Executive Summary

STATE OF IDAHO
DEPARTMENT OF WATER RESOURCES
322 E. FRONT STREET, P.O. BOX 83720, BOISE, IDAHO 83720-0098
PHONE: (208) 287-4800 FAX: (208) 287-6700

DATE: JANUARY 8, 2010

PREPARED BY: Mat Weaver

SUBJECT: **EXECUTIVE SUMMARY OF THE DEPARTMENT'S PERFORMANCE EVALUATION OF UN-CALIBRATED PACKAGED CONTINUOUS DOPPLER FLOW METER SYSTEMS IN A VARIETY OF WATER DIVERSION SCENARIOS.**

INTRODUCTION

This document is intended to serve as an executive summary of the Idaho Department of Water Resources' (Department) performance evaluation of Doppler flow meter (DFM) technology undertaken during the calendar years of 2008 and 2009. Presented in this document is a summary table of the findings from the performance evaluation and the recommendations and conclusions obtained from the evaluation. Please refer to the full technical memo document for elaboration of the technology, manufacturers and products reviewed, performance evaluation goals, deployment scenarios, data, and data analysis.

Doppler flow measurement refers to the technology whereby the physical principal of the Doppler shift is utilized to measure the velocity of a moving stream of water, which when coupled with a known relationship describing the cross section area of the stream of water, yields a stream discharge rate. Although DFM technology has been around for quite some time, it is only in the last five years that it has become commercially available and affordable enough to garner the attention of agricultural water users in Idaho.

Several major advantages of DFM systems are their ability to measure a wide range of water quality types, their ability to measure flow in extreme low energy systems, their ability to measure flow in both directions of a channel (upstream and downstream), their ability to measure flow when the stage-discharge relationship varies with time, and their ability to readily support programmable data collection and logging rates.

Performance Evaluation Data Summary

Table 1 is a summary of deployed DFM measurements summarized in the technical memo for which reliable corresponding corroboration measurements were collected.

Table 1 - Summary of All DFM Flow Rate Measurements Where Corroborating Measurements were Taken with a Summary of Percent Error.

Date	Site	DFM	Channel Desc.	DFM, Q (CFS)	Current Meter, Q (CFS)	% Error
6/25/2008	Ovid Cr.	Unidata	36" Diam. Culv.	8.76	10.92	19.8%
8/14/2008	S39 Diversion	Unidata	36" Diam. Culv.	7.80	7.53	3.6%
8/14/2008	S39 Diversion	Unidata	36" Diam. Culv.	10.17	9.91	2.6%
8/14/2008	S39 Diversion	Unidata	36" Diam. Culv.	11.23	10.38	8.2%
3/13/2009	Hartley Drain	Unidata/CR200	81x59 Pipe Arch	15.53	15.13	2.6%
6/17/2009	Nuffer	Unidata/CR200	73x55 Pipe Arch	16.68	14.45	15.4%
6/17/2009	Nuffer	MACE	73x55 Pipe Arch	15.58	14.45	7.8%
6/17/2009	Cub River	Greyline	36" Diam. Culv.	11.90	10.1	17.8%
6/22/2009	Nuffer	Unidata/CR200	73x55 Pipe Arch	28.50	29.00	1.7%
6/22/2009	Nuffer	MACE	73x55 Pipe Arch	29.61	29.00	2.1%
7/10/2009	Nuffer	MACE	73x55 Pipe Arch	2.40	2.28	5.3%
8/11/2009	Nuffer	Unidata/CR200	73x55 Pipe Arch	0.22	0.00	N/A
9/3/2009	Last Chance Ditch	MACE	3x 40" Diam. Culv.	83.66	77.5	7.9%
9/10/2009	Cub River	Greyline	36" Diam. Culv.	15.5	14.3	8.4%

Performance Evaluation Conclusions & Recommendations

With review and processing of flow rate data from the performance evaluation, overall measurement error was found to be 8.0% with a maximum error of 19.8% at one location. In order to be deemed an acceptable measurement device Department standards require measurement accuracy of open channel devices to be ±10.0% of a trusted standard current meter measurement.

When properly configured and deployed the Department confirmed that DFM devices could provide accurate water measurement in a host of open channel scenarios, including very low energy systems. They were found to be capable of measuring flow over a wide range of water quality types, including the vast majority of situations likely to be encountered in agricultural irrigation settings. The digital read-out display of flow parameters is a feature especially appreciated by users, even though care must be given when relying on these measurements to set head gates as they represent an instantaneous reading, which when evaluated was found to fluctuate by approximately ±8.0% about the mean. The data collection of continuous flow rate parameters is also a valuable characteristic of these systems.

