Center for Water Resources Research
Annual Technical Report
FY 2008

Introduction

The Utah Center for Water Resources Research (UCWRR) is located at Utah State University (USU), the Land Grant University in Utah, as part of the Utah Water Research Laboratory (UWRL). It is one of 54 state water institutes that were authorized by the Water Resources Research Act of 1964. Its mission is related to stewardship of water quantity and quality through collaboration with government and the private sector. The UCWRR facilitates water research, outreach, design, and testing elements within a university environment that supports student education and citizen training. The UCWRR actively assists the Utah Department of Environmental Quality (UDEQ), the Utah Department of Natural Resources (UDNR), the State Engineers Office, all 12 local health departments, and several large water management agencies and purveyors in the state with specific water resources problems. In FY 07, the UWRL expended a total of approximately $9 million in water research support. USGS Section104 funds administered through the UCWRR accounted for about one percent of this total. These funds were used for research addressing water and wastewater management problems, outreach, information dissemination, strategic planning, water resources, and environmental quality issues in the State of Utah. Three research projects were funded in FY08 with funds from the 104−b program. These projects, respectively entitled "Basin-Scale Internal Waves Within the South Arm of the Great Salt Lake", "Low-Level Outlet Works Air Vent Sizing Requirements for Small to Medium Size Dams", and "Increasing Data Accuracy, Reliability, Accessibility, and Understandability to Improve Basin-Wide Water Resources Decision Making", dealt with water management issues involving the hydrodynamic behavior of the Great Salt Lake, improvement of the conventional methodology associated with determining air demand and appropriate air vent sizes for low-level outlet works consistent with small to medium-sized embankment dams, and establishment of a process within the state whereby irrigators could receive assistance in improving water flow measurement at all levels of irrigation distribution systems. The projects all involved collaboration of local, state, and federal water resources agency personnel.

Research Program Introduction

USGS Section 104 funds were used to address possible transport-related issues with regard to available hypotheses for movement of such contaminants as mercury. This project examined an observed Kelvin-Helmholtz instability in circulation patterns of the Great Salt Lake (GSL) which can result in the formation and breaking of short wavelength, high frequency waves. These can significantly enhance mixing of solutes between the lower and upper brine layers, and contribute to the transport of contaminants.

Section 104 funds were also used to examine issues of dam safety in Utah. In particular, research was supported to examine a common design problem involving air vents on low-level outlet works on dams. Available design guidance developed by the US Army Corps of Engineers is limited to low-level outlet works geometries more consistent with large embankment dams; there is very limited information regarding methods for estimating air demand and the corresponding air vent size requirement. This project produced information that explains unacceptable and potentially dangerous hydraulic behavior that has been observed at dams in Utah.

Operators of irrigation distribution systems in Utah make critical decisions regarding water diversions, exchanges, and ultimately delivery of the proper quantity to the end-user. Most distribution systems have some means of flow measurement, but measurement structures are often found to be constructed incorrectly, they suffer maintenance deficiencies which affect the calibration, or the lack of communication between those who developed the head-discharge relationship for the structure and those who apply its results in flow measurement errors. The final project supported with Section 104 funds this year involved sought to develop protocols for inspection of flow measurement structures, identification and correction, where possible, of deficiencies, verification of the structure calibration, and addition of automated data collection and telemetry systems to make data available in real-time.

These projects involved collaborative partnerships with various local, state, and federal agencies throughout the state.

Increasing Data Accuracy, Reliability, Accessibility, and Understandability to Improve Basin-Wide Water Resources Decision Making

Basic Information

Title:	Increasing Data Accuracy, Reliability, Accessibility, and Understandability to Improve Basin-Wide Water Resources Decision Making
Project Number:	2008UT103B
Start Date:	3/1/2008
End Date:	2/28/2009
Funding Source:	104B
Congressional District:	UT 1
Research Category:	Engineering
Focus Category:	Law, Institutions, and Policy, Management and Planning, Water Quantity
Descriptors:	None
Principal Investigators:	Blake P. Tullis, Steven L. Barfuss, Mac McKee, Gary P. Merkley

Publication

Increasing Data Accuracy, Reliability, Accessibility, and Understandability to Improve Basin-Wide Water Resources Decision Making

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ABSTRACT

Effective management of a water resource requires accurate, reliable, and accessible flow measurement data. State Distribution Systems in Utah make critical decisions regarding water diversions, exchanges, and ultimately delivery of the proper quantity to the end-user. Real-time, accurate, flow measurement data should help in making sound decisions and in meeting water delivery obligations. Most Distribution Systems have some means of flow measurement (flumes, weirs, etc.), however, many of those structures are often constructed incorrectly (e.g., out-of-level, incorrect dimensions, and/or the staff gage is located incorrectly), suffer maintenance deficiencies with affect the calibration (e.g., excessive sediment build up in a flume or upstream of a weir), or a lack of communication between those develop the head-discharge relationship for the structure and those who apply it can result in flow measurement errors. In short, the objective of the study was to, in cooperation with a State Distribution System, inspect flow measurement structures, identify and correct where possible and deficiencies, check the structure calibration, and add automated data collection and telemetry system to make the data available real-time.

Summit Creek in Smithfield, UT agreed to participate in this case study. Five flow measurement in this Northern Utah system were evaluated, calibrated, and automated. This report contains the findings of this case study, a list of corrective actions that were recommended/ implemented for the flow measurement structures, a summary of the training provided to the Water Master (or other responsible parties) with respect to maintenance and/or operational deficiencies that impact flow measurement accuracy at specific structures, and recommendations for additional work.

INTRODUCTION

Accuracy in flow measurement, distribution, and a metric for evaluating the impact on agricultural productivity is essential for effective basin-wide water resource management. Real-time access to that data is also critical to real-time decision making. Most State Distribution Systems and water users groups have the infrastructure in place to measure and report flow rates in canals in rivers. In many cases, however, weir and flume calibrations may not be accurate. There are many possible reasons for discrepancies, including sedimentation of the flume or upstream canal, incorrect reference datum for flow depth measurements, an out-of-level structure, and incorrect geometry. Other factors may be that those who perform the maintenance work may not understand the relationship between flow measurement accuracy and specific operational and maintenance issues.

In this study a variety of flow measurement structures were inspected for installation and maintenance problems, corrective actions were identified where appropriate, and a calibration was performed and compared with the design tables. In addition to proving a copy of the project report to those with stewardship over the flow measurement structures inspected during this study, the specific findings of the study were discussed in person with the Water Master in an effort to provide and increased level of understanding on the users' part regarding the proper operation and maintenance of their flow measurement structures. In most cases, a telemetry-based data acquisition system was also installed at each flow measurement structure, making the flow measurement data available real-time online.

OBJECTIVES

The study objectives are summarized in the Table 1.

Table 1. Study Objectives

Objective	Description
1. Find a State Distribution System, preferably in Northern Utah, willing to participate with USU and the Utah Division of Water Rights personnel.	Selection criteria included: the willingness of the Distribution System to participate, an established data monitoring and data logging system (or a willingness to implement such a system with financial assistance from the State of Utah), system size, and proximity to Logan (UT).
2. Inspect flow measurement structures and telemetry instrumentation (if applicable) for data accuracy and reliability.	System inspection focused primarily on evaluation of the flow measurement structures (i.e., level of maintenance, confirm accuracy of flow meter geometry and staff gauge placement, verification of flow measurement structure calibration based on a field calibration to be completed during inspection.)
3. Make recommendations for system improvements where applicable.	If deficiencies were identified in the data measurement, transmission, or management; the research team recommended corrective actions where appropriate. The research team functioned as advisors with respect to the implementation of the corrective actions, but the responsibility of the system improvements fell to the Water Master.
4. Provide feedback to State Distribution System based on the outcomes of the system inspection.	An overall assessment of the data measurement, transmission, and management was provided to the State Distribution System, both informally and in this project report. The Water Master was invited to participate in the generation of the final report as both a reviewer and contributor.
5. Provide training where appropriate to improve system maintenance and reliability.	Where system improvements were identified, training was provided by the research team to the Water Master regarding improvements that should be made, the causes of the current and/or future system deficiencies, and procedures for maintaining a reliable system.
6. Additional work	It is anticipated that similar activities would be beneficial to other Distribution Systems in the State of Utah; therefore, the project team proposed additional studies on other systems within the State of Utah. The objective of any additional studies will remain the same.

STUDY RESULTS

Finding a State Distribution System

Three different State Distribution Systems in Northern Utah were contacted. One Distribution System respectfully declined participation in the project despite the fact that some of their flow measurement structures appeared to be suspect relative to maintenance and accuracy. One operational Parshall flume in a second State Distribution System was inspected; the staff gage position corrected, and a couple of flow measurement calibration points were provided. The Distribution System, in the end, was not interested in automating their structure(s) with data logging and telemetry so no additional work was performed. Based on responsiveness and project interest on the part of Clinton Aston (Summit Creek Water Commissioner), the Summit Creek State Distribution System (Smithfield, UT) was selected as the project case study.

Data Collection

Visits were made to the five Summit Creek flow measurement structures listed in Table 2. The data collected at each structure included the following

1. Elevations data were collected at various locations on the flume using surveying equipment to determine the levelness of the structure.

2. Flume dimensions were measured and compared with the design specifications. The staff gage position and elevation reference, relative to the flume or weir crest, was also determined.

3. A field calibration of the flow measurement structure was performed using a current meter and compared with the predicted discharges from the design tables.

According to design specifications the crest and inlet of the flume must be level for a standard *Parshall* and *Cutthroat* flume design in order to apply standard rating curves or discharge coefficients. The same holds true for *sharp-crested* and other weirs. According to “Correction for Settlement of Parshall Flumes” by A. Genoves, B. Florentin, and A. Garton, out-of-level flumes, laterally and longitudinally, can result in flow measurement errors of up to 28%. Elevations were measured at the inlet, outlet, crest, and staff gauge location using a SOKKIA surveying level and measuring rod. The published head-discharge or rating curve data for *Parshall* and *Cutthroat* flumes are size specific, based on throat width (i.e., 1-ft, 2-ft, etc.).

For the published head-discharge data to be applicable to a particular flume, however, the flume must be built to the standardized dimension specifications. The flume predicted flow rates, which are a function of the upstream flow depth measured relative to the crest elevation, would also be inaccurate if the upstream flow depth is not measured at the prescribed location or based on a reference elevation other than the crest. The structure dimensions of each flow measurement devise were compared against the standard dimensions published in "Utah Water Measurement Pocket Reference." Dimensional requirements for sharp-crested weirs, Parshall flumes, and Cutthroat flumes are presented on pages 10, 15, and 19, respectively.

Field calibrations were conducted as follows: A calibration cross section was selected, typically just downstream of the flume inlet (or upstream of the weir) where flow conditions were well behaved (i.e., no significant local flow accelerations, turbulence, or flow separation regions). A measuring tape was placed across the calibration section, oriented perpendicularly to the centerline of the flume. The calibration cross section was divided up into subsections such that no more than 10% of the total discharge passes through any subsection. Flow depths were measured at each subsection. The flow velocity was also measured in each subsection using a velocity probe located at 6/10ths of the flow depth from the channel bottom. The total discharge was calculated by summing the product of the cross-sectional flow area and the measured flow velocity of each subsection, as shown in Equation 1.

$$Q = \sum_{i=1}^{n} Q_i = \sum_{i=1}^{n} V_i y_i w_i \quad (1)$$

where, Q is the total flow rate, Q_i is the subsection flow rate, V_i is the subsection velocity, y_i is the subsection flow depth, w_i is the subsection width, and n is the number of subsections in the cross-section. For each discharge condition the velocity traverse (i.e., collecting flow depth and velocity data at each subsection) was repeated a second time to verify accuracy. If discrepancies were found between the two traverses, a third velocity traverse was conducted. Based on the irrigation schedules and seasonal flow rate variations in the canals, multiple calibration trips to each flow measurement structure were typically required to obtain a reasonable range of discharges for the head-discharge calibration.

Three different current meters were used for calibration work. A Pigmy propeller meter was used for low velocity applications; an AA Price propeller meter was used for higher velocity applications. A Marsh-McBirney Flo-mate magnetic current meter was also used for high and low velocity applications. Velocity range and meter availability were factors in selecting a current meter for a particular calibration. Once a current meter was selected for a particular flow measurement structure, the same current meter was used for all calibration work on that structure.

Inspected Structures

The five Summit Creek flow measurement structures inspected as part of this study are listed in Table 2.

Table 2. Summit Creek Flow Measurement Structures Inspected and Calibrated.

