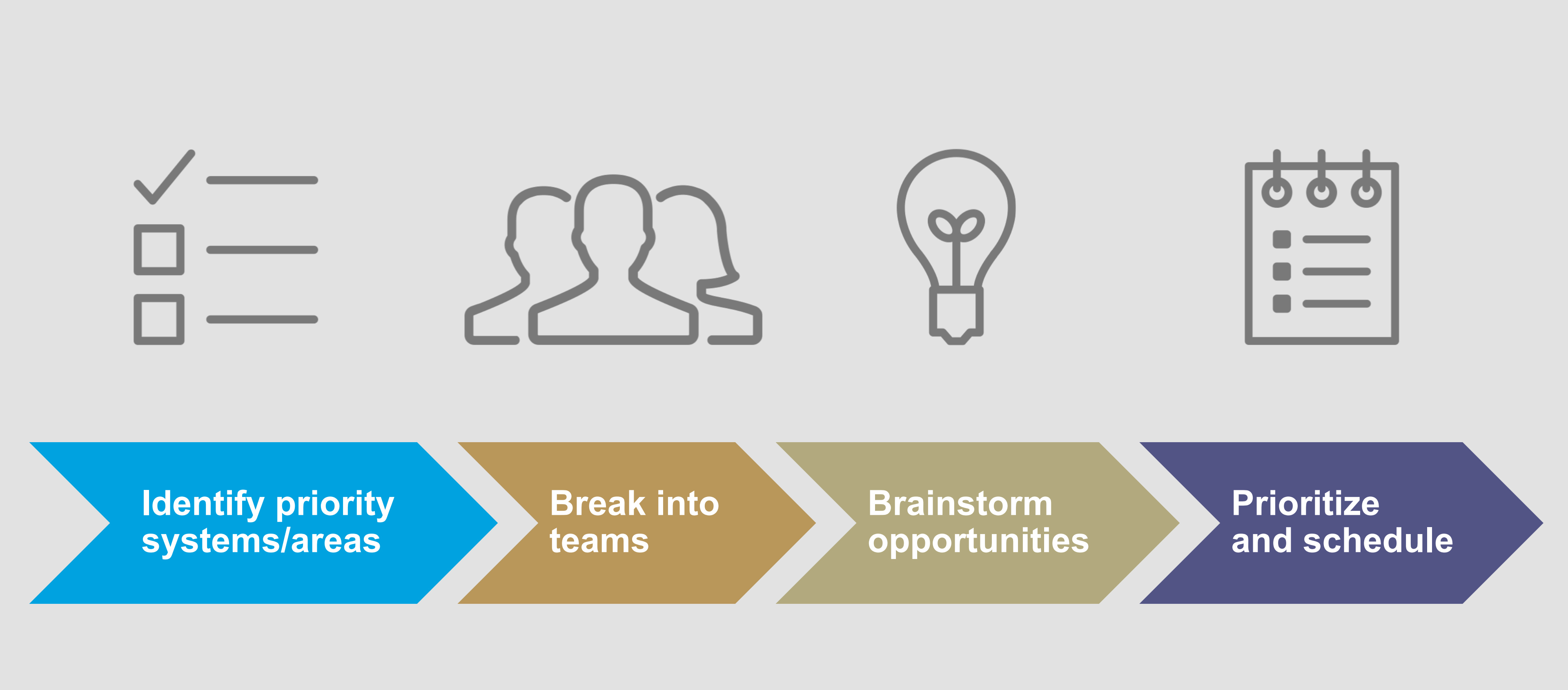
- Intermittent pump operation (short run, high flow)
- Oversized pumping facilities
- Little storage fluctuation
- Hydraulic modeling

How to resolve:

- Use equalization storage
- Modify tank setpoints
- Keep source and pump flow as constant as possible
- Modify pump station

TREASURE HUNTS

Treasure Hunt Overview



Conducting a Treasure Hunt

1. Thorough preparation
2. On-site event
3. Regular follow-up

Preparation

- ❑ Identify focus areas based on energy map and facility knowledge.

- ❑ Who?
- ❑ When?
- ❑ Where?

