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Manly Hydraulics Laboratory

LABORATORY TESTING OF A 600 mm RUBICON SLIPMETER™
February-March 2011

Report MHL2059
April 2011

Rubicon Water

A division of the Department of Services, Technology & Administration

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Document Control

Issue/ Revision	Author	Reviewer	Approved for Issue	
			Name	**Date**
Draft 30/03/11	Andrew Judge	Bob Cook		
Final Draft 1/4/11	Andrew Judge	Damien Pearson, Rubicon		
Final 4/4/11	Andrew Judge		Ed Couriel	4/4/11

Report No. MHL2059
PW Report No. 11027
MHL File No. WW-0064
First published April 2011

Manly Hydraulics Laboratory is Quality System Certified to AS/NZS ISO 9001:2008.

Foreword

This report describes testing of the first production unit of a 600 mm Rubicon SlipMeter™, a member of Rubicon's family of Acoustic Array Technology. The testing was undertaken by NSW Public Works' Manly Hydraulics Laboratory (MHL) for Rubicon Water.

The MHL project manager was Andrew Judge. The Rubicon project manager was Mr Damien Pearson.

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FIGURES

1. Introduction

This report describes the methodology and presents the results of laboratory testing of a 600 mm Rubicon SlipMeter™ flow meter installed in a pit with a sloping grate attached to a pipe into the downstream pit of a Goulburn-Murray Water (G-MW) 600 mm Mann pit. The aim of testing was to determine the accuracy of volumetric measurement of the flow meter in that installation. The manufacturer of the meter intends to seek pattern approval of the meter in that configuration when trade measurement legislation is introduced for irrigation water.

Pattern approval testing requirements for meters in full flowing pipes are described in the National Measurement Institute (NMI) document NMI M 10 *Meters Intended for the Metering of Non-Urban Water in Full Flowing Pipes*, *Part 1: Metrological and Technical Requirements, Part 2: Test Methods, Part 3: Test Report Format*. Sections 6.9 and 6.10 of NMI M 10-2 (August 2009) describe performance testing for meters used in open channel emplacements.

Testing was carried out in the new Know-the-Flow test facility which has been constructed to undertake pattern approval testing of irrigation flow meters as required by NMI. The test facility has not been fully completed and is not currently endorsed by NMI to undertake pattern approval testing. Following completion of the facility accreditation by NATA will be sought under AS ISO/IEC 17025:2005, *General requirements for the competence of testing and calibration laboratories*, to undertake testing to determine errors of indication for irrigation flow meters. The new rig replaces an earlier irrigation testing facility developed at MHL in 1998 as part of the Know-the-Flow project to test irrigation flow meters in flow conditions as near as possible to those in the field.

The rig, which utilises water from Manly Dam, re-circulated at all flow rates other than extremely low flow rates, allows testing over a range of conditions at flow rates up to over 130 ML/day. Complete flow measurement installations, including the common arrangement where irrigation water is supplied through a pipe between open channels, can be tested as well as flow meters in closed conduits. Typical testing can include evaluation of the accuracy of installations and their sensitivity to the various adverse flow conditions that occur in the field and head loss measurements over a range of flows.

In the testing described in this report accuracy was assessed by comparing the volumes of water measured by the Rubicon SlipMeter™ to those measured in the flow rig utilising a NATA-calibrated reference electromagnetic flow meter and determining the uncertainty in measurement of the volumes measured by the flow rig.

2. Testing Methodology and Equipment

This section outlines the methodology and equipment used for the testing. The methodology used is based on NMI M10 and NMI M11.

2.1 Equipment Under Test

Rubicon's SlipMeter™ is a member of Rubicon's ***Acoustic Array Technology*** family. The acoustic array principle maps the velocity profile within the conduit using multiple transecting paths to provide an accurate 3D reconstruction of the velocity distribution within the conduit. This technique measures the entire velocity field within the conduit and is unaffected by swirl or other non-uniform velocity distributions. The meter has an undershot gate that allows the meter to be maintained full and can control flow through the gate. Similar flow rates were tested at differing gate positions to evaluate the effect of gate opening.

A diagram of the meter's installation arrangement is presented in Figure 2.1 and a photograph showing the meter is presented in Figure 2.2. The meter was installed and set up by Rubicon technicians.

Testing was undertaken with a single 2 m length of pipe between the meter pit and the downstream Mann pit. An existing meter comprising a smooth circular tube 600 mm long with the same internal diameter as the pipe and fully sealed to the end of the pipe was located in the pit during all testing, resulting in an equivalent overall pipe length of 2.6 m downstream of the SlipMeter™. The reference level (zero) for water levels was the top of the SlipMeter™ housing. Conditions during testing were judged to be similar to conditions observed in the field.

2.2 Testing Equipment and Instrumentation

Water was supplied to the head box by a DN300 or DN150 supply, depending on the flow rate, to ensure that the reference flow meter operated within its calibrated range. High flow rates and the accumulated volume of water were measured with a DN300 ABB MagMaster LoFlo electromagnetic flow meter in the DN300 supply line with over 50 pipe diameters of straight pipe and a flow straightener upstream of the meter and 20 pipe diameters of straight pipe downstream of the meter. Flow via the DN300 line was controlled by electronically adjusting pump speed.

Low flow rates and accumulated volumes of water were measured with a DN150 ABB MagMaster electromagnetic flow meter in a DN150 gravity supply line with approximately 50 pipe diameters of straight pipe upstream of the meter and 15 downstream. Flow via the DN150 line was controlled with a manually operated gate valve downstream of the meter.

The lengths of straight pipe upstream and downstream of the meters significantly exceed the manufacturer's requirements of five and two diameters respectively.