Structure Name	Type	Location	Water Source
300 South	Pre-fabricated fiberglass Parshall flume set in concrete	900 East 300 South (Smithfield)	Measures water coming from North Logan and Hype Park
Black Pipe	Pre-fabricated fiberglass Parshall flume set in concrete	Inside Birch Creek Golf Course, near the 1st hole (Smithfield)	Water comes from 300 South and measures the water used by the golf course
3 Creeks	Concrete Parshall flume	Located on Canyon Road (Smithfield)	3 creeks are converging into one at this point, some of it is from Black Pipe
Big Ditch	Concrete Cutthroat flume	200 West 100 South (Smithfield)	Measures amount of water being sent to the south west end of Smithfield
Armory	Sharp Crested Weir	Center Street 100 East (Smithfield)	Measures the amount of water sent to Smithfield Irrigation, feeds into Big Ditch

General Problems

All flow measurement structures examined had problems that influenced the flow measurement accuracy. The common problems for each structure included: the staff gage installed at the incorrect height and location and/or the flume was installed or constructed out of level. Most of the *Parshall* flume staff gages inspected are placed on the floor of the flume; thus putting them in the incorrect place. Staff gages can be easily relocated when improperly installed. To minimize confusion or mistakes in flow depth measurement using the staff gage, it is best to position the staff gage such that zero mark corresponds to the crest elevation. In this study, the crest elevation was calculated as the average of three survey points distributed along the crest. As an alternative, if the staff gage is installed at the proper location but not the proper elevation, the crest elevation reference can be determined and subtracted (or added if the staff gage zero is above the crest elevation) from the staff gage readings. This can introduce error if multiple people make flow measurements and the staff gage correction factor is not generally known.

There is no easily correction for an out-of-level flume. Consequently, the published head-discharge data must be replaced with a custom head-discharge relationship developed based on field calibration data.

Specific Findings

The specific findings of the individual flow measurement structure inspections are presented in separate summaries, which are located in the Appendix. The data include name, location, size, type, a description of the approach condition, identified problems, implemented solutions, the flow calibration data, conclusions and recommendations, and a calibration equation where appropriate.

CORRECTIVE ACTIONS

The most common problem that required a corrective action was a staff gage zero that didn't correspond to the flume crest elevation. For each case, a staff gage adjustment (DZ) was determined using surveying equipment consistent with the reference offset. This correction should be added to the h_a value read on the staff gage for use in the recommended head-discharge relationship.

When the 300 South Parshall flume staff gage had a ΔZ offset of 0.31 ft. The uncorrected ha staff gage data, however, predicted a head-discharge curve consistent with the theoretical head-discharge curve (using the standard 3-ft Parshall flume head-discharge relationship). The error associated with the corrected h_a data (adjusted to the crest reference elevation) was significantly higher than the uncorrected data. Apparently, the staff gage elevation had been altered to account for flume geometry problems such as being out of level. No corrective action was required for the 300 South Parshall flume.

At Three Creek, a diversion structure located immediately downstream of the flume creates a high tailwater condition which submerges the Parshall flume (~100% submergence). A confluence with another creek between the flume and diversion structure eliminated the possibility of developing a custom head-discharge relationship for the submerged Parshall flume. For the diversion structure to operate correctly, the water level upstream of the diversion could not be lowered. To facilitate flow measurement at this site, a linear weir was fabricated and installed at the downstream end of the Parshall flume. The crest of the linear weir is sufficiently high to elevate the headwater above the tailwater (at base flow conditions), creating a free-flow weir flow conditions. The weir, which was installed following the 2008 irrigation season, will be calibrated during the 2009 irrigation season.

All corrective actions specific to the individual structures are listed in the summary reports located in the Appendix.

TRAINING

The findings of this study were shared at the annual meeting of the Summit Creek Distribution System and specifically with Clinton Aston, the Water Commissioner. The recommended head-discharge relationships were reviewed, the specific findings and corrective actions taken for each structure were reviewed, the how to access the real-time telemetry flow rate data on the Internet.

CONCLUSIONS

Five flow measurement structures (4 flumes, 1 weir) in the Summit Creek Distribution System were inspected and field calibrated. In general, most flumes were out of level and the staff gages were not correctly zeroed to the crest of the flume. Field calibrations were conducted using a current meter traverse method. The head-discharge relationship associated with the flow rate determined by field calibration and two staff gage readings (the "as-found" and the "adjusted zero" reading) were compared to the standard calibration for that flow measurement device.

In general, the correlation between the

Discuss the % errors associated with each structure.

APPENDIX

INSPECTION AND CALIBRATION DATA

Name:	300 South
Distribution Co.:	Summit Creek
Location:	300 S. 900 E. Smithfield, UT
GPS:	4630992.689 Northing 432995.75 Easting

Type:	Parshall Flume
Width (W):	3 ft
Head Measurement:	Staff Gage
Approach:	Straight channel

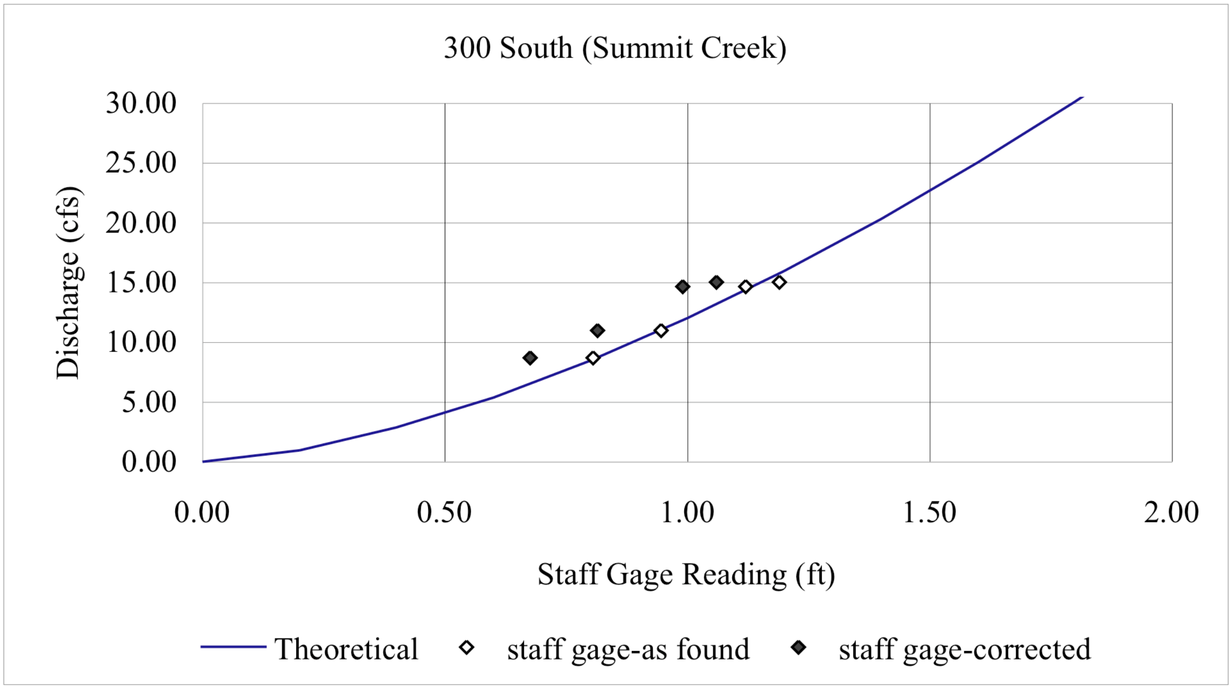
Problems	**Solution**
Staff gage zero not referenced to crest elevation	No corrective action taken†
Flume out of level	No corrective action taken†

† staff gage had been apparently been adjusted relative to flume crest to compensate for out-of-level problems (see calibration data below)†

NAME: 300 South
LOCATION: Summit Creek, Smithfield, UT
ΔZ (ft): -0.13

Q_{actual} (field calibration)	h_a (as found)	Q-pred (as found)	h_a (corrected)	Q-pred (corrected)
(cfs)	(ft)	(cfs)	(ft)	(cfs)
15.03	1.19	15.77	1.06	13.15
	% error from Q_{actual}	*4.92%*		*-12.51%*
14.67	1.12	14.34	0.99	11.81
	% error from Q_{actual}	*-2.28%*		*-19.48%*
10.99	0.95	10.98	0.82	8.7
	% error from Q_{actual}	*-0.11%*		*-20.82%*
8.71	0.81	8.54	0.68	6.47
	% error from Q_{actual}	*-2.02%*		*-25.69%*

ΔZ is the number added to staff gage reading to adjust the staff gage zero to the crest elevation.
Q_{actual} is the flow rate from the field calibration.
h_a (as-found): flow depth and corresponding predicted Q at the existing staff gage location/elevation.
h_a (corrected): flow depth and corresponding predicted Q at the corrected staff gage location/elevation



Conclusions/Recommendations:

The "as found" positioning of the staff gage had apparently compensated for the out-of-level flume. As a result, the staff gage position was not move and the flow rate should be calculated using the uncorrected staff gage reading and the standard 3-ft Parshall Flume head-discharge relationship [i.e., $Q=12.00*(h_a+\Delta Z)^{1.57}$].

A telemetry system was added at this site and the real-time discharge data can be found at http://www.waterrights.utah.gov/distinfo/realtime_info.asp.

Name:	Black Pipe
Distribution Co.:	Summit Creek
Location:	Birch Creek Golf Course Smithfield, UT
GPS:	4632163.246 Northing 432505.746 Easting

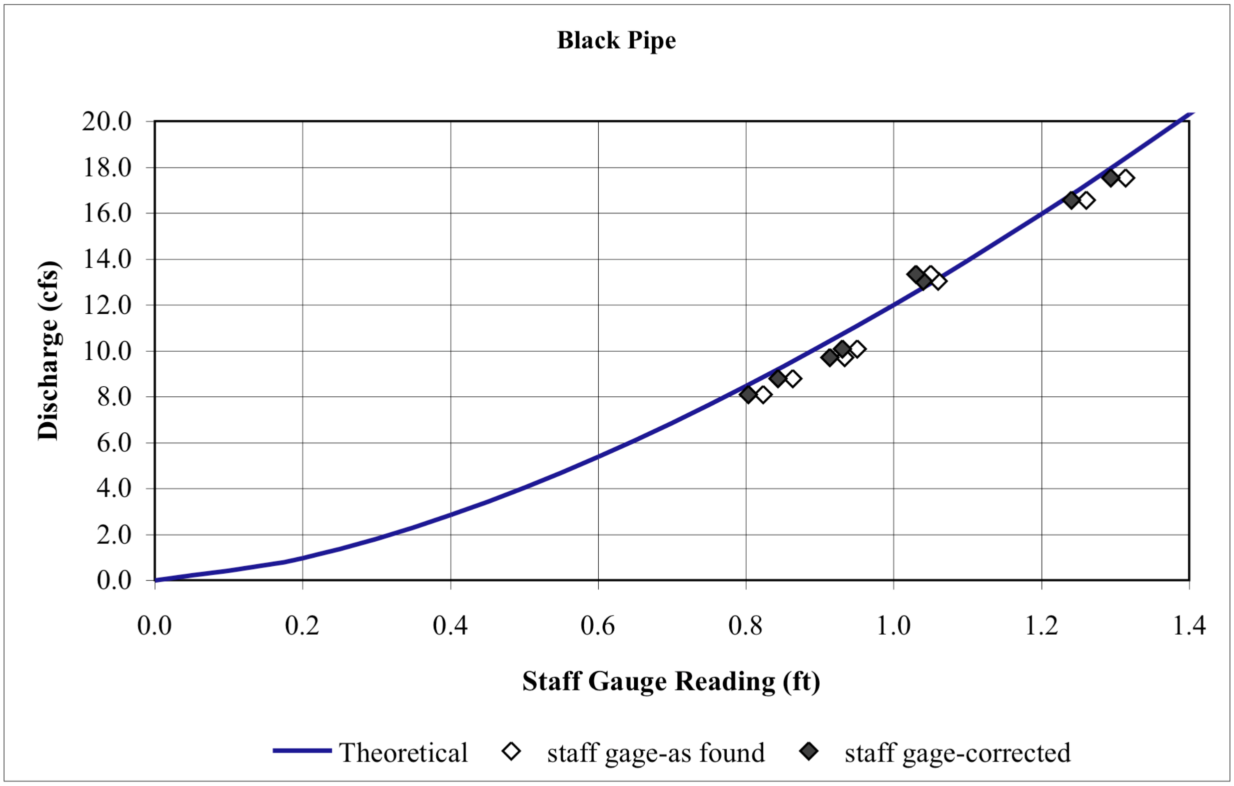
Type:	Parshall Flume
Width (W):	3 ft
Head Measurement:	Staff gage
Approach:	Straight channel

Problems	Solutions
Staff gage is not level with crest	Adjusted staff gage zero to reference the crest elevation.
Flume is out of level	No corrective action taken

