Pumping stations and water transport

Practical applications: Water transport lines

ct5550

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Quote 1978 ‘vakantiecursus’

- ‘It is still impossible to feed computers with certain principles to let them design the most appropriate network taking into account the most economical solution.’
- Addition 2006: ‘And it is still very difficult if not impossible’
- Calculation tools are essential in the creative process of network design and network operation

Network design

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Plan period design

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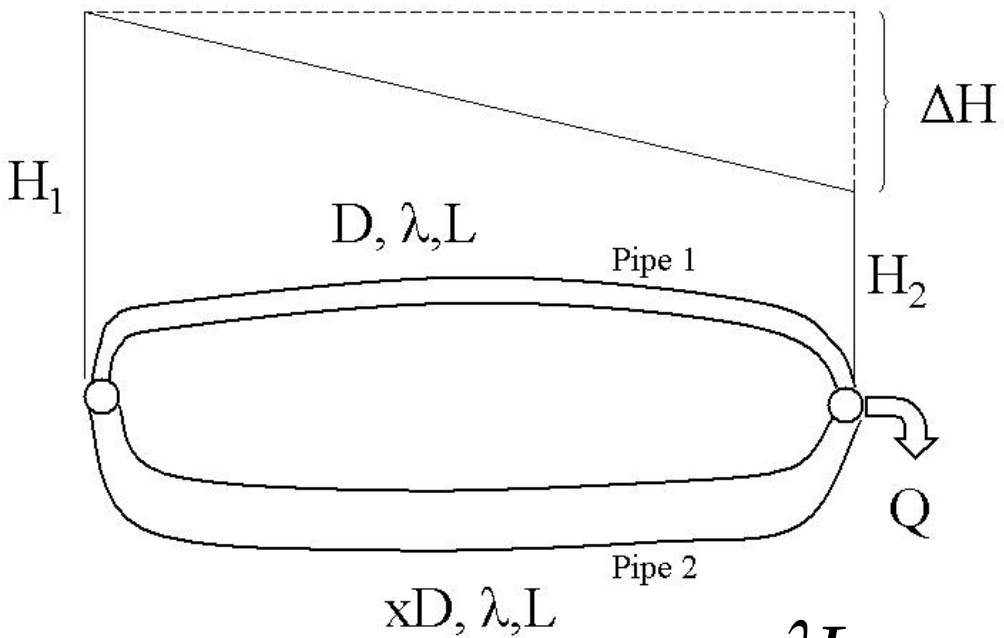
modelling implications for an average water company

- 200.000 - 600.000 – 1.500.000 connections ⇨ as many different demands
- 60%< 300 m^3/year; 15%>10.000 m^3/year
  ⇨ different consumption patterns
- 1-30 treatment plants/pumping stations
  ⇨ as many feeding points
- 3500 - 10.000 km pipe
  ⇨ At least as much pipe components

Not always all data are needed

- Design pipe infrastructure
  - Main structure; prognosis demand
- Operational strategy
  - Main and sub-main structure; actual demand
- Making flush plans
  - All pipes, no demands
- Special application: Reliability

Hydraulic relevance of pipes



$$\Delta H =$$

$$\Delta H_1 = z\frac{\lambda L}{D^5}Q_1^2 =$$

$$\Delta H_2 = z\frac{\lambda L}{(xD)^5}Q_2^2$$

$$\frac{\lambda L}{D^5}Q_1^2 = \frac{\lambda L}{(xD)^5}Q_2^2 \Rightarrow \frac{Q_2}{Q_1} = x^{2,5}$$

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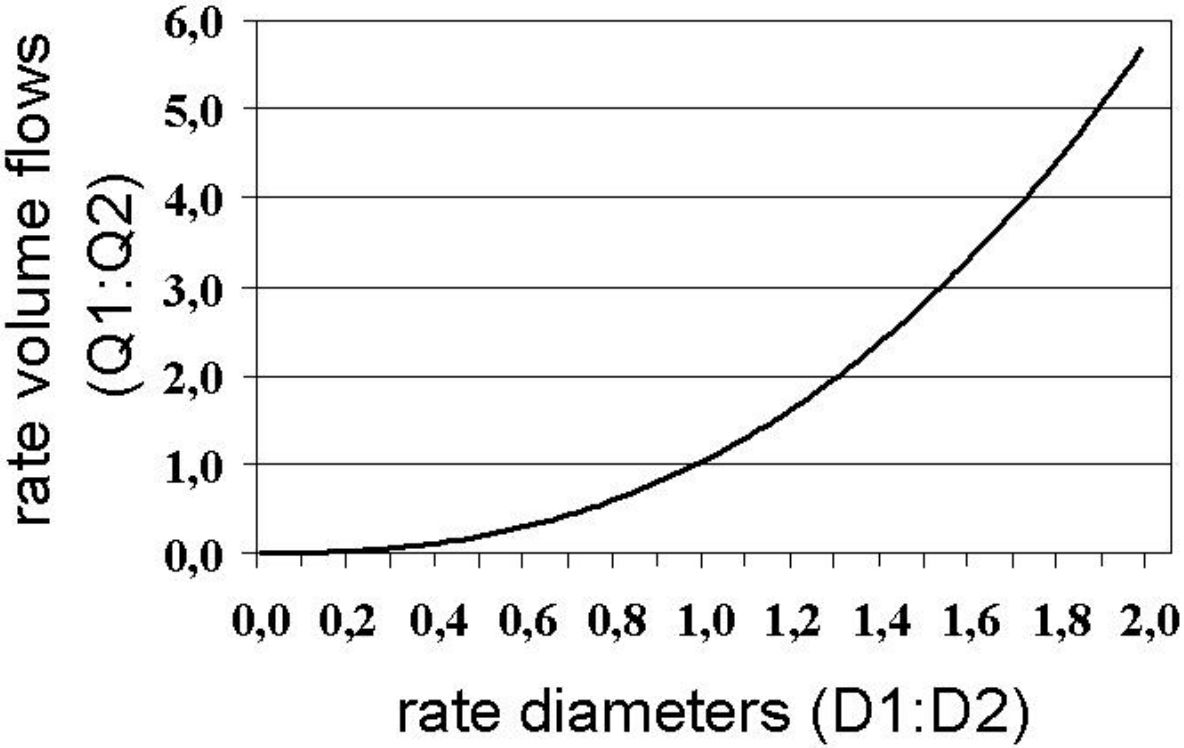
Hydraulic relevance of pipes



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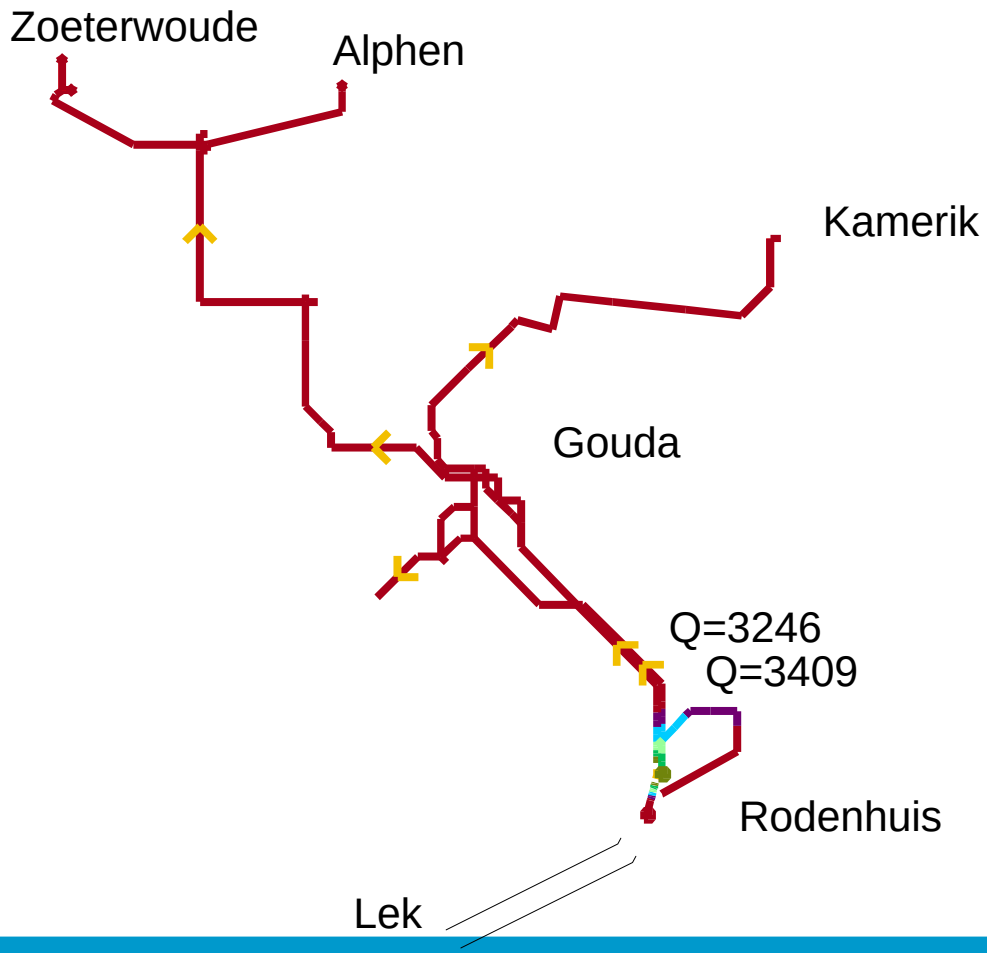
Design pipe infrastructure

- Creative process ⇨ high calculation speed
- Lots of alternatives
- course screening

Rules of thumb design transport networks

- Large transport lines: steady flow, pressure drop is most important
  - Slope: 0,001 – 0,002 m/m
  - Velocity 1m/s
  - Max pressure 60 mWc (Netherlands)

Situation 2010
No extension



Druk mv
P>42.00
P<42.00
P<38.00
P<34.00
P<30.00
P<26.00
P<22.00
mkw +mv

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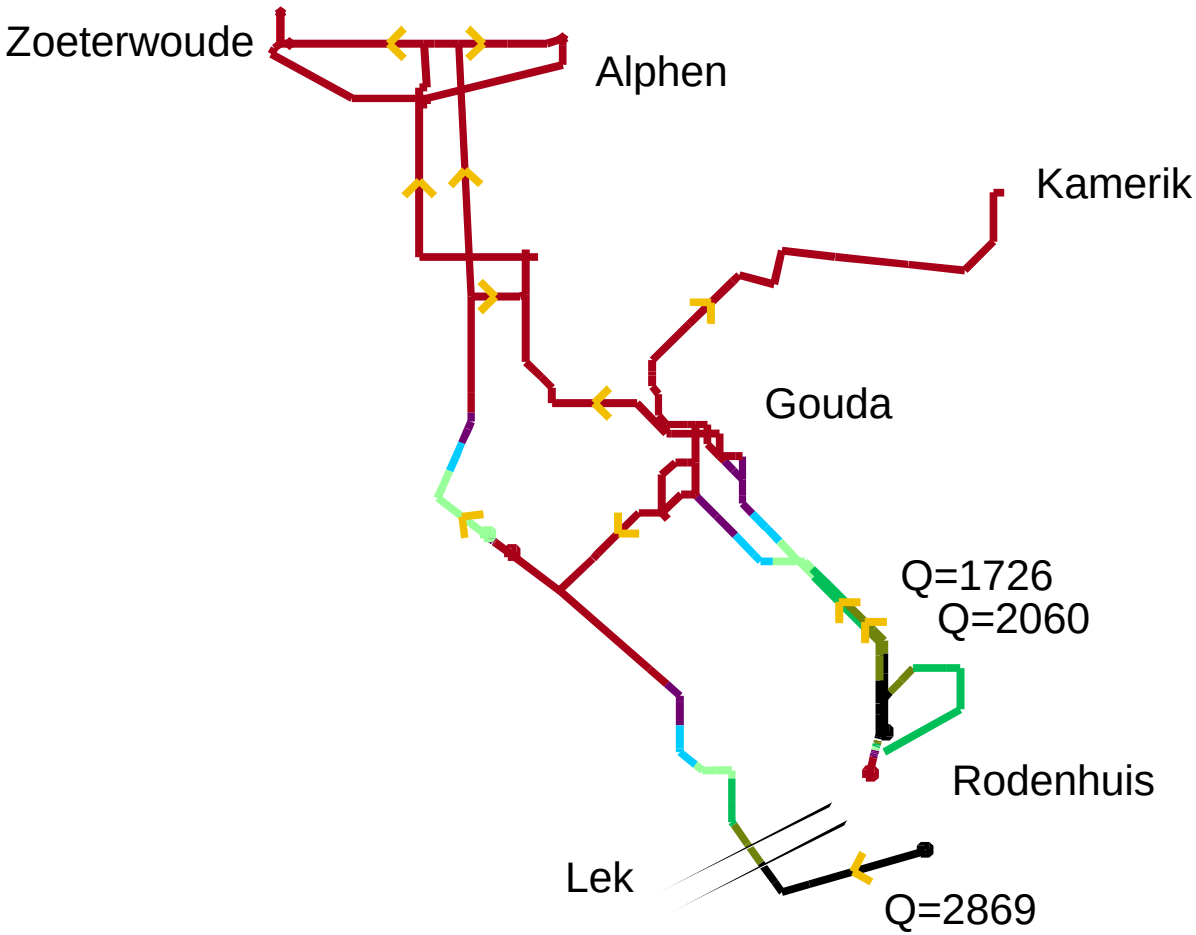
Alternative 1
800 mm with booster



