WATER NETWORK ANALYSIS/DESIGN PRINCIPLES AND TECHNOLOGIES

BY

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OBJECTIVE

Optimize Design to Control Cost, Reduce O&M and Minimize Loss in Water Resources

OUTLINE

- DISTRIBUTION NETWORK COMPONENTS
- HYDRAULIC CONCEPTS
- HYDRAULIC ANALYSIS
- DESIGN METHODOLOGY
- NETWORK MANAGEMENT

DISTRIBUTION NETWORK COMPONENTS

<ins>Treatment / Pumping</ins>

<ins>Storage</ins>

<ins>Distribution</ins>

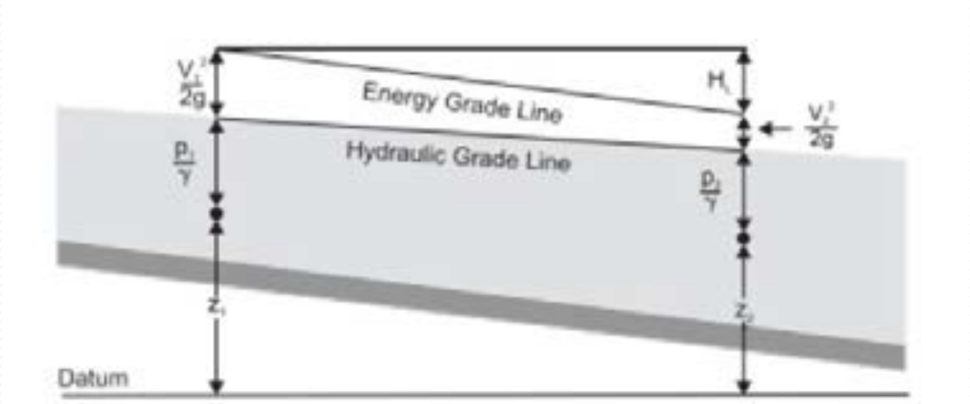
- Piping
- Valves
- Hydrants

<ins>Source</ins>

- Surface Water
- Groundwater

HYDRAULIC CONCEPTS

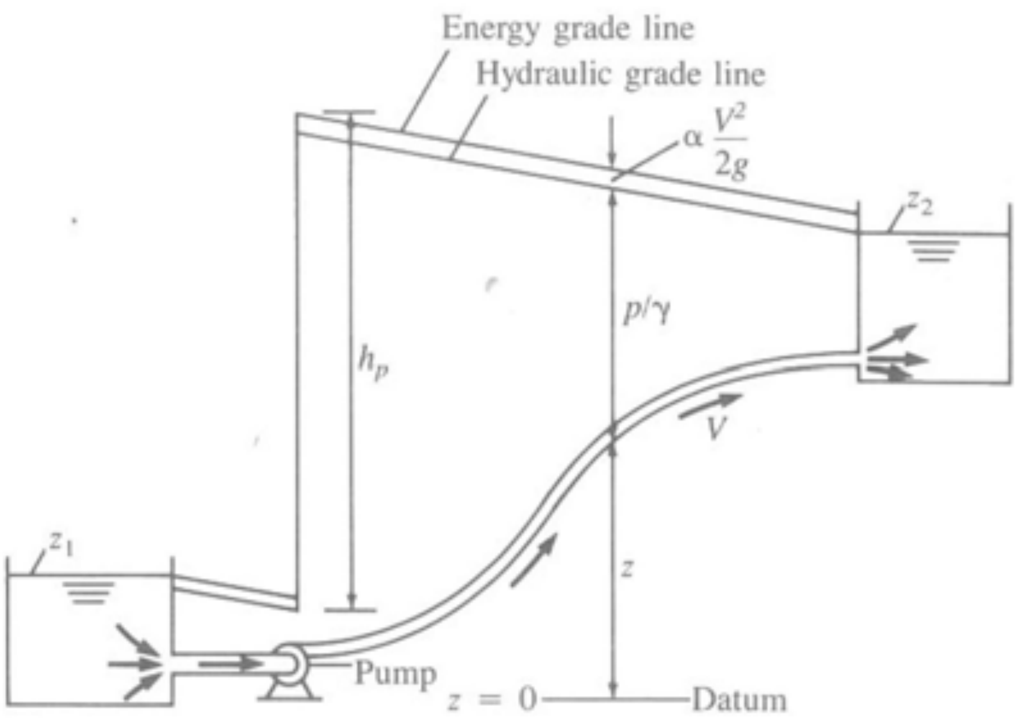
- Energy Equation
  - Elevation Head (Z)
  - Pressure Head (p/γ)
  - Velocity Head ($V^2/2g$)
  - Head Loss or Energy Loss (h_L)



