Hydraulic Analysis of Water Infrastructure Projects for Anticipated Urban Expansion

Cooperative Research between MWU and UW-Madison

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Harrington Group

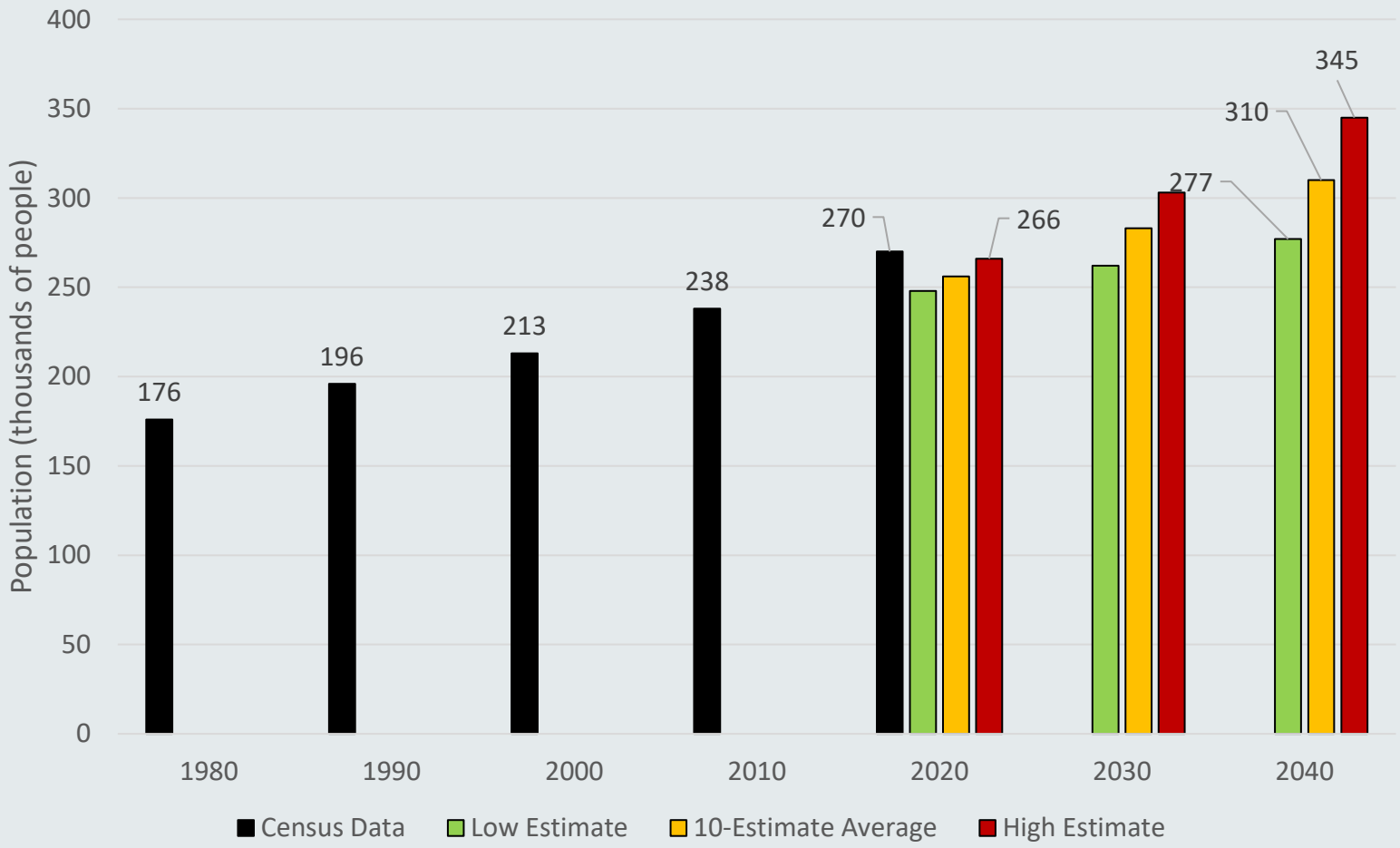
Madison Water Utility

CITY OF MADISON WISCONSIN

DEPARTMENT OF Civil and Environmental Engineering

UNIVERSITY OF WISCONSIN-MADISON

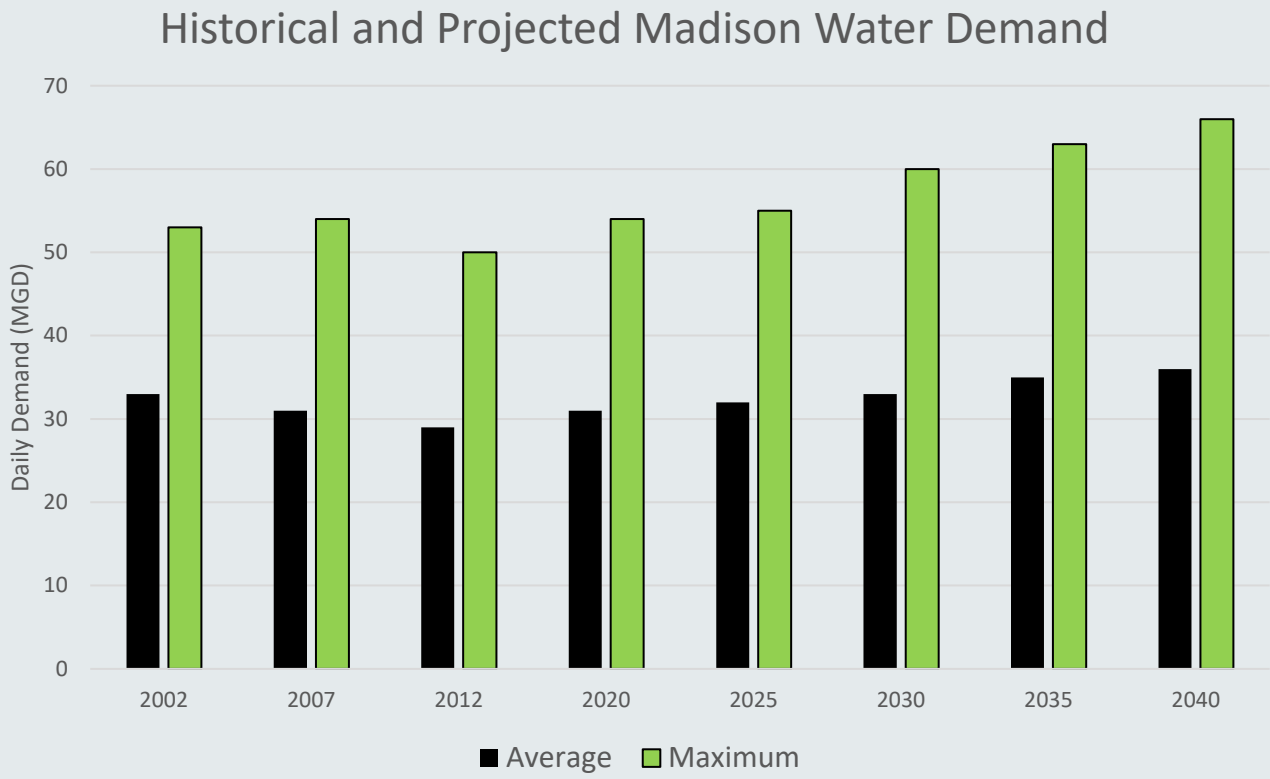
Madison Population Projections



Source: 2019 Madison Water Utility Water System Master Plan

Madison Water and Power Usage

- In 2022, MWU
  - Consumed over 19.7 million kWh of electricity (*Reams 2023*)
  - Made up 41% of the City of Madison's power consumption, per City sources
  - Emitted 13,824 Tons CO2e



