

# Pumping stations and water transport

Reliability of drinking water systems  
ct5550

# Water in the Netherlands



foto: ANP

Water quality: from the natural source to the user's tap

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# Water in the Netherlands



foto: ANP

Water quality. From the natural source to the user's tap

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# Definitions of reliability

- The chance that a customer receives the service he/she demands

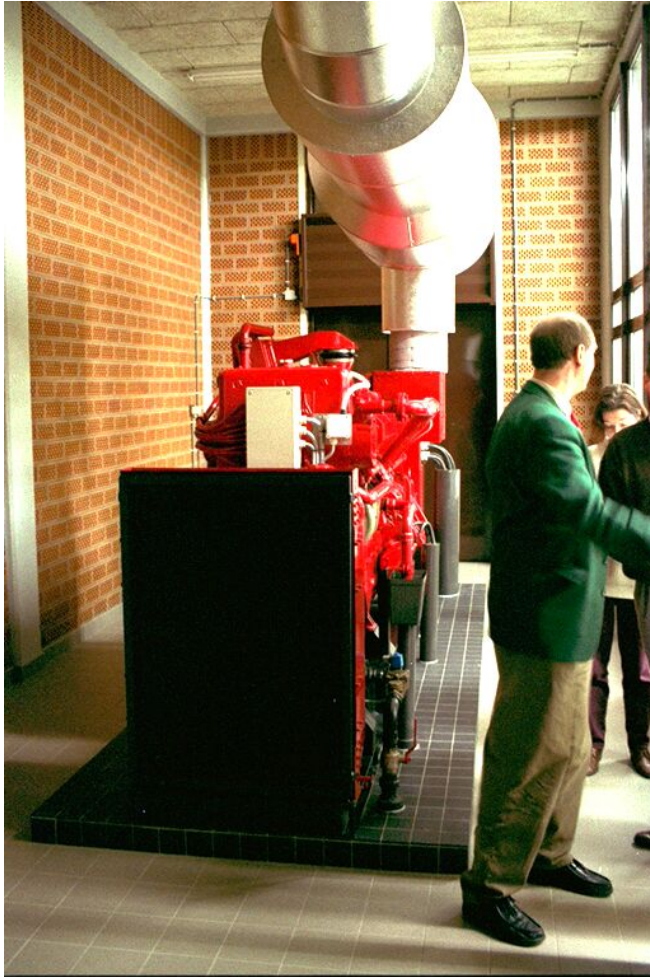
$$\text{Reliability} = \left[ 1 - \frac{\text{Chance} * \text{Duration} * \text{Effect}}{\text{Original demand}} \right]$$

- Data on chance and effects are rare in the drinking water industry
- How to design for reliability

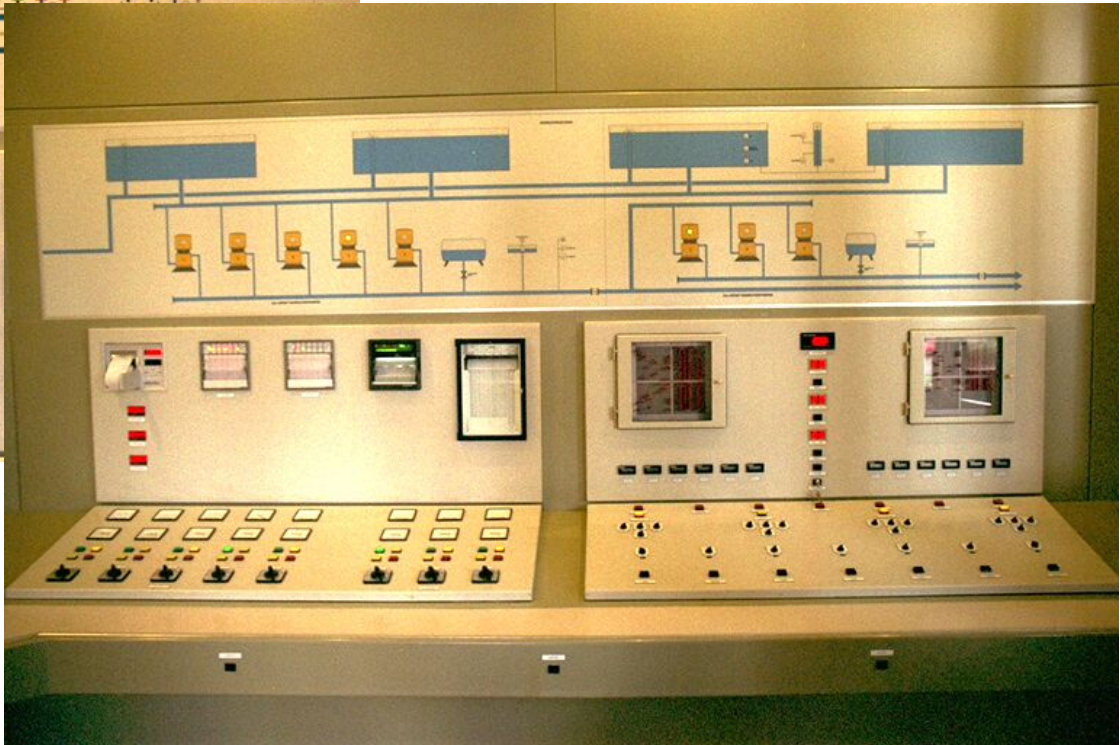
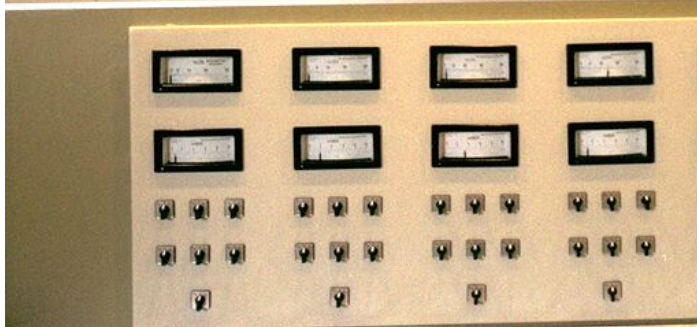
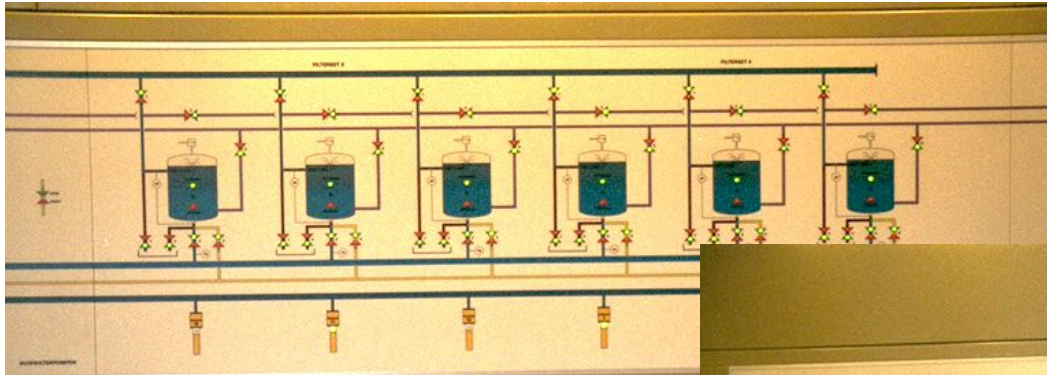
# Applied (historic) rules for reliability

- Redundancy in vital components:
  - Back up facilities
    - Extra pumps, (emergency) power
  - Segmented capacity:
    - Treatment plants in several 'streets'
    - Several pumps in parallel
- Looped pipe-line infrastructure