NAME: Black Pipe
LOCATION: Summit Creek, Smithfield, UT
ΔZ (ft): -0.020 ft

Q_{actual} (field calibration)	Flow Depth (as found)	Q-pred (as found)	Flow Depth (corrected)	$Q\text{-pred}_{corrected}$ (corrected)
(cfs)	(ft)	(cfs)	(ft)	(cfs)
17.53	1.31	18.41	1.29	17.97
	% error from Q_{actual}	*4.99%*		*2.49%*
16.56	1.26	17.25	1.24	16.82
	% error from Q_{actual}	*4.16%*		*1.57%*
13.34	1.05	12.96	1.03	12.57
	% error from Q_{actual}	*-2.89%*		*-5.78%*
13.05	1.06	13.15	1.04	12.76
	% error from Q_{actual}	*0.80%*		*-2.17%*
10.10	0.95	11.07	0.93	10.71
	% error from Q_{actual}	*9.65%*		*6.05%*
9.71	0.93	10.77	0.91	10.41
	% error from Q_{actual}	*10.92%*		*7.21%*
8.80	0.86	9.53	0.84	9.18
	% error from Q_{actual}	*8.30%*		*4.38%*
8.10	0.82	8.84	0.80	8.51
	% error from Q_{actual}	*9.24%*		*5.10%*

ΔZ is the number added to staff gauge reading to adjust the staff gage zero to the crest elevation.
Q_{actual} is the flow rate from the field calibration.
h_a (as-found): flow depth and corresponding predicted Q at the existing staff gage location/elevation.
h_a (corrected): flow depth and corresponding predicted Q at the corrected staff gage location/elevation



Conclusions/Recommendations:

The staff gage zero was adjusted by ΔZ to correspond with the flume crest elevation. The discharge should be calculated by using the staff-gage reading and the standard 3-ft Parshall Flume head-discharge relationship [i.e., $Q=12.00*(ha+\Delta Z)^{1.57}$].

A telemetry system was added at this site and the real-time discharge data can be found at http://www.waterrights.utah.gov/distinfo/realtime_info.asp.

Name:	Big Ditch
Distribution Co.:	Summit Creek
Location:	Smithfield, UT
GPS:	4631853 Northing 430636 Easting

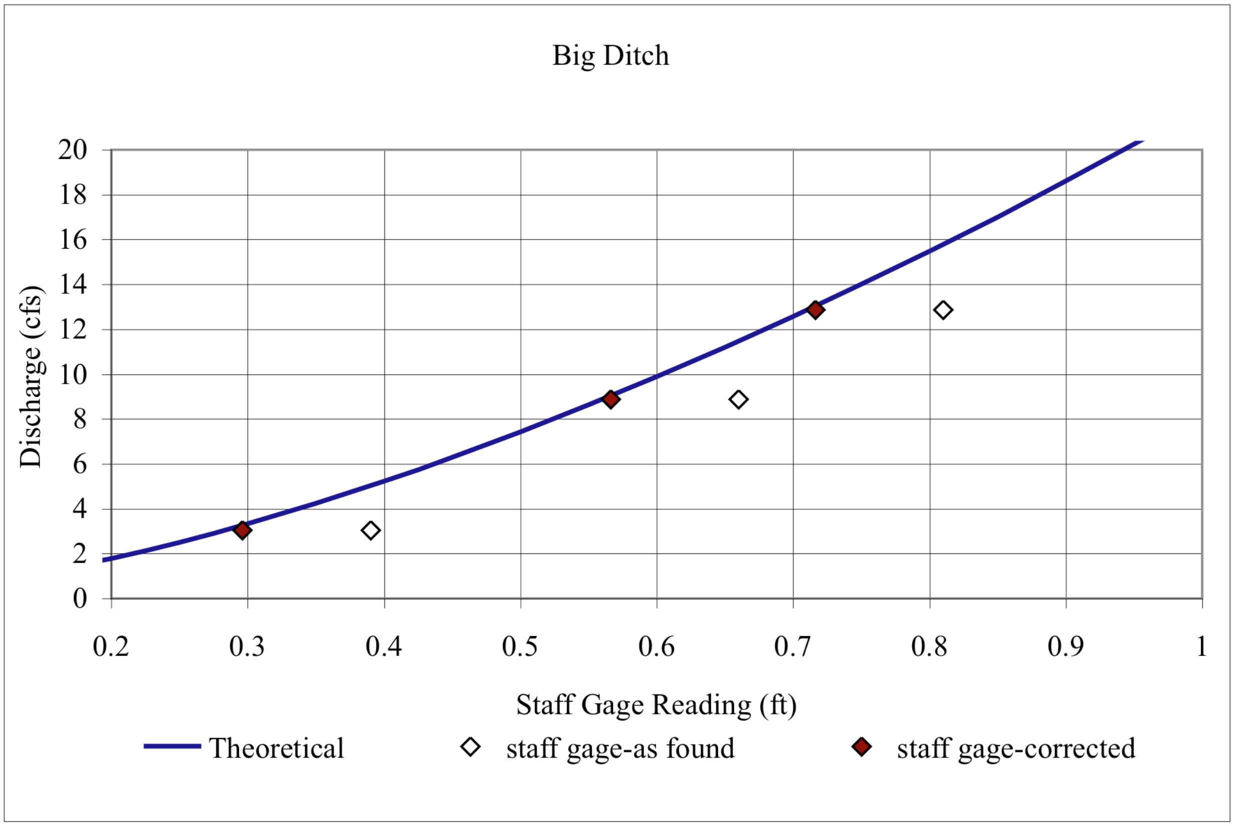
Type:	Cutthroat Flume
Width (W):	6 ft
Head Measurement:	Staff gage inside stilling well
Approach:	Hole dug out just upstream of flume creating a large pool .

Problems	Solutions
Staff gage at incorrect height	Changed staff gage height in stilling well to reference crest elevation.
Out off level	No corrective action taken
Some dimensions do no meet the standards for cutthroat flumes	No corrective action taken
Large excavated pool immediately upstream of flume	No corrective action taken

Name: Big Ditch
Location: Summit Creek, Smithfield, UT
ΔZ (ft): -0.094 ft

Q-actual (field calibration) (cfs)	h_a (as found) (ft)	Q-pred (as found) (cfs)	h_a (corrected) (ft)	Q-pred (corrected) (cfs)
12.89	0.81	15.81	0.72	13.04
	% error from Q_{actual}	*22.64%*		*1.17%*
8.89	0.66	11.49	0.57	9.04
	% error from Q_{actual}	*29.22%*		*1.68%*
3.05	0.39	5.06	0.30	3.29
	% error from Q_{actual}	*65.71%*		*7.77%*

ΔZ is the number added to staff gauge reading to adjust the staff gage zero to the crest elevation.
Q_{actual} is the flow rate from the field calibration.
h_a (as-found): flow depth and corresponding predicted Q at the existing staff gage location/elevation.
h_a (corrected): flow depth and corresponding predicted Q at the corrected staff gage location/elevation



Conclusions/Recommendations:

Despite the fact that the flume is out of level and some flume dimensions were slightly off, with the staff gage adjusted to reference the flume crest elevation, the published head-discharge relationship for a 6-ft wide *Cutthroat* flume predicts the flow rate with reasonable accuracy, particularly for flow depth >0.5ft approximately. The standard 6-ft cutthroat flume head-discharge relationship is recommended for flow measurement [i.e., $Q=3.5x6^{1.025}(ha+\Delta Z)^{1.56}$]. The telemetry system installation will be completed during the 2009 irrigation season.

Name:	3 Creeks
Distribution Co.:	Summit Creek
Location	Smithfield, UT
GPS:	4632563.486 Northing 432529.028 Easting

Type:	Parshall Flume
Width (W):	8 ft
Head Measurement:	Staff gage on flume wall. Stilling well & staff gage installed 07/22/08
Approach:	Windy channel, non-uniform approach conditions, flume located just down stream of a two stream confluence.

Problems:	Solutions:
Sediment in approach channel and flume	Cleaned rocks out of flume and channel.
Non-uniform approach conditions	Custom calibration required.
2 creek confluence	Custom calibration required.
Out of level	Custom calibration required.
Bottom of flume is eroded	No action taken.
Submergence-the flume is fully submerged at base-flow conditions due to high tailwater created by a diversion structure located immediately downstream.	Fabricated and installed a removable linear weir at the downstream end of the flume to facilitate flow measurement during the summer base flows as shown below 
Staff gage at incorrect elevation	Adjusted staff gage zero to reference the crest elevation.

The linear weir was installed after irrigation season and has not been calibrated yet. In the spring, with the linear weir removed, the Parshall flume will be calibrated, provided that submergence is not an issue at high flow conditions.

Conclusion/Recommendations:

The primary concern was the fact that the flume was operating at ~100% submergence. This was caused by a confluence with another canal just downstream followed by diversion structure. When the flume is fully submerged, no critical section exists and it ceases to function as a flow control device. The fabrication and installation of a linear weir at the downstream end of the flume would allow flow measurement during the summer by elevating the upstream head relative to the high tailwater. The weir would be removed during the spring runoff when the discharges may be sufficiently high to allow the Parshall flume to operate unsubmerged. The weir was fabrictated and installed Fall 2008 following the conclusion of the irrigation season.

The telemetry system installation will be completed during the 2009 irrigation season.

Name:	Armory
Distribution Co.	Summit Creek
Location:	Smithfield, UT
GPS:	4631967.911 Northing 431079.478 Easting

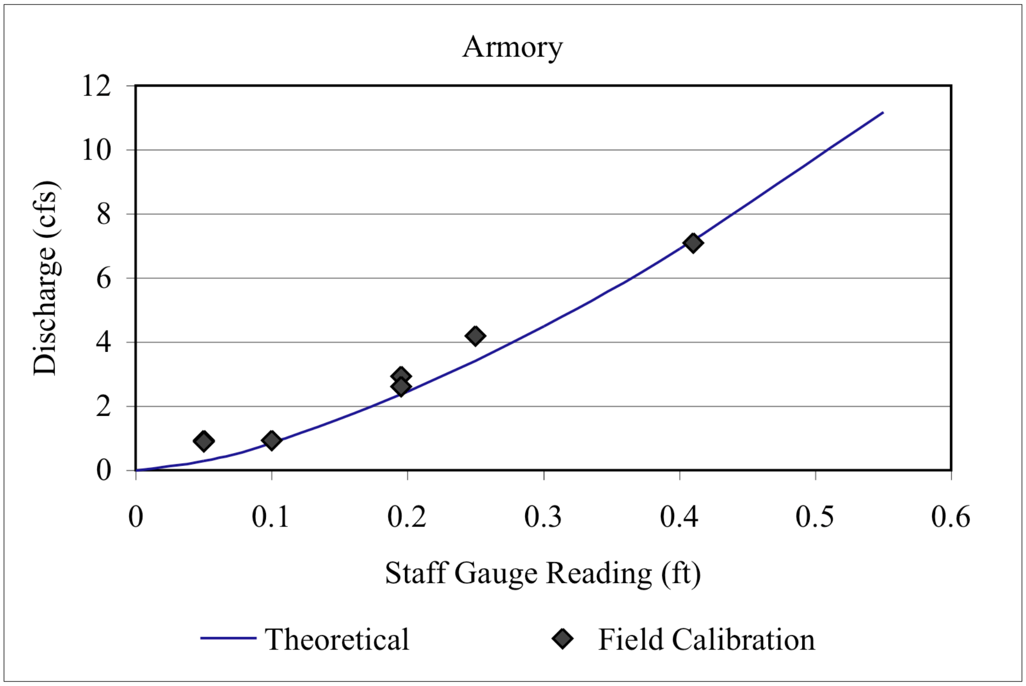
Type:	Sharp Crested Weir
Width (W):	7 ft
Head Measurement:	Staff Gauge
Approach:	Split Canal with bend just prior to weir

Problems	**Solutions**
Out of level	Custom calibration required.
Non-uniform approach conditions	Custom calibration required.
Adjustable gate just before weir	Custom calibration required.
Staff gauge at incorrect height	Adjusted staff gage zero to reference the crest elevation.

Name: Big Ditch
Location: Summit Creek, Smithfield, UT
ΔZ (ft): 0.000 ft

Q_{actual} (field calibration) (cfs)	h_a (ft)	Q-pred (cfs)	error relative to Q_{actual} (%)
7.11	0.41	7.19	*1.15%*
4.20	0.25	3.42	*-18.49%*
2.94	0.20	2.36	*-19.78%*
2.63	0.20	2.36	*-10.26%*
0.94	0.10	0.87	*-7.38%*
0.93	0.05	0.31	*-67.15%*
0.89	0.05	0.31	*-65.77%*

ΔZ is the number added to staff gage reading to adjust the staff gage zero to the crest elevation.
Q_{actual} is the flow rate from the field calibration.
h_a: flow depth and corresponding predicted Q at the existing staff gage location/elevation.