Source: 2019 Madison Water Utility Water System Master Plan

Objective Statement

- MWU has completed analyses (2020 Master Plan) that anticipate additional need for water supply on Madison's west side.

- Addressing this need would involve additional energy consumption to either source new water or move existing water.

Approach

- This study examined several water system modification options from the 2020 Master Plan and assesses their system-wide implications as they relate to energy usage, hydraulics, and water quality.

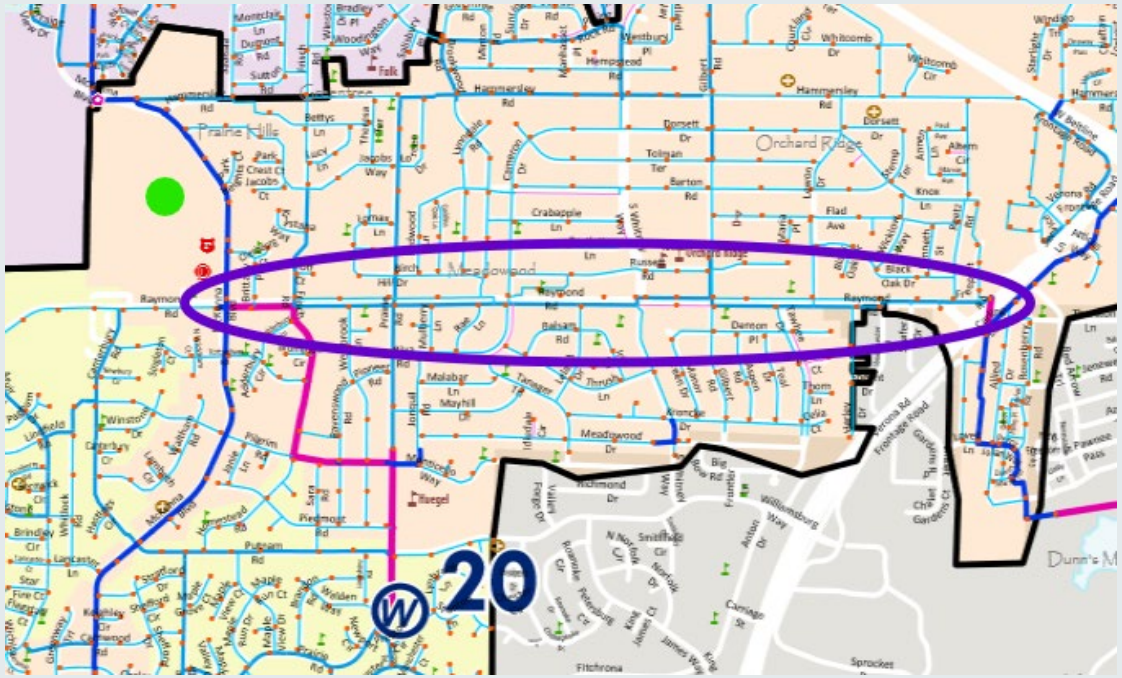
- MWU's current water model was leveraged to describe the above metrics and to begin establishing business case evaluations related to this expected supply need.