Water levels in the upstream head box, downstream pit and tailwater levels were monitored with pressure transducers. The reference flow meters were configured to produce a pulse for each litre of water passing through the meters and underwent NATA calibration in this configuration. The data from the reference flow meters, water level transducers and temperature and humidity sensors were logged to MHL's logging system at 1-second intervals.

A summary of equipment used in presented in Table 2.1.

Table 2.1 Summary of Equipment

Type	Equipment	Serial No	Last Calibration Date	Measurement of Uncertainty *
Flow	DN300 ABB LoFlo MagMaster	3K22/8755	28/09/2010	± 0.25%
Flow	DN150 ABB Water and Waste MagMaster	V/42692/2/15	12/05/2010	± 0.15%
Water Temperature	Amalgamated Instruments RM4-CO	24K08-025	17/05/2010	± 0.13°C
Water Temperature	Amalgamated Instruments RM4-CO	24K08-023	30/08/2010	± 0.13°C
Water Level	Druck PTX1830 pressure transducer	3130359	11/02/2010	± 2.5 mm
Water Level	Druck PTX1830 pressure transducer	3171680	11/02/2010	± 1 mm

* at 95% confidence level

2.3 Testing Summary

2.3.1 Testing Values

Test values, as defined by NMI 2009, were:

Q1 = 1 ML/d

Q3 = 31.5 ML/d (Q3/Q1 = 31.5)

Q4 = 39 ML/d (the ratio Q4/Q3 = 1.25)

Gate Opening Range = 0 – 600 mm

Upstream Water Level Range = 50 mm – 330 mm above top of meter

A minimum water depth above the top of the meter of 50 mm was arbitrarily adopted to ensure that the meter operated flowing full of water. A maximum depth of 330 mm was adopted to ensure that the wave generator was not affected by water inundation.

2.3.2 Test Plan

Testing undertaken and described in the following sections is summarised in Table 2.2.

Table 2.2 Test Plan

Test No.	Flow Rate ML/day	SlipMeter™ Opening mm	Supply Level mm	Test Description
1	1.0–1.1	10-20	50-330	Meter accuracy – normal conditions
2	1.0–1.1	100-200	50-330	
3	1.0–1.1	200-400	50-330	
4	1.0–1.1	400-600	50-330	
5	10.23-11.47	100-200	50-330	
6	10.23-11.47	200-350	50-330	
7	10.23-11.47	350-500	50-330	
8	10.23-11.47	500-600	50-330	
9	20.77-22.94	200-300	50-330	
10	20.77-22.94	300-400	50-330	
11	20.77-22.94	400-500	50-330	
12	20.77-22.94	500-600	50-330	
13	27-30	400-450	50-330	
14	27-30	450–500	50-330	
15	27-30	500-550	50-330	
16	27-30	550-600	50-330	
17	37-39	400-450	50-330	
18	37-39	450-500	50-330	
19	37-39	500-550	50-330	
20	37-39	550-600	50-330	
21	1.0–1.1	10-100	50-330	Submergence testing
22	10.23-11.47	100-200	50-330	
23	20.77-22.94	200-300	50-330	
24	27-30	400-450	50-330	
25	20.77-22.94	200-300	50-330	Wave disturbance
26	0	0	50-330	
27	27-30	600	50-330	Flow disturbance at screen – top obstruction
28	27-30	600	50-330	Flow disturbance at screen - left obstruction
29	27-30	600	50-330	Flow disturbance at screen - right obstruction
30	27-30	600	50-330	Flow disturbance at screen – bottom obstruction
31	1.0–1.1	600	50-330	Head loss
32	15.5-18.6	600	50-330	
33	27-30	600	50-330	
34	37-39	600	50-330	
35	27 - 30	600	50-330	Flow disturbance at inlet – top obstruction
36	27 - 30	600	50-330	Flow disturbance at inlet - left obstruction
37	27 - 30	600	50-330	Flow disturbance at inlet – right obstruction
38	27 - 30	600	50-330	Flow disturbance at inlet – bottom obstruction

2.4 Methodology

2.4.1 Accuracy Testing – Normal Conditions

Tests 1–20 were undertaken over a range of flows from 1 to 39 ML/d and variable gate openings to determine the flow conditions achievable with less than ±2.5% error.

Testing was carried out under normal conditions - pipe flowing full and no obstruction of the flow entry. Testing was undertaken following the general procedure shown below. Other testing was undertaken following the same general procedure, modified by the minimum amount to suit the requirements of the specific test.

General Test Procedure

1. Verify instruments are working correctly.
2. Check rig for leaks.
3. Ensure that all data, including that from meter under test, is being logged in real time and times are synchronised.
4. Set the required flow on the reference flow meter.
5. Adjust the downstream pit level so that the upstream water level is in the desired range.
6. Allow the flow to settle and ensure steady state conditions exist.
7. Commence test by recording start time.
8. Allow test to run for approximately 1 hour (this was variable as lower flows run times were increased).

2.4.2 Accuracy Testing – Submergence Testing

Tests 22–24 were undertaken to assess the effect of fluctuating supply level on the accuracy of the SlipMeter™. During these tests the upstream and downstream water levels were varied between 50 and 100 mm above the meter over approximately a 15-minute cycle throughout the test such that the SlipMeter™ was subjected to varied head conditions during the tests.

2.4.3 Accuracy Testing – Wave Disturbance

This testing was undertaken to determine how small wind waves generated in an irrigation channel may affect meter accuracy. Two tests were required to determine meter behaviour and meet NMI requirements: one with no flow (test 26) and one at Q3 (test 25). A wave paddle was used to create waves at the meter inlet of approximately 100 mm height and 2-second period (consistent with wave action induced by wind on an open irrigation channel).

