# Center for Water Resources Research
# Annual Technical Report
# FY 2009

# 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 08, the UWRL expended a total of approximately $12 million in water research support. USGS Section 104 funds administered through the UCWRR accounted for less than 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. One research project was funded in FY09 with funds from a 104-h grant, and two projects were funded from the 104-b program. These projects, respectively entitled "Drought Index Information System Development for NIDIS", "Drought Planning including Carryover Surface Water Storage for a Utah Water Service Provider", and " Increasing Data Accuracy, Reliability, Accessibility, and Understandability to Improve Basin-Wide Water Resources Decision Making " dealt with water management issues involving development of a capability for evaluation and implementation of drought indices on a spatial basis for inclusion in a National Integrated Drought Information System (NIDIS) pilot study creating a drought early warning system for the Upper Colorado River Basin, development of a method to identify the cost-effective mix of management actions a water service provider should include to plan for and respond to droughts, 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 for development of a capability for evaluation and implementation of drought indices on a spatial basis for inclusion in a National Integrated Drought Information System (NIDIS) pilot study focused on the creation of a drought early warning system for the Upper Colorado River Basin. This involves the creation of a geographic database that is linked to historical time-series and real-time hydroclimatic data made available by establishing a NIDIS drought index server consisting of databases connected using the Internet through web services as well as software for data discovery, access and publication. The NIDIS HIS server will support the storage of drought index values and supporting input data and will include map presentation services, as well as the capability to compute and display custom drought index products. This project is at an early stage of development.

USGS Section 104 funds were also used to develop a drought planning optimization model that identifies the cost-effective mix of management actions (storage, conservation, trades, exchanges, cutbacks, conjunctive use, and other actions) a water service provider should include to plan for and respond to droughts. These engineering methods include using an existing reservoir simulation model to identify the time-series of delivery shortages over a 61-year period of record associated with different reservoir carryover storage and release policies. The project is currently applying and demonstrating use of the methods for the water system operated by the Weber Basin Water Conservancy District in the Weber Basin, 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 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.

# USGS Grant No. G10AP00039 Drought Index Information System for NIDIS

## Basic Information

| | |
|---|---|
| **Title:** | USGS Grant No. G10AP00039 Drought Index Information System for NIDIS |
| **Project Number:** | 2008UT134S |
| **Start Date:** | 1/1/2010 |
| **End Date:** | 12/31/2012 |
| **Funding Source:** | Supplemental |
| **Congressional District:** | UT 1 |
| **Research Category:** | Climate and Hydrologic Processes |
| **Focus Category:** | Drought, None, None |
| **Descriptors:** | |
| **Principal Investigators:** | David Gavin Tarboton, Jeffery S. Horsburgh |

## Publications

There are no publications.

# Drought Index Information System Development for NIDIS

**Investigators**

David G. Tarboton
Jeffery S. Horsburgh
Graduate Student: Jeanny Miles
Programmer: Stephanie Madsen

**Duration**

1/1/2010-12/31-2011

**Project Description**:

The National Integrated Drought Information System (NIDIS) pilot study is focused on the creation of a drought early warning system for the Upper Colorado River Basin. Utah State University has a project that is part of this study for development of a capability for evaluation and implementation of drought indices on a spatial basis. This involves the creation of a geographic database that is linked to historical time-series and real-time hydroclimatic data available over the web. To facilitate this we are establishing a NIDIS drought index server using the capability of and technology from the Consortium of Universities for the Advancement of Hydrologic Science, Inc. (CUAHSI) Hydrologic Information System (HIS). The CUAHSI HIS is an internet based system that supports the sharing of hydrologic data. It consists of databases connected using the Internet through web services as well as software for data discovery, access and publication. The NIDIS HIS server will support the storage of drought index values and supporting input data, the sharing of this data on the web using WaterOneFlow web services and the WaterML data transmission format. The server will include map presentation services for the display of map based drought index information. The CUAHSI HIS uses a desktop application, HydroDesktop, for client-based data access. This is extendible through plug-in capability. We will develop a drought index plug-in to HydroDesktop that will support access to drought index values and supporting information published on the NIDIS server as well as the capability to compute and display custom drought index products.

**Accomplishments (1/1/2010-5/1/2010)**:

This project started January 1/2010 and is still at an early stage of development. The first year of the project primarily involves system development that comprises (1) setting up a NIDIS HIS server, (2) establishing the system, procedures and agreements for gaining access to and publishing NIDIS drought information, and (3) developing the HydroDesktop plugin to support the calculation and display of custom drought index products.

To date a HIS Server has been established as a virtual machine within the Utah Water Research Laboratory data server cluster. Five sets of web services have been identified as required to support the calculation of drought indices, namely:

- SNOTEL
- StreamFlow
- Soil Moisture
- Precipitation
- Reservoir Levels

We have developed a web service to publish SNOTEL data in the WaterML data transmission format and work is under way for the other data sets.

**Work Plan (5/1/2010-12/31/2011)**:

Following establishing the NIDIS drought HIS Server using CUAHSI HIS functionality, our ongoing work will involve the following:

- Establishing procedures for ingesting data into the Observations Data Model (ODM) relational database used by HIS from its primary source and format, drawing upon ODM loader and potentially SQL Server Integration Services capabilities. Primary data sources may be web or ftp sources, or National Weather Service (NWS) Standard Hydrometeorological Exchange Format (SHEF) data streams. Specifically we anticipate obtaining the NRCS SWSI and supporting information in SHEF format.
- Setting up WaterOneFlow Web services for both calculated drought index values and the data inputs used to generate them.
- Setting up map display and visualization services.

Work will also include development of a HydroDesktop plugin that supports user customizable calculation of drought indices based on data available through the NIDIS drought HIS Server.

The HydroDesktop client and drought index plugin will support the following functionality.

- Access to drought index calculation inputs
- Access to published drought index values
- Ability to flexibly work with drought index relevant information to compute and evaluate different custom drought index products and related measures

In the second year of the project we will conduct training workshops on NIDIS HIS in Utah, Wyoming and Colorado. We also plan to iteratively refine and enhance the NIDIS HIS Server and HydroDesktop plugin based on feedback from users.

# Drought Planning Including Carryover Surface Water Storage for a Utah Water Service Provider

## Basic Information

| | |
|---|---|
| **Title:** | Drought Planning Including Carryover Surface Water Storage for a Utah Water Service Provider |
| **Project Number:** | 2009UT125B |
| **Start Date:** | 3/1/2009 |
| **End Date:** | 2/28/2010 |
| **Funding Source:** | 104B |
| **Congressional District:** | UT 1 |
| **Research Category:** | Engineering |
| **Focus Category:** | Management and Planning, Drought, Conservation |
| **Descriptors:** | None |
| **Principal Investigators:** | David Rosenberg |

## Publications

There are no publications.

# Drought Planning including Carryover Surface Water Storage for a Utah Water Service Provider

Prepared by:

Dr. David E. Rosenberg[1]

and

Bereket Tesfatsion[2]

Prepared for:

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

May 2010

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# ABSTRACT

Utah water service providers face periodic droughts that diminish the availability of their surface- and other water supplies and increase demands. Further, many service providers operate integrated and complex water supply systems that draw on surface waters, groundwater, trades and exchanges with neighboring districts, water conservation, and a host of alternative management actions. Yet no standard methods exist to show how these management actions can be optimally, cost-effectively, or economically combined to respond to droughts—for example, how much carryover surface water storage a service provider should retain in "wet" years to use during "dry" ones. This project is developing engineering methods to recommend the cost-effective mix of management actions a water service provider should include to plan for and respond to droughts.

These engineering methods include using an existing reservoir simulation model to identify the time-series of delivery shortages over a 61-year period of record associated with different reservoir carryover storage and release policies. Shortage time-series are post-processed into a probability distribution of shortages and serve as an input to a drought planning optimization model. The drought planning optimization model identifies the cost-effective mix of storage, conservation, trades, exchanges, cutbacks, conjunctive use, and other actions to respond to shortages. Simulation-optimization is used to identify the economical level of carryover surface water storage to reserve for and use during a drought. We are currently applying and demonstrating use of the methods for the water system operated by the Weber Basin Water Conservancy District in the Weber Basin, Utah.

# INTRODUCTION

Drought is "a deficiency of precipitation (or effective moisture) over an extended period of time resulting in a water shortage for some activity, group or environmental sector" and Utah has experienced several droughts that have caused significant economic impacts over the last several decades (UDWR 2008a). Several indices exist to help monitor the onset, severity, and termination of drought. The most common used indices are: Palmer drought severity index (PDSI), surface water supply index (SWSI), and standardized precipitation index (SPI), with SWSI typically used in mountainous areas such as Utah where hydrology is dominated by snowpack melt runoff (Palmer 1965; Sahfer and Dezman 1982). Drought indices provide a way to identify when droughts may occur but cannot tell managers how to plan or respond to them.

