KNOW THE FLOW

DEVELOPMENT OF IMPROVED FLOW MEASUREMENT IN IRRIGATION WATER SUPPLY

Final report

February 1998

Australian Irrigation Technology Centre
Manly Hydraulics Laboratory
Naturally Resourceful Pty Ltd
Sinclair Knight Merz

National Program *for* Irrigation Research and Development

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compiled by

Australian Irrigation Technology Centre
on behalf of
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Executive Summary

The **"Know The Flow"** project was initiated in 1997 to address issues relating to the accurate measurement of the delivery of irrigation water to farms. The current most common method, the Dethridge Wheel, was perceived to have problems in some applications. The project was conceived to research solutions to these problems.

The first stage of the project involved collecting data on the flow regimes to be measured, the current measuring devices in use and the cost of operation of these devices. Simultaneously a glossary of terms was prepared and data was collected for the design and construction of a test facility that could verify the performance of flow meters.

Two workshops were held during the project, the first to verify the accuracy of the data collected and top provide input to the test facility and the second to confirm the uses of the test facility and to recommend methods for disseminating technical information through the industry.

The first stage of the project was reported in March 1999 and confirmed that the data collected was an accurate picture of the situation facing the industry. The second workshop inspected the test facility, constructed at the Manly Hydraulics Laboratory, Manly Vale, NSW, and made recommendations for the communication of technical data. The key recommendations of the project are:

That Manly Hydraulics Lab (MHL)

1. Develop a standard questionnaire for potential clients
2. Prepare a project proposal to the National Program for Irrigation R & D to develop standard testing procedures
3. Scope the development of a training program in basic hydraulics and meter installation for relevant staff of authorities.

That an internet website be created

1. That a flow measurement website be placed within the ANCID website
2. That this be funded by NPIRD as an extension of the project
3. That this continuing project be managed by the existing project team
4. That there be ongoing funding from NPIRD, ANCID, water supply agencies and MDBC to maintain the site
5. That the site be fully developed by mid-2000

At the conclusion of the workshop participants evaluated the project and confirmed that all project objectives had been met.

1.0 **Introduction**

The “**Know The Flow**” project was initiated approximately two years ago by NPIRD to address the important issue of accurate measurement of flows onto irrigation farms from supply systems. The irrigation industry had recognised two major actual and potential problems with the standard device used for this purpose in Australia, the Dethridge Wheel. Like most other mechanical flow measurement devices the Dethridge Wheel can measure flows very accurately, however if it is installed incorrectly or used in flow ranges beyond its calibrated functionality, serious inaccuracies can result. The Dethridge Wheel has also been identified as a potential cause of industrial accidents and in some parts of the country significant occupational health and safety issues have been identified.

Since the implementation of the COAG water reforms accurate measurement of water has become even more critical. As the price of water has increased greater attention has been paid to measurement accuracy. The “**Know The Flow”** project was commissioned to help find alternative solutions to the Dethridge Wheel.

The project objectives are detailed in Chapter 2 below. In general terms the project endeavoured to identify;

- The range of flows to be measured
- The available options for measuring these flows
- A standard methodology for testing flow measurement meters and
- The best method for distributing technical information, such as meter performance, to all the key irrigation water managers in Australia.

This is the final report prepared for the **”Know The Flow”** project and reviews progress against the project milestones. It complements the first milestone report prepared in March 1999.

The report concentrates on the milestones for the second stage of the project rather than dealing with the whole project. In particular, the document reports on the final project workshop and the key recommendations from that workshop. However because project tasks were completed in a different sequence from that initially proposed, the milestones for stage one of the project are also reviewed in this report.

2.0 Project Objectives

The project objectives were detailed in the project schedule that formed the research contract. The objectives were:

- To detail the range of conditions under which flow needs to be measured;
- To identify design conditions and the most appropriate methods for measuring flow in these different conditions in irrigation systems;
- To estimate the number of sites for each condition to be measured;
- To establish a common glossary of terms to be adopted by the Australian irrigation industry in flow measurement and control;
- To provide the facility to test and verify accurate farm inflow measuring devices;
- To identify how rural water supply authorities can most efficiently communicate technical information between themselves and;
- To recommend how to establish this internal communications network.

To measure progress against objectives a series of milestones were developed. These milestones are detailed in Chapter 3, page 3.

3.0 Milestones

The first stage of the project involved data collection and interpretation. The milestones agreed for Stage 1 were;

1. Review and analyse current and future flow measurement needs:
    - Prepare and distribute questionnaire
    - Collate and tabulate responses;
    - Tabulate and rank key criteria and issues for measurement; and
    - Validate results.
2. Develop Cost Benefit/Criteria:
    - Determine average “whole of lifetime costs”;
    - Discuss specific costs with water authorities.
3. Develop equipment performance criteria;
    - Develop criteria and issues; and
    - Discuss specific costs with water authorities.
4. Establish information distribution mechanism:
    - Audit current communication processes;
    - Literature review; and
    - Workshop with Authorities.
5. Develop accurate field measurement standards:
    - Specification of field flow regime;
    - Construction of test facility; and
    - Finalise test program.
6. Prepare milestone report.

The achievement criteria for this milestone were:

- ✓ Criteria developed for flow devices and accepted by water authorities;
- ✓ Response to survey completed by 60% of potential clients;
- ✓ Benefit Cost Criteria developed and accepted by clients;
- ✓ Testing equipment for accuracy of flow measurement built; and
- ✓ Milestone report approved by LWRRDC.

The milestones agreed for Stage 2 of the project were:

1. Develop accurate field measurement standards:
    - Develop measurement accuracy criteria; and
    - Hold workshop
2. Establish a glossary of terms relating to SCADA:
    - Literature review; and
    - Preparation of publication.
3. Workshop with water authorities and potential likely developers of flow measurement devices.

The achievement criteria agreed for these milestones are;

- ✓ Specification criteria for flow measurement devices under a full range of operating devices accepted by water authorities and a high level of awareness of these among manufacturers;
- ✓ QA standard tests established to measure accuracy of flow measurement devices under a range of operating conditions;

- ✓ Clear communication channels and language established to enable water authorities and manufacturers to define systems, components and functions and improve transfer of information between interested parties.

These milestones and the project objectives were discussed at the final workshop. Participants were asked to review the project objectives and milestones to ensure that they had been satisfied.

3.1 Stage 1 Milestones

Stage 1 of the project has been reported in detail in the first milestone report. The primary tasks for the first stage of the project were to collect sufficient data from water authorities to accurately inform all stakeholders with an interest in flow measurement of the key issues to be addressed. A comprehensive survey was responded to by over 80% of potential respondents. This response rate gives confidence that accurate information has been collected.

However it is worth noting the timing changes from the initial schedule.

- The completion of the glossary of terms, originally scheduled for stage 2 of the project, was completed earlier than expected and is now available as a technical publication from ANCID, the Australian National Committee for Irrigation and Drainage.
- The literature review was completed but has not yet been reported on. The review forms appendix 2 of this report.
- The test equipment construction was not completed until stage 2 because of delays in receiving some of the final design criteria for the test facility. The final design is outlined in Appendix 3 of this report.
- All other stage 1 criteria were met. The results of the data gathering exercise were presented to a workshop, attended by the industry, that confirmed and validated the results of the survey. The results gave a detailed picture of the flow regimes to be measured, the accuracy required of flow measurement devices and the cost of their operation. The workshop also confirmed and clarified outstanding issues for the remainder of the project. A summary of the data collection and related activities are reported in Appendix 4, page 20.

3.2 Stage 2 Milestones

Stage 2 milestones were reviewed and checked at the second project workshop, attended by water supply agencies, manufacturers, government agencies and private contractors. The workshop report comprises chapter 4 of this document.

In regard to the specific stage milestones progress has been as follows.

The glossary of terms was previously completed in stage 1 of the project.
The workshop reported in Chapter 4 discussed and agreed guidelines for accuracy measurement, for the dissemination of technical information and for the testing regime.

4 Workshop Report

The third and final **Know the Flow** workshop was held in March 1999 to:

1. Inspect and provide feedback on the testing facility built by Manly Hydraulics Laboratory at their site
2. Provide feedback on the recommended communications processes
3. Meet with manufacturers and inspect product exhibit.

The workshop brought together people from every state in Australia, representing all major water supply authorities, and every major manufacturer and supplier of meters in Australia.

Over a two day period the participants reviewed project progress to date, inspected the testing facility at the Manly Hydraulics Laboratory, inspected a display of flow meters, recommended key next steps, and evaluated the project against it objectives and the workshop process.

The major recommendations from the workshop are detailed in Figure 1:

Figure 1
Key Recommendations

1. That MHL:

- develop a standard questionnaire or brief for potential clients
- prepare project proposal for NPIRD to develop standard testing procedure
- scope the development of training program in basic hydraulics and meter installation for relevant staff of authorities.

2. That a flow measurement website be placed within the ANCID website

- That this be funded by NPIRD/LWRRDC as an extension of the KTF project
- That this continuing project be managed by the existing KTF project team
- That there be ongoing funding from NPIRD, ANCID, water supply agencies and MDBC to maintain the site.
- That the site be fully developed by mid-2000.

Day 1 (Monday 22 March)

Introduction

Sinclair Knight Merz and Manly Hydraulics Laboratory updated the workshop on progress with the project since the previous workshop. This update was followed by an inspection of the Manly Hydraulics Testing Facility.

Day 2 (Tuesday 23 March)

Participants reviewed the visit to MHL the previous afternoon. They were asked what they might use the testing facility for. Their responses are as follows:

- verification testing
- generic testing range of devices under range of conditions
- reference between laboratory and field
- test *in situ* device – need benchmark
- training those who test/use equipment – accreditation
- specific purpose tests of unique sites
- adopt standard arrangement as a starting point for testing
- establish limits and ranges for particular devices in particular situations
- promoting awareness and advantages and disadvantages of available devices, possibly through the proposed website
- durability testing.

Potential clients of the facility said that before they used it they would need to know:

- cost of testing
- turnaround times
- capacity
- accreditation and recognition with other states
- agreement between suppliers and MHL on test specification (benchmarks/standardize?)
- suppliers agreeing on specifications together for how meters should be tested
- physical parameters of the facility e.g. flow rates and other specifications.

This information could be contained in a prospectus or capability statement.

There was agreement that MHL now needs to:

- develop a standard questionnaire or brief for potential clients
- ensure the involvement of regulators, especially DLWC
- obtain from the group specifications for standard test
- develop/design criteria for different systems
- collate test information and design criteria already available
- design training program for relevant staff.

The key recommendations following the review of the Manly Test Facility are detailed in figure 2.

Figure 2
Key Testing Recommendations

That MHL:

1. develop a standard questionnaire or brief for potential clients
2. prepare project proposal for NPIRD to develop standard testing procedure
3. scope the development of training program in basic hydraulics and meter installation for relevant staff of authorities.

Website development process

At the previous project workshop it was agreed that a website represented the best way of communicating technical information in the industry. Participants were asked to consider how a flow measurement website might be resourced, managed and maintained and in what timeframe.

Website recommendations

It is proposed to place the flow measurement information on the ANCID website under "Technical". The key recommendations are contained in Fugure 3.

Purpose of the site is to make available:

- Technical information on flow measurement (channel, and channel to farm)
- Detail personal contacts
- Incorporate field experience e.g. by using case studies

Content of the site to include:

- Equipment available – SKM paper
- Metering equipment categories
- Generic description
- Checklist for new players on what to look for eg accuracy levels, water quality
- Links to manufacturers
- Link into any independent tests done
- Know the Flow reports including participant list
- Email link or contacts for water suppliers
- Testing
  - In situ
  - Lab
- Installations
  - Case studies
  - Specs
- Glossary of terms which is to go on general ANCID website and IAA

The website could be initially funded by NPIRD/LWRRDC as an extension of the Know the Flow project, managed by the existing KTF project team.

Ongoing management of technical content may be the responsibility of one person who has appropriate industry knowledge. This is to be considered a separate task to that of website maintenance.

Ongoing funding of the site may be sourced from NPIRD, ANCID, water supply agencies and MDBC. Some of the group believed that funding from manufacturers may be seen to compromise the independent status of data on the site. Manufacturers may pay a royalty for links posted on the site.

Participants were keen to see the site set up soon with the material that has already been collected from the KTF project plus a contact list. A fully developed site would be ready by mid 2000.

Figure 3
Website Recommendations

4. That a flow measurement website be placed within the ANCID website
5. That this be funded by NPIRD/LWRRDC as an extension of the KTF project
6. That this continuing project be managed by the existing KTF project team
7. That there be ongoing funding from NPIRD, ANCID, water supply agencies and MDBC to maintain the site.
8. That the site be fully developed by mid-2000.

Project evaluation

Each project objective was considered by the group and all present agreed that all objectives had been met.

- To help identify the most appropriate methods for measuring flow in irrigation systems. *Met*
- To detail the range of conditions under which flow needs to be measured. *Met*
- To estimate the number of sites for each condition to be measured. *Met*
- To establish a common glossary of terms to be adopted by the Australian irrigation industry in flow measurement and control. *Met*
- To provide the facility to test and verify accurate farm inflow measuring devices. *Met*
- To identify how rural water supply authorities can most efficiently communicate technical information between themselves. *Met*
- To recommend how to establish this internal communications network. *Met*

Evaluation questions

Participants were asked a series of questions about the project, their involvement in it and what they learned from the project. The following responses were received.

1. *How did your knowledge of metering increase over the life of this project?*

- did not know about different types of flow meters
- found out we were not the only ones with the problem
- found out whether it worked or did not work
- found out fundamental measurements are not straight forward
- technology has progressed over the life of the project - wondering if project was a catalyst for increased technical activity
- meter supplier saw need at the same time
- better meters driven by change in market, reliability and accuracy issues - not aware of KTF but were aware of market change

1. *How valuable were the workshops in contributing to your knowledge?*

- extremely valuable
- we were all working in isolation - now cooperating and pooling information
- forced people to act to meet deadlines
- helped lab to understand field conditions by shared information
- workshops improved as we went along
- interaction with suppliers and manufacturers

1. *Other positives?*

- quantum leap in knowledge about what we can or cannot measure

1. *Disappointments?*

- focus on Dethridge Wheel in earlier workshops
- MHL would have liked to have visited field sites in Tatura
- Lack of economics and cost information for devices, especially installation and lifecycle costs
- website and meter testing should have been written in from beginning as two-stage process - research and implementation
- not gone far enough
- lobby NPIRD committee delegates
- lack of involvement of DLWC despite invitations to participate

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Appendix 2

Communications literature review

By Naturally Resourceful Pty Ltd

This literature review has been carried out for the "**Know the flow**" project which was funded by Land and Water Resources Research and Development Corporation through NPIRD. The project was designed to improve design and operation of flow metering devices for rural water supply channels and to communicate information about them to water supply organisations.