Druk mv
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P<34.00
P<30.00
P<26.00
P<22.00
mkw +mv

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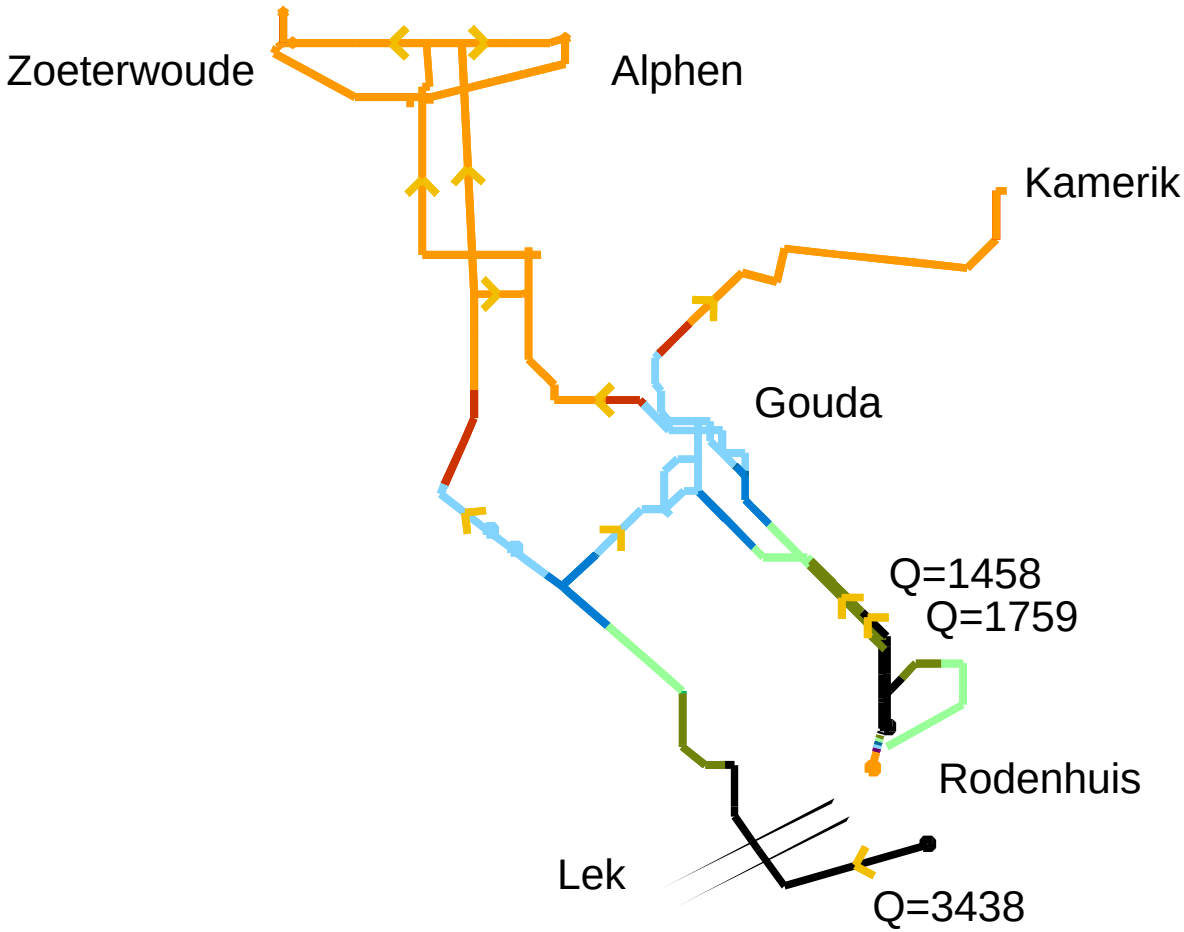
Alternative 2
1000 mm without booster



Druk mv
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P<22.00
mkw +mv

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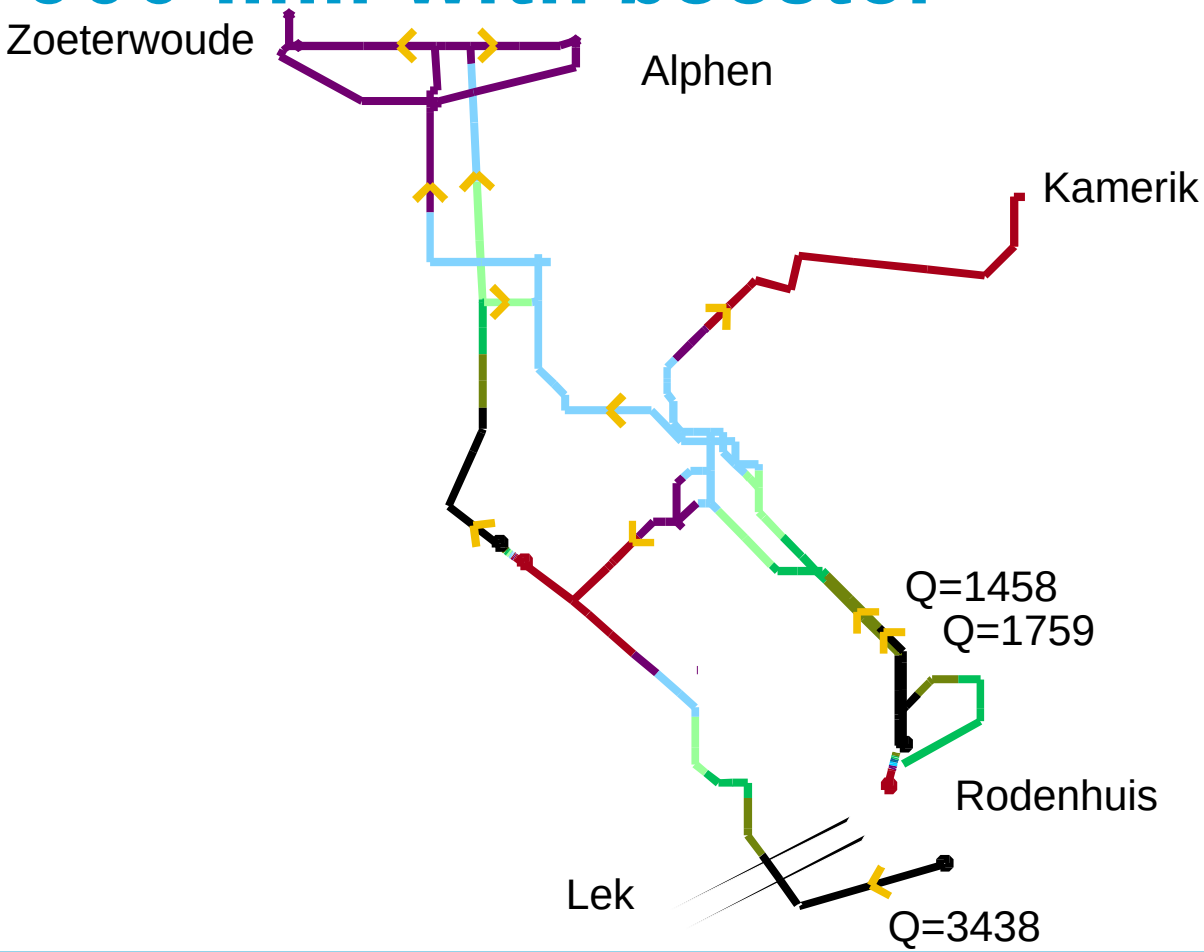
Alternative 3
900 mm with booster



Druk mv
P>42.00
P<42.00
P<38.00
P<34.00
P<30.00
P<26.00
P<22.00
mkw +mv

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Operational strategy

- Focussed on day-to-day practise
- ‘Flight simulator’
- Details on scheduling pumping stations

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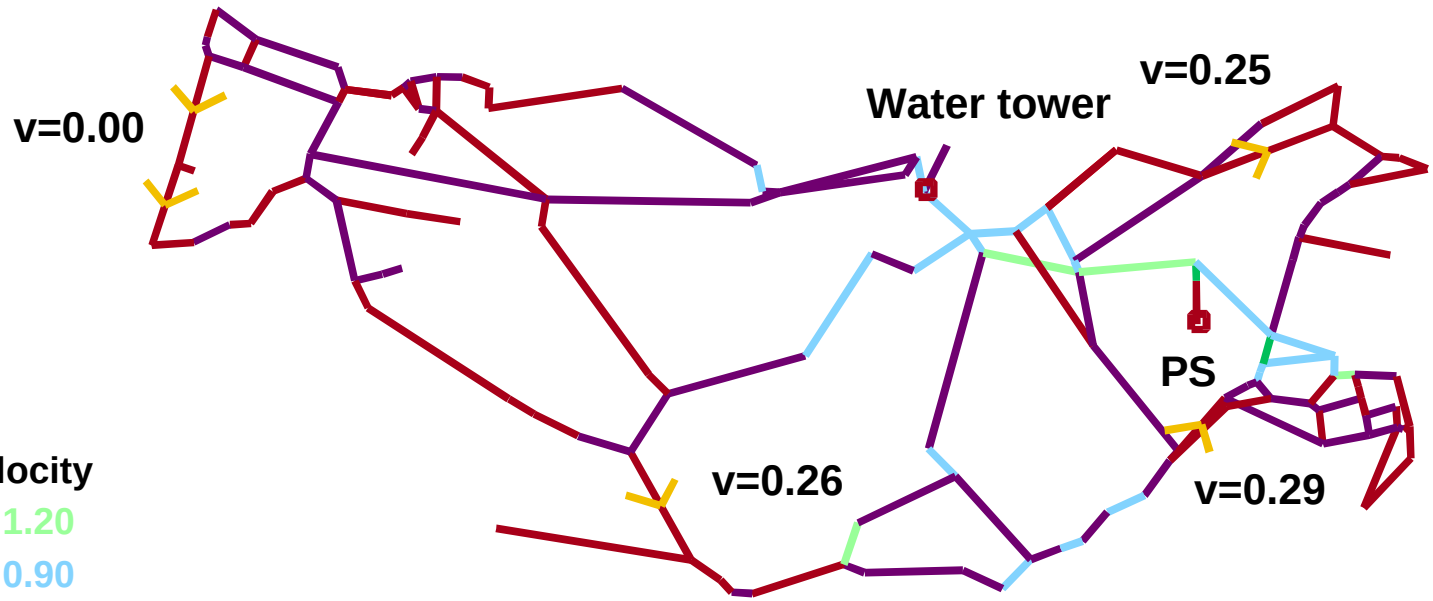
Velocities during maximum hour



