

A decorative vertical border on the left side of the slide, composed of a grid of hexagons in various shades of blue and green. Some hexagons contain white icons: a calendar, a magnifying glass, a hard hat, a leaf, a paint can, and a lightbulb.

Calibrating Distribution System Models

From the Field to the Desktop

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Why build a hydraulic model?



- Answer questions by simulating the distribution system on the desktop
 - Existing system analysis
 - Pressure, available fire flow, water quality, O&M impacts, criticality analyses
 - System design
 - New or rehabilitated facilities, expansion or re-configuration of the distribution system, operational changes



Why calibrate a hydraulic model?



- The hydraulic model needs to answer our questions with acceptable accuracy, or it's not very useful!

Available Fire Flow

- Less than 1,000 gpm
- 1,000 to 1,500 gpm
- 1,500 to 2,000 gpm
- Greater than 2,000 gpm

PHD Pressure

- Under 30 psi
- 30 to 40 psi
- 40 to 80 psi
- 80 to 100 psi
- Over 100 psi

Water Age

- 0 - 2 days
- 2 - 4 days
- 4 - 7 days
- 7 - 14 days
- Greater than 14 days



Damaged pump impeller

How do we define acceptable accuracy?



- WA DOH Water System Design Manual offers some guidelines:

Table 6-1: Industry Criteria for Calibrating Hydraulic Models

Accuracy of Readings	Accuracy of Flow Readings	Reference
Hydraulic grade line of model is within 5 to 10 ft. of field data. Water levels within 3 to 6 feet.	N/A	AWWA 2017
± 5% of maximum head loss for 85% of readings ± 7.5% of maximum head loss for 90% of readings	± 5%, where flow > 10 % of the total demand	WRc 1989
Predict the hydraulic grade line to within 5 to 10 ft. at model calibration points during peak demands, such as fire flows	N/A	Walski et al. 2003

Note: 2.31 feet of head is equal to 1 psi.

- EPS calibration guidelines are sparse.

Initial Desktop Development



- What do you already know about the pipes?
 - Use material type (and sometimes, age) to determine actual diameters
 - **Example:** 8-inch diameter pipe, actual ID
 - Ductile Iron, Class 50 w/ cement mortar lining = 8.4"
 - C900 PVC, DR 18 (235 psi) = 8.0"
 - HDPE DIPS DR 11 (200 psi) = 7.3"
 - Impact on head loss calculations:

$$h_L = 0.002083 \times L \times \left(\frac{100}{C} \right)^{1.85} \times \left(\frac{Q^{1.85}}{d^{4.8655}} \right)$$


h_L = head loss, ft
 L = length of straight pipe, feet
 C = "friction factor", unitless
 Q = flowrate, gpm
 d = diameter, in

Initial Desktop Development



- Use material and age to initialize roughness coefficient/friction factor
 - Impact can be significant depending on the pipe material

Pipe Material	H-W C
AC	140
Cement-lined DI	120
New unlined CI	130
40-year-old CI	64-83
PVC	150

$$h_L = 0.002083 \times L \times \left(\frac{100}{C} \right)^{1.85} \times \left(\frac{Q^{1.85}}{d^{4.8655}} \right)$$




16-inch diameter c. 1926 cast iron (2018)

Initial Desktop Development



- Use as-built drawings or field inspection to accurately model facilities as needed
 - Pump stations
 - Reservoirs
 - Control valves (PRVs, relief valves, etc.)



Initial Desktop Development



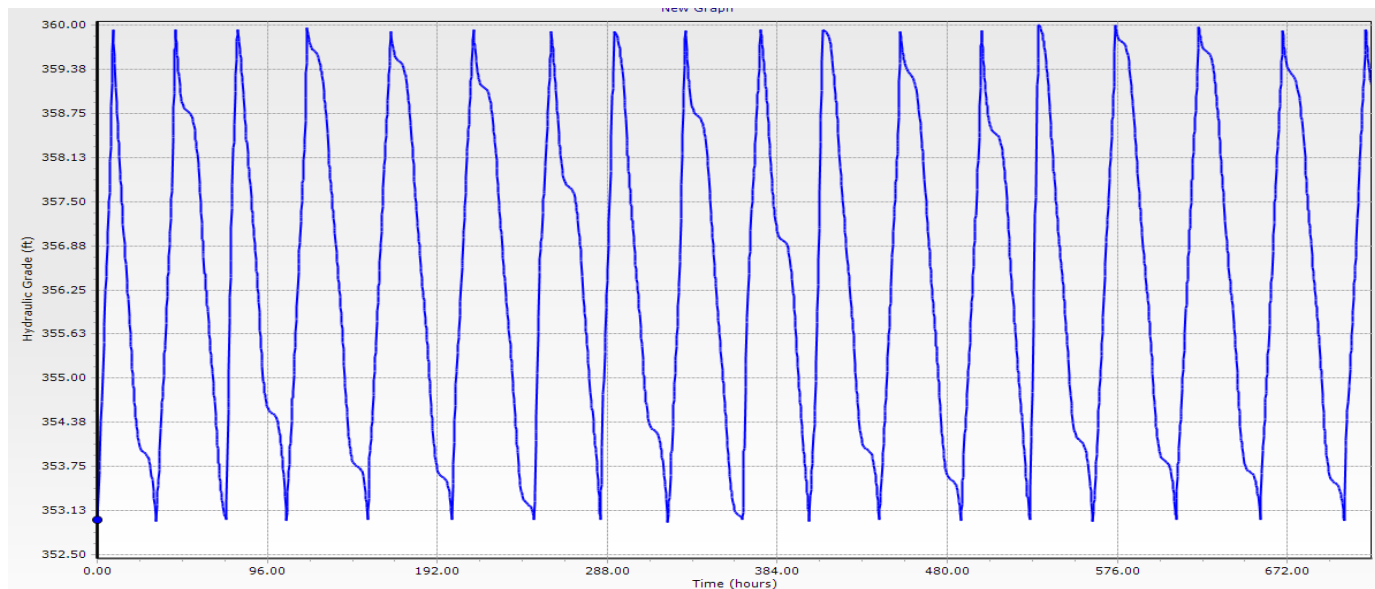
- Obtain the best elevation data available
 - Often LIDAR bare earth DEM is available – usually better than contour data
 - 2.31 ft = 1 psi, consider the +/- 2 psi goal we stated earlier
 - Is 2 psi accuracy reasonable if you're using 10-ft contours?
- Skeletonization and sub-models
 - Generally avoid skeletonization, CPU cycles are cheap
 - If not modeling the whole system, carefully consider assumptions about boundary conditions