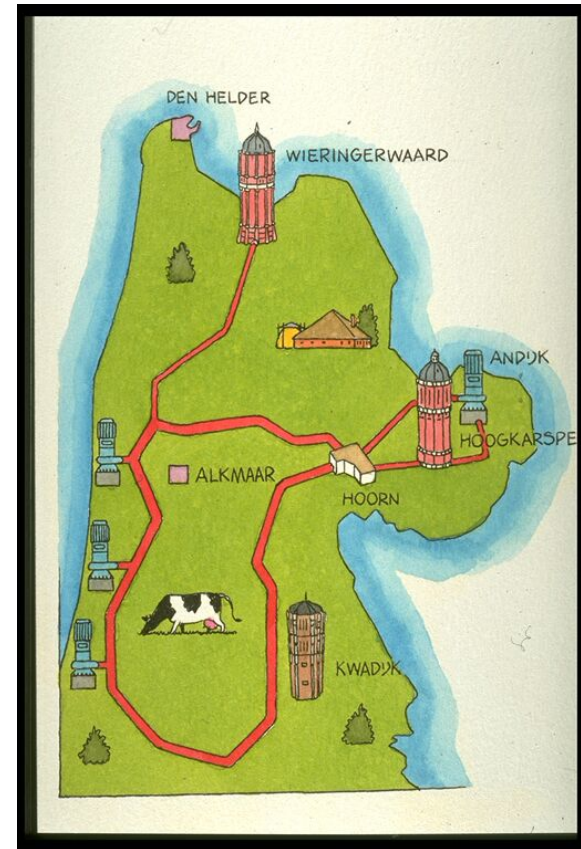
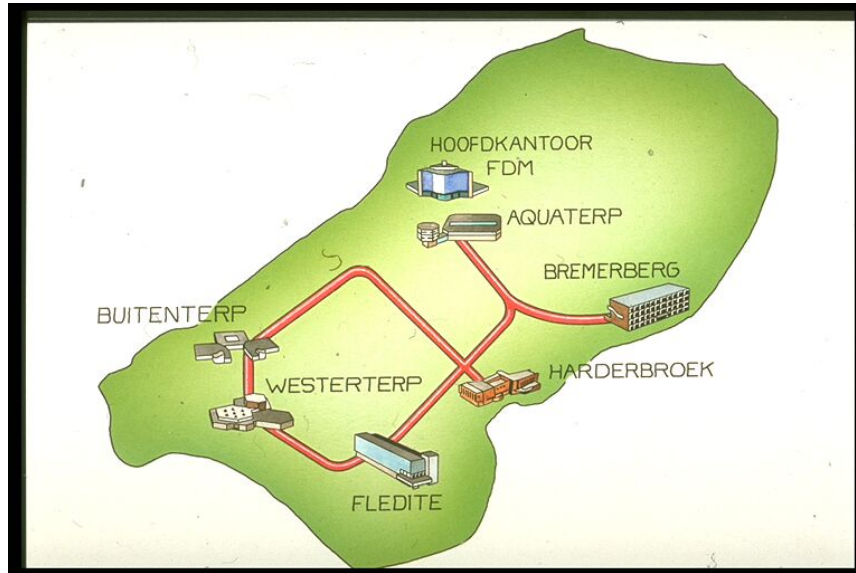
# Back up facilities



# 'Streets' in treatment and pumps



# Looped pipe infrastructure





# Quantitative guideline for reliability drinking water supply

- Basic assumptions for assessing reliability drinking water supply
  - Every element can and will fail
  - Effects of failures should be limited
- Design/evaluation rule on limiting the effect of failure of one element: 'Quantitative guide line for reliability'

# Quantitative guide line for reliability

- Definition in Dutch Drinking Water Act
- ' In case of failure of one element of the drinking water supply system the remaining supply capacity in centres of demand should be at least 75% of the maximum daily demand.'
- Guide line meant for testing and checking ('reactive guide line')

# Quantitative guide line for reliability [1]

- ' In case of failure of *one element* of the drinking water supply system the remaining supply capacity in centres of demand should be at least 75% of the maximum daily demand.'
  - Only one element that can be isolated from the system e.g. a pipe segment between valves or element of the treatment plant, etc.
  - Failure of more elements is not considered in a standard

# Quantitative guide line for reliability [2]

- ' In case of failure of one element of the *drinking water supply system* the remaining supply capacity in centres of demand should be at least 75% of the maximum daily demand.'
  - The total system is considered, including capture, treatment, pumping, transport and distribution

# Quantitative guide line for reliability

## [3]

- ' In case of failure of one element of the drinking water supply system the remaining supply capacity in *centres of demand* should be at least 75% of the maximum daily demand.'
  - Centre of demand is 2000 connections equal to 5000 inhabitants

# Quantitative guide line for reliability

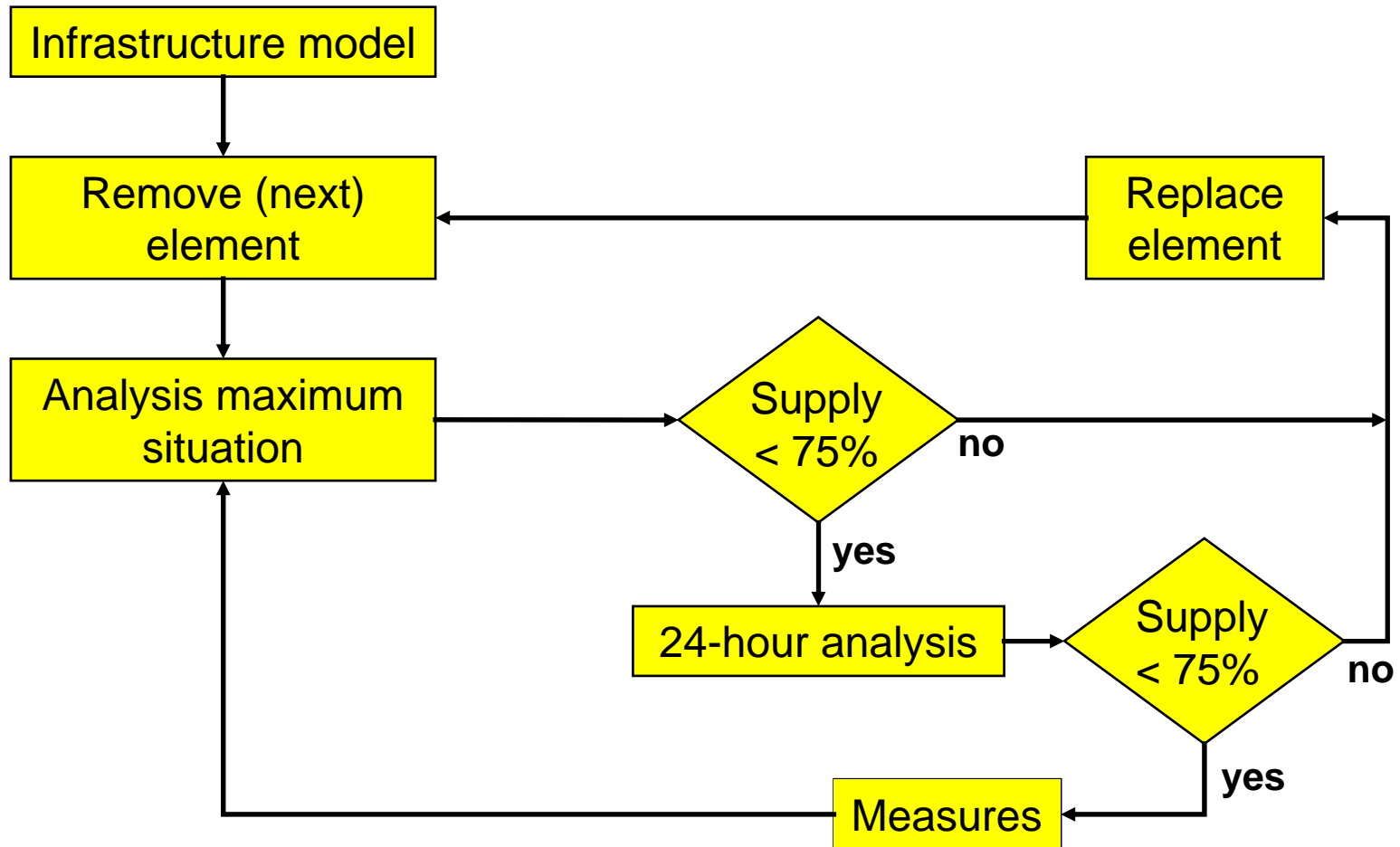
## [4]