$$\frac{p_1}{\gamma} + \alpha_1 \frac{V_1^{\,2}}{2g} + z_1 + h_p = \frac{p_2}{\gamma} + \alpha_2 \frac{V_2^{\,2}}{2g} + z_2 + h_t + h_L$$

HYDRAULIC CONCEPTS

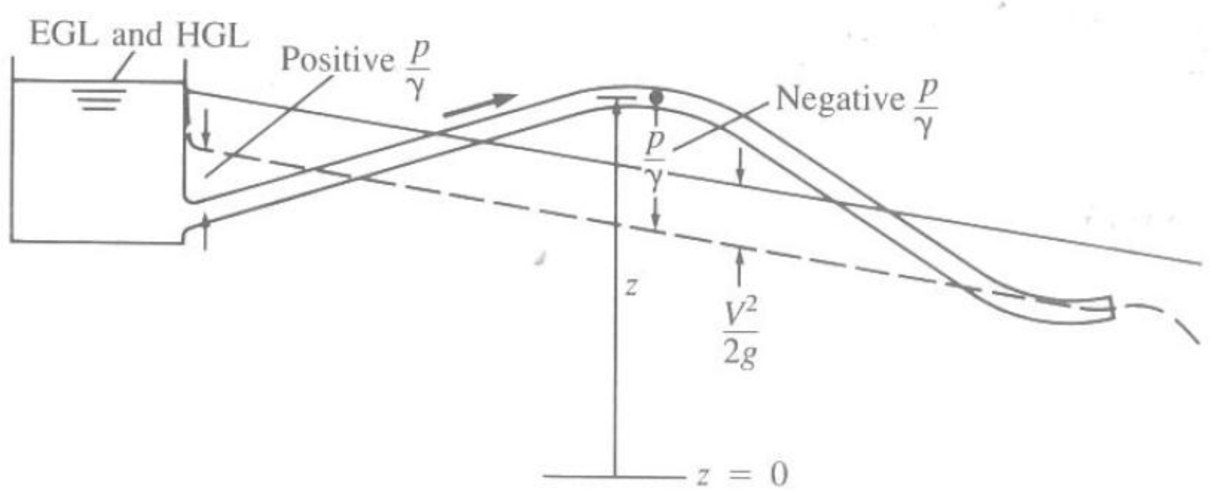
Pumped Flow System



$$\frac{p_1}{\gamma} + \alpha_1 \frac{V_1^2}{2g} + z_1 + h_p = \frac{p_2}{\gamma} + \alpha_2 \frac{V_2^2}{2g} + z_2 + h_t + h_L$$

HYDRAULIC CONCEPTS

Gravity Flow System



$$\frac{p_1}{\gamma} + \alpha_1 \frac{V_1^{\,2}}{2g} + z_1 + h_p = \frac{p_2}{\gamma} + \alpha_2 \frac{V_2^{\,2}}{2g} + z_2 + h_t + h_L$$

ANALYSIS

Applicable Standards

- AWWA- M31 & M32
- 10 State Standard
- Saudi Aramco Standards

Identify Type of Users

- Residential
- Industrial
- Commercial
- Recreational

20 Year Population Projection

ANALYSIS

ESTIMATE FLOW

- 100 Gallons per Capita per Day (Typ. Res.)
- Average Day
- Maximum Day
  - 1.5 x Avg. day (Typ.)
- Maximum Hour
  - 1.5 X Max. Day (Typ.)
- Design Flow
  - Max. Day + Fire Flow Or Max. Hour Flow
- Minimum Pressure
  - Average Flow Conditions- 35 psi-50 psi
  - Peak Flow Conditions - 20 psi