2.4.4 Accuracy Testing – Upstream Disturbance

Tests 27–30 were undertaken to test the effect of a partial upstream blockage of the meter emplacement on the accuracy of the meter.

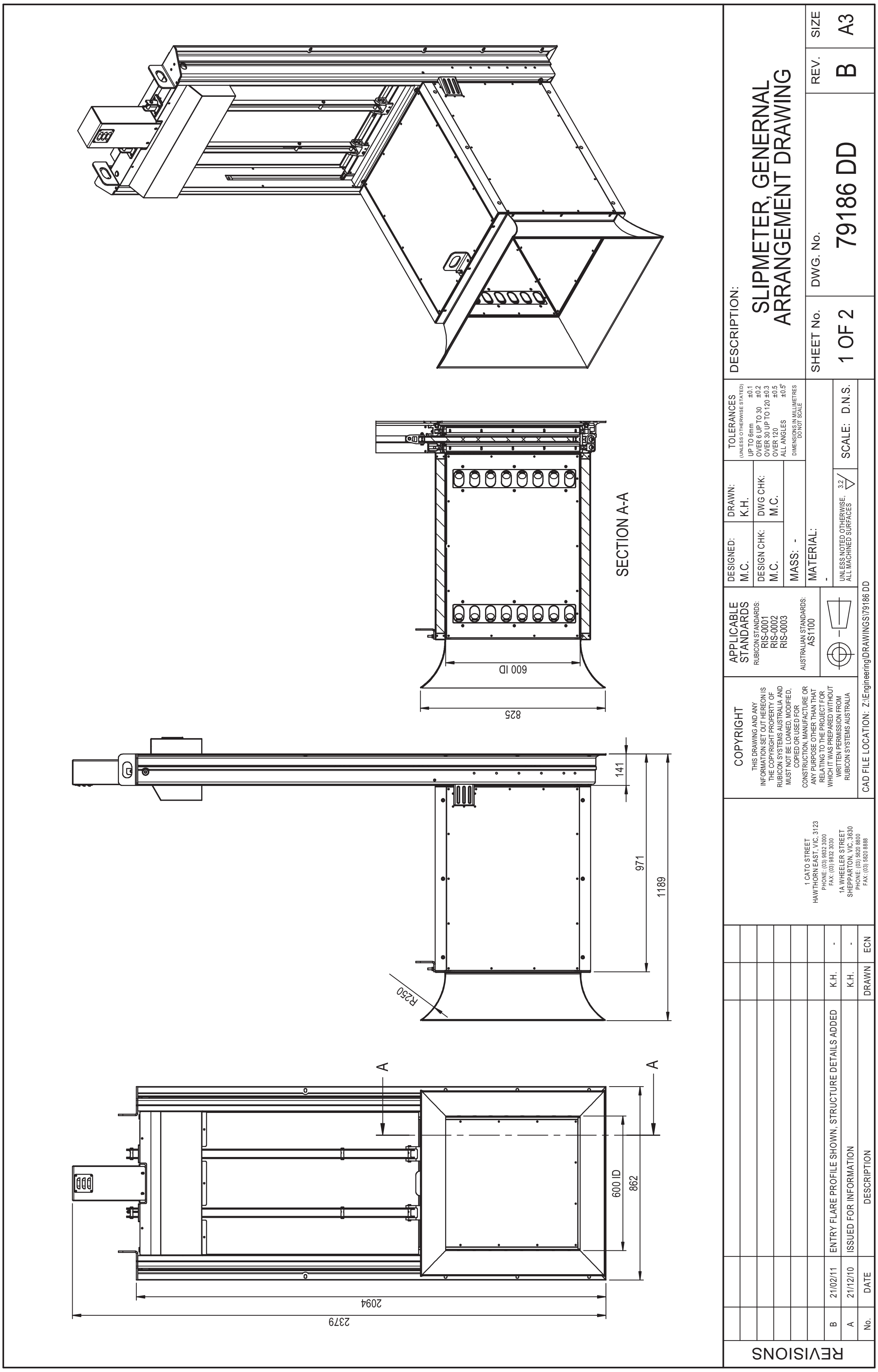
Testing at Q3 was carried out under upstream obstructed conditions defined as:

- A horizontal obstruction introducing an approximate 25% blockage by area at the bottom of the pit – Test 30 obstruction at screen, Test 38 obstruction at inlet.
- A horizontal obstruction introducing an approximate 25% blockage by area at the top of the pit – Test 27 obstruction at screen, Test 35 obstruction at inlet.
- A vertical obstruction introducing an approximate 25% blockage by area at the right-hand side of the pit – Test 29 obstruction at screen, Test37 obstruction at inlet.
- A vertical obstruction introducing an approximate 25% blockage by area at the left-hand side of the pit – Test 28 obstruction at screen, Test 36 obstruction at inlet.

The disturbance on the screen at the entry to the pit blocked 25% of the area of the pit entry. The disturbance at the inlet blocked 25% of the area of the meter inlet.

2.4.5 Head Loss Testing

Tests 31–34 were carried out to determine the head loss characteristics of the meter and the upstream pit in the metering arrangement. Head loss was taken as the difference in water level between the main upstream tank and inside the downstream Mann pit.