For more than a decade now, drought planners have encouraged water providers to consider water conservation and other response actions as potential drought planning tools (Beecher 1998). Most recently, the Utah Division of Water Resources (UDWR) released a drought management toolkit that encourages water providers to consider conservation (UDWR 2008b). The UDWR toolkit includes modules that help a water provider identify actions that can both mitigate the effects of droughts and be implemented as contingencies when a drought occurs.

Much of the UDWR guidance for water providers focuses on helping them identify and characterize potential actions. Wilhite et al (2005) and others describe how to build institutional capacity to support this planning. While the toolkit serves as an important first step to identify and characterize actions, still further guidance can help water providers select the mix of actions to include in drought plans and response programs. Engineering tools, methods, and analysis can help formalize, streamline, and make more transparent a water service provider's planning for and response to droughts.

A variety of engineering drought planning tools exist (Dziegielewski 1998; Rosenberg and Lund 2009; Wilchfort and Lund 1997) and have shown increasing sophistication to integrate a wide range of and recommend the appropriate and cost-effective mix of long-term supply, conservation, and short-term drought response actions. These planning models typically identify a portfolio of management actions to respond to a stochastic and independent discrete set of shortage or drought events with each event characterized by a drought level (shortfall or reduction in water availability) and likelihood (probability). A water service provider should implement long-term actions at the outset, before any droughts occur while short-term drought response actions need only be implemented on an emergency basis as a drought occurs in response to the specific drought level. Recommended short-term emergency actions differ for each drought event (with the number of and costs for short-term actions increasing as droughts become more severe). Together, the recommended long- and short-term actions comprise a drought planning and response portfolio.

Typically, the drought planning models assume very simplified representations of water networks and operations and have thus seen limited use by water providers. These planning tools contrast significantly with the water supply, reservoir, and delivery simulation models that describe and represent in detail how water comes into and moves through the managed water system. Water service providers rely heavily on these latter operations and simulation models to plan and operate their systems.

One challenge for drought management and planning is to better integrate stochastic drought response planning models with the more detailed operations/simulation models. Jenkins and Lund (2000) demonstrated a first integration for the East Bay Municipal Utility District in Oakland, California. They emphasized simulating improved deliveries associated with building new supply infrastructure such as the South Folsom Canal with a variety of drought planning options. Here, we simulate and link operational surface water supply issues important to Utah such as reservoir carryover storage levels with a wide suite of potential long- and short-term conservation and drought planning actions.

## STUDY OBJECTIVES

The three-fold study objectives are:

1. Identify a cost-effective set of long and short term management actions that can respond to a probability distribution of water shortages and drought.

2. Recommend reservoir storage carryover level(s) to include as part of drought management actions and identify the tradeoff between carryover storage levels and drought response costs, and

3. Identify a water provider in Utah and work with them to demonstrate application of the developed methods.

## METHODOLOGY

The basic steps of our research approach include 1) select and understand the study site, 2) simulate different reservoir carryover storage and release policies, 3) calculate the probability distribution of shortage events resulting from the reservoir carryover storage policy, 4) identify and characterize potential long- and short-term drought management actions, 5) optimize to determine the cost-effective mix of actions, and 6) repeat simulations and optimizations to characterize the tradeoff between carryover storage levels and drought response costs. Appendix A shows a flow chart for steps 2 – 6 with required data inputs and generated outputs for each step. We describe each step in the next section along with results.

## RESULTS

### *Identifying a Water Provider and Study Site*

Starting in December 2008 and continuing through September 2010, we met or tried to meet with three large Utah water providers that operate surface water storage—the Weber Basin Water Conservancy District (WBWCD), Metropolitan Water District of Salt Lake and Sandy (MWDSLS), and Washington County Water Conservancy District (WCWCD) (Table 1). We found that WBWCD managers were most interested to cooperate on the project. Managers at other Districts indicated by email or during meetings that they had other more pressing concerns.

**Table 1. Timeline of meetings and contacts to site and understand the study area**

| Date | Format | Person(s) | Title | Organization |
|---|---|---|---|---|
| Dec. 19, 2008 | Email | Corey Cram | Watershed Coordinator | WCWCD |
| May 28, 2009 | Meeting | Scott W. Paxman, P.E. | Assistant General Manager, Water Supply | WBWCD |
| Aug. 24, 2009 | Meeting | Michael L. Wilson<br>Claudia Wheeler | General Manager<br>Environmental Services Director | MWDSLS |
| Sept. 23, 2009 | Meeting | Chris C. Hogge, P.E. | Manager, Power and Irrigation | WBWCD |
| Feb. 16, 2010 | Meeting | Jim Wells | Weber Basin River Commissioner | Utah Division of Water Rights |

In recent years, WBWCD has implemented numerous water conservation, groundwater banking, trades, exchanges, and other programs, plus operates a system of 7 reservoirs with total storage available to the District of approximately 400,000 ac-ft. WBWCD managers' willingness to share data and the details of many of their operations and management contracts also made them WBWCD a good location to site the study.

The WBWCD service area includes the Weber and Ogden River basins and covers over 2,500 square miles in Davis, Weber, Morgan, Summit and part of Box Elder counties. More than 470,000 people (2000 census) live in the service area which includes the City of Ogden. WBWCD delivers approximately 220,000 acre-feet of water annually split approximately 27% and 73%, respectively, between (i) municipal and industrial uses and (ii) irrigation, which includes secondary pressure irrigation systems. WBWCD reservoirs include: Causey, East Canyon, Lost Creek, Pineview, Smith & Morehouse, Wanship, and Willard Bay. Due to the later priority of WBWCD's water rights on the Weber and Ogden Rivers, the district must maintain a surface water storage volume almost twice of its annual delivery amount. This fact suggests the District can be significantly impacted by droughts that diminish surface water availability. It also identifies carry-over surface water storage as an important part of WBWCD operations and an important consideration in its drought planning and response programs.

## *Reservoir Simulation Modeling*

One advantage of locating the study in the Weber Basin was the existence of the Weber Basin reservoir and mass balance model for the basin which personal at WBWCD, UDWR, and the Utah Water Research Laboratory (UWRL) were familiar with and had either previously developed or modified. During fall 2009 and winter 2010, we learned about and tested several versions of the model. We are currently working with the 2010 version of the model developed and updated by David Cole at UDWR and are identifying what model inputs to change to represent different reservoir carryover storage and release policies. Otherwise, the Weber Basin model comes with a full set of input data. This data includes time-series of inflows and reach gains from 1950 to 2010 (61 years) on a monthly time-step along each network arc, time series of deliveries, delivery targets at each service area over the same time period, upper and lower bounds on reservoir storage capacities, and the network connectivity of flows and return flows among gage stations, reservoirs, and service areas. Appendix B shows the model schematic.

In discussions with Scott Paxman and Chris Hogge, respectively, the assistant general manager and manager of power and irrigation at WBWCD, we learned that the District aims to maintain reservoir storage at a level so that they can supply their irrigation and urban customers for two years. This goal means that WBWCD tries to completely fill all their reservoirs (approximately 400,000 ac-ft storage) by the end of the refill/beginning of the irrigation season (spring) and carryover approximately 200,000 ac-ft at the end of the irrigation season (fall) into the next year. This carryover storage level will serve as the base case level against which we will compare alternative carryover storage levels. Work in simulating carryover storage policies is ongoing.

## *Calculating Probability Distributions of Water Shortages*

The Weber Basin model outputs time-series of deliveries and delivery shortages for each service area in a text file which is easily post-processed in Excel or another computational environment to calculate a probability distribution of annual, district-wide water shortages resulting from a particular simulated carryover reservoir storage policy. The drought planning optimization model works at a much coarser spatial and temporal scales, so it is necessary to aggregate monthly shortages to each service area into a time series of annual shortages to the entire WBWCD service area. The resulting probability distribution of annul, district-wide shortages can then be transformed into a discrete set of shortage events (with each event described by a probability mass and shortage level). Work on this activity is also ongoing.

