Audit of Irrigation Modernisation Water Recovery 2015/16 Irrigation season

Report

Prepared for the Victorian Department of Environment, Land, Water and Planning

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Contact Information

Cardno (Qld) Pty Ltd
ABN 57 051 074 992

Level 11 Green Square
515 St Paul's Terrace
Fortitude Valley Qld 4006

Telephone: 07 3369 9822
Facsimile: 07 3369 9722
International: +61 7 3369 9822

www.cardno.com.au

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Summary of findings

Background and scope

This report details the findings from Cardno's audit of the estimates of the water recovery achieved through irrigation modernisation in northern Victoria for 2015/16. The majority of the water recovery is being delivered through the Goulburn-Murray Water (GMW) Connections Project. The GMW Connections Project (GCP) is being implemented in two stages. Stage 1, which is funded by the Victorian Government, has been underway since 2008 and Stage 2, which is funded by the Commonwealth, commenced in 2012. The GMW Connections Project must be audited each year. This is the eighth annual audit of water savings from irrigation modernisation in the Goulburn-Murray Irrigation District.

The scope of activities included in this audit, as described in the audit brief, is as follows:

- The irrigation modernisation works in place for the 2015/16 water year (up to 30 June 2016).
- The GMW Connections Project operating area which is the whole GMID (Central Goulburn, Rochester, Pyramid-Boort, Murray Valley, Shepparton and Torrumbarry Irrigation Areas).
- The cumulative irrigation modernisation works and savings separately accountable to the:
  - GMW Connections Project Stage 1; and
  - GMW Connections Project Stage 2;

Audited Water Savings Estimates

Water savings are achieved through modernisation of irrigation infrastructure. The scope of the audit is to review Phase 3 and Phase 4 water savings estimates. The Phase 3 water savings estimates represent actual savings realised in the 2015/16 irrigation season as a result of works completed to date based on deliveries in 2015/16 and observed losses. Phase 4 savings represent the long term average savings that might be expected from the works completed to date.

The audited Phase 3 and Phase 4 estimates are set out in the following tables and, as required in the project brief, are separately accounted to the:

- Stage 1 project
- Stage 2 project

Water savings from Stage 1 project (2015/16)

Water Savings Intervention	SH	CG1-4	CG 5-9	MV	RO	PB	TO	Total
Phase 3 water savings								
Channel Rationalisation (ML)	22	-	1,007	4,876	914	2,240	7,044	16,102
Channel Automation (ML)	0	-	16,178	2,380	4,286	1,475	3,535	27,854
Service Point Replacement (ML)	25	-	11,960	6,755	5,273	5,566	5,545	35,124
Service Point Rationalisation (ML)	54	-	2,164	3,364	1,830	2,717	3,933	14,062
Channel Remediation (ML)	-	-	4,229	3,442	1,556	-	2,205	11,433
Total Phase 3 savings (ML)	**101**	**-**	**35,538**	**20,816**	**13,861**	**11,997**	**22,262**	**104,576**
Phase 4 water savings								
Channel Rationalisation (ML)	22	-	1,222	6,182	1,221	2,244	10,239	21,130
Channel Automation (ML)	-	-	29,609	6,956	6,730	2,555	7,632	53,481
Service Point Replacement (ML)	26	-	18,348	11,027	8,631	9,881	9,636	57,549
Service Point Rationalisation (ML)	61	-	3,267	5,539	2,926	4,787	6,942	23,522
Channel Remediation (ML)	-	-	5,143	3,844	1,805	-	3,702	14,495
Total Phase 4 savings (ML)	**109**	**-**	**57,589**	**33,548**	**21,313**	**19,467**	**38,151**	**170,177**

Note – Totals may not sum due to rounding

Water savings from Stage 2 project (2015/16)

Water Savings Intervention	SH	CG1-4	CG 5-9	MV	RO	PB	TO	Total
Phase 3 water savings								
Channel Rationalisation (ML)	201	849	838	2,193	2,551	761	3,009	**10,400**
Channel Automation (ML)	408	-	-	-	-	-	-	**408**
Service Point Replacement (ML)	302	-	2,014	794	884	1,064	1,352	**6,411**
Service Point Rationalisation (ML)	34	-	400	807	518	640	1,214	**3,613**
Channel Remediation (ML)	351	1219	658	1167	138	1122	894	**5,549**
Total Phase 3 savings (ML)	**1,296**	**2,067**	**3,911**	**4,960**	**4,091**	**3,587**	**6,469**	**26,381**
Phase 4 water savings								
Channel Rationalisation (ML)	205	1,024	1,290	3,154	3,384	780	4,903	**14,740**
Channel Automation (ML)	1,070	-	-	-	-	-	-	**1,070**
Service Point Replacement (ML)	378	-	3,303	1,324	1,917	1,996	2,415	**11,333**
Service Point Rationalisation (ML)	45	-	676	1,363	1,124	1,188	2,316	**6,713**
Channel Remediation (ML)	374	1392	779	1293	132	1338	1124	**6,433**
Total Phase 4 savings (ML)	**2,071**	**2,417**	**6,048**	**7,134**	**6,557**	**5,302**	**10,758**	**40,287**

Note – Totals may not sum due to rounding

Total water estimated savings for all projects

Project	SH	CG1-4	CG 5-9	MV	RO	PB	TO	Total
Phase 3 water savings								
Stage 1 project (ML)	101	-	35,538	20,816	13,861	11,997	22,262	104,576
Stage 2 project (ML)	1,296	2,067	3,911	4,960	4,091	3,587	6,469	26,381
Total Phase 3 savings (ML)	**1,397**	**2,067**	**39,449**	**25,777**	**17,951**	**15,584**	**28,731**	**130,956**
Phase 4 water savings								
Stage 1 project (ML)	109	-	57,589	33,548	21,313	19,467	38,151	170,177
Stage 2 project (ML)	2,071	2,417	6,048	7,134	6,557	5,302	10,758	40,287
Total Phase 4 savings (ML)	**2,180**	**2,417**	**63,637**	**40,681**	**27,869**	**24,769**	**48,910**	**210,464**

Note – Totals may not sum due to rounding

Note – There are additional water savings volumes that are outside the scope of this audit

Systems and Processes

Our review for the 2015/16 audit of the information systems and processes used by GMW has found that they continue to be sufficiently robust to generate data and inputs that are as accurate as could reasonably be expected for the purpose of calculating water recoveries.

We note that there appears to have been a failure in GMW's business processes to ensure the handover of complete and accurate construction and commissioning records relating to one package of work but we consider that this is not representative of GMW's overall performance in ensuring that adequate construction and commissioning records are kept.

Trailing of construction records

We found that most assets included in our samples for data trailing had sufficient evidence to support the fact that they have been constructed and commissioned. We are satisfied that GMW has completed the works claimed in the calculations.

We noted for some types of construction works that the as-constructed drawings received were of insufficient quality to accurately describe the nature and extent of the works undertaken. Through our audit work, we have obtained sufficient evidence that the work claimed in the samples reviewed has been completed. We are however concerned that poor quality as constructed information will impact on GMW's knowledge of its asset for their long term operation, maintenance and renewals.

We therefore recommend that GMW puts in place strong controls over the quality of work pack information received from contractors under its new delivery model and as-constructed drawings in particular. There is an opportunity for GMW to link contractor payments to the completeness and accuracy of information received to drive the desired results.

We make the following recommendations in relation to quality assurance of construction records:

- We recommend that GMW puts in place strong controls over the quality of work pack information received from contractors under its new delivery model and as-constructed drawings in particular. There is an opportunity for GMW to link contractor payments to the completeness and accuracy of information received to drive the desired results.
- GMW should use consistent asset references between its water savings calculations and construction records to enable reconciliation between the two.
- We recommend that GMW review the events leading to inclusion of the rationalisation of meter R06683 within its water savings estimates to identify if there any opportunities to improve its business processes.
- We recommend that GMW review the pondage testing methodology to reduce the potential for ambiguity in determining pool loss rate. Specific areas we recommend that ambiguity in the methodology can be reduced are:
  - Criteria for acceptance of a correlation as significant
  - Preferred relationship for line of best fit and theoretical basis for its adoption (both linear and exponential relationships are referred to in the report) and basis for selecting alternative lines of best fit.

Water Savings Protocol Reporting Requirements

The Water Savings Audit Process[1] is a document under the Water Savings Protocol that sets out the approach to be taken to the independent audit of water savings. The scope of independent audit work relating to irrigation modernisation is to include the elements detailed below. Where each element is addressed in this report is set out below the individual element.

Verifying that the Phase 3 (and Phase 4) water savings calculations have been calculated in accordance with the Technical Manual for the Quantification of Water Savings.

We address this requirement in Section 6 of this report.

Checking that the data collection and inputs are as accurate as could reasonably be expected for the purpose of calculating water savings.

We address this requirement in Section 4 and 5 of this report.

Spot checks that the program of works has been implemented as documented in the water saving calculations.

We address this requirement in Section 5 of this report.

Checking that water savings have been calculated based on the nature and the extent of all modernisation works

We address this requirement in Section 5 of this report.

Providing a corrected estimate of the water savings for any component where the project proponent calculations are found to be non-compliant or deficient.

We address this requirement in Section 6 of this report.

Identifying potential improvements to the data collection, data analysis, assumptions and methods used to estimate the water savings. Recommend changes to the Technical Manual for the Quantification of Water Savings to the Director of Allocations and Licences within DSE (now DELWP) that will improve useability and accuracy of water savings.

We address this requirement in Section 7 of this report.

Checking if suggestions from the previous year's audit have been actioned upon and report upon the status of each of the suggested improvements.

We address this requirement in Section 8 of this report.

[1] *Water Savings Audit Process (Water Savings Protocol), Department of Sustainability and Environment Victoria, Version 2.0 June 2009.*

Glossary

A	Ratio of the length of channel to be or actually automated to the total length of channel in the defined system (%)
CG	Central Goulburn
CG134	Central Goulburn Channel 1, 3 and 4
CG2	Central Goulburn Channel 2 System
CL	Ratio of length of spur channel length rationalised to total spur channel length in system
D_{base}	Customer Deliveries in the Baseline Year in the irrigation system
DELWP	Department of Environment, Land, Water and Planning
DF	Durability factor to account for the durability of water savings interventions
DF_{error}	Durability factor for reducing measurement error
$DF_{leakage\ around}$	Durability factor for reducing leakage around the meter
$DF_{leakage\ through}$	Durability factor for reducing leakage through the meter
$DF_{unauthorised}$	Durability factor for reducing unauthorised use
D_{Mbase}	Customer deliveries through the Rationalised meters in the Baseline Year
$D_{MYear\ X}$	Customer deliveries through the replaced meters for the year in question
DSE	The Department of Sustainability and Environment
D_{YearX}	Customer deliveries in the year in question to the irrigation system
E_{Base}	Evaporation in Baseline Year
$EF_{bank\ leakage}$	Effectiveness Factor Channel automation (bank leakage)
EF_{error}	Effectiveness Factor for reducing measurement error
$EF_{leakage\ around}$	Effectiveness Factor for reducing leakage around the meter
$EF_{leakage\ through}$	Effectiveness Factor for reducing leakage through the meter
$EF_{rationaliation}$	Effectiveness Factor for channel rationalisation
$EF_{remediation}$	Effectiveness Factor for channel remediation
$EF_{unauthorised}$	Effectiveness Factor for reducing unauthorised use
$F(LTCE_{Base})$	Long Term Cap Equivalent Factor to convert Baseline Year volumes to Long Term Cap Equivalent volume
$F(LTCE_{YearX})$	Long Term Cap Equivalent Factor to convert Current Year volumes to Long Term Cap Equivalent volume
F(PA)	Pondage Testing Adjustment Factor to account for dynamic losses in addition to static losses
FL	Proportion of bank leakage recognised as fixed
GCP	GMW Connections Project
GIS	Geographic Information System
GMID	Goulburn Murray Irrigation District
GMW	Goulburn Murray Water
HR	High Reliability
IPA	Inter-Project Agreement
IPM	Irrigation Planning Module
ITP	Inspection Test Procedure
L_{Base}	Leakage in Baseline Year
$L_{Post\ works}$	Post works bank leakage
LR	Low Reliability

LTA	Defined Fixed Leakage Rate (ML/year/service point) around service points
LTCE	Long Term Cap Equivalent
LTDLE	Long Term Diversion Limit Equivalent
LTT	Defined Fixed Leakage Rate (ML/year/service point) through service points
M&E	mechanical and electrical
MCF	Adopted Meter Correction Factor for Dethridge Meter Service Points or associated with deemed Service Points
MV	Murray Valley
$N_{rationalised}$	Number of meters rationalised
$N_{replaced}$	Number of meters replaced
NVIRP	Northern Victoria Irrigation Renewal Project
O_{Base}	Outfalls in Baseline Year
OP_{yearX}	Ratio of the length of time a channel has been automated in the year in question relative to the irrigation season length in the Baseline Year
O_{yearX}	Outfalls in Current Year
PB	Pyramid-Boort
RL	Ratio of length of channel length remediated to total channel length in system
RO	Rochester
S_{Base}	Seepage in Baseline Year
SCADA	Supervisory Control and Data Acquisition
SH	Shepparton
SMC	Stuart Murray Canal
SMP	Strategic Measurement Project
$S_{post\ works}$	Post works seepage
the *Manual*	the Water Savings Protocol *Technical Manual*
the *Protocol*	the Water Savings Protocol for the Quantification of Water Savings from Irrigation Modernisation Projects
the *Technical Manual*	*Technical Manual for the Quantification of Water Savings*
t_m	Ratio of the length of time that the service point was replaced for irrigation purposes in the year in question to the irrigation season length in the Baseline Year
TO	Torrumbarry
t_r	Ratio of the length of time a channel has been rationalised in the year in question relative to the irrigation season length in the Baseline Year
TSA	Transfield Services Australia
U_{Base}	Unauthorised use loss in the Baseline Year
V_d	Deemed customer deliveries through individual unmetered service points in the Baseline Year
VL	Proportion of bank leakage recognised as variable
WEE	Water Entitlement Entity

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1 Introduction

1.1 Introduction and purpose

The Victorian State Government and the Commonwealth Government have committed significant funding for the renewal and modernisation of the Goulburn-Murray Irrigation District (GMID). The water savings achieved through the renewal and modernisation works are to be shared between the environment, Melbourne and irrigation customers. The works are also expected to improve the efficiency of delivery and increase the level of service provided to irrigation customers.

Goulburn-Murray Water (GMW) is the owner and operator of the GMID. The GMW Connections Project (previously the Northern Victorian Irrigation Renewal Project but since 1 July 2012 part of GMW) forms the greater part of the modernisation of the Goulburn-Murray Irrigation District (GMID).

The water savings achieved by the GMW Connections Project are to be audited each year. Cardno has been engaged by the Department of Environment, Land, Water and Planning (DELWP) to undertake an independent audit of the water recovery for the 2015/16 irrigation season. This purpose of this report is to present the findings of this independent audit. This is the eighth annual audit of the water savings achieved by the renewal and modernisation works in the GMID.

1.2 Water Savings Protocol

The Victorian State Government has developed a Water Savings Protocol so that water savings can be consistently and transparently calculated and audited. The Water Savings Protocol is a series of documents including the 'Audit Process' and 'Technical Manual'. The Audit Process document sets out that independent audit of water savings is to include:

- Verifying that the Phase 3 (and Phase 4) water recoveries calculations have been calculated in accordance with the Technical Manual for the Quantification of Water Savings
- Checking that the data collection and inputs are as accurate as could reasonably be expected for the purpose of calculating water recoveries
- Spot checks that the program of works has been implemented as documented in the water saving calculations
- Checking that water recoveries have been calculated based on the nature and the extent of all modernisation works completed prior to 30th June[2] in the year of the audit
- Providing a corrected estimate of the water recoveries for any component where the project proponent calculations are found to be non-compliant or deficient
- Identifying potential improvements to the data collection, data analysis, assumptions and methods used to estimate the water recoveries. Recommend changes to the Technical Manual for the Quantification of Water Savings to the Director of Allocations and Licences within DELWP that will improve useability and accuracy of water recoveries
- Checking if suggestions from the previous year's audit have been acted upon and report upon the status of each of the suggested improvements.

The Technical Manual defines the components of water savings and the methodology for estimating them. This is the principal document against which water savings estimates are verified.

A copy of the Protocol is available on the DELWP website at this location:
http://www.depi.vic.gov.au/water/rural-water-and-irrigation/improving-irrigation-efficiency/water-savings-protocol

[2] The Audit Protocol previously set the end date for the completion of modernisation works as 15 May. The point in time for determining water savings is now 30 June, as set out in the scope of works issued by DELWP.

1.3 Scope of 2015/16 irrigation season irrigation modernisation water recovery audit

The audit scope has been set by DELWP and is set out in the Project Brief, dated 29 August 2016. The scope of works is broadly an audit of water recovery estimates for the modernisation works being undertaken in Goulburn Murray Water's operating area. The audit scope included the following:

- Irrigation modernisation works in place for the 2015/16 water year (up to 30 June 2016).
- The water recovery estimates for the whole Goulburn Murray Irrigation District (Central Goulburn, Rochester, Pyramid-Boort, Murray Valley, Shepparton and Torrumbarry Irrigation Areas).
- The cumulative irrigation modernisation works and savings separately accountable to the:
  - GMW Connections Project Stage 1;
  - GMW Connections Project Stage 2;

The Project Brief states that audit of remaining works attributed to other water savings projects such as the Shepparton Modernisation Project and CG1234 Modernisation Project are not included in the 2015/16 audit and will be audited at a later date.

The scope has required the auditor to address the following:

- Verifying that stated modernisation works have been carried out.
- Verify that GMW Connections estimated water savings correctly in accordance with the Water Savings Protocol – Technical Manual for the Quantification of Water Savings in Irrigation Water Distribution Systems Version 4. The audit of water savings shall include:
  - Phase 3 – water savings generated in the 2015/2016 water year.
  - Phase 4 – long-term average water savings estimates.
- Confirming the water savings estimates or, if appropriate, establish corrected estimates.
- Identifying and recommending improvements to the collection and processing of information used for estimating water savings.

No audit is required for the long-term average water savings arising from the decommissioning of Campaspe Irrigation District and the East Loddon Stock and Domestic system as these savings are confirmed through independent auditing of water resource modelling

An audit of water entitlement purchases under the Stage 1 project for 2015/16 was completed prior to this audit as a separate exercise.