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RUBICON SLIPMETER™

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Figure 2.1

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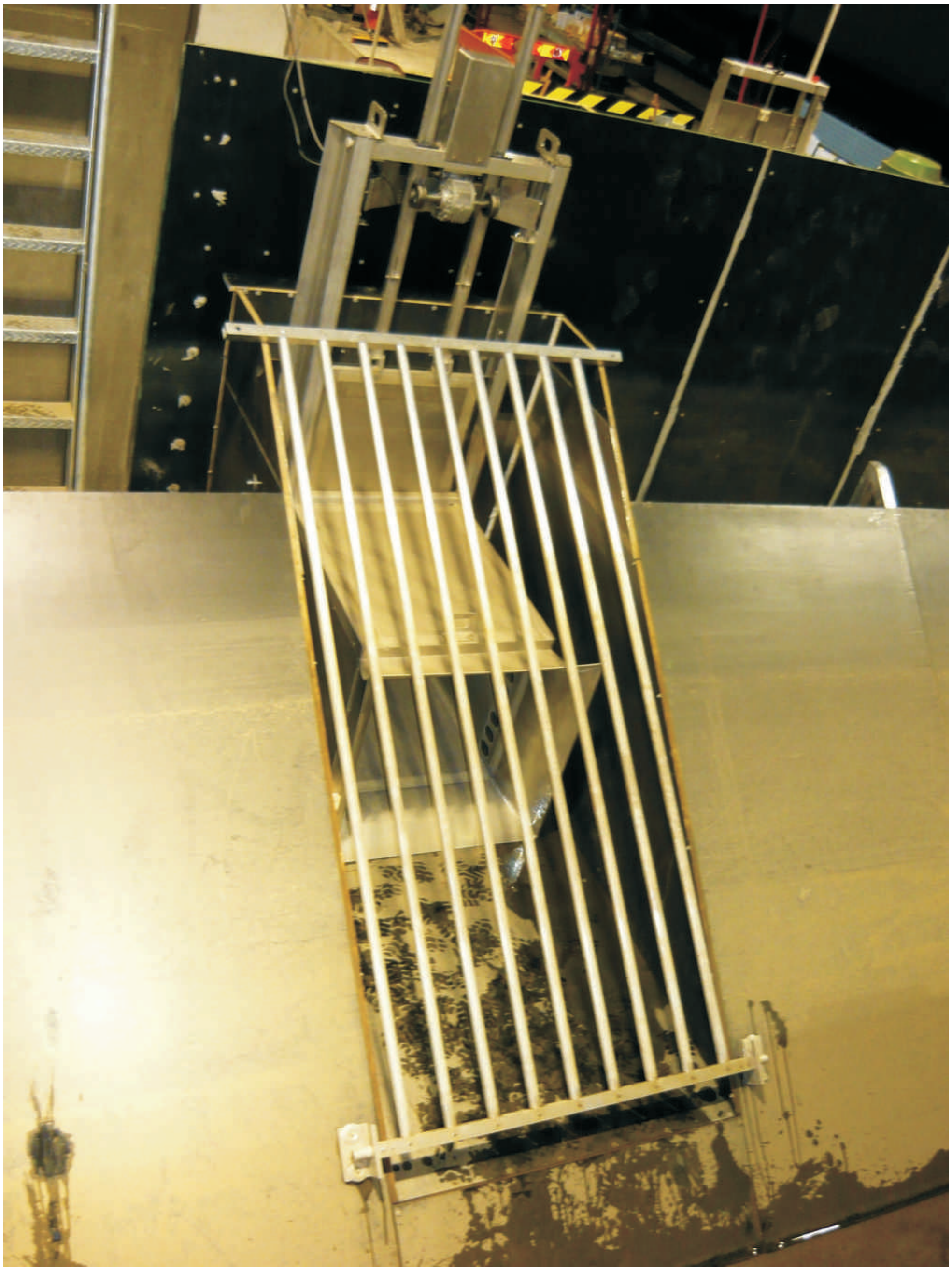

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INSTALLATION CONFIGURATION

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Figure 2.2

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3. Results

This section presents a summary of the testing results. All the logged data used to generate these results are available from MHL if required.

3.1 Data Processing

Data was transferred to MS Excel spreadsheets and processed within Excel. The total volume delivered to the upstream tank, representing the supply channel, over the test period was determined by summing the logged pulses (each 1 L) from the calibrated electromagnetic flow meter over the test period. The volume flowing from the tank over the test period was determined by correcting the volume for any difference between the water level at the start of the test and the end of the test. The water levels at the start and end of the test were taken as the mean water levels in the tank over the first and last 30-second periods of the test respectively. The volume of water leaving the tank, as measured by the meter under test, was determined by summing the logged pulses (each 1 L) from the test meter.

3.2 Meter Accuracy – Normal Conditions

The results for Tests 1–20 are presented in Table 3.1.

Table 3.1 Meter Accuracy – Normal Conditions

Test	Gate Opening mm	U/S Level m	Ref Flow Rate ML/d	Reference Volume L	ETU Volume L	Error %	Reference Uncertainty %	k
1	50	0.220	0.99	48163	47757.00	-0.84	0.28	1.96
2	140	0.216	1.00	41731	42052.00	0.77	0.28	1.96
3	310	0.210	1.00	38060	38570.00	1.34	0.28	1.96
4	554	0.210	1.00	41498	41883.00	0.93	0.28	1.96
5	180	0.276	10.56	440195	443136.00	0.67	0.37	1.96
6	300	0.162	11.06	538000	538416.00	0.08	0.37	1.96
7	399	0.151	11.13	463853	462758.00	-0.24	0.37	1.96
8	559	0.197	10.95	456316	457309.00	0.22	0.37	1.96
9	249	0.243	22.14	922601	926914.00	0.47	0.37	1.96
10	350	0.103	22.41	934155	934267.00	0.01	0.37	1.96
11	443	0.110	22.33	930679	932813.00	0.23	0.37	1.96
12	568	0.157	22.16	923522	923698.00	0.02	0.37	1.96
13	419	0.149	28.47	988873	985881.00	-0.30	0.37	1.96
14	459	0.160	28.09	1170791	1169291.00	-0.13	0.37	1.96
15	537	0.149	28.11	1172061	1170203.00	-0.16	0.37	1.96
16	602	0.141	28.15	1173263	1173687.00	0.04	0.37	1.96
17	420	0.209	38.21	1592335	1590464.00	-0.12	0.13	1.96