Conclusions/Recommendations:

Due to the amount of scatter in the field calibration data, additional data points will be collected in the 2009 irrigation season to help develop a custom head-discharge relationship for the Armory linear weir. The telemetry system installation will also be completed during the 2009 irrigation season.

References

Aisenbrey, A. J. Jr., Hayes, R. B., Warren, H. J., Winsett, D. L., Young, R. B. (1978). Design of small canal structures. Denver, CO: U.S. Government Printing Office, 243-258.

Genovez, A., Abt, S., Florentin, B., Garton, A. (1993, November/December). Correction for settlement of parshall flume. *Journal of Irrigation and Drainage Engineering*, 1081-1091.

Johnson, M. C. (2000). Discharge coefficient analysis for flat-topped and sharp-crested weirs. *Irrigation Science,* 133-137.

Utah Water Measurement Pocket Reference – Irrigation Water Measurement for Agriculture. (2000). Salt Lake City, Utah: Utah Association of Conservation Districts.

Water Measurement Manual – A Water Resources Technical Publication. (1997). Denver CO: U.S. Government Printing Office. 7-1 to 10-40.

Low-Level Outlet Works Air Vent Sizing Requirements for Small to Medium Size Dams

Basic Information

Title:	Low-Level Outlet Works Air Vent Sizing Requirements for Small to Medium Size Dams
Project Number:	2008UT105B
Start Date:	3/1/2008
End Date:	2/28/2009
Funding Source:	104B
Congressional District:	UT 1
Research Category:	Engineering
Focus Category:	Models, Water Quantity, Management and Planning
Descriptors:	None
Principal Investigators:	Blake P. Tullis, Steven L. Barfuss

Publication

Low-Level Outlet Works Air Vent Sizing Requirements for Small to Medium Size Dams

Prepared by:

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and

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Prepared for:

U.S. Geological Survey
Utah Water Research Laboratory
Utah Division of Water Rights

April 2009

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ABSTRACT

State regulators who approve dam designs, report having little or no information regarding requirements for sizing air vents for low-level outlet works. Some work has been done by the US Army Corps of Engineers (USACE) in conjunction with air vent sizing for vertical slide gates in outlet tunnels. Limited amounts of field data were used to validate the model. The gate/intake geometries for small to medium sized dam low-level outlet works typically do not feature a vertical slide gate but rather have slide gates mounted on the sloping upstream face of an earth fill dam, followed by a mitered elbow transition.

In an effort to improve the methodology associated with determining air demand and appropriate air vent sizes for low-level outlet works consistent with small to medium-sized embankment dams, the follow study was conducted. Discharge coefficient data for vented and non-vented slide gates were determined, the value opening with the largest air demand was identified, and a dimensionless relationship air flow, water flow, and reservoir head is presented. Using this data, an air vent sizing method is presented. The presents of size-scale effects have yet to be determined. If size-scale effects exist, that should be accounted for prior to implementing the data in this study for field application.

INTRODUCTION

Air vents are commonly installed in conjunction with low-level outlet works on dams. The air vents supply air at near-atmospheric pressure to the downstream side of the control valve or gate to elevate the local pressure, reducing the chance of damaging cavitation and flow rate instability (surging). To avoid such problems, it is important that the air vent be properly sized so that the full air demand can be met. With funding provided by the Utah State Office of Dam Safety, a literature review on sizing outlet works air vents was conducted at the Utah Water Research Lab (UWRL) at Utah State University. In general, the only air vent sizing information available, which was developed by the US Army Corps of Engineers (USACE), was limited to low-level outlet works geometries more consistent with large embankment dams (i.e., a vertical, rectangular slide gate installed in a near horizontal tunnel with a flat invert). At present there is very limited information regarding methods for estimating air demand and the corresponding air vent size requirement. The following project produced laboratory data, specific to one small to medium sized embankment dam low-level outlet works configuration.

The low-level outlet works geometry for small to medium-sized embankment dams typically consists of a slide gate (round or square) installed on the inclined upstream face of the dam, followed by an elbow and a circular discharge pipe that passes through the dam (See Figures 1 and 2). With this type of geometry, when the flow is fully aerated (just downstream of the slide gate), the pressure just downstream becomes constant (~atmospheric) and the head-discharge relationship through the slide gate is only a function of the reservoir head and the gate opening. When the flow is fully aerated and downstream end of the outlet pipe is unsubmerged, the flow rate is independent of the flow conditions in the pipe, with the possible exception of gate openings near 100% open. The objective of this study is to provide information specific to air demands for low-level outlet works consistent with small to medium-sized embankment dam geometries via a lab-scale model of a low-level outlet works.

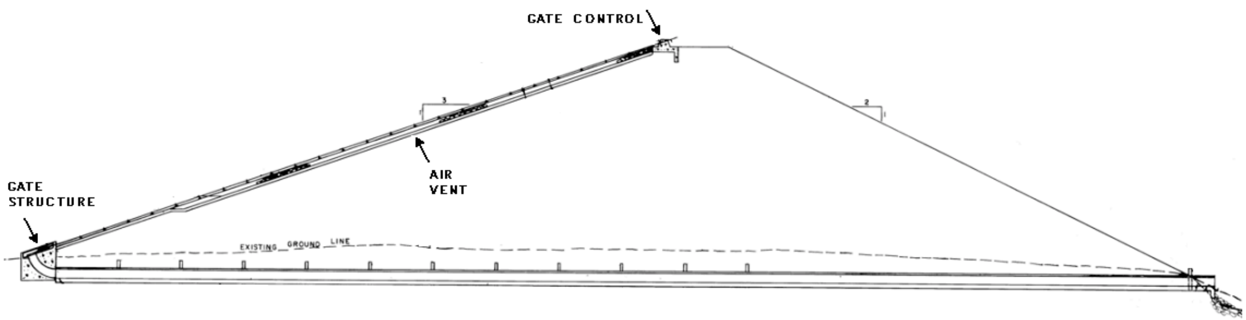

Figure 1. Typical small dam outlet works geometry.

Figure 2. Example of an inclined slide gate installed on a small embankment dam in Utah.

NATURE, SCOPE AND OBJECTIVE

The project had the following five objectives.

1. *Evaluate head-discharge relationships and discharge coefficients for one inclined slide gate geometry (round) at the lab-scale as a function of gate opening, upstream reservoir head, and air venting flow rate. No published literature has been found presenting discharge coefficients for inclined slide gates, with or without air venting influences. Without discharge coefficient data, neither the water discharge rate nor the air demand can be predicted accurately or conveniently.*

2. *Develop an understanding of the influence of gate opening, tailwater elevation, and reservoir head on air demand. With this information, the condition(s) that correspond to the maximum air demand can be identified and incorporated into an air-vent sizing protocol.*

3. *Evaluate head-discharge relationships, discharge coefficients, and air demand using computational fluid dynamics software (CFD) for comparison with the lab and possibly the field data collected as part of this study.* The objective of the CFD study is to determine the accuracy with which commercial CFD software can predict air demand and it's potential as an air vent sizing tool. If the head-discharge relationship and discharge coefficient data correspond with the physical day, the CFD approach could be used to evaluated non-lab tested geometries.

4. *Collect air demand versus gate opening and reservoir head data at dam in Utah and possibly neighboring states. This data will be used to correlate the laboratory findings with prototype performance in an effort to validate or improve the predictive model.*

5. *Communicate the study results via a project report to the USGS, the State of Utah (0ffice of Dam Safety), and if applicable, via a professional journal publication.*

EXPERIMENTAL METHOD

In an effort to analyze air vent sizing requirements and develop a better understanding of the head-discharge relationships and Cd for inclined slide gates, a test facility was constructed (See Figure 2) and lab-scale experiments were conducted at the UWRL. The scale low-level outlet works model(s) featured characteristics consistent with small to medium-sized dams; however, the model did not correspond to a specific prototype structure. Air demand is influenced by the water flow rate through the slide gate. Consequently, without slide gate Cd data (with air venting) the water discharge cannot be calculated without the use of an independent flow measurement structure downstream of the dam. Cd is defined in Equation 1.

$$Cd = \frac{V}{\left(2g\Delta H + V^2\right)^{0.5}} \quad (1)$$

In Equation 1, V is the average flow velocity, ΔH is the driving head across the gate, and g is the acceleration due to gravity).

Discharge coefficient (Cd) data were obtained for the following conditions: non-vented w/ an unsubmerged and submerged exit conditions and vented w/ an unsubmerged exit condition. For all non-vented conditions, the air vent valves were completely closed and for all vented conditions, the valves were full open. Submerged discharge was the condition where a tailwater was above the top of the discharge pipe exit preventing aeration from the end of the pipe. The 3-inch discharge pipe was set to a slope of 4.5 percent for all runs. Data were collected at different gate openings, with gate opening determined as a function of the linear gate stroke between full open and closed (See Figure 4).

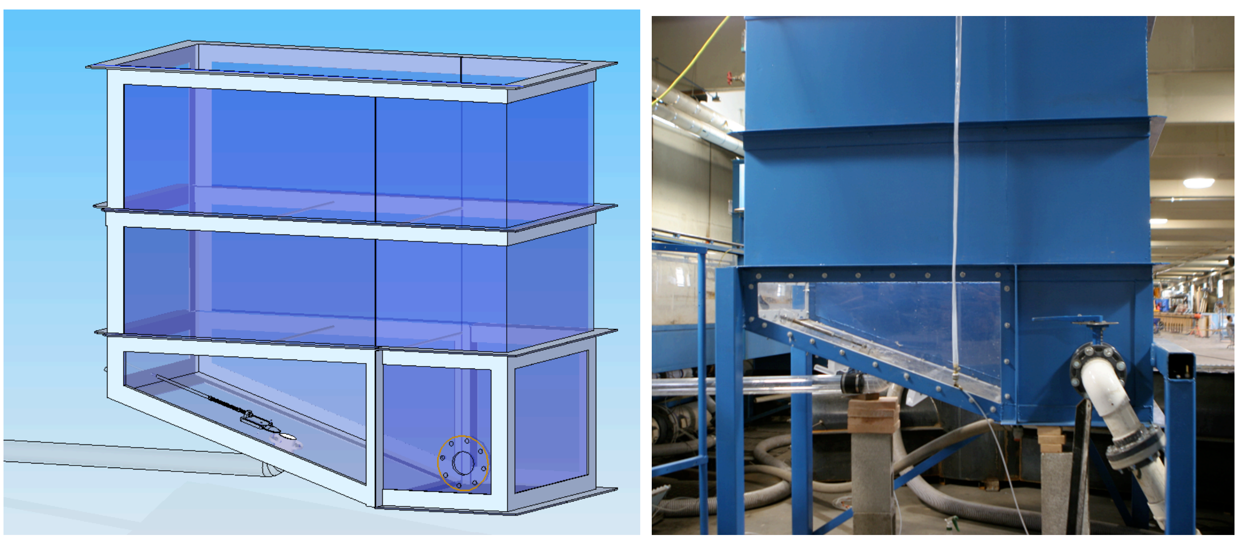

Figure 3. Low-level outlet works test facility.

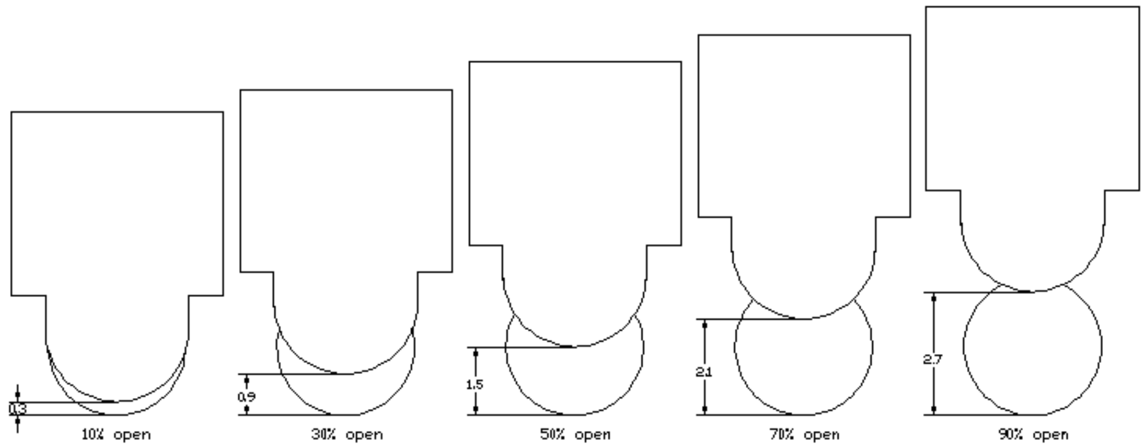

Figure 4. Slide gate positions.