## *Identify Drought Management Actions*

Our meetings with WBWCD managers and readings have identified a wide-ranging list of drought management actions that the district is either currently implementing or could implement. These actions are listed in the tables in Appendix C. Short-term actions (such as rationing, cut backs, or one-time trades or exchanges) tend to have smaller implementation costs, require little advance planning, and can be implemented on an as-needed basis for specific drought events. Long-term actions (such as new facilities, infrastructure, or conservation programs) have larger capital costs and require significant advance planning, but would likely yield new water or water savings over a wide range of shortage events. Work is still ongoing to completely characterize potential actions by their capital and operating costs and effective water acquired or saved.

## *Drought Planning Optimization Model*

Using the probability distributions of water shortages calculated in step 3 and the costs and effectiveness of actions identified in step 4, the drought planning optimization model identifies the cost-effective mix of long- and short-term actions to respond to drought. This optimization is done by minimizing costs of drought response actions while requiring the total effective water volume added or conserved by actions to meet or exceed the storage level associated with each shortage event. The model weights action costs for each event by the event probability to give an expected drought management cost. Thus, the optimization recommends a portfolio of drought management actions: long-term actions that the District should consider starting right away (ahead of any drought) and short-term actions that can be implemented on an emergency basis either as a drought begins or depending on the drought severity.

We have two versions of the drought planning optimization model. One version is in Excel and was used to study the East Bay Municipal Water Utility District in Oakland, CA (Wilchfort and Lund 1997). A second version was written in the General Algebraic Modeling System (GAMS) and has examples for Oakland, CA and Amman, Jordan (Rosenberg and Lund 2009). Some additional (but not significant) work is still required to modify the Excel or GAMS version of the model to include the set of potential actions for WBWCD. This work is also ongoing.

## *Simulation – Optimization*

A final step in the analysis involves repeating steps 2, 3, and 5 to simulate different reservoir carryover storage policies and identify the associated portfolio of drought management actions and expected drought management costs. This simulation-optimization effort can be used to identify a tradeoff between reservoir storage-carryover levels and drought management costs. This effort can also identify the robust drought management actions that should be implemented regardless of and that are not sensitive to reservoir storage and release policies. This step has not yet been started since steps 2, 3, and 5 are still ongoing.

## DISCUSSION

As discussed above, many of the study steps are still ongoing so that model results and findings are neither ready to present nor discuss. In retrospect, the one-year project timeline to complete dual simulation and optimization modeling efforts, develop a post processor to link the simulation model results to the optimization model, collect the required data for drought planning optimization model, and write everything up into a thesis and final report was overly ambitious for one Master's student new-to-the drought planning and reservoir operations topics.

However, work is ongoing and we are making progress towards the eventual goals of (i) linked simulation-optimization models, (ii) identifying the tradeoff for reservoir carryover storage levels and drought management costs, and (iii) writing up findings as a Master's thesis and journal article. We have a reservoir simulation model for the Weber Basin with all the required input data and are currently working to develop, specify, and test different reservoir carryover storage policies. We have an extensive list of potential drought management actions (Appendix C) and are working to finish characterizing the cost and effective water volume added/conserved by each action. The drought planning optimization model requires a few minor modifications to include the set of potential drought management actions for WBWCD. We aim to complete these activities by winter 2011.

## CONCLUSIONS

Utah water service providers face periodic droughts that diminish the availability of their surface- and other water supplies, increase demands, and have significant economic impacts. They operate integrated and complex water supply systems that draw on surface water, groundwater, trades, exchanges, water conservation, and a host of alternative management actions and can benefit from engineering methods that recommend a cost-effective mix of management actions to plan for and respond to droughts.

These engineering methods include using an existing reservoir simulation model to identify the time-series of delivery shortages over a 61-year period of record associated with different reservoir carryover storage and release policies. Shortage time-series are post-processed into a probability distribution of shortages and serve as an input to a drought planning optimization model. The drought planning optimization model identifies the cost-effective mix of storage, conservation, trades, exchanges, cutbacks, conjunctive use, and other actions to respond to shortages. Simulation-optimization is used to identify the expected drought management costs associated with different reservoir carryover storage levels. We are still applying and demonstrating use of the methods for the water system operated by the Weber Basin Water Conservancy District in the Weber Basin, Utah and aim to complete project activities in winter 2011.

# REFERENCES


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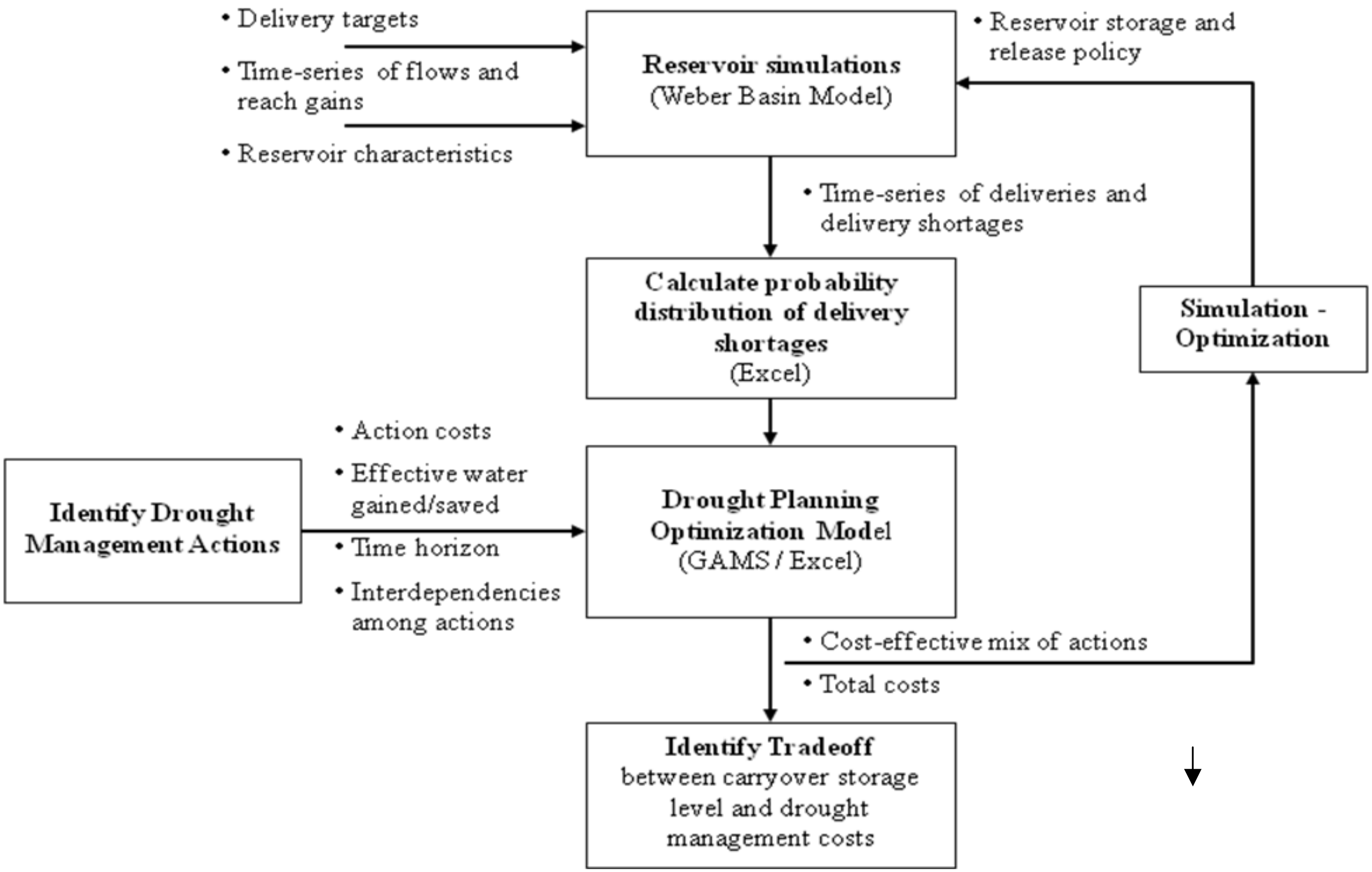
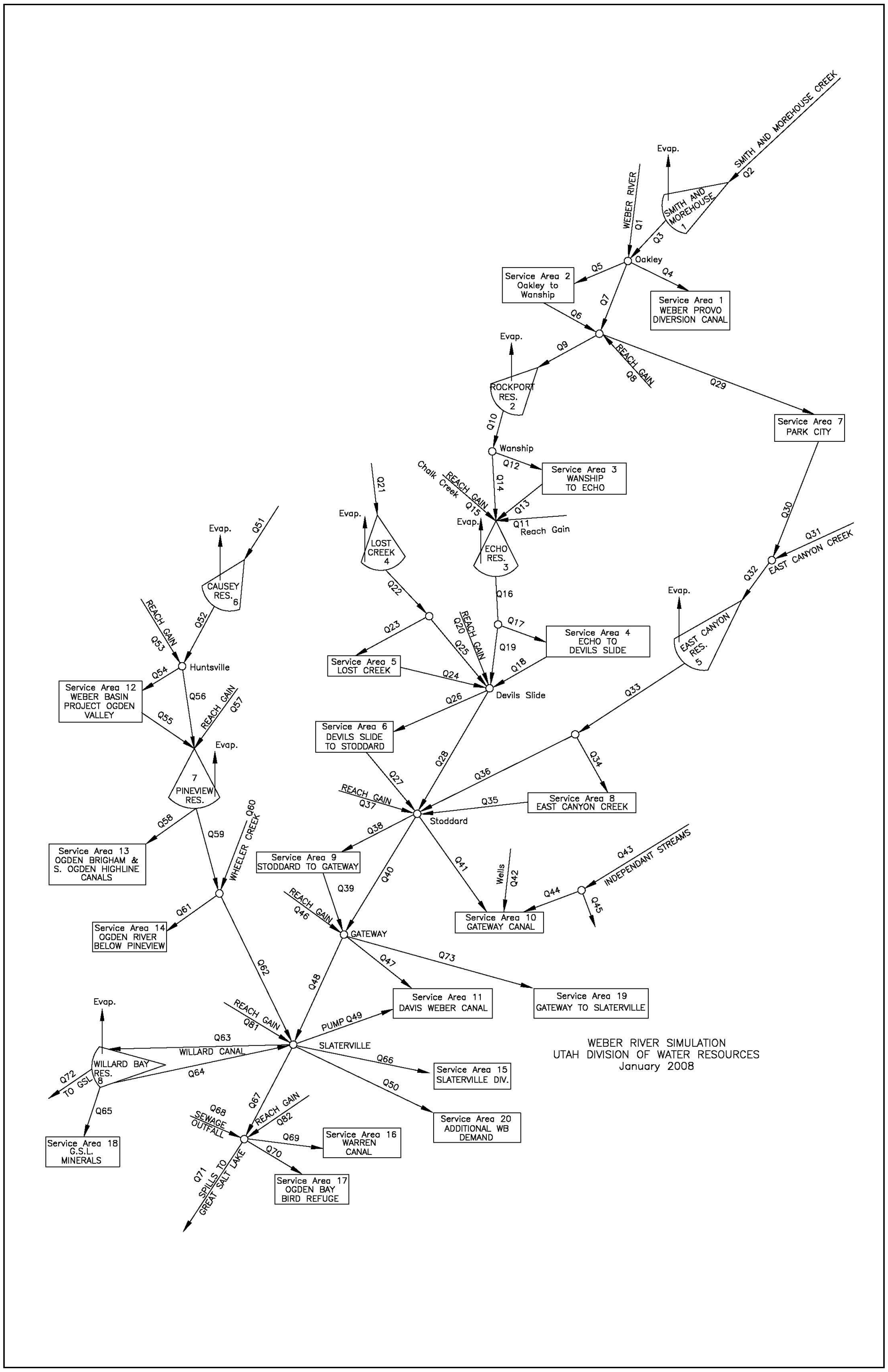
# APPENDICES