2 Background

2.1 Goulburn Murray Irrigation District

The Goulburn Murray Irrigation District (GMID) is composed of the following six main irrigation areas located in northern Victoria:

- Central Goulburn (CG) (which is divided into sub-areas CG1-4 and CG5-9)
- Murray Valley (MV)
- Pyramid-Boort (PB)
- Rochester (RO)
- Shepparton (SH) and
- Torrumbarry (TO).

Goulburn Murray Water (GMW) is responsible as both the Water Resource Manager and System Operator for the GMID. Figure 2-1 shows the location of the GMID and the main irrigation district.

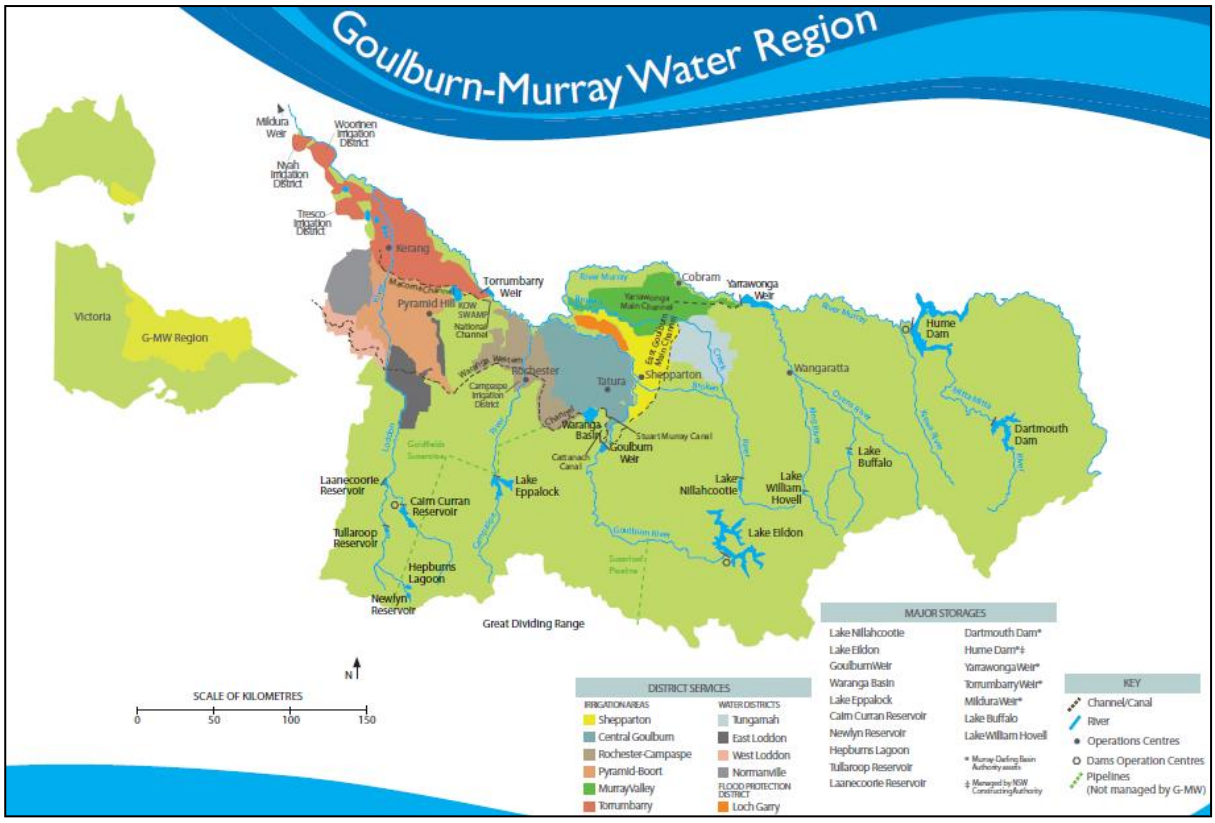

Figure 2-1 Goulburn Murray Irrigation District

Source: http://www.g-mwater.com.au/about/regionalmap

2.2 Irrigation modernisation

In 2004, the Victorian Government put in place a long-term plan for water resource management titled “Our Water Our Future”. A key initiative to deliver the sustainable outcomes targeted in this plan is modernisation of irrigation areas in northern and southern Victoria. Irrigation modernisation seeks to improve the efficiency of irrigation systems.

Irrigation modernisation typically involves the automation of channel infrastructure, construction of pipelines, upgrading the accuracy of metered outlets to farms, lining and remodelling of channels and rationalising the

channel network. Many systems are currently controlled manually and the automation of these systems allows water flows to be delivered more accurately and more quickly. These capital works, in unison with changed operational approaches, should have the twin benefits of reducing the amount of water lost in irrigation systems and improving service levels to customers.

The DELWP website[3] outlines the following main elements of irrigation modernisation:

Channel automation

Channel automation is a way of improving the efficiency of irrigation networks by using new technology to control the flow of water from the storage (usually a dam) through the distribution system to the irrigator. It involves replacing manual flow control structures in channels with updated gates that accurately measure flows, provide real time measurement data and, in most cases, are automated. The automation greatly reduces the water spilt from the end of channels (known as outfalls). Further the gate measurement allows more accurate location of the worst seepage and leakage losses and more effective targeting of channel remediation works.

Automation of the gates also provides the ability to interact with meters and on-farm automation equipment, so best practice irrigation methods can be employed on farms. Other benefits include constant flows and faster water delivery times.

Pipes and channels

Much of the irrigation system relies on open earthen channels to transport water. Inefficient operation and leaky sections resulted in up to 30% of the total volume being lost in the past. Water losses can be minimised by reducing outfall losses, lining, remodelling or pipelining parts of the channel system.

Improved meter accuracy

Dethridge wheels are inaccurate and on average under-measure water delivery by about 8%. They fail to meet the new metering standards introduced by the Australian Government that specify a maximum of plus or minus 5% measurement inaccuracy. There are also occupational health and safety risks associated with using Dethridge wheels.

2.3 Irrigation modernisation projects

The GMW Connections Project is being implemented in two stages. Stage 1, which is funded by the Victorian Government, has been underway since 2008 and Stage 2, which is funded by the Commonwealth, commenced in 2012. Additionally, GMW is also responsible for the delivery of the Shepparton and Central-Goulburn 1234 irrigation modernisation project which was largely complete in 2010.

2.3.1 Stage 1 Project

Under the funding arrangement between the State and Commonwealth Governments, signed in October 2011, Stage 1 of the project is being funded by contributions from the Victorian Government ($600 million initial contribution and $100 Million from a portion of the funds relevant to the sale of 102 GL of long term water savings associated with GMW Connections Project Stage 2) and Melbourne Water ($300 Million). This stage commenced in 2008 and is planned for completion in 2018.

The objectives of the Stage 1 project are to:

- Deliver 225 GL of long-term annual average project generated water savings to be shared equally between irrigators, the environment and other funding contributors

[3] http://www.depi.vic.gov.au/water/rural-water-and-irrigation/improving-irrigation-efficiency/modernising-irrigation-systems. *Note - minor edits have been made to this text to clarify its meaning.*

- Deliver a modernised backbone channel water distribution system
- Connect approximately 30% of those customers currently supplied by smaller spur channels to the backbone channel via a modern connection
- Upgrade metering (including real time measurement)
- Provide channel remediation to reduce high loss channel pools.

2.3.2 Stage 2 project

The Commonwealth and Victorian Governments are providing funding of $1.059 billion for Stage 2 of the GMW Connections Project, which commenced delivery in 2012 and was planned to be completed in 2018. The Commonwealth Government is contributing $953 million and $106 million from a portion of the funds associated with the sale of 102 GL of long term annual average water savings associated with GMW Connections Project Stage 2.

The Stage 2 project is planned to raise the efficiency of the GMID system to over 85%, generating a long-term average of 204 GL of annual water savings from reduced distribution losses. These savings are to be transferred to the Commonwealth Government for environmental use and in particular, contributing to Sustainable Diversion Limits in the Murray Darling Basin.

2.3.3 Project Reset

A condition of the Stage 2 Project funding agreement between the State of Victoria and the Commonwealth government is that a mid-term review of the project be conducted. The review occurred in 2015 and recommended that the Stage 2 Project be reset because the actual operating environment in which the project is being delivered does not align with the assumptions made in the original business case. As a result, the mid-term review concluded that the project would not be delivered on time or on budget.

A Stage 2 Reset Delivery Plan was developed on response to the mid-term review. The Reset Delivery Plan was developed with the objective of ensuring delivery of the full 204GL of water savings to the Commonwealth within the allocated budget. The Reset Delivery Plan recommends a different delivery approach for the remaining modernisation works as well as increased targeting of works in specific locations. The Reset Delivery Plan recommends extension of the timeframe for delivery to 31 October 2020.

The Stage 2 Reset Delivery Plan was agreed by the Victorian and Commonwealth governments on 7 September 2016.

The Stage 2 Project Reset means that some systems and processes referred to in this audit report will transition during 2016/17. Where the transition of systems and processes may impact on the estimation of water savings recovery in the future it has been noted in this report.

3 Audit Methodology

3.1 Water Savings Audit Process requirements

The Water Savings Audit Process[4] is a document under the Water Savings Protocol that sets out the approach to be taken to the independent audit of water savings. The scope of independent audit work relating to irrigation modernisation is to include the elements detailed below. Where each element is addressed in this report is set out below the individual element.

Verifying that the Phase 3 (and Phase 4) water savings calculations have been calculated in accordance with the Technical Manual for the Quantification of Water Savings.

We address this requirement in Section 6 of this report.

Checking that the data collection and inputs are as accurate as could reasonably be expected for the purpose of calculating water savings.

We address this requirement in Sections 4 and 5 of this report.

Spot checks that the program of works has been implemented as documented in the water saving calculations.

We address this requirement in Section 5 of this report.

Checking that water savings have been calculated based on the nature and the extent of all modernisation works

We address this requirement in Section 5 of this report.

Providing a corrected estimate of the water savings for any component where the project proponent calculations are found to be non-compliant or deficient.

We address this requirement in Section 6 of this report.

Identifying potential improvements to the data collection, data analysis, assumptions and methods used to estimate the water savings. Recommend changes to the Technical Manual for the Quantification of Water Savings to the Director of Allocations and Licences within DSE (now DELWP) that will improve useability and accuracy of water savings.

We address this requirement in Section 7 of this report.

Checking if suggestions from the previous year's audit have been actioned upon and report upon the status of each of the suggested improvements.

We address this requirement in Section 8 of this report.

The Audit Process also defines the expected content of the water savings audit report. The minimum requirements of the report and where they are fulfilled in this report is summarised in the following table:

[4] *Water Savings Audit Process (Water Savings Protocol), Department of Sustainability and Environment Victoria, Version 2.0 June 2009.*

Table 3-1 Expected Content of Water Savings Audit Report

Requirement	Relevant Section
A summary of findings.	Summary of Findings
An audited supporting data set and reports.	Section 6
Full evaluation of water savings estimation against protocol.	Section 6
Documentation of any instances of non-compliance and the required changes to the proponent's estimates.	Section 5 and 6
Full tabulation of water savings estimation against Project Proponent's Business Case targets.	Summary of Findings
Description of the audit process undertaken, including a description of how the information was audited and/or verified (e.g. sighted documentation, persons spoken to etc.).	Section 3
In addition to the audit report, the auditor can recommend, to DELWP (formerly DSE), improvements to the method for estimation, calculation and reporting water savings for future years. This may include recommendations of revisions to the Technical Manual for the Quantification of Water Savings, or to the Project Proponent's processes for estimating and reporting water savings.	Section 7

The following sub-sections detail the audit process undertaken.

3.2 Overview of audit methodology

The approach taken to auditing water recovery is based around structured interviews with key GMW staff. These structured interviews scrutinise the water recovery calculations and assess the veracity of the supporting information. The audit focused on these areas:

- The systems and procedures in place to manage the data used in the calculations, including trailing the data used in the calculations back to source records
- Verifying that the works claimed are complete and commissioned through review of works handover and commissioning documents as well as inspection of a sample of assets
- Checking that the audit calculations have been performed correctly
- Reviewing the GMW Connections Projects progress on the implementation of previous audit recommendations.

3.3 Schedule of audit meetings

Table 3-2 lists the meetings held to complete the audit work.

Table 3-2 Schedule of Audit Meetings

Date	Audit Work	Auditee	Position
Monday 24 October 2016	Start-up Meeting	Ross Plunkett	Manager Environment & Water Savings
		Peter Roberts	Project Manager, Water Savings
		Ben Morse	Water Savings Analyst
		Trudi Woodward	Construction Database Administrator
		John Davison	Project Manager
		Steve Nioa	Asset Management
	Audit of water savings calculations	Peter Roberts	Project Manager, Water Savings
	Review of SCADA records for	Chris Tomlinson	Water Systems Planner

Date	Audit Work	Auditee	Position
	outfalls	Peter Roberts	Project Manager, Water Savings
Tuesday 25 October 2016	Channel remediation water savings	Ben Morse	Water Savings Analyst
	Audit of water savings calculations	Peter Roberts	Project Manager, Water Savings
Wednesday 26 October 2016	Review of construction records for modernisation works	Kane Dougherty	Senior Project Manager
		John Davison	Project Manger
		Peter Roberts	Project Manager, Water Savings
	Audit of water savings calculations	Peter Roberts	Project Manager, Water Savings
Thursday 27 October 2017	Site inspections	Peter Roberts	Project Manager, Water Savings
Friday 28 October 2016	Close out meeting	Ross Plunkett	Manager Environment & Water Savings
		Peter Roberts	Project Manager, Water Savings
		Trudi Woodward	Construction Database Administrator
		Ben Morse	Water Savings Analyst

3.4 Site photos

A schedule detailing the assets inspected and photos of each asset is included in Appendix B.

3.5 Document register

A list of the documents received before, during and after the audit are included in Appendix A.

4 Information Systems and Business Processes Supporting Water Savings Calculations

4.1 Introduction

Our audit considers the systems and processes in use by GMW and its contractors that support the calculation of water recoveries to determine whether they are sufficiently reliable to produce accurate, repeatable and transparent data. Our review of systems and processes focuses on those business areas central to the water recovery estimates:

- Planning and delivery of construction works
- Outfall measurement and recording
- Customer deliveries
- Assignment of works between Stage 1 and Stage 2 projects.

Because of the importance of demonstrating that the water recoveries have been calculated based on accurate information, we have complemented this review of systems and processes, with trailing of selected data, used in the calculations, to their source. The results of this trailing are documented in Section 5.

To operate its irrigation network, GMW employs a number of information systems. The key systems are:

- SCADA – provides real time monitoring of gate operation, including trending. Field readings are stored and can be accessed through a data warehouse.
- Maximo – asset information system and computerised maintenance management system
- GIS – records location of channels and control gates. Channel lengths and widths are measured from here.
- The Irrigation Planning Module (IPM) takes customer orders, checks system capacity to deliver orders and records delivered volumes
- Agresso – the finance system for the GMW Connections Project which is used for tracking works progress and costs, as well as recording the categorisation of works between Stage 1 and 2.

4.2 Planning and delivery of construction works

In previous years, construction records were held across a number of different systems reflecting the different parties responsible for providing infrastructure. However, as the project has progressed, the majority of works are undertaken by a single contractor, TransCom Connect with construction records stored in its document management system, SharePoint (previously Aconex). TransCom Connect is a joint venture between Transfield Services Australia and Comdain Infrastructure. Previously, works were predominantly constructed by Transfield Services Australia alone.

TransCom Connect as the managing contractor typically manages a number of sub-contractors including designers, civil works contractors and mechanical and electrical (M&E) contractors to complete the required works. Works within the channels (e.g. regulator gate automation and channel remediation) are usually completed outside of the irrigation season, while service point replacements and rationalisations are delivered throughout the year.

Delivery of the modernisation assets generally follows the following sequence:

1. GMW's planners determines the schedule of works to be undertaken
2. TransCom Connect project manages the asset delivery:
    a. Engage designer to complete detailed design
    b. Engage civil subcontractor to complete civil works

c. Engage M&E subcontractor to complete M&E works

3. Asset commissioning
4. Handover of assets to GMW.

Some works are also being undertaken by GMW work crews.

At this audit, we have audited and inspected works undertaken by another contractor. GMW informed us that this contractor completed a package of works that included construction of around 40km of pipelines and 60 meter replacements. GMW advised that it had only received construction records for 18 of the 60 meters completed. This lack of construction records for this package of works was observed in the sample of construction records that we reviewed which are discussed in Section 5.2. This experience highlights the need for continued vigilance to ensure the quality and completeness of construction records to both confirm the modernisation works completed and for ongoing operational purposes.

When new assets are commissioned, or redundant channel decommissioned, an ITP certificate is produced which records relevant commissioning/decommissioning details. These ITP certificates are stored on SharePoint along with other documents relevant to the construction and commissioning of each site. These documents are collectively referred to as the 'work pack' for the constructed asset.

While handover of assets to GMW following a defects liability period is important for the successful ongoing operation of the modernisation works, we have focused on asset commissioning rather than handover, as water recoveries are typically achieved from the time that an asset is commissioned. Asset commissioning dates are recorded by TransCom Connect on schedules and forwarded to GMW. GMW then uses these dates in its water recovery calculations.

We believe that GMW's and TransCom Connect's systems for asset delivery and commissioning are sufficiently robust to completely and correctly record the details of irrigation modernisation asset installation and commissioning. TransCom Connect's document management system provides the reference database for the storage and retrieval of all construction and commissioning records. The database has been in use for several years. We have less certainty over the systems and processes employed by the other contractor but note that this contractor has delivered only one package of work and that the deficiencies in the records produced appear to be a one-off event rather than reflective in a decline of construction records more widely.

We note that under the project reset GMW will likely entering into new contracting arrangements. It is crucial that the new contracting arrangements include robust systems for recording and reporting on the commissioning and handover of assets to provide confidence for the calculation of water savings and for ongoing operational purposes.

4.3 Recording of outfall flow volumes

The volumes of flows through outfalls are an important data input into water savings calculations as savings from outfalls currently are a significant component of all water savings achieved. Now that irrigation modernisation works in the GMID have been in progress for several years, most major outfalls have online flow measurement which is recorded in the GMW SCADA. A number of unmetered outfalls still exist where flows are estimated by operators (mainly on spur channels that may be decommissioned in the future). However, these account for only a small proportion of the water savings achieved.