Air was supplied to the model outlet works via a 1-inch diameter vent pipe, which bifurcated into two ¾-inch hoses that connected at a different location just below the slide gate. Air flow rate was measured using an anemometer flow meter. Water flow rates were metered using calibrated orifice flow meters installed in the supply piping.

For each gate opening, the pressure near the elbow, the water flow rate, the air flow rate, and the reservoir head, relative to the gate centerline were measured for different reservoir heads. Data were obtained for the open discharge condition to develop coefficients of discharge (C_d) values for the gate positions. Air velocity measurements were recorded for a minimum of 3 minutes for each run; the instrumentation recorded air velocity measurements every second.

EXPERIMENTAL RESULTS

For a uniform dimensionless reservoir head condition, H/d, where H is the reservoir flow depth and d is the diameter of the low-level outlet works, equal to 12, the maximum air demand as a function of gate opening is shown in Figure 5. The data in Figure 5 shows that the maximum air demand occurs at gate openings between 50 and 60 percent. At smaller gate openings, the water flow rate is small and has a limited air carrying capacity. At larger gate openings, the flow separation region (negative pressure region) behind the gate gets smaller resulting in a smaller air demand. At smaller reservoir heads (e.g., H/d=4), the shape of the air demand curve varies from that shown in Figure 5 (maximum air demand does not occur in the 50-60% gate opening range), however it should be noted that air vent sizing should be based on the maximum air demand condition, which corresponds to high heads.

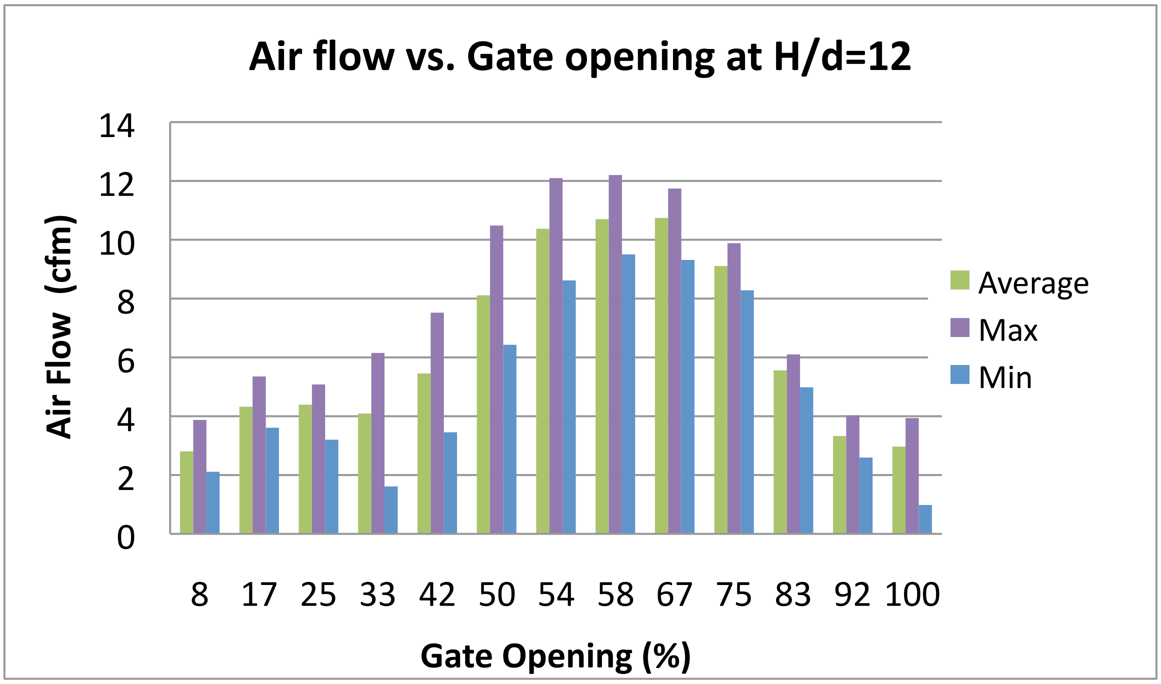

Figure 5. Air vent velocity data at H/d=12.

The maximum air flow demand data for the free-flow condition (unsubmerged pipe exit) are plotted in Figure 6 as a function of gate opening and H/d. The data shows that for H/d > 8, the maximum air demand occurs at the 60 % gate opening. The 60% air demand curve therefore is recommended for air vent sizing purposes. The results of the submerged pipe exit data were similar, but featured a reduced air demand relative to the free-flow condition. Consequently, only the free-flow data are included. It's worth noting that the higher free-flow air demand, relative to the submerged exit condition, is likely associated with free air flowing through the pipe above the water surface that does not exist when the pipe exit is submerged and may represent more air than is required to prevent cavitation or surging. The free-flow condition, however, is still recommended for design purpose as it represents a conservative estimate of air demand.

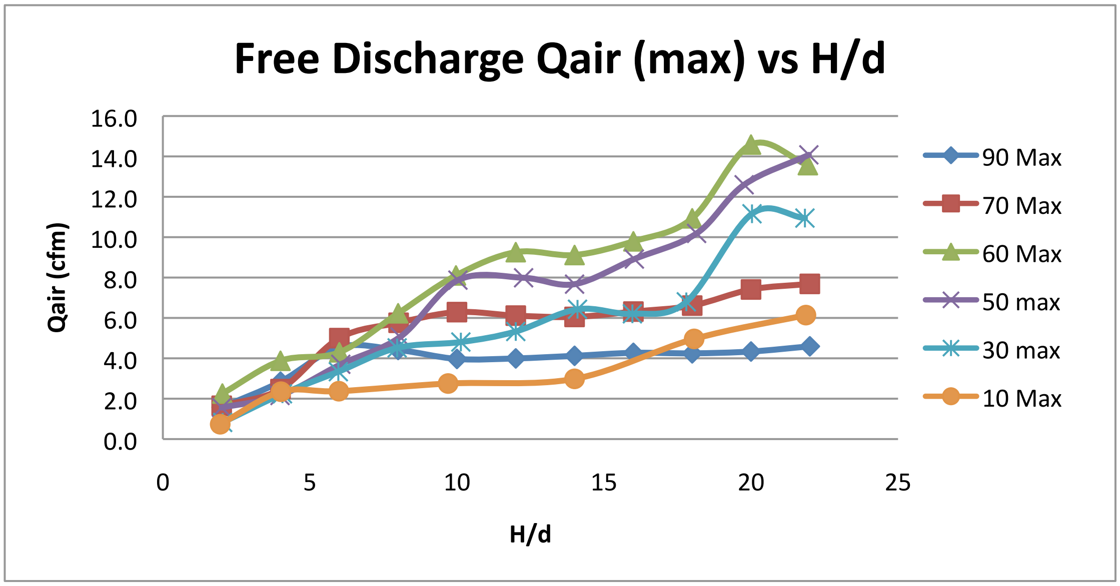

Figure 6. Maximum air demand as a function of gate opening and H/d.

The data in Figure 6 illustrate the maximum air demand trends, however, with the data presented in a quasi-dimensionless form (Qair vs H/d), the data is only applicable to the lab-scale model that produced it. In an effort to apply the data to field-scale outlets, the data are plotted in terms of β, where β equals Qair/Qw (the air flow rate over the water flow rate), and presented in Figure 7. Note that the largest β values (i.e., 10% gate opening) do not correspond to the maximum air demand (as determined in Figure 6). Consequently, the 60% gate opening curve in Figure 7 is recommended for determining air flow requirements and air vent sizing.

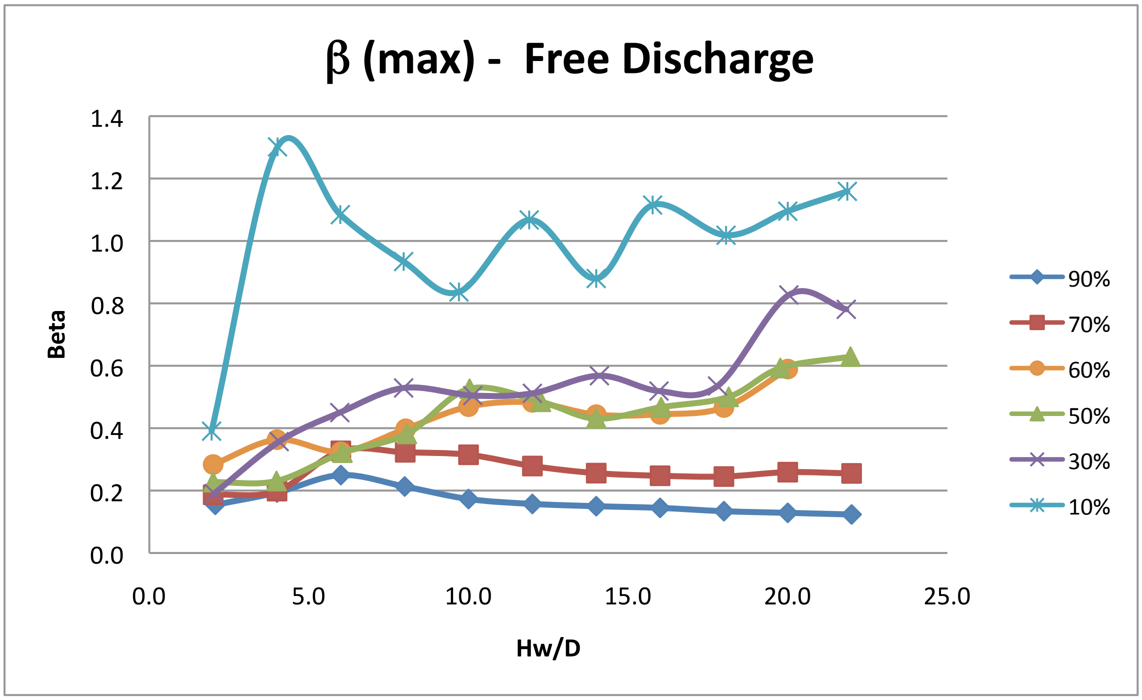

Figure 7. Maximum dimensionless air demand as a function of gate opening and H/d.

In order to determine the air demand from Figure 7, it is consequently necessary to determine the water flow rate through the outlet works. Slide gate discharge coefficient data were calculated using the experimental data set and are presented in Figures 8 and 9 as a function of gate opening and H/d.

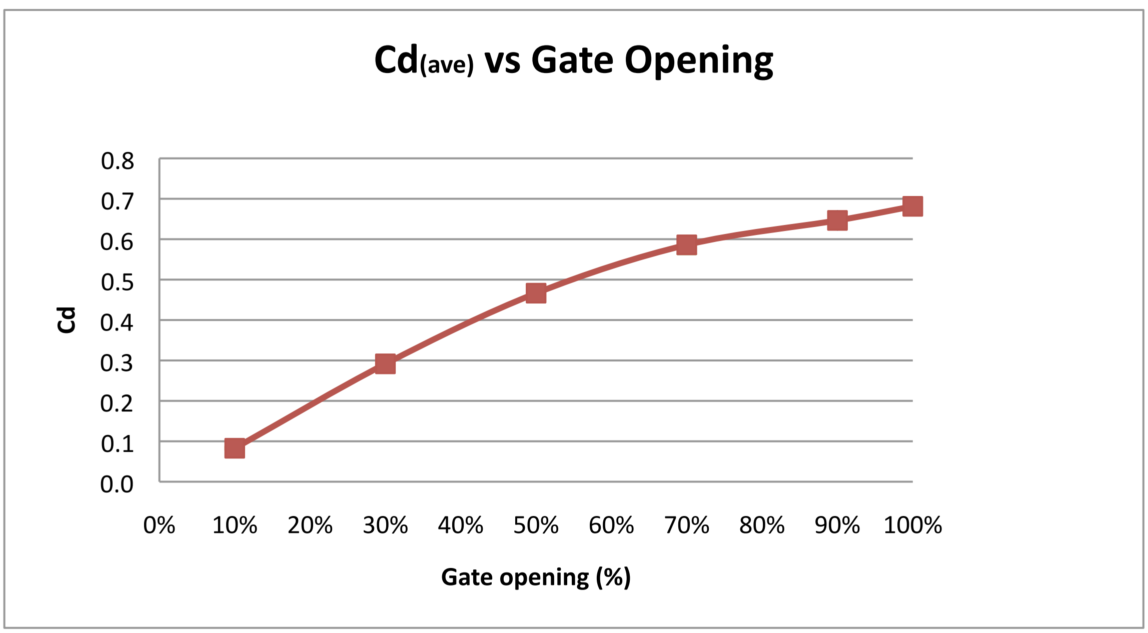

Figure 8. Cd data for a non-vented (no aeration) slide gate.