- ' In case of failure of one element of the drinking water supply system the remaining supply capacity in centres of demand should be at least **75% of the maximum daily demand.**
  - In every centre of demand on 24 hour base at least 75% of a maximum day demand should be delivered
  - Only elements that will be in failure for more than 24 hours are considered

# Characteristics of the guide line

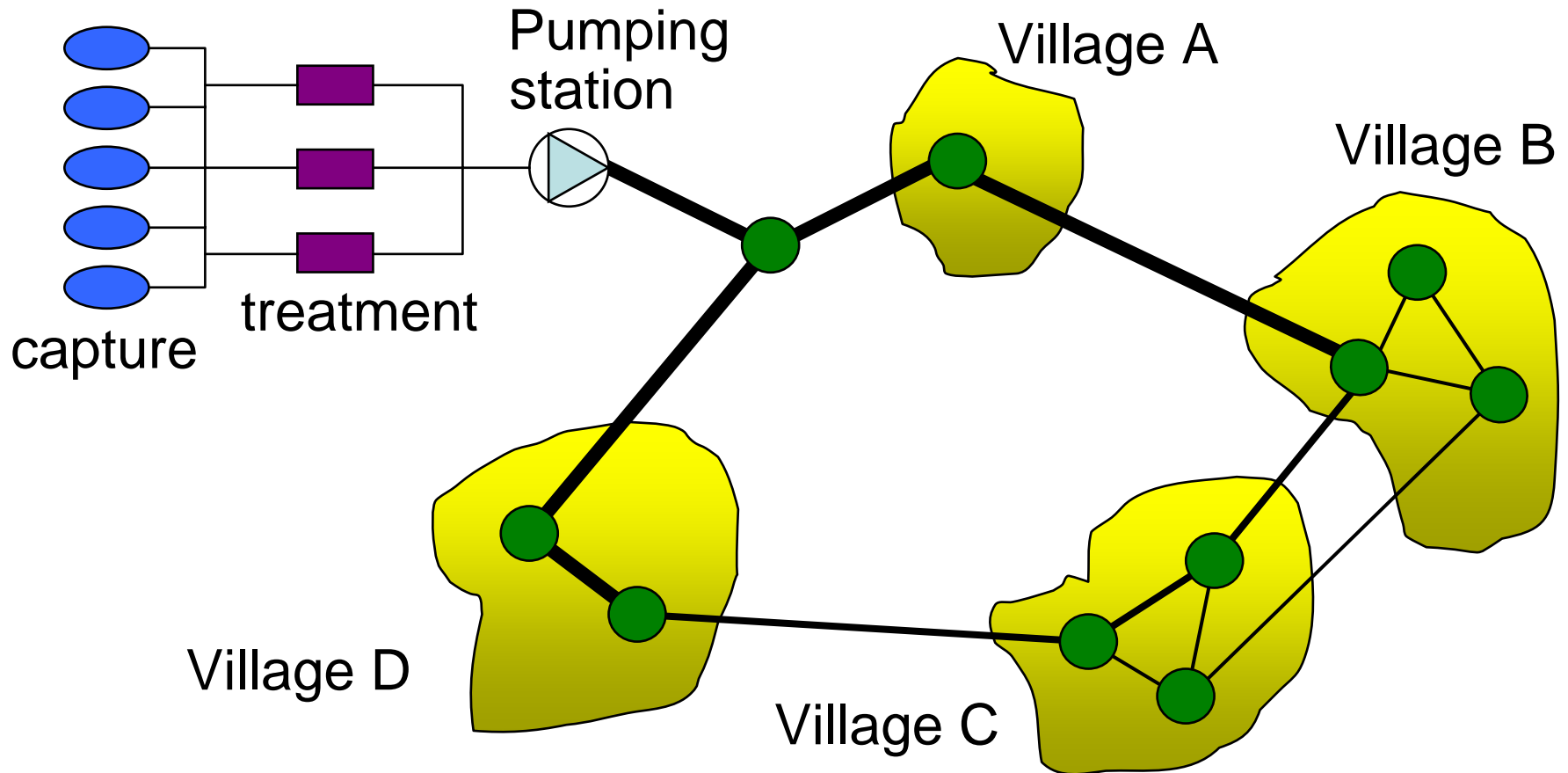
- Optimisation tool: designed or real systems are checked and weak points are identified
- Simulation tool is necessary