- ❑ Identify relevant facility staff
- ❑ SEM Coach – facilitator and technical support

- ❑ Prepare energy map
- ❑ Collect and analyze facility information, as needed

- ❑ Select date
- ❑ Reserve conference room
- ❑ Order food

- ❑ Communicate agenda, goals and expectations
- ❑ Ensure staff availability

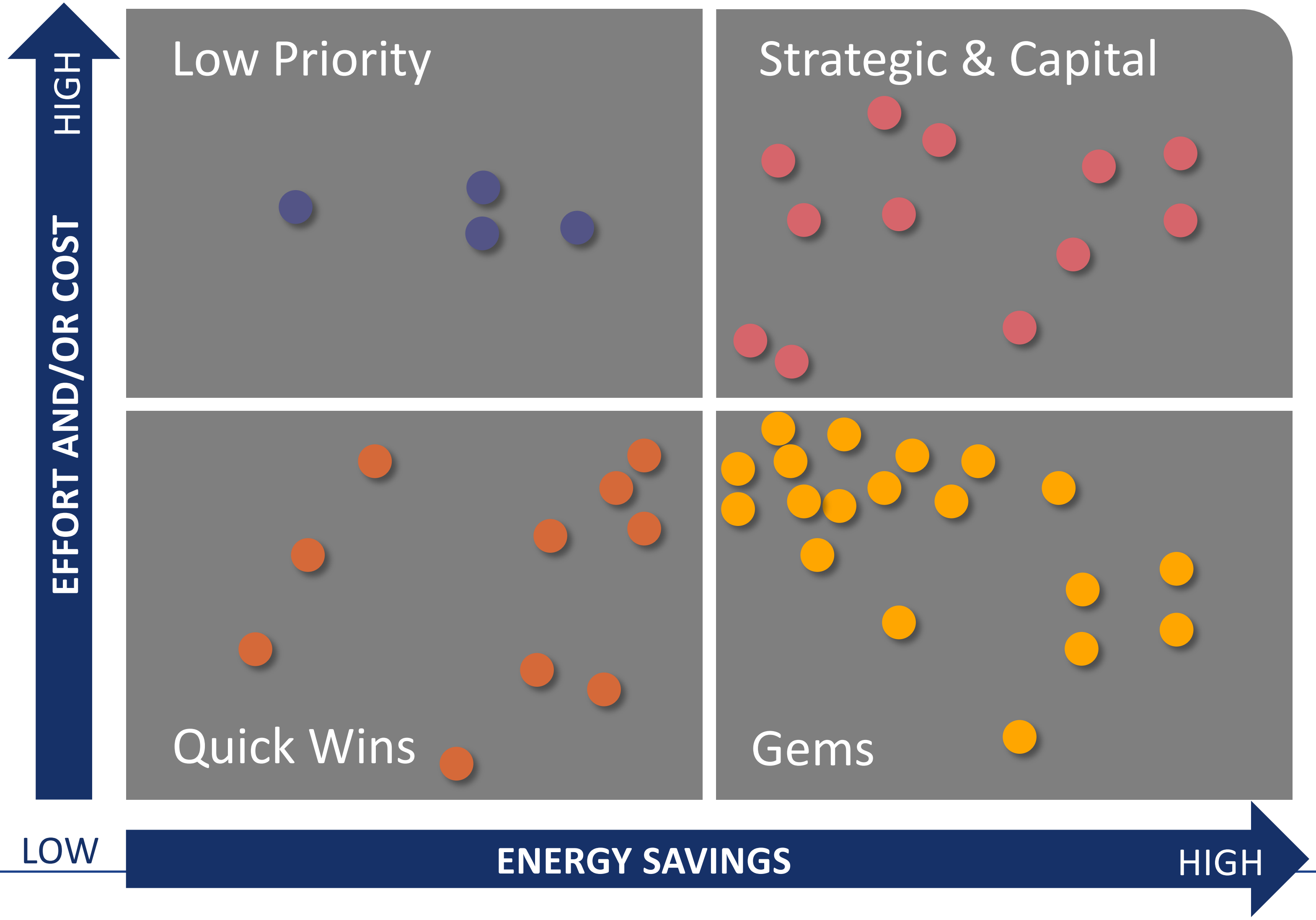
Treasure Hunt

- Executive Sponsor Introduction
- Facility and Energy Overview
- Opportunity Brainstorm
- Hunt!
- Opportunity Sharing
- General Prioritization (Value Graph)
- Top 5 Planning
- Closing: Report to Executive Sponsor