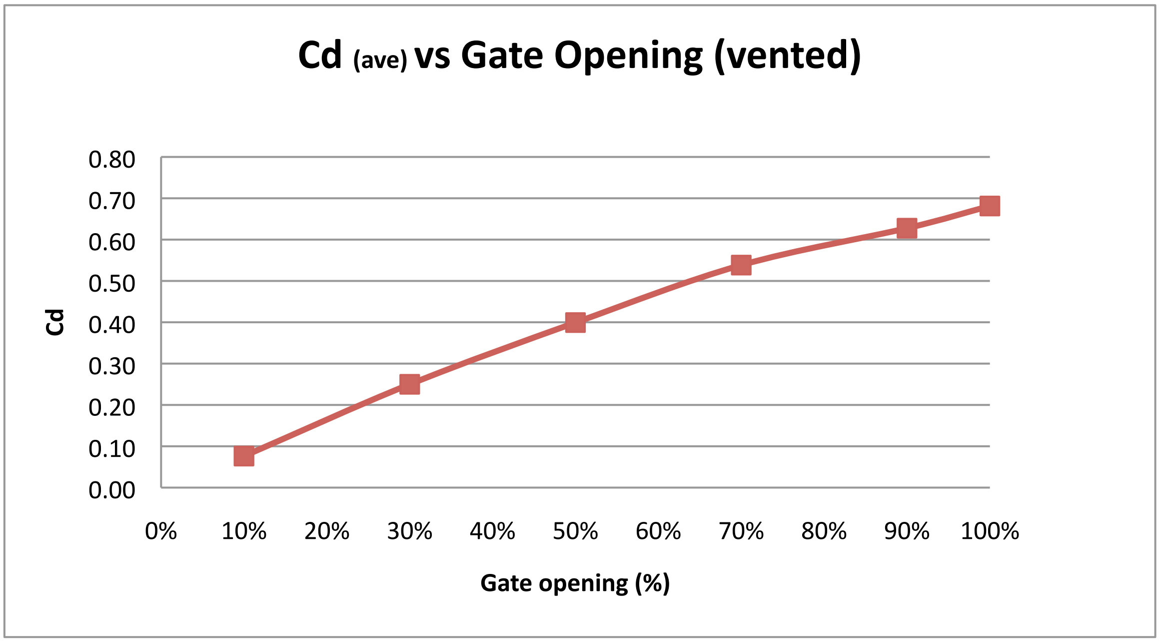

Figure 9. Cd data for a vented (aerated) slide gate.

Comparing the data in Figures 8 and 9 indicate that at large gate openings (i.e., 90 & 100% open), little to no aeration is required and the Cd values are the same for the vented and non-vented cases. For smaller valve openings (i.e., 70% and smaller), the vented Cd values are smaller than the non-vented Cd values. This is caused by the fact that the aeration process creates a fixed-pressure boundary condition (~atmospheric pressure) just downstream of the gate, creating a choked flow condition where Qw becomes only a function of the gate opening and the reservoir head. The discharge pipe is also forced to flow either as an open channel condition or as a 2-phase flow. For the non-vented condition, under some conditions, the pipe flows full and the driving head becomes, for the non-submerged exit case, the elevation difference between the reservoir head and the elevation of the centerline of the pipe exit. The data in Figure 8 are presented to illustrate the influence of air venting on Cd, however, low-level outlet works should not be operated without a vent pipe. The data in Figure 8 should not be used for design purposes.

The air vent sizing process proceeds as follows. The design H/d value is determined. The gate Cd value at 60% open is determined from Figure 9. The gate loss coefficient (K) is determined per Equation 2.

$$K = \frac{1}{Cd} - 1 \qquad (2)$$

The aerated Qw is calculated using Equation 3.

$$Q_w = \sqrt{\frac{2gH}{KA^2}} \qquad (3)$$

In Equation 3, A represents the full-pipe flow area and H is the reservoir head measured relative to the gate centerline.

Using the design H/d, the value of β is determined from Figure 7 using the 60% slide gate opening data curve. Qair equals βxQw. The air vent size is determined by setting a maximum air velocity, such as 100 fps, in the vent pipe and dividing Qair by that velocity to get the cross-sectional area.

UNFINISHED TASKS/FUTURE RESEARCH RECOMMENDATIONS

There was only sufficient time and funding to complete Tasks 1, 2 and 5. It is hoped that additional funding can be acquired to complete Task 3 and 4. Task 3 (CDF modeling of air venting) would give us some idea as to whether CFD represents a reliable tool for determining air demand and air vent sizing. Task 4, field verification, is also needed to verify the existence, if any of size-scale effect that might influence the application of the lab data to prototype structures. These tasks are recommended as future research topics.

Basin-Scale Internal Waves Within the South Arm of the Great Salt Lake

Basic Information

Title:	Basin-Scale Internal Waves Within the South Arm of the Great Salt Lake
Project Number:	2008UT106B
Start Date:	3/1/2008
End Date:	2/28/2009
Funding Source:	104B
Congressional District:	UT 1
Research Category:	Engineering
Focus Category:	Hydrology, Models, Solute Transport
Descriptors:	None
Principal Investigators:	Robert E. Spall

Publication

Basin-Scale Internal Waves within the South Arm of the Great Salt Lake

Problem

Recent studies have shown that mercury deposits in the South Arm of the Great Salt Lake are posing an increased threat to wildlife that makes use of this natural resource. Mercury, which enters the lake primarily through atmospheric deposition, was once thought to be confined to the deep brine layers of the lake. However, through some undefined mechanism, evidence indicates that mercury may be transported to the upper layers of the lake where it then enters the food chain.

Research Objectives

The interface between the upper and lower brine layers within the GSL is subject to internal wave motions and seiching, similar to that which may occur on the surface. However, since the density difference between the upper and lower brine layers is much less than the density difference between the upper brine layer and the atmosphere, for a given amount of energy the displacement of these internal seiches (Kelvin and Poincare waves when rotation is considered) are much larger than surface seiches. The vertical motion of the seiche induces a strong horizontal motion of the brine along the halocline. The vertical shear resulting from this motion is the focus of this study. In particular, it is known that at gradient Richardson numbers (the ratio of stabilization due to stratification to destabilization due to vertical shear) below approximately 0.25 this interface becomes unstable in the manner of a Kelvin-Helmholtz instability. The consequence of this instability is the formation and breaking of short wavelength, high frequency waves which results in significantly enhanced mixing of solutes between the lower and upper brine layers. The ability to predict the possible occurrence of this mixing is the focus of this work.

Limitations

As with any numerical simulation, the model will only predict the general circulation patterns and scalar values over time. As such, it is very important to remember that these values will not generally reflect the conditions at any given period of time. Discrepancies between the actual flow conditions and the solution obtained from the model will exist. However, the general trends predicted by the model are expected to be valid.

Computational Methodology

Computational fluid dynamics (CFD) is the branch of fluid mechanics dealing with the simulation of physical fluid flows through the use of numerical methods and computational algorithms. These methods are based on the governing equations of fluid mechanics, and are used to obtain detailed results about the flow field, such as velocities, pressures, and temperatures. A CFD simulation requires that the physical geometry (bathymetry), fluid properties, initial conditions, and external forcing (boundary) conditions for the lake be defined. A mesh consisting of individual cells is then generated. The advent of computers and the increasing availability of powerful processors has allowed for extensive use of CFD modeling for many industrial and commercial purposes. In recent years, detailed codes have been written specifically for CFD simulations of lakes and other large bodies of water.

CFD models of lakes and other naturally occurring bodies of water require an additional degree of complexity beyond typical industrial CFD simulations to account for all of the natural processes that drive the system. Both the fundamental simulation codes and the forcing functions must be adapted to handle variations over time in air temperature, solar radiation, wind speed, precipitation, cloud cover, and other vital external functions. Appropriate methods for calculating heat transfer through the water surface, evaporation rates, effects of Coriolis forces, and the amount of solar radiation incident upon the lake as a function of time of year and position on the earth's surface must also be incorporated. In addition, variations in water composition (i.e. salinity, total dissolved solids (TDS), density, etc.) and the possibility of a stratified system must be accounted for. All of these complexities introduce approximations and consequent sources of error into the CFD codes. The calculations in the present work were performed using the Estuary, Lake and Coastal Modeling (ELCOM) code.

Development of the computational model for Great Salt Lake required the following steps:

- Generation of a mesh that accurately depicted the physical boundaries of the lake. The resulting discretized lake is shown in Figure 1. The bathymetry was provided to the P.I. by Dr. Robert Baskin of the USGS (private communication).

- Gathering of accurate data on the surface water boundary conditions as a function of time, including river locations, inflow and outflow rates, and water temperature values.

- Collection of accurate meteorological forcing data as a function of time, including air temperature, atmospheric pressure, cloud cover, precipitation, relative humidity, solar radiation, and wind speed and direction. This data was acquired through Mesowest.
- Generation of input files formatted to CWR-ELCOM specifications.

- Execution of the code to run the simulations.

- Post-processing and analysis of the results.

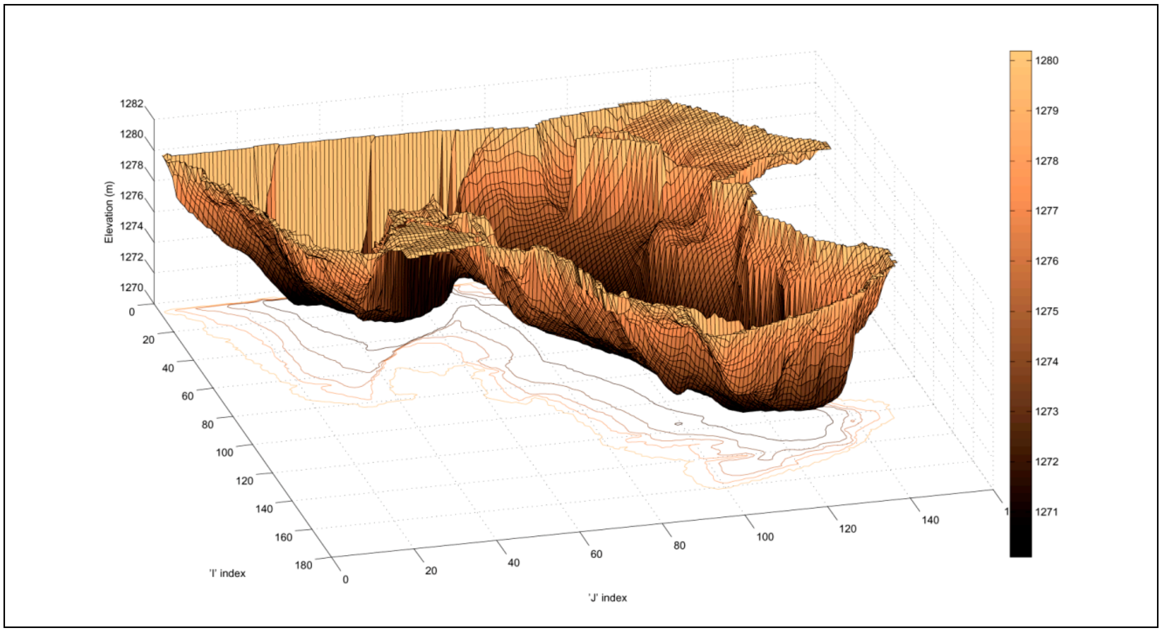

Figure 1. Bathymetry for the south arm of the Great Salt Lake.

Principal Findings

A numerical model was developed to simulate the general flow conditions of the South Arm of the Great Salt Lake for several different salinity profiles. This model makes use of a geophysical CFD solver known as CWR-ELCOM. Results from different regions of the lake were collected and processed to obtain the Richardson number for each time-step of the simulation.

The Richardson number is the ratio of the stabilizing buoyant forces to the destabilizing shear forces caused by a velocity gradient and can be calculated as

$$\mathrm{Ri} = -\frac{g\left(\frac{\partial \rho}{\partial z}\right)}{\rho\left(\frac{\partial U}{\partial z}\right)^{2}}$$

where *z* is the vertical direction and *U* is the mean horizontal velocity. The horizontal velocities arise from seiching motion within the lake. A typical signal describing the vertical motion of the wave as it passes by a given location in the lake is shown in Fig. 2 below. This vertical motion induces the horizontal motion, and vertical gradients of that motion, appearing in the Richardson number equation above.

These two forces continually work against each other. A decrease in the density gradient or an increase in the velocity gradient can cause the wave to become unstable. It is known that for Richardson numbers below approximately 0.25 that the flow is unstable.