The literature was sourced from a search of Australian and overseas publications on personal communications, organisational communication and in particular, communication issues for the utilities sector. A list of references used is included as an Appendix.

Background

The target audience for information about rural flow metering devices is the engineering staff of rural water supply authorities or organisations. These people are located in geographically diverse locations throughout Australia. In the past, government departments were responsible for most water supplies so communication between suppliers was simply a matter of contacting each State agency.

Now much of the water supply system is in the hands of smaller, privatised supply organisations. This means that the old communication networks are no longer available and new ones are just forming. A proliferation of suppliers makes it harder to communicate and this is exacerbated by the fact that some of the R&D and business information which suppliers fund the collection of, is considered to offer market advantage. This situation has a competitive aspect, which has tended to discourage open communication between supply authorities.

Despite these difficulties there is agreement that good communication is important. This is reflected by the inclusion of a communications review in what is essentially a technical project. On the international front, one of the issues to emerge from Agenda 21, a framework developed at a United Nations conference on Environment and Development was a call to establish "comprehensive information networks that allow the exchange of information between different sectors and localities" (Cummings *et al*, *na*)

Andrews (1995), in a book on regulatory reform in the power industry, concurs that in a competitive market cooperative research is likely to suffer. Though some of the R&D may be taken up by equipment suppliers by undertaking competitive research, there remains a need for cooperation between all the players. He recommends regional communications planning that emphasizes joint fact finding, information sharing and consensus building.

Communication networks

Communication is essentially about people. A communication network is a number of interconnected individuals who are linked by patterned information flows. These are sometimes described on paper in the form of sociograms that help to identify the shape of individual networks and how individuals communicate with each other (Rogers *et al*, 1981).

People naturally tend to communicate with those who are close to them in physical distance and who are relatively homophilious in social characteristics. They tend to develop networks that require the least effort or provide the most rewards, whether social, emotional or commercial.

In a world of increasing information people remain an important communication link as "know-who" replaces "know-how". Rogers *et al* (1981) say that as each individual often possesses more information than he knows what to do with, what is more important is who he knows. For example, although every paper is full of job ads and despite the existence of employment agencies, many jobs are found through interpersonal networks.

Communications networks may have different structures. Rogers *et al* (1981) describe horizontal diffusion networks where information flows between peers and vertical diffusion networks, where the information flow is from the top down. They maintain that these different networks suit the movement of different types of information and that horizontal diffusion networks are especially useful for information exchange about innovations that serve local ends.

Communications network maybe formal or informal. Hellweg (1997) says informal networks supplement formal networks and:

- carry 5 out of 6 messages, only a small number of which are rumours
- are largely oral
- are people oriented rather than issue oriented
- carry more accurate information than inaccurate
- operate mainly at the worksite
- flow in all directions
- operate in clusters
- are fast
- are not gender related.

Livingston and Berkes (*na*) say that informal networks provide opportunities not possible with formal networks and that effective workers know how to use these informal networks.

Kknowledge of how people act within a communication network can help to set up structures that foster good communication.

Organisational communications

In a longitudinal study of communication within a new research organisation, Stork (1991) found that with no intervention, communication behaviour changes in the following manner:

1. initially communications will be unstructured and chaotic as individuals seek to understand, clarify and reduce uncertainty.
2. networks will become less dense, more organised (structured) and will break into groups
3. individuals will increasingly communicate with their chosen group
4. intragroup communications will increase
5. intergroup communications will decrease.

As communication networks become more structured over time they become more insular. Stork says that managers may need to intervene to facilitate flow of information and ideas beyond group boundaries. They can do this by:

- Identifying and encouraging individuals who serve as links between groups and across boundaries.
- Building structures that promote information exchange such as meetings and cross-disciplinary teams.

Rogers and Everett (1981) identified this liaison or linking role as crucial but recognise that only a few people naturally act as liaisons.

Communicating technical information

Weiner (1997) says technological change can be a "powerful, disruptive" change agent. Innovations can transform industries overnight and destroy the competitive advantage of entrenched leaders.

Stork (1991) says that different groups may need different types of communication methods. She says that because oral communication is especially effective for processing complex information, scientists rely heavily on verbal exchanges with their colleagues to gather, process and share new information. They also operate with high levels of uncertainty so need extensive and decentralised communication networks with many members communicating externally.

Conversely, development and technical support groups need a more hierarchical network and need specialised gatekeepers to link to external sources for ideas and information.

When communicating technical information people will not only seek objective technical data but also seek subjective experiences to give meaning to a new idea, Rogers and Everett (1981). If people rely on others to inform their decision making, knowing who to go to for information is critical for individual effectiveness.

Personal networks can be so close and homogenous that they are of limited value for obtaining innovative information. Rogers and Everett (1981) say that useful networks do not have to be close relationships. Weak ties, that is, links with people who are socially and spatially distant, can be stronger in carrying useful information.

Hibberd (1997) says that the most valuable information in a workplace comes from tips employees pick up in the course of their work. “Eighty percent of what you need to know is in the company … its just a matter of getting a place for them to tell you what they know”.

A threshold is the number of other individuals who must be engaged in an activity before a given individual will join that activity. An individual is more likely to adopt an innovation if they know of one or more other individuals who have adopted previously.

Communications vehicles

There are numerous vehicles for communication including personal communication, print media, video and audio. Segars and Grover *(na)* say that the richer the information you are trying to communicate the more expensive the process is. For example, videoconferencing provides a level of richness absent in teleconferencing, but comes at a higher cost. The introduction of the Internet and email have improved opportunities for communicating between widely dispersed geographical locations.

Some companies with geographically diverse locations are using intranets to improve communication. An intranet is an “internal communications network that uses internet communications software and hardware but restricts communication with the internet”. Friedman (1996). Friedman reports that an intranet can "improve communication, save money on printing and enhance, but not replace, email".

British Gas (BG) has a history of operating diverse and geographically disparate business units under one banner. To share knowledge amongst these units they are developing a corporate wide superintranet. Business units will still operate their own intranets but will be able to tap into the superintranet. BG also plans to extend its superintranet to an extranet to share data with external partners around the world. "We aspire to be a company not constrained by physical boundaries" (Essick, 1997).

Implications for the water supply sector

In summary, people naturally operate within networks that tend to include those who are close to them both physically and socially. These personal networks, while easy to set up and maintain, cannot supply all their information needs and in fact, innovative information may be more likely to come from those they are not close to.

Therefore, informal networks will tend to be personal networks and not necessarily useful for communicating technical information, especially innovative technical information. What

informal networks are good at is personalising technical information, that is providing advice on the application of technical knowledge or innovations.

At any point in time, different organisations will be at different stages in the communication continuum. Any cross-organisational communication strategy must be able to cover these different stages. The literature also shows that to prevent groups from becoming insular that formal structures may need to be set up to ensure liaison and communication between a group and other sources of information.

Good communication provides people and organisations with both objective and subjective information. The Internet, whether by Webpage or email, may be useful for providing this mix, especially as rural water supply authorities are located throughout rural Australia. The dispersal of ownership of water supply authorities means that close face-to-face networks are not longer viable for many staff.

Informal communications networks may be maintained to obtain subjective information by using email or contact details obtained from a website. Formal networks can be maintained by organisations providing technical data on company websites and linking these to other related sites. For even more objectivity, a separate website may be set up by an independent body to contain research results on a range of relevant technical topics.

A well maintained website can provide a “filter” by providing access only to relevant information preventing information overload (Davies and Harvey, 1994). Getting information electronically is also quick, cheap, replicable and relatively accessible. (Easdown, 1998).

A project involving farmers has shown that they will use electronic information sources more often and more effectively if they are provided some training in use of the medium and some support. (Simpson, 1998)

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Appendix 3
Manly Hydraulics Laboratory Irrigation Test Facility

A component of the *Know the Flow* project was the establishment of a facility to test and verify irrigation flow measuring devices at Manly Hydraulics Laboratory (MHL), Manly Vale, Sydney. This facility will allow laboratory testing of complete flow measurement installations, as opposed to flow meters on their own, in flow conditions as near as possible to those in the field. Typical testing will include head and headloss measurements over a range of flows and evaluation of the accuracy of installations and their sensitivity to the various adverse flow conditions that occur in the field.

The design of the facility was based on:

- satisfying the requirements specified by participants at the first ***Know the Flow*** workshop
- accommodating the range of installations and conditions identified in the survey carried out as part of the project and/or observed by a the field inspection carried out by Bob Cook, from MHL and Brian Foley from Sinclair Knight Mertz

The facility, located in a laboratory building, comprises a regulated water supply, electromagnetic flowmeters, upstream head box, a test area and drainage system. The layout of the rig is shown in the accompanying figure. One side of the head box is constructed from marine plywood to allow either open channel or piped flow measurement systems to be easily installed for testing. The general specifications of the rig are shown in the table below.

Water supply	Gravity pipelines from Manly Dam. 10m head. Total available flowrate is24 ML/day.
Flow measurement	Electromagnetic flowmeters. Flowrate and totaliser display. NATA calibrated. Measurement of uncertainty 0.25% of measured quantity or 60 L. In-situ calibration verification system fitted.
Head box	Above ground, 7.2 m x 6.0 m x 1.2 m. Mechanical water level follower reading to 0.1 mm.
Test Area	8.0 m x 6.0 m. Longer arrangements can be accommodated.
Drainage	Below ground channel to waste or to 2 x 0.8 ML volumetric tanks

A range of approach conditions, such as flow across an intake or eddy shedding from abrupt changes in geometry, can be simulated by arranging baffles in the head box. Piped flow systems requiring more than 1.2 m of head can be tested using other facilities at the laboratory.

The first device being tested is a Combined Instruments Irreflow 12D electromagnetic flowmeter in a Goulburn-Murray Water Dethridge Wheel emplacement. The rig has also been used for developing gauging techniques and training by Murray Irrigation personnel. News of future activities at the test rig will be displayed on the MHL web site at www.mhl.nsw.gov.au.

Appendix 4
Survey & development of specification criteria

Criteria developed for flow devices and accepted by water authorities

The process involved in developing the flow device criteria started with a detailed questionnaire being sent to over 80 irrigation authorities throughout Australia in April 1998. The recipients represented all the known managers of channel based irrigation schemes. The questionnaire asked for a range of technical data concerning dimensions, configuration, flow rates and other operating parameters under which irrigation channels and measurement devices are required to operate.

Replies were received in respect of all major irrigation schemes and a number of smaller ones. A draft report summarising the responses and setting out draft criteria was presented to a Workshop held in Tatura in July 1998 comprising authority managers and operation supervisors from most states. The initial findings and draft criteria were agreed by the authorities at the conclusion of the Workshop.

Benefit Cost Criteria developed and accepted by clients

The questionnaire also sought information from authorities on capital and annual costs of various metering devices as well as water charges and economic criteria used for project management and evaluation. Although there were some variations in cost and revenue information between authorities, due to varying bases of accounting and costing practices, the information was sufficient to determine some general broad principles.

This information was presented to the Tatura workshop and accepted as reasonable by the authorities.

Specification criteria for flow measurement devices under a full range of operating devices accepted by water authorities and a high level of awareness of these among *manufacturers*

Following acceptance of the criteria for flow measurement, a detailed field inspection was undertaken of the full range of typical irrigation channels, system configurations and metering devices that need to be considered. This inspection was undertaken in October 1998 by project staff from Manly Hydraulics Laboratory and Sinclair Knight Merz and covered Goulburn Murray Water, Murray Irrigation, Coleambally Irrigation and Murrumbidgee Irrigation.

The flow measurement checking device was then developed at Manly Hydraulics Laboratory. The desired device adopted, ensured that the full range of measurement situations and flow rates up to 25 ML/day could be handled by the test rig.

The flow measurement at Manly was discussed and demonstrated at the workshop conducted in March 1999. This workshop was attended by representatives of all the major irrigation authorities as well as 10 suppliers of measurement equipment. At the conclusion of the Manly Workshop, all participants expressed satisfaction with the testing equipment.

As part of the Workshop, equipment suppliers were invited to participate in a trade display and demonstrate their measurement devices and ancillary equipment. From the range of devices demonstrated and the interest displayed it is clear that the manufacturers have a clear understanding of the requirements for irrigation measurement.

Know the Flow

INTERIM REPORT 1997-98

Incorporating the proceedings of the workshop held at Tatura in July 1998

prepared by

The Australian Irrigation Technology Centre
on behalf of
Sinclair Knight Merz
Manly Hydraulics Laboratory
&
Naturally Resourceful.

EXECUTIVE SUMMARY

This report details the progress to date of the **Know The Flow** project. It supports the information provided in the August 1998 milestone report.

Surveys have been conducted by mail, telephone and face to face interviews to obtain information about current practice in regard to flow measurement and the communication and acquisition of technical information.

The results of these surveys were discussed and validated at a workshop held at Tatura in July 1998.

The major findings of the surveys and workshop are:

Current Flow Measurement:

- There are approximately 35,000 meters now in service in the survey sample, which comprises over 95% of all Australian irrigated areas.
- Flow ranges measured vary between 2 to 20Ml per day with the majority in the range of 3 to 12Ml per day
- Accuracy desired is between 2 and 5%

TABLE OF CONTENTS

SECTION 1

Introduction

This report summarises the progress of the **Know the Flow** project, LWRRDC Project AIT5 and incorporates a report on the Workshop held at Tatura in July 1998. This report has been compiled by the Principal Investigator, Mr Jeremy Cape, on behalf of the project team which includes;

Sinclair Knight Merz
Manly Hydraulics Laboratory and
Naturally Resourceful.

Each section of the report details the findings related to a particular issue and can be read as a separate document.