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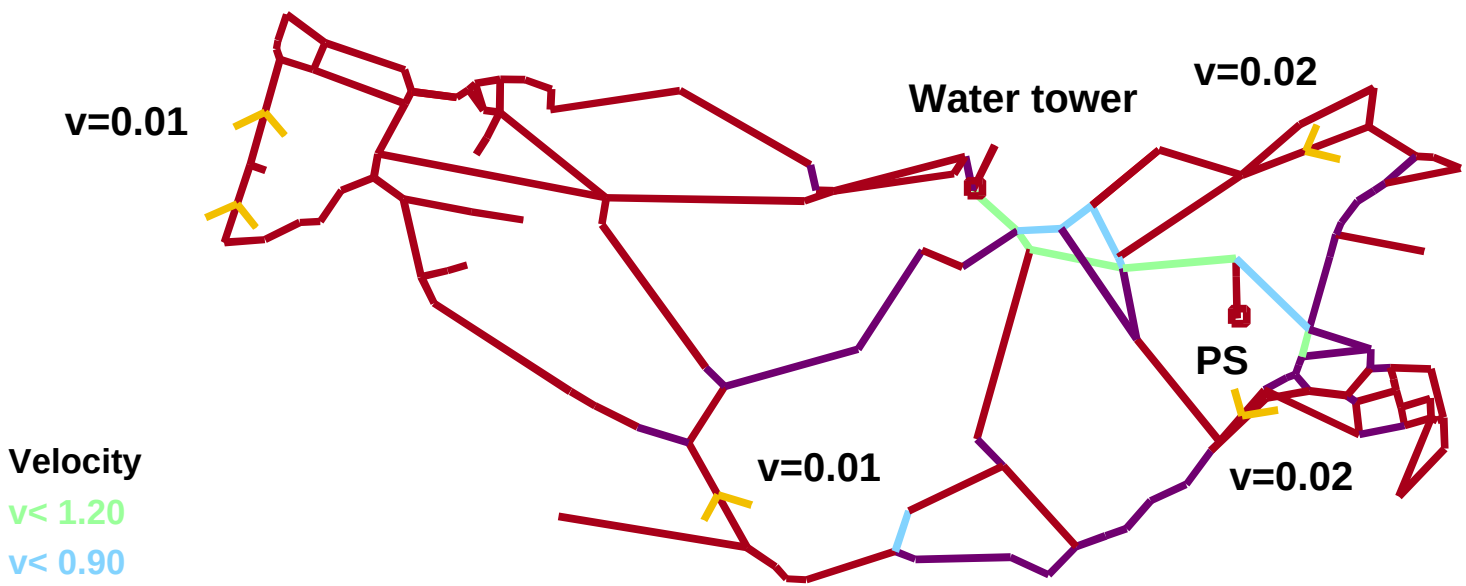
Velocities during minimum hour



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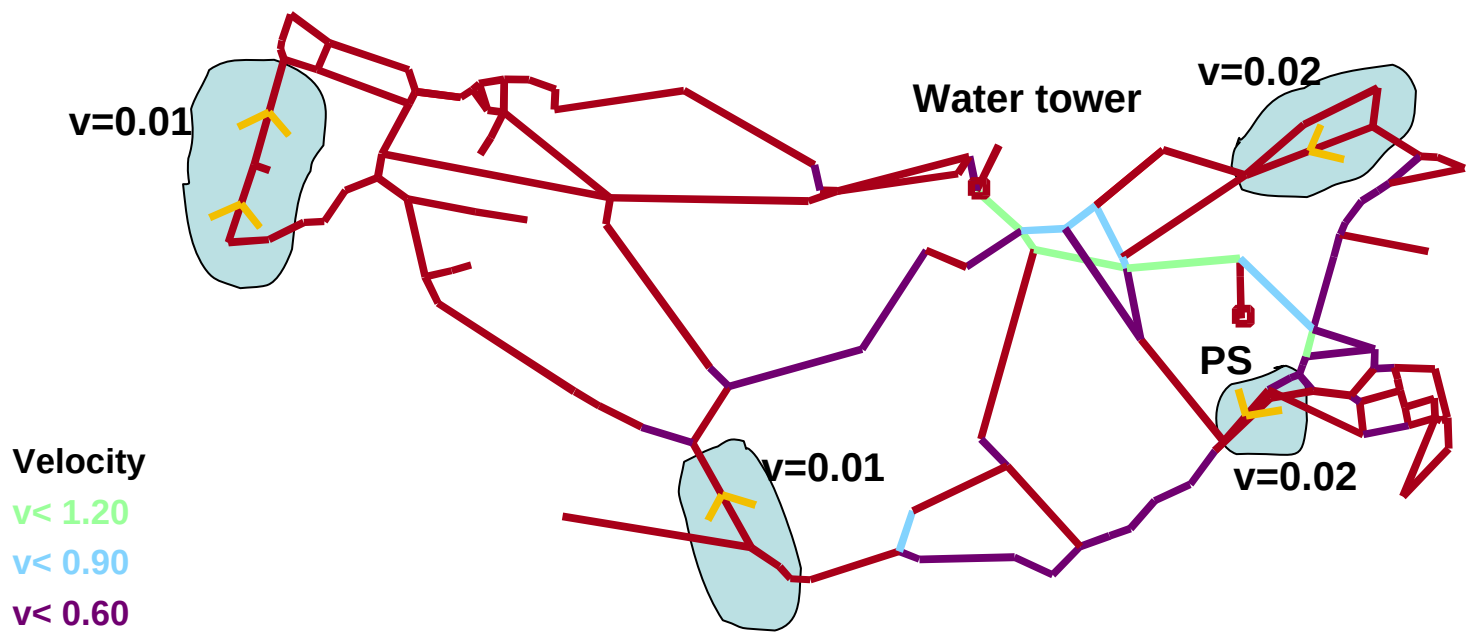
Zero flow zones



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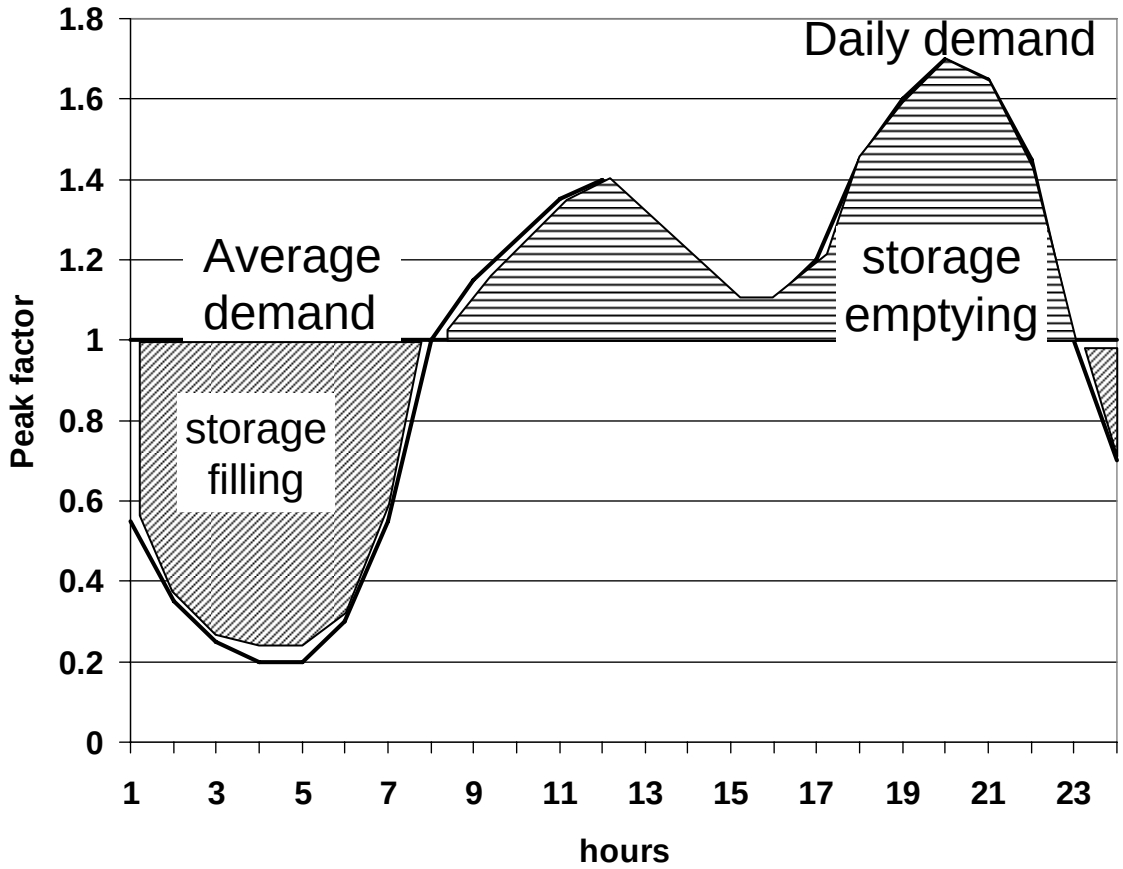
Remedial strategies

- ‘redesign network’
- Monitor critical locations
- Clean the network regularly => Network calculations!

Storage facilities in networks

- Balancing demand and production



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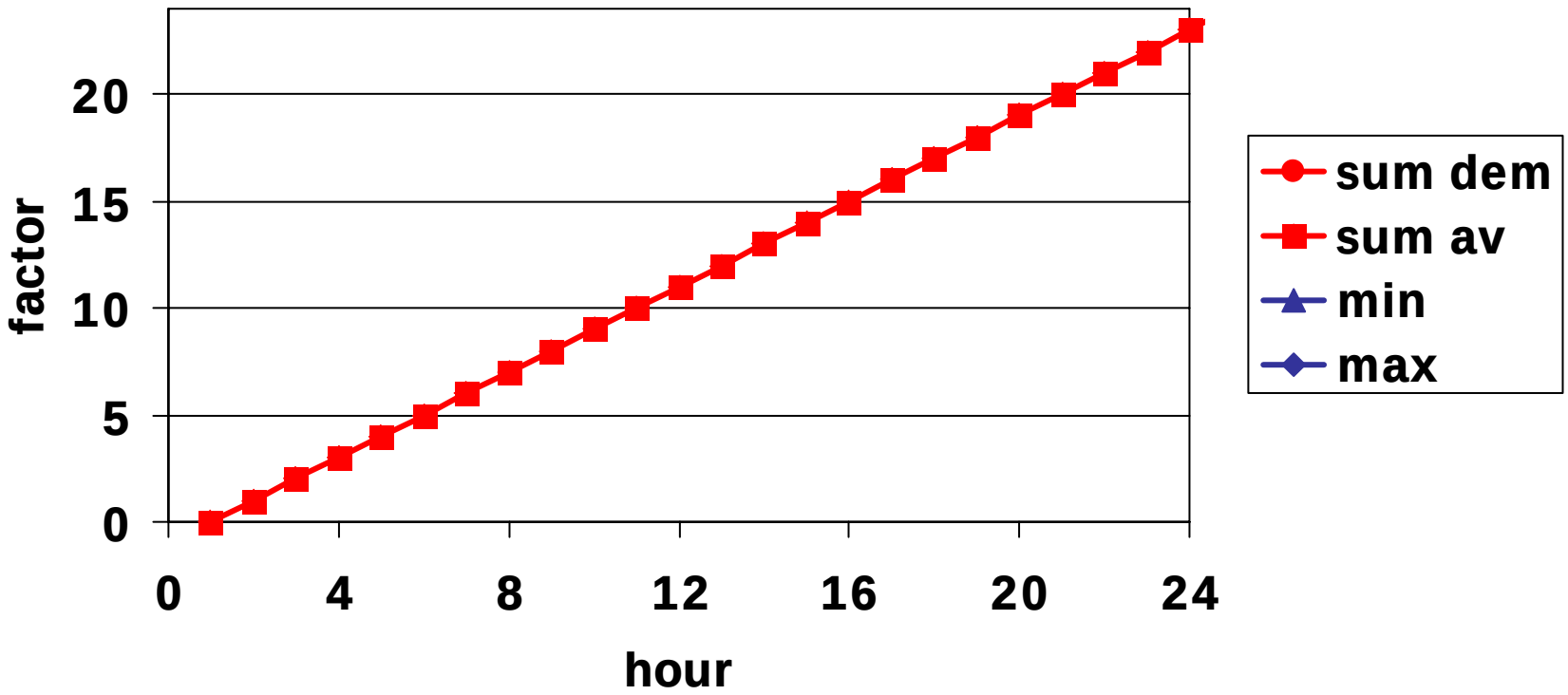
Calculation storage volume