# APPENDIX A. FLOW CHART OF RESEARCH METHODOLOGY



# APPENDIX B. WEBER BASIN MODEL NETWORK SCHEMATIC (UDWR, 2008)



## APPENDIX C. POTENTIAL DROUGHT MANAGEMENT ACTIONS

This appendix describes and characterizes potential actions WBWCD can implement to manage for droughts. Short-term actions which tend to have lower operating costs, do not require significant advance planning, and can be implemented on an as-needed basis as (or after) a drought begins are presented in Table C1. Long-term actions which generally require large capital costs and significant advance planning (long before a drought is declared) are presented in Table C2. Work is ongoing to fully characterize actions, including capital costs, operating costs, and effective water volume added or saved. Much more progress has been made in characterizing long-term than short-term actions.

**Table C1. Potential Short-Term Drought Management Actions for WBWCD**

| Action | Effective Volume | O&M Cost | Notes | Reference |
|---|---|---|---|---|
| **1. Reservoir storage carryover:** Currently WBWCD carries over 50% of their storage to the next water year. Effective volume to be determined through simulation of different carryover storage policies. | Info not acquired yet. | Info not acquired yet. | O&M costs likely to be little to none, as storage carryover will require same volume of operations as regular releases. | |
| **2. Cutback:** Putting in place an agreement with water contracting entities to cutback from the contracted volume of water in response to drought mitigation. It requires identification of areas/contractors from which to cutback an agreed upon volume of water. | Info not acquired yet. | Info not acquired yet. | | |
| **3. Exchange/Trades:** Arranging an agreement to exchange/trade a specified quantity of water during times of shortages such as drought between water users. It requires identification of potential water users that can enter into such kind of an arrangement. | Info not acquired yet. | Info not acquired yet. | Effective volumes and costs specified in trade/exchange contracts provided by WBWCD. | |

## Table C2. Potential Long-Term Drought Management Actions for WBWCD

| Action | Effectiveness Volume/Time | Capital Cost | O & M Cost | Notes | Reference |
|---|---|---|---|---|---|
| 1. **Municipal and Industrial Water Conservation:** *reduce 2000 per capita water demand from public community system by at least 25% before 2050)* | The effectiveness of this action can be measured by comparing the volume of water conserved per unit time against all the costs associated with it in that time interval. | Info not acquired yet. | Info not acquired yet. | In the WRB a substantial progress has been achieved in conserving potable water. However collected data show an increase on the usage of secondary water. | (UDWR 2009) |
| 2. **Agricultural Water Transfers:** As a piece of irrigated agricultural land is urbanized, the water associated with it becomes available for use. | Effectiveness to be assessed once site specific relevant information is available. | Info not acquired yet. | Info not acquired yet. | The UDWR document has estimates on how much water can be converted to M&I uses. However, the special location of the estimated water is yet to be discovered. | (UDWR 2009) |
| 3. **Aquifer Storage and Recovery:** recharge a selected aquifer during times of excess surface water. The water becomes available by pumping during shortages. | Is expensive and can only be used to provide drinking water. WBWCD has a pilot project. Its effectiveness will be assessed when more information is available. | $137,500/Acres (based on the pilot project run by WBWCD) | Info not acquired yet. | Should ASR prove promising , it will be important to determine how much water can be recovered for each cubic meter of water recharged. | (UDWR 2009) |
| 4. **Water Reuse:** non-drinking water purposes may be met by water recycling. | There is high potential for water reuse in the WRB but it is not in practice as yet. Its effectiveness is, therefore, not yet explored…I will try to explore this action | Info not acquired yet. | Info not acquired yet. | Under Utah law, waste water can be treated to two levels for reuse (Type-I and Type-II). Gray water recycling and rainwater harvesting are also other forms of water reuse. | (UDWR 2009) |
| 5. **Kanesville Secondary Irrigation Project:** WBWCD purchased the Kanesville Irrigation company and now has access to its water rights. | The project is in the process of development. This study should be able to explore this option as feasible source of water. | $29 million upon full development | Info not yet acquired | Upon built-out, a total of 11,700 acres will be irrigated by the secondary system | (UDWR 2009) |

### Table C2. Potential Long-Term Drought Management Actions for WBWCD (continued)

| Action | Effectiveness Volume/Time | Capital Cost | O & M Cost | Notes | Reference |
|---|---|---|---|---|---|
| **6. Synderville Basin and Park City Area Projects:** includes studies and proposals that boost the water supply in these areas have been completed. | Info not acquired yet. | According to Synderville Basin Water Reclamation District (SBWRD) the whole project will cost $63 million. | Info not yet acquired | | (UDWR 2009) |
| **7. Bear River Project:** the WBWCD is entitled to 50,000 acre-feet from the Bear River. (Bear River Development Act, 1991). Diversion to Willard Bay still needs to be built. | Info not acquired yet. | The total cost of the project is estimated to be $1.3 billion. | Info not yet acquired | This is considered as the ultimate remaining water source in the district. This project benefits other districts as well such as Jordan Valley Water Conservancy District (JVWCD), and Bear River Water Conservancy District and Cache County water users. | (UDWR 2009) |
| **8. Weather Modification:** cloud seeding projects to induce precipitation. | The action has been proven to be very effective way of increasing water supply from observation made on West Unitas area. From its application has resulted 7% above historical runoff in the seeded areas. It is estimated that the cost due to cloud seeding to be about $1.69 per acre-foot. | In 2006, cloud seeding in West Unitas area costed $46,811. WBWCD's share was $22,049. | Info not yet acquired | It remains to be ascertained whether current cloud seeding are fully fledged or experimental… | (UDWR 2009) |
| **9. Upgrading & Enhancing Existing Infrastructure:** this action may reduce wastage due to leakage and increase the system's capacity. | Effectiveness?? | Info not yet acquired | Info not yet acquired | | (UDWR 2009) |

# 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:** | 2009UT130B |
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| **Research Category:** | Engineering |
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| **Descriptors:** | None |
| **Principal Investigators:** | Blake P. Tullis, Steven L. Barfuss, Mac McKee, Gary P. Merkley |

## Publications

There are no publications.