ANALYSIS

AVAILABLE SOFTWARE

- Hydraulic Modelling (Water CAD, Water GEMS)
- Multi Platform
- Geo Spatial
- Asset Management

ANALYSIS

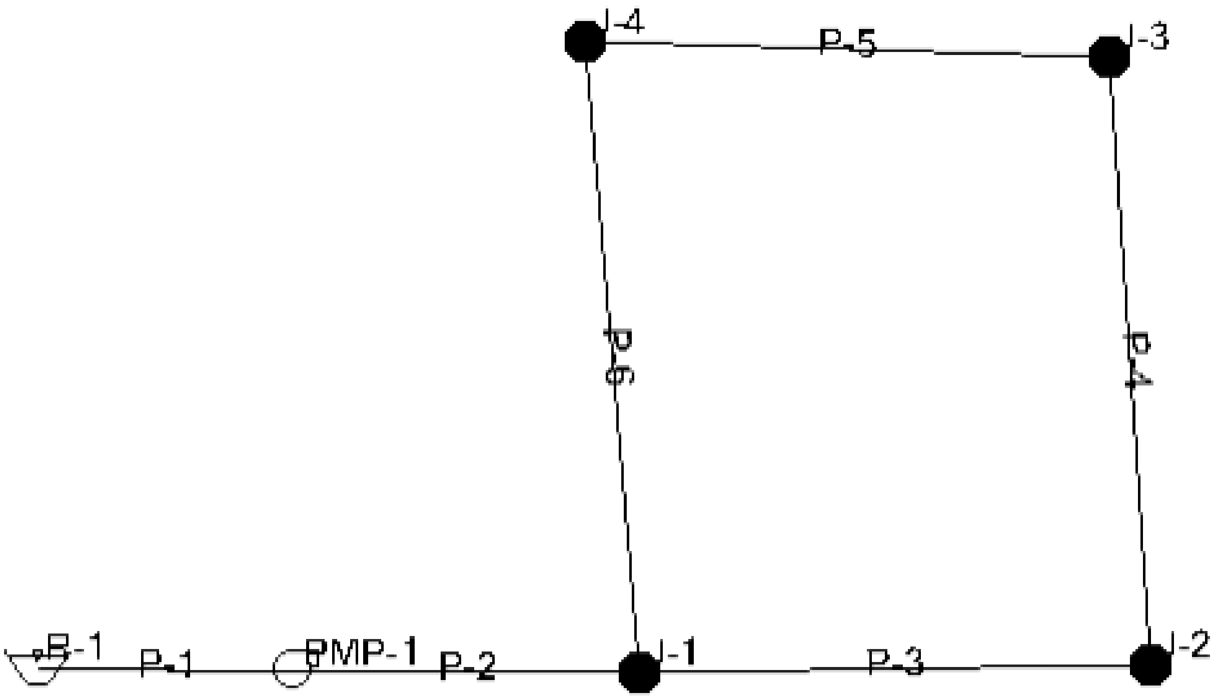
- HYDRAULIC MODELLING
  - Step-1: Identify Network Components
  - Step-2: Build Network Skeleton
    - Draw from Scratch OR Import CAD/GIS Model from Utility Database
    - Assign Pipe Sizes, Node Elevations
    - Pipe Properties (Roughness, C- Value)
    - Assign Flow Demand

ANALYSIS

- Step-3: Define Source
  - Reservoir-Constant Level/Head
  - Tanks –Varying Operating Levels
  - Pumps- Pump Characteristic Curve
    - Single Design Point
    - 3-Point Curve
    - VFD