Project Objectives and Milestones

The research team and LWRRDC agreed to a number of key milestones to monitor the progress of the project. The milestones agreed prior to project commencement were:

"Data collection and interpretation

a) Review and analyse current and future flow measurement needs:
    - prepare and distribute questionnaire
    - collate and analyse responses
    - tabulate and rank key criteria and issues for measurement
    - validate results

b) Develop cost/benefit criteria:
    - determine average "whole of lifetime costs"
    - discuss specific costs with water authorities.

c) Develop equipment performance criteria:
    - develop criteria and issues
    - document current equipment characteristics.

d) Establish information distribution mechanism:
    - audit current communication processes
    - literature review
    - workshop with authorities.

e) Develop accurate field measurement standards:
    - specification of field flow regime
    - design test facility
    - finalise test program.

f) Establish glossary of terms relating to SCADA:
    - literature review
    - preparation of publication.

g) Prepare milestone report.

ACHIEVEMENT CRITERIA: submission of milestone report to LWRRDC according to guidelines including evidence of:

a) Criteria developed for flow devices and accepted by water authorities.
b) Response to survey completed by 60% of potential clients.
c) Benefit cost criteria developed and accepted by clients.
d) Testing equipment for accuracy of flow measurement design accepted."

Project Progress

The research to date has involved the collection and validation of a range of information including:

- Key flow measurement information
- Information network issues
- Key parameters for the design of the testing facility.

This information has been collected, by survey, face to face interviews and literature search and analysed and validated at a project workshop, held on the 6th and 7th July.

Following the workshop a series of field visits were made by members of the project team to finalise the design criteria for the test rig to be build at the Manly Hydraulics Laboratory. In addition further analysis was carried out on the meter survey results.

A final project workshop is planned for the week beginning 22nd March 1999. At this workshop manufacturers will be invited to display the latest measuring technologies; the test facility will be demonstrated and reviewed and the design of the information service and communication network finalised.

SECTION 2

Workshop

The workshop program, detailed below, was designed to enable participants to review and analyse the results of the data collection exercises. Data was collected on current flow measurement practices and on the information and communication network stakeholders required.

WORKSHOP PROGRAM

KNOW THE FLOW PROJECT

Goulburn Murray Water Training Centre, Tatura
July 6^{th} and 7^{th} 1998

Workshop Aims:

1. Review results of flow and communications surveys
2. Review accuracy checking procedures and develop parameters for field checking of accuracy
3. Review irrigation definitions paper
4. Develop information strategy for water authorities in area of flow measurement.

Time	Subject	Presenter
Monday 6^{th} July		
12.30-1.15	Lunch	
1.15-1.45	Introduction Purpose of Workshop Participants introduce themselves and their most important flow measurement issue of the last twelve months	JC
1.45-2pm	Exercise in communication for the group	Nat Res
2.00-2.30	Summary of Results of Flow Survey, followed by questions	BEF
2.30-3-15	Groups to review survey findings • Any omissions from survey • High medium and low priority issues • Additional info required for manufacturers Group findings on butchers paper for review over tea	
3.15-3.45	Afternoon tea	
3.45-4.00	Final agreement on survey findings	
4.00-4.30	Description of proposed accuracy checking procedures incl Manly facility traceable standard procedures possible field checking mechanism	SW/BC
4.30-5.15pm	Groups to develop design specification for field methodology	
5.15-6.00pm	Final agreement accuracy checking	
7.00pm	Dinner	Nat Res

Communications Exercise

	DAY 2	
8.30-9.00	Irrigation Definitions	BEF
9.00-10.30	Development of communications network	Nat Res
10.30-11.00	Tea	
11.00-11.30	Future info needs	
11.30-12.15	Info strategy for future	
12.15-12.30	Review strategy	
12-30-1.30	Where to from here for the project Review workshop	JC
1.30	Lunch	
2.15	Close	

The program involved breaking participants into groups to discuss and review the results of each survey and data collection presentation. The results of the discussions are included at the end of each section containing the summary of each survey. Thus Section 3 details the results of current flow measurement practice and Section 3A the results of the workshop discussions.

SECTION 3

Rural Water Authority Questionnaire on Operating Conditions - May 1998
Summary of Responses

Responses have been received from the following authorities.

Authority	Code *	Meters	Annual Volume Delivered (ML)	Comment
Central Irrigation Trust (SA)	a	1970	n/a	Pressurised pipe system
Narromine Irrigation Board (NSW)	b	6	300	Small private scheme. Pumped
Hay Irrigation (NSW)	c	83	n/a	Small gravity channel system
Murray Irrigation Limited (NSW)	d	3,600	1,400,000	Large open channel system.
Sunraysia Rural Water Authority (Vic)	e	2510	200,000	All supplies pumped. Originally distributed by channel. Now piped.
Lower Murray Irrigation Action Group (SA)	f	-	n/a	Non-metered gravity flood irrigation. Metering under investigation
South West Irrigation (WA)	g	904	72,600	Mainly open channel supplies with about 10% piped.
Yambocully Water Board (Qld)	h	14	20,000	Small private scheme
Burdekin River Irrigation Authority (Qld)	I	1092	474,000	Part channel supply with some pumped direct from river
Coleambally Irrigation (NSW)	j	660	466,000	Open channel supplies
Goulburn Murray Water (Vic)	k	19,650	2,050,000	Mainly open channel supplies. Some pumped to high lands.
Murrumbidgee Irrigation (NSW)	l	4,500	n/a	Large open channel system

*Code letter used to identify each Authority in summarising some responses

Abbreviations used:

DM	Dethridge meter
DM(L&S)	Large and small capacity Dethridge meters
DLM	Dethridge Long Meter (recent type of hydraulically improved Dethridge meter)
prop.	Propeller type meter
u'sonic	Ultrasonic meter
OFM	Open flow meter (refers to a type of propeller meter)
na	Information not available or not applicable for this scheme

Q1 Meter Operating Parameters

(a) Volume of irrigation water delivered annually through each type of meter?

Authority	Meter Type	Volume Delivered ML/a	Total Volume Delivered ML/a
Central IT	prop	n/a	n/a
Narromine IB	prop	300	300
Hay Irrigation	DM	n/a	n/a
Murray IL	DM prop	1,400,000 3,000	1,403,000
Sunraysia RW	DM (S) prop	61,000 140,000	201,000
Lower Murray IAG	not metered	n/a	n/a
South West Irr	DM	72,600	72,600
Yambocully	prop	20,000	20,000
Burdekin RIA	DM prop	152,000 322,000	474,000
Coleambally	DM U'sonic (Mace) prop (OF & saddle)	351,000 50,000 65,000	466,000
GMW- Murray Valley	DM (L&S) DLM prop	301,000 2,100 5,000	308,000
GMW- Central Goulburn	DM (L&S) DLM prop	464,000 6,000 8,000	478,000
GMW- Rochester	DM (L&S) DLM prop	225,000 3,600 7,000	236,000
GMW- Pyramid/Boort	DM (L&S) DLM prop	291,000 3,000 3,000	297,000
GMW- Shepparton	DM (L&S) DLM prop	229,000 1,500 7,500	238,000
GMW- Torrumbarry	DM (L&S) DLM prop	474,000 5,000 15,000	494,000
Murrumbidgee Irr	DM (L&S) prop ultrasonic	n/a	n/a

(b)(i) Level of accuracy wanted/achieved from meters during a season?

Authority % Accuracy	Meter capacity < 3 ML/d	3-12 ML/d	12-20 ML/d	>20 ML/d
Central IT				
% wanted	± 2%	± 2%		
% achieved	n/a	n/a		
Legislation specifies ± 5%. However ± 2% desired to allow for wear of mechanism				
Narromine IB				
% wanted			± 0%	
% achieved			± 5%	
Hay Irrigation				
% accuracy wanted	± 0%	± 0%	± 0%	
% accuracy achieved	-15%	-15%	-15%	
Actual accuracy estimated from percentage losses, diversion to delivery.				
Murray IL				
% accuracy wanted		± 2%	± 2%	
% accuracy achieved				
Lower Murray IAG				
% accuracy wanted			± 5%	± 5%
% accuracy achieved			n/a	n/a
South West Irrigation				
% accuracy wanted		± 0%		
% accuracy achieved		- 30%		
High degree of accuracy desired. Actual determined from Venturi and V notch measurements.				
Burdekin RIA				
% accuracy wanted	-	± 3%	± 3%	± 3%
% accuracy achieved	-	± 10 to 15 %	± 5%	± 3%
Coleambally				
% accuracy wanted	± 5%	± 4%	± 4%	± 2%
% accuracy achieved	?	± 20%	± 5%	± 3%
Desired accuracy based on customer expectation Actual determined from recent check measurements.				
Goulburn Murray (all)				
% accuracy wanted	± 5%	2% - 5%	2% - 5%	± 5%
% accuracy achieved	0 to 15%	0 to 10%	0 to 10%	0 to 15%
Murrumbidgee Irrigation				
% accuracy wanted	<5	<5	<5	<5
% accuracy achieved	>15	>10	>10	>15

b(ii) How are nominated accuracy levels determined?

Wanted level:

- Legislation requires ± 5%. Higher level (± 2%) sought to allow for wear etc. (a)
- Minimum requirement equivalent to Dethridge meter (not currently metered) (f)
- Expected level. (g)
- Customer expectations (j)
- Ideal accuracy level ± 2% achievable under limited and controlled conditions. (k)
- Increased accuracy needed to reduce operating costs. (l)

Achieved level:
- Determined by calculation of percentage water losses diversion to delivery (c)
- Trial check measurements (f)
- Check measurements using alternative meters (venturi, V notch) in series with existing Dethridge meters. (g)
- Check measurements performed on existing meters using alternative devices (j)
- 5% accuracy usually achieved under field conditions when Dethridge meter operates over full flow range. Less accurate when operates outside range. Check measurements performed. (k)
- Known inaccuracy of many Dethridge meters (l).

Conclusions on Accuracy Levels:
- Most authorities indicated desired levels of accuracy ranging from ± 0% to ± 5%. While ± 0% might appear to be an ultimate accuracy objective, in practice this level is unlikely to be achieved under actual field conditions over a complete system.
- The majority of large authorities indicate a desired range of ± 2% to ± 5% which is more practicable.
- Relatively few meters are installed with capacities greater than 20 ML/d and it would appear that higher level of accuracy is desired, and may be achievable, than for smaller flows.
- Although a number of authorities have indicated or estimated the accuracy levels achieved, little information was provided on how the achieved levels were determined. It is known that several authorities have undertaken check field measurements, generally using different equipment or procedures to the existing measurement devices.

c) Number of meters installed or required in various flow ranges?

Authority Flow Range	No of meters (Now + *in 5 years*)				
	< 3 ML/d	3 to 12 ML/d	12 to 20 ML/d	>20 ML/d	Total
Central IT	1970		-	-	1970
Narromine IB	1	1	2	2	6
Hay Irrigation	3+*30*	80	-	-	83+*30*
Murray IL	-	3500	100	-	3600
Sunraysia RW	400	2000+*50*	100	10	2510+*50*
Lower Murray IAG	-	-	+180	-	+180
South West Irr	-	904	-	-	904
Yambocully	-	-	-	9+*5*	9+*5*
Burdekin RIA	-	300	772+*10*	20+*10*	1092+*20*
Coleambally	30 +*20*	600 + *40*		30+*30*	660 + *90*
GMW- Murray Valley	10+*5*	3100+*20*	7+*10*	-	3117+*35*
GMW- Central Goulburn	10+*10*	5220+*50*	20+*10*	-	5250+*70*
GMW- Rochester	-	2300+*30*	20+*10*	-	2312+*40*
GMW-Pyramid/Boort	1	2303+*40*	28+*10*	-	2332+*50*
GMW- Shepparton	10+*10*	2450+*40*	5+*10*	-	2465+*60*
GMW-Torrumbarry	47+*30*	4103+*65*	29+*15*	-	4179+*110*
Murrumbidgee Irr	4500+*1000*				4500+*1000*
Totals					~35000 +*1740*

Conclusion on meter numbers:
Approximately 35,000 meters are installed in these schemes with an expected 5% increase over the next 5 years. Many of the existing meters could also require replacement in the near future.

(d) What water level difference (head) is generally available for metering purposes?

Authority Head Range	% in each range				
	< 20 mm	20-100 mm	100-200 mm	200-300 mm	> 300 mm
Central IT					100
Narromine IB		10	90		
Hay Irrigation			40	60	
Murray IL		100			
Sunraysia RW			10	50	40
Lower Murray IAG					100
South West Irr	30	30	40		
Yambocully					100
Burdekin RIA			30	50	20
Coleambally	10	35	40	10	5
GMW (all)			10	30	60
Murrumbidgee Irr	5	75	10	5	5

Conclusion on head range available:
Schemes with available measurement head less than 100 mm have difficulties achieving accurate measurement at moderate cost. More sophisticated measurement devices may be required.

(e) Examples of flow rate variability through meters during irrigation season and percentage of meters where it occurs:

Authority	Variation, % meters & % time of variation			
	max/min (ML/day)	% of total meters	% time at low flow	% time at high flow
Narromine IB				
Maximum variation	12			
Average variation				
No significant variation		100		
Hay ID				
Maximum variation	8-13	na	na	na
Average variation	10			
No significant variation				
Murray IL				
Maximum variation	0.5-20	na	na	na
Average variation	varies through season			
No significant variation				
Sunraysia RWA				
Maximum variation	4	5	80	20
Average variation	2	15	80	20
No significant variation		80		
***LMIAG** (estimated)*				
Maximum variation	15 -100	100		
Average variation				
No significant variation				
SW Irrigation (WA)				
Maximum variation	na			
Average variation	na			
No significant variation		90		
Yambocully WB (Qld)				
Maximum variation	10 -150	70	40	60
Average variation	50 - 100	30		
No significant variation				
Burdekin River IA				
Maximum variation	5 - 2	30	10	90
Average variation	3	30		
No significant variation		40		

Authority	Variation, % meters & % time of variation			
	max/min (ML/day)	% of total meters	% time at low flow	% time at high flow
Coleambally Irrig.				
Maximum variation	2 - 12	20	80	80?
Average variation	2 - 8	80	30	20
No significant variation		0		
Notes re Coleambally usage: Row crops always use full flow available Horticulture usually in range: 2 - 4 ML/d Rice: 2-10 ML/d per LMO, 2-20 ML/d per farm.				
GMW (all)				
Maximum variation	8	50	50	50
Average variation	4	30	20	80
No significant variation		20		
Murrumbidgee Irrig.				
Maximum variation	1/10	80	40	20
Average variation	3/8	80	60	40
No significant variation				

Conclusions on flow variability:

- There are significant variations in flow rates through many meters during the irrigation season in most schemes.
- Where sufficient head is available, and the flow variations remains well within the allowable range, the effect on measurement accuracy may be slight.
- Where available head is small, and flow variations are extreme, such as at Murray Irrigation and Coleambally Irrigation, consistent measurement accuracy is more difficult to achieve.

