Independent Review of Draft Cardno Report

Supply Mix Optimisation Model and Processes

SA Water

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Tonkin CONSULTING

a better approach

Document History and Status

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Contents

1 Introduction

1.1 Background

Tonkin Consulting has been engaged by SA Water to provide an independent technical review and commentary on the "Review of SA Water Supply Mix Optimisation" report (Cardno, 2013) prepared by Cardno for the Essential Services Commission of South Australia (ESCOSA).

1.2 Skills and Experience of Independent Reviewer

Tonkin Consulting has extensive and detailed knowledge of SA Water's water supply system gained over a period of nearly 30 years. In particular, the author of this report, Dr Phil Crawley has more than 25 years experience of working on projects related to SA Water's water supply systems and has gained an intimate knowledge of the unique nature and complexities of the Metropolitan Adelaide Water Supply System.

Dr Crawley's Master of Engineering Science (Crawley, 1991) used the metropolitan Adelaide water supply headworks system as a case study to examine the application of mathematical optimisation techniques as an aid to the identification of optimal operating policies for water supply headworks systems. The thesis was independently examined and formed the basis for several refereed international journal papers.

The work undertaken formed the basis of the development of SA Water's original decision support tool - Headworks Optimisation Model Adelaide (HOMA), which was subsequently expanded and enhanced to become SA Water's current HOMA^{xp} decision support tool.

Dr Crawley's Doctoral studies (Crawley, 1995) involved further examination of the metropolitan Adelaide Water Supply Headworks system as a case study and focussed on the investigation of risk-cost tradeoffs taking into account hydrological uncertainty, infrastructure component failure uncertainty and the potential use of restrictions policies.

1.3 Comments on Cardno Methodology

1.3.1 Purpose and objectives of the Cardno Review

The indicated purpose of the review work (Cardno, 2013) is to:

> *"Provide independent and expert advice from a consultant regarding the technical robustness of modelling instruments used in performing the supply mix optimisation process of SA Water's water supply portfolio, as well as the appropriateness of the key assumptions underpinning it".*

The stated objectives of the review work (Cardno, 2013) are to:

- *Review the hydrological information and assumptions used by SA Water, including comparisons with any alternative hydrological information.*
- *Examine and review the technical nature of the models used in the optimisation of SA Water's water portfolio.*
- *Make recommendations on the reliability of the re-modelled results, in terms of the extent to which they reflect appropriate optimisation techniques and sound assumptions.*

1.3.2 Limitations of the review

It is clear from our review of the report that Cardno have completed a large amount of work in a very short timeframe. As noted by Cardno however *"This review has been limited by the time available to review SA Water's approach and the documents made available to us."* (Cardno, 2013).

It is particularly relevant to highlight that the Metropolitan Adelaide Water Supply Headworks System has a significant number of unique characteristics that set it apart from other major water supply headworks systems both in Australia and internationally.

Unique elements associated with the Metropolitan Adelaide Water Supply Headworks System include:

- High dependency levels on a remote water source (River Murray);
- Large number (10) of headworks system reservoirs with significant interconnectedness;
- Limited overall reservoir system storage capacity; and
- Relatively low and temporally distributed reservoir inflows.

As noted in the report, Cardno's review was limited by the time available. Tonkin Consulting have identified some misunderstandings regarding SA Water's system and it is Tonkin Consulting's expert opinion, that these misunderstandings bring into question the suitability of a number of the final recommendations and conclusions.

2 Comments on Cardno HOMA Model Review

2.1 Introduction

In their overview of the HOMA model, Cardno indicates that "*HOMA is a linear programmed model which uses monthly time steps to simulate SA Water's bulk water supply network*". (Cardno, 2013)

While this is correct, it should be further pointed out that the HOMA model involves monthly time steps and utilises the mathematical optimisation technique of Linear Programming (LP) to identify an optimal set of monthly operating strategies which minimise the cost associated with a formulated objective function subject to a set of constraint equations.

The objective function which is formulated within the HOMA modelling package involves a series of "cost and penalty" components (including the piecewise linearised pump cost curves (based on SA Water's Bulk Water Power Tariff), penalty costs for spill, penalty costs for shortfalls below target storage levels etc).

The constraint equations include a range of physical system constraints (including reservoir capacities, pipeline capacities, etc).

At its core, the model prepares, formulates and then solves a set of mathematical equations using the mathematical optimisation technique of Linear Programming. The optimal solution identified is then analysed and a series of output files prepared which detail the results included in the optimised LP solution.

The HOMA model has been in regular and ongoing use within SA Water for over 20 years. During this period it has been extensively utilised by both SA Water and external consultants (working for SA Water) to examine a wide range of operational and planning issues. Output from the model has been the subject of extensive scrutiny during this 20 year period and where the model has produced what has been considered to be "non-intuitive" results, these results have been investigated and the model either validated or refined to more accurately reflect the system being modelled.

The original HOMA model research and development work was also subject to both national and international peer review processes.

It is important to note that for the purposes of the preparation of input to the RBP, HOMA has been utilised to identify the annual volume of water (and its spatial distribution) required to be pumped from the River Murray subject to the physical system constraints that are in place during the RBP period.

The estimated pumping costs associated with the volume of pumped water have been determined external to the HOMA model.

