The Optimatics Letter

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Customized Pumping Optimization

Over the past 10 years, a growing number of water utilities have embraced the Optimatics Genetic Algorithm (OGA) approach to optimizing their distribution system improvements. Dozens of OGA studies have achieved projected cost savings of 20% to 50% compared to the utilities' existing master plan or CIP solutions. The optimized solutions have also proven to better solve system deficiencies, to exhibit a decrease in water age, and to achieve improved system reliability and redundancy.

To optimize a water master plan or CIP, the OGA model is first customized and linked to the existing hydraulic simulation model. The OGA searches for the best mix of up to 400 or so decision variables—pipe, tank, pump and valve locations and sizes, as well as pump and valve operational settings. The optimization objective is to minimize project life-cycle or capital improvement costs while also meeting the utility's specified design and performance criteria. In a typical study, 20-30 million individual trial solutions are created and evaluated (running each one in the hydraulic model) to develop the best solution alternatives.

Customized OGA for Pump Operations

Minimizing pumping costs is another powerful GA optimization application that greatly benefits from the capability of customizing the Optimatics GA model to suit the water utility's specific situation. In this case, the decision variables are the individual pump start and stop times and the corresponding "trigger levels" for the discharge reservoirs. The OGA searches for the best mix of pump starts and stops for all pumps over a short-term forecast period, say one week. Pumping costs are minimized based on a reduction in pumping heads, and a shift to pump more during off-peak periods while also avoiding high demand charges. Specific constraints are included in the optimization setup for storage target and operating levels, pump availability, maximum number of pump starts, etc.

In the case study described below, Optimatics designed customized OGA software with extensive input from the utility's operations staff. The result was an easy to use yet highly functional tool that fully met the end users' requirements.

YVW Requests an OGA Tool

Yarra Valley Water (YVW) in Melbourne, Australia, having completed a successful OGA distribution system study, expressed interest in a pump operations optimization tool to help reduce system operating costs. YVW wanted a customized OGA software tool that its operators could use on a daily basis to update their operating plans. In

(Continued on page 2)

Yarra Valley Water is evaluating the potential of its customized OGA operations optimization tool to help them save on pumping costs

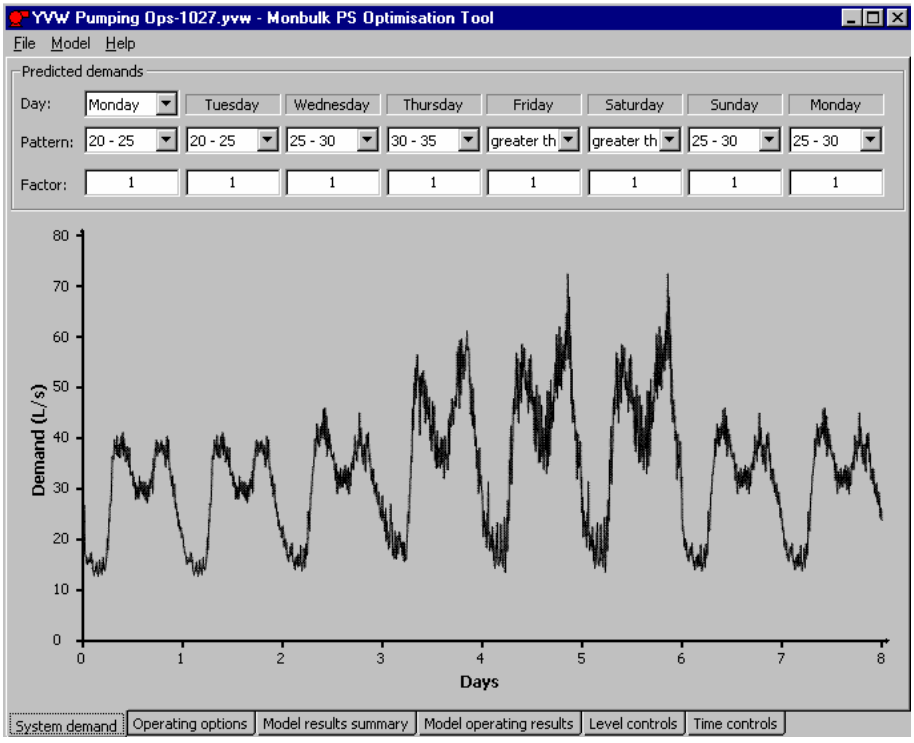

Figure 1. YVW Operations staff input estimated system demands for the next 8 days based on historical relationships between temperatures and demands. (Note that 20°, 25°, 30° and 35°C correspond to 68°, 77°, 86° and 95°F.)

addition to reducing operating costs, YVW also wanted its operators to be able to investigate a range of operating strategies at the pump station to enhance their decision making abilities.