Hour of the day	Demand factor	Average peak factor	Average – demand (volume flow to storage)	Volume storage
1	0,55	1,00	0,45	0,45
2	0,35	1,00	0,65	1,10
3	0,25	1,00	0,75	1,85
4	0,20	1,00	0,80	2,65
5	0,20	1,00	0,80	3,45
6	0,30	1,00	0,70	4,15
7	0,55	1,00	0,45	4,60
8	1,00	1,00	0,00	4,60
9	1,15	1,00	-0,15	4,45
10	1,25	1,00	-0,25	4,20
11	1,35	1,00	-0,35	3,85
12	1,40	1,00	-0,40	3,45
13	1,30	1,00	-0,30	3,15
14	1,20	1,00	-0,20	2,95
15	1,10	1,00	-0,10	2,85
16	1,10	1,00	-0,10	2,75
17	1,20	1,00	-0,20	2,55
18	1,45	1,00	-0,45	2,10
19	1,60	1,00	-0,60	1,50
20	1,70	1,00	-0,70	0,80
21	1,65	1,00	-0,65	0,15
22	1,45	1,00	-0,45	-0,30
23	1,00	1,00	0,00	-0,30
24	0,70	1,00	0,30	0,00

Storage volume



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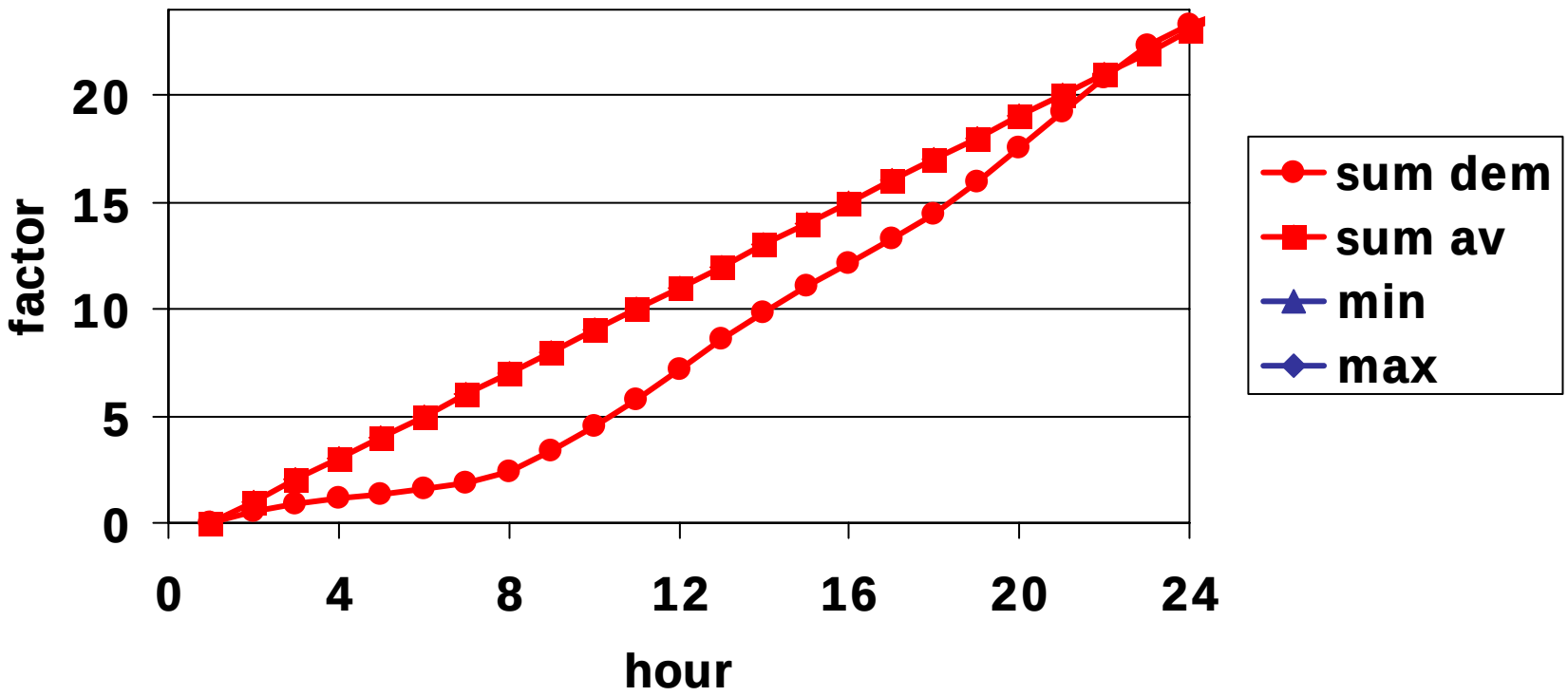
Storage volume



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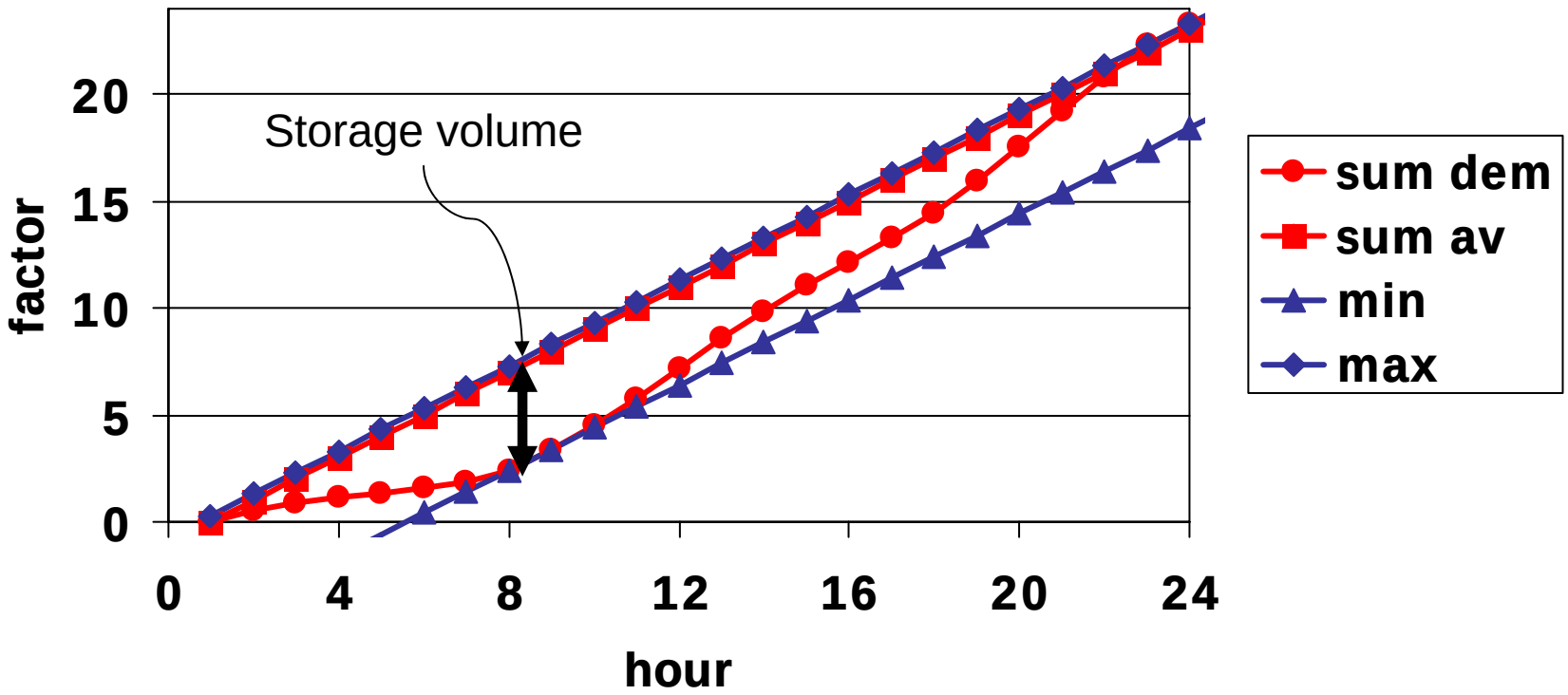
Storage volume



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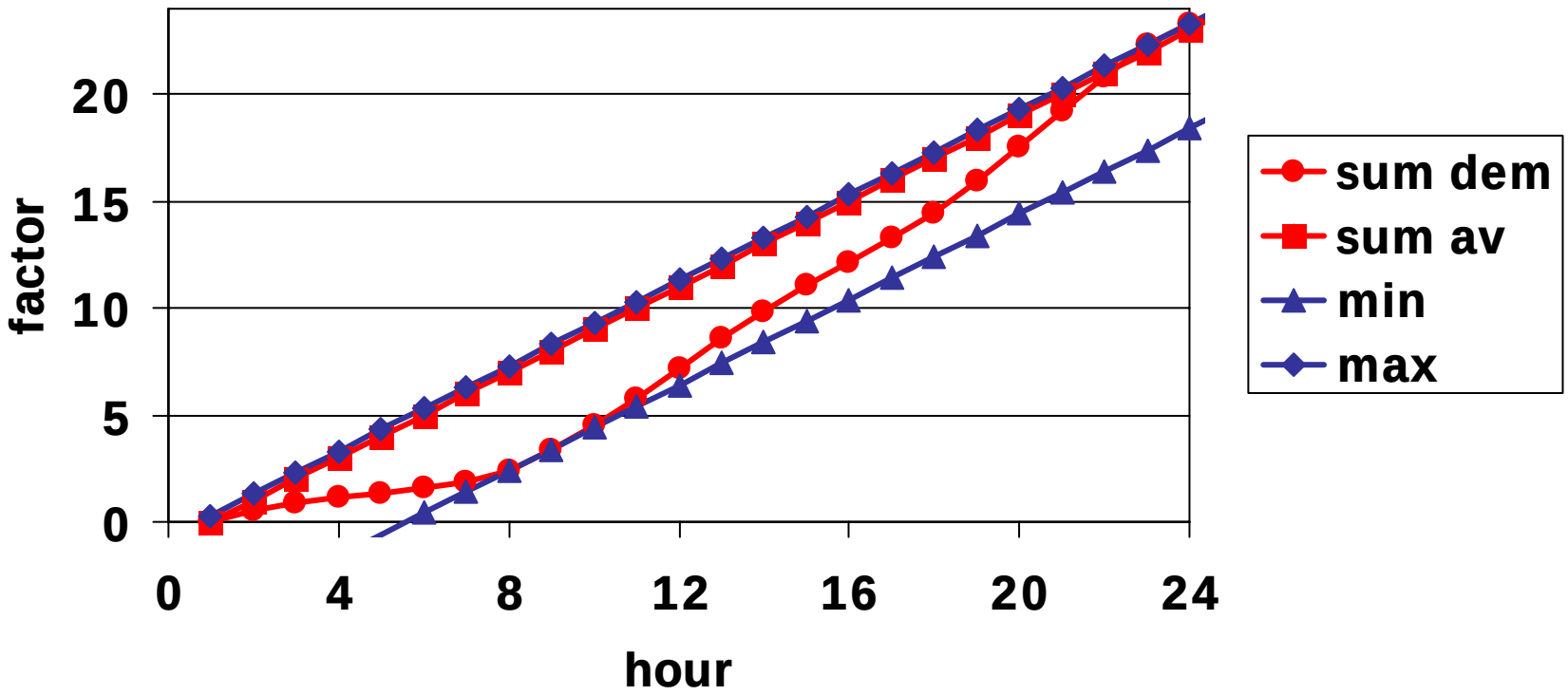

