Simulation tests for the operation of a water main with break pressure tanks

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Abstract

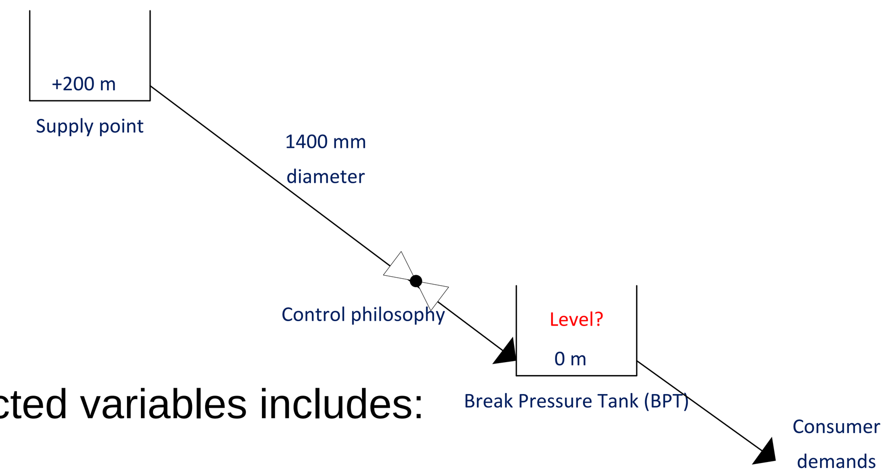
The Western Aqueduct project was conceived by eThekwini Water Services (EWS) to augment current infrastructure and to sustain adequate potable water supply capacity to the rapidly increasing Durban population. The study was initiated at the behest of the Water and Sanitation division of the eThekwini Municipality, and is centered on the Ashley Drive (20 Ml) and Wyebank Road (10 Ml) break pressure tanks (BPTs) that function as pressure-reduction devices for the new Western Aqueduct. Despite the advanced progress with the installation of the Ashley Drive BPT, a working, realistic, hydrodynamic model is still required to undertake simulation studies and evaluate the adequacy of the design. The Western Aqueduct is designed to accommodate anticipated 2036 water supply/demand conditions (peak flow – 400Ml/day). These considerations include the proposed sequencing of the control valves, the speed of valve movements and failure and maintenance modes.

The hydrodynamic simulation model incorporates the trunk main in its entirety, while also accounting for the reservoirs that are supplied by the Western Aqueduct including vital aspects pertaining to these reservoirs, such as the time-based demand profiles (consumer) and level control. Information utilized in the building of the model was sourced primarily from the design information and current-operational results. MATLAB® was selected as the preferred program for the implementation of the model. Inbuilt functions and simple mechanisms were used in conjunction with structured programming principles in order to manage the complexity of the model code. Several solution methods were tested in order to attain the optimum trade-off between model accuracy, model complexity and the resources necessary to obtain meaningful results.

The results of the study are presented as time-sequence plots depicting the results of various random and stress-tests for conditions that range between 2015 and forecasted 2036 conditions. Support for the design concepts, additional recommendations and a heightened ability to anticipate system performance under varying conditions have been derived from the study and are reported in the paper. Concerns regarding the current control philosophy are also expressed.

