The Optimatics Letter

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Private Reclaimed Water Scheme

The Willunga Basin Pipeline Project in South Australia is a privately funded reclaimed water scheme with some innovative engineer-ing and development features. Stage 1 of the project was completed in 1999 and over the past two seasons has successfully served the 15 water users who funded the scheme. In this last 2000-2001 season they expanded the scheme to 54 outlets by licensing third party users. Some 1,400 ha (3,500 ac) of cropland, mainly vineyards, are being irrigated. Avail-able reclaimed water and land resources could support up to a four-fold expansion of the project.

Project Setting

The Willunga Basin is located south of metropolitan Adelaide between the Sellicks Hill Range to the east and the Gulf St Vincent (Southern Ocean) to the west (see map on back). The area is noted for recreation and tourism associated with its vineyards, almond orchards and beaches. The Willunga Basin is home to 50 wineries and the world-renowned McLaren Vale grape-growing region.

Historically the Willunga Basin growers have been served by groundwater. In recent years, however, both groundwater levels and water quality have been in decline at a time when international demand for the region's wine was growing rapidly. Average groundwater use is also higher than the sustainable yield of the local aquifers. Some vineyards have purchased potable water at Aus.$900/ML (US$1.80/1,000 gal) and then carted it by tanker truck from town out to the fields.

Ten kilometers (6 mi) north of Willunga Basin is the Christies Beach Wastewater Treatment Plant (CBWWTP), one of four metropolitan treatment works. Following conventional treatment, wastewater is chlorinated and then discharged to the sea via a 400 m (1,320 ft) outfall pipe. The average plant discharge is 26 ML/day (6.9 MGD) or 9,500 ML/yr (2,510 MG/yr), which compares to an annual groundwater irrigation use of 7,500 ML/yr (1,980 MG/yr) in the basin.

Willunga Basin Water Company

The Willunga Basin Water Company (WBWC) began as a group of 15 water users who recognized that reclaimed water would allow them to pursue their core business of irrigated horticulture, mostly vineyards. Project plans were developed by Hydro-Plan in close cooperation with the users group. Government approval was required to access the water, then WBWC had to win a tender for the right to negotiate a 40-year license agreement with SA Water, a South Australian government corporation. Project design approval was granted in July 1998.

No government funds were used on the Willunga Basin Pipeline Project. The water users group completely funded the pipeline at a cost of Aus.$7.2 million (US$3.8 million). Individuals contributed in proportion to the amount of water they required and arranged their own financing. A joint venture arrangement is used to maximize tax effectiveness. Given the high capital cost of establishing vineyards, it was important to initially have a not-for-profit corporate

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Harford County Master Plan Requires GA

On June 29th, Harford County Water & Sewer (Maryland) issued a call for Expressions of Interest from qualified consultants to prepare a system-wide water master plan. Harford County is calling the project "Water Distribution System Optimization" as it will incorporate the latest proven cutting-edge techniques:

> *The hired consultant must determine future capital improvements and efficiencies in system operation, while maintaining maximum water quality. The project shall also require the optimization of the current and future water distribution system using genetic algorithms to minimize capital and operating costs, and to determine the minimum size and location of proposed improvements.*

As experts in GA, we applaud Harford County for recognizing that optimization will help them achieve both cost savings and improved hydraulic solutions.

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structure to jointly access water and share the costs.

Third party access was assured when the users only allocated themselves 25% of the water available. Expansion of the project to other areas will require new storage (above or below ground) and extension of the existing pipe network to the east and south. Until then, surplus flows from CBWWTP will continue to flow to the sea.

Engineering Summary

The Willunga Basin Pipeline Project is served by a 24 ML/day (6.3 MGD) pipeline from CBWWTP. To balance plant effluent flow during the day, a 6 ML (1.6 MG) lined reservoir was built at the plant. Water flows into the reservoir by gravity through a pipe just upstream of a simple weir constructed between the chlorine contact tank and the outfall. Any water not taken by the WBWC spills over the weir and out to the sea as before.

Water is transferred from the first reservoir to a second reservoir of 12 ML (3.2 MG) located 10.5 km (6.5 mi) along the pipeline near Old Noarlunga. This reservoir allows for off-peak pumping and an opportunity for water quality management. The vertical lift between reservoirs is 52 m (171 ft). Water is distributed from the second reservoir to the farm outlets.