# 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 of water to the end-user. Real-time, accurate, flow measurement data should help in making sound water management decisions and in meeting water delivery obligations. Most Distribution Systems have some means of flow measurement such as flumes, weirs, rated sections, etc. However, many of those structures are often constructed incorrectly (e.g., out-of-level, incorrect dimensions, and/or incorrectly located staff gage), suffer maintenance deficiencies that affect the calibration , or there is a lack of communication between those who develop the head-discharge relationship for the structure and those who apply those relationships. These common problems often result in flow measurement errors where the expected amount of water is not what is available. In short, the objective of the study was to inspect flow measurement structures, identify and correct any deficiencies wherever possible, check the structure calibration, and assist to make the flow rate data for sites with data logging and telemetry systems already in place available online in real time.

The Upper Bear Distribution System in Randolf, UT agreed to participate in this study. Nine flow measurement structures in this Northern Utah system were evaluated and field calibrated. This report contains the study findings, which include a list of corrective actions that were recommended/implemented for the flow measurement structures and recommendations for additional work.


# INTRODUCTION

Accuracy in flow measurement, distribution, and a metric for evaluating the impact on agricultural productivity are essential for effective basin-wide water resource management. Real-time data access 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 build up of the flume or canal, incorrect reference datum for flow depth measurements, an out-of-level structure, or incorrect geometry. Another factor could be that those who maintain the structure do not understand the relationship between flow measurement accuracy and specific operational and maintenance issues.

Nine flow measurement structures were inspected for installation and maintenance problems, corrective actions were identified where appropriate, and a field calibration was performed and compared with the head-discharge tables or formula for each structure. A copy of this project report was provided to the river commissioner. All nine of the inspected flow measurement structures had a telemetry based data acquisition system in place. We assisted in troubleshooting and resolving problems they were experiencing with their telemetry system. Datalogger programs were updated to reflect the corrections that were made in head-discharge relationships and improved the accuracy of the measurement sites. The real-time flows and other related data are located at *www.bearriverbasin.org.*

## 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 and the resources to implement such a system), 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 River Commissioner. |
| 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 River Commissioner was invited to participate in the generation of the final report as a reviewer. |
| 5. Provide training where appropriate to improve system maintenance and reliability. | Where system improvements were identified, training (where appropriate) was provided by the research team to the River Commissioner 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, additional studies with other systems have been or will be proposed. |

## STUDY RESULTS

### *Finding a State Distribution System*

Based on Ron Hoffman's (Upper Bear River Commissioner) expressed interest in participating in the project and its close proximity to Logan, UT, the Upper Bear Distribution System (Randolph, UT) was selected as the project case study.

### *Data Collection*

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

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

2. The flume width was measured (all flow measurement structures were ramp flumes). 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 head-discharge tables or equations currently in use. Due to the considerable distance between the upstream control structure and the measurement structures that was often encountered and the time consuming nature of making flow adjustments to large water conveyance systems, only a limited number of field calibration flow conditions were evaluated for each structure.

Table 2. Upper Bear Flow Measurement Structures that were Inspected and Calibrated.

| Structure Name | Type | Size |
|---|---|---|
| Bear River Canal | Pre-fabricated Steel Ramp Flume | 120 cfs, 9.5' wide |
| Booth | Pre-fabricated Steel Ramp Flume | 40 cfs, 3.17' wide |
| BQ West Side UT | Concrete Ramp Flume | 225 cfs, 20' wide |
| Crawford Thompson | Pre-fabricated Steel Ramp Flume | 180 cfs, 14.25'wide |
| Francis Lee (Upper) | Pre-fabricated Steel Ramp Flume | 80 cfs, 6.33' wide |
| McMinn | Pre-fabricated Steel Ramp Flume | 100 cfs, 8' wide |
| Neville | Pre-fabricated Steel Ramp Flume | 10 cfs, 3' wide |
| R & W | Concrete Ramp Flume | 275 cfs, 36' wide |
| Sage Creek | Concrete Ramp Flume | 250 cfs, 24' wide |

Head-discharge relationships for ramped flumes are typically predicted using a software program called *Winflume*, developed by the U.S. Bureau of Reclamation. *Winflume* head-discharge equations are based on the assumption that the ramp flume is installed level and is geometrically correct (relative to the input data used with *Winflume*).

Elevation data were measured at the inlet, outlet, crest, and staff gauge location using a SOKKIA surveying level and measuring rod.

The ramp flume discharge relationship is based on the upstream flow depth measured relative to the crest elevation and the flume width. Consequently, the accuracy of the flow rate measurement is dependent upon the accuracy to which the upstream flow depth staff gage correctly references the flume crest.

Field calibrations were conducted as follows: A calibration cross section was selected, typically just downstream of the flume inlet 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. In cases where the depth was less than 2.5 ft, the flow velocity was measured in each subsection using a velocity probe located at 6/10$^{ths}$ of the flow depth from the channel bottom. Where the depth exceeded 2.5 ft, the flow velocity was measured at 2/10$^{ths}$ and 8/10$^{ths}$ from the bottom and the velocity was taken as the average of the two measurements. 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.

$$Q = \sum_{i=1}^{n} Q_i = \sum_{i=1}^{n} V_i y_i w_i \tag{1}$$

In Equation 1, $Q$ is the total field-measured 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.

Two different current meters were used for calibration work. 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.

### *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, the location and/or the flume was installed or constructed out of level, and moss and other sediment clogged the channel. 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.

One problem encountered with three of the flumes was that there was a large concentration of algal growth downstream of the ramp, which caused the flume to become submerged. Submergence occurs when the tailwater backs up to the point where it is above the height of the ramp of the flume. The equations used to describe the flumes were based off of non-submerged flow conditions. When the flume became submerged, large errors were introduced and the equation no longer accurately described the flow. In these instances, a new equation was generated based off of the measured data to account for this submergence. It should be noted that due to the nature of submerged flow conditions, the recommended equation only represents an estimate of the flow. Flow could be determined accurately by either direct measurement or a new equation could be generated based on the level of submergence on the flume. In either case it is recommended that a more in-depth field calibration be performed for each of the flumes to better define the head-discharge equation.

There is no easy correction for an out-of-level flume. Corrections would require excavation of the existing flume to level the subgrade and provide an adequate base for the flume to sit on for the pre-fabricated flumes, and reconstruction of the concrete type flumes to achieve the desired results. Consequently, the published head-discharge data must be replaced with a custom head-discharge relationship based on field calibration data.

### *Specific Findings*

The specific findings of the individual flow measurement structure inspections are presented in separate summaries located in the Appendix. The data presented includes the name, type of flume, width, type of instrumentation, upstream approach condition, staff gage crest correction factor ($\Delta Z$), equations that describe the structure-specific head-discharge relationship, observations, and the flow calibration data and graph. Two types of staff gages were used: flow depth staff gages (head gages) that measure in feet, and flow rate staff gauges (flow gages) that indicate flow rate in cubic feet per second based on the flow depth. Each structure had at least one type of staff gage, if not both. The crest correction factor is the distance between the crest elevation and the staff gage zero. The recommended head-discharge relationship is the equation that was most accurate. In most cases, it is the current or existing head-discharge equation modified with the crest correction factor. For three of the flumes, the existing equation did not fit the field calibration data and a new recommended equation was developed.

Several flow rate values are presented in the field calibration data. $Q_{actual}$ is the flow rate corresponding to the field calibration. $h_a$ is the water depth measured from the flow depth staff gage (wherever present). $Q_{predicted}$ represents the flow calculated from $h_a$ using the current equation. $Q_{gage}$ is the flow that was read off of the flow rate staff gages (wherever present). $Q_{corrected}$ is calculated using the same equation as $Q_{predicted}$, however $h_{corrected}$ which equals $h_a + \Delta Z$, is used instead of $h_a$. In some cases, $Q_{new\ equation}$ is calculated from the recommended equation and $h_{corrected}$.