As noted in last year's audit, GMW now uses SCADA data (warehoused in and reported from IPM) as the source data for reporting outfall volumes. Where an outfall does not have online measurement, field staff record the outfall volume in a logsheet. There is a separate logsheet for each irrigation area. Water Systems Planning staff provide to field staff each month a spreadsheet containing outfall data extracted from IPM. Field staff review the spreadsheet and make adjustments for any erroneous readings, e.g. if the water level in the channel is particularly low, the flow reading may be a false high reading when in fact no water is leaving the outfall. Field staff also input into this spreadsheet their readings for outfalls without on-line metering and provide this information back to the planning team.

We identified in our review of outfall records at this year's audit that the change to daylight savings time had created some anomalous records within IPM. However, GMW's quality assurance processes had corrected these anomalies in the records we reviewed.

4.4 Customer delivery volumes

The IPM is the business system used by GMW to manage irrigation supply orders and plan the delivery of these orders. When an order is placed by a customer online or by telephone, it is sent to IPM. For customers on fully automated channels, IPM essentially sends the order to the customer's outlet. The orders specify the times to open and close the customer outlet and the ordered flow rate. The channel automation system uses a combination of feedback control on water level with feed-forward on flow to control to the channel.

IPM also provides management reporting facilities on a range of operational aspects and records delivery volumes for billing purposes. It also records delivery volumes against entitlements and rejects orders where the entitlement has been exceeded.

For the purposes of the water savings calculations, IPM is used to determine customer deliveries through service points. We have reviewed the procedures for extracting this data from IPM and found that they adequately describe the process.

4.5 Assignment of savings between Stage 1 and Stage 2

The Victorian and Commonwealth Governments enter into funding agreements for modernisation works in the GMID which are the basis on which water savings are assigned between the Stage 1 and Stage 2 projects. For all new proposed works, a Business Case is written and this Business Case details the Stage to which the works belong with reference to the relevant funding agreement. For historical works, a Business Case may not have been written, therefore, assignment of the works is undertaken by inspection. However, because the nature of the Stage 1 works, which typically involved the backbone, are generally different to the Stage 2 works, assignment of works to a project stage is usually reasonably straightforward.

When a Business Case is raised, it is entered as a record into the GMW Connections Project finance system, Agresso. The Business Case record has an identification number (referred to as the BCID) and linked to this record is the project stage. Progress and costs relating to the Business Case are then tracked using Agresso.

4.6 Conclusions

Our review for the 2015/16 audit of the information systems and processes used by GMW has found that they continue to be sufficiently robust to generate data and inputs that are as accurate as could reasonably be expected for the purpose of calculating water recoveries.

We note that there appears to have been a failure in GMW's business processes to ensure the handover of complete and accurate construction and commissioning records for one package of work but we consider that this is not representative of GMW's overall performance in ensuring that adequate construction and commissioning records are kept.

4.7 Recommendations

We note that under the project reset GMW will likely entering into new contracting arrangements. We recommend that GMW ensures that the new contracting arrangements include robust systems for recording and reporting on the commissioning and handover of assets to provide confidence for the calculation of water savings and for ongoing operational purposes

5 Data trailing of calculation inputs

5.1 Objective

We have trailed data used in the calculation of water savings back to source systems and original data sets as part of our audit to test that the inputs utilised to estimate water savings is based on complete and accurate data contained in GMW information systems. The data trailing undertaken at the audit is a combination of random and targeted sampling.

We discuss the data trailing undertaken in the following sections.

5.2 Construction records

5.2.1 General

As in previous years, our review of construction records has focused on works constructed during 2015/16 as we have reviewed samples of assets constructed in previous years through previous audits. As noted in Section 4.2, construction of modernised irrigation infrastructure in 2015/16 was predominantly undertaken by TransCom Connect, a joint venture between Transfield Services Australia and Comdain Infrastructure. Some modernisation works are currently being undertaken by GMW.

Under the Project Reset, Transcom Connect will discontinue delivery and GMW will move to an Early Contractor Involvement delivery model. GMW has commenced procurement for this work.

5.2.2 Service point (meter) replacement and rationalisation – Stage 1 and Stage 2 project

We requested commissioning certificates (ITP certificates) for a sample of 23 sites (2.5% sample of 927 work packages undertaken in the 2015/16 irrigation year) where service points had been replaced or rationalised to confirm that the works have been completed.

The results of reconciling these records with the data used in the water savings calculation is summarised in Table 5-1. Note that the initial sample of meters selected included a number of meters which were outside of the scope of the audit, e.g. because they were stock and domestic meters or because they were not commissioned within the audit period. We confirm that GMW has not included savings arising from these out of scope meters.

Table 5-1 Findings from service point replacement and rationalisation data trailing

IPM / Asset Code	Activity	Confirm work done for this meter
SH3465	Rationalised	Construction records include sufficient information to confirm that works are complete as claimed in water savings
RO5108	Replaced	Construction records include sufficient information to confirm that works are complete as claimed in water savings
TN12793	Replaced	Construction records include sufficient information to confirm that works are complete as claimed in water savings
SH3725	Rationalised	Construction records include sufficient information to confirm that works are complete as claimed in water savings
RO6083	Rationalised	No construction records available. GMW provided photos of the works and reviewed the asset records in the GIS which showed that this was recorded as being out of service. We are satisfied that this meter is rationalised as claimed.
RO6392	Rationalised	Construction records include sufficient information to confirm that works are complete as claimed in water savings
TO4027	Rationalised	Construction records include sufficient information to confirm that works are complete as claimed in water savings
RN1986A	Replaced	Construction records include sufficient information to confirm that works are complete as claimed in water savings
TO2788A	Replaced	Construction records include sufficient information to confirm that works are complete

IPM / Asset Code	Activity	Confirm work done for this meter
		as claimed in water savings
RNDS1277A	Replaced	Stock and domestic meter and therefore not in audit. We confirmed no savings have been claimed for replacement of this meter.
PH454A	Rationalised	Construction records include sufficient information to confirm that works are complete as claimed in water savings
RO6143	Replaced	Construction records include sufficient information to confirm that works are complete as claimed in water savings
TN12796A	Replaced	Construction records include sufficient information to confirm that works are complete as claimed in water savings
RO5933A	Rationalise	No construction records available. GMW provided photos of the works and reviewed the asset records in the GIS which showed that this was recorded as being out of service. We are satisfied that this meter is rationalised as claimed.
RODS6363A	Replaced	Stock and domestic meter and therefore not in audit. We confirmed no savings have been claimed for replacement of this meter.
RO5239	Replaced	Construction records include sufficient information to confirm that works are complete as claimed in water savings
TO4033	Rationalised	Construction records include sufficient information to confirm that works are complete as claimed in water savings
RO6683	Rationalised	GMW advised that work is not yet complete at this site. Work has been delayed due to landholder negotiations but it was anticipated that the works would be complete within a month.
TO2695	Rationalised	GMW during the week of the onsite audit advised that no construction records or photos are available for this site. Follow up information provided by GMW shows that the channel with the open outlet had been privatised and no construction workpack is therefore required.
TO5071	Replaced	Construction records include sufficient information to confirm that works are complete as claimed in water savings
RODS6211A	Replaced	Stock and domestic meter and therefore not in audit. We confirmed no savings have been claimed for replacement of this meter.
TN12548	Replaced w-new	Construction records include sufficient information to confirm that works are complete as claimed in water savings
RN1557	Replaced	Construction records include sufficient information to confirm that works are complete as claimed in water savings

Of the 23 meter replacement or rationalisation activities in the sample, three relate to work on stock and domestic meters which are outside of the scope of this audit. Of the remaining 20 items, we found that 16 (80%) had work packs with complete construction records to confirm that the works claimed were complete and consistent with the water savings calculations. This is an improvement from the 2014/15 audit where we found that 60% of the records reviewed were complete.

Of the remaining four items, three have incomplete or no construction records available. Two of these items (10% of the sample) relate to meter rationalisation work undertaken under one package of work by a contractor other than TransCom Connect. As noted in Section 4.2, this contractor has provided incomplete construction records for a package of works that it completed. For these sites, GMW provided us with photos and other evidence to confirm that the work at these sites was completed and we are satisfied that they should be included in the calculations.

For one other site (R06683), GMW advised that work to rationalise this meter was not yet complete. The work had been delayed due to landholder negotiations but it was expected that the meter would be rationalised within a month. This meter is included in GMW's water savings calculations. However, the calculations include a note that this meter cannot be included within the Phase 3 savings calculations because it was decommissioned after the end of the season and the savings have been set to zero. Similarly, the Phase 4 savings have been set to zero. We note that the reason noted for exclusion is not correct – it was not decommissioned after the end of the season, it has not been decommissioned at all, although GMW may reasonably conclude that it would be. We do not consider that there is any systemic

problem in GMW recognising when work is complete but recommend that GMW reviews its work acceptance processes for this work package.

5.2.3 Remediation

We requested that GMW provide construction records for a sample of remediation works completed in 2015/16 to verify that the channel remediation works claimed in the water recovery calculations had been completed and that the results of pre-works pondage tests had been. A total of 22 pools were remediated in 2015/16. Six pools were included in the sample of sites reviewed and these are detailed in Table 5-2.

The records provided included maps, photos, track sheets and commissioning paperwork. Based on the evidence provided, we were able to confirm that the works in our sample are complete.

Table 5-2 Findings from trailing remediation records

Pool	Audit notes
MV864-867	The construction records reviewed provide assurance that the work claimed is completed. We confirmed the length of channel claimed. We cross checked with pre-works pondage test value used in the calculation with the pondage test database and report and found that they were consistent.
RO299-300	The construction records reviewed provide assurance that the work claimed is completed. However, it does not include any photos of the works. GMW was able to provide photos of the works in its Dekho GIS. We found that the as-constructed drawing was difficult to interpret with the extent and nature of works not clear. This drawing is of a lesser quality than other as-constructed drawings witnessed. After review, we were able to reconcile the works with the length of remediation claimed. We cross checked with pre-works pondage test value used in the calculation with the pondage test database and report and found that they were consistent.
RO231-232	The workpack information review provides assurance that the work claimed is completed. However, one of the sheets of the as-constructed drawing is missing. We were unable to confirm the length of the channel works from this drawing. In reviewing the pondage test results, we found that GMW's consultant responsible for pondage testing had recommended a loss rate of 21.6mm/day but that GMW had used a lower loss rate of 15mm/day in its calculations. GMW advised that in compiling the water savings calculations, it identified that the consultant's analysis included a data point in error. Removing this data point led to the lower loss figure being adopted. We note that the lower loss rate leads to a lower estimate of water savings achieved. GMW provided to us a schedule of updated pondage testing results at audit with the revised figure included.
RN62A-65(b)	The workpack information review provides assurance that the work claimed is completed. This work had both a clay lining and HDPE lining element. GMW uses separate lines in its calculation spreadsheet for each construction type. We saw on the as-constructed drawing that the length of channel clay-lined was around 170m which is greater than the 150m used in the calculations. GMW explained that it does not typically claim the short length of channel clay lined before a HDPE liner is installed. In reviewing the pondage testing results we note that GMW's consultant recommends a loss rate of 50mm/day be adopted based on an average of 2006 and 2007 test data. However, GMW used a loss rate of 60mm/day based on the 2007 data only. We queried why the higher loss rate had been adopted to which GMW responded: *This pool has a long, well established, and continuous issue with leakage. This can be confirmed through Maximo/Dekho (report provided). Based on this and on the early dates for pondage testing in the GMID when the process was just getting developed by GMW, GMW and Jacobs agreed that the 2007 data was more representative of the long-term condition and loss rate of this particular channel.* We accept this justification but comment further on the pondage testing methodology below.
TO97-98	The workpack information review provides assurance that the work claimed is completed. GMW advised that claiming this work was opportunistic as the works are being undertaken outside of the remediation program
RN642-645	The workpack information review provides assurance that the work claimed is completed. We confirmed the length of channel claimed. We cross checked with pre-works pondage test value used in the calculation with the pondage test database and report and found that they were

Pool	Audit notes
	consistent.

Based on our review of recent remediation construction records, we consider that there is an opportunity for GMW to improve the consistency of the quality of as-constructed drawings for remediation works (and possibly other works). This may take the form of establishing a minimum standard for as-constructed drawings and withholding part of the contractor's payment until a drawing of this standard is received.

We noted for pools RO231-RO2232 and RN62A-65(b) that GMW had adopted a loss rate that differed from that recommended by its consultant that undertakes pondage testing. One adopted loss rate was higher than that recommended by the consultant and one was lower. While GMW has provided justification in each instance, we have reviewed the report *Pondage Testing Program – Methodology* (SKM, 2013) and consider that there is ambiguity in this methodology that should be reduced to provide greater confidence that the appropriate loss rate has been adopted. We consider that a review of the methodology may provide benefit to GMW. Specific areas we recommend that ambiguity in the methodology can be reduced are:

- Criteria for acceptance of a correlation as significant
- Preferred relationship for line of best fit and theoretical basis for its adoption (both linear and exponential relationships are referred to in the report) and basis for selecting alternative lines of best fit.

5.2.4 Channel rationalisation

We reviewed the construction records for ten decommissioning activities. The records reviewed and the finds are detailed in Table 5-3.

Table 5-3 Findings from trailing rationalisation records

Business case ID	Region	IPM/ Asset Code	Audit notes
1588	Murray Valley	MV4094ABlock	Records provided confirmed work is done and extent of assets decommissioned is consistent with calculations
2329	Torrumbarry	2/13/9 BBEP	Records provided confirmed work is done and extent of assets decommissioned is consistent with calculations
2351	Torrumbarry	ST001097	The water savings calculations make reference to ST00109 being the relevant structure decommissioned. However, the construction records provided did not include any reference to this structure number. After reviewing GMW's GIS we were able to identify that this structure number relates to IPM code TO474 which we confirmed is referenced in the work package. We recommend that GMW uses consistent references for its assets between construction records and the water savings calculations.
1388	Torrumbarry	ST044221 - Block	Records provided confirmed work is done and extent of assets decommissioned is consistent with calculations
1023	Murray Valley	ST042444	Records provided confirmed work is done and extent of assets decommissioned is consistent with calculations
2386	Pyramid-Boort	ST023527 - Block	Records provided confirmed work is done and extent of assets decommissioned is consistent with calculations
2512	Murray Valley	5/1 BBEP	Records provided confirmed work is done and extent of assets decommissioned is consistent with calculations
2201	CG5-9	ST007013 - Block	Records provided confirmed work is done and extent of assets decommissioned is consistent with calculations
2102	CG5-9	RN1670	Records provided confirmed work is done and extent of assets decommissioned is consistent with calculations

We recommend that GMW uses consistent asset references between its water savings calculations and construction records to enable reconciliation between the two.

5.2.5 Automation

GMW upgraded 77 regulator gates to automatic gates in the 2015/16. We audited the construction records of a sample of four of these gates. Table 5-4 details the findings of the records reviewed.

Table 5-4 Sample of automation sites 2015-16

IPM Number	Comment
RO396	Evidence sufficient that work undertaken
RO420	Evidence sufficient that work undertaken
RO713	Evidence sufficient that work undertaken
RO730	Evidence sufficient that work undertaken

All four workpacks provided evidence of works being completed including ITPs and photos.

5.3 Outfall volumes

As noted at the 2014/15 audit and in Section 4.3, GMW now used SCADA data stored in IPM as the primary source of outfall volume data. We selected a sample of outfall data used in the water savings and trailed these back to the IPM database. The findings of this data trailing are summarised in Table 5-5.

Table 5-5 Findings from trailing outfall data

IPM Code	Audit notes
SP218	Review of SCADA records shows a positive reading. GMW advised that this is due to this being a level sensor output rather than a flowmeter.
RN829	Outfall data used in water savings consistent with data recorded in IPM for this outfall
TN364	Outfall data used in water savings consistent with data recorded in IPM for this outfall
MV426	GMW advised that at this outfall higher than usual volumes were recorded due to herbicide being flushed from the system. We comment on this occurrence further following.
MV799	Outfall data used in water savings consistent with data recorded in IPM for this outfall
RO735	Outfall data used in water savings consistent with data recorded in IPM for this outfall
RO720	Outfall data used in water savings consistent with data recorded in IPM for this outfall
TO278	Outfall data used in water savings consistent with data recorded in IPM for this outfall
TO254D	Outfall data used in water savings consistent with data recorded in IPM for this outfall
PH301	Outfall data used in water savings consistent with data recorded in IPM for this outfall
PH895	We found that the outfall volume used in the water savings calculations 628ML was inconsistent with the volume generated by a report on the IPM data (659ML). GMW investigated and found that this discrepancy was due to the changeover to daylight savings time which had created duplicate records that were included in the reported total. GMW's quality assurance processes had not included the duplicated records in its reported total which demonstrated that the quality assurance processes were effective in this instance.

GMW advised that during winter 2015/16 it used a herbicide for weed control with an active ingredient that had not previously been employed. Routine testing to determine the remaining concentration of the active ingredient after its application found that the chemical was present in the irrigation system in higher than acceptable concentrations for use of irrigation water on farms. GMW reports that this was due to slower than expected decay of the active ingredient. Consequently, GMW commenced a program to flush channels to remove the chemical. GMW advised that around 370km of channels (of its 6,000km total) in the Shepparton, Murray Valley and Central Goulburn and Rochester irrigation areas were affected.

The flushing program has led to outfalls volumes at some locations being substantially higher than recorded in previous years. GMW has included these higher than previous volumes in its water savings calculations for the estimate of Phase 3 savings. This has the impact of reducing the Phase 3 water savings achieved. However, it has excluded these higher than previously recorded outfall volumes from the calculation of Phase 4 water savings estimates on the basis that this is an uncharacteristic event that it does not intend to repeat. We accept this argument as we have not observed this event in previous years. Further, future audits of water savings will be able to identify any future flushing events.

GMW also advised that during 2015/16 groundwater pumping to lower the level of a local watertable had been undertaken The groundwater is saline, hence the need to lower the watertable to protect crops. This groundwater is discharged into the irrigation network which necessitates that the saline water be diluted with irrigation water or flushed out of the system so that the water received by customers is within acceptable limits for salinity. GMW advised that groundwater pumping was undertaken routinely in past years but has not been conducted for more than 10 years. This is because the drier conditions during and after the millennium drought has led to lower groundwater levels. Dilution and flushing of the saline groundwater led to higher than typical volumes being outfalled at some locations.

GMW has included the high outfall volumes due to groundwater dilution and flushing in its Phase 3 and Phase 4 water savings estimates (leading to lower estimates of water savings). We consider that this is an appropriate approach. GMW will undertake further investigation to ascertain the likely long term level of groundwater pumping and its potential impact on outfalls and water savings. It also intends to investigate whether the saline groundwater may be discharged to a location not within the irrigation network.