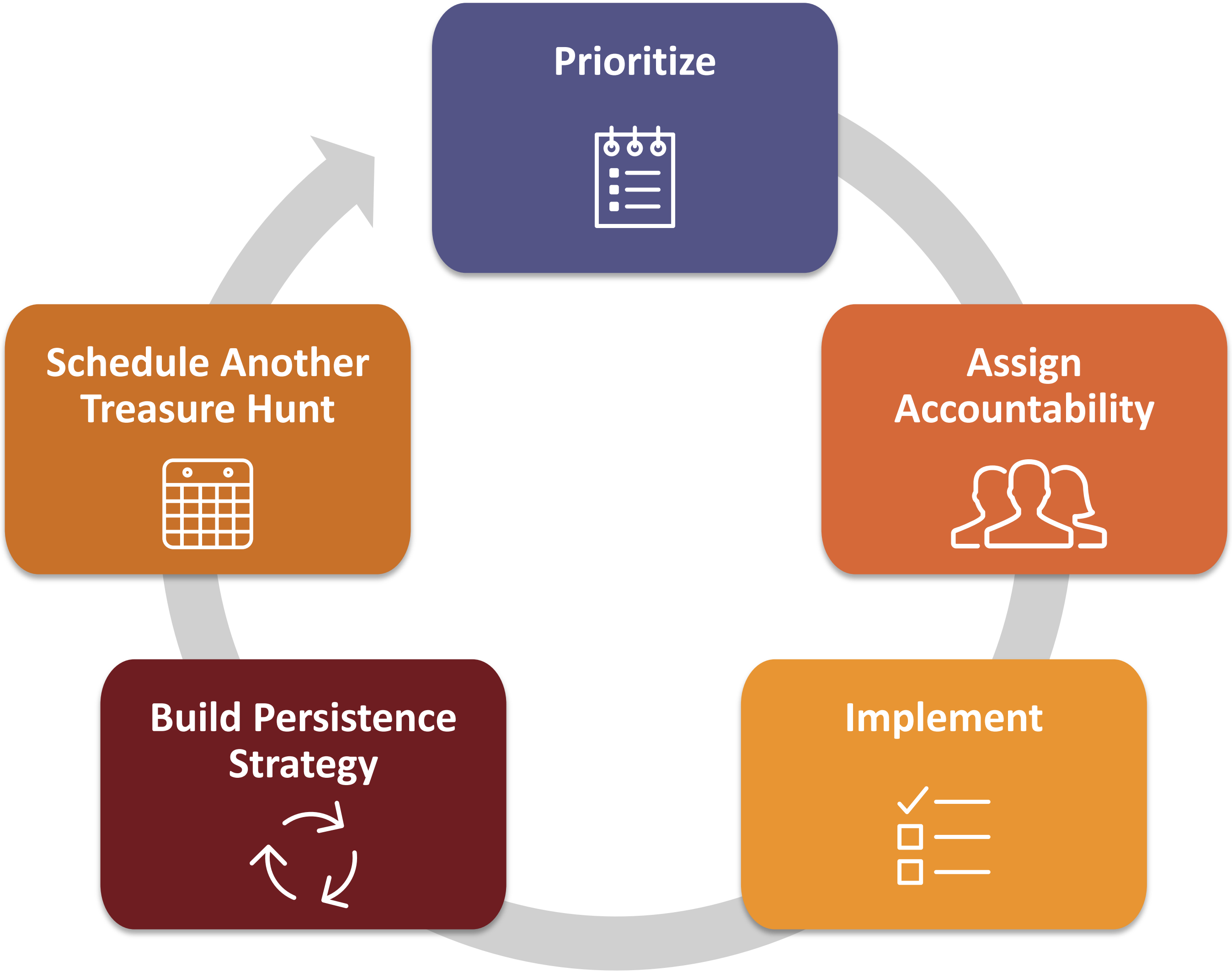
Ensuring a Successful Treasure Hunt

1. Involve the right people
2. Quantity not quality
3. Discuss "just enough"
4. "Best guess" on energy savings
5. Data log, where needed

