YARRA VALLEY WATER DRY AND WET WEATHER FLOW BALANCING

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Background

Yarra Valley Water was established in January 1995 and is the largest of Melbourne's three retail water companies. Melbourne Water Corporation is the wholesaler to the retail companies which are divided according to geographic area. Yarra Valley Water's Operating Licence covers 4 thousand square kilometres across Melbourne's northern and eastern suburbs. The company is fully owned by the State Government and is regulated by a number of statutatory bodies.

The company's sewerage system includes approximately 8,100 kilometres of sewer pipe, 70 sewer pumping stations and 9 sewage treatment plants. Melbourne Water owns the bulk transfer system including two treatment plants, which service over 90 percent of Metropolitan Melbourne's sewerage system. The company currently provides water and sewerage services to more than 1.5 million people.

The company is subject to economic regulation, which is overseen by the Essential Services Commission (ESC). The ESC is responsible for setting the company's prices and as part of this process is keen to ensure that Yarra Valley Water's capital expenditure program is efficient. Under this regulatory regime it is necessary to consider all servicing options and not just pursue "big pipe solutions".

Currently, the northern suburbs include some of Melbourne's major development corridors. Over the next 25 years, in excess of 250 thousand additional people are expected to populate the north of Melbourne, and this has meant an increasing demand for both water and sewer infrastructure. Figure 1 below shows a map of the Melbourne Metropolitan area, in particular detailing the locations with the high development and the location of Melbourne's two major wastewater treatment plants.

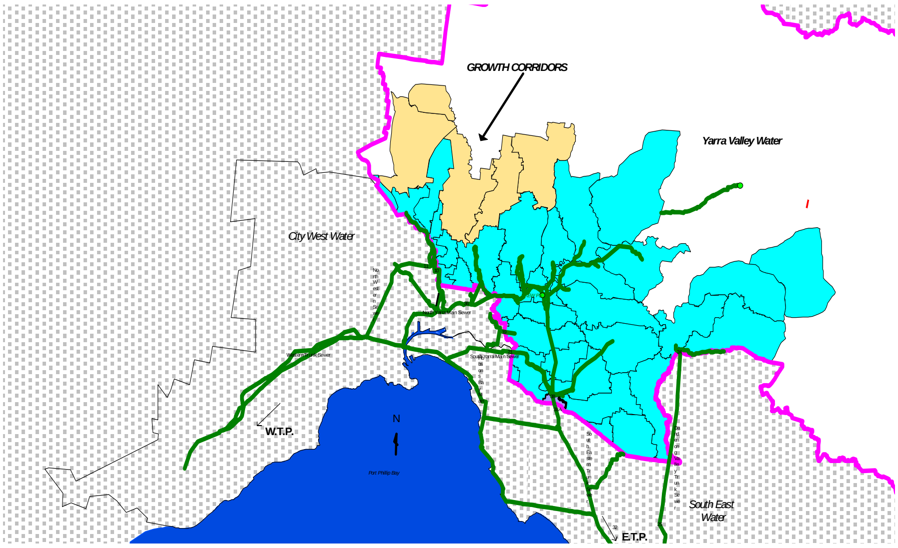

Figure 1: Sewer Network, Melbourne, Australia

This combination of forecast development, existing system deficiencies and regulation represents a major challenge for both Yarra Valley Water and Melbourne Water. In short it will not be possible to just simply connect the forecast new development to the northern suburbs of Melbourne to existing sewers because they are already over capacity and or too expensive to upgrade.

Challenges/Constraints

The observation that sewerage systems have a significant amount of unused off-peak capacity was probably the biggest reason why the concept of flow control facilities have been investigated in detail. In a typical Melbourne Metropolitan sewerage system the ratio of average dry weather flow to peak wet weather flow is 6 times. This means that, in the absence of a storm event, sewers typically run about 15 percent full. Put another way, this means that 85 percent of the capacity of gravity sewer systems is infrequently used.

One way of servicing the rapid development in the northern parts of Melbourne is to use the capacity of existing sewers during these non-peak flow periods. During peak flow periods, wastewater will be stored upstream, in detention tanks or flow control facilities, until such time when capacity is available in the downstream sewer. This concept of flow control facilities buffering flows to maximise the capacity of the downstream sewer challenged the more traditional methods of simply upgrading the downstream sewers to carry higher flows. However, there was a potential saving in the order of $200 million in real terms in employing such a strategy over the more conventional method of upgrading sewers.

