Steady and Unsteady Hydraulic Analysis of Water Transmission Lines and Distribution Network for Al-Qademah City

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ABSTRACT

This is a graduation project that aims to investigate the steady and transient hydraulic design of a water supply system by designing a water supply system for Al-Qademah city. The task to be solved is to determine the most cost-effective design for the water supply system using the following applications (QGIS, Google Earth, EPANET, Excel, and Allievi) and by developing many alternatives for each section of the system and picking the most cost-effective. Following this design process, the following conclusions were reached:

- Future design consumption will be 112,382 m^3/d, with annual transmission line costs of 13,310,868.55 USD/year.
- The cost of the network is 2,151,756 USD/year.
- The annual total cost of the water supply system is $15,462,624 USD/year.
- A network reliability assessment revealed that pipes 136, 156, and 157 had high risk indices, indicating that if they break, they will have the greatest impact on the flow, hence it is advised that these pipes be well maintained.
- Some pipe sizes must be altered to allow hourly demand variations and to resist demand in the event of a fire.
- To safeguard the line that comes from the well, three relief valves must be installed to minimize high pressure and cavitation.
- The regulatory valve must remain open for at least 180 seconds before closing.
- Relief valve rooms have a maximum capacity of 30 m^3.
- Determining the optimal locations for the Air vessel to be stationed by trial and error.
- Reducing the highest pressure of the water wave in the pump line and ensuring it does not reach the cavity.

OBJECTIVS

The following are the objectives for this graduation project:

- Determine the amount of water to be taken from each water source.
- Carry out the full hydraulic design of the main water transmission lines.
- Design the water distribution network for the city using Excel and EPANET2 Packages. Several design alternatives should be developed and analyzed technically and economically to select the most relevant design alternative.
- Transient analysis of the transmission lines and water hammer protection.
- Extended period analysis (EPS) of the water network, and optimization against hourly demand variations.
- Protection against fire demand.
- Checking network reliability and risk index.
- A survey of the literature on the analysis and design of water supply networks and transmission lines.
- The technique for the project is outlined, as well as the procedure for designing the water supply system.
- analyzes the design possibilities and lists the design findings.

LOCATION

Figure 1: Location of Al-Qademah City

Figure 2: Transmission line from desalination plant

Figure 3: Transmission line from well field

Software

Figure 4: EPANET program

Figure 5: ALLIEVI program

Figure 6: Fireflow2l program

Figure 7: QWater program

Figure 8: QGIS program

Elements

Figure 9: Air vessel

Figure 10: Relief valve

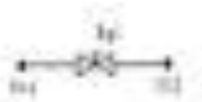

Figure 11: Regulation valve

Figure 12: Pump

RESULTS

Table 1: Future water demand

district	future population	Q l/d/capita	Q l/d	Q m^3/day	total Q m^3/day (average)	Q design m^3/d (max)
A	1632	350	571200	571.2	77251.2	112,381.18
B	104000	270	28080000	28080		
C	180000	270	48600000	48600		

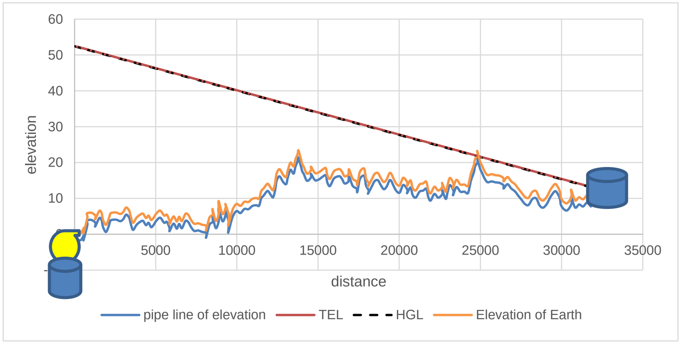

Figure 13: TEL and HGL for desalination plant line

Figure 14: Pipeline, tanks, regulation valves and air vessels for desalination plant line

Figure 15: Pressure envelope for desalination plant line (with water hummer protection)

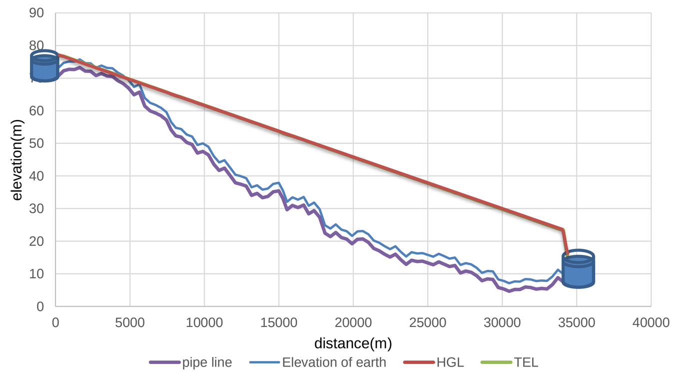

Figure 16: TEL and HGL for well field line

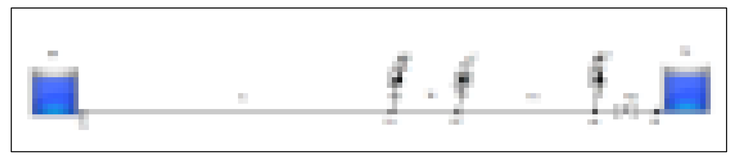

Figure 17: pipeline ,tanks, relief valves, and regulation valve for well field line