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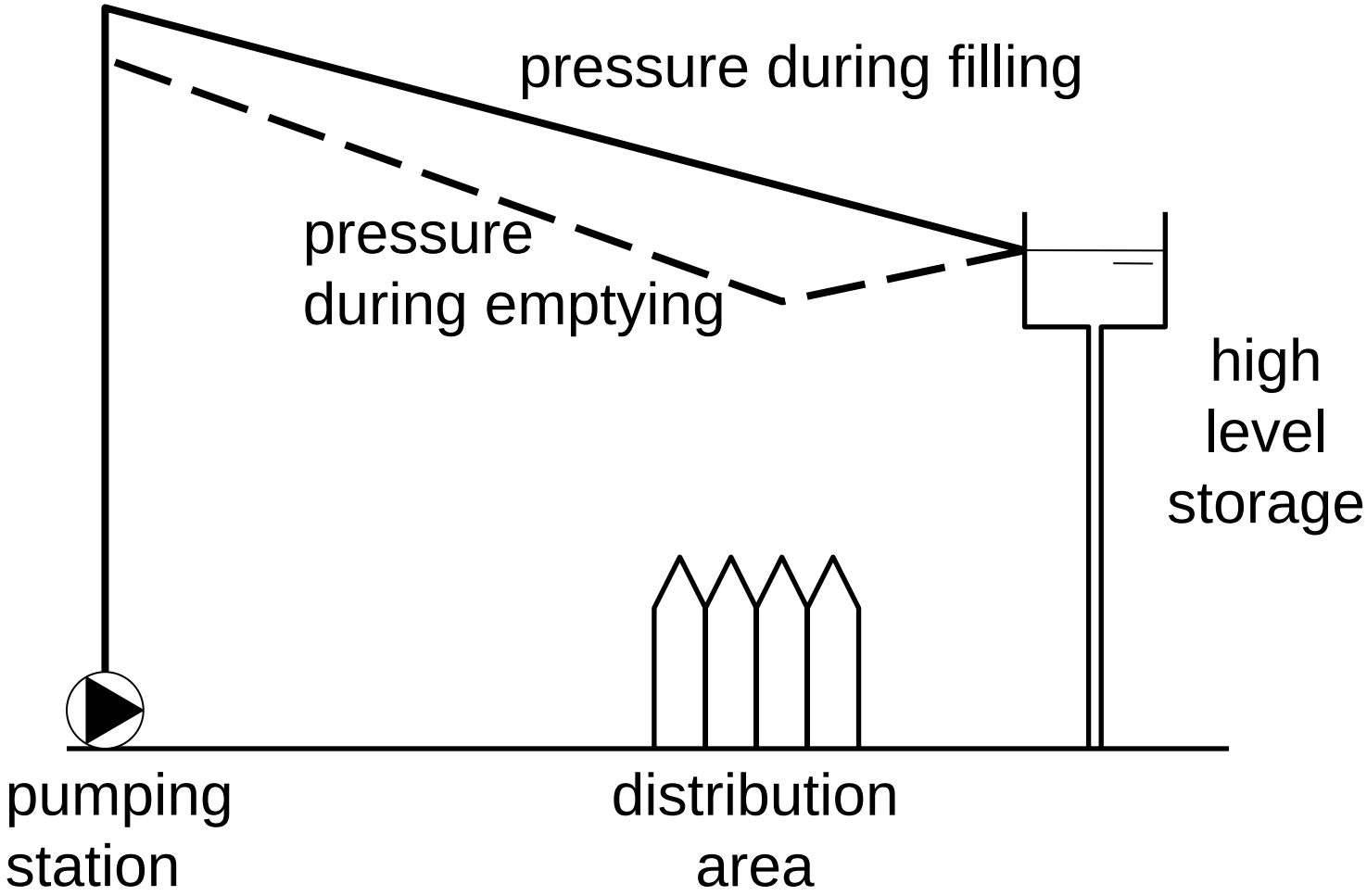
High level reservoir



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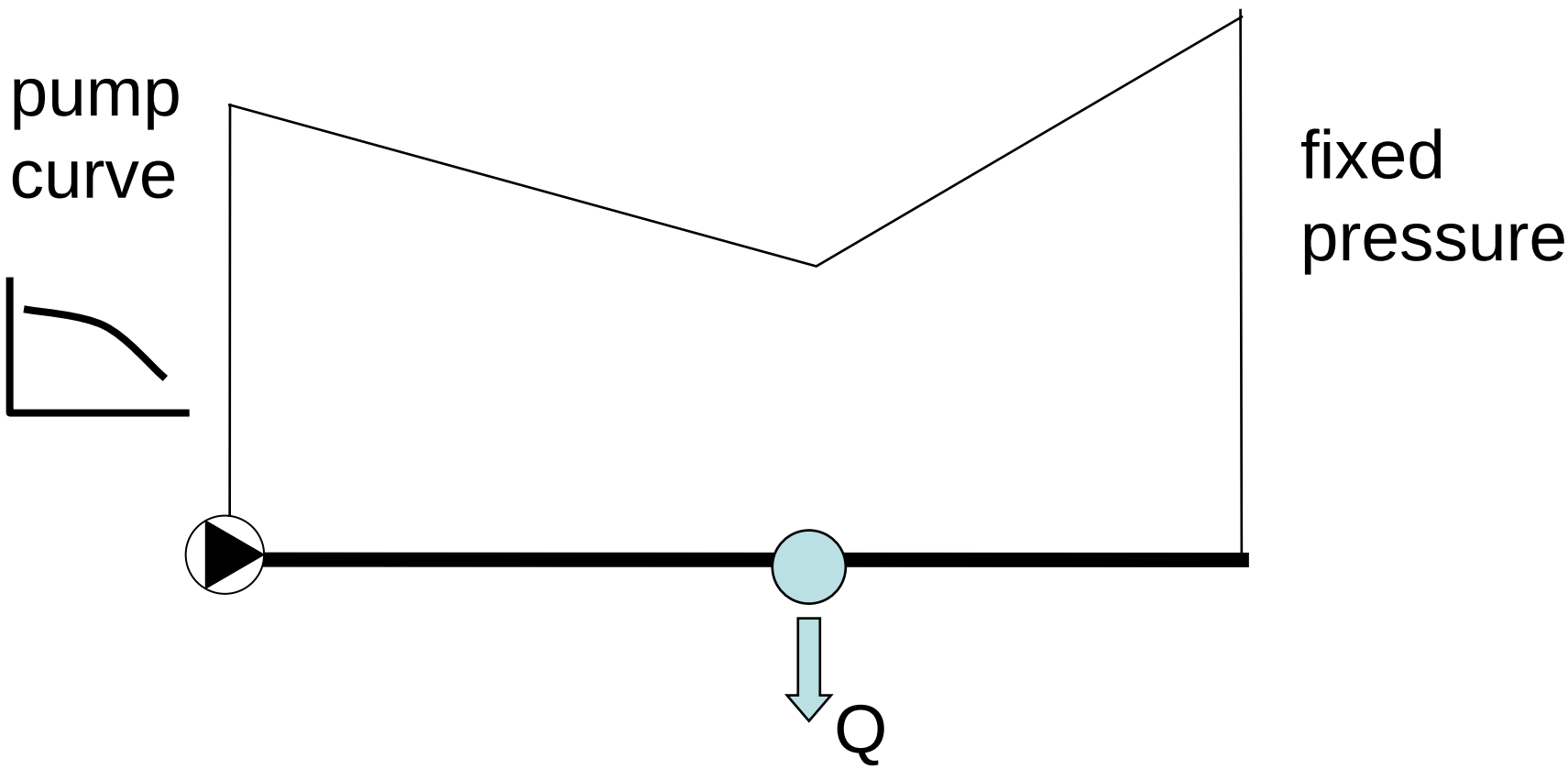
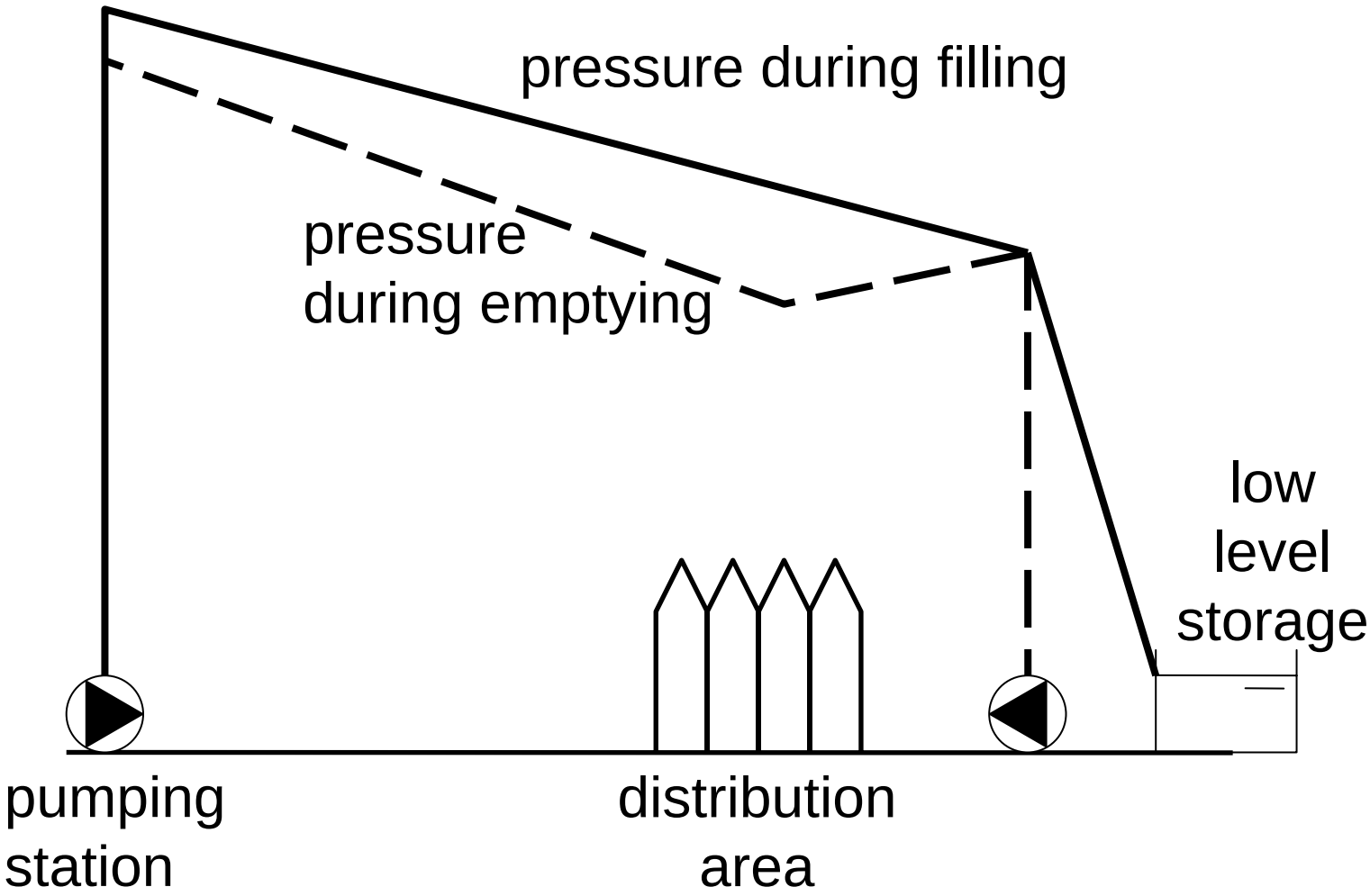
Modelling high level reservoir