HOMA is not (and has not been) used to identify actual weekly operational pumping decisions, but rather as correctly noted in Section 3.5 of the Cardno report "*Results from the HOMA model are imported as inputs into the pump scheduler.*" (Cardno, 2013).

HOMA outputs are just one factor considered when making operational decisions and SA Water use a range of other tools as part of their operational decision making process.

2.2 Model Inputs

2.2.1 Network Configuration

The Cardno report correctly notes that there are a number of elements that have been included in the HOMA network schematic for future potential system option investigation work. It is important to note that many of these elements have not been constructed, however they were

included within the HOMA modelling facility in 2005 to enable potential investigation of a range of alternative future augmentation options.

2.2.2 Demands

The Cardno report noted that ESCOSA had commissioned its own review of the ACIL work and they did not provide comment on this review.

2.2.3 Distribution of Demands across WTPs

Cardno have noted that *"SA Water utilises a desktop spreadsheet model to distribute network demands across each of its six WTPs in the MAWSS"*, (Cardno, 2013) and that HOMA is not utilised for this purpose. (For the record it should be noted that there are 5 (rather than 6) treatment plants in SA Water's Metro Water Distribution Model).

In their report Cardno indicate that *"The stated objective of this spreadsheet is to minimise transfers across the NSISP"* (Cardno, 2013) however this is potentially misleading as this is not "the stated objective" but rather an assumption. In addition, the complete statement as it appears in SA Water's spreadsheet is "The network configuration is modelled on the basis of minimising NSISP transfers where possible to minimise network costs" which significantly changes the implications of this statement.

2.2.4 Inflows to MLR Reservoirs

Cardno confirms that *"it is reasonable that the median catchment inflow as estimated by SA Water's water balance from the last 10 years be used for the purpose of RBP modelling rather than the inflows determined by catchment hydrology models*". (Cardno, 2013) (Median MLR inflow of 113GL/a.)

Cardno also concludes that *"it is reasonable to use the reservoir mass balance method to calculate these inflows, as this will best correlate with the assumptions and constraints of the HOMA modelling"*. (Cardno, 2013)

Cardno also make a range of recommendations regarding the refinement of SA Water's reservoir mass balance method including:

- *Allowance for evaporation losses from the smaller reservoirs.*
- *Allowance for direct rainfall onto the reservoirs.*
- *Regular calibration checks of the rating curves of flow meters used into determine transfer volumes and spills.*
- *Semi-regular review of the rating curves for reservoir which related measured depth to volume and areas (the last review was conducted in 2008).*
- *Allowance for losses during transfers.*
- *Allowance for seepage from reservoirs. This can be determined through calibration of the reservoirs in WaterCress or use of typical seepage rates based on local soil conditions.*
- *Allowance for groundwater inflow if considered applicable.*

As SA Water uses a water balance method to calculate the historical inflows, a range of losses and/or uncertainties associated with the MAWSS (Metropolitan Adelaide Water Supply System) headworks are implicitly taken into account within the water balance method adopted including:

- Inaccuracies in evaporation loss estimates from the large reservoirs.
- Evaporation losses from Barossa, Gumeracha, Gorge and Clarendon Weirs (smaller reservoirs).
- The effect of direct rainfall onto reservoirs.

- In-stream losses associated with bulk water transfers.
- Seepage from reservoirs.
- Allowance for groundwater inflows.

Any refinements to SA Water's reservoir mass balance model, particularly involving improving gauging and/or monitoring facilities will involve additional capital and operating costs and in our expert opinion the additional expenditure required to make these refinements are likely to provide only marginal if any real benefits.

By way of example the sum total of the estimated annual evaporation losses associated with the four small reservoirs (Barossa, Gumeracha, Gorge and Clarendon Weirs) is just over 200 ML (less than 0.2% of the total annual average MAWSS demand).

Cardno also notes that the inflow estimates determined by SA Water's reservoir mass balance model should be reconciled against estimates determined by DEWNR's catchment hydrology models. Tonkin Consulting understands that this reconciliation process is currently underway.

2.2.5 Costs

The Cardno report asserts that the fixed electricity charges should be included within the pump cost curves utilised – "*since their omission is likely to underestimate the cost of pumping water (from the River Murray) and therefore possibly 'overuses' this source in preference to other sources."* (Cardno, 2013)

As previously noted, HOMA utilises the mathematical optimisation technique of Linear Programming. The objective function associated with the Linear Programming formulation of the MAWSS implicitly will select the lowest cost water supply source subject to the model formulated system constraints. As there is a significant marginal cost differential between the local catchment and River Murray water, the conclusion drawn by Cardno is incorrect. As long as water sourced from the Mount Lofty Ranges (which is always cheaper than the River Murray) it can never "overuse" the River Murray source.

It is important to note that for the purposes of the preparation of SA Water's RBP submission, the HOMA modelling work has been utilised to determine an estimate of the **annual volume of water** (not cost) that is to be pumped from the River Murray. Costing estimates have then been determined separately utilising SA Water's financial models which include both the fixed and variable components of SA Water's bulk water electricity tariff.

2.3 Operating Constraints

There are three major projects which will impact on the operation of the MAWSS within the regulatory period. These three projects are:

- Adelaide Desalination Plant (ADP),
- North South Interconnection System Project (NSISP), and
- Hope Valley and Happy Valley WTP Filter Upgrade projects.