YVW proposed the OGA tool be developed for the McCarthy Road pump station. This facility was chosen based on its water supply simplicity, its criticality to the system operation, and the fact that pump station operating costs make up a large proportion of YVW's total operating costs.

Monbulk Pumping System

YVW's McCarthy Road pump station (six pumps in total) draws water from Monbulk Reservoir and pumps it about 6 km (4 mi) to the Olinda Township Reservoir, comprising three tanks—two 4.5 ML (1.2 MG) tanks and one 16 ML (4.2 MG) tank. Typical summer arrangements consist of the 16 ML (4.2 MG) tank combined with one or two of the 4.5 ML (1.2 MG) tanks being online, depending upon demand and the minimum storage required to meet the risk of bushfire. In winter, either the 16 ML (4.2 MG) or the two 4.5 ML (1.2 MG) tanks are typically online.

YVW extracted the critical pumping elements to create a simple hydraulic model to which the OGA could link. The model included:

- The Monbulk Reservoir from which the pumps draw water
- The McCarthy Road pump station (6 pumps in parallel)
- A rising main leading to the Olinda Reservoirs (3 connected tanks on a hilltop)
- A single demand pattern approximating the network supplied by the tanks.

YVW determined the demand supplied by the tanks using SCADA data. This data was processed into system demand profiles for different conditions including temperatures. Using the SCADA data, YVW operations staff are able to forecast demands to be drawn from the tanks based on weather conditions over the previous week.

OGA Ops Tool Look & Inputs

YVW and Optimatics agreed the OGA pump operations tool should have a custom-built graphical user interface and optimization module. YVW tested a prototype version of the software and then provided feedback that helped improve the layout and usability of the final user interface.

The OGA tool is set up to optimize the operation of the McCarthy Road pump station over a period of 8 days. YVW staff establish service requirement goals for the period which the optimized solutions attempt to satisfy. The service requirements that can be input include:

- The predicted temperature range over the next 8 days
- The minimum storage levels allowed for each of the 8 days
- Minimum storage levels at key times during the week
- Pump operational constraints (available pumps; starts per hour; etc.)

These input data fields can be seen on the two input screenshots shown in Figures 1 and 2. In addition, YVW staff are able to make useful adjustments directly in the hydraulic model, such as updating the pump operating curves and pump efficiency curves as pumps are maintained, replaced or decommissioned.

OGA Operations Tool Outputs

YVW runs the OGA tool on a daily basis using an 8-day forecast of demands and pump availability to identify an optimized strategy that minimizes pumping costs. The specific operating decisions are displayed to the user in a set of output pages in clear graphical