Unfortunately the size of flow control facilities is not dependent on the amount of spare off-peak capacity. A sewer may have ample off peak capacity but require a very large flow control facility. A flow control facility is required to store up to 72 hours of sewage before releasing it back into the sewerage system. (Storms longer than 72 hours typically do not have enough intensity to cause the sewer system to spill.) As a result the volume of a flow control facility can be quite large in comparison to other urban sewerage infrastructure.

One of the major constraints with respect to large sewerage infrastructure in urban environments is a lack of space. This can require that they be placed near local residents. Residents typically do not have positive perceptions of large waste water infrastructure. In contrast, detention facilities commonly used in storm water systems (eg. retarding basins and wetlands) tend to be well received by the public.

Due to the community angst that flow control facilities may cause and because of the size of the infrastructure, planning permits are typically required. Such permits require the flow control facilities to be fully specified before construction commences. This means that it is not possible to address community concerns by retrofitting or experimenting with equipment if problems arise, the town planning process requires that all potential issues be identified and designed away from the beginning.

FCF Development Strategy

The need and sizing of these FCF's was determined through the sewerage planning process for the capacity deficient and high growth areas. Through a process of detailed hydraulic modelling, options development and assessment, around 4 to 5 options were short listed. These were then assessed on financial (net present value) and non-financial basis. As a result of the optioneering, flow control facilities were proposed in 14 locations.

In order to ensure a fair comparison of options, it was necessary to develop some conceptual designs for the FCF's to establish baseline costings and to confirm suitability of operation. A benchmarking study was undertaken to develop the concept of the flow control facilities and because Yarra Valley Water wanted the best possible design for local conditions. The study enabled a fair comparison of flow control facilities with conventional gravity sewer systems. Without the knowledge gained from the benchmarking study, engineers would not have had the confidence to recommend a strategy that required a flow control facility and or would not have been able to cost it properly.

Benchmarking

The benchmarking study commenced with a series of workshops to identify the key issues potentially associated with flow control facilities. Some of the issues identified during workshops were odour, solids handling, cleaning/flushing, visual aesthetics and maintenance requirements.

The objective of the benchmarking study was not only to facilitate a more rigorous planning study but also to compare the designs of various flow control facilities around the world, with a view to recommending systems and arrangements for future adoption by YVW. The report addressed various aspects of the FCF design, construction and operation. Part of the problem in the planning and design of such facilities in Australia is the lack of local working examples. Most pump stations have emergency storage facilities commonly designed to cope with an outage of up to 3 hours of PDWF, but the flow control facilities, with its significantly longer storage times and flow buffering capability required special attention, especially with regard to maintenance and operational aspects. In particular, there are no examples within Australia of detention tanks specifically designed to store dry weather flows, a case where the tank is used for the explicit purpose of flow buffering only, in order to utilise spare capacity in the downstream sewers.

Given that there was a number of FCF's to develop, it was essential for YVW to standardise the design for the facility, to ensure that facilities developed as part of the program would have the same key features in terms of process, operability and maintenance requirements.

For each of the key issues identified above, the benchmarking study aimed to assess world's best practices in the design and operation of such tanks, and to assess the implications and relevance to YVW's operational requirements. This was achieved by a number of workshops held with YVW Network Operations and Maintenance groups, to assess the importance of specific facets of the detention tanks. Operational and maintenance preferences were then used to determine the requirements of the facilities for YVW, and these requirements used to identify which of the best practice methods collated were applicable to meet the requirements. Some of the key issues and requirements were:

- Recognition of operational and maintenance complexity
- Attendance frequency for operators
- Visual Aesthetics and Odour impacts
- Simplicity of operation
- Minimise wasteful use of potable water
- Whole of life costs to be considered on even par with upfront capital costs
- Stakeholders
- Durability and Design Life

A literature search was also conducted to find relevant papers and technical documents on flow control facility design, construction and operation. Much of the information was sourced from the UK and Europe, where such detention tanks have been used with great success for mitigation of intermittent discharges from sewers during peak flow periods. The sites studied in the UK pertain to combined sewer systems rather than sole wastewater applications. There was a site in Germany where such detention tanks were used for the express purpose of storing wastewater (Bielefeld, Germany)

The information from the UK and Europe confirmed that some of the key issues with the design and operation of such tanks were the accumulation of solids and screenings, the odour from storing wastewater and the cleaning of the base of the tanks.