Test	Gate Opening mm	U/S Level m	Ref Flow Rate ML/d	Reference Volume L	ETU Volume L	Error %	Reference Uncertainty %	k
18	499	0.137	38.25	1594308	1591167.00	-0.20	0.13	1.96
19	539	0.136	38.25	1594196	1591624.00	-0.16	0.13	1.96
20	602	0.130	38.61	1609119	1609264.00	0.01	0.13	1.96

Figure 3.1 gives a graphical representation of the test results.

3.3 Meter Accuracy – Submerged Conditions

The results for Tests 21–24 are presented in Table 3.2.

Table 3.2 Meter Accuracy – Submerged Conditions

Test	Gate Opening mm	U/S Level m	Ref Flow Rate ML/d	Reference Volume L	ETU Volume L	Error %	Reference Uncertainty %	k
21	79	Varying	1.34	65306	64759.00	-0.84	0.37	1.96
22	160	Varying	10.75	709446	710721.00	0.18	0.37	1.96
23	300	Varying	20.63	1003051	1007013.00	0.39	0.37	1.96
24	450	Varying	28.22	980154	981879.00	0.18	0.37	1.96

3.4 Meter Accuracy – Wave Disturbance

The results for Tests 25–26 are presented in Table 3.3.

Table 3.3 Meter Accuracy – Under Wave Conditions

Test	Gate Opening mm	U/S Level m	Ref Flow Rate ML/d	Reference Volume L	ETU Volume L	Error %	Reference Uncertainty %	k
25	300	0.087	20.87	869782	868950.00	-0.10	0.37	1.96
26	0	0.061	0.00	0	0.00	0.00		

3.5 Accuracy Testing – Upstream Disturbance

The results of Tests 27–38 are presented in Table 3.4.

Table 3.4 Meter Accuracy – With Upstream Disturbance

Test	Gate Opening mm	U/S Level m	Ref Flow Rate ML/d	Reference Volume L	ETU Volume L	Error %	Reference Uncertainty %	k
27	603	0.166	29.16	1215496	1215745.00	0.02	0.37	1.96
28	603	0.172	29.30	1221221	1215202.00	-0.49	0.37	1.96
29	603	0.170	29.31	1221504	1216765.00	-0.39	0.37	1.96
30	603	0.161	28.79	1000156	998922.00	-0.12	0.37	1.96
35	603	0.300	29.49	1228825	1217506	-0.09	0.37	1.96
36	603	0.295	29.26	1218970	1206092	-1.06	0.37	1.96
37	603	0.297	29.28	1219843	1196105	-1.95	0.37	1.96
38	603	0.295	29.29	1220579	1224923	0.36	0.37	1.96

3.6 Meter Head Loss

This testing determined the head loss characteristics of the metering arrangement measured between the upstream entry level of the meter and the discharge point of the pipe in the Mann pit downstream of the meter.

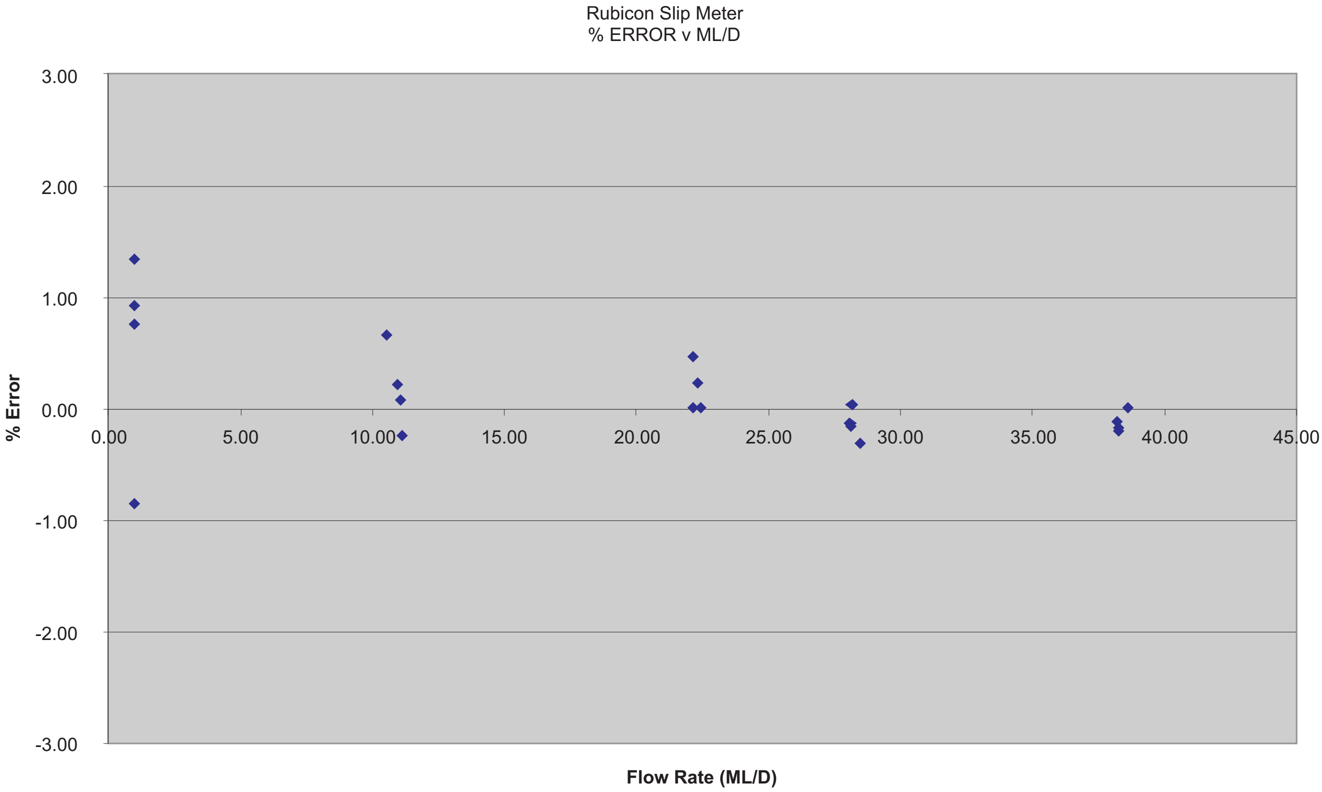
The results of Tests 31–34 are presented in Table 3.5. Plots of head loss vs. flow rate are presented in Figure 3.2.