While the ADP and NSISP, once fully proved, will result in increased operational flexibility for the MAWSS, there are a range of operational limitations that have had to be accommodated within the modelling work undertaken as part of SA Water's RBP submission.

In particular, during the proving period of the ADP (for the period up to December 2014), the volume of water to be supplied via each of the metropolitan Adelaide WTPs will be almost exclusively dictated by the ADP proving requirements (which has been *"accepted by ESCOSA as prudent and efficient"* (Cardno, 2013))

SA Water's Metro Water Distribution Model (which is external to HOMA) has been utilised to determine the annual production volumes for five of the metropolitan Adelaide WTPs (Barossa, Little Para, Anstey Hill, Hope Valley and Happy Valley) for the period 2012/13 to 2015/16 taking

into account the requirements of the three major projects, the metropolitan Adelaide WTP capacities together with the demand zone transfer capacities.

2.3.1 WTP Operating assumptions

The WTP operating capacity and availabilities are included as model constraints within the HOMA model. At an operational level Tonkin Consulting understands that SA Water manages the WTP service zones based on a range of operational constraints.

As correctly noted in Cardno's report the adopted operating procedure for Anstey Hill WTP involves strategies to manage *Cryptosporidium* risks historically observed in the Millbrook Reservoir.

A detailed description of these risks and the strategies that have been adopted by SA Water to manage these risks are provided below which has been based on detailed discussions with SA Water personnel.

Millbrook Reservoir *Cryptosporidium* Risk Management Strategy

Tonkin Consulting understands that for the purposes of the RBP modelling, SA Water have assumed that it is prudent to only **plan** to use water extracted from the Millbrook Reservoir between February and May.

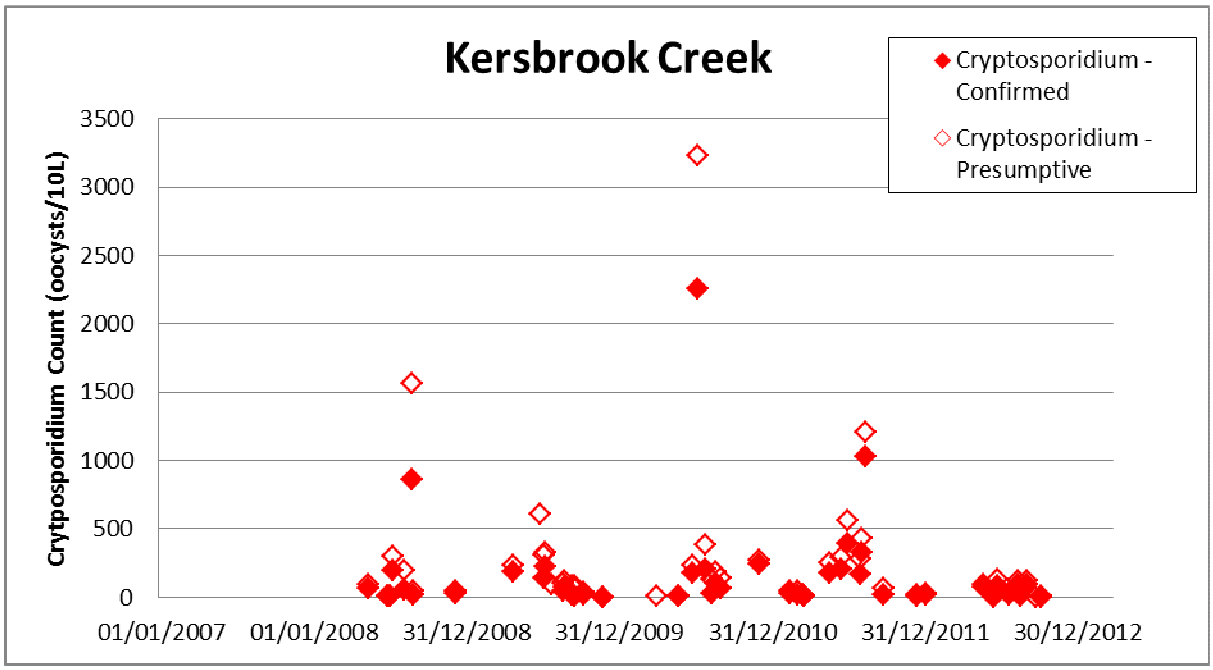
In discussion with SA Water's water quality experts it has been confirmed that *Cryptosporidium* can survive for up to 3 months in a reservoir, and so once detected the risk remains present for some time. SA Water has developed *Cryptosporidium* speciation tests which are actively used to determine *Cryptosporidium* risk both in catchment locations and WTPs, and to assist with operational decision making to ensure risks are appropriately managed.