5.4 Mitigating Flows

We did not trail mitigating flows back to Environmental Watering Plans for the 2015/16 audit as these allowances have been included in previous years' audits.

5.5 Conclusions

We found that most assets included in our samples for data trailing had sufficient evidence to support the fact that they have been constructed and commissioned. We are satisfied that GMW has completed the works claimed in the calculations.

We noted for some types of remediation construction works that the as-constructed remediation drawings received were of insufficient quality to accurately describe the nature and extent of the remediation works undertaken. Through our audit work, we have obtained sufficient evidence that the work claimed in the samples reviewed has been completed. GMW identified that there are areas for improvement with some as constructed remediation drawings and this would be included in any new contracting arrangements.

We therefore recommend that GMW puts in place strong controls over the quality of work pack information received from contractors under its new delivery model and as-constructed drawings in particular. There is an opportunity for GMW to link contractor payments to the completeness and accuracy of information received to drive the desired results.

5.6 Recommendations

We make the following recommendations in relation to quality assurance of construction records:

- We recommend that GMW puts in place strong controls over the quality of work pack information received from contractors under its new delivery model and as-constructed drawings in particular. There is an opportunity for GMW to link contractor payments to the completeness and accuracy of information received to drive the desired results.
- GMW should use consistent asset references between its water savings calculations and construction records to enable reconciliation between the two.

- We recommend that GMW review the events leading to inclusion of the rationalisation of meter R06683 within its water savings estimates to identify if there any opportunities to improve its business processes.
- We recommend that GMW review the pondage testing methodology to reduce the potential for ambiguity in determining pool loss rate. Specific areas we recommend that ambiguity in the methodology can be reduced are:
  - Criteria for acceptance of a correlation as significant
  - Preferred relationship for line of best fit and theoretical basis for its adoption (both linear and exponential relationships are referred to in the report) and basis for selecting alternative lines of best fit.

6 Audit Findings –Water Savings Calculations

6.1 Structure of this chapter

This chapter has been structured to align with the structure of the *Technical Manual,* with each water saving intervention presented in the same order as found in that document. The *Technical Manual* provides additional discussion on the application of the water savings calculations that have been omitted from this report to avoid repetition.

For each water saving intervention (channel rationalisation, channel automation, service point replacement and rationalisation, and channel remediation) we detail:

- The nature of the works that lead to water recovery and the scope of works undertaken to date
- An overview of the components that contribute to water recovery in each irrigation area
- The calculations from the *Technical Manual* used to determine the savings in that area
- The data used in the calculation. Input data is sourced mainly from the *Technical Manual*, the baseline year water balance and operational records
- The water savings resulting from applying the calculation.

The scope of this audit is to review Phase 3 and Phase 4 water savings achieved, where:

- Phase 3 water savings are the annual post-works measurement or verification of interim water savings able to be allocated from the water savings account
- Phase 4 water savings are the assessment of the overall long term water savings achieved through the modernisation program.

6.2 Baseline year water balance

In calculating water savings, reference is made for some components to water loss that occurred in a baseline year. For most water savings components, the baseline year was the 2004/05 irrigation season. A water balance that establishes the value for water loss components in each irrigation area for this baseline year was compiled by GMW. This baseline year water balance has been previously independently audited.

Since the completion of this independent audit, GMW has revisited the baseline year water balance and made some revisions on the basis of better information being available or a more complete understanding of the nature of losses in the irrigation districts. This revised baseline year water balance was independently audited in 2012 and has been used as the basis of this audit.

6.3 Overview of water recovery achieved in 2015/16

The 2015/16 audit requires water savings to be separately accounted to the Stage 1 and Stage 2 projects. The Stage 1 project has been in progress since 2008 while the Stage 2 project commenced in 2012. Therefore, the Stage 1 project accounts for the great majority of savings, as shown in Table 6-1. Note that this table excludes savings from the residual works undertaken in the Shepparton and CG1-4 irrigation areas.

Table 6-1 Audited Phase 4 water savings by project

Project	Phase 4 water savings (ML)	% Total
Stage 1 project	170,177	81%
Stage 2 project	40,287	19%
Total	**210,464**	

Figure 6-1 provides an overview of the contribution of the different modernisation activities to the audited Phase 4 water savings for 2015/16 for both the Stage 1 and Stage 2 projects. This figure shows that service

point replacement (33%) and channel automation (26%) are the most significant contributors to water savings achieved to date. Channel Automation works are largely complete and the share accountable to this intervention will reduce as a proportion of the total with time. As the Stage 2 projects progress, savings due to service point replacement and rationalisation and channel rationalisation are expected to increase.

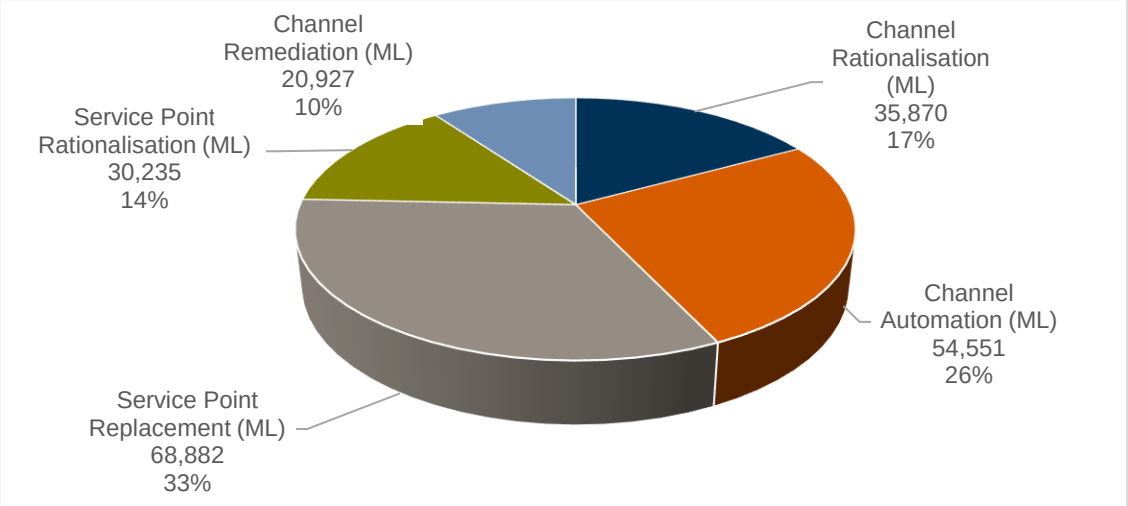

Figure 6-1 Audited Phase 4 Water Savings Estimates (Stage 1 and Stage 2 projects) 2015/16

6.4 Savings from Channel Rationalisation

6.4.1 Scope of Channel Rationalisation Works

Channel rationalisation involves redesigning the channel network so that channel length can be minimised while still providing service to customers. Channels that are determined to be redundant are abandoned and isolated from the distribution network and no flows enter them. This means that there are water savings due to reduced evaporation, bank seepage and bank leakage.

Channel rationalisation has been completed under the Stage 1 and Stage 2 projects. Rationalisation of spur channels under the Stage 2 project is expected to contribute significantly to water savings in future years as the GMW Connections Project progresses.

Figure 6-2 details the length of channels rationalised in each irrigation area under the Stage 1 and Stage 2 projects.

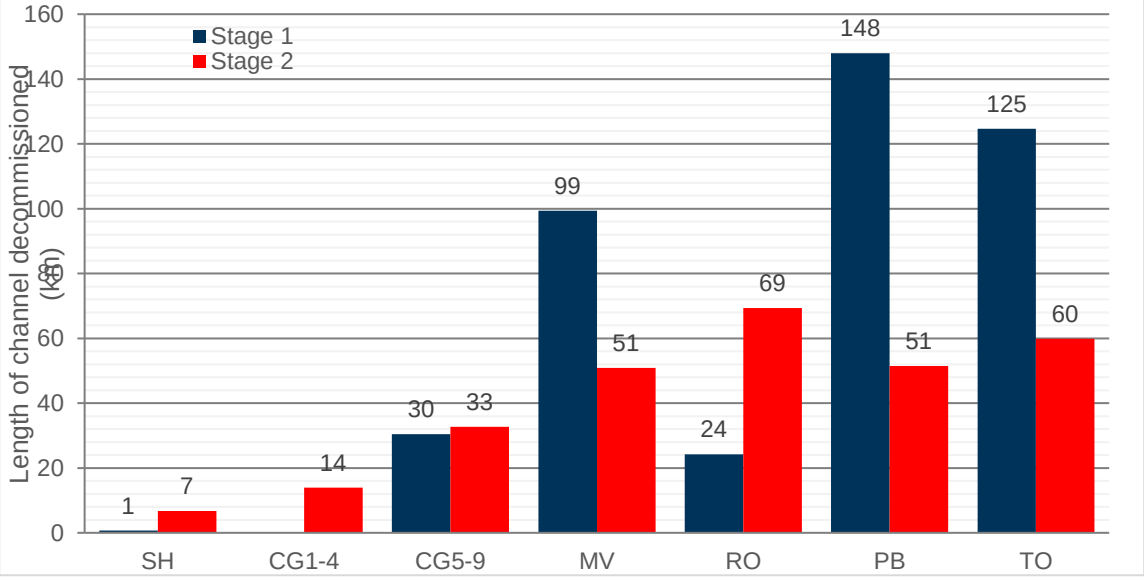

Figure 6-2 Length of rationalised channel by irrigation area under Stage 1 and Stage 2 project

6.4.2 Overview

Water savings due to channel rationalisation are the sum of the savings due to water no longer being lost in the channel to seepage, bank leakage, and evaporation:

Phase 3: $WS_{Yearx} = WS_{seepage} + WS_{bank\ leakage} + WS_{evaporation}$

Phase 4: $WS_{(LTCE)} = WS_{seepage(LTCE)} + WS_{bank\ leakage(LTCE)} + WS_{evaporation\ (LTCE)}$

6.4.3 Water Savings Calculations

Phase 3 Calculations

Phase 3 water savings have been calculated by GMW using the Phase 3 channel rationalisation formulae from the *Technical Manual*:

$$WS_{Seepage} = S_{Base} \times CL \times t_r \times EF$$

$$WS_{bank\ leakage} = [(L_{Base} \times FL) + (L_{Base} \times VL \times (D_{YearX} / D_{Base})] \times CL \times t_r \times EF$$

$$WS_{evaporation} = E_{Base} \times CL \times t_r \times EF$$

Phase 4 Calculations

Phase 4 water savings due to channel rationalisation are estimated by the following equations from the *Technical Manual*:

$$WS_{Seepage(LTCE)} = S_{Base} \times CL \times EF \times DF$$

$$WS_{bank\ leakage(LTCE)} = [(L_{Base} \times FL) + (L_{Base} \times VL \times F(LTCE_{Base}))] \times CL \times EF \times DF$$

$$WS_{evaporation(LTCE)} = E_{Base} \times CL \times EF \times DF$$

The differences between the Phase 4 calculations and the Phase 3 calculations are the addition of the durability factor (DF) and the replacement of the deliveries ratio with F(LTCE). The revision of the *Technical Manual* for Version 4 has also eliminated the time factor t_r from the Phase 4 calculation.

The revision of the baseline year in 2011/12 adjusted the baseline year losses for leakage, seepage and evaporation losses. Seepage and evaporation losses are also now taken to occur over a full year rather than just the irrigation season.

GMW applies the calculations on a channel by channel basis which gives a more accurate assessment of Phase 3 estimates than if the time and length factors were applied as an average across the entire irrigation area.

6.4.4 Input Data

The inputs required to calculate Phase 3 and Phase 4 water savings due to channel rationalisation are summarised Table 6-2 and Table 6-3.

The first table details the parameters that are fixed or have been previously audited, e.g. the baseline year parameters. The second table details the input data from the current year.

Table 6-2 Fixed Parameters and Baseline Year Parameters for Channel Rationalisation Water Savings Calculation

Parameter	Description	Source
S_{Base}	Seepage in Baseline Year	Baseline Year water balance
L_{Base}	Leakage in Baseline Year	Baseline Year water balance
E_{Base}	Evaporation in Baseline Year	Baseline Year water balance
D_{Base}	Deliveries in Baseline Year	Baseline Year water balance
FL	Proportion of bank leakage recognised as fixed	Technical Manual
VL	Proportion of bank leakage recognised as variable	Technical Manual
EF	Effectiveness Factor for channel rationalisation	Technical Manual
DF	Durability Factor to account for the durability of water savings	Technical Manual
F(LTCE)	Long Term Cap Equivalent Factor to convert Current Year volumes to Long Term Cap Equivalent volume	Calculated from deliveries and base figure advised by Department of Environment, Land, Water and Planning

Table 6-3 Current Year Parameters for Channel Rationalisation Water Savings Calculation

Parameter	Description	Source
CL	Ratio of length of spur channel length rationalised to total spur channel length in system	GIS and direct measurement
t_r	Ratio of the length of time a channel has been rationalised in the year in question relative to the irrigation season length in the baseline year	Construction records
$D_{Year\ x}$	Customer deliveries in the year in question to the irrigation system	IPM reports

We have reviewed the input data and confirm that the fixed parameters sourced from the *Technical Manual* are correct. We cross-checked the baseline year values against the baseline year audit report and confirmed that GMW has used values from the spur channels water balance.

Our review of the current year parameters used in the calculations found the following:

Customer Deliveries in the Current Year (D_{YearX})

Customer deliveries through the meters replaced in each irrigation district are determined through IPM. These delivery volumes are used for customer billing, as noted previously, and therefore we believe they will be reliable due to the scrutiny they are subject to by GMW and customers.

Ratio of Channel Length Rationalised to Total Channel Length (CL)

We confirm that GMW has correctly used the length of spur channels in each irrigation area as the denominator in this calculation. The numerator is the length of channels rationalised. We believe that the systems used for capturing and reporting lengths of channel rationalised are robust. GMW has improved its processes for estimating channel lengths with additional verification through GIS. We comment on our trailing of channel rationalisation records in section 5.2.4

Ratio of Length of Time Channels Rationalised to Baseline Year (t_r)

This variable is determined from the channel de-commissioning date recorded. This factor has previously been material for Phase 3 savings given that the amount of rationalisation work completed each year is a significant proportion of the total. However, this is less so for 2015/16 and will not be significant in future. We note in our review of channel rationalisation construction records in section 5.2.4 that GMW provided comprehensive construction records.

We found in our audit of GMW's calculations that it calculates the time ratio for different water loss components as start date – end date. This approach does not include both the start and end dates in the calculation meaning that a regular (non-leap) year will be calculated as having 364 days. We recommended to GMW that time periods be calculated as being (start date – end date) + 1 day. GMW has accepted this recommendation. This has a small impact on the water savings estimated.

We also identified that in calculating the time ratio for works in Pyramid-Boort that the time ratio was incorrectly referenced for all rows.

6.4.5 Results

The audited water savings due to channel rationalisation, corrected for the errors discussed above, are summarised in Table 6-4 and Table 6-5.

Table 6-4 Phase 3 Water Savings due to Channel Rationalisation – Stage 1 and Stage 2

PHASE 3	SH	CG1-4	CG5-9	MV	RO	PB	TO	Total
Stage 1								
Seepage (ML)	15	-	391	1,620	301	1,480	1,754	**5,562**
Bank leakage (ML)	1	-	449	2,540	486	1	4,696	**8,174**
Evaporation (ML)	6	-	167	716	133	758	594	**2,374**
Pipeline deduction (ML)	-	-	1	-	6	-	-	**7**
Total	**22**	**-**	**1,007**	**4,876**	**914**	**2,240**	**7,044**	**16,102**
Stage 2								
Seepage (ML)	139	302	327	735	851	503	741	**3,597**
Bank leakage (ML)	7	457	381	1,139	1,401	0	2,023	**5,408**
Evaporation (ML)	54	105	139	325	375	257	251	**1,506**
Pipeline deduction (ML)	-	16	10	5	75	-	6	**111**
Total	**201**	**849**	**838**	**2,193**	**2,551**	**761**	**3,009**	**10,400**
Total (Stage 1 and Stage 2)	**223**	**849**	**1,844**	**7,069**	**3,465**	**3,000**	**10,052**	**26,502**

Table 6-5 Phase4 Water Savings due to Channel Rationalisation – Stage 1 and Stage 2

PHASE 4	SH	CG1-4	CG5-9	MV	RO	PB	TO	Total
Stage 1								
Seepage (ML)	15	-	397	1,632	323	1,483	1,751	**5,601**
Bank leakage (ML)	1	-	657	3,829	771	2	7,895	**13,156**
Evaporation (ML)	6	-	170	722	142	759	593	**2,391**
Pipeline deduction (ML)	-	-	2	-	16	-	-	**19**
Total	**22**	**-**	**1,222**	**6,182**	**1,221**	**2,244**	**10,239**	**21,130**
Stage 2								
Seepage (ML)	140	301	427	837	936	516	842	**3,998**
Bank leakage (ML)	11	661	707	1,963	2,232	1	3,795	**9,369**
Evaporation (ML)	55	104	182	370	412	264	285	**1,672**
Pipeline deduction (ML)	-	42	27	16	197	-	18	**300**
Total	**205**	**1,024**	**1,290**	**3,154**	**3,384**	**780**	**4,903**	**14,740**
Total (Stage 1 and Stage 2)	**227**	**1,024**	**2,512**	**9,336**	**4,605**	**3,024**	**15,142**	**35,870**

Note – Totals may not sum due to rounding

6.5 Savings from Channel Automation

6.5.1 Scope of Automation Works

Automation involves the replacement of manual flow control structures with modern automated gates that accurately measure flows, provide real time operational data, and can be controlled to meet the flow demands of customers. Automation greatly reduces the water spillage from the end of channels (outfalls), and reduces bank leakage by maintaining the level of water in a pool within a relatively restricted band.

Automation of the backbone channels in the GMW Connections Project works areas is complete for the Central Goulburn 5-9, Rochester and Pyramid-Boort areas.

6.5.2 Overview

Water savings due to automation are the sum of the savings realised through reduced outfall volumes:

Phase 3: $WS_{YearX} = WS_{outfalls}$

Phase 4: $WS_{YearX(LTCE)} = WS_{outfalls(LTCE)}$

There has been an important change in determining savings due to automation in that the updated version of the *Technical Manual* no longer includes savings due to reduced upper bank leakage in this component. Savings due to upper bank leakage when calculated previously composed less than 1% of all savings so it was not material. However, there is significant uncertainty in this estimate. Therefore, it has been omitted from the calculation until stronger evidence supporting its inclusion in savings estimates is established.