# Reliability analysis

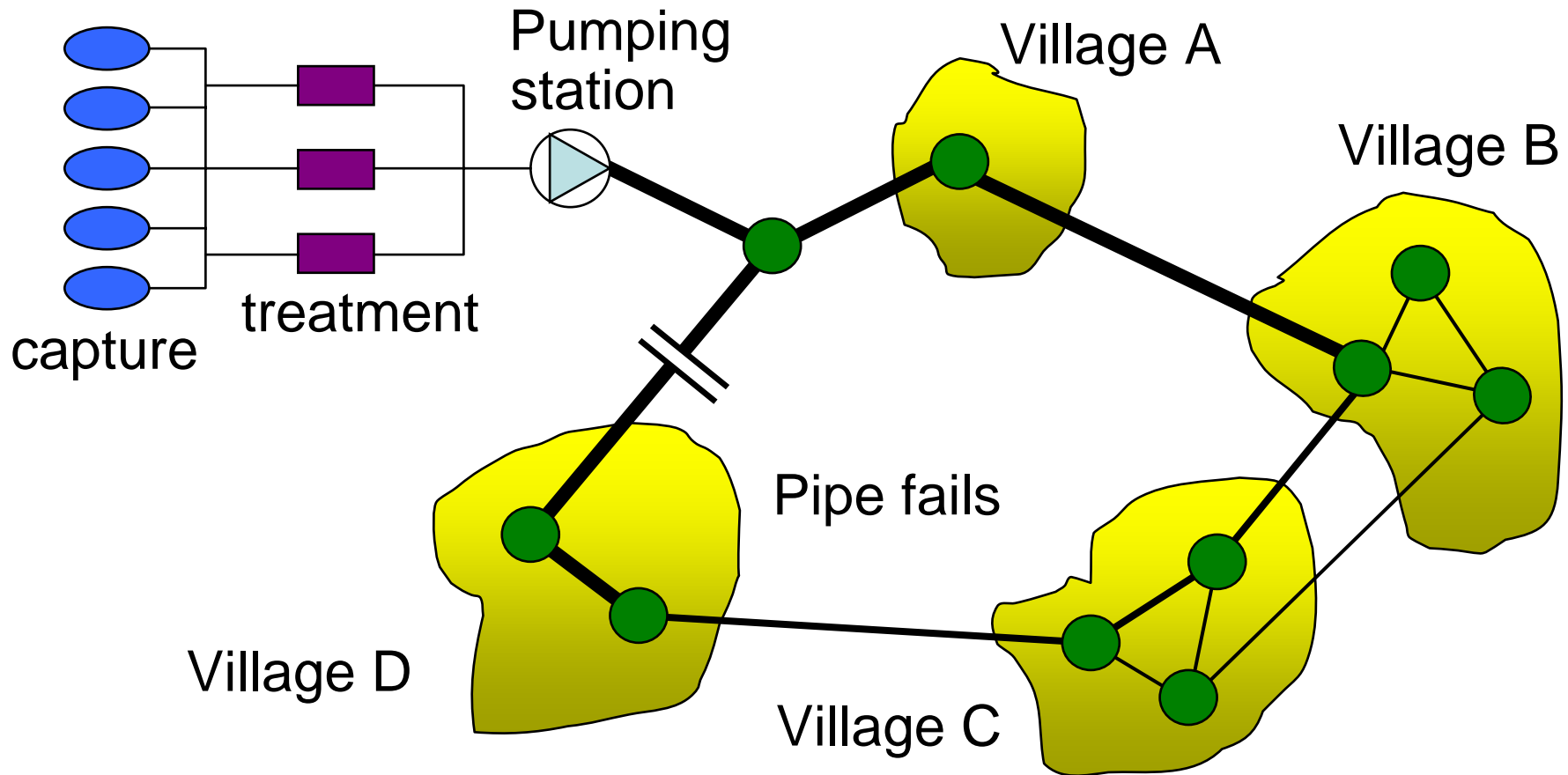




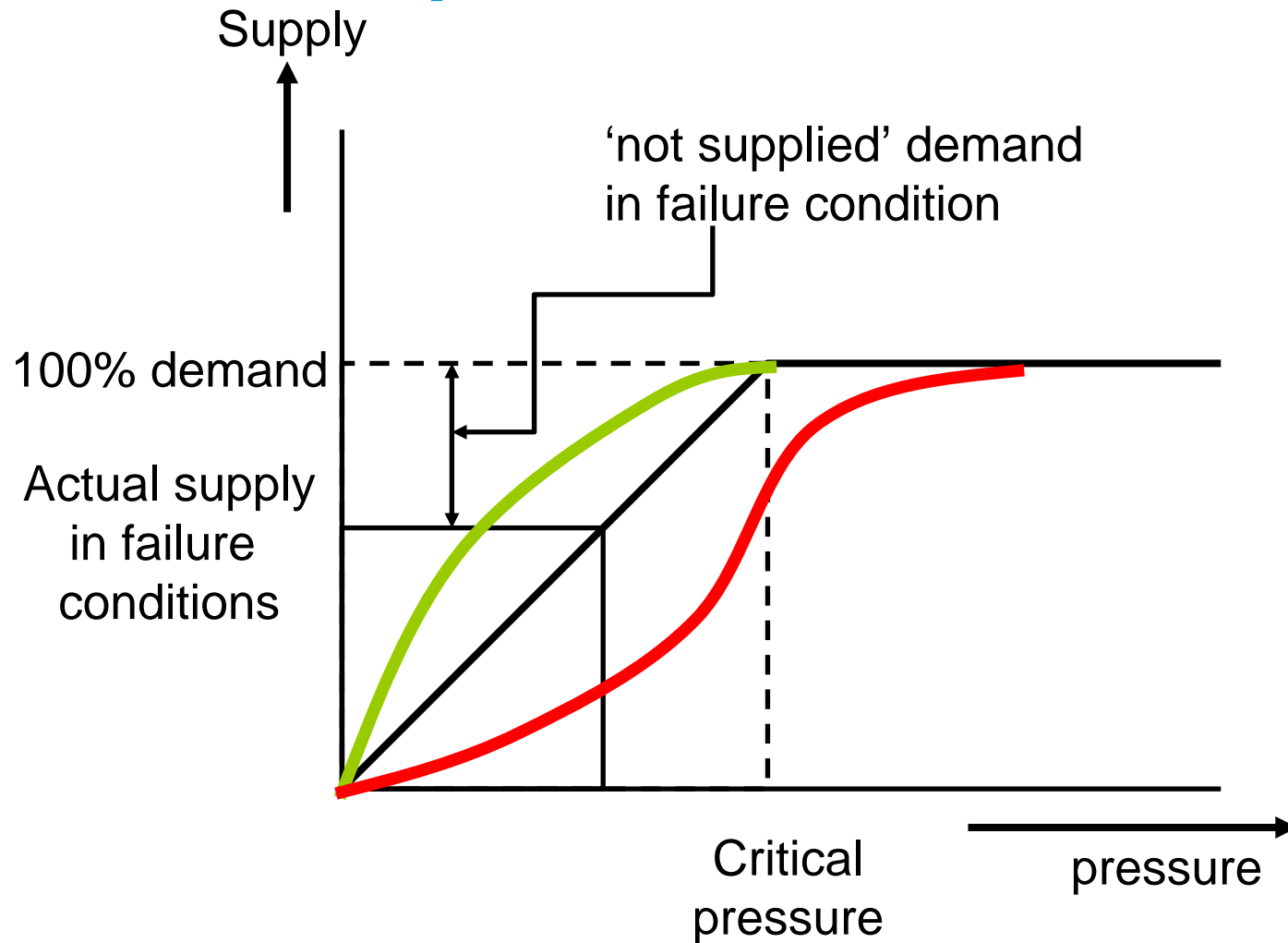
# Schematic of a drinking water system



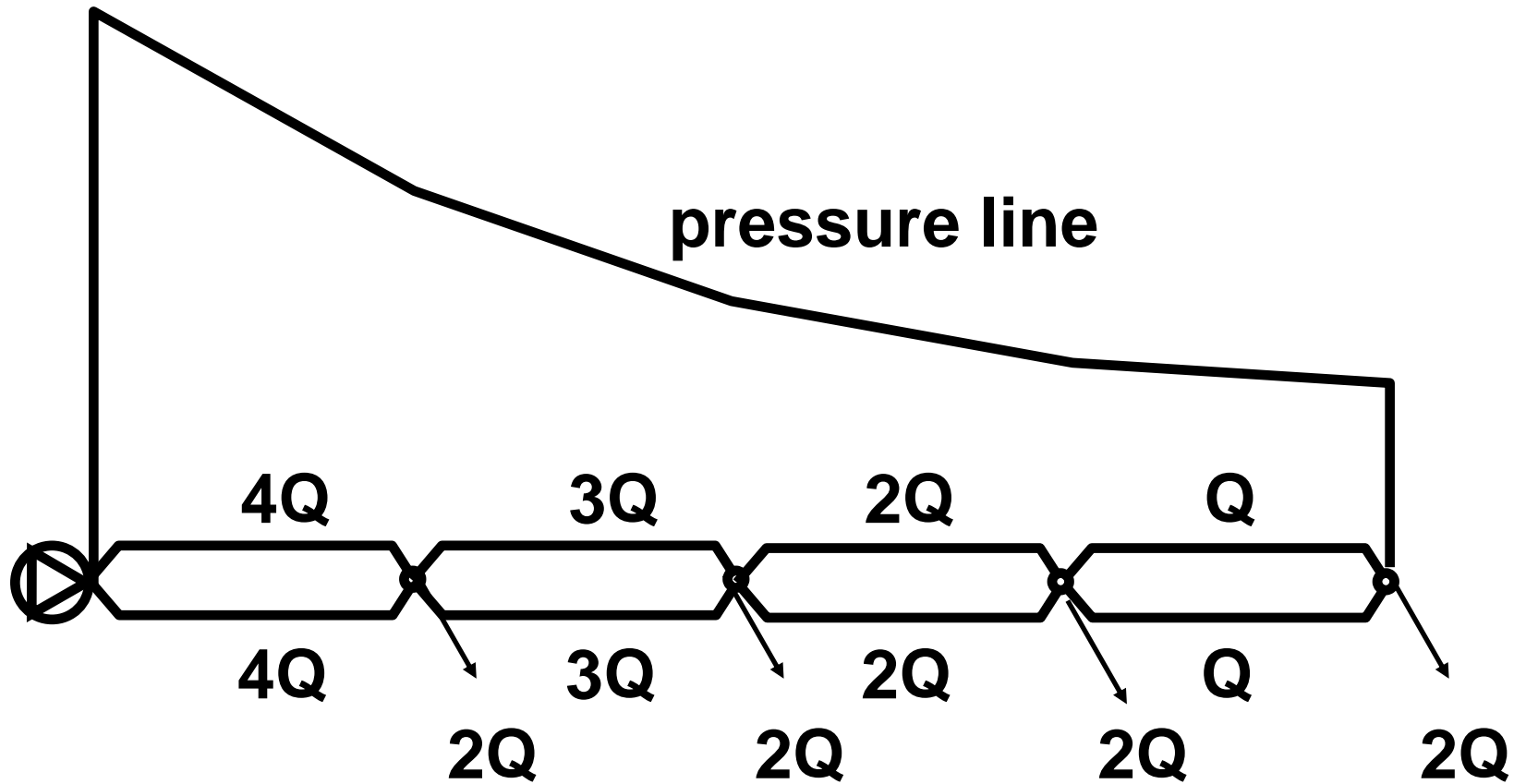
# Analysis effect of failure of one element



