RESIDENTIAL WATER DISTRIBUTION

This case study demonstrates the steady-state simulation of the fresh water (drinking water) reticulation system in a small village.

WATER RETICULATION

CHALLENGE:

An existing water distribution network for a village needs to be expanded to include a new block of houses. This expansion will create a higher demand on the existing infrastructure and we need to ensure that adequate water pressures are delivered at each house.

BENEFITS:

- The entire grid can easily be simulated to ensure high fidelity and accurate results at each point of water delivery.
- The effects on the entire system can be seen and correct measures can be taken to ensure adequate delivery.
- Seasonal and daily variation in consumption conditions can be simulated and evaluated.

SOLUTION:

The entire distribution grid was built and simulated in Flownex. This allowed users to investigate and thoroughly test various scenarios after the expansion of the current reticulation system. The optimization and design capabilities of Flownex were used to optimize the system and maintain adequate water pressures during peak demand.

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SYSTEM DESCRIPTION

The layout of the village considered in this example is shown in Figure 1.

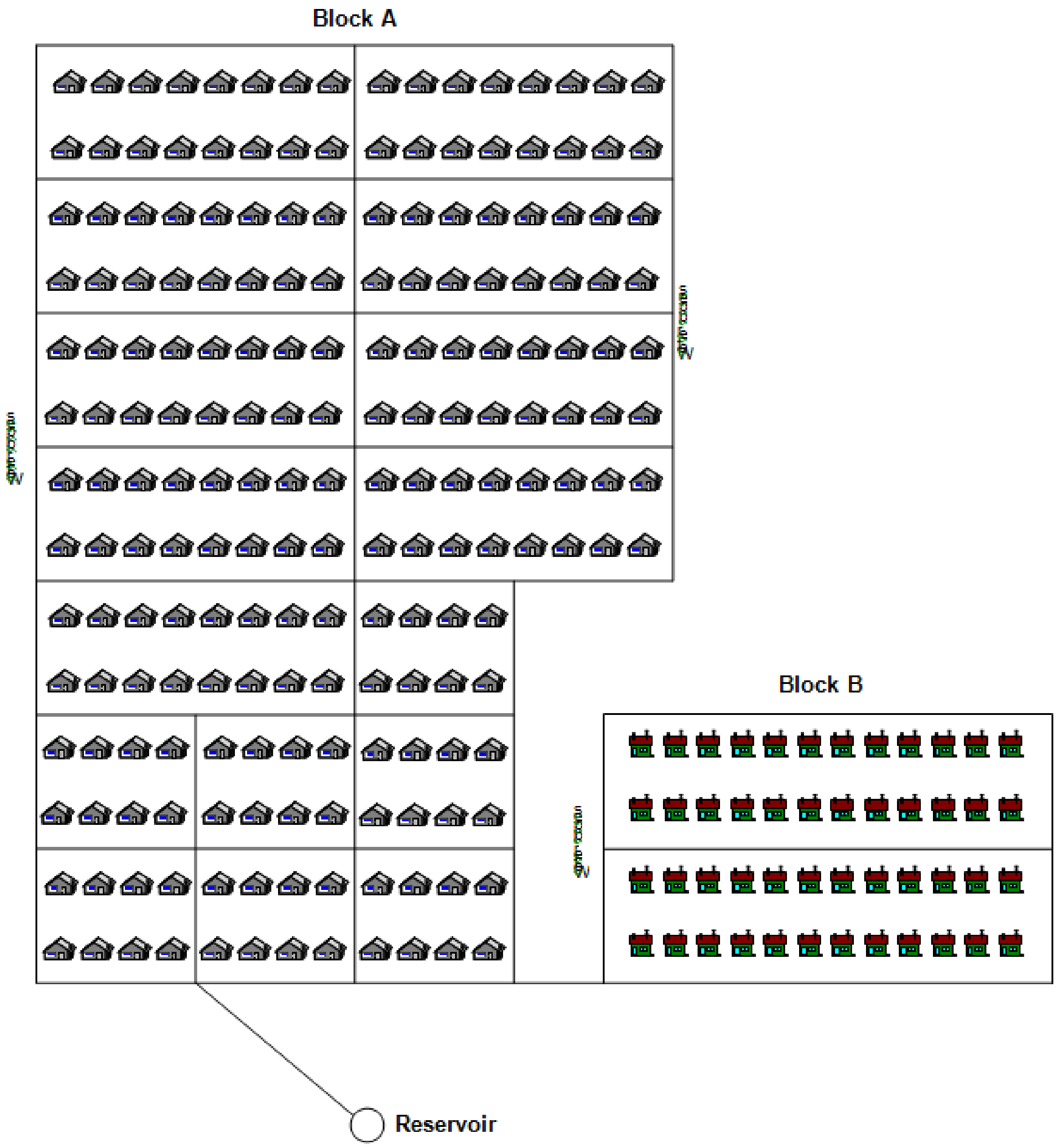

Figure 1: Schematic layout of the water reticulation system of the village.

Water is pumped to the reservoir located on a hill, which is 40 meters above the village. From there the water flows under gravitation to the town and provides the system with water at a pressure of about 4 bar (gauge).

The village consists of 200 houses (Block A) and recent economical development in the region has required the extension of the village with an additional 48 houses (Block B).

OBJECTIVE OF SIMULATION

The objective of the simulation is to model the steady-state operation of the current water reticulation system. The additional houses must then be added and the size of the connecting pipe between the blocks must be investigated to ensure adequate water pressures of at least 2.5 bar at each house.

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FLOWNEX MODEL

The Flownex model of the system is shown in Figure 2.