(e) Water level fluctuations upstream and downstream of meter.

(i) Percentage of outlets where the water level upstream of the meter varies from the standard design level? (-) sign is below standard level. (+) sign is above standard level.

Authority	Variation & % of outlets						
Water level	> -200 mm	-200 to -100 mm	-100 to -20 mm	-20 to +20 mm	+20 to +100 mm	+100 to +200 mm	>+200 mm
Hay Irrigation							
% of outlets				60	40		
Murray IL							
% of outlets				10	90		
South West Irrigation							
% of outlets				90	10		
Burdekin River IA							
% of outlets				68	30	2	
Coleambally Irrigation							
% of outlets	2	3	5	30	40	15	5
Goulburn Murray Water (all)							
% of outlets	0	5	30	10	50	5	0
Murrumbidgee Irrigation							
% of outlets	1	10	30	18	30	10	1

Other Authorities not shown above:
- not applicable or negligible variation: a, b, e, h (generally piped schemes)
- river level greater than 1 m above land: f (Lower Murray lands supplied direct from river)

(ii) At what percentage of all outlets does water level fluctuate during supply?

Authority	Variation and % of meters		
	< ± 20 mm	± 20 to 100 mm	> ± 100 mm
Hay Irrigation			
Upstream of meter	60	40	
Farm side of meter	70	30	
Murray IL			
Upstream of meter	10	85	5
Farm side of meter			100
Burdekin River IA			
Upstream of meter		98	2
Farm side of meter			
Coleambally Irrigation			
Upstream of meter	5	55	40
Farm side of meter	5	15	80
Goulburn Murray Water			
Upstream of meter	70%	20%	10%
Farm side of meter	80%	15%	5%
Murrumbidgee Irrigation			
Upstream of meter	-	80	20
Farm side of meter	-	80	20

Conclusions on water level fluctuations:
- Variations < ± 20 mm are not significant.
- Greater variations would be significant for measurement accuracy especially where there is also limited available head.

Q2 Capital costs of meter installation

Typical capital cost of recent meter installations:

(a) Propeller meters

Meter type, size/capacity	PA *Central IT*	PA (200mm 8 ML/d) u/s of pump *Sunraysia*	PA (200mm 8ML/d) d/s of pump *Sunraysia*	PA in-line (13 ML/d) *Burdekin*	PA OFM (13 ML/d) *Burdekin*	PA OFM 450mm *Coleambally*	PA (in-line) 150-300 mm 5-12 ML/d *GMW*	PA (0-25 ML/d) *M'bidgee*
Meter supply & delivery		$800	$800	$1,100	$1,800	$2,000	$500	$2,000
Other materials & services		$2,200	$1,000	$4,700	$4,400	2,400	-	$2,000
Installation cost		$1,200	$600	$7,000	$7,000	$800	$1,800	$2,000
Supervision & overhead		$200	$100	$700	$700	$400	-	$500
Total installed cost.	$1800 (50mm) $2000 (80mm) $3000 (100mm) $3750 (150mm) $5000 (200mm)	$4,400	$2,500	$11,500	$13,900	$5,600	$2,300	$6,500
Year	1998	1998	1998	1998	1998	1997	1998	1998

(b) Dethridge meters

Meter type, size/capacity	DM (6ML) *Hay Irrig*	DM (12 ML) *Murray IL*	DM (12 ML) *South West Irr*	DM (5 ML) *South West Irr*	DM (12 ML) *Burdekin R IA*	DM (5ML) *GMW*	DM (12ML) *GMW*	DLM *GMW*	DM (12 ML) *M'bidgee*
Meter supply & delivery	$850	$300	$1,183	$1,133	$1,700	$900	$1,180	$2,260	$1,500
Other materials & services	$200	$2,600	$882	832	$2,200	-	-	-	$1,000
Installation cost	$400	$800	$300	300	$7,000	$2,400	$2,570	$3,040	$3,000
Supervision & overhead costs	$400	$100			$700	-	-	-	$500
Total installed cost.	$1,850	$3,800 (Extra $11,000 for road culvert)	$2,365	2,265	$11,500 (includes road culvert)	$3,300	$3,750	$5,300	$6,000
Year	96/97	1998				1998	1998	1998	1998

(c) Ultrasonic

Meter type, size/capacity	(Mace Agriflow) *Coleambally*	U'Sonic (Doppler) (50 ML/d) *M'bidgee*
Meter supply & delivery	$2,600	$2,000
Other materials & services		$2,500
Installation cost	$400	$2,000
Supervision & overhead costs	$300	$500
Total installed cost.	$3,300	$7,000
Year	1998	1998

Q3 Operation and Maintenance Costs and Comments on Performance

(a) Propeller and Ultrasonic meter O&M costs

Authority	*Central IT*	*Narromine IB*	*Sunraysia RW*	*Burdekin RIA*	*Coleambally*	*Coleambally*	*GMW*	*M'bidgee Irr*	*M'bidgee Irr*
Type of meter	prop (all)	prop	prop & DM	prop	prop (OFM)	u'sonic (Mace)	prop	prop	u'sonic (Doppler)
(a) Average direct operational costs per meter per year:									
Meter reading/data collection. Frequency of reading	low	$1 - 2 monthly	$	quarterly	$20 15 days	$30 15 days	$75 3/year	$600 ?	$600 ?
Power costs	low		$		$-	solar	$-	$-	$-
Other direct costs	-		$	$4	$-	-	$-	$-	$-
(b) Annual maintenance costs ($ per meter)									
Routine inspection and cleaning		-	$20/meter	$20 in-line $5 OFM	$100 clean solar panel & trash rack	$5	$25	Included in reading cost	Included in reading cost
Major overhaul /replacement. (average over life of meter)	$300	$4/year	$	n/a	$100. life n/a add $10/y for digital display	n/a	$50	$100	$5

Q3 Operation and Maintenance Costs and Comments on Performance (continued)

(b) Dethridge meter O&M costs

Authority	*Murray IL*	*South West Irr*	*Burdekin RIA*	*Coleambally*	*GMW*	*GMW*	*M'bidgee Irr.*
Type of meter	DM (all)	DM (all)	DM (all)	DM (large)	DM (L&S)	DLM	DM
(a) Average direct operational costs per meter per year:							
Meter reading/data collection. Frequency of reading	n/a weekly	$300 14 days	quarterly	$25 15 days	$75 3/year	$75 3/year	$600 ?
Power costs					$-	$-	$-
Other direct costs			$4		$-	$-	$-
(b) Annual maintenance costs ($ per meter)							
Routine inspection and cleaning of meters	weekly if used	$200	$-	$35	$25	$25	Included in reading cost
Major overhaul /replacement. (average over life of meter)	Wheel $300 over 10 years. Bearing blocks annually	$50	$90	$60	$45	$50	$100

(c) Comments on meter performance and maintenance

(i) Propeller and Ultrasonic meters

Authority	*Central IT*	*Narromine IB*	*Sunraysia RW*	*Yambocully*	*Burdekin RIA*	*Burdekin RIA*	*Coleambally*	*Coleambally*	*GMW*	*M'bidgee Irr*	*M'bidgee Irr*
Type of meter	prop	prop	prop	prop	prop (in-line)	prop (OFM)	prop (OFM) 450 mm	ultrasonic (Mace)	prop	prop	u/sonic (Doppler)
Ease of use and data collection	Good	Very easy	-	Good	Above ground good. Below ground difficult	Good	-	-	OK. Some problems with specific types	Good	Excellent
Ease of maintenance	Good. Worn out parts replaced rather than repaired	Excellent	Easy. Access an occasional problem	Satisfactory	Difficult to inspect	Good	Mod. skill for Tempress High skill for McCrometer	High skill needed	High life cycle costs	Good	Excellent
Days per year meter operates	36	35	70	40	200	200	200	200	125	100 to 200	100 to 200
Reliability	Good	Good	Fair to good	Fair	Good	Very good			Mixed average	Good	Excellent
Frequency of failure.	Rare	Seldom	-	Once/year	1 in 2 years	Nil to date	2 - 10 years	n/a (new)	Variable	Medium	Negligible
Is this satisfactory?	Yes	Yes	-	No	Yes	Yes	n/c	n/c	No	?	Yes
Any particular maintenance difficulties.	Occasional blockages	No	-	Slow parts supply	Ceramic bearings good performance	Ceramic bearings good performance	Moisture entering mechanism		Effects by water quality, silt/sediment on component life	-	-
Other issues or problems.	-	None	-	-					Standardise to ML/d	Allows flow when stopped (blocked?)	-

(ii) Dethridge meters

Authority	*Hay Irrigation*	*Murray IL*	*Sunraysia RW*	*South West Irr*	*Burdekin RIA*	*Coleambally*	*GMW*	*GMW*	*GMW*	*M'bidgee Irr*
Type of meter	DM	DM	DM (small)	DM	DM	DM	DM (5ML/d)	DM (12ML/d)	DLM	DM
Ease of use and data collection	Very easy. Direct reading	Direct reading pendulum. Easy	-	Good	Moderate. Weeds, drowning, gravel	-	OK. Need to time wheel	OK. Need to time wheel	OK. Need to time wheel	Medium
Ease of maintenance	Minimal	Minimal for galvanised wheels	Easy. Concrete. structures a problem	Reasonable	Not bad. Small size better	Low skill	Replacement only	Replacement only	Replacement only	Poor
Days per year meter operates	36	217	70	15	200	200	25	45	20	100 to 200
Reliability	Good	Very	Fair to good	Good	Very good	Rare	OK	OK	OK	Good
Frequency of failure.	Rare	Nil	-	Rarely	Rare	About 4 years	0.5%	0.5%	0.5%	Low
Is this satisfactory?	Yes	Yes	-	Yes	Yes	n/c	yes	yes	yes	Yes
Any particular maintenance difficulties.	No	No	-	No	Flows >rated capacity. Maintaining clearances	Rust problems	No	No	High RPM reduces component life	Lifting wheels
Other issues or problems.	No	Nil	-	No		OH&S due to heavy lifting.	OH&S concerns	OH&S concerns	OH&S concerns	Dangerous device!

Q4 Water Cost and Revenue Implications

(a) Are water charges levied to users on a volumetric basis? (Yes or No):

(b) If yes please provide the following information if possible:

Authority	*Narromine IB*	*Murray IL*	*Sunraysia RW*	*South West Irr*	*Burdekin RIA*	*Coleambally*
Details of tariff and rating schedule including fixed and variable components.	$16/ML	$5.30/ML fixed + $7.02/ML variable	$36/ML fixed + $53/ML variable	$15.75/ML fixed + $19.8/ML variable	$3.00/ML fixed + $35.60/ML variable	n/a
Annual revenue from water charges. ($ per annum)	4,000	$15 mil.	$10 mil.	$1.6 mil	$13.5 mil.	$5.0 mil.
Current capital cost of water (market price) to farmers for new allocations or TWE ($ per ML)	335	$350 $15 - $70 /year temp TWE	$800 - $1000	na	$250 river $100 channel	No new alloc. Temp TWE $30 Perm TWE $300
Expected capital cost of water in 5 years time. ($ per ML 1998 cost levels)	?	?	~$3,000	na	as above	$625?

Authority	*GMW-MV*	*GMW-CG*	*GMW-Roch*	*GMW-PyrB*	*GMW-Shep*	*GMW-Torr*
Details of tariff and rating schedule including fixed and variable components.	Vol $19/ML fixed for WR. Sales payable if used.	Vol $22/ML fixed for WR. Sales payable if used.	Vol $20/ML fixed for WR. Sales payable if used.	Vol $17/ML fixed for WR. Sales payable if used.	Vol $22/ML fixed for WR. Sales payable if used.	Vol $19/ML fixed for WR. Sales payable if used.
Annual revenue from water charges. ($ per annum)	$8.0 mil.	$12.0 mil.	$6.0 mil.	$6.0 mil.	$6.0 mil.	$11.0 mil.
Current capital cost of water (market price) to farmers for new allocations or TWE ($ per ML)	$600 - $800/ML	$600 - $800/ML	$600 - $800/ML	$600 - $800/ML	$600 - $800/ML	$600 - $800/ML
Expected capital cost of water in 5 years time. ($ per ML 1998 cost levels)	$800 - $1000/ML	$800 - $1000/ML	$800 - $1000/ML	$800 - $1000/ML	$800 - $1000/ML	$800 - $1000/ML

Q5 General Aspects of Meter Performance

Comments on Suggested Criteria for the design of farm offtake meters. Relative importance of each of these criteria indicated by tick.

Criteria	Essential	Very Important	Moderately Important	Not Important
Operation over a greater range of flows than at present, the suggested range being 0.3 to 25 ML/d.	d, f*, j**,l	j**	b, c, k	e, g, h, i
Operation over a greater range of channel water levels than at present.	d, j, l	e, I, k	b, c, h	g
Ability to pass flows with low head loss requirements.	c, d, f, j	e, g, h, i, k, l		b
Consistent levels of accuracy commensurate with the value of the water resource being delivered.	d, f, g, j, k	c, h, i, l	b, e	
Pose minimal risk to operators and the general public.	d, e f, g, j, l	c, h, k	i	b
Have low maintenance costs.	g	b, c, d, e, f, h, j, k, l	i	
Be vandalproof or, where unauthorised interference occurs, be easily detectable.	c, d, e, f, g, j, k	b, h, l	i	
Provide minimum impedance to access along channel banks for operation and maintenance purposes.	f	b, c, d, h, j, l	e, g, I, k	
Provide for flow data as both instantaneous flow rates and totalised volume.	d, f, j, l	b, c, h, i	e, g, k	
Provide for remote interrogation and/or transmittal of data.	b, d	c, e, h, j	f, g, i, k, l	

* greater range than 0.3 to 25 ML/d needed
** 1-25 ML/d essential, 0.3-1.0 ML/d very important

Code to Authorities:

a Central Irrigation Trust (SA) - mainly piped
b Narromine Irrigation Board (NSW)
c Hay Irrigation Limited (NSW)
d Murray Irrigation Limited (NSW)
e Sunraysia Rural Water Authority (Vic)
f Lower Murray Irrigation Action Group (SA)
g South West Irrigation (WA)
h Yambocully Water Board (Qld)
i Burdekin River Irrigation Area (Qld)
j Coleambally Irrigation (NSW)
k Goulburn Murray Water (Vic)
l Murrumbidgee Irrigation (NSW)

Q6 Particular Features desired in the performance of a new meter?