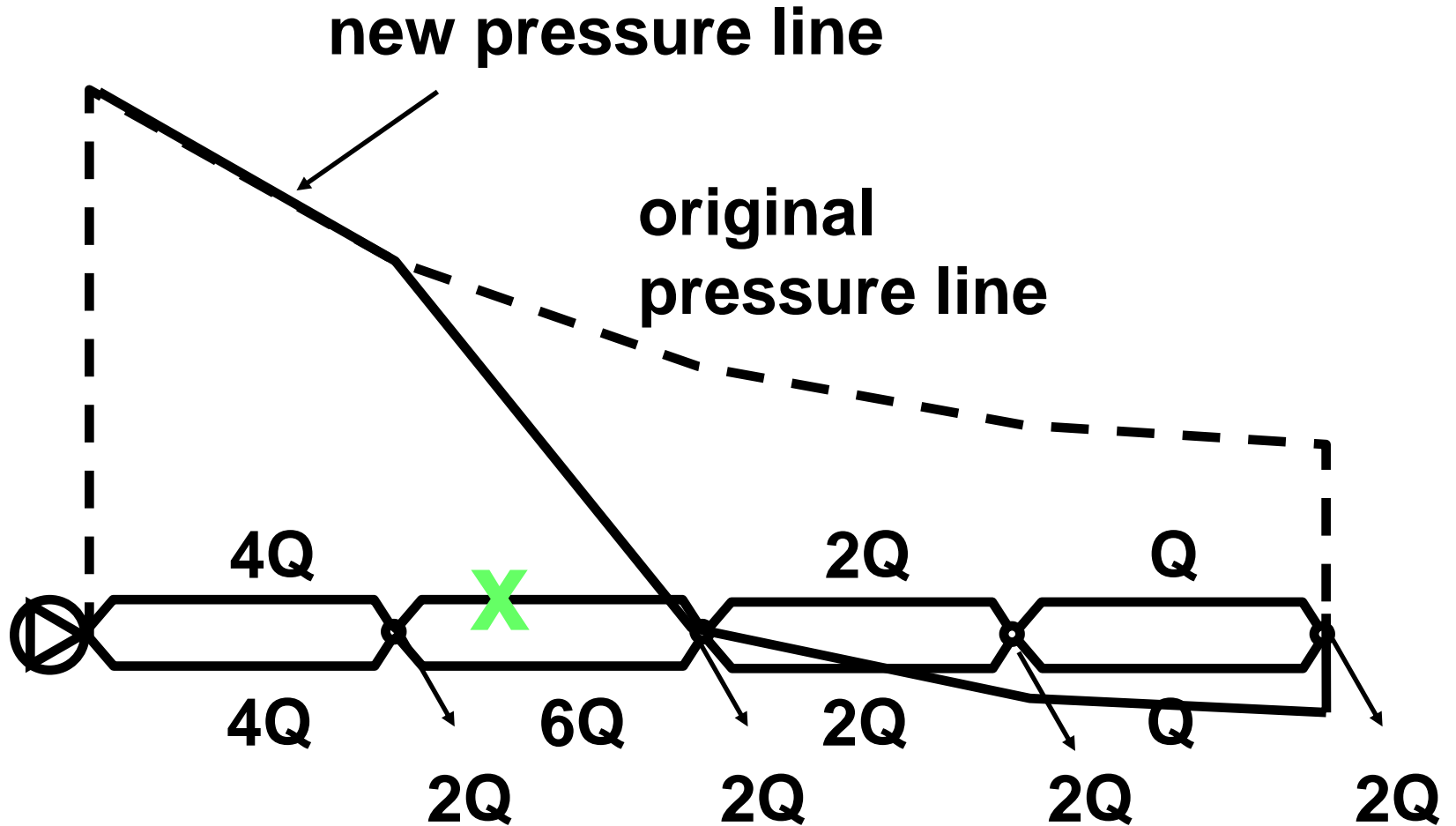
# Pressure dependant demand



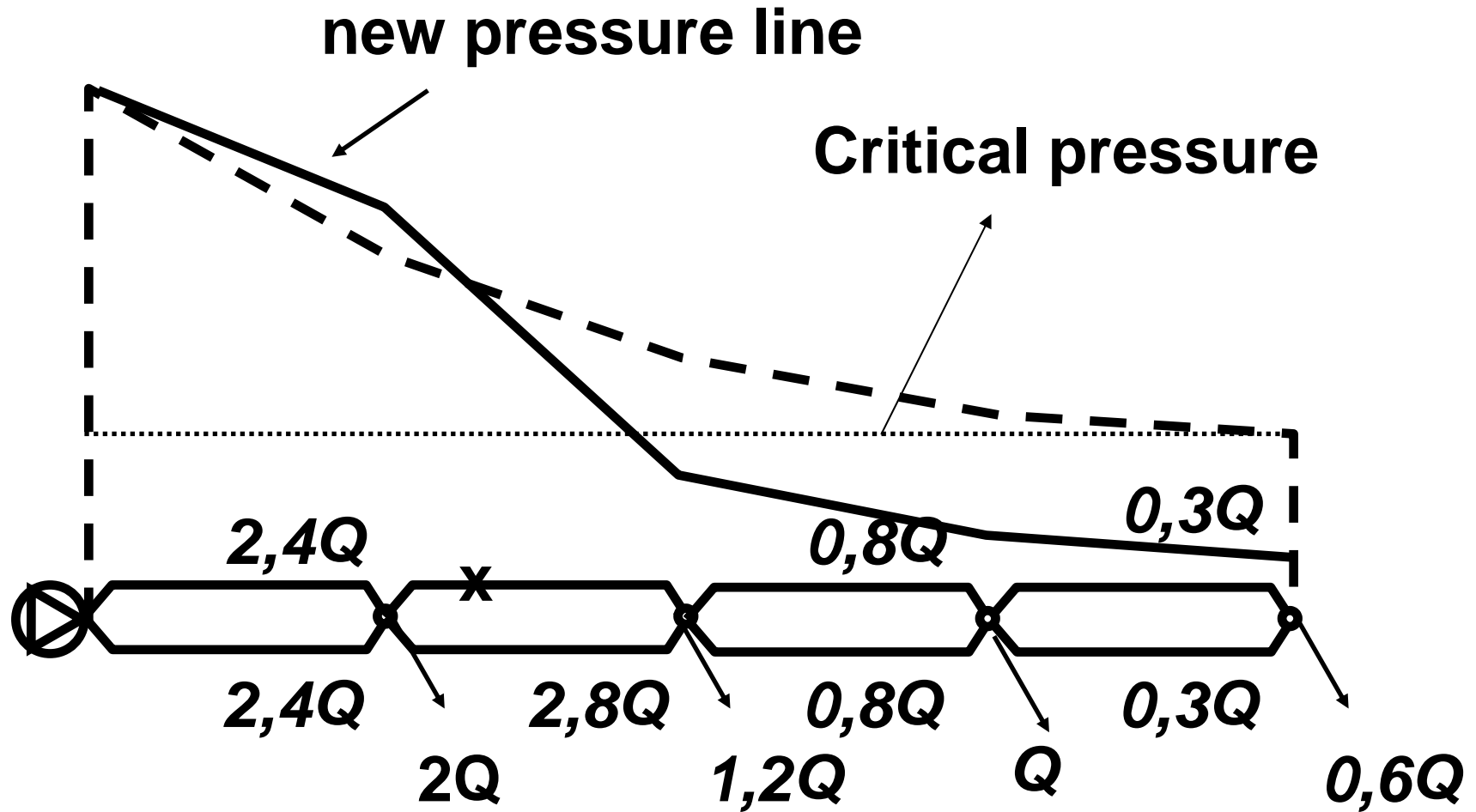
# Normal pressure situation

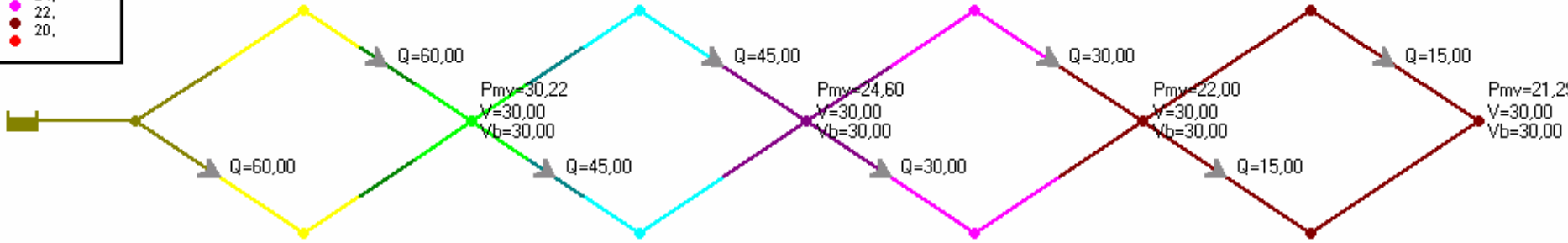
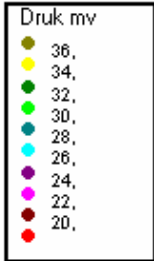