Examined Alternatives

- Selected based on…
  - Location on West Side
  - Variety in Cost
  - Variety in Performance

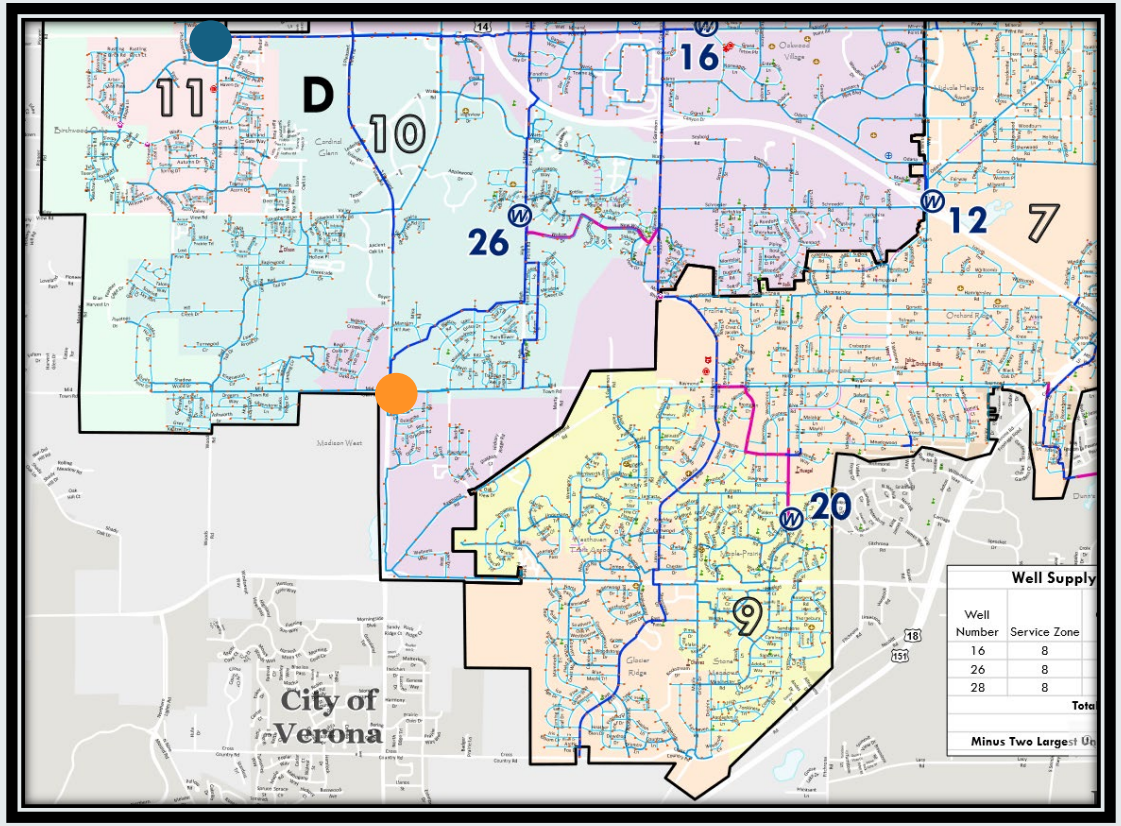
Alternatives: Transmission

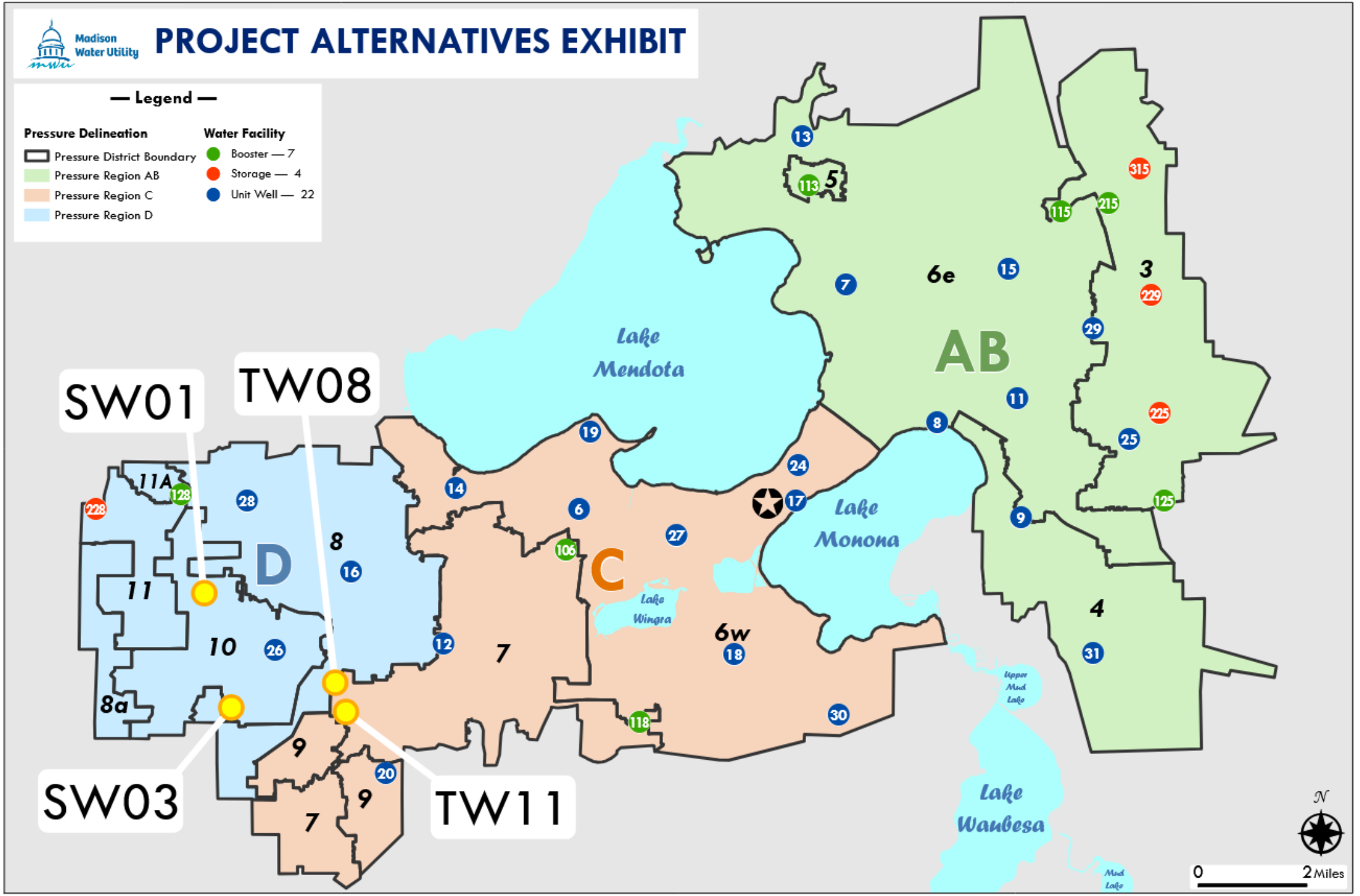
- Transmission: Change Distribution of Existing Supply
  - **TW-08**: New Booster Station near Elver Park
  - **TW-11**: Replace and Upgrade Raymond Road Piping