Table 3.5 Head Loss

Test	Flow Rate ML/d	Downstream Level m	Upstream Level m	Head Loss m
31	1.025	0.214	0.218	0.004
32	17.823	0.135	0.173	0.038
33	29.410	0.061	0.156	0.095
34	38.083	0.054	0.209	0.154

3.7 Assessment of Uncertainty

An uncertainty assessment was conducted for the calculated MHL volumes using ISO (1995). Uncertainty calculations are performed to give a quantitative assessment of the accuracy achievable by the test set-up and instrumentation. Uncertainty is a measure of the confidence in a measured quantity. A thorough analysis of the contribution of uncertainty of each element in the test system allows specification of an interval of confidence for the value measured. The primary source of uncertainty in the MHL facility is the reference electromagnetic flow meter, with minor contributions from other sources such as water level sensors and recording equipment.



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GRAPH OF TEST RESULTS
TESTS 1-20

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Figure 3.1

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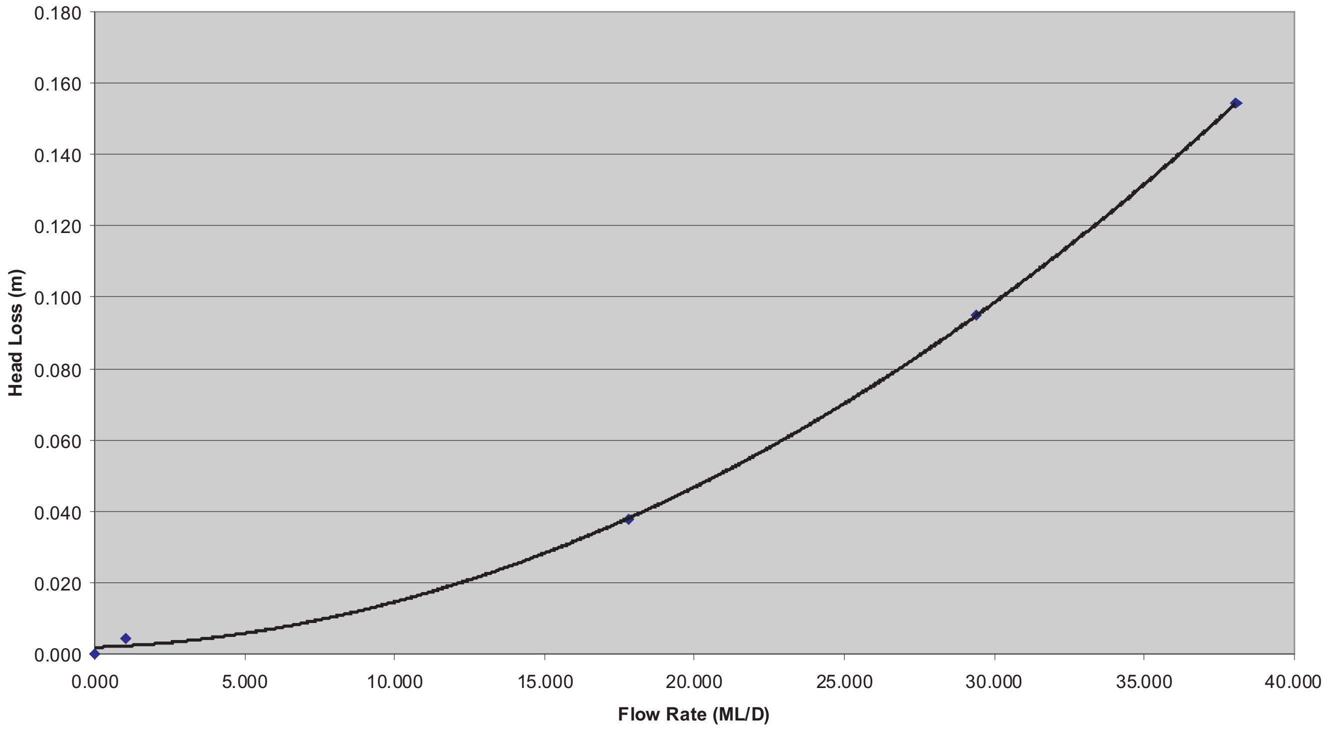
Head Loss



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GRAPH OF HEAD LOSS vs. FLOW RATE

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Figure
3.2

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4. Conclusions

This was the first production version of the 600 mm Rubicon SlipMeter™ meter that MHL has tested, and follows previous testing of a prototype unit. MHL testing has shown that it meets the accuracy requirements defined in NMI 10 of better than a ±2.5% error in measurement at 95% confidence level under laboratory conditions.