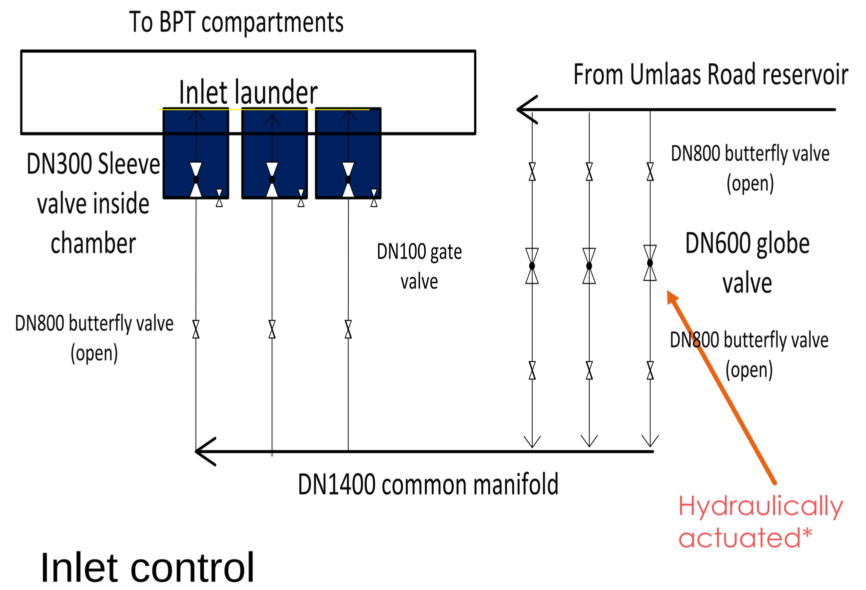
Background

- Task: Analyze the system stability and vulnerability by simulating the BPT tank levels and the system's behaviour for each control system.



- Numerous interconnected variables includes:
  - BPT tank levels
  - Consumer demands
  - Reservoir intake flows
  - System hydraulics (dynamic losses)
  - Static pressure and system topography