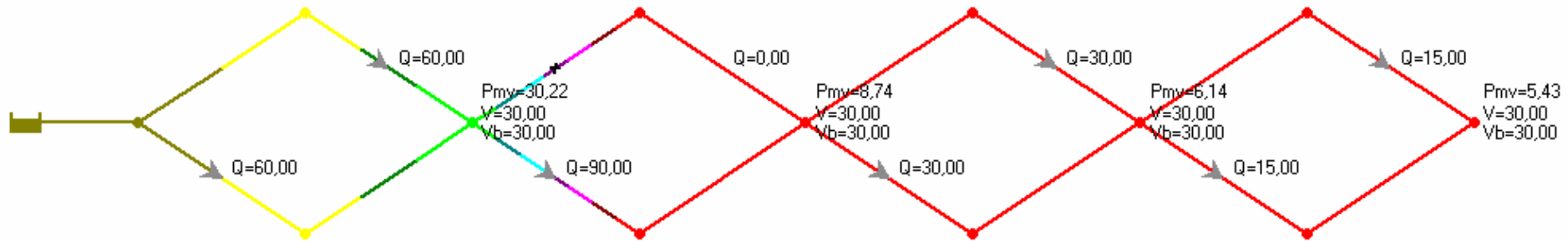
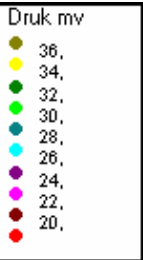
# Extreme pressure situation