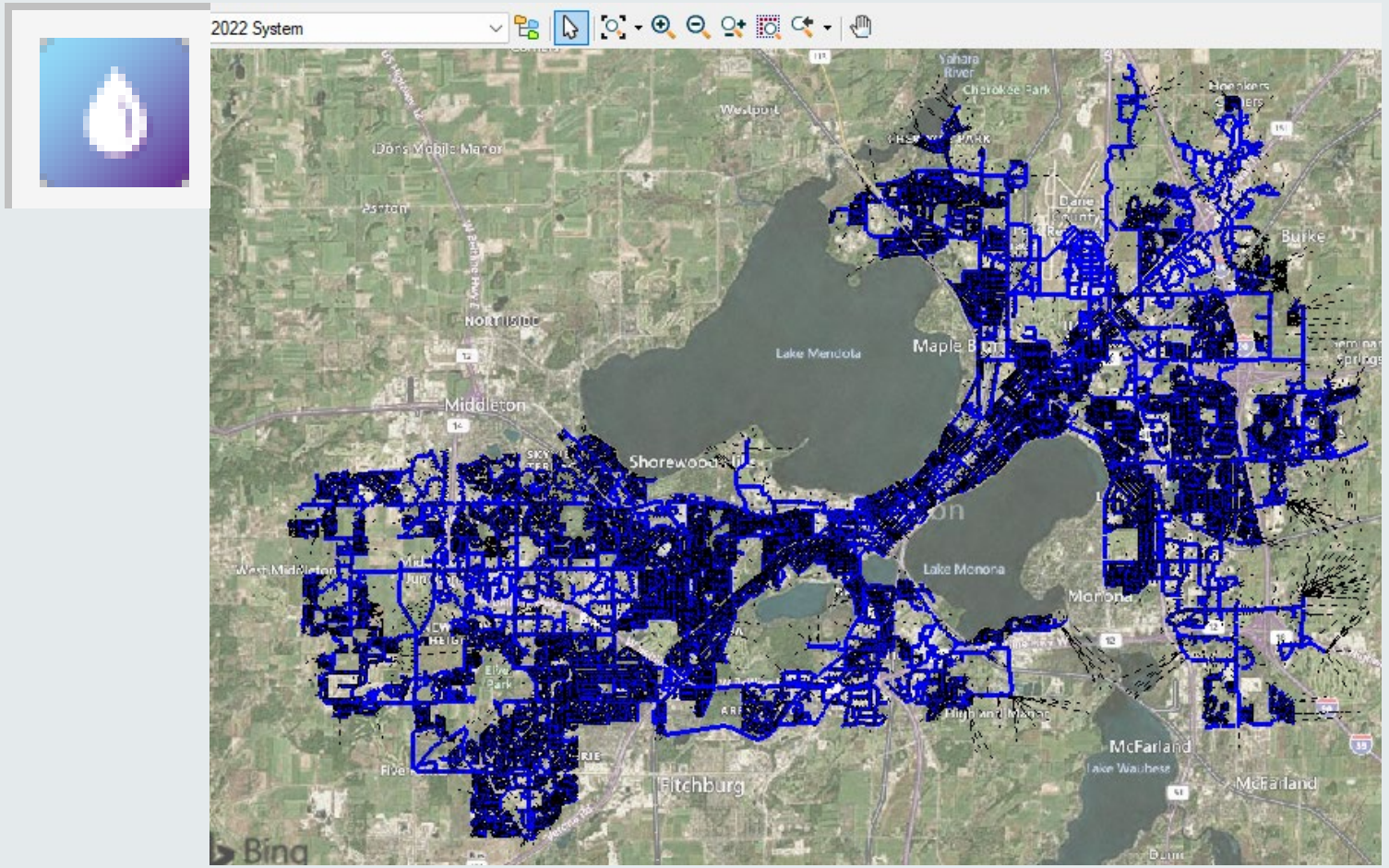
Alternatives: Supply

- Supply: Introduce New Sources of Water
  - **SW-01**: New Unit Well at Mineral Point Rd. and South Point Rd.
  - **SW-03**: New Unit Well at Pleasant View Rd. and Mid Town Rd.




Madison Water Utility
PROJECT ALTERNATIVES EXHIBIT
— Legend —
Pressure Delineation
Pressure District Boundary
Pressure Region AB
Pressure Region C
Pressure Region D
Water Facility
Booster — 7
Storage — 4
Unit Well — 22
SW01
TW08
SW03
TW11
Lake Mendota
Lake Monona
Lake Wingra
Lake Waubesa
Upper Mud Lake
Mud Lake
AB
C
D
6e
6w
11A
11
10
8a
8
7
9
5
3
4
N
0
2 Miles

Hydraulic Model: Bentley OpenFlows WaterCAD



Hydraulic Model: Inputs and Outputs

- Inputs:
  - Pipes, Nodes, Hydrants, and Associated Metadata
  - Pumps and Pump Curves
  - SCADA (Supervisory Control and Data Acquisition) Demand Data
  - Diurnal Demand Curves
    - One for each Pressure Zone
    - 2040 and 2035 curves projected using MWU Master Plan data

- Outputs:
  - Flow and Storage Data
    - Analyzed water level stability in six head-setting reservoirs.
  - Energy Data
    - Used to calculate energy intensity and greenhouse gas intensity.