Break Pressure Tanks

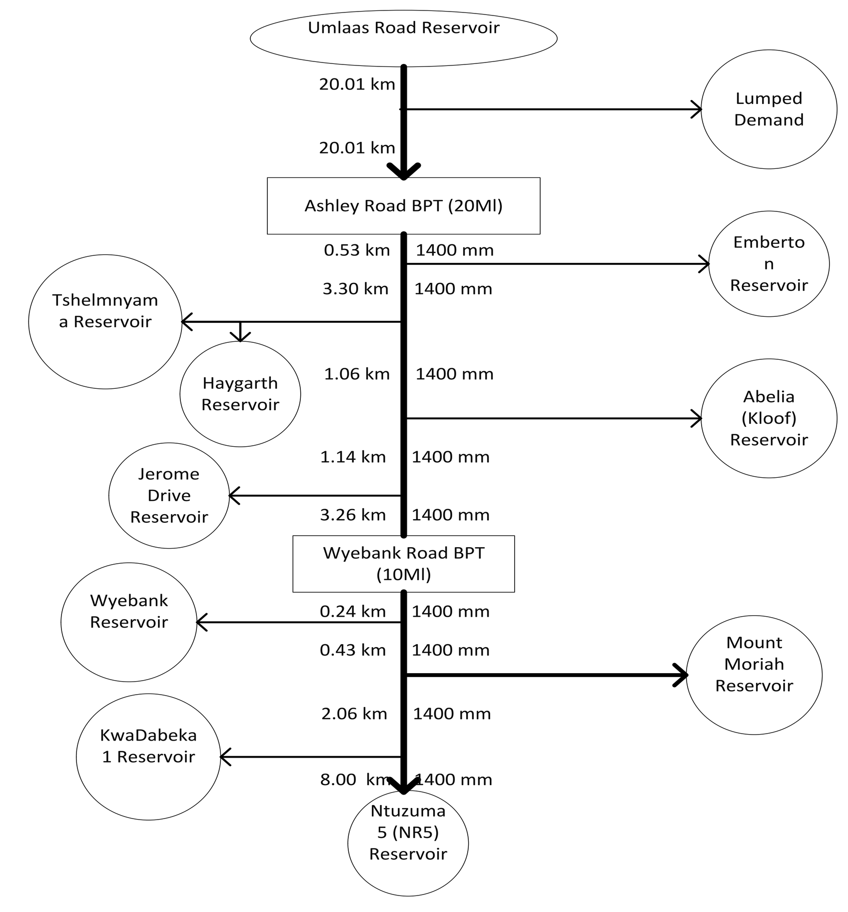


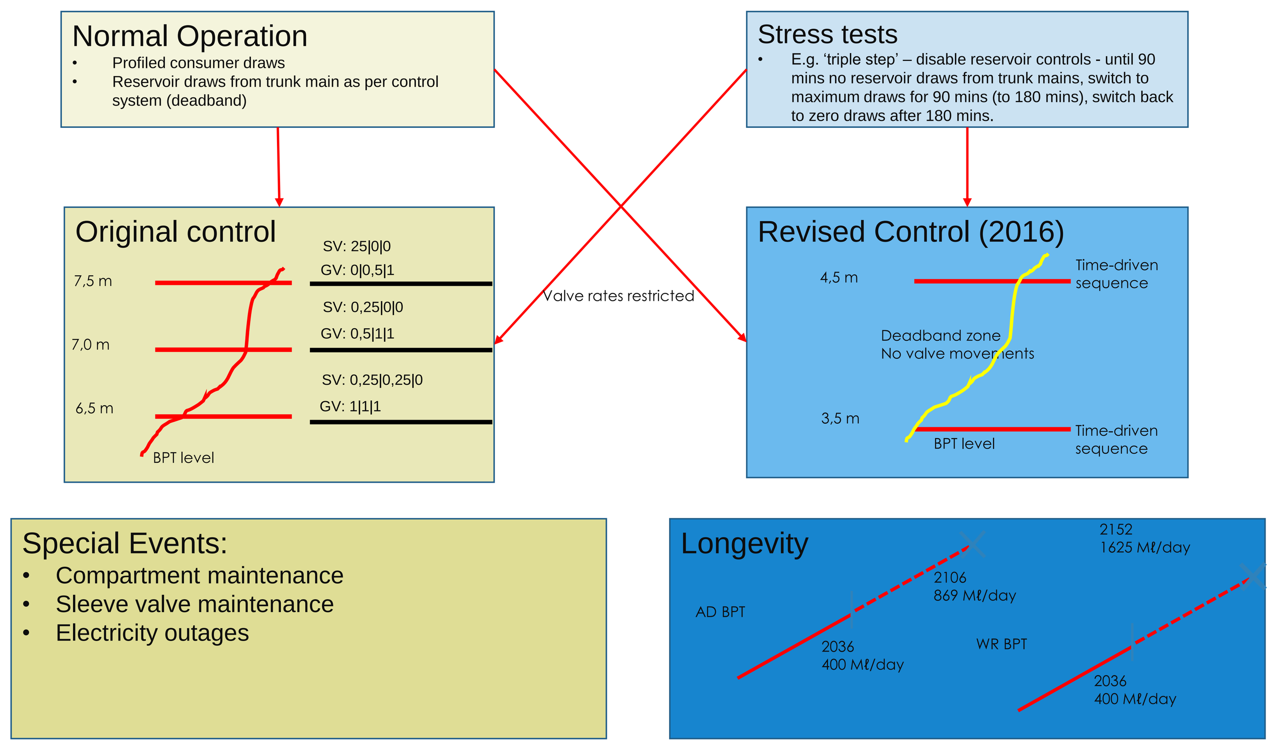
Purpose: Reduce system pressure to manageable levels

- Inlet control
- Bottom-fed
- Parallel offtakes – both globe valves and submerged sleeve valves
- Common inlet chamber + overflow weir