Low level storage



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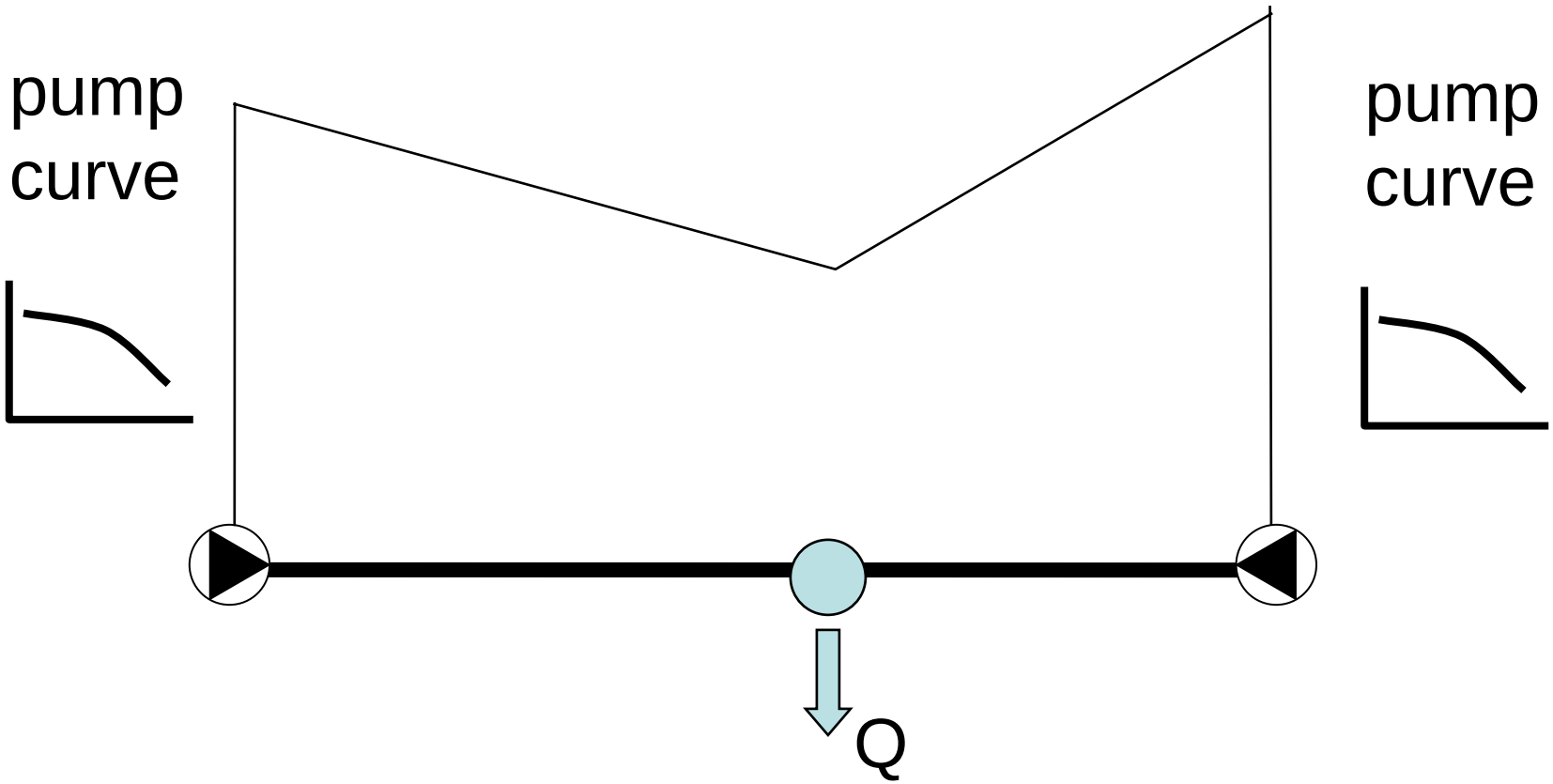
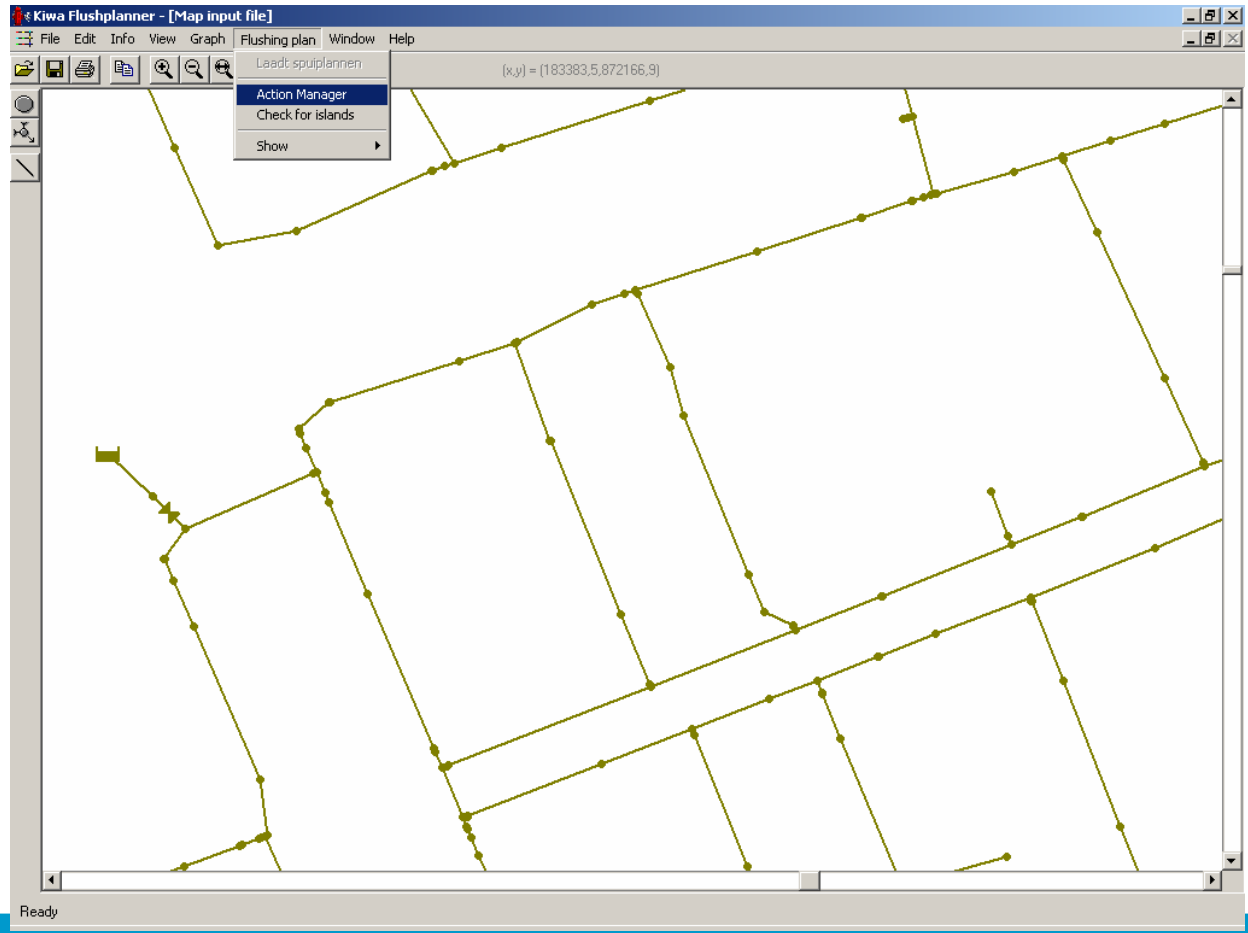
Modeling low level storage



Flush plans

- Water flushing most effective *WHEN:*
  - clear water front
  - velocity at least 1,5 m/s
  - flushed volume three times content pipe
- Tool:
  - computer aided design of flushing programs: Flush Planner®

Flush Planner® Software Demonstration



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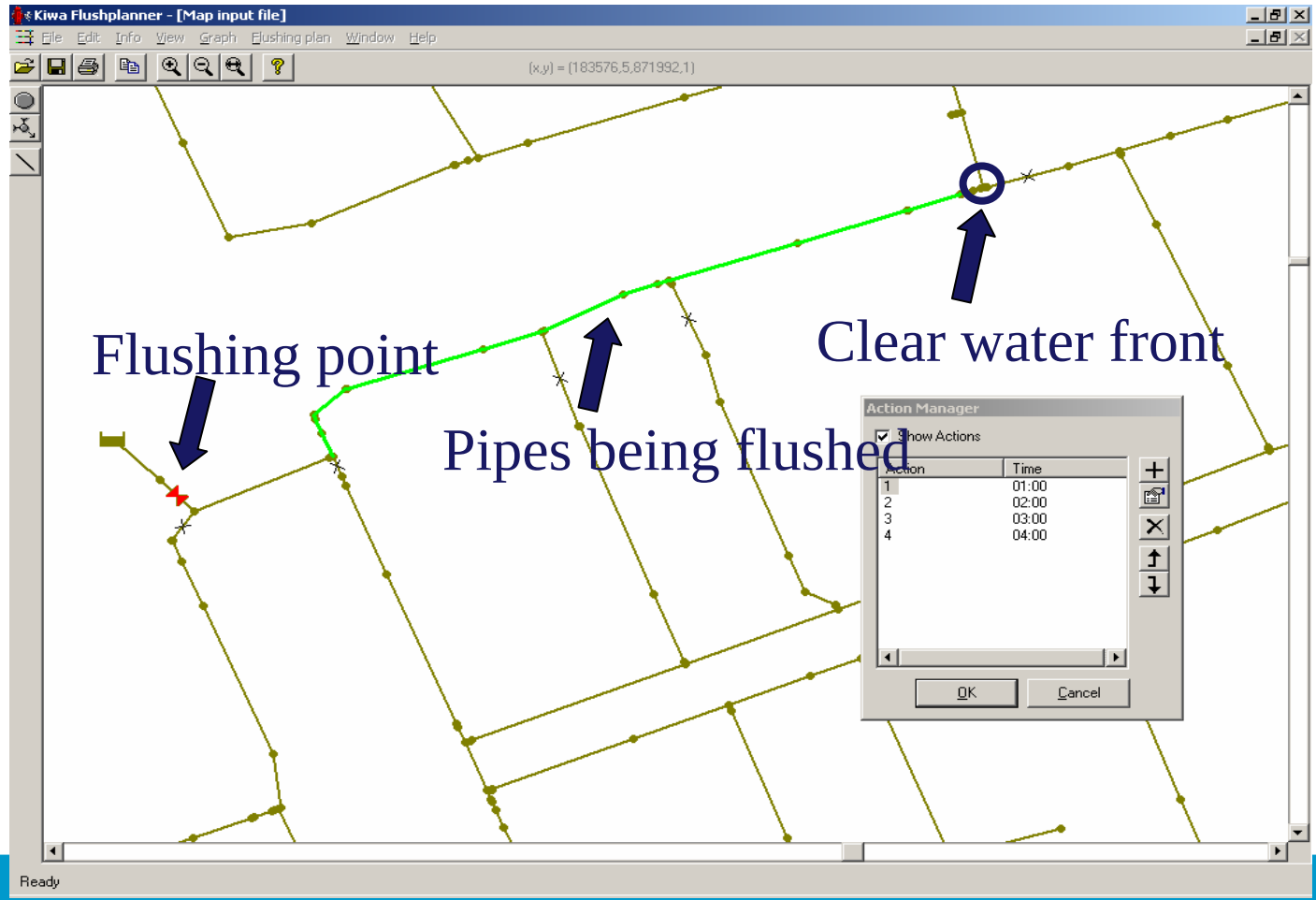
Flush Planner® Software
First action



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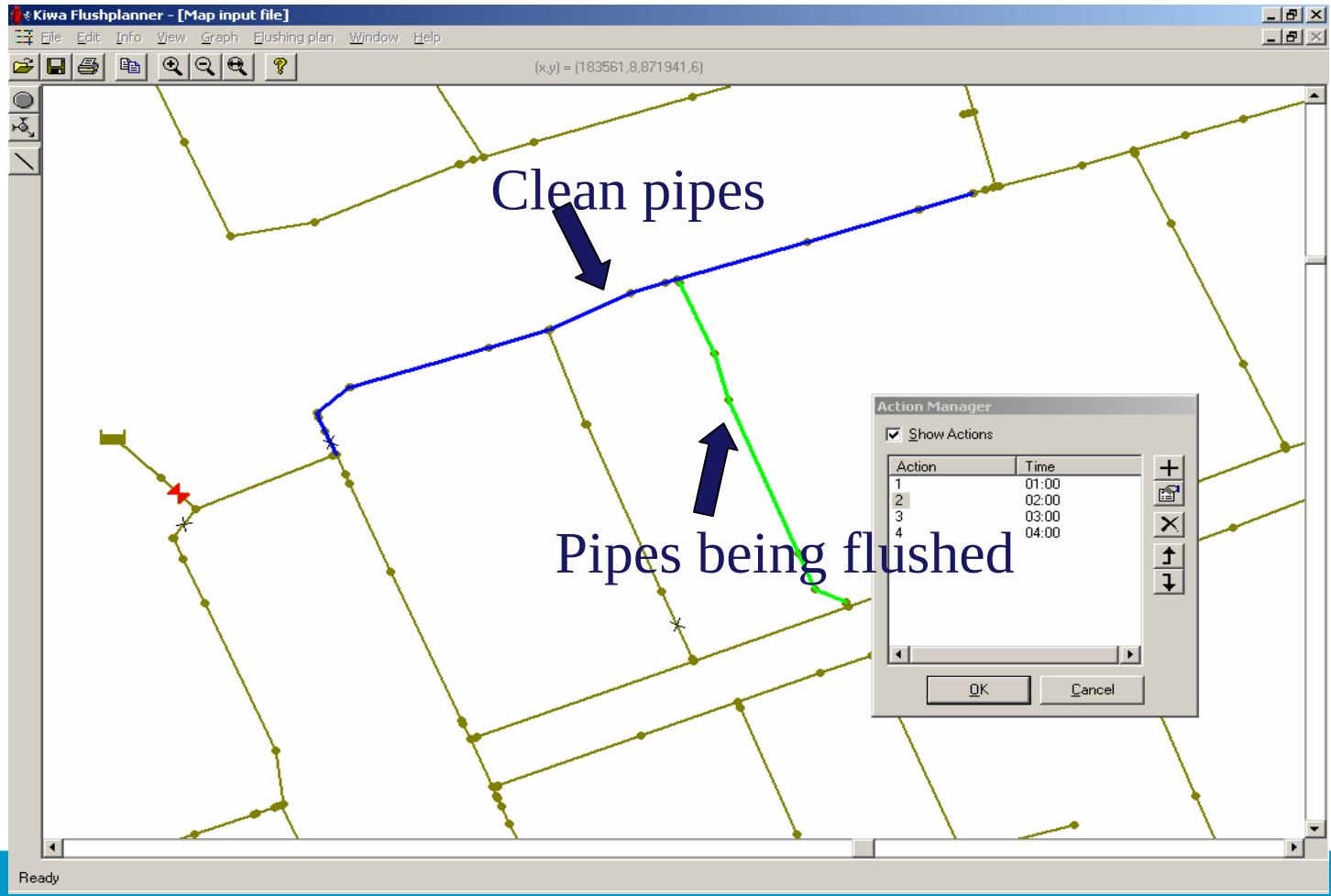
Flush Planner® Software
Second action