Energy value graph



After the Treasure Hunt



Good Project management

Identify

- Project name
- Description
- Location
- System

Prioritize

- Energy savings
- Cost/effort required
- Decision to implement

Implement

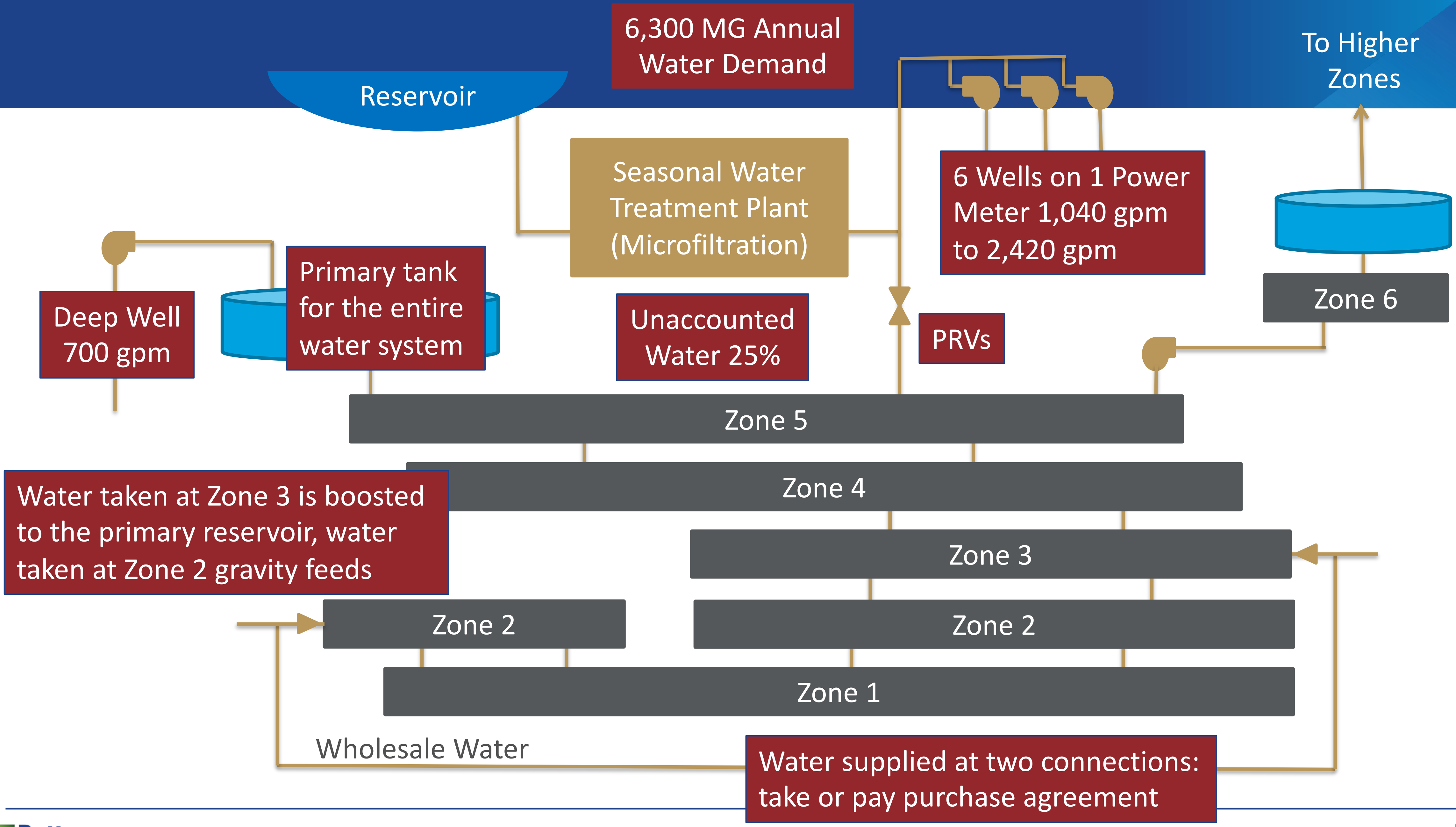
- Assigned to
- Required action
- Status
- Important dates

Ensure Persistence

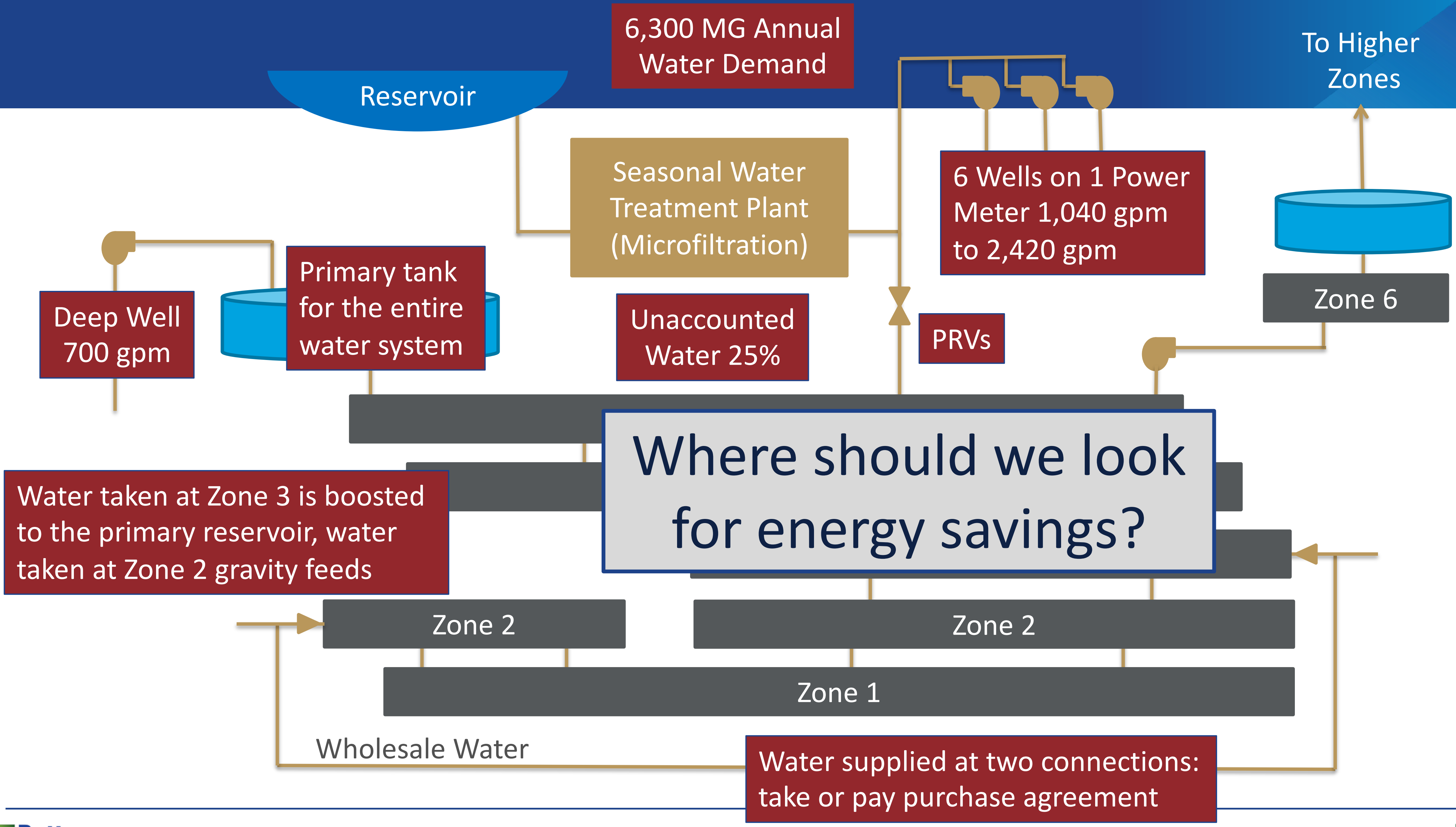
- Risk of backsliding
- Persistence strategy