Stage 1 of the pipeline comprised 20 km (12.4 mi) of 450 mm (18") diameter modified PVC pipe and 4 km (2.5 mi) of spur mains in 300, 200 and 150 mm (12", 8" and 6") sizes. The length of mains was almost doubled in 2000, mostly using sizes from 375 (15") to 150 mm (6"). A booster pump was added because the height of outlets above the second reservoir increased from 30 m (98 ft) to 94 m (308 ft).

Design Constraints

As the scheme is owned and operated by the water users, the design had to provide the most secure, equitable and cost effective means of accessing the reclaimed water.

The scheme operates automatically to deliver constant pressure using variable speed controls and to refill the second reservoir at night. Users are allowed to turn on their valves whenever they want. Timing of irrigation is critical for controlling fruit quality.

The minimum residual pressure is sufficient to directly operate on-farm drip irrigation systems. This high level of service avoids the need for growers to store water on their farms, and it precludes the need for power and pumps at each outlet. The slightly higher cost of the scheme is amply compensated by savings on-farm.

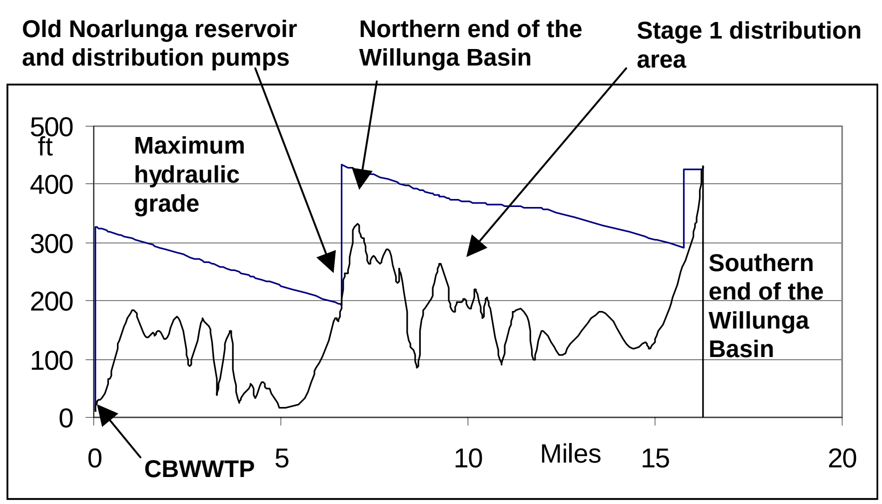
All of the 52 farm outlets can be flowing at once. Flow meters, data loggers and telemetry constantly record flow at the outlets to monitor that individual flows are within the limits agreed. The largest user can draw water 34 times more quickly than the smallest user, because he has contributed 34 times more towards the cost of the scheme.

During the 1999-2000 growing season, 950 ML (251 MG) was pumped to growers at a cost of around Aus.$300/ML (US$0.60/ 1,000 gal). The high initial capital cost will eventually be offset by the low project operating and water costs.

Willunga Basin Pipeline Benefits

The Willunga Basin Pipeline Project is obviously first of all benefiting the 15 water users who own and operate the private reclaimed water scheme. It is also benefiting the third party users who are tapping into the expanded scheme. When new water was brought to the region, grain farmers were able to sell their land which was otherwise unattractive and non-viable.

The OGA was helpful in quickly and impartially choosing between routes while taking into account alternative materials, pressure classes, and pumping costs each time new data became available.



Profile of the Willunga Basin Pipeline Project

In addition, the project is delivering benefits to SA Water by mitigating storm water flows, thus delaying the urgency of upgrading the ocean outfall. The project is reducing demand on the groundwater resource and also reducing the discharge of pollutants into the Gulf St Vincent, thus helping to meet new EPA requirements for marine discharge.

Given the availability of irrigable land in the basin, the project has the potential to deliver all of the treated wastewater flow from CBWWTP to the Willunga Basin. This would further alleviate pressure on ground and surface water resources, as well as the coastal marine environment.

GA Optimization Applications

Early in the project planning process, Hydro-Plan applied the Optimatics genetic algorithm (GA) optimization to help determine the best route through the city to the country. Compared to other optimization problems, the initial application was simple, but the OGA was helpful in quickly and impartially choosing between routes while taking into account alternative materials, pressure classes, and pumping costs each time new data became available. The final route was chosen from a relatively short list to avoid Aboriginal heritage issues that would slow the approval processes.

The current optimization problem being investigated by the OGA is much more complex. It involves addition of storage to the existing transfer mains, and a doubling (or more) of the distribution network. Both underground and above-ground storage are being considered, in various proportions and locations.