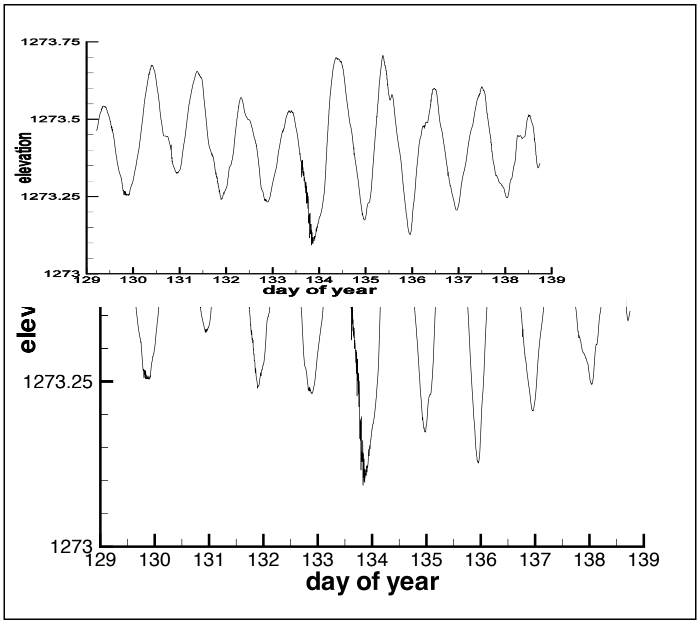

Figure 2. Computed elevations of the 180 ppt salinity contour at south end of the lake over a ten day period.

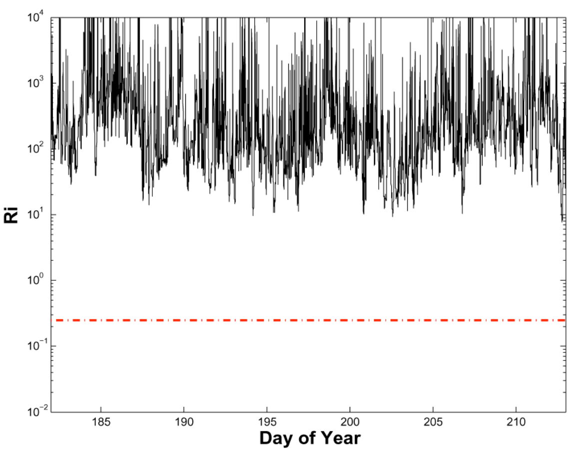

Figure 3. Case 1 Richardson number calculations.

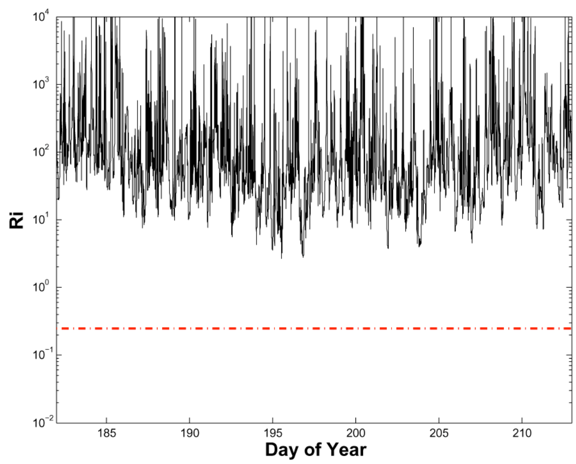

Figure 4. Case 2 Richardson number calculations.

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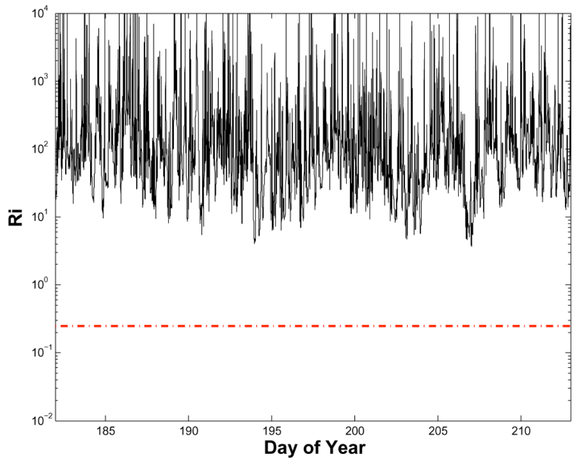

Figure 5. Case 3 Richardson number calculations.

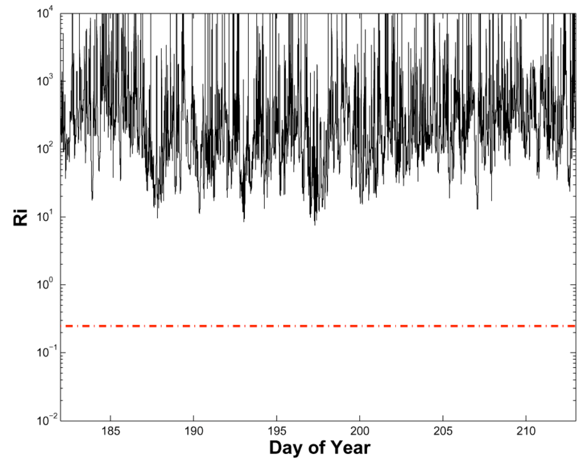

Figure 6. Case 4 Richardson number calculations

Results of the study, in terms of stability of the waves, are shown in Figures 3-6 above. The horizontal red dashed line indicates the stability threshold of 0.25. The different cases refer to varying representative initial salinity (density) gradients within the lake. The figures indicate that in all cases, buoyancy effects dominate, resulting in stable internal waves for each salinity profile simulated. These values were all measured at the same location off the west shoreline of Antelope Island. While only the results from one location are reported here, results similar to these were seen throughout the south arm of the lake. To conclude, the stability exhibited by the internal waves indicates that breaking of the waves is not likely to constitute a primary transport mechanism for heavy metals—such as mercury—to reach the upper layers of the lake.

Information Transfer Program Introduction

The individual research projects documented in the Research Project section of this report have integrated within them information and outreach components. These include publication of research findings in the technical literature and provision of findings and water management models and tools on the web pages of the Utah Center for Water Resources Research (UCWRR) and individual water agencies. Beyond this, Information Transfer and Outreach activities through the UCWRR, the Utah Water Research Laboratory (UWRL), and Utah State University (USU) have had an impact on the technical and economic development of the State of Utah. As part of the UCWRR outreach activities supported by USGS 104 funds, there continues to be a vigorous dialogue and experimentation with regard to efficiency and effectiveness of outreach activities of the UCWRR. Faculty are engaged in regular meetings with State of Utah water resources agencies, including the Department of Environmental Quality (DEQ), the Department of Natural Resources (DNR), and the State Engineer's Office to provide assistance in source water protection, on-site training, non-point source pollution management, technology transfer, development of source water protection plans (SWPPs), and efficient management of large water systems within the context of water–related issues in Utah. UCWRR staff through the facilities at the UWRL, provides short courses both on- and off-site within the State of Utah, regionally, and internationally. Generally offered from one to five days duration, short courses are tailored to meet the needs of the requestor. The following is a partial list of short courses, field training, and involvement of UCWRR staff in information transfer and outreach activities.

Principal Outreach Publications

Principal outreach items include newsletters addressing the on-site wastewater issues (Utah WaTCH), and Mineral Lease Report to the Utah Office of the Legislative Fiscal Analyst. Other publications from the UCWRR and UWRL appear regularly as technically-reviewed project reports, professional journal articles, other publications and presentations, theses and dissertation papers presented at conferences and meetings, and project completion reports to other funding agencies.

Short Courses

Introduction to Water Quality. Iraqi Agriculture Extension Revitalization Training, Amman, Jordan, January 2008 (5-day workshop). J.J. Kaluarachchi, M. McKee, B. Neilson, and W. Walker.

International Workshop on Tolerable Risk Evaluation for Life Safety. US Army Corps of Engineers (USACE) - Bureau of Reclamation (Reclamation) - Federal Energy Regulatory Commission's Office of Energy Projects - Division of Dam Safety and Inspections (FERC), Alexandria, VA, March 18-19, 2008. D.S. Bowles.

Training workshop on Dam Safety Risk Assessment for Stantec. Louisville, KY. March 28-30, 2008. D.S. Bowles.

Introduction to Water Quality Modeling. Iraqi Agriculture Extension Revitalization Training, Amman, Jordan, April 2008 (5-day workshop). J.J. Kaluarachchi, M. McKee, B. Neilson, and W. Walker.

Level 1: Certification: "Soil Evaluation and Percolation Testing." Utah On-Site Wastewater Treatment Training Program, April 15-16, 2008, Provo, UT. P. Cashell, B. Cowan, and J.L. Sims.

Level 2: Certification: “Design, Inspection, and Maintenance of Conventional Systems.” Utah On-Site Wastewater Treatment Training Program, April 17-18, 2008, Provo, UT. B. Cowan and J.L. Sims.

Level 1: Certification: “Soil Evaluation and Percolation Testing.” Utah On-Site Wastewater Treatment Training Program, April 29-30, 2008, Cedar City, UT. P. Cashell, B. Cowan, and J.L. Sims.

Level 1: Renewal of certification: “Soil Evaluation and Percolation Testing.” Utah On-Site Wastewater Treatment Training Program, May 1, 2008, Cedar City, UT. B. Cowan and J.L. Sims.

Level 2: Renewal of certification: “Design, Inspection, and Maintenance of Conventional Systems.” Utah On-Site Wastewater Treatment Training Program, May 2, 2008, Cedar City, UT. B. Cowan and J.L. Sims.

Level 3: Renewal of certification: “Design, Inspection, and Maintenance of Alternative Systems.” Utah On-Site Wastewater Treatment Training Program, May 6, 2008, Logan, UT. B. Cowan and J.L. Sims.

Level 2: Certification: “Design, Inspection, and Maintenance of Conventional Systems.” Utah On-Site Wastewater Treatment Training Program, May 21-22, 2008, Logan, UT. B. Cowan and J.L. Sims.

Level 3: Certification: “Design, Inspection, and Maintenance of Alternative Systems.” Utah On-Site Wastewater Treatment Training Program, May 28-30, 2008, Logan, UT. B. Cowan, R. Jex, and J.L. Sims.

Level 1: Certification: “Soil Evaluation and Percolation Testing.” Utah On-Site Wastewater Treatment Training Program, September 9-10, 2008, Heber City, UT. P. Cashell, B. Cowan, and J.L. Sims.

Level 1: Renewal of certification: “Soil Evaluation and Percolation Testing.” Utah On-Site Wastewater Treatment Training Program, September 11, 2008, Heber City, UT. B. Cowan and J.L. Sims.

Level 2: Renewal of certification: “Design, Inspection, and Maintenance of Conventional Systems.” Utah On-Site Wastewater Treatment Training Program, September 12, 2008, Heber City, UT. B. Cowan and J.L. Sims.

Level 1: Certification: “Soil Evaluation and Percolation Testing.” Utah On-Site Wastewater Treatment Training Program, September 23-24, 2008, Provo, UT. P. Cashell, B. Cowan, and J.L. Sims.

Level 2: Certification: “Design, Inspection, and Maintenance of Conventional Systems.” Utah On-Site Wastewater Treatment Training Program, September 25-26, 2008, Provo, UT. B. Cowan and J.L. Sims.

Level 1: Renewal of certification: “Soil Evaluation and Percolation Testing.” Utah On-Site Wastewater Treatment Training Program, October 1, 2008, Logan, UT. B. Cowan and J.L. Sims.

Level 2: Renewal of certification: “Design, Inspection, and Maintenance of Conventional Systems.” Utah On-Site Wastewater Treatment Training Program, October 2, 2008, Logan, UT. B. Cowan and J.L. Sims.

Level 2: Certification: “Design, Inspection, and Maintenance of Conventional Systems.” Utah On-Site Wastewater Treatment Training Program, October 22-23, 2008, Logan, UT. B. Cowan and J.L. Sims.

Level 3: Certification: “Design, Inspection, and Maintenance of Alternative Systems.” Utah On-Site Wastewater Treatment Training Program, October 28-30, 2008, Logan, UT. B. Cowan, R. Jex, and J.L. Sims.

Training Workshop for DAMRAE (DAM Safety Risk Analysis Engine). Software for US Army Corps of Engineers, October 28-29, 2008, Logan, Utah. D.S. Bowles.

Level 3: Renewal of certification: “Design, Inspection, and Maintenance of Alternative Systems.” Utah On-Site Wastewater Treatment Training Program, November 6, 2008, Logan, UT. B. Cowan and J.L. Sims.

Training Workshop for DAMRAE (DAM Safety Risk Analysis Engine). Software for US Army Corps of Engineers, January 20-23, 2009, Logan, Utah. D.S. Bowles.