Western Aqueduct system

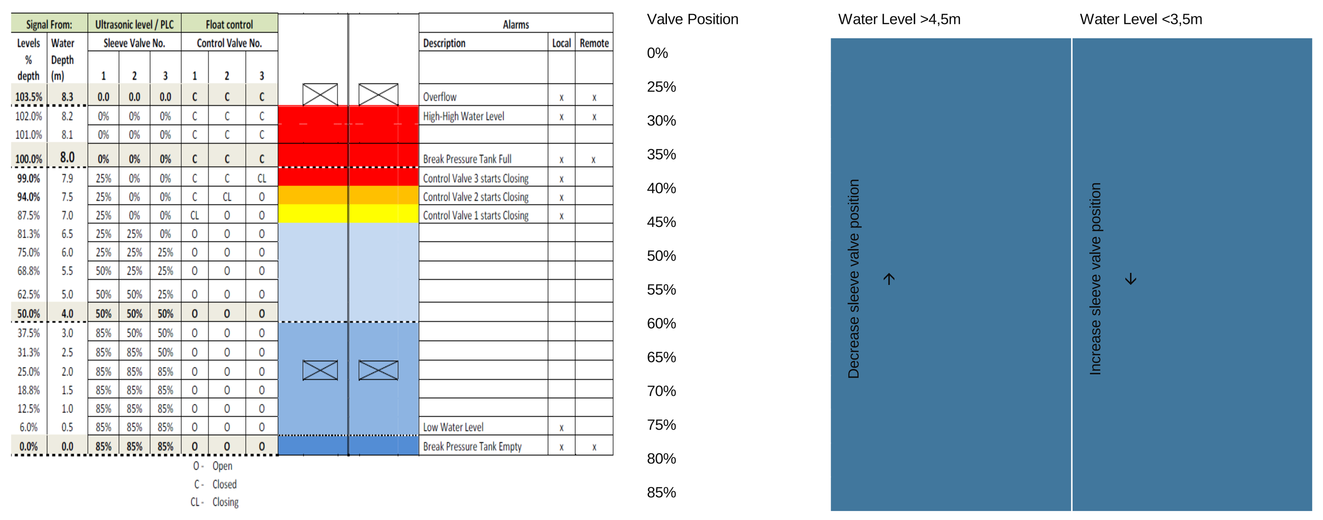
- Skeletonization :
  - Hydraulically simplify the complex pipeline network
- Account for:
  - reservoir draws from trunk mains
  - Consumer draws from reservoirs
  - Pipeline pressure profiles
  - BPT levels