2040 Demand cannot be met by the MWU System as it is currently designed.

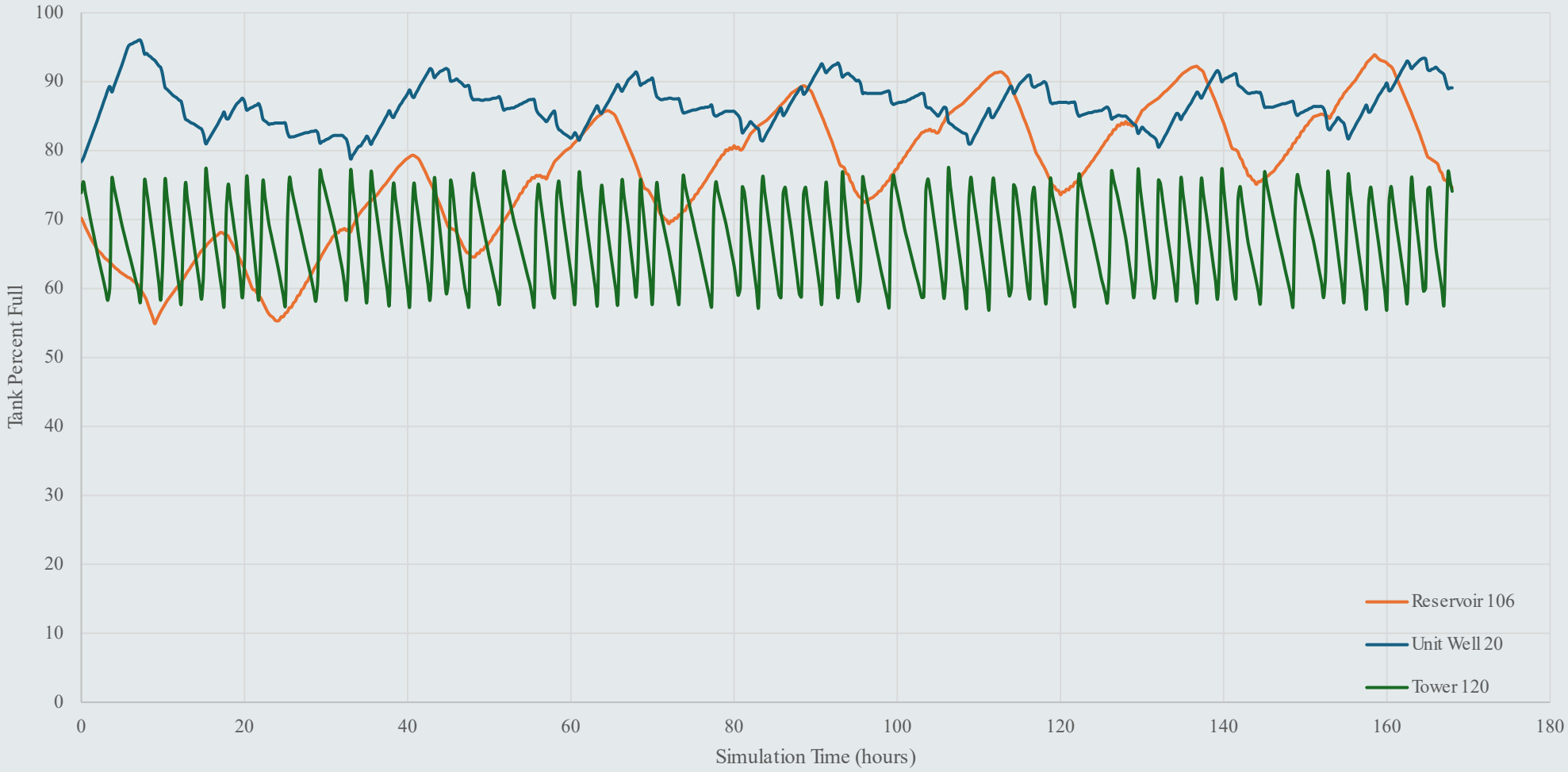
Current System Findings

- Pressure Zones 6w, 7, and 9 have enough supply to meet demand until at least 2040.
- Pressure Zone 8 is expected to meet 2040 demand if Unit Well 12 is converted to a Zone 8 well.