TREASURE HUNT ACTIVITY

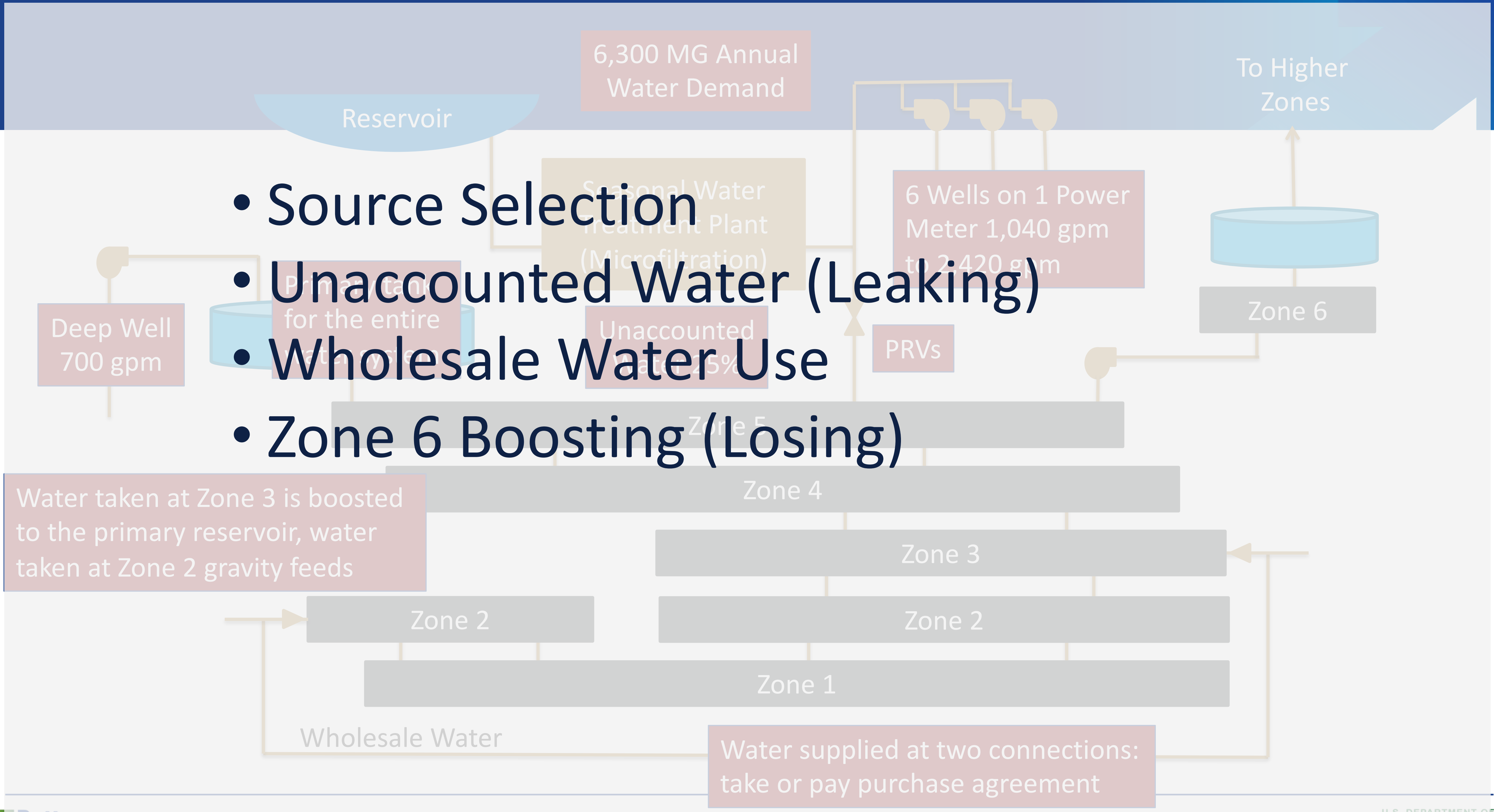
Buenaventura Water System


6,300 MG Annual Water Demand
Reservoir
To Higher Zones
Seasonal Water Treatment Plant (Microfiltration)
6 Wells on 1 Power Meter 1,040 gpm to 2,420 gpm
Primary tank for the entire water system
Deep Well 700 gpm
Unaccounted Water 25%
PRVs
Zone 6
Zone 5
Zone 4
Water taken at Zone 3 is boosted to the primary reservoir, water taken at Zone 2 gravity feeds
Zone 3
Zone 2
Zone 2
Zone 1
Wholesale Water
Water supplied at two connections: take or pay purchase agreement

Where should we look for energy savings?



- Source Selection
- Unaccounted Water (Leaking)
- Wholesale Water Use
- Zone 6 Boosting (Losing)



Unaccounted Water Reduction

- Total Water Production: 6,300 MG
  - Unaccounted Water: 1,575 MG
  - Delivered Water: 4,725 MG

- It is not reasonable to eliminate all unaccounted water losses:
  - Target an unaccounted water percentage of 15% through leak reduction
  - New production target: 5,670 MG
  - Monthly production reduction: 52.5 MG

Source Selection - Water Supply by Source

- Total Produced: 6,300 MG
  - Wellfield: 3,798 MG
  - Wholesale Purchase: 1,227 MG
  - Treatment Plant: 1,081 MG
  - Deep Well: 194 MG

Wellfield Energy Intensity

Wellfield Energy Intensity Comparison

Well	Power kW	Power Factor %	Flow gpm	Flow MGD	Energy Intensity kWh/MG
1	64.7	89.6%	1477	2.1	730
2	37.7	87.4%	1040	1.5	604
3	47.1	83.0%	1310	1.9	599
4	64.0	90.3%	1197	1.7	891
5	74.4	92.2%	1960	2.8	633
6	70.8	90.6%	2420	3.5	488