## CORRECTIVE ACTIONS

The most common problem that required a corrective action was the staff gage zero didn't correspond to the flume crest elevation. For each case, a crest correction factor ($\Delta Z$) was determined using surveying equipment consistent with the reference offset. In instances where the crest correction factor improved the accuracy of the predicted discharge, it was included in the recommended head-discharge relationship.

For the Bear River Canal, BQ West Side Utah, and Neville flumes, the equation currently used to describe the flow correlated poorly with the field-measured flow rates. In most cases, adding the crest correction factor to the measured head provided only a modest improvement in the discharge predictive accuracy, with $Q_{corrected}$ still varying significantly from $Q_{actual}$ (up to ~ 80%). A new head-discharge relationship was developed from the field calibration data collected. It is recommended that a more in-depth field calibration be performed for each of the flumes mentioned above to better define the head-discharge equation.

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

## TRAINING

The findings of this study were shared at the annual meeting of the Upper Bear River Distribution System and specifically with Ron Hoffman, the Water Commissioner. The recommended head-discharge relationships, the specific findings and the corrective actions recommended for each structure, and the need for additional work was reviewed.

## CONCLUSIONS

Nine ramp flumes in the Upper Bear River Distribution System were inspected and field calibrated. In general, most flumes were slightly out of level and the staff gages were not accurately 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 ($Q_{predicted}$ and $Q_{corrected}$) were compared to the standard calibration for that flow measurement device.

With the exception of three flumes that needed new head-discharge relationships, the correlation between $Q_{actual}$ and $Q_{corrected}$ was good, with errors < 15%.  In instances where a new equation was generated, errors ranged from 0 – 7%.

## APPENDIX

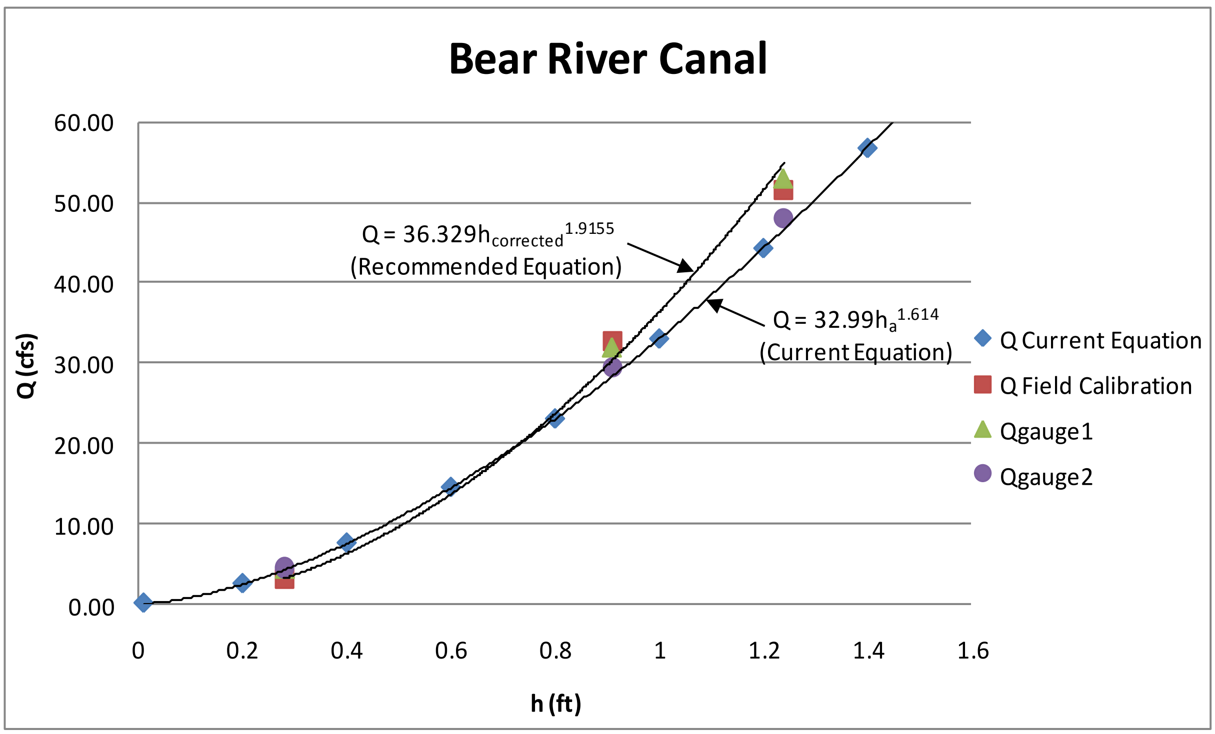
## INSPECTION AND CALIBRATION DATA

| | |
|---|---|
| Name: | Bear River Canal |
| Irrigation Co.: | Upper Bear Distribution |
| Type: | Ramp (Prefabricated) |
| Width (W): | 9.5 ft |
| Instrumentation: | Two flow gauges<br>One head gauge |
| Approach: | Straight Channel |
| Crest Correction Factor ($\Delta Z$): | -0.001 ft |
| Current Equation: | $Q = 32.99h^{1.614}$ |
| Recommended Equation: | $Q = 36.329(h - 0.001)^{1.9155}$ |

| | |
|---|---|
| Observations: | • Flume is in good condition.<br>• Approach channel elevation (deviation from average): +0.02"/-0.04".<br>• Crest elevation (deviation from average): +0.31"/-0.35".<br>• Ramp was initially covered in moss, which was scraped off prior to taking measurements.<br>• The staff gage offset relative to the crest elevation was small ($\Delta Z$ = -0.001 ft), consequently $Q_{corrected}$ ~ $Q_{predicted}$. $Q_{corrected}$, however, varied significantly from $Q_{actual}$ (up to ~ 36%). A new head-discharge relationship is presented based on the limited data collected. This recommended equation is accurate only up to the highest flow measured (51.57 cfs). A more extensive field calibration should be performed to better understand the behavior across the full range of flow rates.<br>• $Q_{gage1}$ is more accurate than $Q_{gage2}$ (3% vs. 10%, respectively), compared to $Q_{actual}$. Both gages produce large errors (~45%), however, at low flow rates ($Q$ = 3 cfs). $Q_{new\ equation}$ has an uncertainty of up to 7% over the full range of discharges evaluated. |

| $Q_{actual}$ [a] | $h_a$ | $Q_{predicted}$ [b] | $Q_{gage1}$ [c] | $Q_{gauge2}$ [c] | $Q_{corrected}$ [d] | $Q_{new\ equation}$ [e] |
|---|---|---|---|---|---|---|
| (cfs) | (ft) | (cfs) | (cfs) | (cfs) | (cfs) | (cfs) |
| 51.57 | 1.24 | 46.68 | 53.00 | 48.00 | 46.63 | 54.78 |
| | *% error for $Q_{actual}$* | *9.48%* | *-2.77%* | *6.93%* | *9.58%* | *-6.22%* |
| 32.67 | 0.91 | 28.33 | 32.00 | 29.50 | 28.29 | 30.27 |
| | *% error for $Q_{actual}$* | *13.28%* | *2.05%* | *9.70%* | *13.41%* | *7.34%* |
| 3.10 | 0.28 | 4.23 | 4.50 | 4.50 | 4.21 | 3.15 |
| | *% error for $Q_{actual}$* | *-36.19%* | *-44.96%* | *-44.96%* | *-35.54%* | *-1.59%* |

[a] $Q_{actual}$ is the flow measured in the field
[b] $Q_{predicted}$ is calculated using $h_a$ and the current equation
[c] $Q_{gage1}$ and $Q_{gage2}$ were read off of the flow gauges in the field
[d] $Q_{corrected}$ is calculated using $h_{corrected}$ and the current equation
[e] $Q_{new\ equation}$ is calculated using $h_{corrected}$ and the recommended equation