6.5.3 Water Savings Calculations

Phase 3 Calculations

Phase 3 water savings have been calculated by GMW Connections Project using the Phase 3 outfalls formula from the *Technical Manual:*

$$WS_{outfalls} = [(O_{base} \times (D_{YearX} / D_{Base})) - (O_{YearX})]$$

Phase 4 Calculations

Phase 4 water savings due to reduction in outfalls are estimated by the following equations from the *Technical Manual*:

$$WS_{outfalls} = [(O_{base} \times F(LTCE_{base})) - (O_{YearX} \times F(LTCE_{YearX}))] \times DF$$

The latest version of the *Technical Manual* has omitted the time factor OP which was the ratio expressing the proportion of the irrigation season for which the channels had been fully automated.

6.5.4 Input Data

The inputs required to calculate Phase 3 and Phase 4 water savings due to outfall automation are summarised in Table 6-6 and Table 6-7.

The first table details the parameters that are fixed or have been previously audited, i.e. the baseline year parameters. The second table details the input data from the current year.

Table 6-6 Fixed parameters and baseline year parameters for Automation water savings calculation

Parameter	Description	Source
O_{Base}	Outfalls in Baseline Year	Baseline Year water balance
D_{base}	Customer Deliveries in the Baseline Year in the irrigation system	Baseline Year water balance
DF	Durability factor to account for the durability of water savings interventions	Technical Manual
F(LTCE$_{Base}$)	Long Term Cap Equivalent Factor to convert Baseline Year volumes to Long Term Cap Equivalent volume	Department of Environment, Land, Water and Planning

Table 6-7 Current Year Parameters for Automation Water Savings Calculation

Parameter	Description	Source
O_{yearX}	Outfalls in Current Year	SCADA and operator logsheets
D_{yearX}	Customer Deliveries in the Current Year in the irrigation system	IPM reports
F(LTCE$_{YearX}$)	Long Term Cap Equivalent Factor to convert Current Year volumes to Long Term Cap Equivalent volume	Calculated from deliveries and base figure advised by Department of Environment, Land, Water and Planning

We have reviewed the input data and confirm that the fixed parameters sourced from the Technical Manual are correct. We also found that the parameters sourced from the Baseline Year Water Balance are correct, noting that only outfall volumes for channels that have now been automated are included in the 2015/16 calculations.

GMW has applied an adjustment factor of 1.6 to the volumes recorded at unmetered outfalls in the baseline year to arrive at an adjusted baseline outfall volume.

The following summary is a review of the inputs from the current operating year:

Outfalls in Current Year (O_{yearX})

The largest outfalls responsible for the greatest water savings are generally measured on-line with feedback to GMW's SCADA. We note in Section 4.3 that GMW now uses SCADA data as the point of truth for outfall records.

Again this year, GMW has acted on the recommendation included in the 2011/12 audit and not set equal to zero the savings from groups of outfalls (pods) where the outflow in the current year exceeded that in the baseline year (which would result in 'negative' savings) unless it has been able to find sufficient justification for doing so[5].

The impact of this change *can be* material – in 2011/12, the zeroing of outfalls contributed 1,831ML to Phase 4 savings. We support this conservative approach.

GMW has subtracted environmental mitigating flows volumes from its savings. Environmental mitigating flows are specified in Environmental Watering Plans and are volumes determined by catchment managers as necessary to support specific high value habitats. Mitigating flows occur only in the Torrumbarry and Pyramid-Boort irrigation areas. Because mitigating flows occur through

[5] Where the outfalls from a pod in the current year exceeded that in the baseline year the calculated saving would be less than zero, i.e. worse performance than in the baseline year. The *Technical Manual* allows these negative numbers to be set to zero on the basis that they are considered to be operational aberrations that would disappear in time. However, we consider that it is more appropriate, and a better indication of current water savings performance, to not set these values to zero. If these are operational aberrations, the savings will be 'caught up' in future

some outfalls that have 'negative' savings (i.e. the outfall in this year is greater than that in the baseline year) the mitigating flow cannot be subtracted from the outfall meaning that it is not possible to reconcile outfall savings and mitigating flows on an outfall by outfall basis. In this case the mitigating flow is zeroed and the loss is deducted from the overall automation savings.

As decommissioning of channels occurs, where an outfall previously existed, this may cause outfall volumes to be directed to neighbouring outfalls, increasing outfall at neighbouring sites relative to 2004/05 losses, potentially creating negative losses. Over the remainder of the project, with decommissioning of outfalls occurring, the interaction of outfalls into larger groups (or for the operating system) needs to be taken into account by GMW.

Customer Deliveries in the Current Year (D_{YearX})

Customer deliveries in each irrigation district are determined from IPM reports. The volumes used are sourced from the same reports used for GMW's annual reporting.

Long Term Cap Equivalent Factor F($LTCE_{YearX}$)

This factor has been calculated by GMW in accordance with the formula in the Technical Manual using a factor of 1.3 for $LTCE_{Base}$ as advised by the Department of Environment, Land, Water and Planning. The ratio of delivered volumes has been applied for all operating areas.

6.5.5 Results

The audited water savings due to channel automation are summarised in Table 6-8. All channel automation works are attributable to the Stage 1 project except for channel automation works for Shepparton which are part of the Stage 2 project.

Table 6-8 Phase 3 and Phase 4 Water Savings due to Channel Automation

	SH	CG5-9	MV	RO	PB	TO	Total
Inputs							
O_{base} (ML)	1,539	26,549	8,981	7,728	5,159	8,285	**58,241**
O_{yearx} (ML)	448	1,116	2,229	1,902	1194	413	**7,302**
D_{base} (ML)	191,844	312,082	293,026	199,271	221,668	405,049	**1,622,940**
D_{yearx}(ML)	106,721	216,264	191,781	149,517	153,410	242,088	**1,059,781**
Phase 3 Water Savings							
Gross Phase 3 savings (ML)	**408**	**16,178**	**2,380**	**4,286**	**2,376**	**4,194**	**29,823**
Zeroed outfalls (ML)	-	-	-	-	-	-	**-**
Mitigating flows (ML)	-	-	-	-	901	659	**1,560**
Net Phase 3 savings (ML)	**408**	**16,178**	**2,380**	**4,286**	**1,475**	**3,535**	**28,262**
Phase 4 Water Savings							
Gross Phase 4 savings (ML)	**1,070**	**29,609**	**6,956**	**6,730**	**4,157**	**8,815**	**57,336**
Zeroed outfalls (ML)	-	-	-	-	-	-	**-**
Mitigating flows (ML)	-	-	-	-	1,602	1,183	**2,785**
Net Phase 4 savings (ML)	**1,070**	**29,609**	**6,956**	**6,730**	**2,555**	**7,632**	**54,551**

Note – Totals may not sum due to rounding

6.6 Savings from Service Point Replacement and Rationalisation

6.6.1 Scope of Service Point Replacement and Rationalisation Works

Water savings are achieved when existing customer service points, usually Dethridge Wheels, are replaced with modern outlets. The modern designs are typically pipes with magflow meters or flume gates. Savings may also be achieved when existing service points are removed and not replaced (i.e. rationalised). The savings achieved are due to the improved construction of the service points, preventing leakage through and around the meter, as well as the increased accuracy of the new meters which better account for water use.

Service point replacement and rationalisation has been completed under the Stage 1 and Stage 2 projects. Figure 6-3 shows the number of service points replaced and rationalised in each irrigation area.

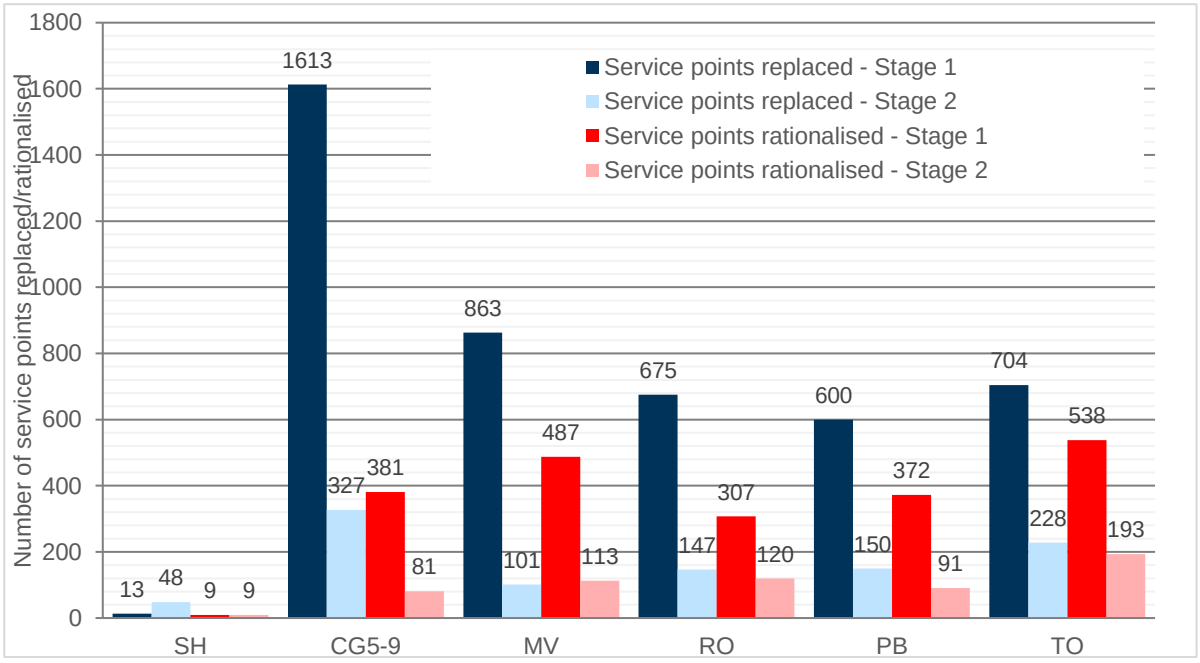

Figure 6-3 Numbers of service points replaced and rationalised (Stage 1 and Stage 2)

6.6.2 Overview

Water savings due to service point replacements and rationalisations are the sum of the savings realised through reduced meter errors, lowered leakage through and around the old meter, previously unmetered volumes and reduced unauthorised use. The same high level Phase 3 and 4 equations apply to both replacements and rationalisations although the individual components are determined differently.

The high level equations are the same for both Phase 3 and Phase 4 savings:

$$WS_{YearX} = WS_{meter\ error} + WS_{leakage\ through} + WS_{leakage\ around} + WS_{unmetered} + WS_{unauthorised}$$

6.6.3 Water Savings Calculations

The components of the Phase 3 and 4 water savings calculations are detailed following. Version 4 of the *Technical Manual* no longer includes the time discounting factor (t_m) in the Phase 4 calculations for either replacement or rationalisation of service points. GMW does not include the component for savings due to unmetered volumes as it believes that these are negligible.

Phase 3 Calculations – Service Point Replacement

Phase 3 water savings have been calculated by GMW using the formula in the *Technical Manual*:

$$WS_{YearX} = WS_{meter\ error} + WS_{leakage\ through} + WS_{leakage\ around} + WS_{unmetered} + WS_{unauthorised}$$

where

$WS_{meter\ error} = D_{MyearX} \times (1/MCF) \times (MCF - 1) \times EF$

$WS_{leakage\ through} = N_{replaced} \times t_m \times LTT \times EF$

$WS_{leakage\ around} = N_{replaced} \times t_m \times LTA \times EF$

$WS_{unmetered} = \Sigma\ D_{MyearX} \times (1/MCF) \times (MCF - 1) \times EF$ ***(not used)***

$WS_{unauthorised} = N_{replaced} \times U_{base} \times EF \times (D_{YearX}/D_{base}) \times t_m$

In the cases where a new service point has been added into a channel previously serviced by less meters, GMW denotes these as a "new-new meter". The new-new meter decreases water savings due to the leakage through and around the structure. Therefore, GMW has used a slightly different formula to calculate 'savings', which accounts for introduced losses that would not have been experienced before. The formulas only change in leakage through and unauthorised losses in Phase 3, and Leakage through, around, meter error and unauthorised losses for Phase 4. This is a conservative approach that we feel is appropriate.

Phase 3 Calculations – Service Point Rationalisation

Phase 3 water savings due to service point rationalisation have been calculated by GMW using the formula in the *Technical Manual*:

$$WS_{YearX} = WS_{meter\ error} + WS_{leakage\ through} + WS_{leakage\ around} + WS_{unmetered} + WS_{unauthorised}$$

where

$WS_{meter\ error} = (D_{MBase} \times (MCF - 1) \times EF) \times (D_{YearX}/D_{base})$

$WS_{leakage\ through} = N_{rationalised} \times t_m \times LTT \times EF$

$WS_{leakage\ around} = N_{rationalised} \times t_m \times LTA \times EF$

$WS_{unmetered} = (V_D \times (MCF - 1) \times EF) \times (D_{YearX}/D_{base})$

$WS_{unauthorised} = N_{rationalised} \times U_{Base} \times EF \times (D_{YearX}/D_{base}) \times t_m$

Phase 4 Calculations – Service Point Replacement (not used, see explanation at end of this section)

Phase 4 water savings have been calculated by GMW using a formula from the May 2012 *Technical Manual*, however with meter error estimated on D_{Base} rather than $D_{Year\ X}$:

$$WS_{YearX(LTCE)} = WS_{meter\ error(LTCE)} + WS_{leakage\ through(LTCE)} + WS_{leakage\ around(LTCE)} + WS_{unmetered(LTCE)} + WS_{unauthorised(LTCE)}$$

where

$WS_{meter\ error} = D_{MYearX} \times (1/MCF) \times (MCF\text{-}1) \times EF \times DF \times F(LTCE_{YearX})$

$WS_{leakage\ through} = N_{replaced} \times LTT \times EF \times DF$

$WS_{leakage\ around} = N_{replaced} \times LTA \times EF \times DF$

$WS_{unauthorised} = N_{replaced} \times U_{Base} \times EF \times DF \times F(LTCE_{base})$

$WS_{unmetered} = D_{MBase} \times (1/MCF) \times (MCF - 1) \times EF \times DF \times F(LTCE_{YearX})$

Phase 4 Calculations – Service Point Rationalisation

Phase 4 water savings due to service point rationalisation have been calculated by GMW using the formula in the *Technical Manual:*

$$WS_{YearX(LTCE)} = WS_{meter\ error(LTCE)} + WS_{leakage\ through(LTCE)} + WS_{leakage\ around(LTCE)} + WS_{unmetered(LTCE)} + WS_{unauthorised(LTCE)}$$

where

$$WS_{meter\ error(LTCE)} = (D_{MBase\ x} \times (MCF - 1) \times EF \times DF) \times F(LTCE_{base})$$

$$WS_{leakage\ through(LTCE)} = N_{rationalised} \times LTT \times EF \times DF$$

$$WS_{leakage\ around(LTCE)} = N_{rationalised} \times LTA \times EF \times DF$$

$$WS_{unmetered(LTCE)} = (V_D \times (MCF - 1) \times EF \times DF) \times F(LTCE_{base})$$

$$WS_{unauthorised(LTCE)} = N_{rationalised} \times U_{Base} \times EF \times DF \times F(LTCE_{base})$$

The same formula for calculating Phase 4 long term meter error savings (Equation 13.3.4) as the basis for both rationalised and replaced service outlets has been adopted. The meter error savings is based on customer deliveries in the baseline year (2004/05) instead of the year in question as previously used in Equation 12.3.4 for the calculation of long term meter error savings for service point replacement. DELWP and the Water Savings Protocol Implementation Review Committee endorsed this approach in 2014/15 and intend to seek Ministerial approval to revise the Technical Manual accordingly at the next opportunity.

6.6.4 Input Data

The inputs required to calculate Phase 3 and Phase 4 water savings due to service point replacement and rationalisation are summarised in Table 6-9 and Table 6-10. Table 6-9 details the parameters that are fixed or have been previously audited. Table 6-10 details the input data from the current year.

Table 6-9 Fixed Parameters and Baseline Year Parameters for Service Point Replacement and Rationalisation Water Savings Calculation

Parameter	Description	Source
MCF	Adopted Meter Correction Factor for Dethridge Meter Service Points or associated with deemed Service Points	Technical Manual
$EF_{meter\ error}$	Effectiveness Factor for reducing measurement error	Technical Manual
$EF_{leakage\ through}$	Effectiveness Factor for reducing leakage through the meter	Technical Manual
$EF_{leakage\ around}$	Effectiveness Factor for reducing leakage around the meter	Technical Manual
$EF_{unauthorised}$	Effectiveness Factor for reducing unauthorised use	Technical Manual
LTA	Defined Fixed Leakage Rate (ML/year/service point) around service points	Technical Manual
LTT	Defined Fixed Leakage Rate (ML/year/service point) through service points	Technical Manual
U_{base}	Unauthorised use loss in the Baseline Year	Technical Manual
D_{base}	Customer Deliveries in the Baseline Year	Baseline Year water balance
DM_{base}	Customer deliveries through the Rationalised meters in the Baseline Year	Baseline Year water balance
DF_{error}	Durability factor for reducing measurement error	Technical Manual
$DF_{leakage\ through}$	Durability factor for reducing leakage through the meter	Technical Manual

Parameter	Description	Source
$DF_{leakage\ around}$	Durability factor for reducing leakage around the meter	Technical Manual
$DF_{unauthorised}$	Durability factor for reducing unauthorised use	Technical Manual
$F(LTCE_{base})$	Long Term Cap Equivalent Conversion Factor for the baseline year	Department of Environment, Land, Water and Planning

Table 6-10 Fixed Parameters and Baseline Year Parameters for Service Point Replacement and Rationalisation Water Savings Calculation

Parameter	Description	Source
D_{MYearX}	Customer deliveries through the replaced meters for the year in question	IPM reports
D_{YearX}	Customer deliveries in the year in question to the irrigation system	IPM reports
$N_{replaced}$	Number of meters replaced	Construction records
$N_{rationalised}$	Number of meters rationalised	Construction records
$F(LTCE_{YearX})$	Long Term Cap Equivalent Factor to convert Current Year volumes to Long Term Cap Equivalent volume	Calculated from deliveries

We have reviewed the input data and identified that GMW had used incorrect effectiveness factors for service point replacement for some meter works in Pyramid Boort. Correcting for this error has increased the estimated water savings.