ANALYSIS

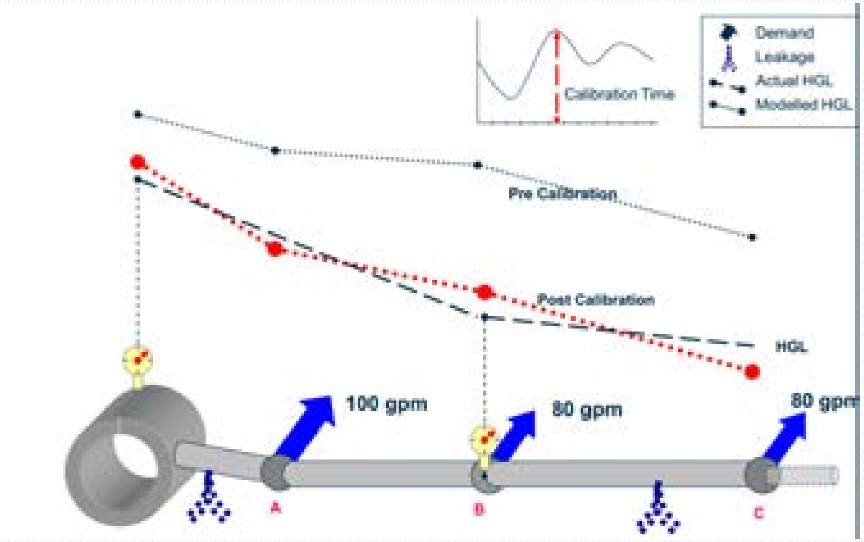
EXAMPLE NETWORK



ANALYSIS

- Step-4: Steady State Simulation
  - Hydraulic Analysis at Peak Conditions
  - Simple Solution for Small Network

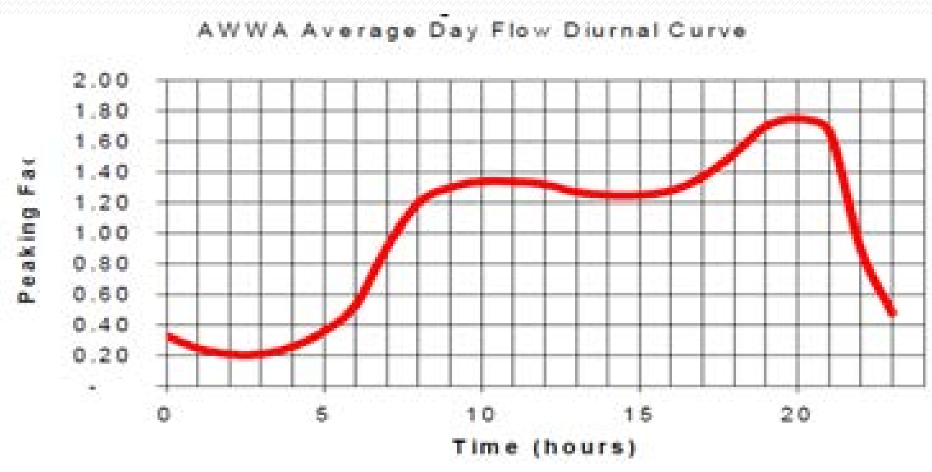
- Step-5: Calibration
  - Flow Meters
  - Pressure Sensors

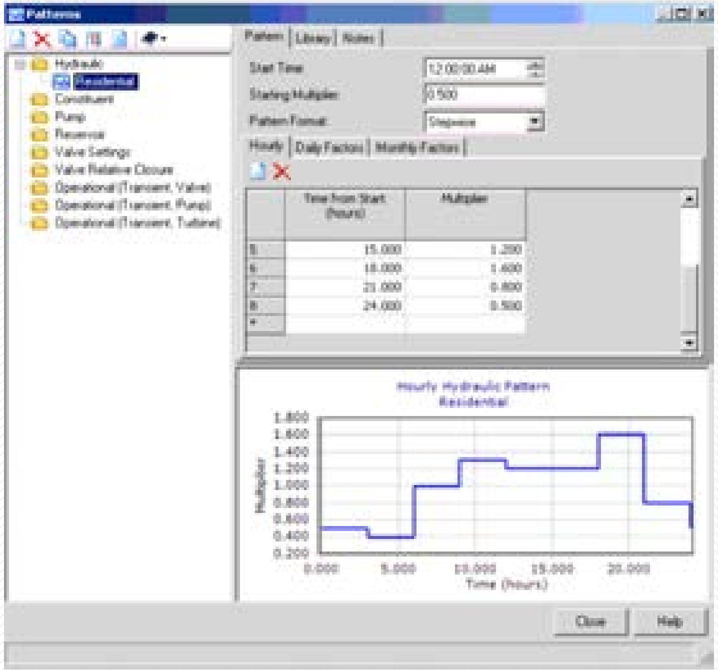


Ref: Bentley

ANALYSIS

- Step-6: Extended Period Simulation
  - Diurnal Pattern Simulation
  - Optimum Design