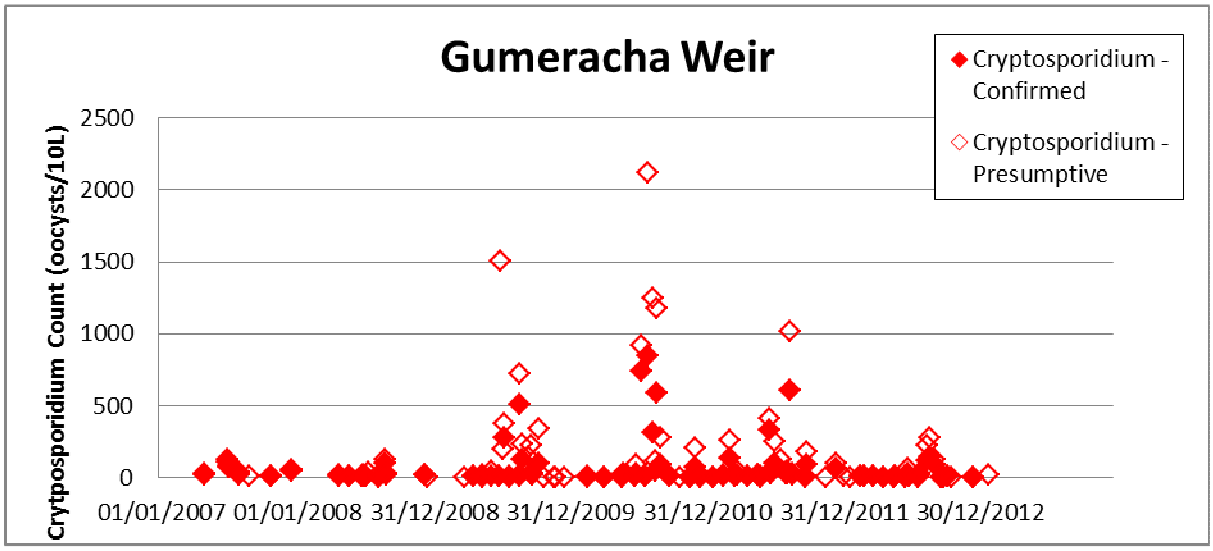
Millbrook Reservoir receives controlled inflows from the River Torrens (transferred via Gumeracha Weir) and uncontrolled inflows via Kersbrook Creek (catchment area 23km^2).

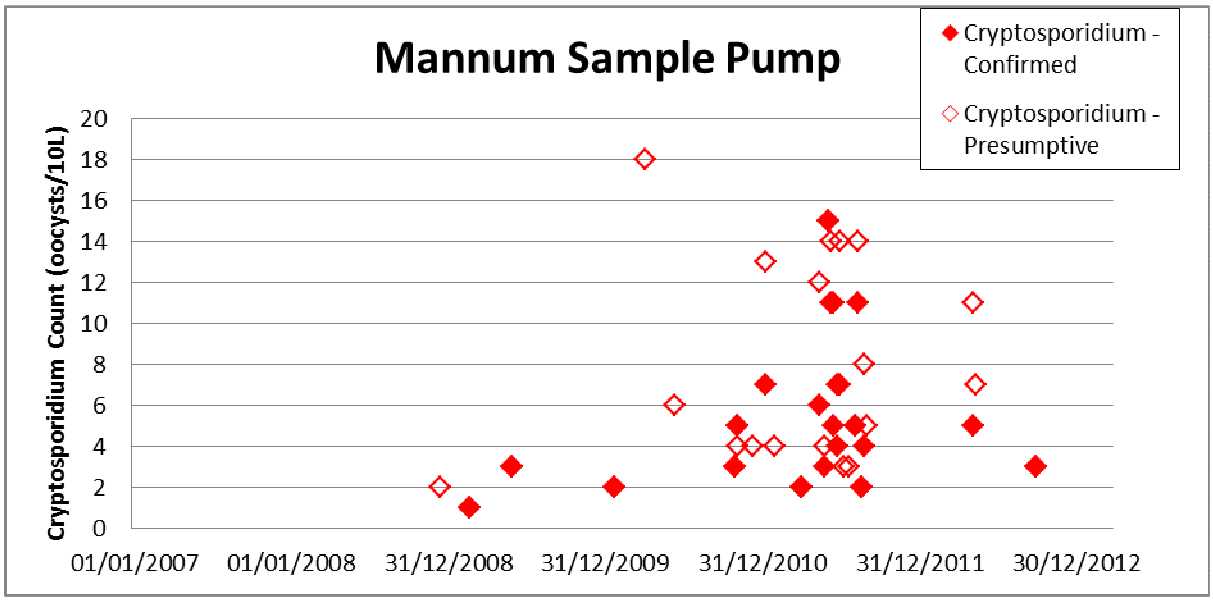
In addition to the intensive land use in the catchment (predominantly grazing), flows in Kersbrook creek can also be impacted from the Kersbrook Community Wastewater Management Scheme upstream. Importantly, Millbrook reservoir is the only reservoir which has had *Cryptosporidium hominis* detected (human derived *Cryptosporidium*) and is therefore considered at higher risk by the Department for Health and Ageing than the other Mt Lofty catchments supply reservoirs.

SA Water's Water quality monitoring records indicate that raw water inflows from Kersbrook Creek carry the highest *Cryptosporidium* loads of any reservoir inflow creeks monitored by SA Water (highest count to date was 2259 confirmed *Cryptosporidium*/10L which is a Department of Health and Ageing (DHA) Type 1 incident reportable both to DHA and the Minister for Water).