We also found that the parameters sourced from the Baseline Year Water Balance are correct. The following summary is a review of the inputs from the current operating year:

Customer Deliveries through Replaced Service Points (D_{MYearX}) and in the Irrigation System (D_{YearX})

Customer deliveries through the replaced meters and in each irrigation district are determined through IPM. These delivered volumes are used for customer billing and, as noted previously, we believe they will be reliable due to the scrutiny they are subject to by GMW and customers.

Number of Service Points Replaced and Rationalised ($N_{replaced}$, $N_{rationalised}$)

The number of meters replaced and rationalised is determined from construction records. GMW demonstrated the process it undertakes for handling service point record data. This process includes collating data from different sources and then filtering this data and removing any duplicate or anomalous records. We are satisfied that this process is robust. GMW also achieves meter error savings where new meters have been installed as part of system decommissioning works.

We reviewed the commissioning certificates for a sample of service points under the Stage 1 and Stage 2 projects, as outlined in Section 5.2.2. This review provided evidence that the sample of works claimed as complete by GMW had been completed. Although we found one site in our sample where works were not yet complete and poor record keeping for one package works, we consider that the identification of service point works is sufficiently robust for the purpose of calculating water savings.

Ratio of time Service Point in use compared to Baseline Year (t_m)

This factor is calculated by GMW based on the commissioning (or de-commissioning in the case of rationalisation) dates for each service point. As the works have been in progress for a number of

years, the t_m factor has limited impact on the calculated Phase 3 savings. We found that the t_m factor has been calculated and applied correctly by GMW for service point replacements.

Our review of commissioning certificates for a sample of service points is outlined in Section 5.2.2.

Long Term Cap Equivalent Factor F($LTCE_{Base}$)

This factor has been calculated by GMW in accordance with the formula in the Technical Manual using a factor of 1.3 for $LTCE_{Base}$ as advised by the Department of Environment, Land, Water and Planning. The ratio of deliveries volumes has been applied for all of the GMW operating areas.

6.6.5 Results

The audited water savings due to service point replacements are summarised in Table 6-11 and Table 6-12. Note that GMW performs these calculations on a meter by meter basis and not for an irrigation area nor as a whole system.

Table 6-11 Phase 3 and Phase 4 Water Savings due to Service Point Replacement and Rationalisation– Stage 1 project

	SH	CG5-9	MV	RO	PB	TO	Total
Service point replacement							
Phase 3 Water Savings							
Meter error (ML)	22	7,578	4,556	3,503	3,979	3,820	23,459
Leakage through service points (ML)	2	2,941	1,491	1,176	1,072	1,190	7,873
Leakage around service points (ML)	0	643	333	255	231	261	1,723
Unauthorised Use (ML)	0	798	375	340	284	273	2,070
Total (ML)	25	11,960	6,755	5,273	5,566	5,545	35,124
Phase 4 Water Savings							
Meter error (ML)	24	13916	8788	6786	8248	7781	45,543
Leakage through service points (ML)	2	2336	1180	978	870	978	6,344
Leakage around service points (ML)	1	1490	751	617	543	622	4,023
Unauthorised Use (ML)	0	605	308	251	220	255	1,640
Total (ML)	26	18,348	11,027	8,631	9,881	9,636	57,549
Service point rationalisation							
Phase 3 Water Savings							
Meter error (ML)	28	1,061	2,006	966	1,693	2,494	8,249
Leakage through service points (ML)	17	717	895	552	665	964	3,810
Leakage around service points (ML)	4	151	184	116	140	202	797
Unauthorised Use (ML)	5	235	278	196	218	273	1,206
Total (ML)	54	2,164	3,364	1,830	2,717	3,933	14,062
Phase 4 Water Savings							
Meter error (ML)	29	1948	3870	1872	3510	5080	16,309
Leakage through service points (ML)	17	722	916	578	699	1020	3,952
Leakage around service points (ML)	11	445	564	356	431	628	2,434
Unauthorised Use (ML)	4	152	189	122	147	214	827
Total (ML)	61	3,267	5,539	2,926	4,787	6,942	23,522
Total Phase 3 savings (Replacement and rationalisation)	**79**	**14,124**	**10,118**	**7,104**	**8,283**	**9,478**	**49,186**
Total Phase 4 savings (Replacement and rationalisation)	**87**	**21,615**	**16,566**	**11,557**	**14,668**	**16,578**	**81,071**

Note – Totals may not sum due to rounding

Table 6-12 Phase 3 and Phase 4 Water Savings due to Service Point Replacement and Rationalisation – Stage 2 project

	SH	CG5-9	MV	RO	PB	TO	Total
Service point replacement							
Phase 3 Water Savings							
Meter error (ML)	177	1,244	560	596	779	858	4,213
Leakage through service points (ML)	82	516	159	191	191	341	1,482
Leakage around service points (ML)	19	116	36	43	47	76	337
Unauthorised Use (ML)	23	138	39	54	47	77	379
Total (ML)	302	2,014	794	884	1,064	1,352	6,411
Phase 4 Water Savings							
Meter error (ML)	249	2438	1076	1558	1668	1870	8,858
Leakage through service points (ML)	66	455	131	191	173	285	1,301
Leakage around service points (ML)	45	291	83	120	109	183	831
Unauthorised Use (ML)	18	119	34	49	46	76	343
Total (ML)	378	3,303	1,324	1,917	1,996	2,415	11,333
Service point rationalisation							
Phase 3 Water Savings							
Meter error (ML)	10	204	518	271	409	756	2,167
Leakage through service points (ML)	16	128	190	158	150	307	949
Leakage around service points (ML)	2	27	40	33	32	65	198
Unauthorised Use (ML)	5	42	59	56	49	87	298
Total (ML)	34	400	807	518	640	1,214	3,613
Phase 4 Water Savings							
Meter error (ML)	15	399	995	708	876	1647	4,639
Leakage through service points (ML)	17	152	201	228	171	367	1,136
Leakage around service points (ML)	11	94	124	140	105	226	700
Unauthorised Use (ML)	2	32	42	48	36	77	237
Total (ML)	45	676	1363	1124	1188	2316	6713
Total Phase 3 savings (Replacement and rationalisation)	**336**	**2,415**	**1,601**	**1,402**	**1,704**	**2,566**	**10,024**
Total Phase 4 savings (Replacement and rationalisation)	**423**	**3,980**	**2,687**	**3,041**	**3,184**	**4,731**	**18,045**

Note – Totals may not sum due to rounding

6.7 Savings from Channel Remediation

6.7.1 Scope of Irrigation Channel Remediation Works

Channel remediation involves lining earthen channels, replacing channels with pipelines and bank remodelling. These works can generate irrigation water savings through reduced bank seepage and reduced bank leakage. A total of 242km of channel lining has been completed to date. 53km was completed in 2015/16 compared with 13.8km in 2014/15. The length of channel that has been remediated by irrigation area is shown in Figure 6-4.

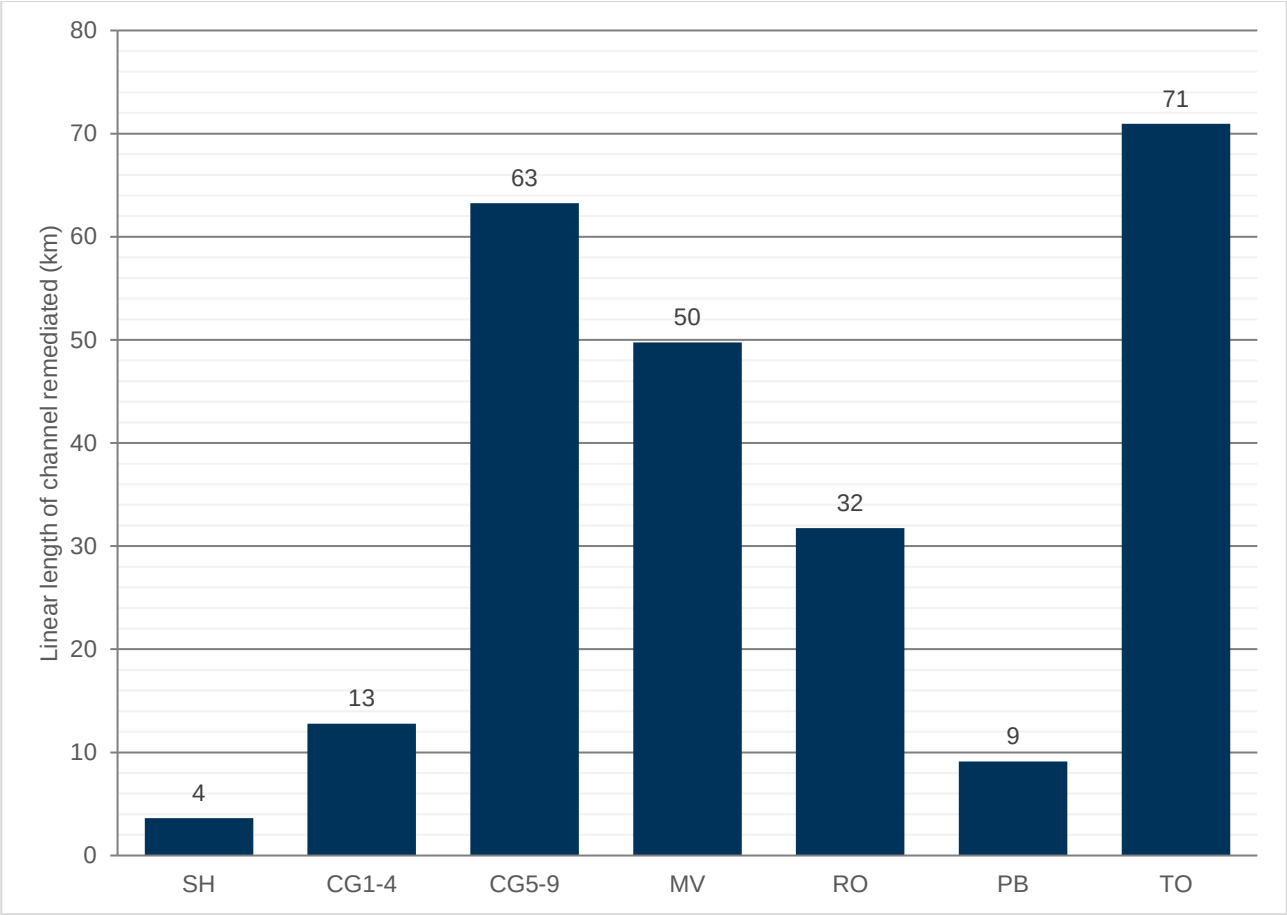

Figure 6-4 Length (Km) of channel remediated by irrigation area

6.7.2 Overview

The type of calculation employed for determining water savings due to channel remediation depends on the availability of pre and post works pondage data as detailed in Table 6-13 13.

Table 6-13 Calculation methods for Channel remediation works

Data availability	Calculation method
No pre or post remediation pondage testing data available	Theoretical method (No pre-works pondage test data) using Technical Manual Phase 2 calculations
Pre remediation pondage testing only available	Theoretical method (using pre-works pondage test data)
Both pre and post remediation pondage testing data available	Direct method

For the remediation works completed in 2008 (5km), no pre or post works pondage test data is available. Therefore, the theoretical method has been used for these works. The inputs and method are unchanged from the 2009/10 audit report for these works from 2008 and will not be discussed further.

For the works completed in 2009 pre-works pondage data is available for all sites except one. Post-works pondage testing data is only available for three of the 13 sites. For the works completed in 2010, 30 of 42 sites have both pre and post works pondage testing data available. This total is an increase on the 27 sites where both pre and post works data was available. The remaining sites from 2010 have only pre works pondage testing data available.

Savings estimates made using only pre works data and historical typical expected effectiveness factors will be validated with post works data over time. This may adjust the savings claimed in later years.

GMW omits the evaporation component from its savings as it assumes that there is likely to be negligible change in surface area of a channel pre and post remediation. This is a reasonable assumption and is conservative.

Both direct and theoretical equations have the same high level form:

$$WS_{YearX} = WS_{bank\ leakage} + WS_{seepage} + WS_{evaporation}$$

6.7.3 Water Savings Calculations

New equations, given by GMW to adopt the equations, given in chapter 14 of the technical manual are

Theoretical Method - Phase 3 Calculations– Pre-works pondage test data available

$$WS_{bank\ leakage} = [(((PT^{PRE\ WORKS} \times F(PA)) - S^{PRE\ WORKS}) \times VL \times (D_{YearX}/D_{Base})) + (((PT^{PRE\ WORKS} \times F(PA)) - S^{PRE\ WORKS}) \times FL)] \times EF$$

$$WS_{seepage} = S^{PRE\ WORKS} \times EF$$

$$WS_{evaporation} = E^{PRE\ WORKS} \times EF$$

Direct Method - Phase 3 Calculations– Measured pre-works and post-works pondage test data is available

$$WS_{bank\ leakage} = \{[(((PT^{PRE\ WORKS} - PT^{POST\ WORKS}) \times F(PA)) - (S^{PRE\ WORKS} - S^{POST\ WORKS})) \times VL \times (D_{YearX}/D_{Base})] + [(((PT^{PRE\ WORKS} - PT^{POST\ WORKS}) \times F(PA)) - (S^{PRE\ WORKS} - S^{POST\ WORKS})) \times FL]\}$$

$$WS_{seepage} = S^{PRE\ WORKS} - S^{POST\ WORKS}$$

$$WS_{evaporation} = E^{PRE\ WORKS} - E^{POST\ WORKS}$$

Theoretical Method - Phase 4 Calculations– Pre-works pondage test data available

$$WS_{leakage} = [(((PT^{PRE\ WORKS} \times F(PA)) - S^{PRE\ WORKS}) \times VL \times F(LTCE_{Base})) + (((PT^{PRE\ WORKS} \times F(PA)) - S^{PRE\ WORKS}) \times FL)] \times EF \times DF$$

$$WS_{seepage} = S^{PRE\ WORKS} \times EF \times DF$$

$$WS_{evaporation} = E^{PRE\ WORKS} \times EF \times DF$$

Direct Method - Phase 4 Calculations – Measured pre-works pondage test data is available

$$WS_{leakage(LTCE)} = \{[(((PT^{PRE\ WORKS} - PT^{POST\ WORKS}) \times F(PA)) - (S^{PRE\ WORKS} - S^{POST\ WORKS})) \times VL \times F(LTCE_{Base})] + [(((PT^{PRE\ WORKS} - PT^{POST\ WORKS}) \times F(PA)) - (S^{PRE\ WORKS} - S^{POST\ WORKS})) \times FL]\} \times DF$$

$$WS_{seepage(LTCE)} = (S^{PRE\ WORKS} - S^{POST\ WORKS}) \times DF$$

$$WS_{evaporation(LTCE)} = (S^{PRE\ WORKS} - S^{POST\ WORKS}) \times DF$$

In 2015/16 a revision to the approach of the application of the F(PA) factor in the Technical Manual was endorsed by DELWP and the Water Savings Protocol Implementation Review Committee. Ministerial approval to revise the Technical Manual accordingly will be sought at the next opportunity. The F(PA) factor is now first applied to the total seepage and leakage losses in static test. The fixed seepage loss (not scaled by the F(PA) factor) is deducted from this scaled total loss, before applying other factors. We consider that this approach is appropriate.

Theoretical Phase 3 calculations, where no pre-works pondage testing data is available, are not discussed as these only apply to the 2008 works. These were reviewed in 2009/10 and there has been no change since then. The equations in the updated *Technical Manual* for determining savings due channel remediation have been revised with the length and time discounting factors being removed.

Theoretical Method - Phase 3 Calculations– Pre-works pondage test data available

$$WS_{bank\ leakage} = [(L^{PRE\ WORKS} \times VL \times F(PA) \times (D_{YearX}/D_{base})) + (L^{PRE\ WORKS} \times FL \times F(PA)] \times EF$$

$$WS_{seepage} = S^{PRE\ WORKS} \times EF \times F(PA)$$

$$WS_{evaporation} = E^{PRE\ WORKS} \times EF$$

Direct Method - Phase 3 Calculations– Measured pre-works and post-works pondage test data is available

$$WS_{bank\ leakage} = (L^{PRE\ WORKS} - L^{POST\ WORKS}) \times F(PA)$$

$$WS_{seepage} = (S^{PRE\ WORKS} - S^{POST\ WORKS}) \times F(PA)$$

$$WS_{evaporation} = (E^{PRE\ WORKS} - E^{POST\ WORKS})$$

Theoretical Method - Phase 4 Calculations– Pre-works pondage test data available

$$WS_{leakage} = [(L^{PRE\ WORKS} \times VL \times F(LTCE)) + (L^{PRE\ WORKS} \times FL)] \times DF \times EF_S \times F(PA)$$

$$WS_{seepage} = S^{PRE\ WORKS} \times EF \times DF \times F(PA)$$

$$WS_{evaporation} = E^{PRE\ WORKS} \times EF \times DF$$

Direct Method - Phase 4 Calculations – Measured pre-works pondage test data is available

$$WS_{leakage(LTCE)} = [[(L^{PRE\ WORKS} - L^{POST\ WORKS}) \times F(PA) \times FL] + [(L^{PRE\ WORKS} - L^{POST\ WORKS}) \times F(PA) \times VL \times F(LTCE_{YearX})]] \times DF$$

$$WS_{seepage(LTCE)} = (S^{PRE\ WORKS} - S^{POST\ WORKS}) \times F(PA) \times DF$$

$$WS_{evaporation(LTCE)} = (S^{PRE\ WORKS} - S^{POST\ WORKS}) \times DF$$

GMW has adopted an alternative direct method for calculating $WS_{leakage}$ for Phase 3 savings as the Technical Manual appears to incorrectly omit the variable proportion of bank leakage. For calculating $WS_{leakage(LTCE)}$ in Phase 4 using the direct method, factor $F(LTCE_{base})$ replaces $F(LTCE_{YearX})$ as factor **F(PA)** in the equation is estimated for the baseline year. We consider that this is an appropriate approach and note that the water savings estimate are lower using this approach than that in the Technical Manual.

The revised baseline year water balance[6], has removed the concept of system fill. System fill was treated as operational flows that were not impacted by improved irrigation infrastructure because they occurred outside of the irrigation season. However, it has now been recognised that most channels that have been lined will hold water over the full year, including the non-irrigation season, and therefore water savings occur across the full year. In particular, there is reduced seepage in both the irrigation and non-irrigation seasons. As a result, the interpretation of the seepage calculation has been updated to be applied across the full 365 days of the year of operation, instead of only the irrigation season as previously calculated.

[6] The revised baseline year water balance was independently audited in 2011/12.

GMW has adjusted the water savings estimated due to channel remediation downwards for old leaking outlets existing when pondage tests were carried out. This is to avoid any possibility of double counting savings on both the remediation program and from service point upgrade works.