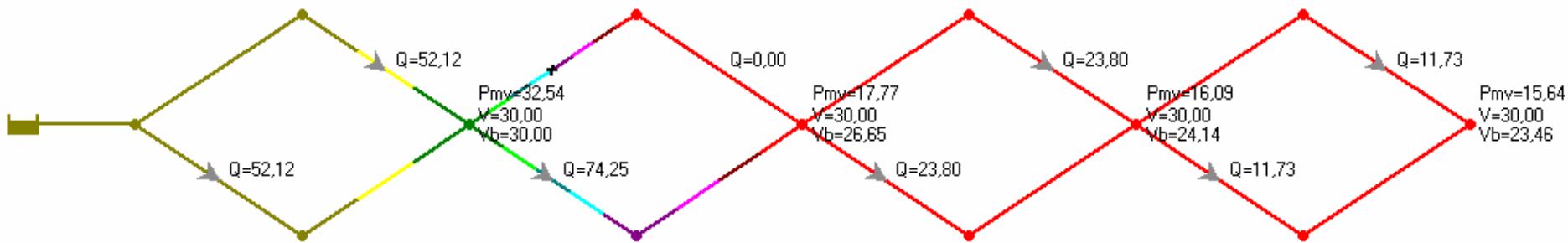
# Pressure dependant situation



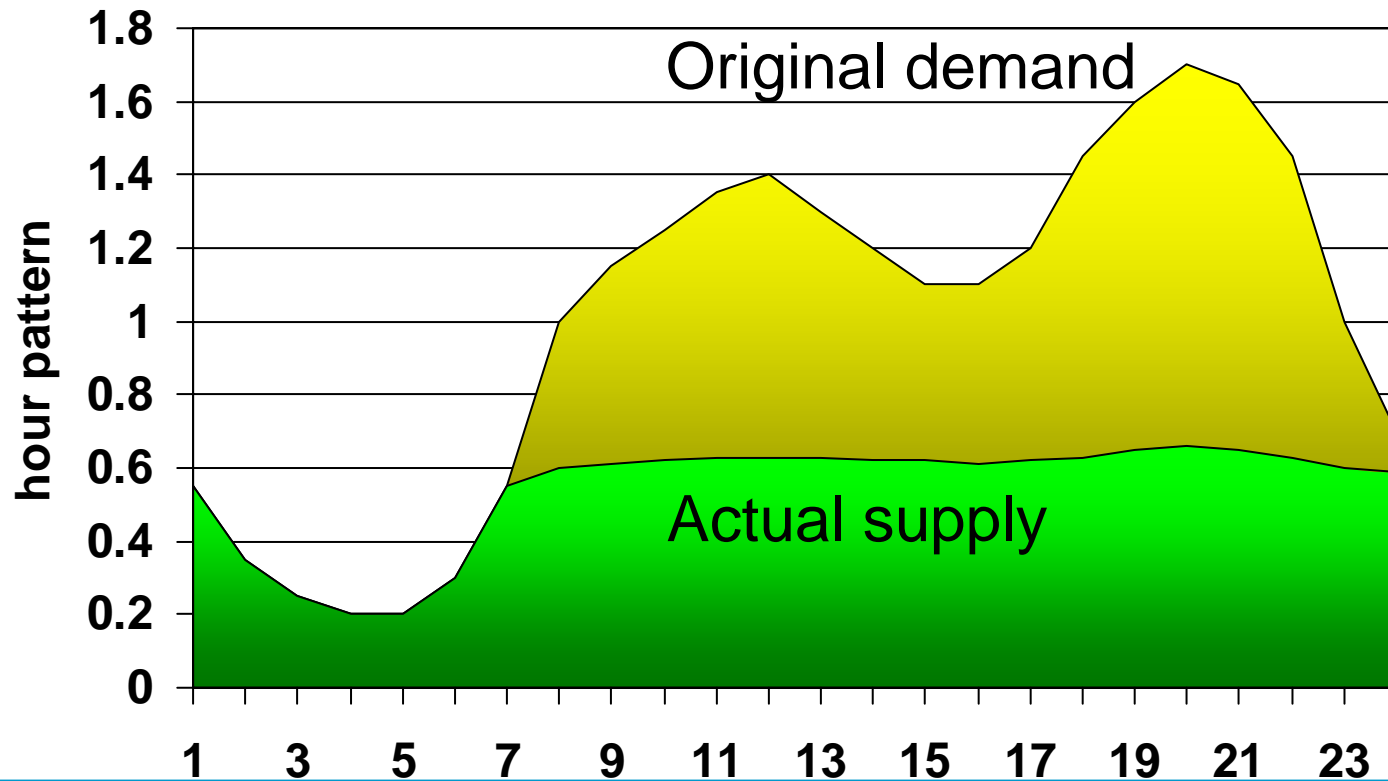




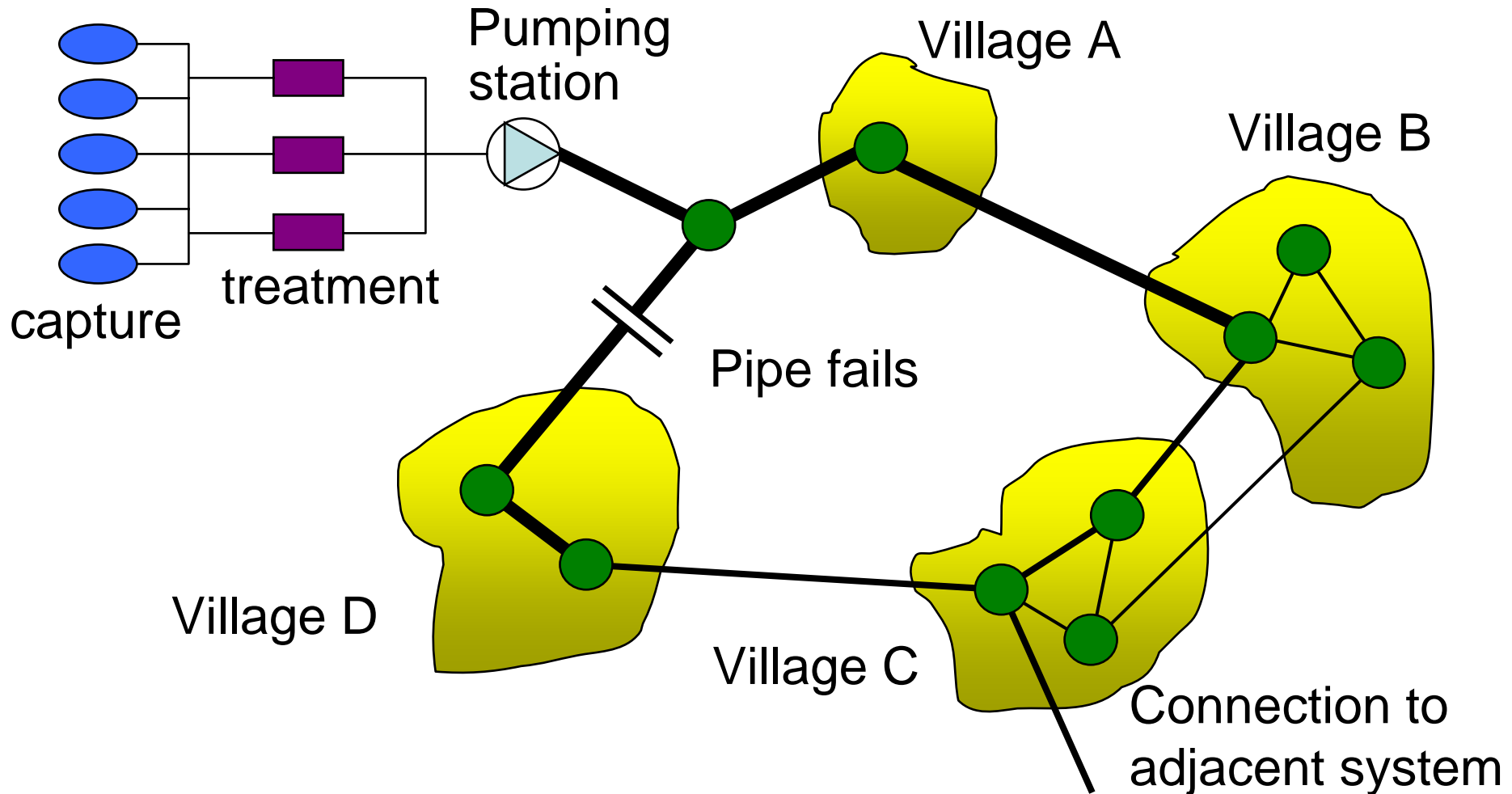




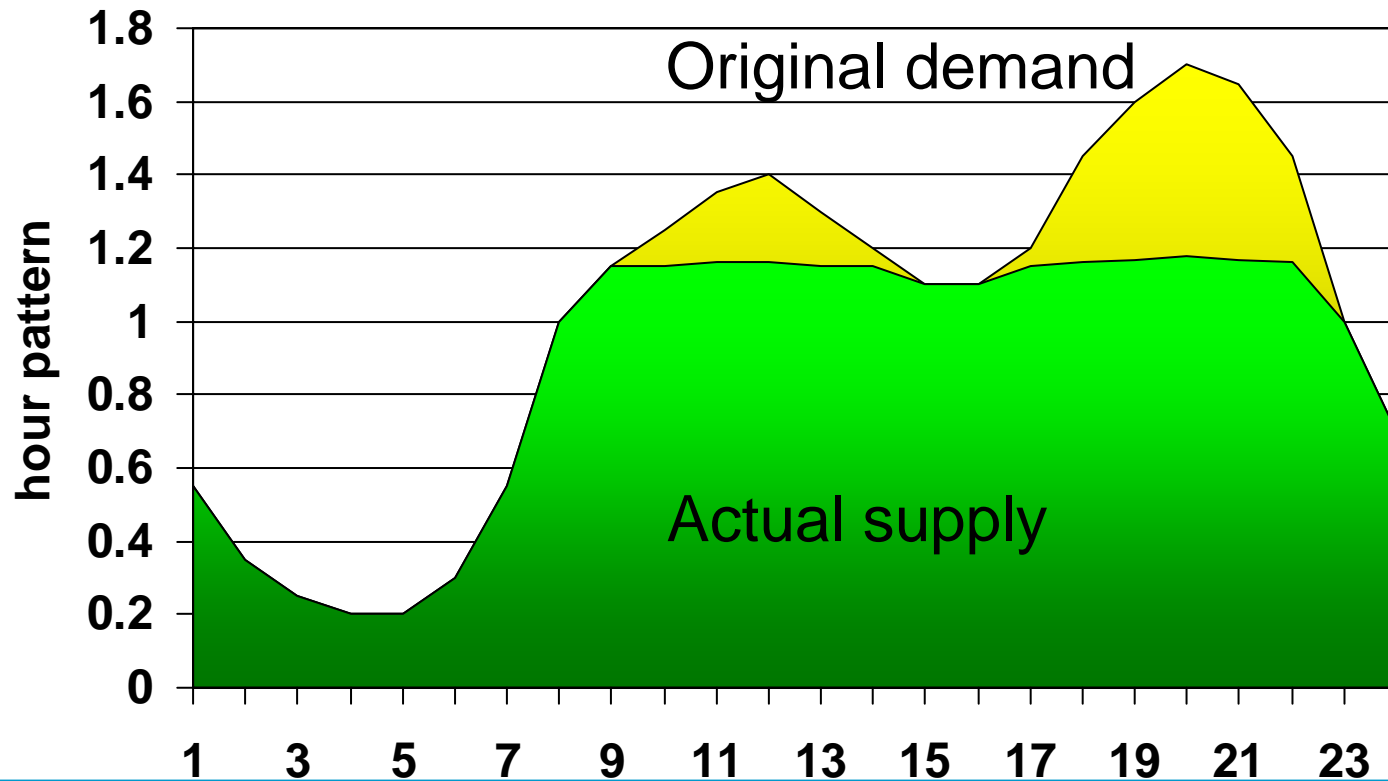
# Demand and supply in village D



# Countermeasure enhancing reliability



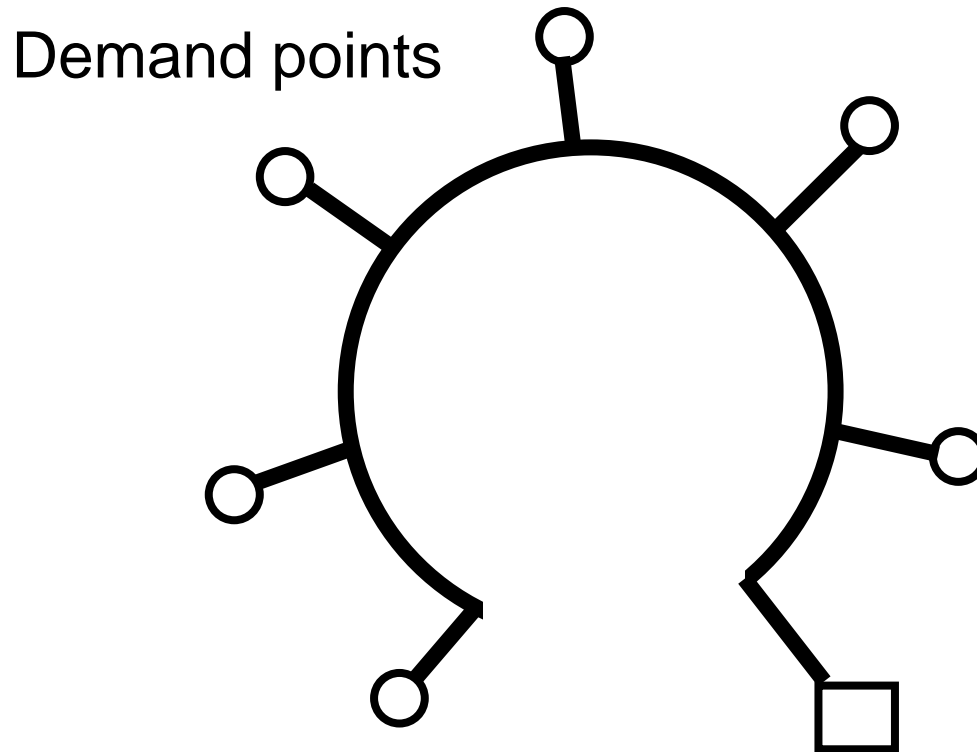
# Demand and supply in village D after measure