Graphical results showing historical detections of *Cryptosporidium* at key locations in the Torrens System (Kersbrook Creek (located approximately 650m upstream of Millbrook Reservoir) and Gumeracha Weir) and River Murray water pumped via the Mannum-Adelaide pipeline as recorded by SA Water are provided below.


Kersbrook Creek
Cryptosporidium - Confirmed
Cryptosporidium - Presumptive
Crytposporidium Count (oocysts/10L)
3500
3000
2500
2000
1500
1000
500
0
01/01/2007
01/01/2008
31/12/2008
31/12/2009
31/12/2010
31/12/2011
30/12/2012


Gumeracha Weir
Cryptosporidium - Confirmed
Cryptosporidium - Presumptive
Crytposporidium Count (oocysts/10L)
2500
2000
1500
1000
500
0
01/01/2007
01/01/2008
31/12/2008
31/12/2009
31/12/2010
31/12/2011
30/12/2012



SA Water aims to achieve effective operation of its coagulation, flocculation and filtration treatment processes and is required to meet a Department of Health and Ageing Type 1 incident criterion of 0.15 NTU on individual filters. Any exceedance of 0.15 NTU on an individual filter results in a DHA reportable Type 1 incident. Although low turbidity will provide optimal removal of *Cryptosporidium*, it is important to note that:

- The Anstey Hill WTP was not specifically designed to remove *Cryptosporidium*.
- The Millbrook Reservoir has been assessed as the highest risk source of *Cryptosporidium* in the South Australia.
- Other factors such as ripening of the filters and hydraulic shocks through the plant can generate increased risk from *Cryptosporidium*, even though on average the turbidity is low and previous outbreaks in other countries have been caused by these short-term failures allowing *Cryptosporidium* to enter the filtered water storage.

Based on information provided by SA Water to Tonkin Consulting contained in the "Practical Guide to the Operation and Optimisation of Media Filters" (Mosse and Murray), even with well optimised media filtration, only about 99% of protozoan pathogens are removed. Where this is considered inadequate, additional control measures need to be implemented. Anecdotal information obtained by Tonkin Consulting from DHA indicates that the Millbrook catchment is considered to be of high risk, and on this basis we understand that SA Water has adopted additional control measures to manage these risks.

The *Cryptosporidium* risk posed from the River Murray is understood to be of the order of 100 times less than that posed by the inflows to Millbrook Reservoir, and is therefore considered by SA Water to be a lower risk from *Cryptosporidium* in general. This is confirmed in the data included in the above graphs. Tonkin Consulting understands from discussion with SA Water that other water quality parameters in the two sources can vary significantly. The changing of source water at frequent intervals in response to individual rain events is also considered high risk given the, potentially, significantly different raw water quality of the two sources and the time delay between sampling and confirmation of the presence of *Cryptosporidium*. Changing sources frequently is also considered inefficient as treatment processes must be modified significantly.

The above detailed description of the water quality risks associated with water sourced from the Millbrook Reservoir and treated at Anstey Hill WTP has been prepared following consultation with SA Water personnel. In Tonkin Consulting's professional view, the operating procedures adopted by SA Water are considered to be prudent.

2.3.2 Environmental Flows

The Cardno report notes the various environmental flows that have been included in the HOMA modelling for the RBP period. These environmental flows volumes are based on the trial environmental flow agreement that is currently in place between the Department for Environment, Water and Natural Resources, the Adelaide and Mount Lofty Ranges Natural Resources Management Board and SA Water.

2.3.3 Reservoir Target Levels

Cardno correctly note that reservoir target storage levels are utilised by SA Water to "*reflect a desired standard for reliability of supply*" and that "*'Penalty' costs are included within the model so that these target storage levels can be met*". (Cardno, 2013)

2.3.4 Pipeline capacities

Minimum and maximum pipeline capacities are included as constraints within the HOMA LP model formulation.

Cardno correctly note that *"HOMA does not materially account for transmission losses within the bulk water supply network"*. (Cardno, 2013)

While this is correct, it should be recognised that the water balance approach adopted by SA Water effectively includes these transmission losses.

2.3.5 North-South Interconnection System Project (NSISP)

Cardno notes that the purpose of the recently commissioned NSISP is to link the distribution networks to allow greater flexibility in the water supply system.

The flexibility associated with the NSISP has been incorporated within SA Water's Metro Water Distribution Model (which is external to HOMA). The Metro Water Distribution Model has been utilised to determine the annual production volumes for five metropolitan Adelaide WTPs (Barossa, Little Para, Anstey Hill, Hope Valley and Happy Valley) for the period 2012/13 to 2015/16 taking into account the various operational constraints associated with the distribution network.

2.4 Relationship of HOMA to other system modelling tools

The Cardno report correctly notes that the HOMA model is utilised in conjunction with other in-house models and planning tools.

However Cardno appears to be somewhat confused in relation to the manner in which HOMA has been used as part of the preparation of input in SA Water's RBP submission. In particular it would appear that Cardno may have misunderstood that HOMA has only been utilised by SA Water to provide the estimated volume of water to be pumped (and not the costs) on the basis of the constraints over the next three years listed in the assumptions SA Water's RBP submission.

HOMA has not been used to calculate the cost of electricity assumed in SA Water's RBP nor for pump scheduling purposes. Rather separate systems have been utilised by SA Water associated with these elements of the preparation of their RBP submission.