That being said, the proper configuration and deployment of DFM systems can be challenging, even when undertaken by professionals in the field of water measurement. Based on the findings from this evaluation, DFM systems may not be appropriate for individual water users, or laypeople in the field of water measurement. When viable, individual water users should always give preference to the selection of a standard or traditional gravity measurement device. More sophisticated water use entities such as Irrigation Districts, Canal Companies, Water Districts, and the Department, may give strong consideration to the selection of a DFM for permanent water measurement when more traditional devices are not practical or there is a compelling motivation for the use of a DFM.

When DFMs are selected and implemented as a permanent water measurement device, careful consideration should be given to the selection of a measurement location. DFM devices are only accurate when a stable relationship between the mean channel velocity and the mean velocity of reflective particles within the pathway of transmitted acoustic waves can be established over the entire range of anticipated flows. Unsteady flow, non-uniform flow, turbulent flow, water temperature gradients, and fluid density gradients will all undermine the strength of the relationship between mean channel velocity and mean acoustic path velocity resulting in inaccurate flow measurement. In a separate study the department found that under ideal conditions velocity measurements from DFMs were within 2.1% of a corroborating measurement; under less than ideal conditions the percent discrepancy increased to 8.7%. Some of the inaccuracies in flow measurement encountered by the Department in this performance evaluation can be attributed to the location of DFMs where the previous characteristics of velocity and flow were not sufficiently constrained.

Immediately after installation, measurements from the DFM device should always be verified by a secondary trusted means of water measurement over the entire range of anticipated flows. Periodic verification measurements should continue throughout the operational lifetime of the device to establish the devices ongoing ability to provide accurate measurement. If a DFM device is not capable of consistently obtaining flow rate measurements within ±10.0% of the known flow rate, modification of the device must be undertaken. All of the DFMs considered in this evaluation support the in-situ calibration of the device to allow for the development of a site specific relationship for flow measurement. However, calibration is only a feasible means of increasing accuracy for channels in which the stage-discharge relationship is constant throughout the entire season of use. As an example, accuracy will not be improved by calibration in systems where back water effects are prominent due to vegetative growth or downstream gates as the device can only be calibrated to one flow condition out of the potentially many that may exist over the entire regime of flows. In instances where calibration will not improve measurement accuracy, the location of the DFM may need to be reconfigured to address those detrimental characteristics effecting measurement, or the DFM may need to be relocated to a more suitable point of measurement.

When a DFM has been selected for use in water measurement, the following items should be thoughtfully considered when deciding on a DFM package and water measurement location:

- **Power Supply:** Is local permanent AC power available at the measurement location? Different DFM packages have different power requirements, and different DFM packages have different memory types where power can be an issue. The availability of permanent AC power versus a remote DC power supply should be taken under consideration when selecting the DFM package and measurement location.
- **Data Collection:** Is permanent data collection required? All of the DFMs considered came with proprietary data loggers that had different capacities, features, and functions. The data collection needs of the sight should be considered when selecting a DFM Package.
- **Telemetry:** Is the telemetrization of the DFM anticipated? None of the DFMs considered supported telemetry in their base packages. The telemetrization of a site is an indicator that a separate data logger and larger power supply may be needed.
- **Number of Channels to be Measured:** Different DFM packages more readily support the measurement of multiple channels than do others. When selecting a DFM package consideration should be given to the number of flow channels being measured.
- **Channel Type:** What is the channel type? Is it physically constrained or likely to change with time? Can a relationship between depth of flow and cross sectional channel area be easily defined that is stable over the entire range of diverted flows and channel conditions? All of these factors should be considered when selecting a measurement location. The simpler (rectangle, circle, etc.) and more permanent (steel, concrete, etc.) the channel geometry the better.
- **Channel Velocity:** Is the velocity distribution across the width of the channel uniform? DFMs measure velocity at a single static location in the channel. Flow characteristics and DFM sensor location must be such that the single velocity measurement location of the DFM is representative of the entire channel.
- **Flow Type:** What are the flow conditions at the measurement sight? Are they uniform? Are they steady? Both are requirements for accurate DFM measurements. Do they change over the course of the season? Are they overly turbulent? Answers to all of these questions should be understood when selecting a measurement sight.
- **Water Quality:** What is the water quality of the stream flow? It is unlikely this will affect the selection of most measurement locations, however, when dealing with extremely high water quality sources (springs or well water) a measurement of water quality and verification of DFM efficacy at the location should be considered.
- **Verification of Measurement Accuracy:** Deployed DFMs should be regularly (annually) verified for measurement accuracy over the entire range of anticipated flows.
- **Calibration/Reconfiguration/Relocation:** All of the DFMs considered allow in-situ device calibration. As necessary DFMs should be calibrated, reconfigured, or relocated to assure accurate flow rate measurement, with measurements routinely demonstrating an average percent error of 10.0% or less.