Using SCADA Data



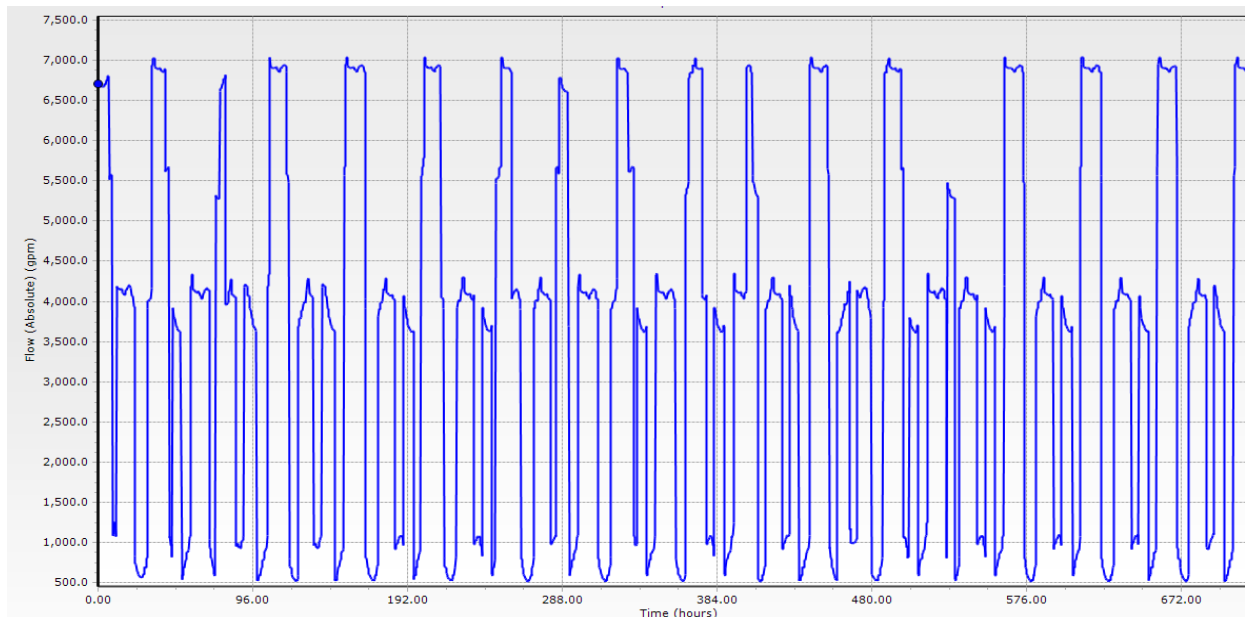
- Determine system demand trends
 - Demand scenarios depend on modeling goals
- Verify facility setpoints
 - Reservoirs, pump stations, control valves
- Collect real-time data for field testing



Using AMI Data



- As advanced metering infrastructure (AMI) data is implemented, better calibration is possible
- Better determination of actual demand trends
 - Pressure zone or sub-pressure zone level
 - Can be critical information for closed-zone BPS design!