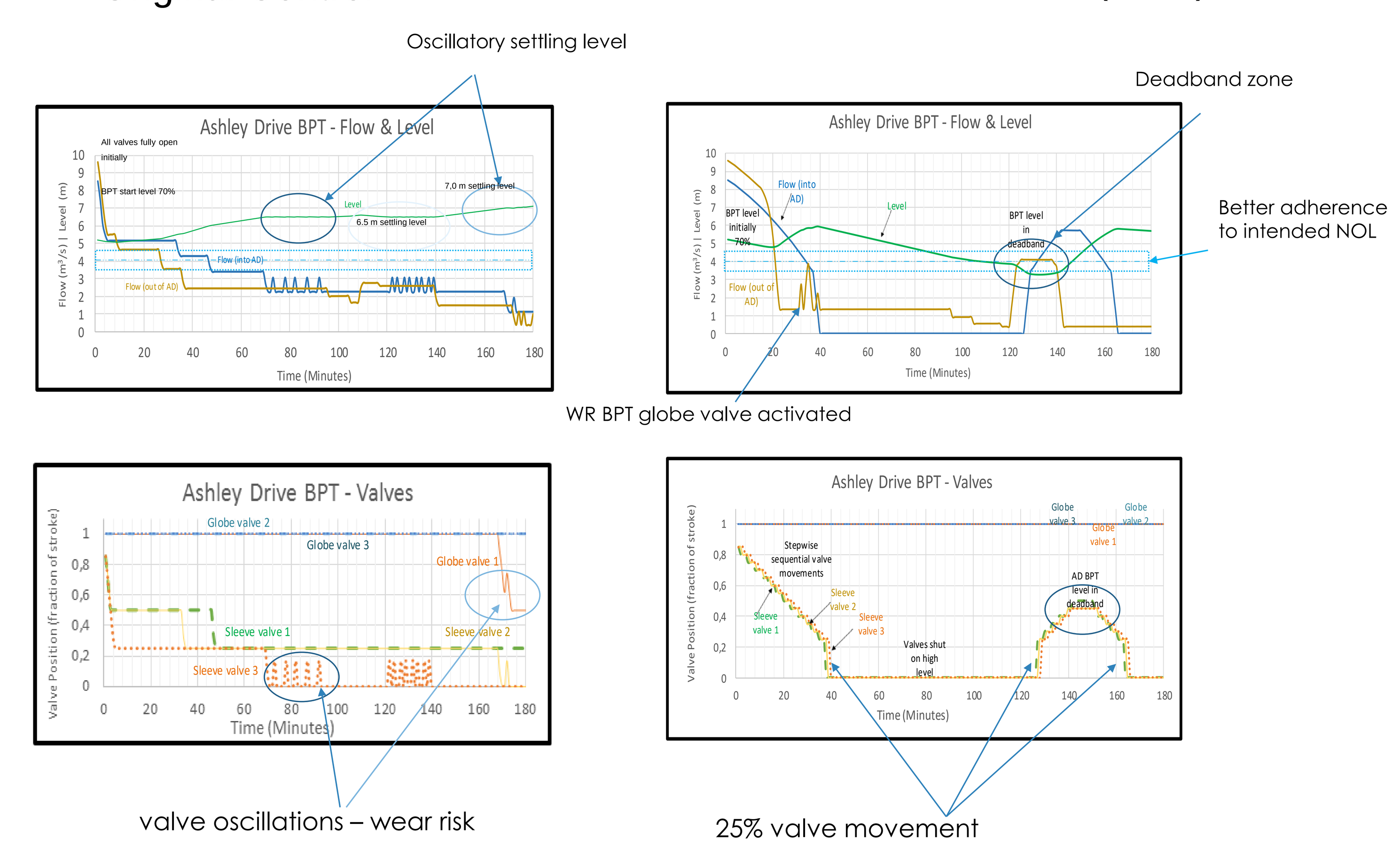
Control systems

Staggered valve movements & Restricted valve movement rates

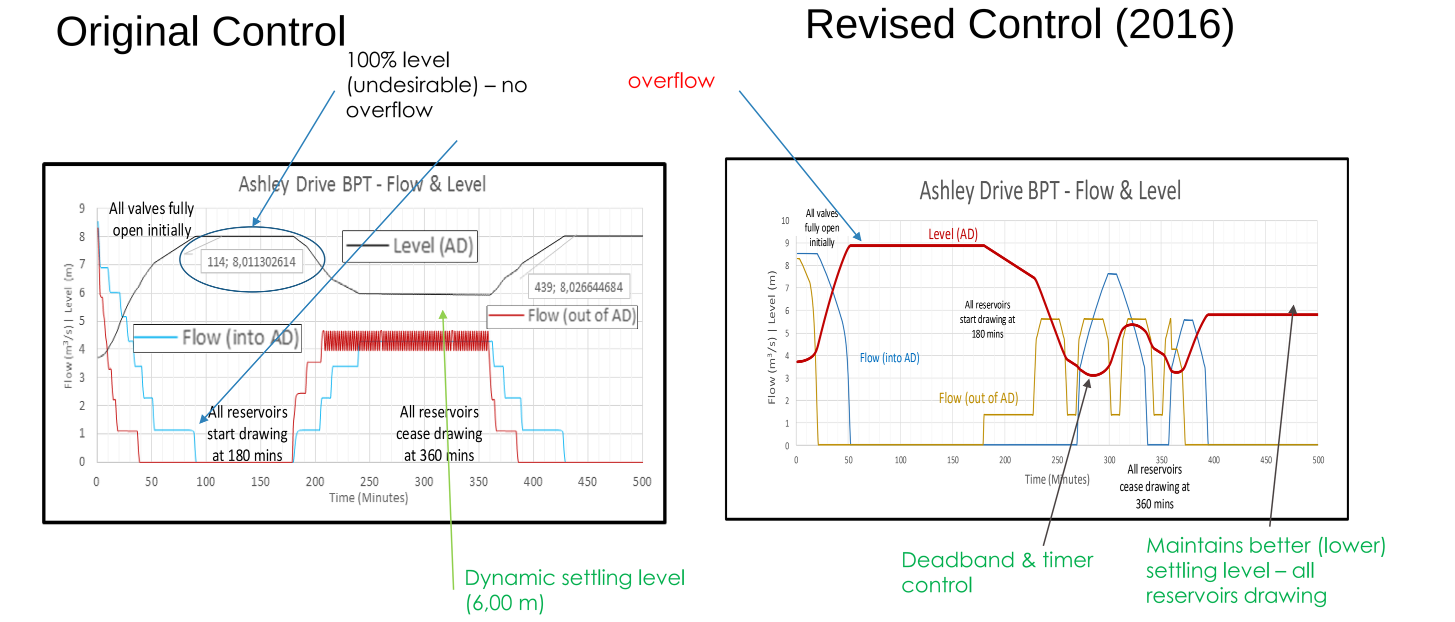


Results

Normal Operation



3-Step stress test (nil/full/nil)



Findings

- Robust, capable of handling most special events
- System viable until **2106**
- Overflows likely with high demand variations– ample drainage
- Water loss consideration – no override 'smart' controls – higher than intended maximum flow (~double)
- Globe valve action – deviation from design intent of intervention only during power outages.
- Valve oscillations – maintenance risk
- NOL (normal operating level – 50%) – not adhered to in original control – improved with revision
- Transient overpressures (7 bar) – significant consideration
  - Maintenance & wear