3 Comments on Cardno Assessment of Results of HOMA used in RBP

3.1 Introduction

The Metropolitan Adelaide Water Supply System is a complex system comprising:

- 5 major pumping systems (plus the Millbrook Pumping Station),
- 10 reservoirs,
- 21 demand nodes,
- 8 Water Treatment Plants, and
- The Adelaide Desalination Plant (ADP).

The system involves three potential alternative water supply sources.

This complex system does however have a number of constraints (both in terms of quantity and quality) which impose a range of limitations on the manner in which the system can be operated.

Many of these constraints have far reaching implications on the overall manner in which the system can be operated which may not have been evident in the time provided to Cardno to undertake their review.

3.2 Analysis of Mannum-Adelaide system in 2013/14

In Section 4.1 of their report, Cardno have investigated the Mannum-Adelaide system and *"performed a water balance around this system for the 2013/14 year"* (Cardno, 2013).

From the investigation observations are made in relation to:

- Spill over Gorge Weir,
- Operation of the Hope Valley WTP, and
- Water Balance in the South Para System.

A brief discussion of the three matters raised by Cardno as a result of their water balance assessment is presented below.

3.2.1 Spill volumes lost at Gorge Weir

The HOMA modelling work undertaken for the 2013/14 year indicates that approximately 19.3GL of inflows will spill over the Gorge Weir. This spill occurs predominantly during the period June 2013 to October 2014 period and occurs as a result of some significant system constraints and in particular the requirements associated with the proving period of the ADP.

A noteworthy system constraint (local to Gorge Weir) is associated with Sixth Creek, which flows into the Torrens River downstream of Kangaroo Creek. Natural runoff from Sixth Creek can only be harvested at Gorge Weir (capacity ~25ML) and transferred to Hope Valley Reservoir via the Hope Valley aqueduct.

As noted in the Cardno report the 4.1 GL of pumping from the River Murray to the River Torrens system exceeds the 0.89 GL environmental flow release from Gorge Weir. This release is part of the environmental flows trial agreement that is currently in place between the Department for Environment, Water and Natural Resources, the Adelaide and Mount Lofty Ranges Natural Resources Management Board and SA Water.

Through discussions with SA Water an improvement to the current modelled assumption has been identified. When remodelled this is anticipated to reduce the pumping from the River Murray by a volume less than 4.1 GL.

3.2.2 Operation of Hope Valley WTP

Cardno have noted that in SA Water's RBP submission, Hope Valley WTP does not operate at all during the 2013/14 year.

From their water balance assessment, Cardno concludes that the reason for the natural inflows to the Millbrook and Kangaroo Creek Reservoir not being used in this modelled scenario are largely due to:

- The way that the demand is distributed across the WTPs, and
- The restriction imposed with the modelling that Hope Valley WTP not be used due to concerns over *Cryptosporidium* risk.

The following comments are provided in relation to these two conclusions.

Demand Distribution across the WTPs

The transfer of water within the distribution system between demand zones is constrained by the capacity and configuration of components within the distribution system. These capacity and configuration constraints are as per Figure 3-2 noted in the Cardno report which includes the additional distribution system transfer capacities that have been provided as a result of the NSISP.

As noted in this figure there are still significant constraints on the matching of supply from WTP and demands, ("*a grey coloured grid square means that the demand node cannot be supplied by the corresponding water treatment plant*") (Cardno, 2013).

Review of this figure highlights that it is not possible to transfer Hope Valley water into the Little Para or Barossa supply zones.

Modelling restriction imposed on Hope Valley WTP

From interviews with SA Water staff, Tonkin Consulting understands that the primary reason that restrictions were imposed within the modelling on the operation of the Hope Valley WTP was to enable maximum utilisation of the ADP water during the ADP proving period and not as concluded by Cardno "*due to concerns over Cryptosporidium risks*" (Cardno, 2013).

In our expert opinion it is anticipated that the additional modelling requested by ESCOSA will show that if Hope Valley WTP is operated at its full capacity, the volume of water produced will be well in excess of customer demand and that demand will become the limiting factor.

For example during winter, the forecast demand in the area that can be supplied by the Hope Valley WTP is significantly less than the full capacity of the plant. As previously discussed there is nowhere else for this water to go and therefore there is a physical constraint associated with implementing this recommendation.

As a result there is still likely to be "spill" from the MAWSS headworks system but the distribution of the spill from the system will change. Given that many of the WTPs associated with the system must operate at minimum flow, discharge of excess water from the ADP into Happy Valley reservoir is considered to be the likely outcome, which in effect will result in the transfer of high quality treated water into a reservoir.

If water from the ADP is discharged into Happy Valley reservoir it will subsequently need to be retreated at the Happy Valley WTP.

Additional spill is also likely to occur at Clarendon Weir as Happy Valley Reservoir will be filled with treated ADP water.

As highlighted in Table 4-3 of Cardno's report, when the ADP is operating in 2013/14 and 2014/15, the volume of spill form the system is significantly greater than when the ADP is not operating.

It is also anticipated that the additional modelling work currently being undertaken will demonstrate that if the Hope Valley WTP is forced to operate at full capacity through the regulatory period, pumping costs associated with the Mannum Adelaide pipeline will increase.

