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Report to Utility Services Committee
from Keith Woolley, Asset Engineer

System Optimiser

1. Purpose

To provide information on the recent commissioning of a system optimiser.

2. Introduction

The optimiser is essentially computer software that controls the Wainuiomata and Waterloo Water Treatment Plants and associated pumping stations. It enables water to be treated and delivered at the lowest marginal cost.

Generally capital expenditure projects are infrastructure oriented. Often they use proven technology and invariably perform as expected, for example, pipeline refurbishments.

Development of computer software is different. The end result is lines of software code designed for a specific purpose. For this reason the risk analysis process undertaken as part of this development was particularly important.

An optimisation system (Optimiser) for the Wainuiomata and Waterloo Water Treatment Plant (WTP) supplied wholesale water supply system was fully commissioned in July 2000. The key of objectives for the Optimiser were to:

- Maintain supply of water within system constraints
- Use the cheapest source of water
- Reduce overall power costs

Consultants, Beca Carter Hollings and Ferner (BCHF) developed the Optimiser. Planning for the project started in 1998. Commissioning commenced in March 2000.

In the New Zealand context, the Wellington Regional Council (WRC) is the third water organisation to undertake an optimisation project of this kind. BCHF have implemented an optimisation solution for the New Plymouth and Hamilton water supply systems. The

Optimiser would be the most extensive and complex water supply optimisation project in New Zealand.

The cost of investigation work for the project totalled approximately $35,000. Design and implementation costs for the project totalled approximately $325,000.

3. How the Optimiser Works

The optimised system includes:

- Three WTPs supply water; Wainuiomata, Waterloo and Gear Island (emergency standby plant)
- Eleven customer owned reservoirs; Wainuiomata No. 1 and No. 2, Point Howard, Gracefield, Naenae, Rahui, Ngaio, Onslow, Rahui, Carmichael and Macalister, and their associated WRC owned pumping stations along with the Thorndon Low Level Zone
- Water pumped up, or gravity fed down, the Ngauranga Gorge to or from the Te Marua system when required

The Optimiser operates by scheduling pumps and WTPs 'over the top of' the existing control systems. Complex software, including linear programming along with a hydraulic model and nearly 20 user interface screens, form the Optimiser.

Optimisation takes account of daily demand variations, available supply capacity, system constraints, and chemical and power cost information.

At 8am every day optimal pump and WTP daily schedules are prepared for 48 half-hour periods until 8am the following day, then every half-hour these schedules are updated based on real time demand data and reservoir levels.

3.1 Cost Information

The Optimiser supplies water from the lowest cost source based on fixed or calculated chemical power costs. Pumping is scheduled to minimise costs. Power costs include both network and energy.

Energy charges are a two-tariff per day structure with different rates for weekends and weekdays that change every month for each pumping station and WTP. If in the future the tariff structure is altered, the Optimiser can handle half-hourly power tariff changes. The low tariff period (night tariff) is from midnight to 8am. For instance, for the Waterloo WTP night tariffs vary throughout the year from 1 to 3.5c/kWh and day tariffs from 2.7 to 5.5c/kWh.

Network charges are a monthly charge based on coincident maximum demand (CMD) and anytime maximum demand (AMD). The CMD charge is the highest half hour power consumption for the month between 8 am and 10 am and 5.30 pm and 7 pm on any weekday. The AMD charge is the highest half hour power consumption for the month.

3.2 Demand Prediction

The Optimiser predicts reservoir and supply point daily demand. Demand can vary significantly within each day, from day to day, from weekday to weekend and from season to season.

Standard weekday and weekend demand curves for winter and summer are stored in the Optimiser. At 8 am, the standard demand curve is adopted. Every half-hour an algorithm adjusts the standard demand curve based on reservoir levels and pump flows or actual demand telemetered from customer demand meters.