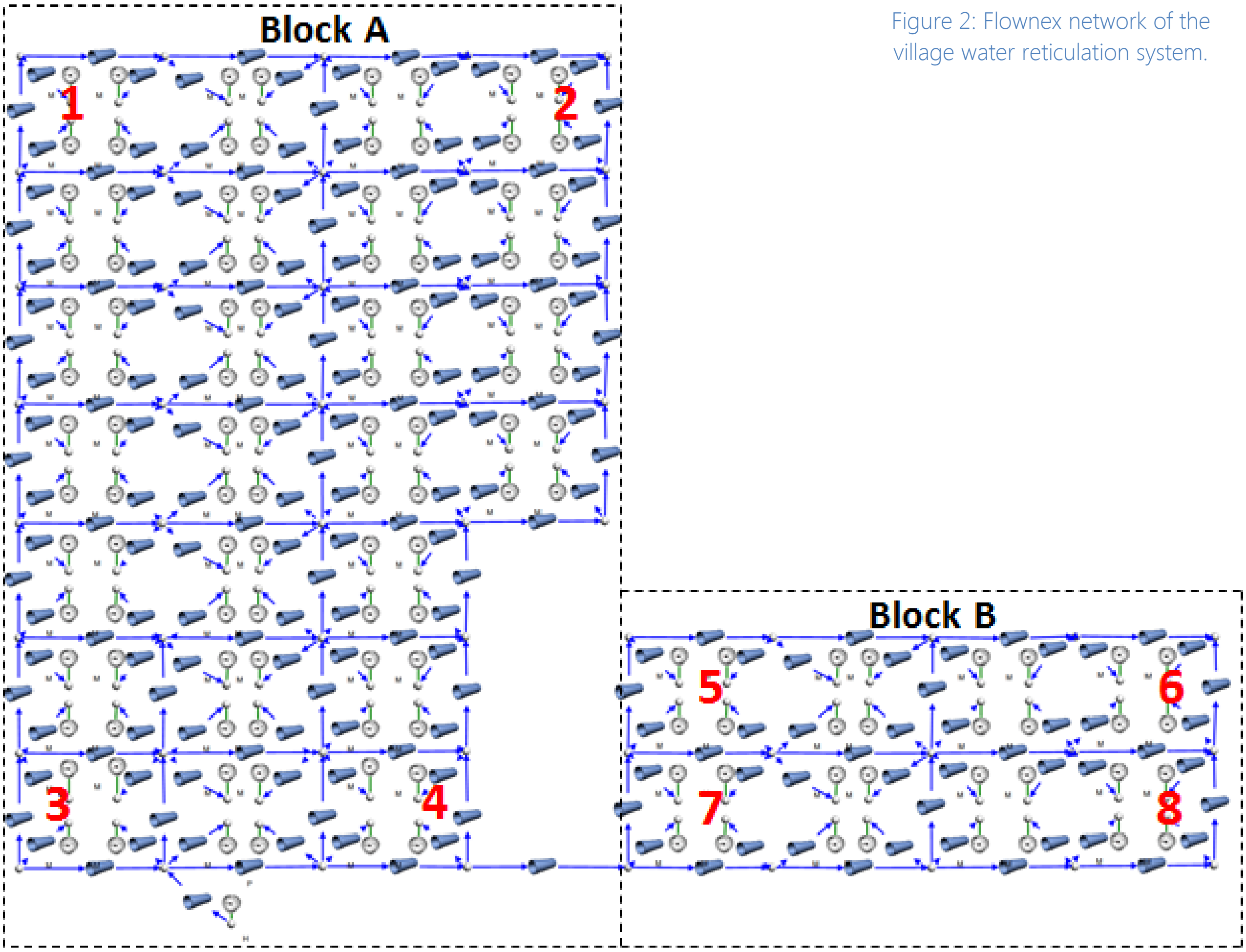

Figure 2: Flownex network of the village water reticulation system.

In the Flownex simulation, two houses were simulated as one node with a combined water tap-off, because in the village, two adjacent houses share one tap-off pipe. These tap-off pipes are supplied with water from the pipe system circling the blocks of houses. The Flownex network is constructed only from pipes and nodes and a fluid with constant properties similar to that of water is used. Each pipe is assigned a roughness of 100 µm and a loss factor of 2 to account for bends, valves and T-junctions.

DESCRIPTION OF SIMULATION

Measurements at the reservoir have shown that the peak water consumption of the village is 50 kg/s. Assuming that in a worst case, all the houses simultaneously use water, the consumption per house is 0.25 kg/s. A mass flow of 0.5 kg/s out of the network was thus assign to each node that represents two houses. Exactly the same consumption (0.25 kg/s per house) will be used for the new houses and the peak water consumption will thus increase to 62 kg/s.

The reservoir is situated 40 meters above the town and a height of 40 meters is assigned to the node representing the reservoir. The rest of the network is at the default height of zero meters. No ambient pressure difference was applied between the reservoir and the consumption point of the houses.

The simulation is done in 4 scenarios:

1. Simulation of the current village layout, only Block A.
2. Simulation of both Blocks, connected with a 0.11 m diameter pipe.
3. Simulation of both Blocks, connected with a 0.15 m diameter pipe.
4. Simulation of both Blocks, connected with a 0.2 m diameter pipe.

RESULTS

Table 1 compares the Flownex results for the different scenarios.

Table 1: Comparison between the different scenarios

Parameter	Units	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Mass flow rate from reservoir	kg/s	50	62	62	62
Pressure 1 (Left top of Block A)	kPa	284.27	263.41	263.41	263.41
Pressure 2 (Right top of Block A)	kPa	284.07	263.19	263.19	263.19
Pressure 3 (Left bottom of Block A)	kPa	312.61	296.67	296.67	296.67
Pressure 4 (Right bottom of Block A)	kPa	307.44	280.71	280.71	280.71
Pressure 5 (Left top of Block B)	kPa	-	246.46	272.37	277.69
Pressure 6 (Right top of Block B)	kPa	-	245.71	271.62	276.94
Pressure 7 (Left bottom of Block B)	kPa	-	247.75	273.67	278.98
Pressure 8 (Right bottom of Block B)	kPa	-	246.06	271.98	277.30
Maximum velocity in system	m/s	1.59	1.97	1.97	1.97

CONCLUSION

The steady-state simulation of the water reticulation system of a village is demonstrated in this example. In order to ensure that all the houses have adequate water pressure during peak demand, various scenarios were investigated. It was seen that a connection pipe of 0.15 m diameter ensures that all the houses have a pressure of more than 2.5 bar.

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