3.2.3 Transfers from Mannum-Adelaide to the South Para System

Cardno's report (Cardno, 2013) correctly asserts that the total end use at the Barossa WTP is 12.7 GL. The total inflow estimates into the South Para system in the 2013/14 water year are 15.4 GL (inflows) plus 8.4 GL from the River Murray (transferred via the Mannum-Adelaide pipeline) which equals 23.8 GL.

However there appears to be an error in Cardno's discussion on the water balance in the South Para system.

The total offtake from the South Para system comprises the following components:

- Barossa WTP demand - 12.7 GL
- Contractual Supply to the private entity Barossa Infrastructure Limited (BIL) - 4.1 GL
- Environmental flow releases from Barossa Weir - 2.2 GL
- Evaporation losses from the reservoirs comprising the South Para supply system - 4.8 GL

3.3 Analysis of spill volumes lost to the MLR reservoir system

In Section 4.2 of their report, Cardno have undertaken a water balance assessment of spills volumes lost to the MLR reservoir system.

Cardno acknowledge in their assessment that "*some of this spill may be unavoidable due to the timing of inflows and demand*". (Cardno, 2013)

Cardno draws the following two conclusions that excess spills appear to be caused by "*Hope Valley WTP being underutilised and because it is assumed that Anstey Hill is supplied by the Mannum-Adelaide pipeline for the majority of the year due to concerns relating to Cryptosporidium in the Millbrook Reservoir.*" (Cardno, 2013)

A brief commentary is provided in relation to these two conclusions.

Under utilisation of Hope Valley WTP

A detailed discussion regarding the utilisation of Hope Valley WTP (particularly during the proving period of the ADP) is provided in Section 3.2.2. Tonkin Consulting understands that ESCOSA have requested additional modelling which should assist with further clarifying the implications of forcing greater utilisation of the Hope Valley WTP on other areas of the system and in particular the implications on the water produced by the ADP during its proving period.

Supply of Anstey Hill primarily from the Mannum-Adelaide Pipeline

A detailed discussion of the water quality risks associated with *Cryptosporidium* in Millbrook Reservoir is provided in Section 2.3.1 which provide further background regarding the basis of the adoption of the water quality imposed constraints by SA Water in relation to the operation of the Anstey Hill WTP.

4 Comments on Cardno Report Conclusions

4.1 Introduction

A range of conclusions have been drawn in the Cardno report and comments on these conclusions are provided below (or reference provided to the relevant sections in our report).

4.2 Network Configuration

4.2.1 HOMA Model Rigidities

We note that Cardno has reinforced the recommendation that the proving program for the ADP has been "*accepted by ESCOSA as prudent and efficient*" (Cardno, 2013), however it should be noted that this ADP proving program imposes a number of significant operating constraints on the manner in which the MAWSS can be operated during this period which we believe have been misinterpreted by Cardno as model rigidities.

A number of constraints have been included in the formulation of the HOMA modelling work undertaken to reflect the various system constraints including:

- ADP operation during the proving period.
- Impacts of the Hope Valley and Happy Valley WTP Filter Upgrade projects.
- Water Quality issues associated with Millbrook Reservoir.

Each of these constraints and the reasons for their inclusion have been discussed in some detail within this report.

4.2.2 System Losses

Cardno has concluded that *"it is reasonable to use the reservoir mass balance method to calculate these inflows, as this will best correlate with the assumptions and constraints of the HOMA modelling"* (Cardno, 2013).

Tonkin Consulting endorses the use of SA Water's reservoir mass balance model for the purposes of calculating inflows.

4.2.3 Model Monthly Timestep

It is important to recognise that the primary utilisation purpose of HOMA is as one of a range of tools and models to **support the decision making processes** undertaken by SA Water planners and operators.

The monthly pumping program provided by HOMA is utilised by the system operators as a guide but will regularly need to be adjusted to take into account specific operational constraints (eg. water quality incidents or equipment failure).

Given that the objective of the HOMA modelling work undertaken for the RBP submission was to provide an estimate of the annual River Murray pumping volumes, in our expert opinion the monthly timestep used by HOMA is considered appropriate.

4.3 MLR reservoir inflows

As discussed in Section 2.2.4 because the water balance method is used, a range of losses and/or uncertainties associated with the MAWSS headworks system are automatically taken into account within the water balance method adopted including three of the four inaccuracies identified by Cardno:

- Evaporation losses from small reservoirs (Barossa Weir, Gumeracha Weir, Gorge Weir and Clarendon Weir).

- Direct rainfall on the reservoirs.
- Losses during transfers.

Any refinements to SA Water's reservoir mass balance model, particularly involving improvements to gauging and/or monitoring facilities will involve additional capital and operating costs and in our expert opinion the additional expenditure required to make these refinements is likely to provide only marginal benefits.

Regular updating of reservoir storage and area curves will potentially be beneficial for improving the accuracy of the water balance approach, however this will also involve cost.

4.4 Costs

4.4.1 Fixed Electricity Costs

As detailed in Section 2.2.5 – in our expert opinion given that the MLR are a considerably cheaper water source than the River Murray the omission of the fixed electricity cost components within the HOMA pump cost curves will have no impact on the modelled pumping volumes determined.

4.4.2 WTP Costs

The relative capacities associated with the different WTPs are taken into account in SA Water's Metro Water Distribution Model.