Solutions

The key issues identified through the various workshops undertaken during the benchmarking study were odour, solids handling, cleaning/flushing of the tank, the visual impacts and minimisation of operational and maintenance requirements. The next stage of the benchmarking process was to identify options to mitigate against these impacts.

Visual Impacts

With the FCF volumes ranging between 1000m^3 to 8000m^3 in size and around depths of 5 m to 14 m in some, the visual impact of such facilities required addressing. Burying the structure was the obvious solution to reduce the impact of such large infrastructure. It was decided that the top of the tanks would be approximately 0.5 m below the ground, allowing for topsoil to be added on top of the structure. There would only be turrets rising from the tank ceiling up to the surface, allowing man access. The area for the facility also be landscaped to reduce the visual impact of the aboveground facilities. The facilities were located in fenced compounds, with access roads to the above ground structure. To reduce roof slab sizes, traffic was restricted above the structure.

Operation and Maintenance

The size of such detention tanks raises several OH&S issues, in particular confined space requirements. To minimise operations and maintenance requirements, it was decided that personnel should not need to enter the tank, except for inspection purposes. Where mechanical equipment was required inside the tank, it would be designed in such a way that operators could have full access to undertake their maintenance activities from the surface.

Odour

The generation of hydrogen sulphide gas depends on a number of factors including but not limited to sewage composition, temperature, detention times, turbulence and sewage pH. It was estimated that in the most severe cases that a significant levels of H2S could be generated (100-1000 ppm) during raw wastewater storage with several days detention.

The mitigation measures included a variety of liquid phase chemical dosing products and gas phase treatment systems. Three options were identified as viable for this particular application: -

- Liquid Phase Chemical Dosing (Iron Salts, Magnesium Hydroxide or Hydrogen Peroxide) PLUS Gas Phase treatment (Impregnated Activated Carbon Filter);
- Liquid Phase Chemical Dosing (Iron Salts, Magnesium Hydroxide or Hydrogen Peroxide) PLUS Gas Phase treatment (Ionised air);
- Gas Phase treatment alone (Ionised air);

Discussion through various workshops revealed that Option A or B had an advantage over Option C. With liquid phase treatment, the generation of H2S is suppressed, which has significance in terms of the protective system required. Liquid phase dosing also provides a benefit to the downstream network, which in several cases consists of a long pressure main with additional detention periods. The workshop also identified that adopting a dual treatment philosophy would provide flexibility in its operation and added security in that the odour control does not rely on a single system. Given the criticality of the odour management to this project for both community and environmental reasons, the redundancy provided with the liquid suppression and gas phase polishing was seen as a reliable and robust design solution.

With the range of chemicals available for liquid phase dosing, ferric chloride and/or magnesium hydroxide were seen as the two chemicals that would be considered for each flow control facility. This was on the basis of familiarity and whole of life cycle cost. Activated Carbon was the preferred method of gas phase scrubbing on the basis of familiarity with the treatment system to the operators.

Cleaning and Flushing

The requirement for a flushing system was established during discussions on the issue of solids settling during storage times, especially since the FCF's would contain raw wastewater, regardless of whether the facilities are for wet weather or dry weather flow control. A flushing/cleaning system was seen as essential to remove accumulated solids in the tank, which would settle out on the base of the structure and become malodorous if not passed downstream.

The benchmarking study identified three methods as acceptable and appropriate options for flushing FCFs, these were: -

- Vacflush;
- Tipping Buckets;
- Sprays.

The Vacflush and Tipping Buckets system were deemed suitable for flushing the tank base. The spray system could be used for flushing both the tank base and walls.