The scheme owners are keen to minimize capital costs and to control construction stages to suit cash flow. The cost of water includes a one-time contribution of Aus.$6,000/ML (US$12/1,000 gal) for infrastructure. Although high, this amount is less than the scheme under construction in the Barossa Valley (another famous wine region). Following each construction stage, the scheme must prove financially viable, as well as fully operable and robust. As the OGA conducts a rigorous benefit-cost analysis, it is being used to determine where to expand next.

The OGA is set up with many allowable choices for locations of pumps and pipes. A pipe is “allowed” down almost every road, but unit costs vary depending on road surfaces and vegetation.

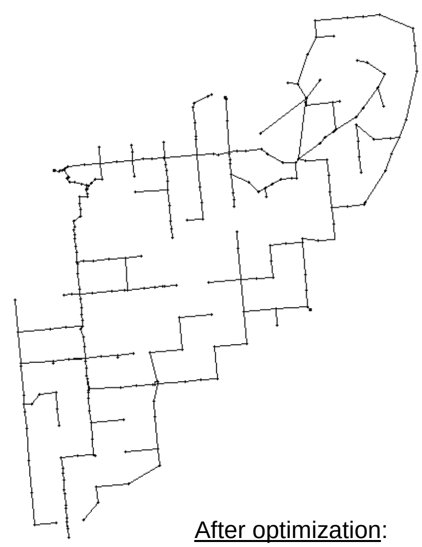
During an optimization run, to minimize overall costs (including energy), the OGA drops out the unnecessary elements and determines the size of the remaining elements (pump head/flow; pipe type, diameter and pressure class).

Due to limited history of demand data and the high value crops, risk minimization strategies include wide ranging analyses of the network when subjected to many potential demand patterns and operating scenarios.

Conclusion

This project has set a new benchmark for irrigation projects in Australia. It demonstrates what can be achieved when communities are given the tools to solve their own problems, and that all water, including ‘waste’ water has greatest value when it is delivered in the manner which is most useful to the enterprise it serves. Genetic algorithm optimization has helped all stakeholders in the community achieve maximum benefit from limited resources.

Before optimization:
A pipe is “allowed” down almost any road.



After optimization:
Only the most cost effective pipes remain.

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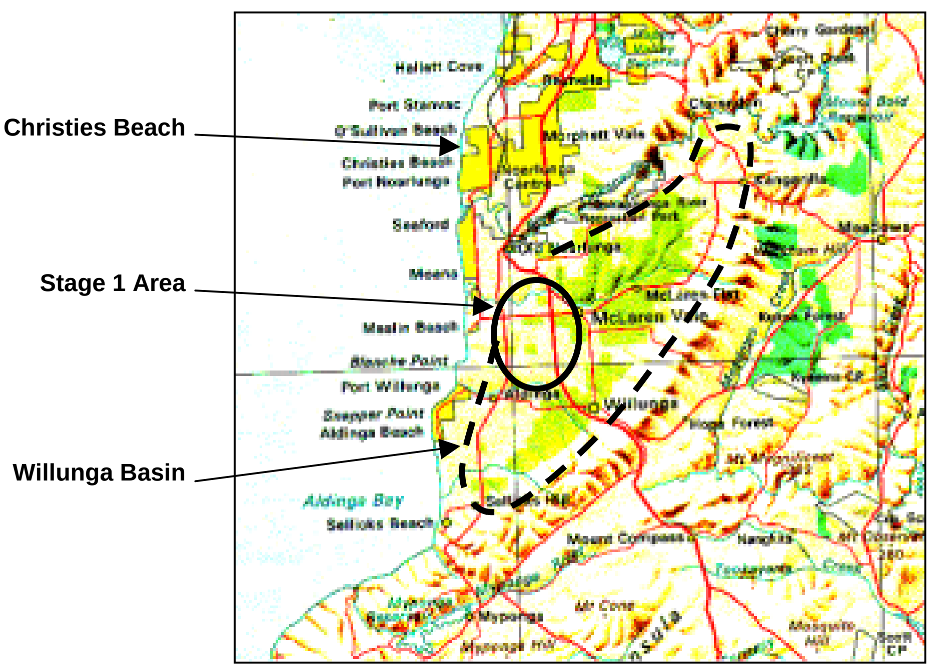
Advances in Optimization for Water Distribution System Design & Operations



Location Map for Willunga Basin Pipeline Project

A privately funded reclaimed water scheme is enabling growers to expand vineyards in the world-renowned McLaren Vale grape growing region in South Australia.