- Remote interrogation and data transmittal (c)
- Lower cost and higher accuracy for pipe outlet meters (propeller type ?) (c)
- Non-intrusive, non-mechanical, logged (f)
- Moderate capital cost, waterproof mechanism, available spare parts, reliability, accuracy all essential (j)
- Simple operation and checking of usage (k)
- Delivery lead time, available support and spare parts (k)
- Life cycle cost effectiveness. Relatively low capital cost (k)
- Robust technology and construction for field use (k)
- Operation not affected by water quality, blockage or fouling (k)
- All features listed in Q5 (l)

Q7 Water Borne Debris

What types of debris are carried in the supply system and are required either to pass through or be filtered before the metering device?

water weeds	b, d, e, f, i, j, k, l
tumble weeds/umbrella grass	c, d, f, h, j, k, l
small twigs	b, c, f, h, j, k, l
tree branches.	d, e, f, g, j, k, l
dead animals	g, j, l
fish	d, j
yabbies, turtles etc	d
algae	e, i, j, k
logs, sticks, drop bars etc.	d, j
silt/sediment	k

Q8 Field Testing of Flows

(a) Would you use a portable flow testing device for field checking of meter accuracy if one is developed? Yes or No

Yes:	b, c, d, e, f, g, h, I, k, l
	j (already have a device)

(b) If yes:

(i) How many days per year?

1-5	b, f
5 - 20	e, h, I, k
>20	d, g, j (have full time staff)
not sure	c, l (as required)

(ii) Would you prefer to purchase or hire the test equipment?

purchase	d, e, i, l
hire	g
not sure	c, f, k

(depends on cost, life, level of skill etc)

already purchased	j

SECTION 3 A

Summary of Workshop Group Discussion following Presentation on Questionnaire Responses

Following the presentation of the data detailed in Section 3 workshop participants were asked two questions; What were the key points and What was missing in their view from the presentation. The group responses are recorded here.

Question 1 What were the key points for you in the presentation?

Group 1
Low working heads available in many situations
Variations in flow rates
Variation in head
Not one metering solution is suitable to suit all applications, requirements due to:
- crop type
- system hydraulics and configuration

Accuracy levels of 2-5% are generally required
Suitability for field operation should include:
- ruggedness
- reliability
- be vandal proof

A range of water quality conditions might be encountered

Group 2
Number of measurement locations required
Measurement requirements are a reflection of geography and historical use bias (e.g. NSW and Victorian usage patterns are different. SA more intensive)
Need separate analysis for each different type of meter
The level of accuracy needs to be defined (for various applications?)
Capacity of meters: most existing meters in 3 to 12 ML/d range.

Group 3
Range of flows required to be measured
Range of technology used or available
There is no "one best" measurement solution
Different perceptions of accuracy requirements
Systems for measuring accuracy
Cost of replacement meters (to replace existing means)

Question 2 What points were omitted from the presentation?

Group 1
Life cycle costs
Channel geometry
Installation requirements
Power supply requirements

Group 2

Why water is being measured is not clearly defined. ie. charging for political, social or environmental reasons. This influences how water is to be measured and accuracy targets.

Need to address measurement other than just improving on the Dethridge meter as the future focus.

Capital costs. Comparison not possible because costing basis not defined clearly

More focus on return on metering. Marginal return on metering accuracy

Specification required for metering to include

- dirty water (possible follow up LWRRDC project?)
- drainage flow measurement

Look to future flow requirements, not necessarily the same as at present.

SECTION 4

Key parameters for the design of the testing facility.

Following the collection of data from the flow measurement questionnaire a preliminary list of design criteria for the testing facility were established. These criteria were examined and confirmed at the project workshop.

The water authorities identified the following criteria to be considered in the design of the testing facility.

The criteria are divided into the upstream conditions, emplacement or meter structure and the downstream conditions. Respondents were emphatic that the testing facility must have the capability to test meters taking into account the following conditions:

Upstream Conditions (U/S)

- orientation of structure related to upstream
- head (variable)
- velocity of passing flow
- streamline entry
- distance to u/s control device (if there is one)
- geometry

Emplacement/Structure

- open/closed - channel or pipe
- geometry (x-section and plan)
- minimum head loss
- flow control (u/s or d/s)
- materials

Downstream Conditions (D/S)

- tailwater (diff head conditions)
- geometry
- exit velocity
- orientation
- general
- water quality

The workshop also identified the following key activities for the test facility:

- test replacement for large existing wheels in standard emplacement (test in parallel ie wheel and new device)
- devices available now ➔evaluate operating system for those devices
- key criteria for range of devices
- adjustable structure to recreate field conditions ➔ test different devices
- compare accuracy and operation of new devices with present ones

- test whole system ie complete outlet structure rather than just meter ➔ 3rd party verification of accuracy
- test robustness of unit ➔ life cycle testing (in addition to field testing)

SECTION 5

Information and Communication Network.

This section details the research work completed in the analysis of current communication networks and the recommendations for an information service.

Audit of present communication methods

The audit was based on a 2-stage process consisting of the following:

Stage 1. A preliminary audit based on face-to-face semi structured interviews with staff from four rural water supply authorities. The information from these interviews was used to develop a questionnaire on communicating information to do with flow measurement.

Appendix 1 is the report on this preliminary audit.

Stage 2. Based on the literature review, a methodological framework for the questionnaire of network analysis was chosen.

The questionnaire was faxed to a list of relevant eleven individuals in rural water supply authorities around Australia, from the Ord River in WA to authorities in SA, Victoria and NSW, and the resource manager in Queensland. Appointments were made to do telephone interviews with the ten people who responded to our fax or follow up phone call.

Appendix 2 is an analysis of the results of this questionnaire.

Literature review

A review of the literature has been done using the keywords including communications, communication networks, organisational communications, deregulation, utilities and geographical disparity.

The methodological framework for this project of network analysis was used because it:

- was an effective way of mapping the variety of networks that people in water supply authorities access
- provided a format for describing the categories of information rural water supply authority staff are searching for to do with flow measurement
- provided a basis on which to develop a preferred way of accessing information in the future.

Preliminary Communications Audit

This preliminary audit was done with four water supply authorities: Goulburn Murray Water, based in Victoria; and Coleambally Irrigation, Murrumbidgee Irrigation and Murray Irrigation, all of which are based in NSW.

The aim of the audit was to elicit preliminary information through semi structured interviews with representatives from the above authorities. This information was used to develop a questionnaire on communications that was sent to all rural water authorities.

To context the interviews, the *Know the Flow* project was described, objectives described, and participants offered the opportunity to clarify any issues that were not clear.

INTERVIEW QUESTIONS

1. What informal and formal communications networks exist now both within your authority and with other groups in the industry?
2. What sort of information is exchanged?
3. Who or what is your best source of up-to-date technical information?
4. What sorts of technical information do you need but have trouble getting access to?
5. How would you characterise the amount of information you receive – a lot, a little, adequate?
6. In an ideal world what would be the best way for you to be able to access technical information?
7. Are you connected to and do you use the Internet?

GENERAL OBSERVATIONS FROM INTERVIEWS

- The Water Reform process has had a major impact on how authorities access technical information. Previously the agencies were a primary source of information but this is no longer the case. Authorities seem to be dealing in different ways and with different degrees of success in filling the information void from relying on informal personal networks to formal links with consultants.
- The amount of contact between authorities generally has decreased, especially as staff who were employed before corporatisation have left thus breaking up previous personal networks. There appears to be little indepth knowledge generally of what each authority is doing in technical areas such as metering flow. While some people expressed a desire to have more contact with colleagues in other authorities they didn't seem to know how to go about this.
- Suppliers, manufacturers and consultants have become a major source of information about technical matters. How do staff in authorities access independent information in this situation or get an independent assessment and comparison of equipment and systems? This also has implications for who is actually included in any information network service.

- Three out of four authorities questioned agreed that issues surrounding intellectual property and corporatisation had decreased the potential for and amount of information sharing between authorities.
- The Internet was seen as having great potential as a source of technical information now and in the future. The idea of a "one stop shop" for technical information was referred to by many people interviewed as being a good idea and all agreed they would be willing to pay for a service that met their needs.
- The need for technical information is now driven much more by business imperatives and any information service would need to recognise that information has to be focussed in this way.

GOULBURN MURRAY WATER

630 staff

Interviewed: John Mapson, Derek Poulton, and Ian Moorhouse

General comment. Address metering issues to do with groundwater and pipelines rather than just gravity supply.

Communications networks

CEOs meet through the Association of Rural Water Authorities (Victoria only). This addresses strategy and policies on statewide basis. An information bulletin is done by the secretary through the minutes. No equivalent in other states.

National network is through ANCID but this is not technology oriented.

Newsletters:

- Fortnightly staff newsletter dealing with staff issues
- Newsletters are produced and sent to clients
- External newsletters – plentiful and valuable e.g. commodity, CRC, IAA, Centre for Water Policy Research, Landcare, AWWA, funding bodies.

There is a library at GMW but it was identified that there is no one-stop shop for information

Technical information

- Role of distributing information was previously filled by agencies. Now, as a result of Water Reform process, personal networks within states and across borders are most important methods of contact.
- Other important sources of information were identified as: manufacturers, who provide info through trade days, visits, info sessions; ANCID conference (seems to be a way of transmitting technical info while avoiding problems of intellectual property); consultants, who provide information specifically to GMW based on a relationship; workshops organised by funding bodies; and information exchange

with ISIA and CSIRO. There are also chat pages but these are mainly R&D oriented.

- It was identified that the need for technical information is now much more based on business drivers. Less information is required but what is needed is more focussed because of these drivers. Needs can range from engineering to agronomic to rehabilitation.
- Intellectual property was highlighted as an issue now privatisation has been introduced. Authorities where an enterprise has been privatised/corporatised are guarding information that has a commercial value or leverage.

The future

Identified an electronic information service where individuals would register interest in particular topics and the service would filter information for these topics. Would subscribe if the information was of value.

Already on the Internet. Identified that they spend less time now searching for info than previous but this searching was more focussed (see business drivers).

Also identified corporate farmers as a special group "desperate for information but without the time or resources to find out".

Contact

John Mapson
Librarian – Jennifer Morris

MURRUMBIDGEE IRRIGATION

Interviewed. Neil Rickard, Engineer (Operations)

General comment. No longer use dethridge wheels, rather propeller meters. Next year will be using doppler meters, mainly because of OH&S.

Communications networks

- Main network is personal contact (through father) providing access to other networks. Also networks with industry (manufacturers)
- Is isolated from authorities and commented that he didn't think anyone else is any further ahead than Murrumbidgee Irrigation.
- Internally there is an established way of doing things based on manuals/no internal newsletter/some networking with other engineers.

Technical information

- Access to technical info is on the phone and personal. External to authorities

- Doesn't have access to library resources on basic material "Core civil things are easy". More difficult is "ability to get indepth technical information" like hydraulics. Feels starved of information and has to hunt for it.
- Email is "important" for getting technical information and becoming more so. Office is networked.
- Intellectual property is becoming an issue

The future

Internet connection to a library where he can read books on line. Would pay to subscribe to such a service ($1000 a year). Phone and informal networks are still important.

Contact

Neil Rickard, PO Box 492 Banna Ave, Griffith NSW 2680
Phone 02 6962 0200

COLEAMBALLY IRRIGATION

38 staff

Interviewed. Kevin Kelly, Operations Manager and Mark Bramston, CEO

General comment. Unavailable for workshop in May – August (OK first week May).

Communications networks

- Staff newsletter to communicate "complex topics" e.g. policy, board decisions. Lot of informal internal communication.
- Networks with other authorities "not good" although would appreciate improving them. At a policy and business level contact with authorities is decreasing with privatisation (competition). Contact is increasing with suppliers and manufacturers.
- There is a CEO network that is policy driven.
- Kevin obtains information from conferences, sales reps, CSIRO, DLWC, Rubicon
- Channel attendants belong to an interdepartmental committee and meet twice a year. Would appear to be industrially based.

Technical information

- No one particularly good source of information. Most is accessed through personal contact e.g. Rubicon and through publications such as *Irrigation Australia*.
- Does receive a huge amount of information which is used for making immediate decisions/reactive.
- Needs detailed technical info to "make business decisions on". This appears to be something that is missing now e.g. on channel seepage.

The future

- Identified e-mail and Internet as being vital. Would pay to subscribe to internet info service – "one stop shop". Kondinin model also identified as a "great system"
- Coleambally has a dedicated R&D budget ($100,000 a year) to manage information needs.

Contact

Kevin Kelly, Operations Manager, PO Box 103, Coleambally NSW 2707
Phone 02 6954 4003 Fax 02 6954 4321

MURRAY IRRIGATION

138 staff (10-12 technical staff)

Interviewed. George Warne (CEO), David Watts, Phil Thompson

General comments. Offered support for in field trials.

Communications networks

Networks include client newsletter which staff also receive: corporate group meeting monthly; engineers meeting quarterly; newsletter from instrument and other companies; journals.

Technical information

- Sources of technical information identified as being Kinhills (on retainer) which completes specific projects and is a source of introductions to other networks; Thiess Engineering; IAA conference and Expo; SMEC; sales staff; and other authorities and ANCID (commented that Murray Irrigation is acting more as an information provider to these latter two).
- General agreement that there was no problem getting technical information, especially through Kinhills (which = an "information bureau") and no problem with intellectual property decreasing amount of info available form other authorities. George Warne commented that he saw more exchange of info between authorities in future, not less.

The future

Despite the belief that there was no problem getting technical information the need for central information point on water measurement was identified. This broadened to general agreement that a central point or "one stop shop" that was updated regularly would be good. This could include things such as independent assessment of equipment and the experiences of those who had used it (1 page on strengths and weaknesses etc).

Would subscribe to such a service that could be provided through the Internet.

Contact

Phil Thompson, PO Box 528 Deniliquin NSW 2710
Phone 03 5881 9185 Fax 03 5881 9317

Communication Survey Results

Telephone survey to find how and where rural water supply agencies get their information on flow measurement

Preliminary results - June 1998

Demographics

No. interviews

NSW	2
VIC	3
QLD	1
SA	1
WA	2
Tas	1

What type of information are they seeking?

Mostly information on:
- water flow in channels
- flow measurement when diverting onto farms.