The meter was fully submerged by at least 50 mm for all tests and hence the meter was full when testing was undertaken. The results should not be taken as representative of the meter's performance when it is submerged by less than 50 mm. The maximum level the meter was tested at was 330 mm above the meter. This was a limitation of the test facility and not the meter and it is believed the meter will be accurate for levels above 330 mm. It was observed that the SlipMeter provides a 'pipe not full' output which indicates when the water level is less than 50 mm above the top of the meter and the meter is operating outside of its design range, but the meter was still able to record discharges under these conditions.

The change to the entrance design of the production version has provided a marked decrease in head loss through the meter compared to the previous prototype tested. The enclosing screen over the pit and meter provided both safety and security to the meter.

5. References

AS ISO/IEC 17025:2005, *General requirements for the competence of testing and calibration laboratories.*

International Organisation for Standardization (ISO) 1995, *ISO Guide to the Expression of Uncertainty in Measurement*, 1993, (corrected and reprinted, 1995), ISBN 92-67-10188-9

NMI 2009, NMI M 10 *Meters Intended for the Metering of Non-Urban Water in Full Flowing Pipes*, *Part 1: Metrological and Technical Requirements, Part 2: Test Methods, Part 3: Test Report Format,* Third edition, July 2010.

NMI 2009, NMI M 11 *Meters Intended for the Metering of Non-Urban Water in Open Channels and Partially Filled Pipes*, *Part 1: Metrological and Technical Requirements, Part 2: Test Methods, Part 3: Test Report Format,* Second edition, first revision, August 2009.

NMI 2004, *Uncertainty in Measurement: the ISO Guide*, National Measurement Institute Monograph 1: NMI Technology Transfer Series, Ninth Edition, December 2004, author Robin E Bentley.

Appendix A

Abbreviations and Glossary

Abbreviations and Glossary

Accuracy (of Measurement)	The closeness of the agreement between the result of a measurement and a true (conventional) value of the measured quantity.
Disturbance	An influence quantity having a value within the limits specified in these requirements, but outside the specified rated operating conditions of the meter.
Error (of Measurement)	The result of a measurement minus a true (conventional) value of the measured quantity.
EUT	equipment under test
Expanded Uncertainty	Expanded uncertainty determined in accordance with the *Guide to the Expression of Uncertainty in Measurement*
ISO	International Organization for Standardization
k	coverage factor
L/s	litres per second
ML/d	megalitres per day
NMI	National Measurement Institute
Pattern Approval	The process whereby an impartial body examines the pattern of an instrument against a set of national or international metrological specifications. This determines whether an instrument is capable of retaining its calibration over a range of environmental and operating conditions.
Performance Test	A test intended to verify whether a meter is capable of accomplishing its intended functions.
Q	flow rate
Q_1	minimum flow rate
Q_3	permanent flow rate
Q_4	overload flow rate
Relative Error (of Measurement)	The error of measurement divided by a true value of the measured quantity.

Appendix B

SlipMeter™ Technical Information

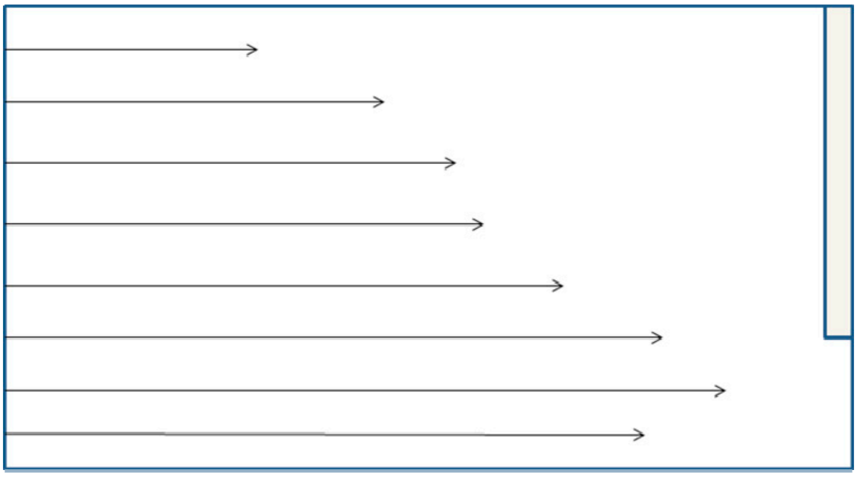
SLIPMETER TECHNOLOGY DESCRIPTION – Provided by Rubicon Pty Ltd

Rubicon's SlipMeter™ is a member of Rubicon's family of ***Acoustic Array Technology***. The acoustic array principle maps the velocity profile within the conduit being measured using multiple transecting paths to provide an accurate 3D reconstruction of the velocity distribution within the conduit. This technique measures the entire velocity field within the conduit and is unaffected by swirl, or other non-uniform velocity distributions.

The Acoustic Array technology is a new innovation offered by Rubicon, and borrows concepts from medical imaging technology such as ultrasound in which an array of acoustic transducers is used to provide a three dimensional image of the medium being scanned. This established science, known as tomographic mapping, uses multiple image slices to reconstruct detail of the three dimensional details being scanned.