- Pressure Zones 10 and 11 do not have enough supply to meet demand in 2040.

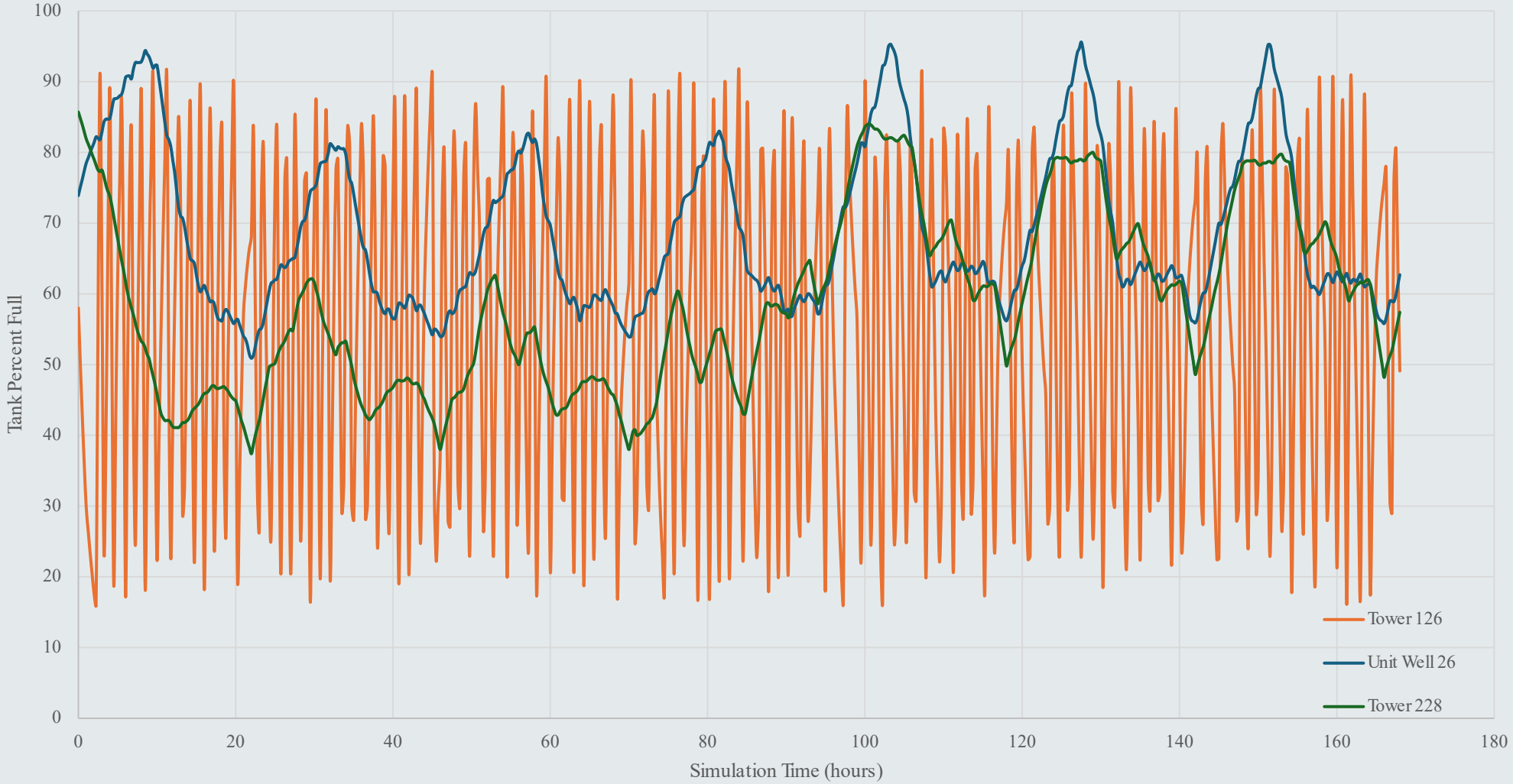
Transmission Alternatives

- TW-08 meets 2040 demand in Zone 8.
- TW-11 only meets 2040 Zone 8 demand if Unit Well 12 is converted to a Zone 8 well.
- Neither alternative meets 2040 demand in Zones 10 or 11.