Interviewees generally report that they need practical information. They do not necessarily want to know how a flow metering device works (theoretical information) though some do, but most want to know if it will work in their particular circumstances (applied information).

Some wanted sophisticated systems with data loggers while others needed simple robust meters that need minimal maintenance.

Many expressed their needs for a flow metering device as a list of desirable attributes. For example, one interviewee developed the following list to guide his search:

- Cost
- Ease of installation
- Discharge accuracy ±5%*
- Reliability

- Robustness
- Low voltage**
- Onsite display and totaliser
- Loggable
- Will not reduce discharge rates
- Tamper resistant
- Australian supplier.

*Different suppliers had different requirements for accuracy ranging from ±2% to ±10%.
** Needs for power sources ranged from solar, low voltage (battery) to mains power.

Other criteria were:
- Ability to cover a range of flow rates
- Few wearing parts
- Ability to turn water on and off at farm.

Sources of information	**Ranking for importance** (1 = very important to 5 = least improtant) (PP = personal, NP = nonpersonal)				
Web/Internet	3 NP	2 NP	4 NP	4 NP	4 NP
Text based					
Journals and magazines and newsletters	2 NP	2 NP	3 NP		
Product catalogues	4 NP	3 NP	4 NP		
Texts and reports	3 NP	2 NP	1 NP		
ISO standards	2 NP				
Lit reviews	2 NP				
Other users					
State natural resources departments	2 PP	1 NP			
Neighbouring rural water suppliers	1 PP	1 PP	2 PP	1 PP	
Field trips to other rural water suppliers	1 PP	1 PP	4 PP	3 PP	
Overseas field trips	3 PP	1 PP			
Own trials	1	1			

	NP	PP					
Professional advice							
Consultants	1 PP	2 PP	1 PP				
AITC	1 PP						
Other staff in same organisation	1 PP	5 PP	2 PP				
Companies							
Sales reps	1 PP	4 PP					
Software firms	5 PP						
Electronics companies	PP	3 PP	5				
Equipment manufacturers	2 PP	2 PP	1 PP	1 PP	1 PP	3 PP	1 NP
Equipment retailers	2 NP	1 PP					
Networking							
Personal networks	1 PP	1 PP					
Conferences and trade displays	2 PP						
Workshops	3 PP						

From this data it can be seen that sources of information that were regarded as being personal have a high likelihood of being regarded as important.

Non-personal information sources were most often ranked as number two for importance. It could be interpreted that they are very important as secondary sources.

Did they find what they wanted and if not, why not?

What they wanted	Did they find anything?	Was it what was wanted?	If not, why not? (respondent's comments)
General flow measurement	Yes	yes	Have I missed anything?
Replacement for Badger impellor type	Some	No	• Cannot find many people using them in local conditions so don't know how they last. • Is there more information out there? Other industries?

Measurement of water flow in channels	Some	Some	• not looking hard enough • smaller market for this • expensive, bulky and cumbersome and easily vandalised
Open channel flow metering	Yes	no	being sent to me now
Flow metering from channel to farm	No		Not a lot out there and what is there is too expensive
Product specification of flow meters	Yes	Yes	
What equip/products avail	Yes	Yes	
Info/manufacturers details on products	Yes	Yes	
Review of literature, theory and cataloguing of avail info	Yes	Yes	
Major flow channels	Yes	Yes	
Magflow type meter to replace Dethridge wheel	Yes	Yes	
Electronic version of mechanical/chemical driven capsules used in water meters	Yes	Yes	
Transect ultrasonics to replace Doppler	Yes	Yes	
Method for logging pressure in pressurised pipelines	Yes	Yes	
More accurate devices	Yes		Not enough indepth information
Flow measurement in pipes	Yes	Yes	
Wheel accuracy	Yes		Not sure have covered all variables
Probes with installed MACE U/S devices	Yes	Yes	
Turning water on and off	Yes		Hard to compare cost & life expectancy because of different designs

Some other general comments from this section were:
"Information is too hard to find and (is) all manufacturer based (and) not centralised".
"Have I missed anything … I feel uncomfortable".
"How do you know what you don't know?"

The future

Preferred method	Type of information	Other comments
Electronic		
Email/web as it is good to establish a knowledge base as people will not be looking for this information forever	Will need information on updates and developments and industry standards	Information to get independent information Difficult to get whole package flow because separate industries that don't talk to each other eg. Attach to automated SCADA network.
Internet site as it is available, updatable, centralised Independent	Out needs will broaden, eg. Measuring water infiltrating into watertable	Need more information as pressure increases to get value out of every last drop of water. We know the problems, now (need to put) most energy into looking for right instruments.
website	Want filtered information like information on use, contacts,	Flow measurement becoming increasingly important

	must be easier to find.	
Internet but will not read huge masses of information		
Personal		
Working groups across Australia giving personal contact.	To know what others are doing. See bidding against each other on jobs so not sharing information.	Personal contact has become harder, not easier – try to reverse this trend. Web searches when desperate
Field trips in small groups to look at equipment and get people's views – include users and manufacturers for crossfertilisation of views	Will want more information on electronic metering and the related problems of power supply.	
Water measurement group formed (user group)		
Discussion with other people who have practical field experience like other system users	Improved accuracy and reliability and reduced cost of flow measurement to farms. What you accept in accuracy today (5%) may not may not be acceptable in future.	
Personal contact from sales people to tell me what's available, specifications and where it is being used	This will be an issue for years to come.	Want people to tell me their experiences with the meter.
Advertisement to seek out those with information		
Text-based		
Bulletin of published results of trials and tests and comparisons produced by independent body eg IAA, LWRRDC, AITC.		Am presently looking everywhere, know its there but can't find it.
IAA journal		

Observations on future needs

Though Web is ranked low at present it is seen as a preferred tool for the future. Keyword searching is not considered useful so future use of the Web is centred on a Website with links to manufacturers and other users. One participant said "*I don't want a Website full of email numbers but phone numbers so I can convert a non-personal contact immediately into a personal contact by picking up the phone*".

Personal contact is valued highly by most participants, especially contact with other users and work collegues.

There was a general feeling that flow measurement will be an issue for some years to come as they need more sophisticated meters to better manage a scarce resource.

SECTION 5A

Workshop Report

Sessions on communication held at the workshop had the following aims:

- to gauge participant perceptions of how successful they are at finding information on flow measurement
- for participants to describe their vision of the situation in which they will be operating in the year 2001 with regard to flow measurement and the features of an information system to deal successfully with this situation
- to validate responses to the survey questionnaire
- to identify a future information system or network to do with flow measurement.

The year 2001

The following descriptors were used to describe the situation in which water supply authority staff will be operating with respect to flow measurement:

- importance of data collection and analysis
- repeatability
- degree of automation with accurate flow devices
- wheel will be reinvented to be accurate and field operators as we know them (channel attendants) will be replaced
- ongoing quality supply
- accountability for water used
- no water for supply
- efficient water use
- comprehensive, system wide, integrated measurement network providing balance
- water allocation (need for accurate measurement)
- up-to-date measurement of on farm usage
- measurement of allocation sharing
- measuring losses
- agreed common measurement standards
- equity of measurement and distribution of a scarce resource
- smart sensors will be integrated into water measuring systems
- accurate and remote automatic measurement into a total information system
- accuracy
- “Irriflow” success (replacement development)

In summary, the group saw a future where water will be supplied in an environment dominated by the need for more accurate measurement than at present and where supply authorities are more accountable that at present. Measuring both supply and losses will be important with equipment that is accurate, can be accessed remotely and is part of a total information system.

The role of some staff, i.e. channel attendants is predicted to change substantially.

Validation of survey

As a way of validating the survey results participants were asked to respond to two activities:

- presentation of data
- draw present personal information/communication network.

As data was presented participants were asked to identify any gaps. None were identified.

Drawing individual information/communication networks served to validate responses already received in the survey. It was noticeable that other supply authorities, personal contacts and consultants were confirmed as the most important sources of information while less personal sources such as journal, books, catalogues and texts were rated as important secondary sources.

The Internet is, at present, not an important source of information mainly because the information on it is hard to find (dispersed rather than centralised), manufacturer based (not independent), and overwhelming in quantity (not filtered).

Identify a future information system

As a final exercise participants were asked to identify the key components of an information system that would meet their needs into the future. The four small working groups came up with the following:

Group 1. A centralised industry, i.e. managed by supply authorities, site that is accredited and web based.

Group 2. A library that has modules of information and references with links through the Internet. It also needs to have links to external sources of information. This library should be accredited and clients be able to access information remotely by telephone line at a cost of 20c/minute.

Group 3. A centralised office with a "phone and a desk". Information on factors such as crop water use should be disseminated in the same day. This information should not be too technical so that farmers are able to use it. Clients should be able to access all data and the system should be quality assured.

Group 4. A foolproof, reliable system that has a "self checking routine and data availability". Education should be a feature of this system and there should be stronger links between agency and farmer.

In summary, the information system of the future needs to be:

- industry based and managed
- able to be accessed remotely (Internet)
- centralised
- be quality assured or accredited to ensure the quality, up-to-date nature and accuracy of information on it
- responsive to client needs.

SECTION 6

Rural Water Industry Terminology and Units

Table of Contents

Preface

In 1997 the Executive of the Australian National Committee on Irrigation and Drainage suggested that a document be produced to assist authors of technical papers, as well as seminar presenters and participants, by setting out preferred units of measurement and common definitions for various infrastructure components and scientific processes in Australia. This suggestion arose from the realisation that the rural water industry embraces a broad range of professionals, managers and practitioners of various disciplines and there is also a range of terminology used to describe the processes of water supply, drainage and plant growth. While some expressions are self explanatory or understood universally, it is evident that others have specific regional or functional meaning which might not be widely understood by everyone.

This guideline is intended to be used for the preparation of technical papers, presentations, publications and correspondence for nationwide dissemination within Australia.

The document has been prepared by Peter Alexander and Brian Foley of Sinclair Knight Merz' Melbourne office, who have wide experience of rural water supply and irrigation throughout Australia. During the course of preparation, and as part of this LWRRDC funded project on flow measurement to farms referred to as *Know the Flow*, the draft document has been referred to a number of persons and organisations including:

- Individual members of the Irrigation Association of Australia,
- Participants in a Murray Darling Basin Commission Irrigation Forum in March 1998, and
- The ANCID Executive which has representation in all States of Australia.

Valuable inputs have been received from a number of these persons and their comments have been incorporated into the draft document where appropriate.

Know the Flow PROJECT

Rural Water Industry Terminology And Units

Introduction

The rural water industry in Australia embraces engineers, agriculturalists, educationalists, farmers, equipment manufacturers and suppliers, administrators and various other disciplines. A wide range of terminology is used to describe the physical and scientific processes required to deliver water to farms, remove drainage and provide for plant growth. While some are self explanatory, or are commonly used within the water or agricultural industries worldwide, others have developed locally to describe particular features or procedures and their meaning may not be clear or even contrary to the understanding of persons from other regions. Some expressions, such as "irrigation efficiency", can have legitimate differences in meaning according to the particular context or component of the irrigation system being considered so that clear definition is necessary. The rapid growth and application of electronic technology in recent years has introduced many additional expressions from the information technology industry to describe equipment and processes.

This document is a guideline to appropriate terminology and units for the rural water industry throughout Australia. It should be used for preparation of technical papers, presentations, publications and correspondence for nationwide dissemination. The use of variations to the terminology defined in this document should be confined, as far as possible, to regional usage where there is no ambiguity. Terms having particular legal significance in a State or region, such as "Irrigation District", "water entitlement", etc., or generally accepted meaning outside the rural water industry are not covered.

Units of Measurement - The International System of Units (SI)

Generally the terminology is based on the International System of Units (SI) which contains the basic and derived SI units and symbols appropriate for the rural water industry are shown in Table 1. The preferred units in SI are based mainly on decisions by the Commonwealth and State Governments in 1973 when the Australian water industry transferred from the Imperial to the International System of Units for weights and measures. It should be noted that although SI is decimal it is not the same as the old European "metric" system.

Table 1 - Basic and Derived SI Units

Quantity	***Unit***	***Symbol***
Base Units		
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Amount of substance	mole	mol
Derived Units		
Force	newton	N
Pressure	pascal	Pa
Energy, work, quantity of heat	joule	J

Power, radiant flux	watt	W
Electric potential	volt	V
Conductance	siemens	S

The preferred and acceptable prefixes for use in SI are shown in Table 2 while other units in common use are shown in Table 3.

Table 2 - SI Unit Prefixes

Multiplication factor	*Prefix*	*Symbol*	*ANCID Preferred*
1 000 000 000 = 10^9	giga	G	Preferred
1 000 000 = 10^6	mega	M	Preferred
1 000 = 10^3	kilo	k	Preferred
0.1 = 10^{-1}	deci	d	Acceptable
0.01 = 10^{-2}	centi	c	Acceptable
0.001 = 10^{-3}	milli	m	Preferred
0.000 001 = 10^{-6}	micro	µ	Preferred

Table 3 - Other Units in Use with SI

Quantity	*Unit*	*Symbol*	*Definition*
Time	minute	min	1 min = 60 s
	hour	h	1 h = 60 min
	day	d	1 d = 24 h = 86 400 s
Temperature	degree Celsius	^oC	^oC = K - 273.15
Area	hectare	ha	1 ha = 10 000 m^2
Volume (fluids)	litre	L	1 L = 0.001 m^3
(solids)	cubic metre	m^3	1 m^3 = 1 m x1 m x1 m
Mass	tonne	t	1 t = 1000 kg

Further details on the application of SI are set out in Australian Standard AS 1000-1979.

General Units of Measurement

The list of units of measurement adopted for general use in the Australian irrigation and rural water industry is set out in Table 4. The list comprises base and derived SI units together with some non SI units adopted through common use to meet particular circumstances.

It should also be noted that the SI units in this list are internationally acceptable, whereas the non-SI units are intended primarily for use only within Australia. In some countries a few units derived from the old European metric system are still used, and editorial advice should be sought when preparing documents for local publication or use on local projects. SI units should be used for international conferences and publications, with conversion factors to local units if appropriate. The use of the term "megalitre" is largely restricted to Australia, with "cubic metre" being the more common unit for large volumes of water in other countries using SI.

Particular care should also be taken with the term "EC Unit" which is a non SI unit defined as "microsiemens per centimetre" (µS/cm) in the Australian water industry. The approximate conversion factor from EC in µS/cm to milligrams per litre is 0.6. The term EC also has alternative definitions and numerical values in other areas of science in Australia and overseas. For example EC is often expressed as "decisiemens per metre" (dS/m) for which the approximate conversion factor to milligrams per litre is 600.