During the workshops, it was established that Vacflush was the preferable system (for FCF volumes ranging from 1000m^3 to 8000m^3) for the following reasons: -

- Potable water not required as raw sewage can be used to flush tank;
- Minimise mechanical plant within FCF and hence requirement for operator entry and maintenance eliminated;
- Simple operation;
- Flexibility to adopt circular or rectangular structure arrangements;

For significantly smaller storage volumes with less onerous access and entry requirements the use of a spray system may be more appropriate (eg: circular structures <6m diameter).

This decision was primarily based on OH&S issues, nonetheless a comparative costing of each system was undertaken.

Despite several advantages over the comparable systems several issues were identified with the Vacflush system for further consideration, these included: -

- Investigate noise emission from the diaphragm whilst air entering flush column;
- Verify whether a supplementary spray system should be installed for wall cleaning;;
- Verify ability of Vacflush system to effectively clean tank bases in raw wastewater applications.

A study tour in the UK and Germany and discussions with operators of Combined Sewer Overflow Detention tanks resolved some of these issues, as summarized below: -

- Vacflush system was effective in flushing any solids which accumulate on the base of the FCF in raw wastewater applications;
- The noise emission from the Vacflush diaphragm valve on the flush chamber is detectable, although they are of low duration and frequency. Noise mitigation measures would be required at some FCF locations to attenuate the noise generated to an acceptable level;
- Screenings and solids have been observed to accumulate on detention tank walls in raw wastewater storage applications. These tend to self regulate by drying and dropping off periodically and do not appear to have a significant adverse effect on normal tank operation. The effectiveness of a spray system to remove these solids is not guaranteed. The use of a supplementary wall spray system does not appear to have a significant benefit to the tank operating system;
- The design of the outlet sump is important to ensure that any solids removed from the tank base do not settle in the sump.

Typically in any comparative analysis, the cost of the equipment requires assessment on a whole of life basis. Flushing systems typically represent

10% of the total capital cost associated with such infrastructure. It was found that the Vacflush system was marginally more expensive that its tipping bucket or flush gate counterparts. However, in the current climate of water restrictions in Australia, the ability to use the stored medium as the flushing water (rather than potable water) was seen as advantageous, and environmentally sustainable. Therefore, the decision to adopt Vacflush as the flushing system across all the FCF's was primarily based on operational and environmental drivers.

Solids Handling

The requirements for pre-treatment and an analysis of various pre-treatment systems were required, based on discussions with UK counterparts on CSO Detention Tanks. Four screening systems were identified and assessed during the benchmarking study:

- Solids Retention Screens;
- Static Screens;
- Non Powered Self Cleaning Screens;
- Powered Screens.

The benchmarking study concluded that where pre-treatment was to be adopted, that powered screens or a CDS unit (form of powered screen) would be suitable systems for this application and that these should only be used in systems where a continuous pass forward flow could be guaranteed. The recommendation was that the use of pre-treatment should be assessed on an individual basis and that Yarra Valley Water's operational preferences would be a key consideration in adopting a pre-treatment system.

Workshop discussions concluded that the use of a pre-treatment system would not be adopted unless the other systems used in the facility were not capable of handling the solids anticipated. The main reasons for this decision were as follows:

- Operational issues with screens. Periodic preventative attendance at site would be required for cleaning and removal of screenings. Involves man entry to the sewer environment;
- Introduces a process treatment element to Flow Control Facilities and possibly public perception that the structures are for treatment rather than storage and transfer.

The Benchmarking Study also identified that the design of the inlet structure can minimise the amount of solids transferred to the FCF. Careful design of the inlet structure should be undertaken in situations where continuous pass forward flow can be guaranteed.

Program Implementation

The benchmarking study was followed by functional designs of several of these facilities. MWH have completed the detailed design for two of these facilities and are currently undertaking the design of another.

The current construction program is detailed below. The first flow control facility is due to be commissioned in late 2005.

FCF Name	Size ML	Construction
Greensborough	1.10	2006
Janefield	8.30	2005
Cooper Street	4.90	2005
Bundoora	8.00	2006
Mernda North	1.00	2006
Mernda South	2.34	2006
Doreen	2.30	2006
Laurimar	1.14	2007
Craigieburn	8.00	2005
Lalor	4.60	2008
Bundoora Business Park	3.90	2010