6.7.4 Input Data

The inputs required to calculate Phase 3 and Phase 4 water savings due to channel remediation are summarised in Table 6-14 and Table 6-15. The first table details the parameters that are fixed or have been previously audited. The second table details the input data from the current year.

Table 6-14 Fixed Parameters and Baseline Year Parameters for Channel Remediation Water Savings Calculation

Parameter	Description	Source
VL	Proportion of bank leakage recognised as variable	Technical Manual
FL	Proportion of bank leakage recognised as fixed	Technical Manual
D_{base}	Customer deliveries in the baseline year	Baseline Year water balance
EF	Effectiveness Factor for channel remediation	Technical Manual
DF	Durability Factor for Channel Remediation	Technical Manual
F($LTCE_{base}$)	Long Term Cap Equivalent Conversion Factor for the baseline year	Department of Environment, Land, Water and Planning
F(PA)	Pondage Testing Adjustment Factor to account for dynamic losses in addition to static losses	Technical Manual Appendix F

Table 6-15 Current Year Parameters for Channel Remediation Water Savings Calculation

Parameter	Description	Source
$L^{PRE\ WORKS}$	Pre works bank leakage	Pondage testing
$L^{POST\ WORKS}$	Post works bank leakage	Pondage testing
$D_{Year\ X}$	Customer deliveries in the year in question to the irrigation system	IPM reports
$S^{PRE\ WORKS}$	Pre works seepage	Pondage testing
$S^{POST\ WORKS}$	Post works seepage	Pondage testing

We have reviewed the input data and confirm that the fixed parameters sourced from the Technical Manual are correct, as are the deliveries in the Baseline Year sourced from the Baseline Year Water Balance. Where no post-works pondage testing data is available, GMW has adopted an EF estimate of 90% for HDPE, 85% for clay, and 50% for bank remediation, having been revised overtime from a flat 90% EF as more pre and post-works pondage testing data became available.

The following summary is a review of the inputs from the current operating year:

Pre Works and Post Works bank Leakage and Seepage ($L^{PRE\ WORKS}$, $L^{POST\ WORKS}$, $S^{PRE\ WORKS}$, $S^{POST\ WORKS}$)

Where pondage testing data is available, pre and post works leakage and seepage are determined through evaluation of site testing results. We have reviewed the pondage testing methodology and results in previous audits and commented that we believe that the pre and post works seepage and leakage estimates, determined through site testing, are sound. Where post pondage data is estimated from pre works data and assumed remediation effectiveness (based on the measured remediation effectiveness in other pools), follow-up validation of the estimates with measured post pondage test data, needs to be made in the future.

Customer Deliveries in the Current Year (D_{YearX})

Customer deliveries in each irrigation district are determined from IPM reports. The volumes used are sourced from the same reports used for GMW's annual reporting.

6.7.5 Results

Water savings due to channel remediation are calculated on a channel by channel basis as each channel has a different leakage and seepage rate. The meter error correction is applied to whole irrigation areas.

Table 6-16 Phase 3 and Phase 4 Water Savings due to Channel Remediation

	SH	CG1-4	CG 5-9	MV	RO	PB	TO	Total
Phase 3 savings (ML)								
Stage 1	-	-	4,229	3,442	1,556	-	2,205	11,433
Stage 2	351	1,219	658	1,167	138	1,122	894	5,549
Total	**351**	**1,219**	**4,888**	**4,608**	**1,694**	**1,122**	**3,099**	**16,981**
Phase 4 savings (ML)								
Stage 1	-	-	5,143	3,844	1,805	-	3,702	14,495
Stage 2	374	1,392	779	1,293	132	1,338	1,124	6,433
Total	**374**	**1,392**	**5,922**	**5,137**	**1,937**	**1,338**	**4,827**	**20,927**

Note – Totals may not sum due to rounding

7 Recommendations on Technical Manual and Water Savings Approach

The Audit Protocol requires that comment be made following audit work regarding:

- Potential improvements to estimate the water savings in the areas of:
  - data collection
  - data analysis
  - assumptions
  - methods.
- Recommended changes to the Technical Manual for the Quantification of Water Savings.

We have made the following recommendations regarding GMW's approach to estimating water savings for GMW to consider for implementation:

- We recommend that GMW puts in place strong controls over the quality of work pack information received from contractors under its new delivery model and as-remediation constructed drawings in particular. There is an opportunity for GMW to link contractor payments to the completeness and accuracy of information received to drive the desired results.
- GMW should use consistent asset identifiers/references for construction work records to enable water savings calculations to be made and the reconciliation between the two.
- We recommend that GMW review the events leading to inclusion of the rationalisation of meter R06683 within its water savings estimates to identify if there any opportunities to improve its business processes.
- We recommend that GMW review the pondage testing methodology to reduce the potential for ambiguity in determining remediation pool loss rate. Specific areas we recommend that ambiguity in pondage test methodology can be reduced are:
  - Criteria for acceptance of a loss correlation as significant
  - Preferred relationship for line of best fit and theoretical basis for its adoption (both linear and exponential relationships are referred to in the report) and basis for selecting alternative lines of best fit.

This audit has not identified any need to change the Technical Manual. However, there may be merit in formalising in the manual the amended methodology applied by GMW in calculating water savings in certain areas. For example, subtracting from savings the losses incurred by new meters being introduced into the system. We are also aware that GMW has identified potential changes to the Technical Manual for consideration by DELWP and the Water Savings Protocol Implementation Review Committee and we suggest that these should be included in a revised Technical Manual when accepted.

8 Progress against previous audit recommendations

The Audit Protocol requires the current year audit to report on the progress made by the relevant organisations in achieving the recommendations from previous audits. For the 2014/15 audit, we retained the consolidated recommendations from previous years to streamline the tracking of implementation of the recommendations. The 2014/15 audit found that GMW had closed out all outstanding recommendations. Table 8-1 details the recommendations made at this year's audit for the purpose of tracking these recommendations in future audits.

Table 8-1 Schedule of progress against previous audit actions

Ref	Year	Area	Comment	2015/16 Audit comment
2014/15-1	2014/15	Construction records	If decommissioning of channels or service points has occurred through a channel block then an ITP or other quality assurance document should still be generated that covers all assets downstream of the block with asset data and photos included, as well as a plan showing the location of the decommissioned assets in relation to the block.	We have seen that GMW has made effort to improve construction records for works to block channels. We did not identify any issues with records for these works in 2015/16. We consider this recommendation closed.
2014/15-2	2014/15	Construction records	GMW should reiterate to all internal staff and external contractors responsible for recording construction activities the importance of the quality of documentation	We have again seen some incomplete or missing construction records, particularly for one package of work. The project reset means that GMW's processes for obtaining and verifying construction records will change. This recommendation should remain open.
2015/16-1	2015/16	Construction records	We recommend that GMW puts in place strong controls over the quality of work pack information received from contractors under its new delivery model and as-constructed drawings in particular. There is an opportunity for GMW to link contractor payments to the completeness and accuracy of information received to drive the desired results.	
2015/16-2	2015/16	Asset identification	GMW should use consistent asset identifiers/ references between its water savings calculations and construction records to enable reconciliation between the two.	
2015/16-3	2015/16	Water savings calculations	We recommend that GMW review the events leading to inclusion of the rationalisation of meter R06683 within its water savings estimates to identify if there any opportunities to improve its business processes.	
2015/16-4	2015/16	Pondage testing	We recommend that GMW review the pondage testing methodology to reduce the potential for ambiguity in determining pool loss rate. Specific areas we recommend that ambiguity in the methodology can be reduced are: ▪ Criteria for acceptance of a correlation as significant	

Ref	Year	Area	Comment	2015/16 Audit comment
			▪ Preferred relationship for line of best fit and theoretical basis for its adoption (both linear and exponential relationships are referred to in the report) and basis for selecting alternative lines of best fit.	

Audit of Irrigation Modernisation Water Recovery 2015/16 Irrigation season

APPENDIX A

Document Register

Cardno
Shaping the Future

Calculations

Automation outfalls

- tat doc 4288351 v1 7 Outfall Automation Savings 2015 16.xls

Channel decommission

- TATDOC-#4286051-v1-CHANNEL_DECOM_AND_PIPELINES_AUDIT_WATER_SAVINGS__2015_2016_.XLSX
- ver3 TATDOC-#4286051-v1-CHANNEL_DECOM_AND_PIPELINES_AUDIT_WATER_SAVINGS__2015_2016_.xlsx
- ver4 TATDOC-#4286051-v1-CHANNEL_DECOM_AND_PIPELINES_AUDIT_WATER_SAVINGS__2015_2016_.xlsx

Meter outlets

- TATDOC-#4289492-v1-METER_SAVINGS_FOR_AUDIT_2015_16.XLSX
- ver 2 TATDOC-#4289492-v1-METER_SAVINGS_FOR_AUDIT_2015_16.xlsx

Remediation

- TATDOC-#4280461-v1-2016_WATER_SAVINGS_AUDIT_CHANNEL_REMEDIATION_-_EX_V6_1_CHANNEL_REMEDIATION_DATABASE.XLSM
- TATDOC-#4280461-v2-2016_WATER_SAVINGS_AUDIT_CHANNEL_REMEDIATION_-_EX_V6_1_CHANNEL_REMEDIATION_DATABASE.XLSM

Summaries

- TATDOC-#4289749-v1-DRAFT_SUMMARY_OF_WATER_SAVINGS_2015_16_FOR_AUDIT.XLSX
- TATDOC-#4289760-v1-VER_2_UPDATED_SUMMARY_SHEETS_SUN_23_OCT_2016_FOR_WATER_SAVINSG_AUDIT_2015_16_.XLSX
- TATDOC-#4300994-v1-VER_2_SUMMARY_STGAE_1_AND_2_WATER__SAVINGS_TABLE_BY_PROJECT_AUDIT_2015_16.XLSX
- TATDOC-#4304779-v1-SUMMARY_OF_WATER_SAVINGS_AUDIT_2015_16.XLSX

Supporting calculation documents

Outfall records

- TATDOC-#3925811-v4-MURRAY_VALLEY_OUTFALL_REPORT.XLSX
- TATDOC-#3928257-v3-CENTRAL_GOULBURN_OUTFALL_REPORT - Copy.xlsx
- TATDOC-#3928794-v3-ROCHESTER_OUTFALL_REPORT.XLSX
- TATDOC-#3928800-v4-LODDON_VALLEY_OUTFALL_REPORT.XLSX
- TATDOC-#3928803-v3-SHEPPARTON_OUTFALL_REPORT.XLSX
- TATDOC-#3928807-v3-TORRUMBARRY_OUTFALL_REPORT.XLSX
- TATDOC-#4015650-v4-GMW_OUTFALLS.XLSX
- TATDOC-#4037587-v1-OUTFALL_FLUSHING_MV_CHANNELS_-_IMAZAPYR_RESIDUES.xlsx

Automation outfalls

- TATDOC-#4238874-v1-OUTFALL_WATER_SAVINGS_VARIABLE_AND_NON_VARIABLE_COMPONENTS -RDP 15072016.docx
- IR226964 A0-L Regulators & Outfalls_Central Goulburn.pdf
- IR226964 A0-L Regulators & Outfalls_Loddon Valley.pdf

- IR226964 A0-L Regulators & Outfalls_Murray Valley.pdf
- IR226964 A0-L Regulators & Outfalls_Rochester.pdf
- IR226964 A0-L Regulators & Outfalls_Shepparton.pdf
- IR226964 A0-L Regulators & Outfalls_Torrumbarry.pdf
- RO 720 Section 8.2 - Commissioning Plans and Documentation_Part52 (2).pdf
- RO396 FL010160_RO396_REGULATORS_WP_ROCHESTER_3_14.pdf
- RO420 ITP Lid.pdf
- RO420 ITP Structure.pdf
- RO713 ITP.pdf
- RO720 (Outfall) Construction ITP.pdf

Channel decommission

- TATDOC-#4286244-v1-GHD_REPORT_ON_DEDUCTION_WATER_SAVINGS_FOR_PIPELINES_235902_(PIPELINE_LOSS__)_FINAL_(1).pdf
- IR234146 A0-L Decommissioning Maps_Central Goulburn Gravity Irrigation.pdf
- IR234146 A0-L Decommissioning Maps_Loddon Valley Gravity Irrigation.pdf
- IR234146 A0-L Decommissioning Maps_Murray Valley Gravity Irrigation.pdf
- IR234146 A0-L Decommissioning Maps_Rochester Gravity Irrigation.pdf
- IR234146 A0-L Decommissioning Maps_Torrumbarry Gravity Irrigation.pdf
- Meter outlets
- baseline 2004 05 delivery data revision with Daves Fehering data shared outlets change.xlsx
- draft master meter listing for cardno to identify workpacks.xlsx
- revised 2004 05 baseline data follows review Daves IPM raw baseline data.xlsx

Remediation

- TATDOC-#4285131-v1-Water_Savings_Protocol_Technical_Manual_Update_Proposal_-_FPA_Factor_and_Other_Channel_Remediation_Equations.pdf
- TATDOC-#4285133-v1-GHD_remediation_Tech_Manual__F(PA)_support_paper_change_--_235896_(final).pdf
- IR225735 Remediation_Central Goulburn Gravity Irrigation.pdf
- IR225735 Remediation_Loddon Valley Gravity Irrigation.pdf
- IR225735 Remediation_Murray Valley Gravity Irrigation.pdf
- IR225735 Remediation_Rochester Gravity Irrigation.pdf
- IR225735 Remediation_Shepparton Gravity Irrigation.pdf
- IR225735 Remediation_Torrumbarry Gravity Irrigation.pdf

Summaries

- TATDOC-#4293880-v1-GENERAL_WATER_SAVINGS_PROCEDURES_2015_16.docx

Workpack documents

Automation outfalls

- RO370/DSC04228.JPG
- RO370/RO730 ITP.pdf

- RO370/Section 9.1 - Red Line Drawing Mark Ups_R1.pdf
- compare SPM and operator records Flushing flows.xlsx
- PH1152A.pdf

Channel decommission

- RO8-8/
    - item 5 item 8 RO5237_WP_PHOTO_US.JPG
    - item 5 RO8-8 ITP Offtake structure.pdf
    - item 5 RO8-8 offtake.jpg
    - item 5 WP_20160323_10_45_24_Pro.jpg
    - item 5 WP_20160323_10_45_40_Pro.jpg
    - item 5 WP_20160323_10_45_44_Pro.jpg
    - item 5 WP_20160323_10_45_55_Pro.jpg
- STO42444/
    - 483088.pdf
    - 483099.pdf
    - 483332-01 Rev 12.pdf
    - 483332-02 Rev 8.pdf
    - 483332-03 Rev 10.pdf
    - 483332-04 Rev 7.pdf
    - 483986-2.pdf
    - 486594.pdf
    - 486665.pdf
- item 8 ---MV 5-1 BBEP Offtake ITP for TCC.pdf
- ref 1 Block MV 4094A TATDOC-#4055764-v1-WORK_PACK_1588_-_MURRAY_VALLEY_STAGE_2.pdf
- ref 2- Backbone extension Pipeline BBEP 21 13 9 BBEP Creamery Rd WP.zip
    - Creamery Rd Pump Station Civil Works ITP.PDF
    - WP_20160629_13_13_25_Pro.jpg
    - WP_20160630_12_54_35_Pro.jpg
    - WP_20161025_10_10_34_Pro.jpg
- ref 3- Backbone Extension Pipeline BBEP TO6-1_WP_HANDOVER_Pipeline.zip
    - TO6-1_CivilConstruction.pdf
    - to6-1_WP_PHOTOS07d66052-1afd-4353-ab47-cd78db71457f.jpg
    - to6-1_WP_PHOTOS122f2e36-1caa-4c28-98ee-3a5c975403ca.jpg
    - to6-1_WP_PHOTOS149159ce-b4e2-4c3c-a3ed-5930bb8d7f7d.jpg
    - to6-1_WP_PHOTOS2224be69-5713-4307-add5-4477b438a97f.jpg
    - to6-1_WP_PHOTOS3f543553-b106-4f79-a3d4-afa7c02bb11c.jpg
    - to6-1_WP_PHOTOS5d72ef5f-cbb4-4374-bf39-6b9aae946402.jpg
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- to6-1_WP_PHOTOSadf232d6-4863-4c10-8446-f9e40fc9098a.jpg
- to6-1_WP_PHOTOSb0ac5611-1271-44ee-99a3-f8e4da9664cb.jpg
- to6-1_WP_PHOTOSbc99e96b-1c68-4270-919d-a36901624f5c.jpg
- to6-1_WP_PHOTOSc4b8c891-8220-4e6c-be32-deded4c6919b.jpg

- ref 4 Block ST 044221 TATDOC-#4146890-v1-WORK_PACK_1388_-_TORRUMBARRY_STAGE_2.pdf
- ref 5 ST 032996 RO8-8 d-stream of channel block.jpg
- ref 5 ST 032996 RO8-8 offtake.jpg
- ref 6 Effective block related ST 042444 MV5593_WP_HANDOVER_Remote Operate.zip
  - MV5593_Commissionning.pdf
  - MV5593_Workpack.pdf
  - MV5593_WP_PHOTO_DS.JPG
  - MV5593_WP_PHOTO_LEFT.JPG
  - MV5593_WP_PHOTO_RIGHT.JPG
  - MV5593_WP_PHOTO_US.JPG
- ref 7 Block st023527 and ST023529 TATDOC-#4146894-v1-WORK_PACK_2386_-_PYRAMID_HILL_BOORT_STAGE_2.pdf
- ref 8 MV 5-1 WP_20160729_14_33_32_RICH.JPG
- ref 8 MV 5-1 WP_20160729_14_36_24_RICH.JPG
- ref 9 -Block st 007013 CG1-31-28-9_WP_HANDOVER_Pipeline.zip
  - CG1-31-28-9_CivilConstruction.pdf
  - cg1-31-28-9_WP_PHOTO_1.jpeg
  - cg1-31-28-9_WP_PHOTO_10.jpeg
  - cg1-31-28-9_WP_PHOTO_11.jpeg
  - cg1-31-28-9_WP_PHOTO_12.jpeg
  - cg1-31-28-9_WP_PHOTO_13.jpeg
  - cg1-31-28-9_WP_PHOTO_14.jpeg
  - cg1-31-28-9_WP_PHOTO_15.jpeg
  - cg1-31-28-9_WP_PHOTO_16.jpeg
  - cg1-31-28-9_WP_PHOTO_17.jpeg
  - cg1-31-28-9_WP_PHOTO_18.jpeg
  - cg1-31-28-9_WP_PHOTO_19.jpeg
  - cg1-31-28-9_WP_PHOTO_2.jpeg
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  - cg1-31-28-9_WP_PHOTO_21.jpeg
  - cg1-31-28-9_WP_PHOTO_22.jpeg
  - cg1-31-28-9_WP_PHOTO_23.jpeg
  - cg1-31-28-9_WP_PHOTO_24.jpeg
  - cg1-31-28-9_WP_PHOTO_25.jpeg