The choice of the appropriate multiplier and corresponding prefix (kilo, mega, milli etc) is governed by convenience with the multiple generally chosen to lead to a majority of numerical values falling within a practical range 0.1 to 1000. The choice of "megalitres" as the preferred measure for irrigation delivery in Australia (rather than cubic metres) accords with this principle and resulted in numerical values being of the same order of magnitude as the earlier Imperial units (acre feet, cusecs) which is significant for volumetric flow measurement.

Table 4 - General Units of Measurement

Description	Preference	Unit name	Symbol
Length	**Base Unit** Optional	**metre** millimetre kilometre	**m** mm km
Area	**Preferred** Optional	**hectare** square millimetre square metre square kilometre	**ha** mm^2 m^2 km^2
Volume – Fluids	**Base Unit** Optional	**litre** megalitre gigalitre	**L** ML GL
– Solids	**Preferred** Optional	**cubic metre** cubic millimetre	**m^3** mm^3
Flow Rates	**Preferred** Optional	**megalitre per day** (channel flows) litre per second (plant use, small pumps) cubic metre per second	**ML/d** L/s m^3/s
Mass	**Preferred** Optional	**kilogram** milligram gram tonne	**kg** mg g t
Concentration/Density – Fluids a) General	**Preferred**	**milligram per litre**	**mg/L**
b) Salinity (total dissolved salts, TDS)	**Preferred**	**microsiemen per centimetre at 25°C (commonly referred to as Electroconductivity Units)**	**µS/cm (EC Unit)**
	Optional	milligram per litre (approx. 0.6 x EC = mg/L)	mg/L
	Optional	decisiemen per metre (also referred to as EC units where 600 x EC = mg/l	dS/m
– Solids	**Preferred**	**kilogram per cubic metre**	**kg/m^3**
Force	**Preferred**	**newton**	**N**
Velocity	**Preferred** Optional	**metre per second** kilometre per hour	**m/s** km/h

Description	Preference	Unit name	Symbol
Pressure	**Preferred** Optional	**head in metre of water** kilopascal	**m** kPa

Table 4 (continued)

Description	Preference	Unit name	Symbol
Power	**Preferred**	**kilowatt**	**kW**
Energy (electrical)	**Preferred**	**Kilowatt hour**	**kW.h**
Rainfall and Evaporation	**Preferred**	**millimetre**	**mm**
Hydraulic Conductivity/ Permeability	**Preferred**	**metre per day**	**m/d**
Aquifer Transmissivity	**Preferred**	**square metre per day**	**m^2/d**
Aquifer Storage Coefficient	**Preferred**	**cubic metre per cubic metre**	**S** (unitless)
Groundwater Hydraulic Gradient	**Preferred**	**metre per metre**	**i** (unitless)
Acidity/Alkalinity	**Preferred**	**pH unit**	**pH**
Turbidity	**Preferred**	**nephlometric turbidity unit**	**NTU**
Dissolved Oxygen (DO)	**Preferred**	**milligram per litre**	**mg/L**
Biological Oxygen Demand (BOD)	**Preferred**	**milligram per litre**	**mg/L**
Nitrogen – Oxidised Nitrogen NO_X – Total Kjeldahl Nitrogen TKN – Nitrates NO_3 – Nitrites NO_2	 **Preferred** **Preferred** **Preferred** **Preferred**	 **milligram per litre** **milligram per litre** **milligram per litre** **milligram per litre**	 **mg/L** **mg/L** **mg/L** **mg/L**
Phosphorous – Total Phosphorous TP – Filterable Reactive Phosphorous FRP	 **Preferred** **Preferred**	 **milligram per litre** **milligram per litre**	 **mg/L** **mg/L**
Algal Count	**Preferred** Optional	**cell per millilitre** filament per millilitre	**cell/mL** filament/mL
Invertebrates – Qualitative – Quantitative	 **Preferred** Optional	 **Taxa** No preferred unit. Assessment according to AUSRIVAS standard	 - -

		sampling methodology for biological monitoring. Options include: – number per square metre (river bed) – number per sample	

Notes on writing unit names and symbols:

1. The name of a unit derived from a proper name does not take a capital letter unless it occurs at the beginning of a sentence. The only exception to this rule is the unit degree Celsius which always takes a capital letter.

2. Names of units use the plural form when attached to units greater than one. (e.g. 10 metres per second, 0.5 metre per second).

3. Unit names and symbols should not be used together in the same expression.

4. Names of units should be written in full. The symbols for the product (.) and division (/) of quantities should only be used when attached to unit symbols. (e.g. metre per second, m/s).

5. A space is left between the numerical value and the symbol. Unit symbols remain unaltered when plural and are written without a final full stop except where they occur at the end of a sentence. (e.g. 10 m/s).

Commonly Used Terminology

A number of commonly used terms can have different meanings in different contexts, organisations or localities. The following common definitions shall apply for the rural water industry across Australia.

Water Supply

Automatic Control — Self regulating flow control system with sensing and operation initiated via electronic, mechanical or hydraulic means without operator intervention.

Channel — See "Supply Channel"

Channel Lining — Low permeability membrane of concrete, compacted clay, bituminous or plastic material, placed on the inner face of earthen channel, or within the bank, to prevent water loss by seepage. Linings may be protected by earth cover.

Channel Regulator — A permanent structure constructed across a channel and fitted with means of adjusting the waterway area so as to control the rate of water flow along the channel and the upstream water level. Most regulators are one of two general types which utilise different hydraulic characteristics for specific applications, viz:

- Overfall weir where water flows over a weir crest which can be varied in level for changing flow rates,
- Undershot gate having an adjustable sliding gate allowing flows to pass beneath the gate, the rate of flow being controlled by the size of the opening.

Check Regulator — Channel regulator for overfall flow where flow adjustment is performed by adding or removing timber drop bars ("drop boards" or "stop logs") to provide a moveable weir crest. Where the regulator includes a step in the channel bed it is referred to as a "check and drop" regulator. Small check regulators on farm channels are also referred to as "channel stops".

Dethridge Meter Outlet — Positive displacement flow measurement device used to determine water volumes supplied from authority supply channel to an individual farm. The meter consists of metal wheel fitted with 8 vanes around the circumference and mounted on a horizontal axis in a concrete flume emplacement. Water flowing along the flume causes the wheel to rotate and a counting device records the number of revolutions which provides a direct measure of the volume of water supplied over a given time.

Size:

The meter is available in several sizes, viz:

Large Meter Outlet (LMO) of 12 ML/d capacity

Small Meter Outlet (SMO) of 5 ML/d capacity

A 6 ML/d capacity model has also been used in NSW and experimental versions were developed for flows less than 2 ML/d.

The **Dethridge Long (DL) Meter** is an improved high capacity meter with flows up to 20 ML/d.
The Dethridge Meter is intended primarily for measurement in open channel systems but can also be adapted for use in low pressure pipe systems, channel outfalls and drainage systems.
Flow rate:
The counting mechanism records the volume in ML passing through the meter over a given time from which flow rate in ML/d may be derived. In field use the rate of rotation of the wheel in **"Revolutions per minute"**, (usually abbreviated to "**Revs"**) is used to determine the approximate flow rate by application of a conversion factor determined by the size and geometry of the particular meter.

Drainage Subway — Conduit laid transversely under supply channel to convey natural drainage flows across the channel. (See also Section D3 for definition of a subway forming part of drainage infrastructure).

Drop Structure — Concrete, timber or steel weir structure placed in supply channel or drain in order to maintain water velocity below the rate that would cause erosion of the earthworks.

Fixed Crest Weir — Permanent weir structure across a channel waterway used to measure water flow and/or control upstream water level. This may include both sharp crested and broad crested weirs.

Flume — Open conduit having concrete, metal or timber sides and floor used as a supply channel where topography is not suitable for a conventional earthen channel. Flumes are often raised above natural surface and supported by columns or piers.

Freeboard — Vertical distance between the designed discharge water level profile of a supply channel and the top of the channel banks.

"Left Bank," " Right Bank" — Left and Right side banks of a supply channel when looking in the direction of flow.

Inverted Siphon (usually shortened to "Siphon") — Section of pipeline that conveys channel flow under a natural depression, river or drain.

Measurement Flume — A section of concrete channel flume with specially shaped side walls and/or floor that forms a constriction in the waterway. Measurement of the difference in water surface levels through the constriction allows calculation of water flow rate by referral to rating tables calibrated for the site. Particular types of measurement flume include the Parshall and Venturi flumes.

Outfall Structure — Regulating structure located at the downstream end, or

(also called "Escape")	intermediate points, of a supply channel to allow safe discharge of surplus flows arising in the system due to the effects of rainfall inflow, planned channel shutdown or operational error. An outfall can also be used to drain water from the channel at the end of the irrigation season. Water released through the outfall is usually discharged to a drainage channel, natural waterway or Regulating Storage (see below).

Regulating Storage	Water storage located within, or close to, the channel system and used to regulate fluctuations in channel flows. Excess channel flows are directed from an Outfall Structure to the Regulating Storage and returned for use in the channel system at a time when demand increases. A Regulating Storage can reduce system water losses and improve water efficiency and service standards particularly at the downstream end of a large system.
Remote Control	Remote control of channel flow regulators initiated by a signal from a distant location.
Remote Surveillance	Remote sensing of water levels and system operation using electronic data collection and transmission systems.
SCADA	**S**upervisory, **C**ontrol **A**nd **D**ata **A**cquisition process using dedicated computer equipment and purpose written software. SCADA differs from "automatic control" in that it provides the facility for remote surveillance and control of supply works.
Siphon Tube	Small flexible pipe used to discharge water from a farm channel on to land using siphonic action.
Supply Channel (usually shortened to "Channel")	Open channel or flume designed to convey water from upstream source to farms. Supply channels can be categorised as: **Main channels** whose primary purpose is to convey bulk water from headworks storage or river diversion point into the distribution system; or **Distribution channels** whose primary purpose is to deliver water from main channels to individual farms. The expression "Canal" is also used for some main channels and usually forms part of the proper name in these cases, e.g. Cattanach Canal, Mulwala Canal.
Supply Pipeline	Closed conduit designed to convey water under pressure from upstream source to farms. Supply pipelines are categorised as: **Main Pipelines** whose primary purpose is to deliver water from storage or river into the distribution system; **Rising Mains** are particular forms of main pipeline that convey water directly from a pump to a higher elevation; or **Distribution Pipelines** whose primary purpose is to deliver water from main channels or pipelines to individual farms. Pipeline systems can also be classified as: **High Pressure Systems** where the delivery pressure is sufficient to operate pressurised on-farm irrigation systems; or **Low Pressure Systems** where the delivery pressure is usually sufficient to allow flood or furrow irrigation and additional pumping is required on farm to operate pressurised irrigation.

Supply Point (Farm Offtake)	Point of delivery from an irrigation authority supply system to an individual farm. A supply point from a channel system usually consists of a small gated regulator or pipe outlet which may incorporate a measurement device such as a Dethridge meter outlet or in-line flow meter.

Irrigation Water Use and Efficiency

Crop Coefficient (K_c)	Dimensionless coefficient used to calculate evapotranspiration (ET) requirement for a particular crop from the potential evapotranspiration for a reference crop (ET_o). Crop coefficients are determined experimentally and take into account leaf area development of the crop and the crop canopy physiology.
Crop Water Requirement	The total volume of water required to meet the water requirements for evapotranspiration for a given planting area and during a given time (excluding leaching fraction).
Effective Rainfall	That portion of total precipitation that is available for plant growth.
Evapotranspiration (ET)	The combined loss of water from a given area, and during a given time, by evaporation from the soil surface and by transpiration from plants. (mm/d) Evapotranspiration can be further defined for different contexts or components, e.g. **"ET_o"** or **"ET_{ref} "** is the potential evapotranspiration of a well watered grass reference crop, usually expressed in mm/d. Multiplication of ET_o by an appropriate "crop coefficient" (K_c) is used to estimate the ET for a particular crop. **"E_{pan}"** is the evaporation from a standard USBR Class A evaporation pan which can be multiplied by an appropriate "Pan coefficient" (K_p) to estimate the value of ET_o.
Field Water Requirement	Total volume of water required to meet the combined water requirements for evapotranspiration, leaching and distribution for a given planting area and during a given time.
In situ Field Capacity	The percentage of water remaining in a soil two or three days after having been saturated and after free drainage has practically ceased.
Irrigation efficiency	A measure, expressed as a percentage, of the volume of water used or delivered by a system relative to the total volume of water entering the system. Irrigation efficiency can be defined for different components of the irrigation system, e.g. **"supply channel efficiency"** expresses volume delivered to farms, or passed to other channels/users, as a percentage of water entering the channel. (%) **"on farm irrigation efficiency"** expresses the volume of water

supplying the crop water requirement (i.e. crop water requirement less effective rainfall) as a percentage of water delivered to the farm. (%)
"field application efficiency" expresses the volume of water supplying the crop water requirement in a field as a percentage of water delivered to that field. (%(
"total irrigation efficiency" expresses the volume of water supplying the crop water requirement (i.e. crop water requirement less effective rainfall) as a percentage of total water entering the supply system. (%)
(See separate definition of "Water Use Efficiency" below)

Leaching — The passage of water past the plant root zone in order to flush accumulated salts from the root zone by application of additional irrigation water than is needed to supply the plant evapotranspiration requirement.

Leaching Fraction — The fraction of infiltrated irrigation water that percolates below the plant root zone. For this unit to be meaningful, it needs to specify the time over which the leaching fraction is measured and the depth interval over which it is calculated.

Maximum Allowable Depletion — The maximum level of depletion to which the soil can dry without causing water deficit stress in a crop that has a fully expanded root zone. Notionally, the sum of the readily available water in each soil horizon within the plant root zone with an allowance made for the soil water extraction pattern of the crop.

Permanent Wilting Point — The maximum water content of a soil at which indicator plants wilt and fail to recover when placed in a humid chamber. Usually estimated by the water content at - 1.5 MPa soil matric potential.

Readily Available Water — Water that can be removed from a soil horizon by a crop without resulting in water deficit stress. This is often estimated to be half the "total available water".

Total Available Water — The portion of water in a soil that can be absorbed by plant roots. It is the amount of water released between in situ field capacity and the permanent wilting point. (Usually estimated by water content at soil matric potential of -1.5 MPa).