# General pro-active guide lines

- Single source systems are vulnerable
- Pumping stations are vulnerable
- Connecting systems is a good way to enhance reliability
- Reliability = consequence management

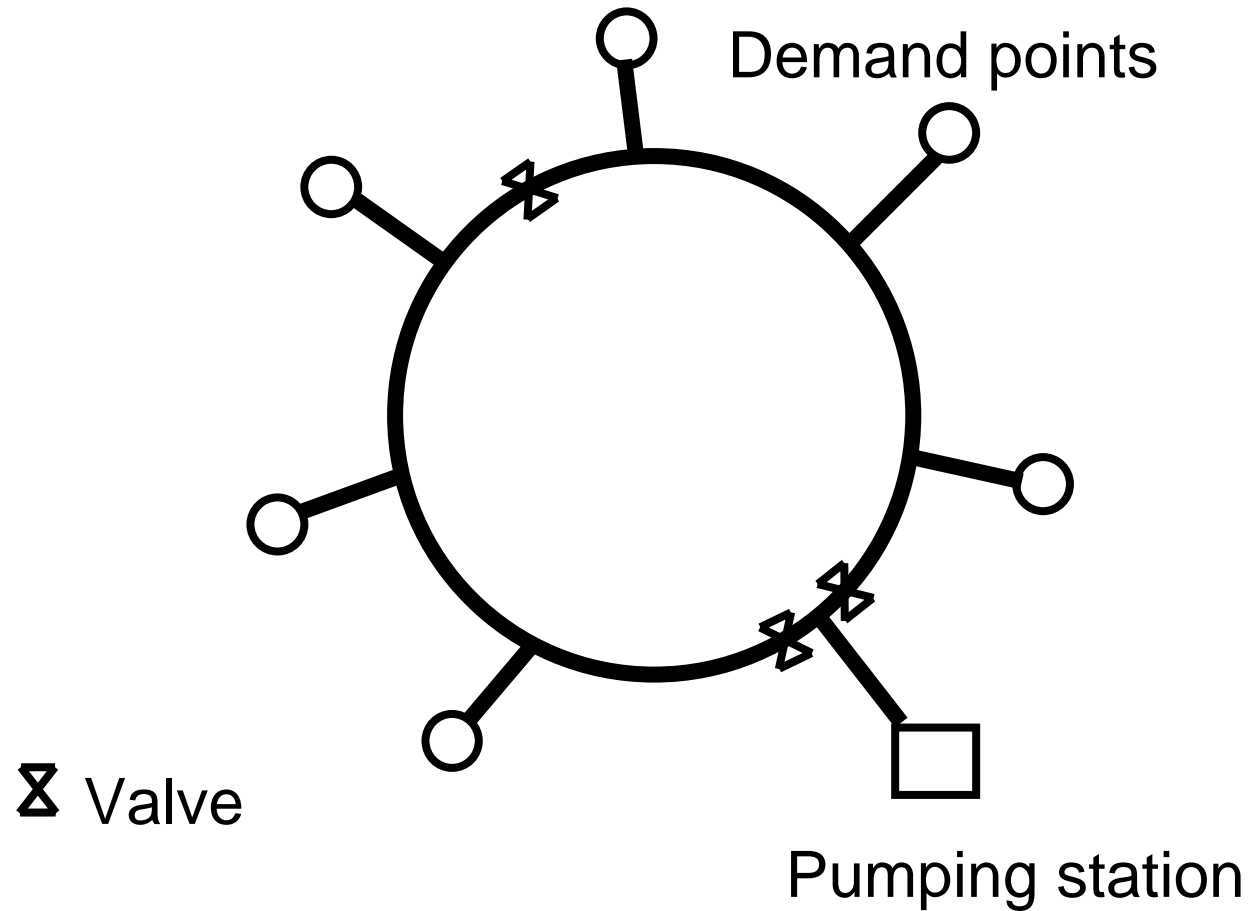
# Basic design, step 1



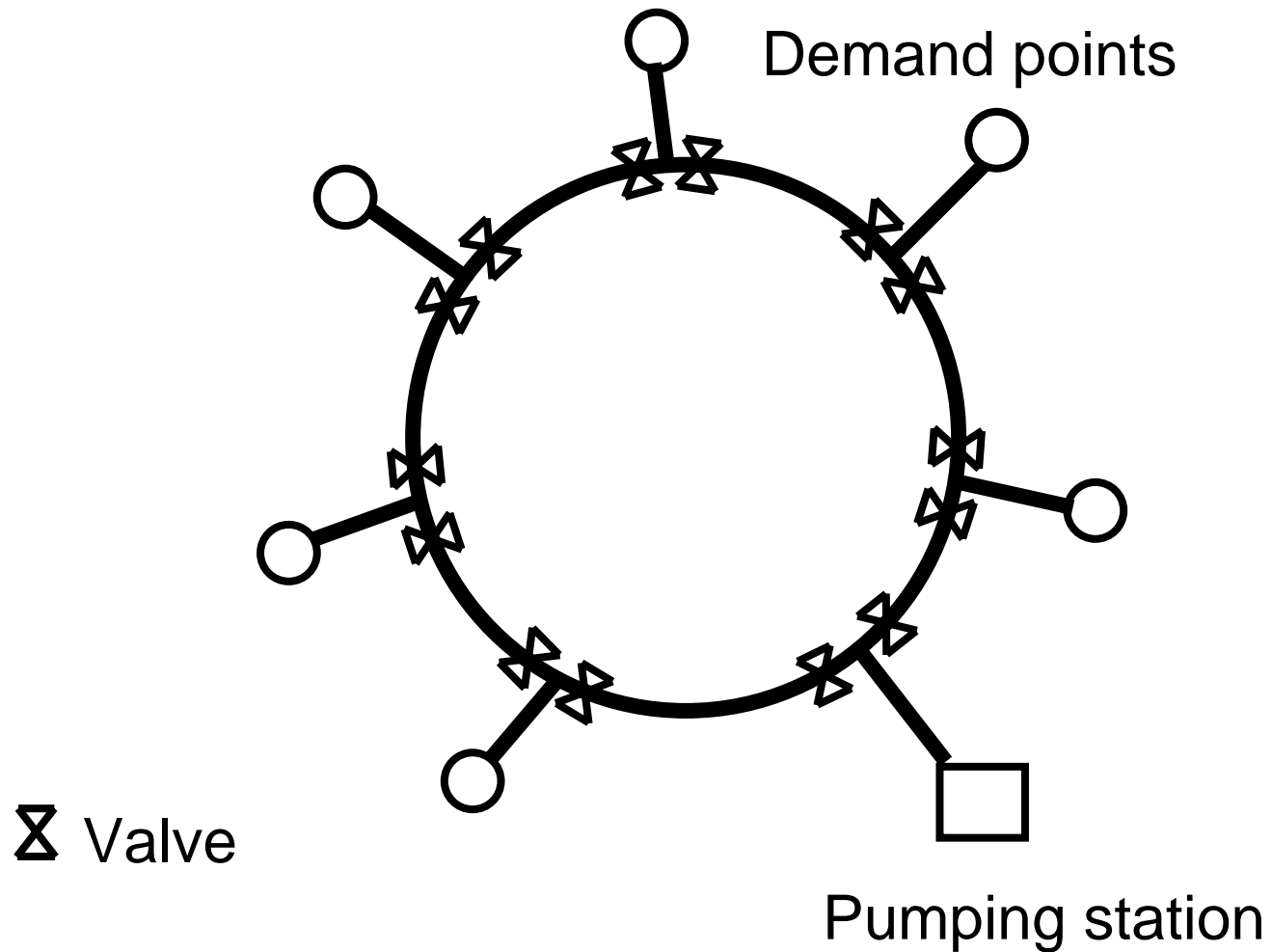
Pumping station

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# Basic design, step 2



# Basic design, step 3





# Basic design, step 4