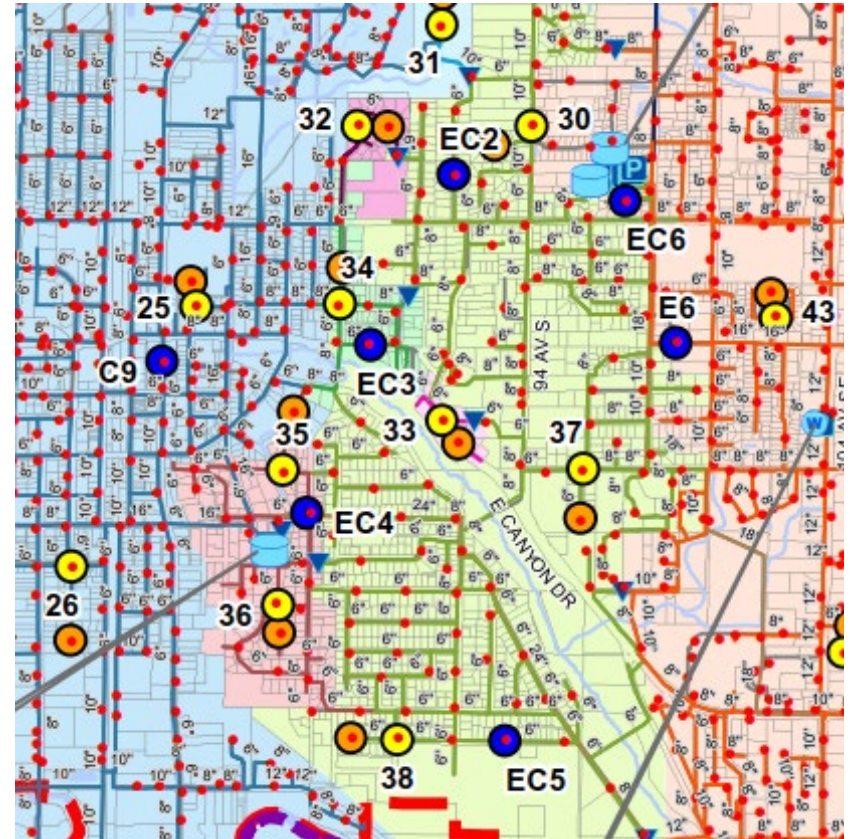
Field Testing

- Pressure transducers
- Hydrant flow testing



Field Testing

- Develop field data collection plan
 - Deploy pressure transducers strategically in the distribution system
 - Conduct hydrant tests – measure “static” pressure and hydrant flowrate/residual pressure



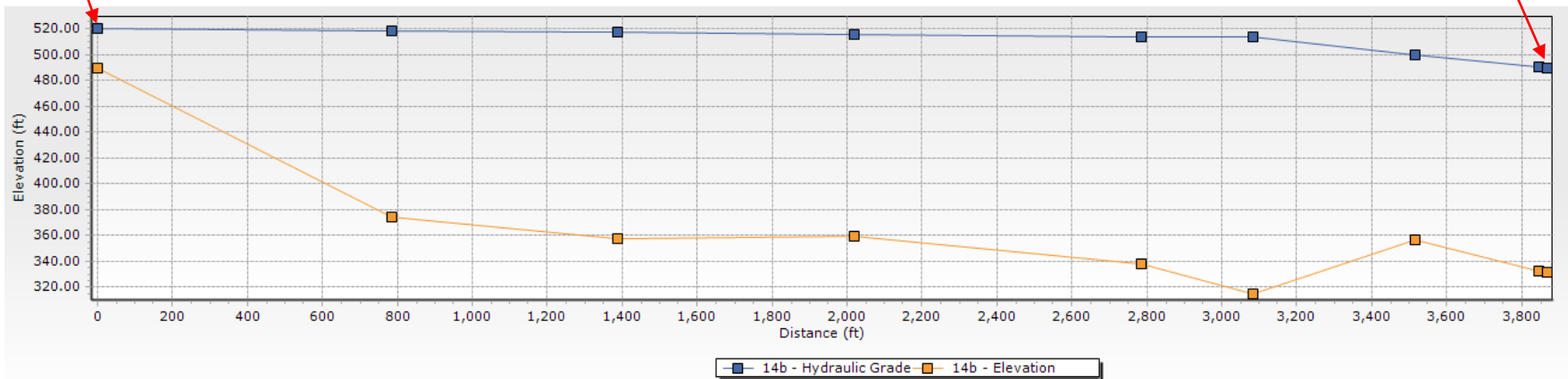
Field Testing



- Use pressure transducer data to track the HGL in the distribution system
 - Check for accuracy in facility setpoints
 - Check real-world head loss in the distribution system against the initial model
 - Adjust roughness coefficients accordingly

Reservoir

Residual hydrant



Troubleshooting



- Model isn't calibrating by conventional means
- Head loss observed in the field is higher than expected
 - Closed or partially-closed valve?
 - Diameters are incorrect (smaller in the field)
 - Network topology is incorrect (modeled looping that doesn't exist)
- Head loss observed in the field is lower than expected
 - Diameters are incorrect (larger in the field)
 - Network topology is incorrect (system has more looping than is modeled)

Troubleshooting - EPS



- Model behavior doesn't match real-world data
 - System supply and demand is incorrect
 - Customer demands mischaracterized or incorrectly allocated
 - Facility supply rates are incorrect
 - Have pump curves been added? Are source and supply facilities accurately modeled to capture the head losses that would move the duty point?



Questions?