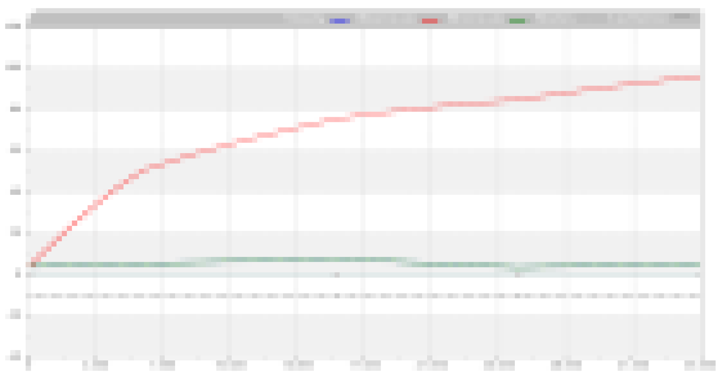

Figure 18: Pressure envelope for desalination plant line (with water hummer protection)

Figure 19: Pipe placements

Figure 20: Network (velocity)

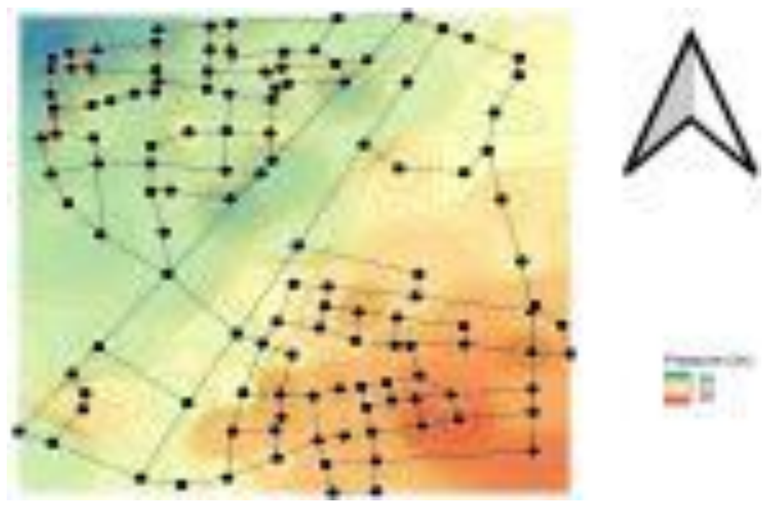

Figure 21: Network (pressure)