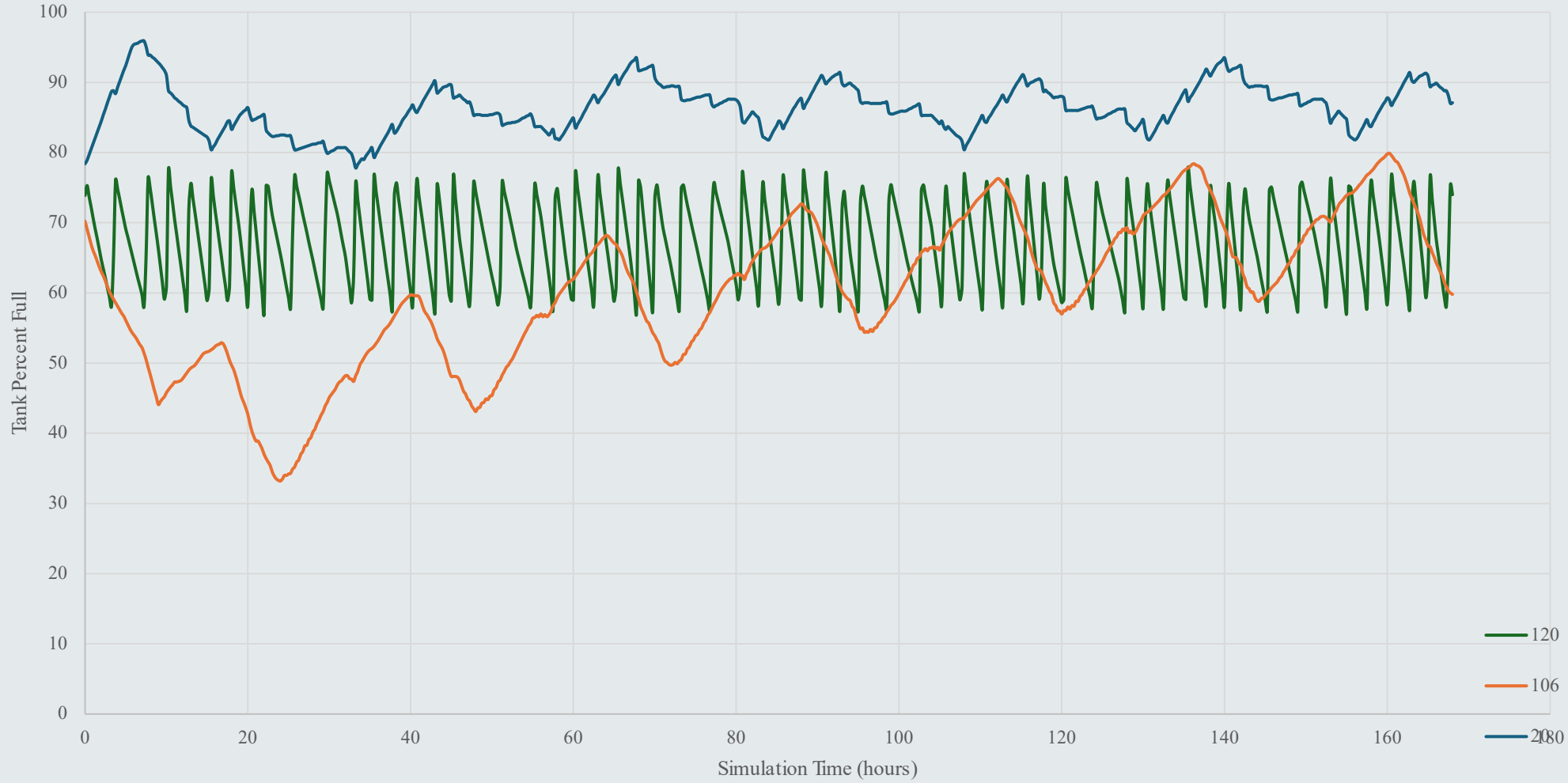
Well SW-01: 2040 Region C Demand



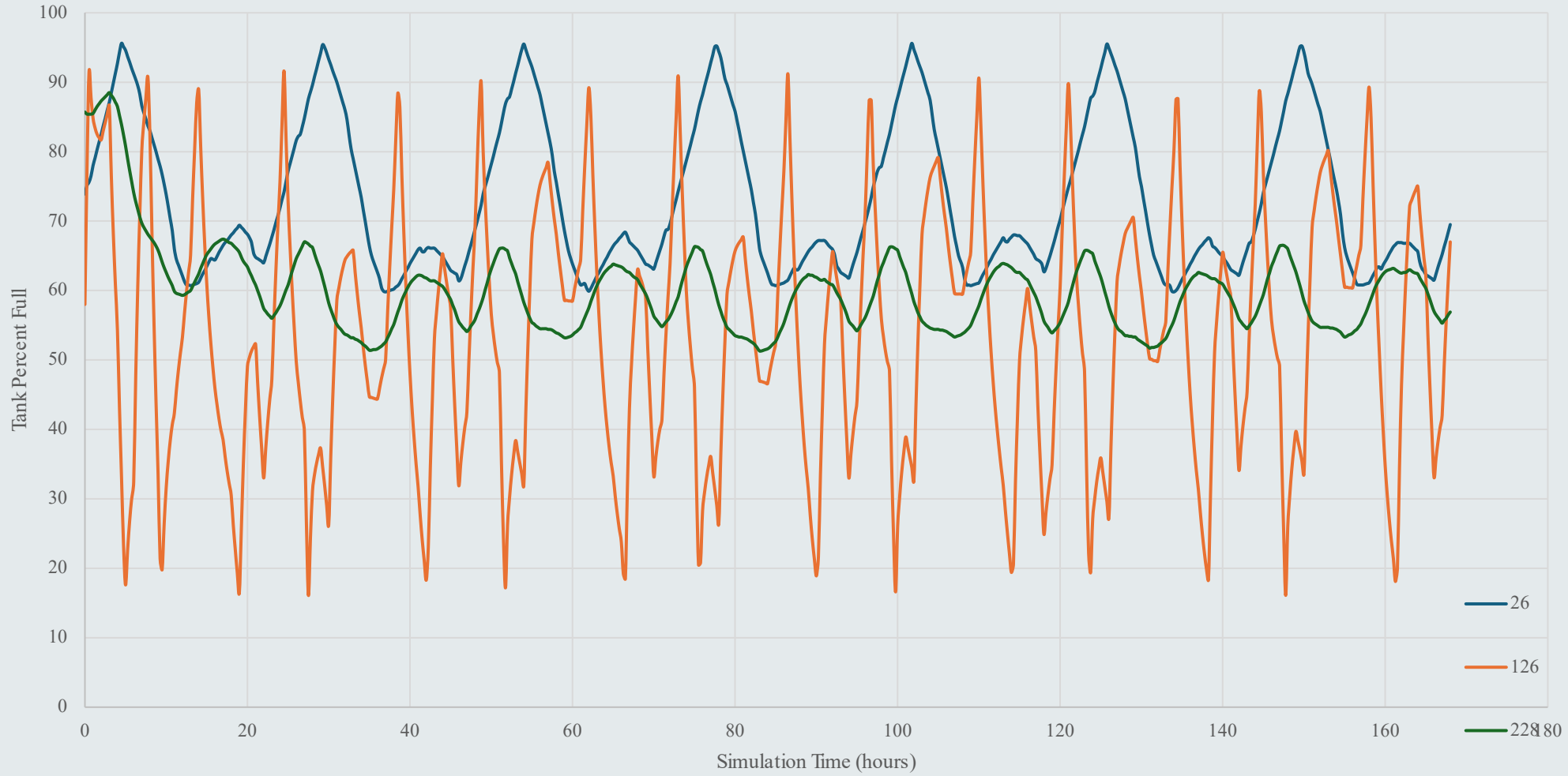
Well SW-01: 2040 Region D Demand



Well SW-03: 2040 Region C Demand



Well SW-03: 2040 Region D Demand



Economic and Energy Analysis

Alternative	Capital Cost	Year	Scaled Energy Intensity (kWh/MG)	Scaled Emissions (lb CO_2e/MG)
Current	None	2022	2180 (observed value)	2990
Current	None	2040	Does Not Meet Water Demand	
TW-08	$4.1M	1040	Does Not Meet Water Demand	
TW-08	$4.1M	2035	2070	2830
TW-11	$4.1M	2040	Does Not Meet Water Demand	
TW-11	$4.1M	2035	2280	3120
SW-01	$12.0M*	2040	2210	3040
SW-03	$13.4M*	2040	2340	3200

*Note: Capital Cost does not include land purchase.

Conclusions

- As it currently exists, the MWU system will be able to keep up with the projected increase in demand on the City of Madison's west side until approximately **2030**. Around that time, Unit Well 12 may need to serve as a dedicated PZ 8 facility.

- Projects TW-08 and TW-11 could meet the increasing west side demand until approximately **2035**. Project TW-11 would also require Unit Well 12 to serve as a dedicated PZ 8 facility to achieve this.

- Completing either of projects SW-01 or SW-03 would enable MWU's system to meet anticipated west side water demands through at least **2040**.

- Given the modeling estimate uncertainties (margins of error) for energy usage, there is no significant difference between the facility project alternatives in terms of energy usage or greenhouse gas intensity.

Questions?

Acknowledgements

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  - Chad Katzenberger, PE
  - Heather Schumacher, PE
- City of Madison Office of Sustainability
- WRE Group

Sources:

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- *100% Renewable Madison* https://www.cityofmadison.com/sustainability/energy/renewable-energy
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- *Whitman, Brian E. et al. Computer Applications in Hydraulic Engineering (9th Ed.) Bentley Institute Press, 2021.*
- *Google Earth*

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