3.3 Available Reservoir Capacity

The Optimiser maximises the use of the limited operating reservoir capacity available. Pumps and WTPs are scheduled to maintain reservoir levels between operator adjustable minimums and maximums. Reservoir levels are generally as outlined in the 1997 Draft Wholesale Water Supply Agreement and range from 60 percent to 95 percent. Local controls override Optimiser control by starting or stopping pumps should levels go beyond present minimums and maximums.

3.4 Optimisation

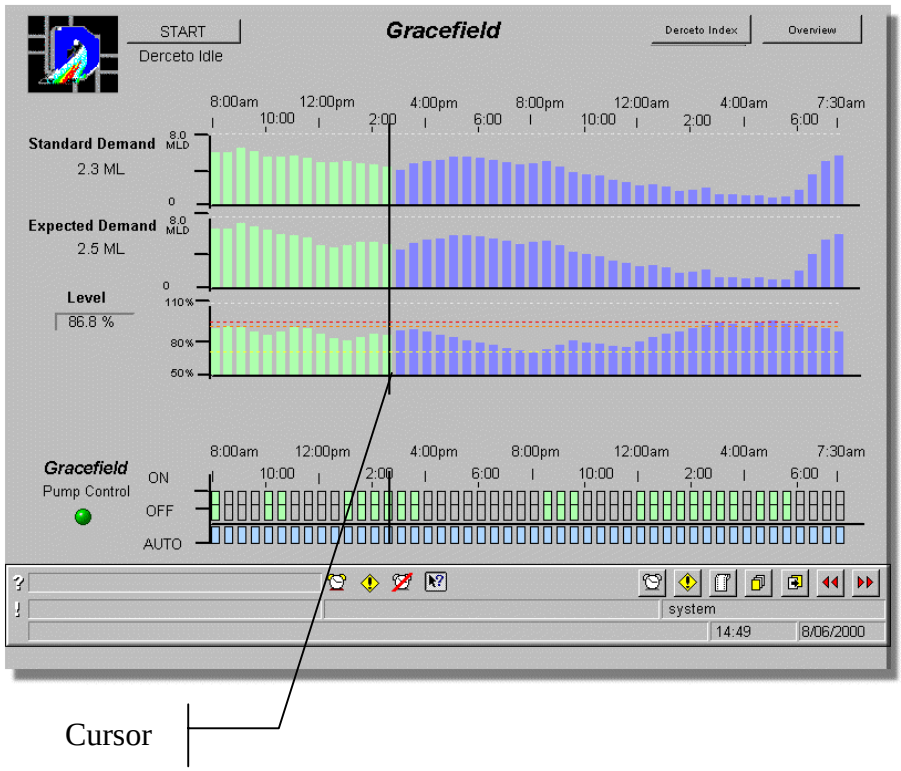
Water is supplied from the lowest cost source of water. Typically, reservoir levels are lowest at midnight and highest at 8am to maximise night pumping. Having the reservoirs full at 8am allows storage to be used to avoid pumping during the 8am to 10am CMD period. Reservoir levels are increased before 5.30pm to enable reservoir storage to be used to avoid pumping during the 5.30pm to 7pm CMD period.

The current CMD charging regime means that, if there is pumping for even one half-hour during CMD periods within a month, CMD charges are incurred. This, along with operational, demand and shutdown requirements, makes avoidance of CMD charges at pumping stations and WTPs difficult.

3.5 Typical Optimiser Interface Screen

An operator interface screen for Gracefield Reservoir for 8 June 2000 at 14:49 hours is provided below. The screen shows standard demand, predicted demand, reservoir levels and pump schedules. Actual recorded data is displayed after the cursor and predicted data before the cursor.

Note that expected demand is similar to a standard demand day. The reservoir is full at 8am to avoid pumping during the 8am to 10am CMD period. Reservoir storage is increased in the afternoon to avoid pumping during the 5.30pm to 7pm CMD period. The predicted reservoir level is near minimum level near midnight and near maximum level at 8am the following day to maximise night pumping.



4. Benefits

Benefits from the operation of the Optimiser are mainly from power savings, chemical savings and reduced environmental impacts. Reported benefits are based on an assessment for the three months since full commissioning.