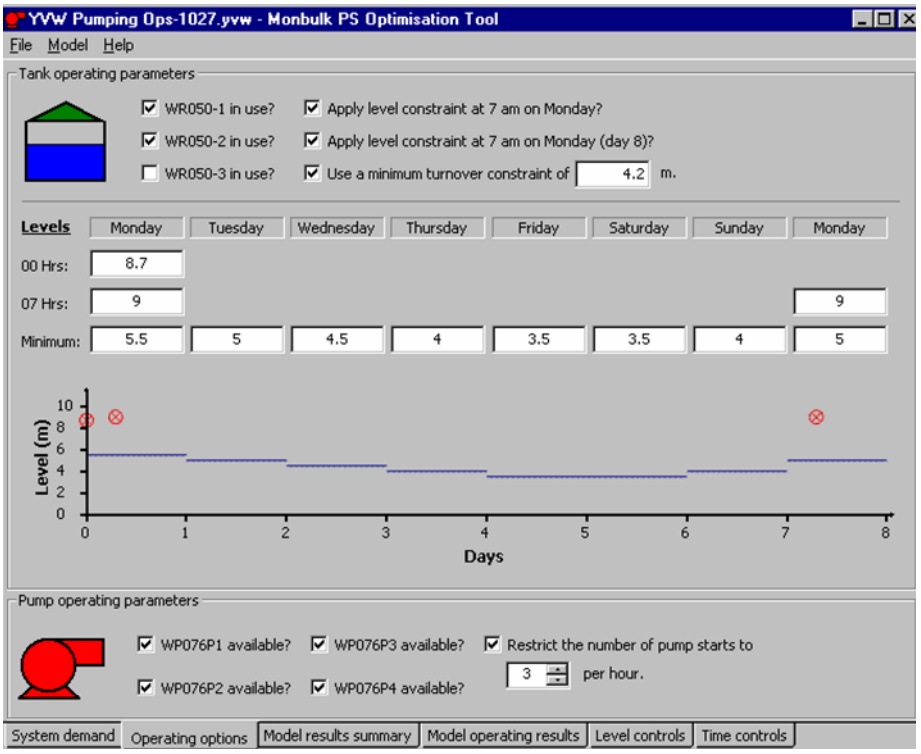

Figure 2. This input data screen is used to specify the available tanks and pumps, maximum number of pump starts, minimum tank drawdown, tank starting level, minimum tank levels each day, and level constraints at other key times during the week.

format. Two of the results output screens are configured to look like views found on the existing pump station operations control panel. For time-dependent data, plots are used to show how the data varies over the 8 days.

The outputs include:

- Start and stop time control settings
- Level control settings for each day
- The number of pumps required, with highlights to show where more than two pumps are required to be running at the same time
- The water level of the tanks, highlighting where the minimum level requirements have not been met, if at all
- The operating cost of the pump station, including the demand charge incurred at maximum capacity usage
- The operating efficiency of the pump station

Figures 3 and 4 show two of the OGA tool output screens. These screens are updated continuously as successive trial solutions improve on the performance of the earlier solutions in an OGA run. Near-optimal operating solutions are identified relatively quickly for the YVW McCarthy Road pump station due to the limited number of pumps and operational decisions.

How Pumping is Optimized

Optimatics developed the OGA pump operations tool using an iterative process of testing and fine-tuning to determine the most efficient approach to use. The best results were produced when the OGA tool was configured to select a combination of off-peak pumping (using time control settings) and tank trigger levels to stop pump #1 each day. Other approaches were tested, but this combination achieved the best balance of reliability, complexity and ease of use for this particular pumping system application.

The OGA tool selects a set of time control settings for each of the off-peak periods. For weekdays, the number of pumps required and the number of hours for which the pumps should operate are chosen by the tool. During the weekend the tool selects the number of hours to wait before starting to pump, and the number of pumps to use. This configuration ensures that most refilling is done during the weekend off-peak times.

Because the model seeks to minimize the static head pumped over the 8 days, the minimum allowable tank levels, as well as on-peak pumping, guides the way the tank levels are varied over the 8-day period. When the optimization tool is configured to start late in the week and high-demand scenarios are analyzed, sensible minimum allowable tank levels are needed to ensure that the tanks refill.

When run with high demands and low available storage volume, the optimization tool has the option to use a relatively small range between the pump start and pump stop values. This can act to minimize the static head pumped during on-peak, while maintaining tank levels above the minimum level specified.

Current Status

Yarra Valley Water is currently utilizing the OGA operations optimization tool at its McCarthy Road pump station facility and is evaluating its potential to achieve pumping cost savings. Data on cost savings are not yet available since the project has just recently been completed.