- cg1-31-28-9_WP_PHOTO_26.jpeg
- cg1-31-28-9_WP_PHOTO_27.jpeg
- cg1-31-28-9_WP_PHOTO_28.jpeg
- cg1-31-28-9_WP_PHOTO_29.jpeg
- cg1-31-28-9_WP_PHOTO_3.jpeg
- cg1-31-28-9_WP_PHOTO_30.jpeg
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- cg1-31-28-9_WP_PHOTO_32.jpeg
- cg1-31-28-9_WP_PHOTO_4.jpeg
- cg1-31-28-9_WP_PHOTO_5.jpeg
- cg1-31-28-9_WP_PHOTO_6.jpeg
- cg1-31-28-9_WP_PHOTO_7.jpeg
- cg1-31-28-9_WP_PHOTO_8.jpeg
- cg1-31-28-9_WP_PHOTO_9.jpeg
- cg1-31-28-9_WP_ROAD_CROSSING.pdf

- ref 10 Block RN1670_WP_HANDOVER_Remote Operate.zip
  - RN1670_Commissionning.pdf
  - RN1670_Workpack.pdf
  - RN1670_WP_EPWPC_NEWBERYS.jpg
  - RN1670_WP_ITP_NEWBERYS.jpg
  - RN1670_WP_PHOTO_DS.JPG
  - RN1670_WP_PHOTO_LEFT.JPG
  - RN1670_WP_PHOTO_RIGHT.JPG
  - RN1670_WP_PHOTO_SP.jpg
  - RN1670_WP_PHOTO_US.JPG
  - RN1670_WP_SDS_NEWBERYS.jpg
- SCP TO 32 Creamery Rd Pipeline (2-13-9) Drawings IFC Rev0.pdf
- TO 6-1 IFC Detailed Design Report.pdf

Meter outlets

- meter RO6392 TATDOC-#4109359-v1-WORK_PACK_0569_-_ROCHESTER_STAGE_2.PDF
- Meter SH3465 WORK PACK 1022 - TORRUMBARRY - STAGE 2.PDF
- meter SH3725 WORK PACK 2342 - TORRUMBARRY STAGE 2.PDF
- Meter TO 2695 inside WORK PACK 0464 TORRUMBARRY STAGE 1.PDF
- PH454A_WP_HANDOVER.zip
  - PH454A_Workpack.pdf
  - PH454A_WP_RATIO_PHOTO.JPG
- RN1557_WP_HANDOVER_Remote Operate.zip
  - RN1557_Commissionning.pdf

- RN1557_Workpack.pdf
- RN1557_WP_PHOTO_DS.JPG
- RN1557_WP_PHOTO_LEFT.JPG
- RN1557_WP_PHOTO_RIGHT.JPG
- RN1557_WP_PHOTO_SP.jpg
- RN1557_WP_PHOTO_US.JPG

- RN1986A_WP_HANDOVER_Remote Read.zip
  - RN1986A_Commissionning.pdf
  - RN1986A_Workpack.pdf
  - RN1986A_WP_PHOTO_DS.JPG
  - RN1986A_WP_PHOTO_LEFT.JPG
  - RN1986A_WP_PHOTO_RIGHT.JPG
  - RN1986A_WP_PHOTO_SP.JPG
- RNDS1277A_WP_HANDOVER.zip
  - RNDS1277A_Workpack.pdf
  - RNDS1277A_WP_PHOTO_DS.JPG
  - RNDS1277A_WP_PHOTO_LEFT.JPG
  - RNDS1277A_WP_PHOTO_RIGHT.JPG
  - RNDS1277A_WP_PHOTO_US.JPG
- RO5108_WP_HANDOVER_Remote Operate.zip
  - RO5108_Commissionning.pdf
  - RO5108_Workpack.pdf
  - RO5108_WP_PHOTO_DS.JPG
  - RO5108_WP_PHOTO_LEFT.JPG
  - RO5108_WP_PHOTO_RIGHT.JPG
  - RO5108_WP_PHOTO_SP.JPG
  - RO5108_WP_PHOTO_US.JPG
- RO5239_WP_HANDOVER_Remote Operate.zip
  - RO5239_Commissionning.pdf
  - RO5239_Workpack.pdf
  - RO5239_WP_PHOTO_DS.JPG
  - RO5239_WP_PHOTO_LEFT.JPG
  - RO5239_WP_PHOTO_RIGHT.JPG
  - RO5239_WP_PHOTO_SP.jpg
  - RO5239_WP_PHOTO_US.JPG
- RO5933A.JPG
- RO6083.JPG
- RO6143_WP_HANDOVER_Remote Operate.zip

- RO6143_Commissionning.pdf
- RO6143_Workpack.pdf
- RO6143_WP_PHOTO_DS.JPG
- RO6143_WP_PHOTO_LEFT.JPG
- RO6143_WP_PHOTO_RIGHT.JPG
- RO6143_WP_PHOTO_SP.JPG
- RO6143_WP_PHOTO_US.JPG

- RODS6211A_WP_HANDOVER_Local Read.zip
  - RODS6211A_Workpack.pdf
  - RODS6211A_WP_PHOTO_DS.JPG
  - RODS6211A_WP_PHOTO_LEFT.JPG
  - RODS6211A_WP_PHOTO_RIGHT.JPG
  - RODS6211A_WP_PHOTO_US.JPG
- RODS6363A_WP_HANDOVER_Local Read.zip
  - RODS6363A_Workpack.pdf
  - rods6363a_WP_PHOTO_DS.jpg
  - rods6363a_WP_PHOTO_LEFT.jpg
  - rods6363a_WP_PHOTO_RIGHT.jpg
  - rods6363a_WP_PHOTO_SP.jpg
  - rods6363a_WP_PHOTO_US.jpg
- TN12548_WP_HANDOVER_Remote Read.zip
  - TN12548_Commissionning.pdf
  - TN12548_Workpack.pdf
  - tn12548_WP_PHOTO_DS.JPG
  - tn12548_WP_PHOTO_LEFT.JPG
  - tn12548_WP_PHOTO_RIGHT.JPG
  - tn12548_WP_PHOTO_SP.JPG
  - tn12548_WP_PHOTO_US.JPG
- TN12793_WP_HANDOVER_Remote Read.zip
  - TN12793_Commissionning.pdf
  - TN12793_Workpack.pdf
  - tn12793_WP_PHOTO_DS.JPG
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  - tn12793_WP_PHOTO_RIGHT.JPG
  - tn12793_WP_PHOTO_SP.JPG
  - tn12793_WP_PHOTO_US.JPG
- TN12796A_WP_HANDOVER_Remote Read.zip
  - TN12796A_Commissionning.pdf

- TN12796A_Workpack.pdf
- tn12796a_WP_PHOTO_DS.JPG
- tn12796a_WP_PHOTO_LEFT.JPG
- tn12796a_WP_PHOTO_RIGHT.JPG
- tn12796a_WP_PHOTO_SP.JPG
- tn12796a_WP_PHOTO_US.jpg

- TO 2695 additional RE Work pack BC464.msg
- TO2788A_WP_HANDOVER_Remote Read.zip
  - TO2788A_Commissionning.pdf
  - TO2788A_Workpack.pdf
  - TO2788A_WP_PHOTO_DS.JPG
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  - TO2788A_WP_PHOTO_RIGHT.JPG
  - TO2788A_WP_PHOTO_SP.JPG
  - TO2788A_WP_PHOTO_US.JPG
- TO4027 and TO 4033 WORK PACK 1529 - TORRUMBARRY STAGE 2.PDF
- TO5071_WP_HANDOVER_Remote Operate.zip
  - TO5071_Commissionning.pdf
  - TO5071_Workpack.pdf
  - TO5071_WP_PHOTO_DS.JPG
  - TO5071_WP_PHOTO_LEFT.JPG
  - TO5071_WP_PHOTO_RIGHT.JPG
  - TO5071_WP_PHOTO_SP.JPG
  - TO5071_WP_PHOTO_US.JPG

Remediation

- MV864-867 - TATDOC-#4248392-v1-CH011734_MV864-MV867_CHANNEL_LINING_WP.pdf
- MV864-869 AsCon.pdf
- RN62A-65 - CHANNEL_LINING_CH001333_FINAL_INSPECTION_ITP_CENTRALGOULBURN_1_3.pdf
- RN62A-65 - CHANNEL_LINING_CH001333_WP_CENTRALGOULBURN_1_3.pdf
- RN642-645 - TATDOC-#4250190-v1-CHANNEL_LINING_CH011136_WP_CENTRAL_GOULBURN_4.pdf
- RN642-645 - TATDOC-#4250192-v1-CHANNEL_LINING_CH001117_WP_CENTRAL_GOULBURN_19_6.pdf
- RO231-232 - CHANNEL_LINING_CH012629_FINAL_INSPECTION_ITP_ROCHESTER_11.pdf
- RO231-232 - TATDOC-#4250271-v1-CHANNEL_LINING_CH012629_WP_ROCHESTER_11.pdf
- RO299-300 - CHANNEL_REMODELLING_CH012659_FINAL_INSPECTION_ITP_ROCHESTER_11.pdf
- RO299-300 - TATDOC-#4250337-v1-CHANNEL_REMODELLING_CH012659_WP_ROCHESTER_11.pdf

- TO97-98 Related Documents/
  - EXECUTED CONTRACT - CON-1208 TSE Channel Bank Raising.pdf
  - ToServiceEnhancement Detailed Design and Approval Report_Final Part1of3.pdf
  - TSE - FORM-CONST-TERR TSE Bank Remodelling-Signed_061014.pdf
  - TSE - PRACTICAL COMPLETION CERTIFICATE - CON-1208.pdf
  - TSE Detailed Design and Approval Report_Final Part2of3.pdf
  - TSE Detailed Design and Approval Report_Final Part3of3.pdf
  - WP_20141124_006.jpg
  - WP_20141124_007.jpg
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- WP_20150427_006.jpg
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- WP_20150427_011.jpg
- WP_20150427_012.jpg
- WP_20150430_001.jpg
- WP_20150430_002.jpg

- WP_20150430_003.jpg
- WP_20150430_004.jpg
- WP_20150430_005.jpg
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- WP_20150430_007.jpg
- WP_20150430_008.jpg
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- WP_20150430_010.jpg
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- WP_20150430_012.jpg
- WP_20150430_013.jpg
- WP_20150430_014.jpg
- WP_20150430_015.jpg
- WP_20150430_016.jpg
- WP_20150430_017.jpg
- WP_20150430_018.jpg
- WP_20150430_019.jpg
- WP_20150430_020.jpg
- WP_20150430_021.jpg

Audit of Irrigation Modernisation Water Recovery 2015/16 Irrigation season

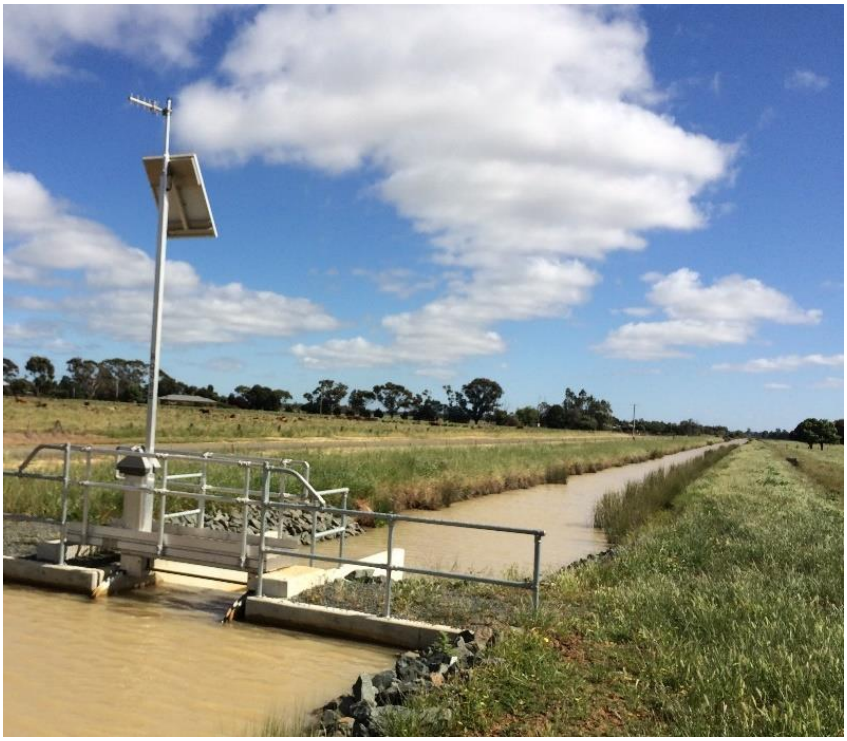
APPENDIX B

Site Photos

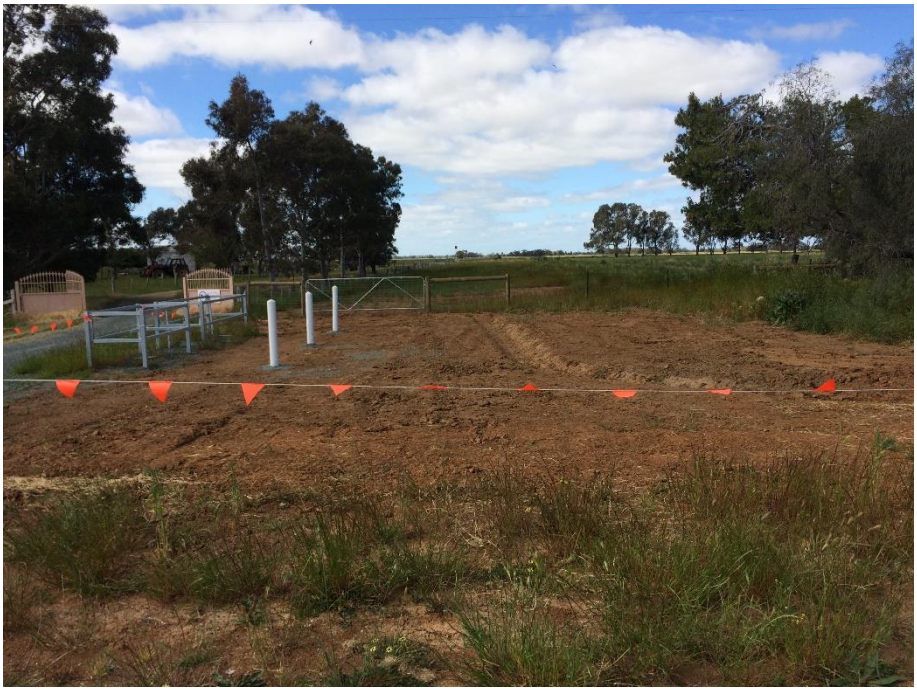
Cardno
Shaping the Future

Asset	Photo
Outfall RO394	
Service point RO5799	

Asset	Photo
Service point RO5800	
Former channel RO 5/3/14 now buried pipeline	

Asset	Photo
Regulator RO0396	
Regulator RO0397	

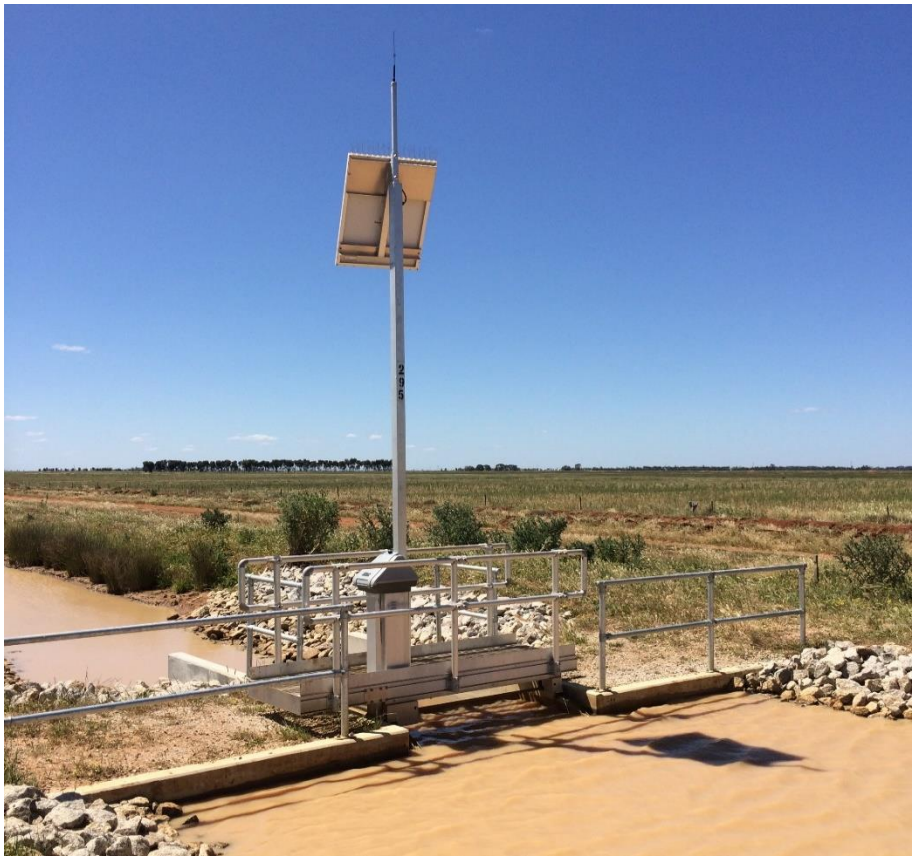
Asset	Photo
Outfall RO0720	 

Asset	Photo
Pipeline upstream of RO720	
Outfall RO735	

Asset	Photo
Service point RO6693	
Service point RO6693A	

Asset	Photo
Regulator RO731	
	

Asset	Photo
Outfall **RO730**	
PH1152B (looking downstream). PH1152A sighted but not accessible	

Asset	Photo
Regulator PH295	
Service point PH1451A	

Asset	Photo
Service point PH1452	
Service point PH1452A	

Asset	Photo
Regulator PH292	
Service point PH1447	

Asset	Photo
Regulator PH834