4.1 Energy Savings

Power savings are predominantly from shifting pumping from high day tariffs to lower night tariffs. It is estimated that energy savings for the three months of approximately $12,000 have been made. This amounts to approximately 10 percent of the energy bill. Increases in available operating storage would increase potential energy savings.

The shift in pumping to night rates is particularly noticeable at Waterloo WTP, as shown on **Attachment 1**, *Waterloo WTP Night Energy as a percentage of Total Energy Use*. For Waterloo WTP night pumping has increased from approximately 23 percent to 45 percent. Approximately 80 percent of energy use under control of the Optimiser is at Waterloo.

Other pumping stations have also shown increases in night pumping since commissioning of the Optimiser of approximately:

- 10 percent to 50 percent for Moores Valley Pumping Station
- 15 percent to 30 percent for Wainuiomata Pumping Station
- 20 percent to 40 percent for Point Howard Pumping Station
- 17 percent to 30 percent for Kaiwharawhara Pumping Station

The three months of assessed savings to date suggest an annual saving of around $50,000 per year in energy costs.

4.2 Network Charge Savings

Network charge saving opportunities are mainly from CMD avoidance. CMD avoidance is more attainable in the winter demand months when there is more reservoir storage in relation to demand. The greatest opportunity for CMD savings is at Waterloo WTP where a $2,800 saving was achieved in September. CMD avoidance at Waterloo is very dependent on operational requirements (such as system shutdowns, the availability of Wainuiomata WTP water every day to maintain pressure at Thorndon, pump failures, etc.) and demand. Based on September's savings, allowing for eight months of winter demand and some operational requirements, a saving of $15,000 per year is possible.

If the CMD charging regime is changed by the network provider to a favourable daily rather than monthly basis, savings could be increased.

4.3 Chemical Costs

Currently Wainuiomata WTP marginal production costs per cubic metre are on average approximately two cents more than that of Waterloo WTP. For operational reasons Wainuiomata must always operate above a 20 MLD minimum flow when suitable source water is available. Waterloo WTP's lower cost means that Waterloo supplies Wellington in preference to Wainuiomata, except when Waterloo has insufficient capacity or it is cheaper to supply from Wainuiomata during the CMD periods.

Prior to commissioning the Optimiser, the Wainuiomata WTP operated at a constant flow set by operators each day.

Chemical cost savings achieved by supplying water from Waterloo rather than Wainuiomata for the three months since full commissioning are approximately $10,000. These savings have been achieved during a typical winter demand period. Annual savings are estimated to be approximately $20,000.

4.4 Environmental Benefits

The Environmental Management System target "*4.2.3: Reduce power use during coincident charge hours*" was achieved with commissioning of the Optimiser. Peak energy use during the CMD periods has been reduced by over 80 percent since full commissioning of the Optimiser. The reduction is shown on the graph in **Attachment 2**.

4.5 Other Benefits

Implementation of the Optimiser has brought about a number of other benefits including:

- Calibration of pumping equipment, pressure transducers and reservoir level instrumentation
- Demand prediction capability through use of the customer's demand meters
- Improved capability to focus on cost savings
- Certainty that least cost energy is being used

- Certainty that best use is being made of lowest cost water
- A review of pumping equipment
- Ability to reflect possible future energy cost tariffs and source costs in system operation

4.6 **Summary of Benefits**

Estimated economic benefits can be summarised as:

Energy saving	$50,000pa
Savings in network charges	$15,000pa
Savings in chemical costs	$20,000pa
Total	$85,000pa

These savings suggest that the $360,000 investment in the optimiser will be recovered within four to five years.

5. Communications

Presentation of a technical paper jointly by BCHF and WRC staff at the 2001 NZWWA Conference in Wellington, and possibly the next Australian Water Association conference, is proposed. A paper is also being considered for an energy journal.

6. Recommendations

That the report be received and the information noted.

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Attachments

Attachment 1 Waterloo WTP Night Energy as a percentage of Total Energy Use
Attachment 2 Wainui-Waterloo System 99/01