Water Use Efficiency — Volume of crop produced (harvested dry matter) per unit of water delivered to the crop. This is usually expressed as tonnes per megalitre (t/ML).
(See separate definition of "Irrigation Efficiency" above)

Drainage and Groundwater

Aquifer	A water bearing stratum or layer of rock or sediment below the earth's surface within which water is transmitted and is capable of being removed by pumping.
Drainage channel ("Surface Drain" or "Drain")	An open channel to take drainage water or an improved natural waterway designed to remove excess water from rural lands.
Drainage Overpass	Pipe or flume conduit to convey natural drainage flows across supply channel. Used in steep topography where a drainage subway is not practicable.
Drainage Runoff (or "Runoff")	Flow of surface water from a given area resulting from the effects of rainwater and/or applied irrigation water in excess of crop water requirement and leaching. Also see "Tailwater".
Drainage Subway	Conduit laid transversely under a drainage channel to convey local drainage under a regional drain. (See also Section D.1 for definition of a subway forming part of supply infrastructure)
Groundwater	That portion of water below the surface of the ground at a pressure equal to or greater than atmospheric. See also "water table"
Hydraulic head	The elevation with respect to a specified reference, usually soil surface, at which water stands in a piezometer connected to the point in question in the soil.
"Left Bank," " Right Bank"	Left and Right side banks of a drainage channel when looking in the direction of flow.
Perched Water Table	See "Water table, Perched"
Piezometer	Vertical tube with its lower end connected to an aquifer, and its upper end located at, or above, the ground level used to determine the hydraulic head of that aquifer.
Phreatic Surface	The profile of the groundwater surface where the water is at atmospheric pressure.
Sub-Surface Drainage System	System of drainage collector pipes, wells, ditches and/or pumps designed to intercept and remove excess groundwater so as to control water table level to below plant root zone. Often designed to exclude or restrict entry of surface drainage and rainfall.

Surface Drainage System System of open drainage channels, pipelines and improved natural waterways designed to collect drainage from rainfall and irrigation runoff on rural lands and convey it to disposal. A system may include private, community and public works.

Tailwater Flow of surface water from a given area resulting from the effects of applied irrigation water in excess of crop water requirement and leaching. Also see "Drainage Runoff".

Test Well See "Piezometer"

Tile Drain Buried horizontal pipeline containing openings (or slots) to allow gravity entry of excess groundwater which is then lead to a suitable point of discharge or pit. A tile drain system can include linings constructed from joined slotted plastic pipes or terracotta pipes laid end to end.

Water Logging Process of soil becoming saturated with water.

Water Table The upper surface of groundwater or that level in the ground where the water is at atmospheric pressure. See also "Groundwater"

Water Table, Perched The water table of a saturated layer of soil which is separated from an underlaying saturated layer by an unsaturated layer of lower permeability.

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SECTION 7

Commonly Used Flow Measurement Devices.

The following section was prepared by Sincliar Knight Merz during a previous LWRRDC funded project. The results have been included here because they are an important reference for the industry.

Description and Characteristics of Measurement Devices Currently Used or Available for Irrigation Flows

Name	Dethridge Meter (standard)
Description and function	The meter consists of a cylindrical metal drum fitted with 8 vanes around the circumference mounted on a horizontal axle in a concrete flume emplacement. Water flow causes the wheel to rotate in the emplacement and a counting device records the number of wheel revolutions and thus a direct measure of the volume of water passing. The concrete emplacement and wheel are constructed to close dimensional tolerances and these must be maintained to achieve accuracy within about 2%. Older wheels were made from mild steel coated with a coal tar or bituminous paint. Galvanised mild steel is the normal material used now although aluminium, various grades of stainless steel and plastics have also been used to improve durability. Axle bearings were originally red gum timber and have been mostly replaced by sealed ball bearings to retain accurate tolerances. The meter is available in several sizes, namely: Large meter: Flow range 3.5 to 12 ML/d Small meters: Flow ranges 1.5 to 5 ML/d 1.5 to 6 ML/d (NSW only)
Comments on Application and Usage	The Dethridge meter was invented in 1910 and is in widespread use with over 40,000 meters installed in all States of Australia. The meter has proved to be satisfactory under a range of field conditions due to its relative simplicity, low cost, accuracy and robustness compared with other meters of similar capability. The basic design and dimensions remained unchanged for over 80 years although there have been many modifications and improvements including more durable materials and peripheral equipment such as control gates and counting mechanisms.
Advantages and Benefits	□ Suitable for wide range of irrigation applications. □ Reasonable accuracy provided that clearances and settings are correct and channels are operated at correct levels. □ Relatively easy to use. Direct displacement method is easily understood by operators and farmers. □ Capital cost is economical in comparison with many other meters of

similar capacity.

- No power source required.
- Robust and can resist forces from impact by debris.
- Correct operation and flow rate can be ascertained from a distance.
- Security features make unauthorised water use difficult but easy to detect if it is attempted.
- Relatively low head difference (up to 75 mm) required to operate the meter.

Disadvantages

- Measurement accuracy is reduced when channel levels rates fluctuate significantly or flow rate is outside the range 3 to 12 ML/d.
- Excessive wear of bearings can be a maintenance problem. Bearing failure or incorrect setting contributes to inaccuracy.
- Some evidence of damage to wheels and vanes at high flow rates.
- Corrosion of steel components is significant in moderately saline conditions.
- Safety hazard may be posed for operators, farmers and public due to large mass, manually operated gates and exposed rotating vanes.
- Can create a barrier to access along the channel unless an access pipe or culvert is also installed.
- Yabbies can burrow under structure and cause channel leakage if there is insufficient cut-off provision.

Device Name	Dethridge Long (DL) meter
Description and function	The key dimensions and basic configuration and operation are as for a large standard Dethridge meter although the upstream approach section is longer. The new meter has only six vanes attached to the drum and carefully shaped to minimise splash and flow restrictions. The emplacement is also redesigned. The emplacement can be constructed from conventional reinforced concrete or light weight fibre reinforced concrete. The latter material provides the high dimensional accuracy needed to maintain high levels of measurement accuracy. Wheels and vanes are constructed from galvanised mild steel. The flow range for acceptable accuracy is 2 to 20 ML/d.
Comments on Application and Usage	This meter was developed during the 1980s and adopted for general use about 1990. So far about 200 have been installed. The meter can be constructed as a new installation or by modification of a standard meter emplacement. There are generally two different situations favouring installation of a DL meter, namely: □ Where a higher maximum flow is required than is possible with the standard Dethridge meter; or □ For irrigation of land where level is critical and the reduced head losses through a DL meter allow improved flow conditions and measurement accuracy.
Advantages and Benefits	The DL meter has the same advantages and benefits of the standard Dethridge meter and the following additional ones: □ Meter accuracy (<±2%) over the flow rate range 2 to 20 ML/d □ Capital cost is about 30% above that of the standard large meter. However for flow rates greater than 12 ML/d, which would require two standard meters, the total metering cost is therefore generally reduced. □ Decreased splash and wash reduces leakage and erosion around emplacement. □ Improved irrigation of large, very flat properties. □ Meter operation and accuracy is less affected by fluctuating water levels. □ Very low head is required to operate the meter
Disadvantages	The DL meter was designed specifically to overcome reported disadvantages of the standard Dethridge meter. Experience to date is that the DL meter overcomes most of these and no significant disadvantages have been identified. □ The potential safety hazard associated with wheel rotation remains and might be greater due to increased rotation speed. □ Some DL wheels have experienced premature failure at high flow

rates although these were due mainly to manufacturing defects rather than an inherent design fault.

Device Name	Propeller meter, closed type
Description and function	A propeller meter can be used to measure the volume delivered from water authority channel or pipeline to a farm system. The meter consists of a metal or plastic propeller mounted inside a pipe section with its rotation axis set parallel to the water flow. The speed of propeller rotation provides a measure of flow velocity from which volumetric flow can be calculated for a given pipe cross section. Meters are produced in a range of standard sizes with calibrations determined by the manufacturers from laboratory testing.
Comments on Application and Usage	The common configuration is as an in-line meter in a closed pipe system. It is also used where water is pumped from an open channel or natural water course to irrigate land situated above the level of the water supply carrier. In the latter case the meter is located in the pipework either on the suction or delivery side of the pump. For accuracy, the meter must be carefully located clear of pipe bends or fittings and configured so that the pipe flows full at the meter. Installation of a propeller meter is also possible in a gravity pipe offtake from a supply channel where the layout ensures that the pipe and meter flow full and the flow is reasonably uniform. The computed water flow is normally displayed as a progressive volume.
Advantages and Benefits	□ Reasonably accurate means of measurement provided the meter is correctly installed and maintained □ Can be installed to suit many different irrigation layouts. □ Operates satisfactorily in turbid water.
Disadvantages	□ Very difficult to detect malfunction or unauthorised interference to meter while operating. □ Propeller can be stopped by floating debris, weeds or other obstruction. □ Older type propellers susceptible to abrasion or mineral build up. □ Relatively expensive to repair and requires specialist skills

Device Name	Open Flow Propeller Meter
Purpose	Measurement of water delivered from supply channel to farm distribution system.
Description and function	This device is a propeller type meter similar to that described earlier. The meter consists of a plastic propeller and extended spindle shaft which is mounted on the downstream end of a pipe culvert with the propeller projecting inside the pipe with its axis located at the centre of and parallel to the flow. The culvert pipe must always flow full of water. The rate of propeller rotation provides a measure of flow rate from which flow volume can be derived and recorded. There is little head loss through the meter.
Comments on Application and Usage	A number of these meters have been installed in NSW schemes over the past two years as an alternative to Dethridge meters. Experience to date is reported to be generally good with satisfactory levels of accuracy.
Advantages and Benefits	□ Reasonably accurate measurement provided that meter is correctly installed, calibrated and maintained. □ Operates satisfactorily in turbid water. □ Supplier claims long life and low maintenance for working parts. □ Recording mechanism can display flow rate and totalised volume. □ Should allow meter to operate with fluctuating water levels, provided that installation ensures full pipe flow.
Disadvantages	□ Very difficult to detect malfunction or unauthorised interference to meter while it is operating. □ Culvert pipe and propeller can be obstructed by debris and weeds. □ The meter cost is low but total installation cost may be greater than for a Dethridge meter depending on cost of the culvert. □ A baffle or weir is required downstream of the culvert to ensure that propeller always operates in a full pipe for accuracy.

Device Name	Ultrasonic water meter (Transit time and Doppler methods).
Description and function	Ultrasonic meters measure the instantaneous and total water flow in carrier channels or pipelines. The meter calculates the velocity of liquid flowing in a conduit from differences in transit time or frequency for a sound impulse to cross a moving column of water in opposite directions. Flow rate is determined from the velocity for a given conduit cross section. 1. The Transit Time Method calculates velocity from differences in time for an impulse to pass between two transducers located on opposite sides of the pipe according to flow direction. 2. The Doppler Method calculates the velocity from differences in frequency of an emitted and reflected sound impulse which impinges on a particle suspended in the moving liquid. The meter generally consists of a section of pipe with transducers and associated peripheral equipment located on or outside the pipe circumference so that there are no obstructions or moving parts to impede the flow. These meters are intended to flow full and are produced in a range of standard sizes and flow capacities. The ultrasonic principle can also be used to measure flow in a part full pipe or open channel with a free surface. This is more complex and requires additional numbers of transducers and sound paths together with a means of water level measurement to determine an accurate flow profile for various water depths.
Comments on Application and Usage	Ultrasonic meters are in widespread use for urban water and wastewater systems and many industrial applications. For irrigation they are used in pumping stations and fully pressurised systems but only to a limited extent in channel systems to date. A number of trial installations have been made by irrigation authorities in recent years. This is a proven new technology which has potential for greater use in irrigation applications. Further trials are desirable, particularly of meters combining both velocity and depth measurements for measurement in open water surfaces and part full conduits.
Advantages and Benefits	□ High degree of accuracy (<1%±) and consistent over full flow range when installed and calibrated properly. □ Robust with only minimal routine maintenance required. □ Can be fitted with telemetry equipment to transmit data to a remote location
Disadvantages	□ Repairs require skilled technician and specialised equipment. □ Power supply required (Solar panel with battery back up is generally suitable if mains power is not available). □ Electronic components liable to lightning damage. □ Relatively high cost although this is expected to decrease.

Device Name	Electromagnetic flow meter
Description and function	An electromagnetic meter consists of a section of pipe with a magnetic field across it and electrodes to detect electrical voltage changes. Under the laws of induction, when a conductive fluid passes along the pipe an electrical voltage is created in the fluid which is proportional to the fluid velocity. Measurement of the voltage is thus converted to velocity from which the flow rate can be derived for a given pipe section. This type of meter is produced in a range of standard sizes and flow capacities.
Comments on Application and Usage	Electromagnetic meters are used widely in urban and wastewater systems and in industrial applications where a high degree of accuracy is required. They have been used rarely to date in Australian irrigation systems due mainly to their relatively high cost. They could be used in similar configurations to ultrasonic meters.
Advantages and Benefits	□ High degree of accuracy (<0.5%±) and consistent over full flow range when calibrated correctly. □ No obstructions to flow □ Robust with only minimal routine maintenance
Disadvantages	□ Relatively high cost. (Indicative costs for meter and sensor only range from $2, 500 to $7,000 for 3.5 to 20 ML/d units. Power and installation costs could double these amounts) □ Power supply required (solar panels with battery back up suitable if mains power not available) □ Electronic components liable to lightning damage □ Repairs require skilled technician and specialised equipment.

SECTION 8

Workshop Participants.

People attending the workshop were keen that the contacts made at the workshop were not lost. The following list is provided to assist members of the industry to keep in contact with their colleagues.

Name	Organisation	Address	Phone	Fax	Email
Alison Carmichael					
Andrew Sinn					
Anne Currey					
Anne Marie Boland					
Bill Barratt					
Bob Cook					
Brett Spurling					
Brett Tucker					
Brian Foley					
David Aughton					
Derek Poulton					
Evangel Aseerveetham					
Graham Armstrong					
Hugh Torral					
Ian Moorhouse					
Jason Leach					
Jeremy Cape					
John Mapson					
Kevin Devlin					
Kevin Kelly					
Monique Aucote					
Neil Rickard					
Nick Austen					
Peter Dillon					
Phil Thompson					
Steve Wyllie					
Tilo Schmidt					