It is important to note that for the purposes of the preparation of SA Water's RBP submission, the HOMA modelling work has been utilised to determine an estimate of the **annual volume of water** (not cost) that is to be pumped from the River Murray. Costing estimates have then been determined separately utilising SA Water's financial models.

4.5 HOMA results used in RBP

A detailed commentary on Cardno's assessment of the HOMA results used in SA Water's RBP submission and the conclusions drawn by Cardno of this assessment has been provided in Section 3.

5 Comments on Cardno Report Recommendations

5.1 Introduction

A range of short term and medium term recommendations have been made in the Cardno report. Comments on these recommendations are provided below (or reference provided to the relevant sections in our report).

5.2 Short term Recommendations

5.2.1 Hope Valley WTP Output

Cardno have included a recommendation that the *"Hope Valley WTP output for all years … be at full capacity"* and that *"ADP water should be transferred to its next best use"*. (Cardno, 2013)

In our professional opinion this recommendation indicates a lack of understanding by Cardno of the operating constraints associated with the Hope Valley WTP.

As noted in Figure 3-2 of Cardno's report, it is not possible to transfer Hope Valley into the Little Para or Barossa supply zones ("*a grey coloured grid square means that the demand node cannot be supplied by the corresponding water treatment plant*"). (Cardno, 2013)

During the winter months demand associated with the maximum supply area that can be serviced from the Hope Valley WTP will be considerably less than the Hope Valley WTP full capacity.

Tonkin Consulting understands that ESCOSA have requested SA Water to undertake additional modelling, and until the modelling work is completed it is not possible to accurately draw conclusions. In our expert opinion it is anticipated that the modelling results will show that if Hope Valley WTP is operated at its full capacity, the volume of water produced will be well in excess of customer demand.

As a result there is still likely to be "spill" from the MAWSS headworks system but the distribution of the spill from the system will change. Given that many of the WTPs associated with the system must operate at minimum flow, discharge of excess water from the ADP into Happy Valley reservoir is considered to be the likely outcome, which in effect will result in the transfer of high quality treated water into a reservoir.

Additional spill is also likely to occur at Clarendon Weir as Happy Valley Reservoir will be filled with treated ADP water.

As highlighted in Table 4-3 of the Cardno report, when the ADP is operating in 2013/14 and 2014/15, the volume of spill form the system is significantly greater than when the ADP is not operating.

It is also anticipated that the modelling will indicate that as a result of the Hope Valley WTP operating at full capacity through the regulatory period, pumping costs associated with the Mannum Adelaide pipeline will increase.

5.2.2 Model Results Testing

It is anticipated that the additional modelling work currently being undertaken by SA Water, as requested by ESCOSA, will provide additional *"logical testing of the modelled outputs"* (Cardno, 2013) to further demonstrate the appropriateness of the modelling work that was undertaken associated with the preparation of SA Waters RBP submission.

5.2.3 Anstey Hill WTP Operating Assumptions

Comments on Cardno's recommendations regarding the *Cryptosporidium* risks associated with the operation of the Anstey Hill WTP have been discussed in detail in Section 2.3.1.

5.2.4 Hope Valley and Happy Valley WTP Operating Assumptions

The results of modelling work currently being undertaken by SA Water at the request of ESCOSA will assist in further clarifying the appropriateness of the Hope Valley WTP operating assumptions.

5.3 Medium term Recommendations

5.3.1 Refinement of SA Water's Reservoir Mass Balance Model

It is acknowledged that there is potential for refinement of SA Water's reservoir mass balance model so that greater confidence in the average catchment inflows and direct comparison with catchment hydrology models can be achieved, however it should be noted that any refinements, particularly involving improving gauging and/or monitoring facilities will involve additional capital and operating costs and provide limited benefit.

5.3.2 Reconciliation of SA Water Inflow Estimates with DEWNR's Models

Cardno note that the inflow estimates determined by SA Water's reservoir mass balance should be reconciled against estimates determined by DEWNR's catchment hydrology models. Tonkin Consulting understands that this reconciliation process is currently underway.

5.3.3 Accuracy of SA Water Inflow Estimates

It is acknowledged that there is limited potential opportunity to improve the accuracy of the SA Water's inflow estimates. It should however be noted that any refinements, particularly involving improving gauging and/or monitoring facilities will involve additional capital and operating costs and provide limited benefit.

5.3.4 Updated Pumping and Treatment Costs

While updating model input with the latest available information is always ideal, in Tonkin Consulting's expert opinion the impact of utilising updated information on the results of the modelling undertaken as part of SA Water's RBP submission will be insignificant.

6 Bibliography

1. Cardno, “Review of SA Water Supply Mix optimisation” 3603-83, Report prepared for Essential Services Commission of South Australia, April 2013.
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3. Crawley, PD, “Risk and Reliability Assessment of Multiple Reservoir Water Supply Headworks Systems”, Thesis for the degree of Doctor of Philosophy, University of Adelaide, March 1995.
4. Mosse, P and Murray, B, “Practical Guide to the Operation and Optimisation of Media Filters”, Water Industry Operators Association of Australia, http://www.wioa.org.au/publications/documents/MediaFiltersBookcontent.pdf accessed 9th April, 2013.