ANALYSIS

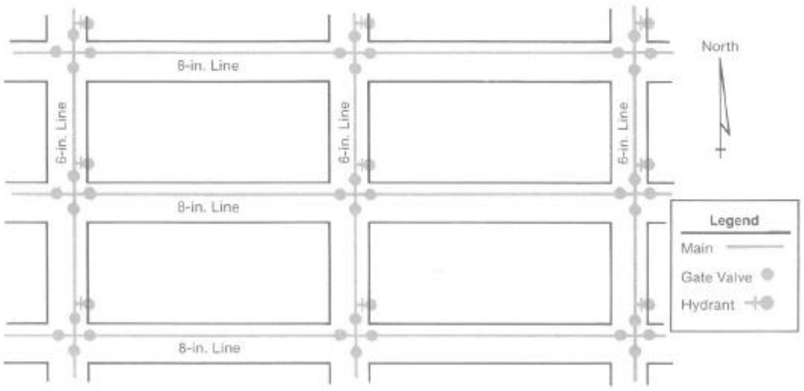
- Surge Consideration
  - Pipes > 12”
  - Flow > 1000 gpm
  - Valve Closure Time
  - Pump Failure

$$\Delta P = 0.70 * Vel * \frac{Length}{Time}$$

- Solution
  - Soft Start or VFD
  - MOV
  - Hydro-Pneumatic Tanks

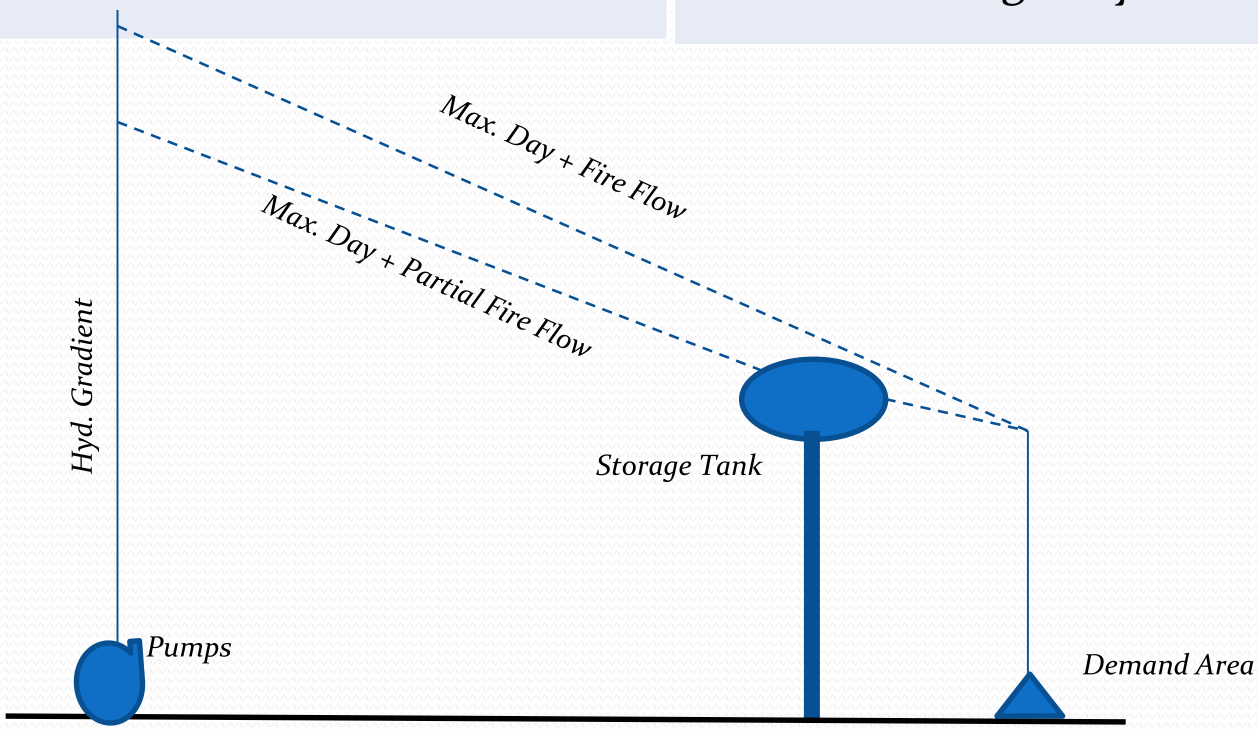
DESIGN METHODOLOGY

- Looped System
  - Reliable
  - Eliminate Dead Ends
  - Reduce Water Age
  - Valves at Intersection
  - Min. 6" Main for Hydrants



DESIGN METHODOLOGY

Direct Pumping	In Direct Pumping
Direct to Distribution System	Uniform Pumping