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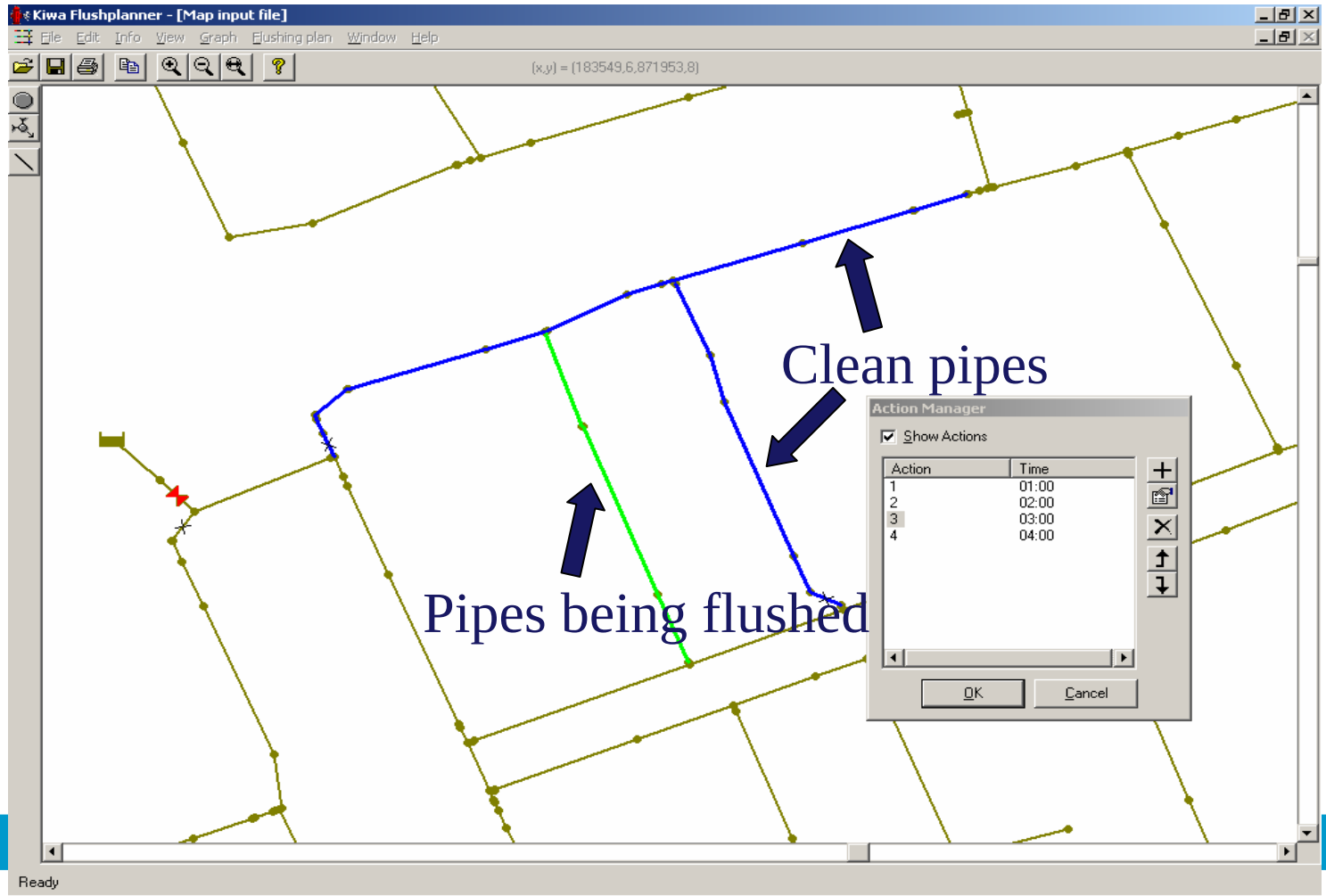
Flush Planner® Software
Third action



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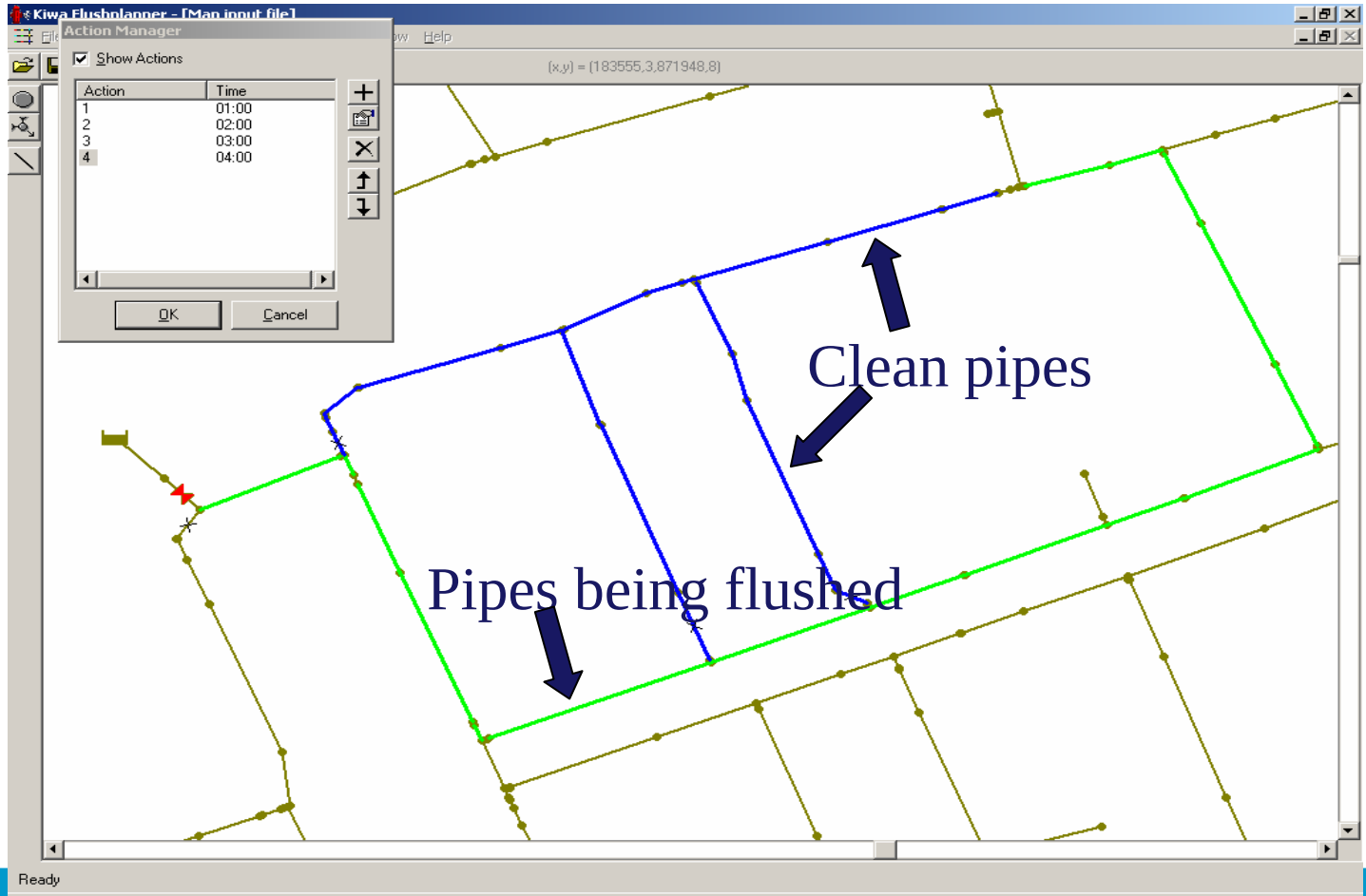
Flush Planner® Software
Fourth action



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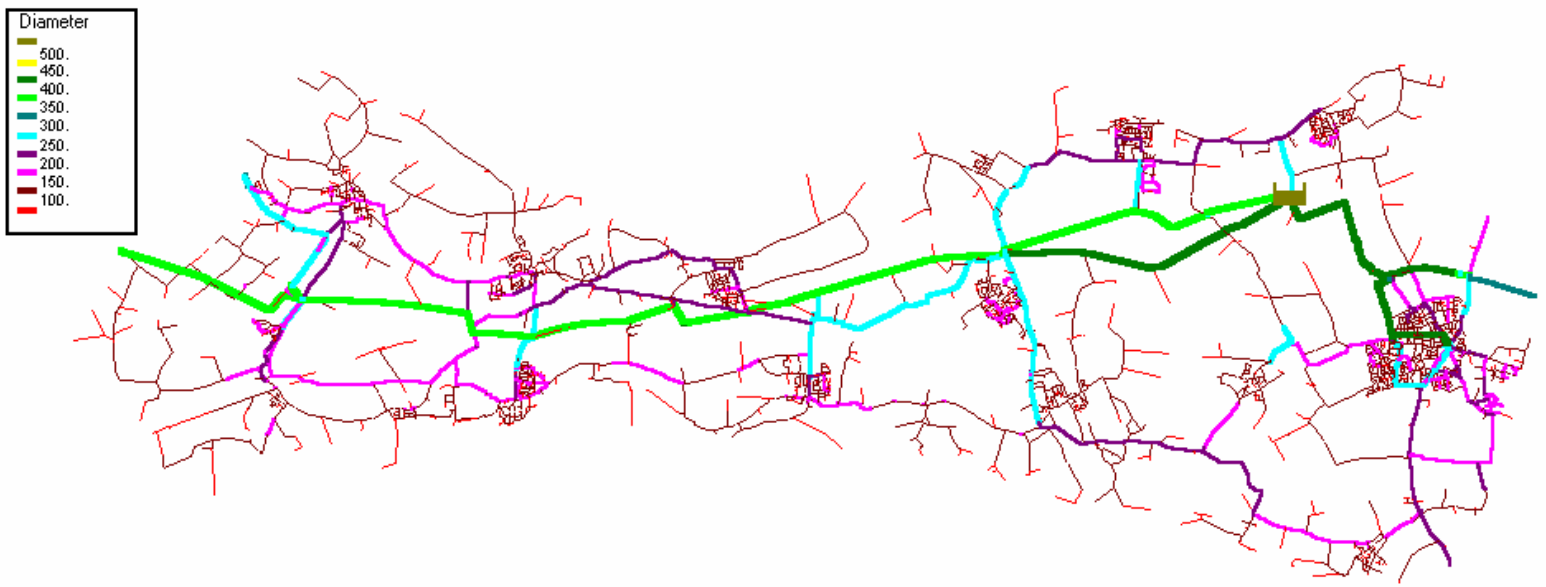
Characteristics applications network calculations

- Every application demands its own model:
- Design infrastructure
  - Course schematisation/modelling
  - Prognosis supply at large agglomerations
- Operational strategy
  - Tailored schematisation/model
  - Input pumping station important
  - Actual supply patterns
- Flush plans
  - All pipe model + all valves
  - Actual supply less important

Model built up

- Accuracy of demand determines the level of schematisation/skeletonisation
- Increasing availability of digital information increases the need for skeletonisation