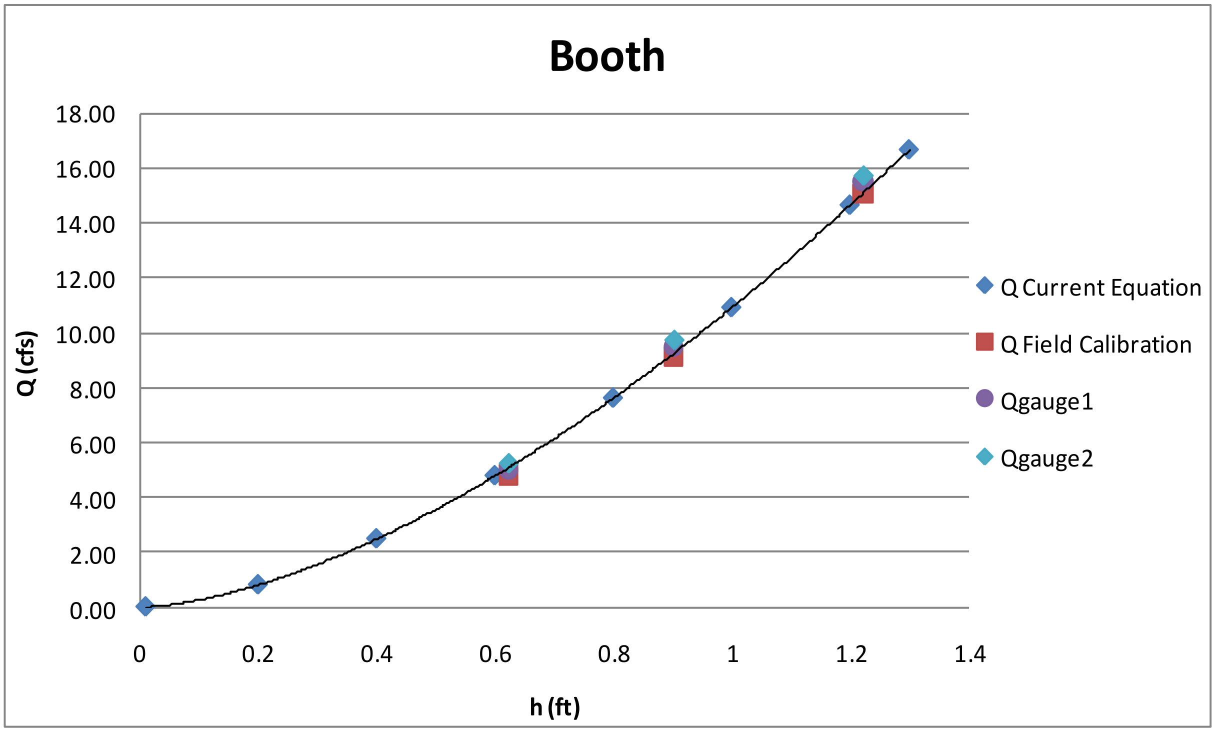


| | |
|---|---|
| Name: | Booth |
| Irrigation Co.: | Upper Bear Distribution |
| Type: | Ramp (Prefabricated) |
| Width (W): | 38 in |
| Instrumentation: | Two flow gauges<br>One head gauge |
| Approach: | Straight Channel |
| Crest Correction Factor (*ΔZ*): | -0.019 ft |
| Recommended Equation: | $Q = 10.92(h-0.019)^{1.613}$ |

| | |
|---|---|
| Observations: | • Large step in the upstream approach, but it doesn't seem to impact the water level at staff gage.<br>• Approach channel elevation (deviation from average): +0.12"/-0.12".<br>• Crest elevation (deviation from average): +0.105"/-0.135".<br>• Ramp is reasonably free from moss and sediment buildup.<br>• $Q_{gauge1}$ and $Q_{gauge2}$ are approximately equal to $Q_{actual}$, with $Q_{gauge1}$ being more accurate than $Q_{gauge2}$ (4% vs. 9%, respectively). $Q_{corrected}$, calculated from $h_a$ and the crest correction factor ($\Delta Z$) gives the more accurate measurements across the range of flow rates. |

| $Q_{actual}$[a] | $h_a$ | $Q_{predicted}$[b] | $Q_{gauge1}$[c] | $Q_{gauge2}$[c] | $Q_{corrected}$[d] |
|---|---|---|---|---|---|
| (cfs) | (ft) | (cfs) | (cfs) | (cfs) | (cfs) |
| 9.13 | 0.92 | 9.55 | 9.50 | 9.75 | 9.23 |
| | *% error for $Q_{actual}$* | *-4.52%* | *-4.02%* | *-6.75%* | *-1.10%* |
| 4.82 | 0.64 | 5.32 | 5.00 | 5.25 | 5.07 |
| | *% error for $Q_{actual}$* | *-10.22%* | *-3.67%* | *-8.85%* | *-5.06%* |
| 15.07 | 1.24 | 15.45 | 15.50 | 15.75 | 15.07 |
| | *% error for $Q_{actual}$* | *-2.49%* | *-2.83%* | *-4.49%* | *0.00%* |

[a] $Q_{actual}$ is the flow measured in the field
[b] $Q_{predicted}$ is calculated using $h_a$ and the current equation
[c] $Q_{gauge1}$ and $Q_{gauge2}$ were read off of the flow gauges in the field
[d] $Q_{corrected}$ is calculated using $h_{corrected}$ and the current equation

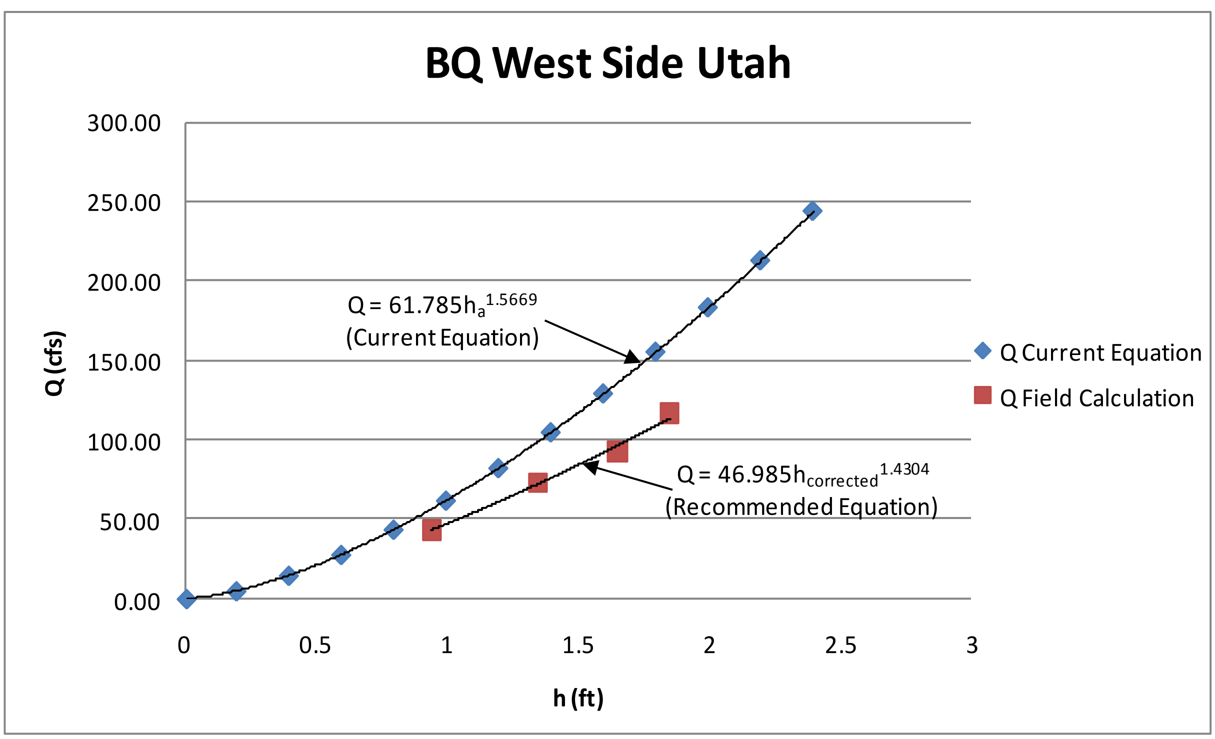


| | |
|---|---|
| Name: | BQ West Side Utah |
| Irrigation Co.: | Upper Bear Distribution |
| Type: | Ramp (Concrete) |
| Width (W): | 20 ft |
| Instrumentation: | One head gauge |
| Approach: | Straight Channel |
| Crest Correction Factor (*ΔZ*): | -0.029 ft |
| Current Equation: | $Q = 61.785h^{1.5669}$ |
| Recommended Equation: | $Q = 46.985(h - 0.029)^{1.4304}$ |

| | |
|---|---|
| Observations: | • Approach channel elevation (deviation from average): +0.06”/-0.12”.<br>• Crest elevation (deviation from average): +0.435”/-0.465”.<br>• Ramp was initially covered in moss, which was scraped off prior to taking measurements.<br>• A fence spanning the channel is located a short distance downstream that can cause submergence problems.<br>• $Q_{corrected}$ varied significantly from $Q_{actual}$ (up to ~ 46%). A new head-discharge relationship is presented based on the limited data collected. This recommended equation is accurate only up to the highest flow measured (116.56 cfs). A more extensive field calibration should be performed to better understand the behavior across the full range of flow rates.<br>• The recommended equation should be used when operating under submerged conditions. Using this equation and the current staff gauge, the flow rate can be calculated with minimal error (up to ~ 4%). |