Speed Controls to Match Demand	Demand Managed by Tank Level



DESIGN METHODOLOGY

RELIABILITY

- Standby Pumps
- Emergency Power
- Emergency Fuel for Generator

NETWORK MANAGEMENT

GOAL: Minimize Water Losses/Revenue

- Real Time Monitoring (SCADA)
- Maintain Supply During Peak Condition
- Regulate Flow/Pressure
- Leak Detection
- Routine Maintenance Programs
- Continuous Database Update (GIS)

QUESTIONS?

WATER DISTRIBUTION NETWORK DESIGN

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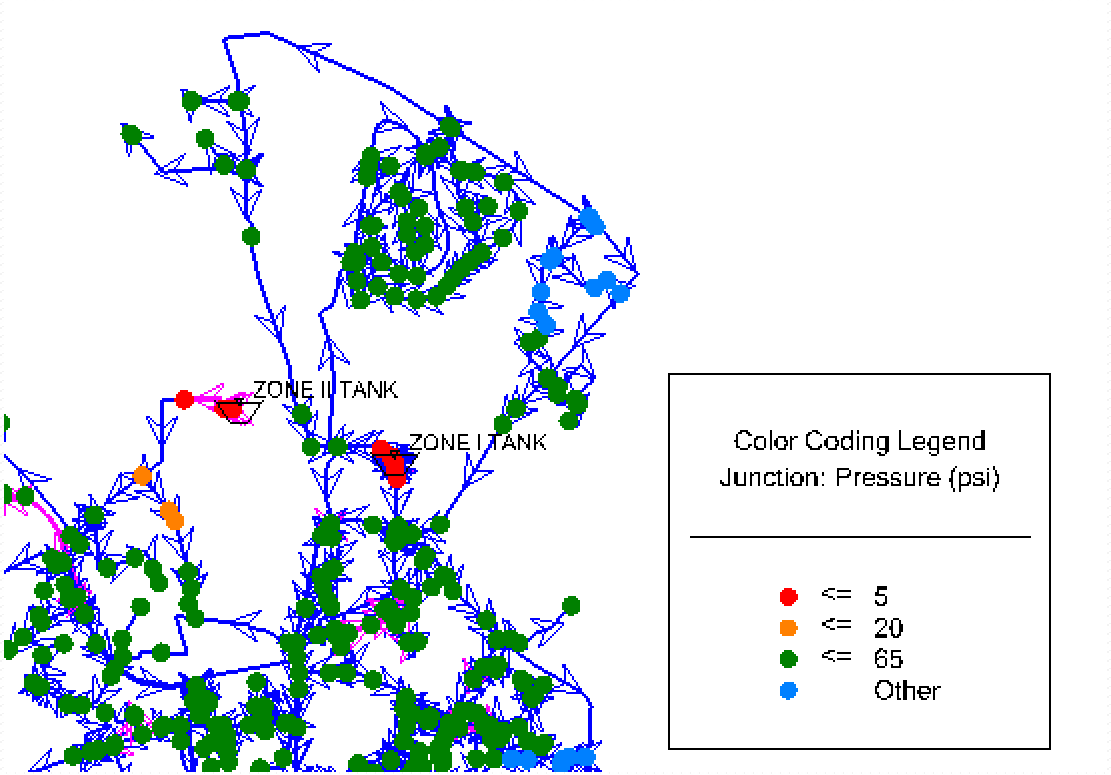
EXAMPLE