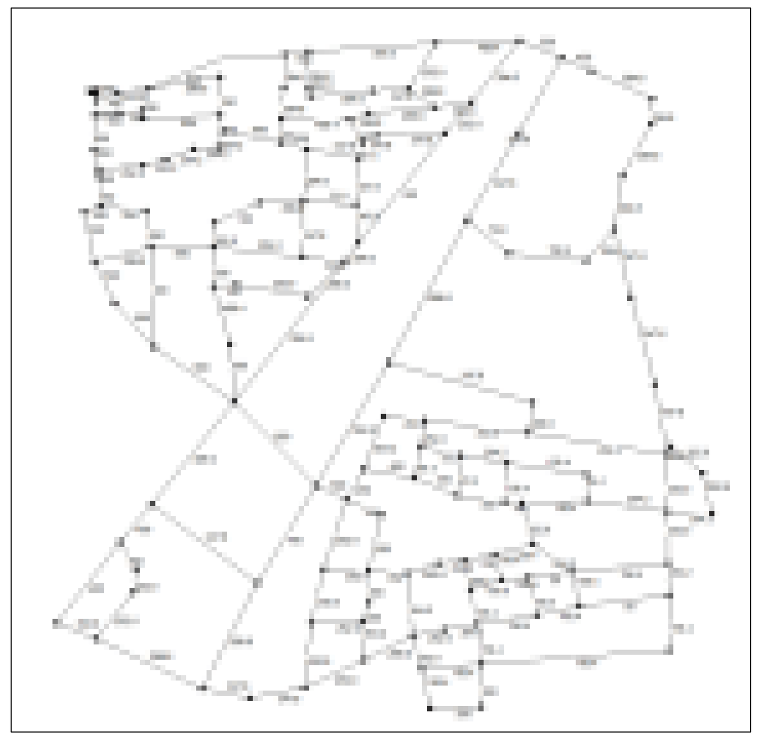

Figure 22: Pipe sizes

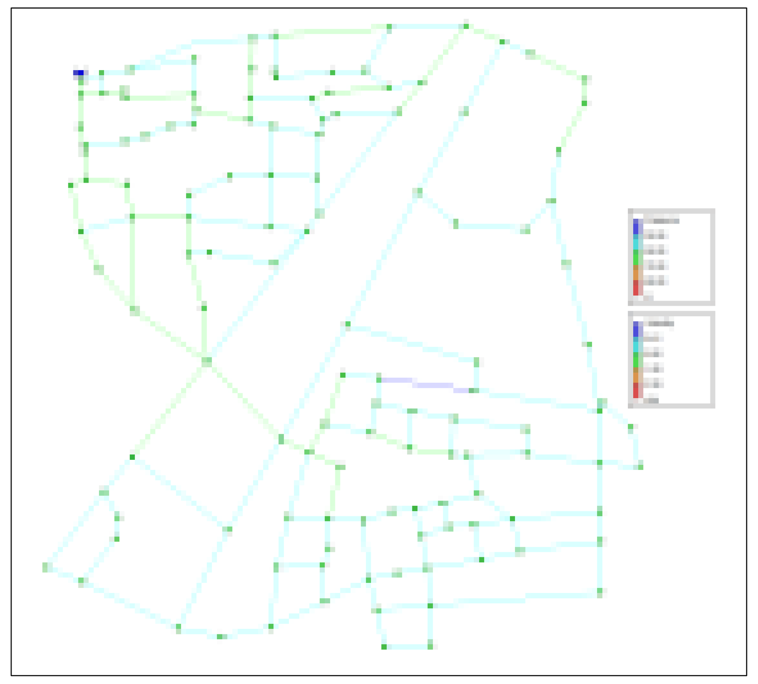

Figure 23: Network velocity and pressure at 7:00 a.m.

Network reliability and risk index

Network reliability is the study of the network in case if one or more pipes are closed (maintenance or failure) and how the provided flow to junctions will be affected. In this project only the case of one pipe closure will be studied. This will be done using EPANET software by repeat and manually closing one pipe at each run, then comparing the original flow in each junction with the new flow.

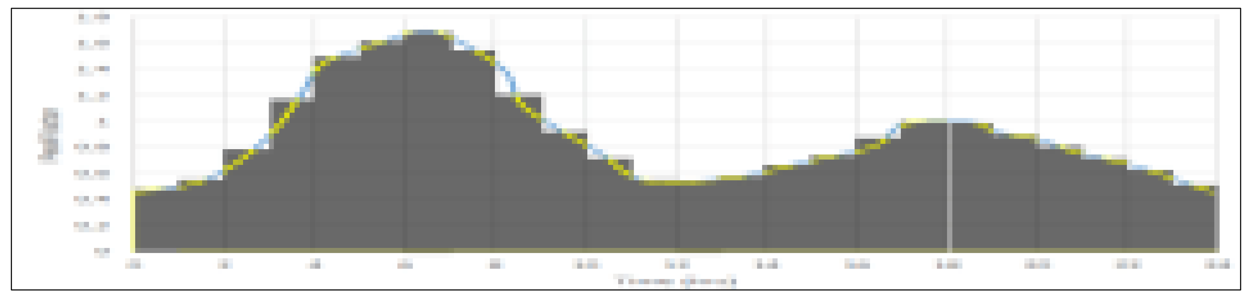

Figure 24: Peak demand factor for each hour in the day

Table 2: Highest risk pipes in case of closure

pipe	Risk index
136	4.98
156	1.89
157	1.72

CONCLUSIONS

- Future water demand of the city found to be 112381 m3/day.
- With the constraints on the water sources for the city it was found that taking 50% of the water demand from each source will yield the minimum cost.
- Transmitting water from the desalination plant needed a pumping station (a system of two pumps), While the line from the well was a gravity line.
- The total annual cost of the Transmission lines is 13,310,869 USD/year. with a diameter of 1100 mm for both lines.
- Three network alternatives were designed but network B costs the least with an annual cost of 2,151,756 USD/year .
- Total cost of the water supply system (network, transmission, pumps and water price) will be: 15,462,624 USD/year.
- The cost per km length was found to be: 2,233,947 USD/km. And the cost per km2 area was found to be: 101,616 USD/km^2. And the cost per cubic meter of water was: 2 USD/ m^3.
- Pipe sizes are optimized to withstand fire flow demand and hourly demand variations.
- Maximum pressure in the transmission lines found to be 173 and 95 meters, And minimum pressure was found to be -4 and 0 meters.
- Regulation valve closure time must not exceed 180 s.
- Relief valve room must be 30 m^3 or more.