Energy Used: 2,621,279 kWh
Water Produced: 3,798 MG

Energy Intensity: 690 kWh/MG

Energy Intensity of Wholesale Water

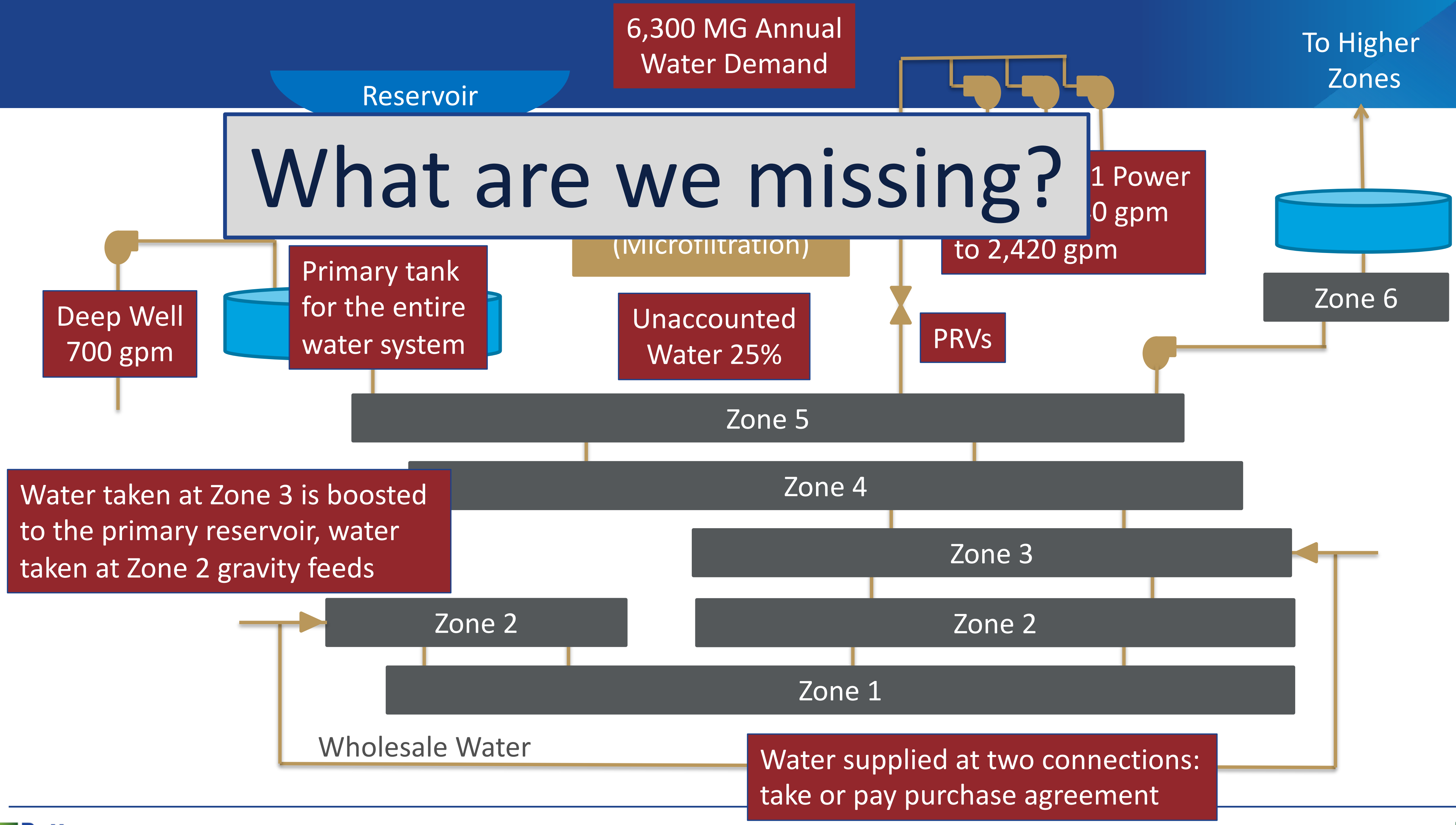
- Total Purchased Water Taken: 1,227 MG
- Zone 3:
  - Water taken and boosted to primary reservoir: 905 MG
  - Energy to boost water: 760,001 kWh
  - Energy Intensity: 840 kWh/MG
- Zone 2:
  - Water gravity fed: 322 MG
  - Energy to gravity feed: 0 kWh
  - Energy Intensity: 0 kWh/MG

Wholesale Water Purchase

- Total Purchased Water: 2,200 MG/year
- Water Taken by City: 1,227 MG
  - 55.8% of purchased water
- What are some reasons for using less than purchased?
- Target: 90% of purchased water
  - 1,980 MG

But are we missing something?

What are we missing?



Water Demand by Zone

Total Annual Water Use (Including Unaccounted Water)	6,300	MG
Zone 1	630	MG
Zone 2	1890	MG
Zone 3	1575	MG
Zone 4	945	MG
Zone 5	630	MG
Zone 6 and Higher	315	MG

- Can all the wholesale water be used in Zone 3 or lower?
- Target: 90% of purchased water
  - 1,980 MG
  - Energy intensity: 0 kWh/MG

Energy Intensity of the Water Treatment Plant

- Energy Used: 1,101,599 kWh
- Water Produced: 1,081 MG
- Energy Intensity: 1,019 kWh/MG

- Oct – Mar Energy Use: 57,700 kWh
- Assumed Baseload: 692,400 kWh

- Production Energy Used: 409,199 kWh
- Production Energy Intensity:
  379 kWh/MG

	Treatment Plant	
	kWh	MG
January	59,100	0.0
February	59,400	0.0
March	47,400	0.0
April	43,800	7.7
May	60,600	108.2
June	132,300	224.8
July	170,100	288.8
August	173,100	304.7
September	175,500	146.5
October	64,499	0.0
November	50,400	0.0
December	65,400	0.0
Total	**1,101,599**	**1,081**

Energy Intensity of the Deep Well

- Energy Used: 512,840 kWh
- Water Produced: 195 MG
- Energy Intensity: 2,624 kWh/MG

Non-Production Energy Use

- Total Energy Use: 5,475,778 kWh
  - Wellfield Energy: 2,621,279 kWh
  - Deep Well Energy: 512,840 kWh
  - Treatment Plant Energy: 1,101,599 kWh
  - Wholesale Water Energy: 760,001
- Production Energy Use: 4,995,719 kWh
- Non-Production Energy Use: 480,059 kWh
  - What is the energy?
  - Can it be reduced?