Information Transfer in Support of the Utah Center for Water Resources Research

Basic Information

Title:	Information Transfer in Support of the Utah Center for Water Resources Research
Project Number:	2008UT102B
Start Date:	3/1/2008
End Date:	2/28/2009
Funding Source:	104B
Congressional District:	UT 1
Research Category:	Not Applicable
Focus Category:	None, None, None
Descriptors:	None
Principal Investigators:	R. Ivonne Harris

Publication

Information Transfer in Support of the Utah Center for Water Resources Research (UCWRR)

Problem

The Water Resources Research Act of 1964 established the Utah Center for Water Resources Research (UCWRR). The Center is housed at Utah State University in Logan, Utah. The general purposes of the UCWRR are to foster interdepartmental research and educational programs in water resources; administer the State Water Research Institute Program funded through the U.S. Geological Survey at Utah State University for the State of Utah; and provide university-wide coordination of water resources research.

Objectives

The center plays a vital role in the dissemination of information. Utah is home to approximately 50,000 miles of rivers and streams and 7,800 lakes. This water is an essential resource for the economic, social, and cultural well being of the State of Utah. As one of 54 water research centers, the UCWRR works to "*make sure that tomorrow has enough clean water.*"

A major component of the information transfer and outreach requirements of the UCWRR is the development of appropriate vehicles for dissemination of information produced by research projects conducted at the Center. This project provides on-going updates of the UCWRR web page, with information transfer specifically identified as the key objective. This project is in the process of disseminating quarterly newsletters for the Utah Center that feature research projects and their findings, water-related activities in the state, and on-going work by researchers affiliated with the Center.

Methods

Web Page

A vital objective in the dissemination of information for the UCWRR was the development of an up-to-date web page. The web page was designed and approved after several samples were submitted to the Director and a committee. The web pages were developed to make information available and thus creating a tool wherein interested parties can find solutions to water problems. The design of the web pages was developed with Adobe "Dreamweaver" software and CSS. Pictures were taken from the various on-going projects and added to the web pages. The address for the UCWRR is http://uwrl.usu.edu/partnerships/ucwrr/. Figures 1 and 2 are pictures of two of the pages. The web pages are a work-in-progress and the pages are periodically updated.

1. The "Homepage" explains the center's purpose.

2. The "About Us" gives an overview of the center and its affiliations.

3. The "People" page gives an overview of the governing body of the center as well as key contact staff.

4. The "Research and Publications" page guides you to the various projects and reports. This page is updated periodically.

5. The "Contact" page has the center's address and mode of contact.

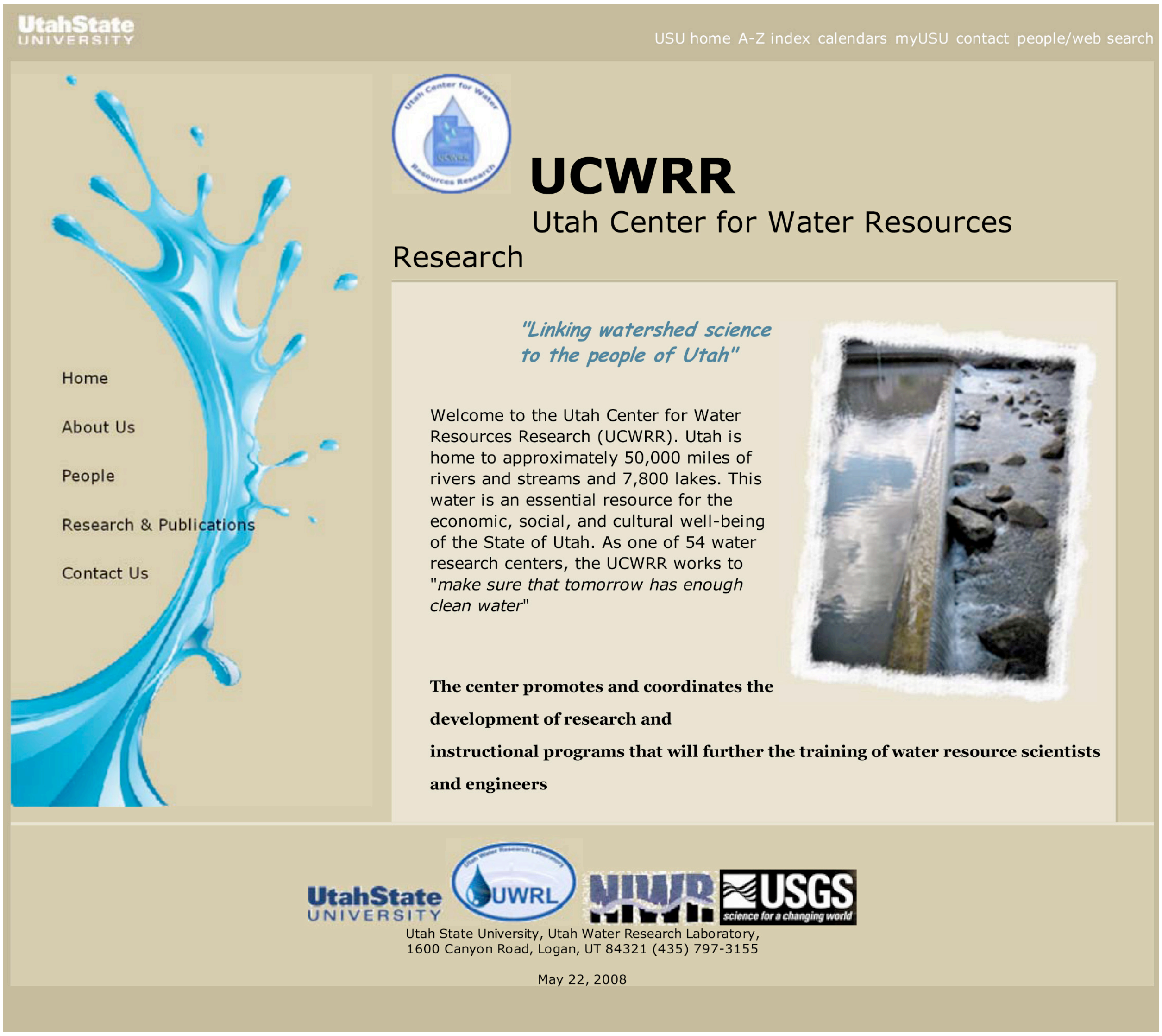

Figure 1. Home page for the UCWRR.

Figure 2. Research and Publications page for the UCWRR.

Newsletter

We are presently working on publishing a newsletter. This newsletter will be published quarterly. It will be disseminated electronically as well as through e-mail. The main purpose of the newsletter will be to highlight research projects and their findings. These will be of great interest and value to the State of Utah, also nationally and internationally.

Data Base

Another concern the UCWRR has is making available electronic copies of research projects and reports. These are being converted to PDF format and being added to a database so these can be available through our site.

USGS Summer Intern Program

None.

Student Support					
Category	Section 104 Base Grant	Section 104 NCGP Award	NIWR-USGS Internship	Supplemental Awards	Total
Undergraduate	9	0	0	0	9
Masters	2	0	0	0	2
Ph.D.	0	0	0	0	0
Post-Doc.	0	0	0	0	0
Total	11	0	0	0	11

Notable Awards and Achievements

Utah State University graduate student Noah Schmadel captured top awards at the 2009 Spring Runoff Conference and Intermountain Meteorology Workshop held on campus April 2-3, 2009. The two-day gathering, hosted by Water@USU and the USU-based Utah Climate Center, featured a slate of national speakers and more than 80 oral and poster research presentations by academics, professionals and students.

Ashleigh Restad, a student in the Environmental Engineering program in the College of Engineering has received the "Undergraduate Researcher of the Year" award. Ashleigh started working for the Utah Water Research Laboratory in 2007 assisting with various laboratory and field projects. She is also involved with the Utah State University's chapter of Engineers Without Borders (EWB) as the Board President. Congratulations Ashleigh.

Dr. R. Ryan Dupont has received the "Undergraduate Research Mentor of the Year" award. Dr. Dupont mentors undergraduate students and hires them in their freshman and sophomore years for research projects in laboratory, field work, and data analysis. Dr. Dupont involves the students in all aspects of research. Because of his mentoring many students have gone on to graduate school.

Dr. Thomas B. Hardy will head a team of eight scientists that will study the existing springflow requirements for three endangered species found exclusively in the Comal and San Marcos Springs: A small freshwater fish called the Fountain Darter, the Comal Springs riffle beetle, and an aquatic grass known as Texas Wild-Rice. Dr. Hardy is a nationally recognized expert in determining what the minimum and maximum requirements are for various endangered species.

The Director of the Utah Water Research Laboratory at USU, Dr. Mac McKee presented "Exciting Projects at the Utah Water Research Laboratory" as part of the USU Sunrise session series, Friday, April 25, 2008 in Salt Lake City. Researchers at the UWRL are currently working on more than 300 contract projects from around the world in an effort to deal with water issues. There are three main water problems arid communities such as Utah and others worldwide need to address. Water per person is decreasing, there is an increase in diversification of water uses and there is a stronger demand from stakeholders to play a role in the decision-making process. The UWRL aims to get in front of these problems and develop solutions before they get out of hand.

Publications from Prior Years

1. 2006UT69B ("Irrigation Demand Forecasting for Management of Large Water Systems") - Articles in Refereed Scientific Journals - Kaheil, Y.H., M.K. Gill, M. McKee, L.A. Bastidas, and E. Rosero (2008). Downscaling and Assimilation of Surface Soil Moisture Using Ground Truth Measurements. IEEE Transactions of Geoscience and Remote Sensing, Vol. 46, NO. 5.
2. 2006UT69B ("Irrigation Demand Forecasting for Management of Large Water Systems") - Articles in Refereed Scientific Journals - Kaheil, Y.H., E. Rosero. M.K. Gill, M. McKee, L.A. Bastidas (2008). Downscaling and Forecasting of Evapotranspiration Using a Synthetic Model of Wavelets and Support Vector Machines. IEEE Transactions on Geoscience and Remote Sensing, Vol. 46, No. 9.
3. 2005UT ("Alternative Decentralized Wastewater Treatment Systems for Utah Conditions") - Dissertations - Hurst, J. (2008). The Use and Management of Alternative On-Site Wastewater Treatment Systems in Utah. Master of Science, Plan B Project Report, Department of Civil and Environmental Engineering, College of Engineering, Utah State University, Logan, Utah.
4. 2003UT29B ("Source Water Protection Assessment Tools Development") - Dissertations - Gogate, S.V. (2004). Groundwater Modeling for a Source Water Protection Tool. Master of Science Thesis, Department of Civil and Environmental Engineering, College of Engineering, Utah State University, Logan, Utah.
5. 2003UT29B ("Source Water Protection Assessment Tools Development") - Conference Proceedings - Gogate, S., D.G. Tarboton, M.W. Kemblowski, Q. Shu, W. Wahlstrom, D.L. Sorensen, D.K. Stevens (2004). Terrain Analysis for Water Quality Modeling. In American Water Resources Association 2004 Spring Specialty Conference, Nashville TN, May 17-19.
6. 2003UT29B ("Source Water Protection Assessment Tools Development") - Conference Proceedings - Tarboton, D.G. (2003). Terrain Analysis Using Digital Elevation Models in Hydrology. In ESRI Users Conference, San Diego, California, July 7-11.
7. 2003UT29B ("Source Water Protection Assessment Tools Development") - Conference Proceedings - Sorensen, D.L., K.D. Moncur, D.G. Tarboton, M.W. Kemblowski, S. Quiang, S. Gogate (2003). A Surface Water Protection Assessment Tool that Uses Digital Elevation Models. In American Water Works Association, Source Water Protection Symposium, Albuquerque, N.M., January 19-22.
8. 2006UT70B ("Evaluating Water Allocation Strategies in the Virgin River Basin for the Protection and Enhancement of Native Fish") - Articles in Refereed Scientific Journals - Kaheil, Y.H., M.K. Gill, M. McKee, L.A. Bastidas, and E. Rosero. 2008. Downscaling and Assimilation of Surface Soil Moisture Using Ground Truth Measurements. IEEE Transactions on Geoscience and Remote Sensing, 46(5):1375-1384.
9. 2006UT70B ("Evaluating Water Allocation Strategies in the Virgin River Basin for the Protection and Enhancement of Native Fish") - Articles in Refereed Scientific Journals - Kaheil, Y.H., E. Rosero, M.K. Gill, M. McKee, and L.A. Bastidas. 2008. Downscaling and Forecasting of Evapotranspiration Using a Synthetic Model of Wavelets and Support Vector Machines. IEEE Transactions on Geoscience and Remote Sensing, 46(9):2692-2707.