Knowledge of the three-dimensional velocity profile within the conduit allows Rubicon's Acoustic Array Technology to measure accurately in the presence of severe flow disturbances. This is because the calibration of the meter does not rely on assumptions about the shape of the velocity distribution, but simply relates the integral of the velocity distribution to the flow passing through the conduit – the fundamental principle of velocity-area metering.

Rubicon's SlipMeter™ product features eight planes of velocity sampling to account for the severe velocity profile changes which occur when the meter's undershot control gate moves through its range of operation. These velocity paths are illustrated in Figure 1 below, which represents a vertical section taken through the body of the meter.



Sampled Vertical Velocity Distribution

Figure B1 – Velocity samples in Rubicon SlipMeter™ product

These velocity samples are integrated as shown in Figure B2 to produce a highly accurate map of the velocity through the body of the meter, which is directly proportional to the flow through the meter.

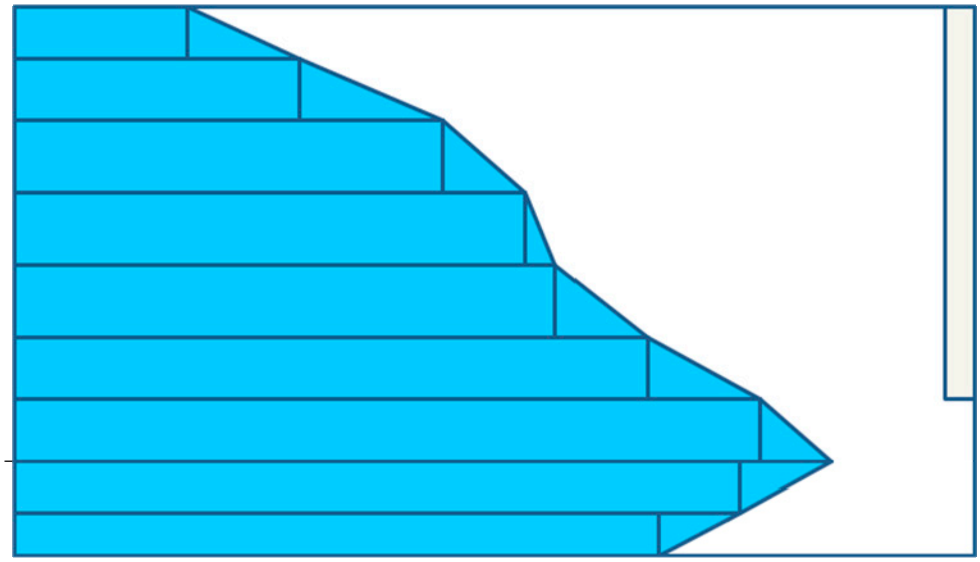


Figure B2 – Integration of the velocity samples yields a highly accurate velocity profile

The Acoustic Array measurement technique is an extension of traditional cross-path transit time flow metering, which is an established standard metering technique described in international standards such as ISO6416.

In addition to the use of multiple paths to reconstruct a three dimensional velocity profile, the Sonaray technology developed by Rubicon is able to measure significantly lower flow velocities than older acoustic technologies. Rubicon's Sonaray technology has extremely high timing resolution, with a standard deviation better than 100 picoseconds. This permits accurate flow measurement (better than ±2.5%) at low velocities down to 25mm/s (25/1000 m/s). This is a significant improvement on traditional acoustic technology which is limited to velocities typically greater than 300 mm/s. Rubicon has committed significant development resources in conjunction with the University of Melbourne which uses propagation delays through logic gates to create this precise timing capability. These propagation delays are highly stable and are calibrated to a quartz measurement standard on every reading to ensure that the Sonaray technology is truly digital and that it is not possible for the meter to drift over time.

An additional innovation offered by Rubicon's Sonaray technology is the rapid sampling conducted by the meter which measures a new flow velocity sample every 10 milliseconds. In addition to rapid sampling, the Sonaray technology is not subjected to air disturbances of traditional acoustic technologies. Each reading is assessed using air detection algorithms and air effected reads are discarded. The rapid sampling (100 samples per second) allows repeat readings to be made after the air has passed through the system so that it no longer interferes with the path, so that the measurement is updated with non air effected measurements. The presence of air in a pipe is a highly transient disturbance, meaning that a large number of unaffected measurements can be made in the presence of air-entrained flows.

The Sonaray technology is low power, with a typical current consumption below 20mA at 12V. Rubicon is soon to release a 3V Sonaray system which can operate off lithium batteries for many years with or without a solar panel. The Sonaray pipe meter is also offered with multiple telemetry options, including Zigbee or spread-spectrum wireless options. These wireless options permit zero cabling installations, and are particularly beneficial when meters are clustered around a central communications node.

The Sonaray technology was developed in Australia by Rubicon Water in conjunction with the University of Melbourne. The technology was developed under a Federal Government AusIndustry Grant to provide a low cost and low power measurement technology specifically designed for the detection of distribution losses in non-urban and urban water networks. Prior to the Sonaray technology there was no known metering device which could be economically used to measure a combination of very low flows and very high flows in large pipes. The accurate measurement of low flow velocities in large pipes is an essential part of the detection of losses in pipe networks, and the Sonaray technology provides new tools which can now allow this new level of distribution network management.

The Sonaray flow meter is factory calibrated as a single unit and each flow meter is supplied with a factory calibration certificate. The calibration is performed in Rubicon's flow laboratory in Shepparton, where the meter is calibrated against two NATA traceable ABB Magmaster flow meters.

All Sonaray flowmeters are constructed from high quality marine grade aluminium which is proven resistant to aggressive water. The transducers are contained within an inert plastic housing, and plastic pipe materials can be offered on smaller meter sizes if required.

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