Energy Intensity Summary

- Non-Production Energy Use: 480,059 kWh
- Treatment Plant Fixed Energy Use: 692,400 kWh
- Water Sources:
  - Wellfield:
    - Well 1: 730 kWh/MG
    - Well 2: 604 kWh/MG
    - Well 3: 599 kWh/MG
    - Well 4: 891 kWh/MG
    - Well 5: 633 kWh/MG
    - Well 6: 488 kWh/MG
  - Treatment Plant (variable): 379 kWh/MG
  - Deep Well: 2,624 kWh/MG
  - Wholesale: 0 kWh/MG

Buenaventura Water System

- Annual Energy Use: 5,475,778 kWh
- Annual Production: 6,300 MG
- Annual Energy Intensity: 793 kWh/MG
- Production Capacity
  - WTP: 216 MGM (May – Sep)
  - Wholesale: 1,980 MGY
  - Deep Well: 25 MGM
  - Wellfield:
    - Well 1: 64 MGM
    - Well 2: 45 MGM
    - Well 3: 57 MGM
    - Well 4: 52 MGM
    - Well 5: 85 MGM
    - Well 6: 104 MGM

New Buenaventura Strategy

Only
May – Sep

		WTP	DW	#1	#2	#3	#4	#5	#6	Wholesale
Capacity (MGM)		216	25	64	45	57	52	85	104	1980/yr
Intensity (kWh/MG)		379	2,624	730	604	599	891	633	488	0
Demand (MGM)										
Jan	358									
Feb	312									
Mar	374									
Apr	333									
May	539									
Jun	669									
Jul	805									
Aug	752									
Sep	543									
Oct	385									
Nov	291									
Dec	311									

New Buenaventura Strategy

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409,320

New Buenaventura Strategy

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409,320

609,024

New Buenaventura Strategy

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Jul	805	216				57			104	
Aug	752	216				57			104	
Sep	543	216				57			104	
Oct	385	0				57			104	
Nov	291	0				57			104	
Dec	311	0				57			104	
		409,320				409,716			609,024	

New Buenaventura Strategy

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May	539	216			45	57			104	
Jun	669	216			45	57			104	
Jul	805	216			45	57			104	
Aug	752	216			45	57			104	
Sep	543	216			45	57			104	
Oct	385	0			45	57			104	
Nov	291	0			45	57			104	
Dec	311	0			45	57			104	

409,320

409,716

326,160

609,024

New Buenaventura Strategy

		WTP	DW	#1	#2	#3	#4	#5	#6	Wholesale
Capacity (MGM)		216	25	64	45	57	52	85	104	1980/yr
Intensity (kWh/MG)		379	2,624	730	604	599	891	633	488	0
Demand (MGM)										
Jan	358	0			45	57			104	
Feb	312	0			45	57			104	
Mar	374	0			45	57			104	
Apr	333	0			45	57			104	
May	539	216			45	57			104	
Jun	669	216			45	57			104	
Jul	805	216			45	57		85	104	
Aug	752	216			45	57		55	104	
Sep	543	216			45	57			104	
Oct	385	0			45	57			104	
Nov	291	0			45	57			104	
Dec	311	0			45	57			104	

409,320

409,716

609,024

326,160

88,620

New Buenaventura Strategy

		WTP	DW	#1	#2	#3	#4	#5	#6	Wholesale
Capacity (MGM)		216	25	64	45	57	52	85	104	1980/yr
Intensity (kWh/MG)		379	2,624	730	604	599	891	633	488	0
Demand (MGM)										
Jan	358	0			45	57			104	152
Feb	312	0			45	57			104	106
Mar	374	0			45	57			104	168
Apr	333	0			45	57			104	127
May	539	216			45	57			104	117
Jun	669	216			45	57			104	247
Jul	805	216			45	57		85	104	298
Aug	752	216			45	57		55	104	275
Sep	543	216			45	57			104	121
Oct	385	0			45	57			104	179
Nov	291	0			45	57			104	85
Dec	311	0			45	57			104	105
		409,320			326,160	409,716		88,620	609,024	0

Water System Energy Use

Non-Production Energy:	408,059 kWh
WTP Fixed Energy:	692,400 kWh
WTP Variable Energy:	409,320 kWh
Well #2:	326,160 kWh
Well #3:	409,716 kWh
Well #5:	88,620 kWh
Well #6:	609,024 kWh
Wholesale Water:	0 kWh

Total: 2,943,299 kWh

Energy Savings

Original Strategy: 5,475,778 kWh
Revised Strategy: 2,943,299 kWh
Energy Savings: 2,532,479 kWh
Percent Savings: 46.2%

Original Intensity: 793 kWh/MG
Revised Intensity: 519 kWh/MG

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

KAHOOT!

Takeaways

- Identify leaking, losing, and loading opportunities in your water system
- Keep track of energy saving opportunities
- Start working on energy saving opportunities

Closing

Questions
Comments
Discussion

SEE YOU TUESDAY!

aquafficiency

Saving energy, one gallon at a time