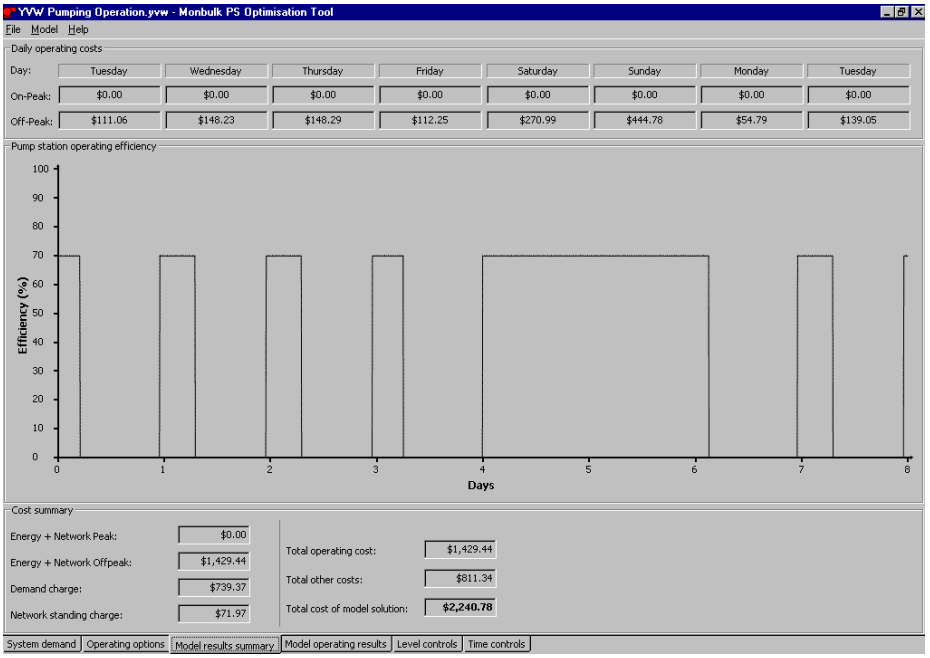

Figure 3. This output screen reports calculated on-peak and off-peak energy costs, demand charges and other costs, as well as the pump station operating efficiency. The screen is updated as each OGA trial solution is evaluated.

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Advances in optimization for water utilities and consultants

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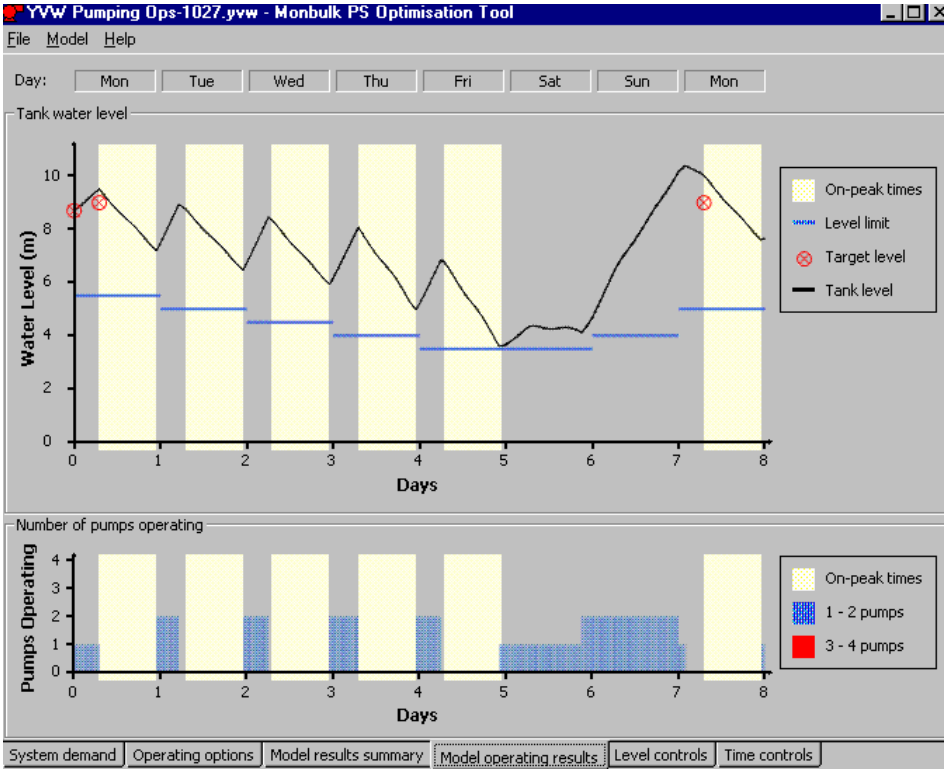

Yarra Valley Water in Melbourne, Australia guided development of its own customized OGA optimization tool to meet its operators' needs while minimizing pumping costs.

Figure 4. This output screen displays the tank level profile and number of pumps operating during on-peak and off-peak times for the best OGA-optimized solution developed so far in the optimization run.