Unskeletonised network



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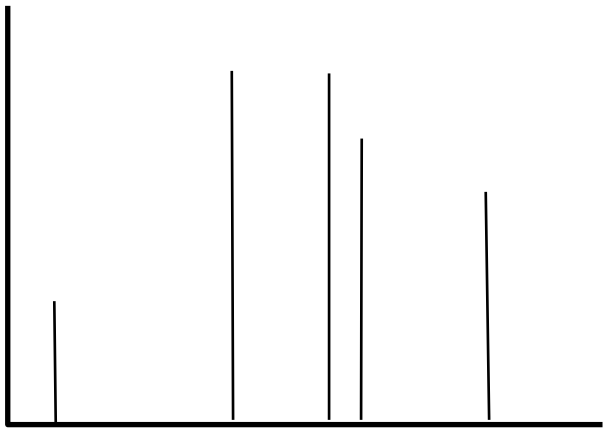
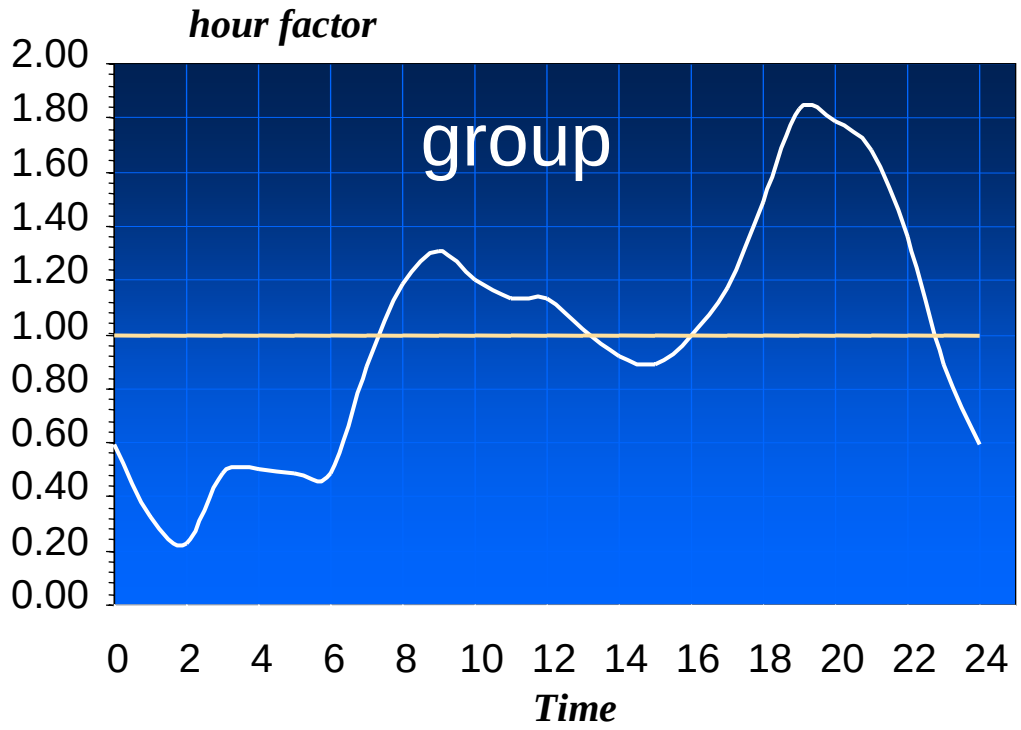
Demand patterns

Individual connection





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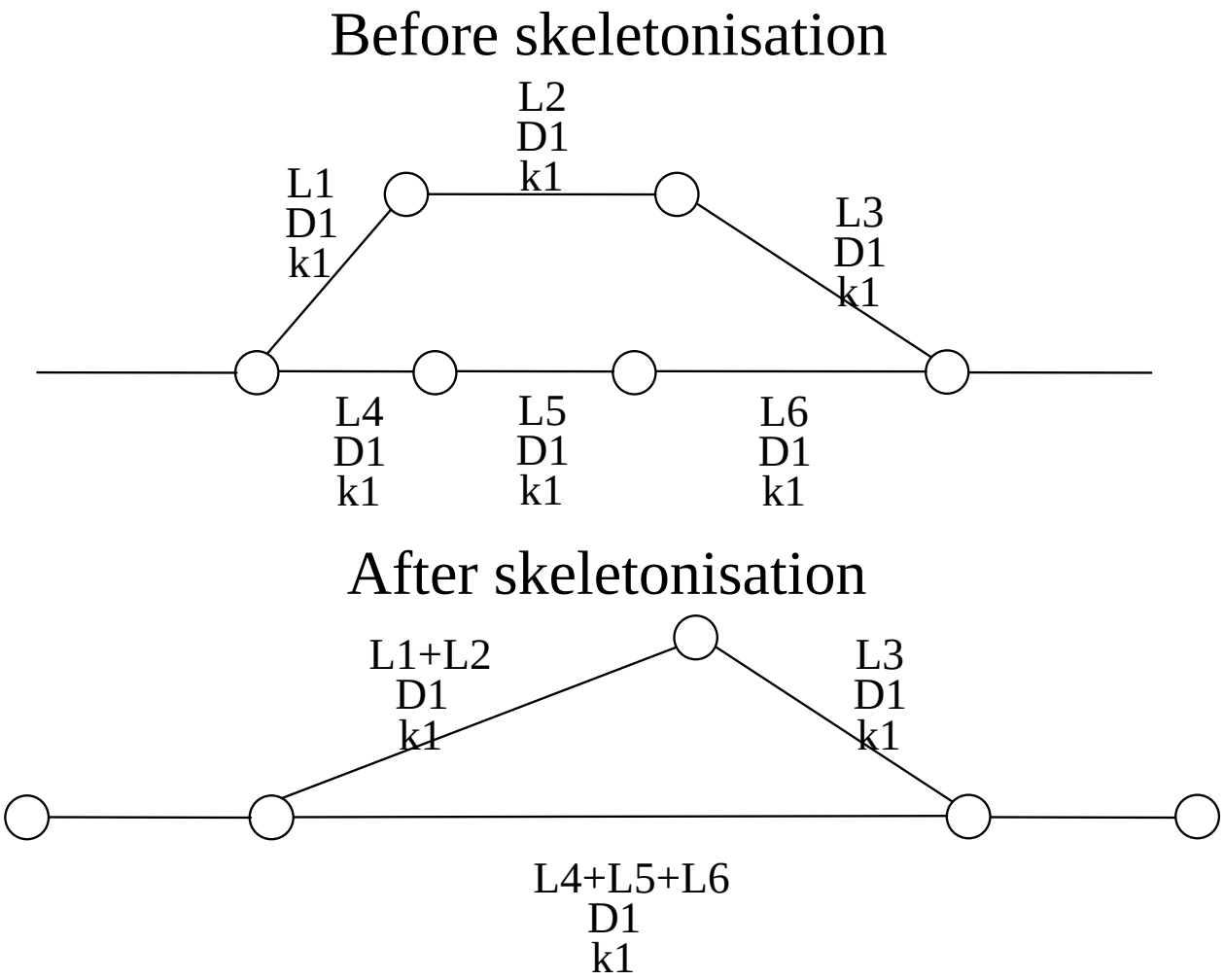
Hydraulic skeletonisation



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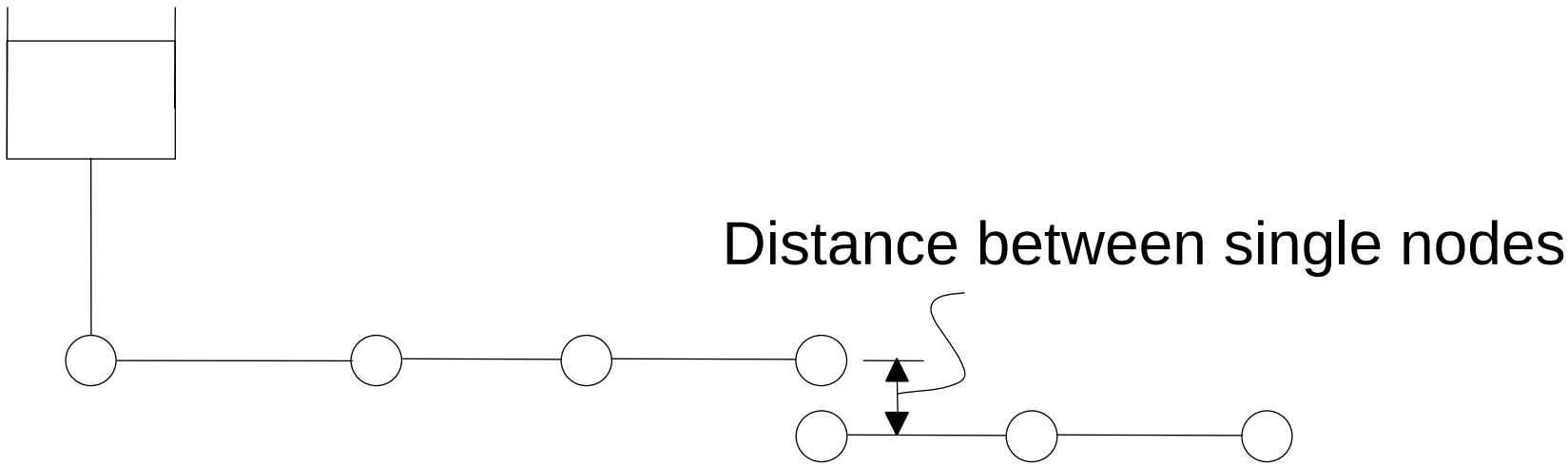
‘Administrative’ skeletonisation



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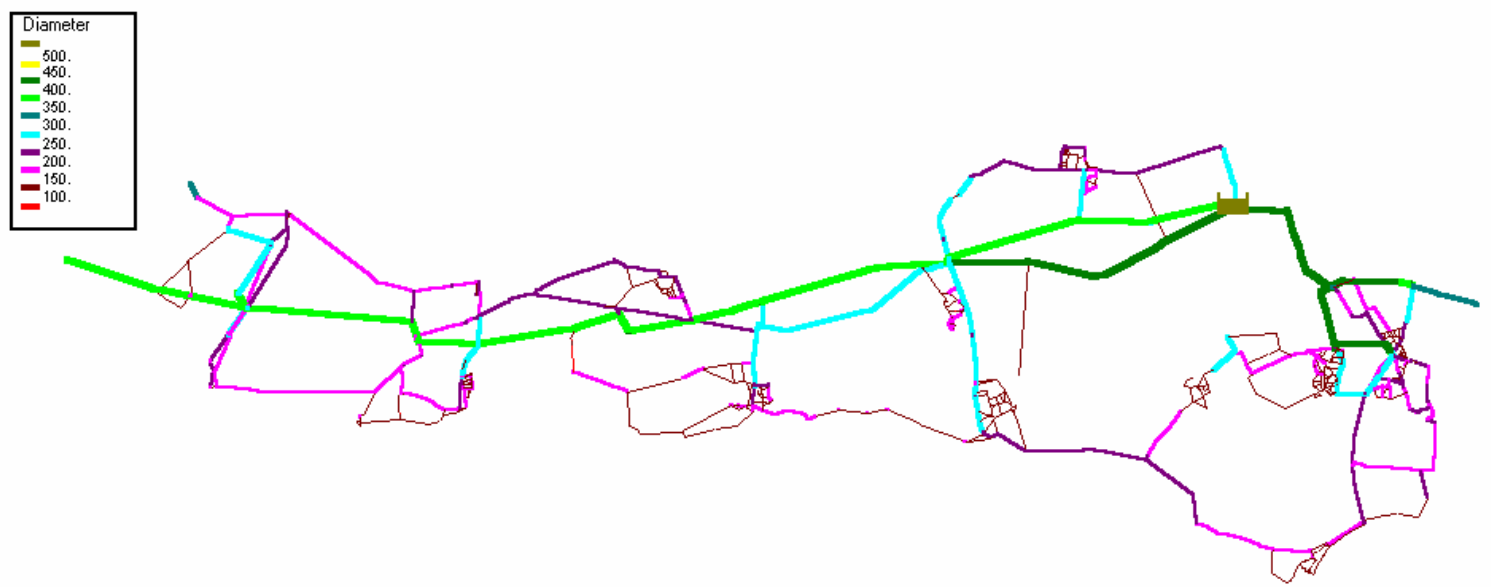
Skeletonised network



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