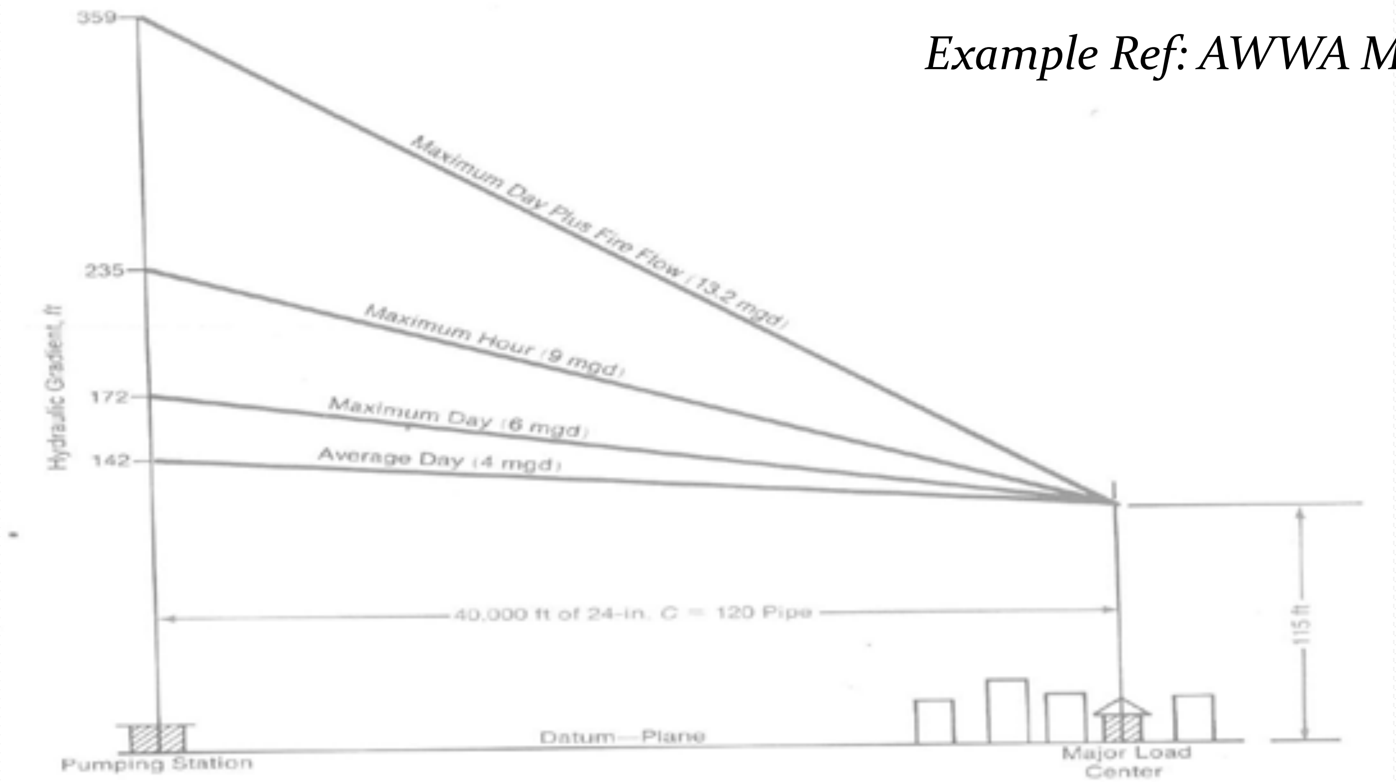

ZONE II TANK
ZONE I TANK
Color Coding Legend
Junction: Pressure (psi)
<= 5
<= 20
<= 65
Other

DESIGN METHODOLOGY

<u>DIRECT PUMPING SYSTEM</u>

- Pumps Directly to Distribution System
- Needs Variable Speed Pumping

Example Ref: AWWA M32



DESIGN METHODOLOGY

<u>INDIRECT PUMPING SYSTEM</u>

- Uniform Pumping Rate
- Demand Managed By Tank Level