| $Q_{actual}$[a] | $h_a$ | $Q_{predicted}$[b] | $Q_{corrected}$[c] | $Q_{new\ equation}$[d] |
|---|---|---|---|---|
| (cfs) | (ft) | (cfs) | (cfs) | (cfs) |
| 116.56 | 1.88 | 166.13 | 162.17 | 113.38 |
| | % error for $Q_{actual}$ | -42.53% | -39.13% | 2.73% |
| 92.59 | 1.68 | 139.29 | 135.57 | 96.28 |
| | % error for $Q_{actual}$ | -50.44% | -46.43% | -3.98% |
| 72.54 | 1.38 | 101.76 | 98.45 | 71.89 |
| | % error for $Q_{actual}$ | -40.28% | -35.71% | 0.90% |
| 43.19 | 0.97 | 58.91 | 56.19 | 43.09 |
| | % error for $Q_{actual}$ | -36.39% | -30.11% | 0.23% |

[a] $Q_{actual}$ is the flow measured in the field
[b] $Q_{predicted}$ is calculated using $h_a$ and the current equation
[c] $Q_{corrected}$ is calculated using $h_{corrected}$ and the current equation
[d] $Q_{new\ equation}$ is calculated using $h_{corrected}$ and the recommended equation

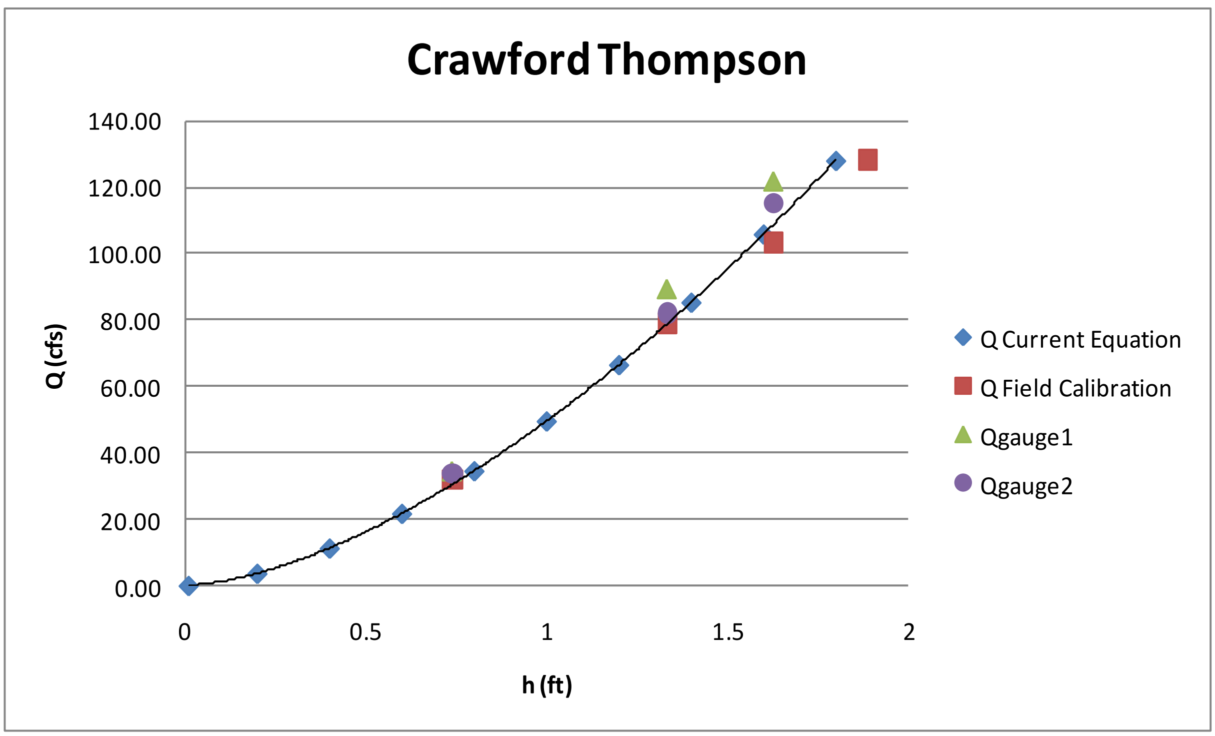


| | |
|---|---|
| Name: | Crawford Thompson |
| Irrigation Co.: | Upper Bear Distribution |
| Type: | Ramp (Prefabricated) |
| Width (W): | 14.35 ft |
| Instrumentation: | Two flow gauges<br>One head gauge |
| Approach: | Straight Channel |
| Crest Correction Factor (*ΔZ*): | - 0.051 ft |
| Recommended Equation: | $Q = 49.54h^{1.614}$ |

| | |
|---|---|
| Observations: | • Approach channel elevation (deviation from average): +0.2”/-0.16”.<br>• Crest elevation (deviation from average): +0.71”/-0.25”.<br>• Water surface dips just before the staff gauge at high flows.<br>• Ramp is reasonably free from moss and sediment buildup.<br>• $Q_{gauge1}$ and $Q_{gauge2}$ estimate the flow higher compared to $Q_{actual}$, with $Q_{gauge2}$ being more accurate than $Q_{gauge1}$ (13% vs. 18%, respectively). $Q_{corrected}$, calculated from $h_a$ and the crest correction factor ($\Delta Z$) gives the most accurate measurements across the range of flow rates (up to ~ 8%). |

| $Q_{actual}$ [a] | $h_a$ | $Q_{predicted}$ [b] | $Q_{gauge1}$ [c] | $Q_{gauge2}$ [c] | $Q_{corrected}$ [d] |
|---|---|---|---|---|---|
| (cfs) | (ft) | (cfs) | (cfs) | (cfs) | (cfs) |
| 128.11 | 1.94 | 144.37 | 150.00 | 145.00 | 138.29 |
| | *% error for* $Q_{actual}$ | *-12.69%* | *-17.08%* | *-13.18%* | *-7.94%* |
| 103.37 | 1.68 | 114.45 | 122.00 | 115.00 | 108.89 |
| | *% error for* $Q_{actual}$ | *-10.72%* | *-18.03%* | *-11.26%* | *-5.35%* |
| 78.98 | 1.39 | 83.80 | 89.50 | 82.00 | 78.88 |
| | *% error for* $Q_{actual}$ | *-6.10%* | *-13.31%* | *-3.82%* | *0.13%* |
| 31.72 | 0.79 | 33.86 | 34.50 | 33.50 | 30.41 |
| | *% error for* $Q_{actual}$ | *-6.76%* | *-8.77%* | *-5.61%* | *4.14%* |

[a] $Q_{actual}$ is the flow measured in the field
[b] $Q_{predicted}$ is calculated using $h_a$ and the current equation
[c] $Q_{gauge1}$ and $Q_{gauge2}$ were read off of the flow gauges in the field
[d] $Q_{corrected}$ is calculated using $h_{corrected}$ and the current equation



| | |
|---|---|
| Name: | Francis Lee (Upper) |
| Irrigation Co.: | Upper Bear Distribution |
| Type: | Ramp (Prefabricated) |
| Width (W): | 6.35 ft |
| Instrumentation: | Two flow gauges |
| Approach: | Straight Channel |
| Crest Correction Factor (*ΔZ*): | NA |
| Recommended Equation: | $Q = 0.3943h^{1.617}$ |

| | |
|---|---|
| Observations: | • Flume is in good condition<br>• Approach channel elevation (deviation from average): +0.18”/-0.18”<br>• Crest elevation (deviation from average): +0.14”/-0.17”<br>• Ramp is reasonably free from moss and sediment buildup<br>• $Q_{gauge2}$ is more accurate than $Q_{gauge1}$ (5.3% vs. 7.7%, respectively) and should be used when taking flow measurements. |

| $Q_{actual}$[a] | $Q_{gauge1}$[b] | $Q_{gauge2}$[b] |
|---|---|---|
| (cfs) | (cfs) | (cfs) |
| 13.00 | 14.00 | 13.00 |
| *% error for $Q_{actual}$* | *-7.72%* | *-0.02%* |
| 8.98 | 9.50 | 8.50 |
| *% error for $Q_{actual}$* | *-5.80%* | *5.33%* |

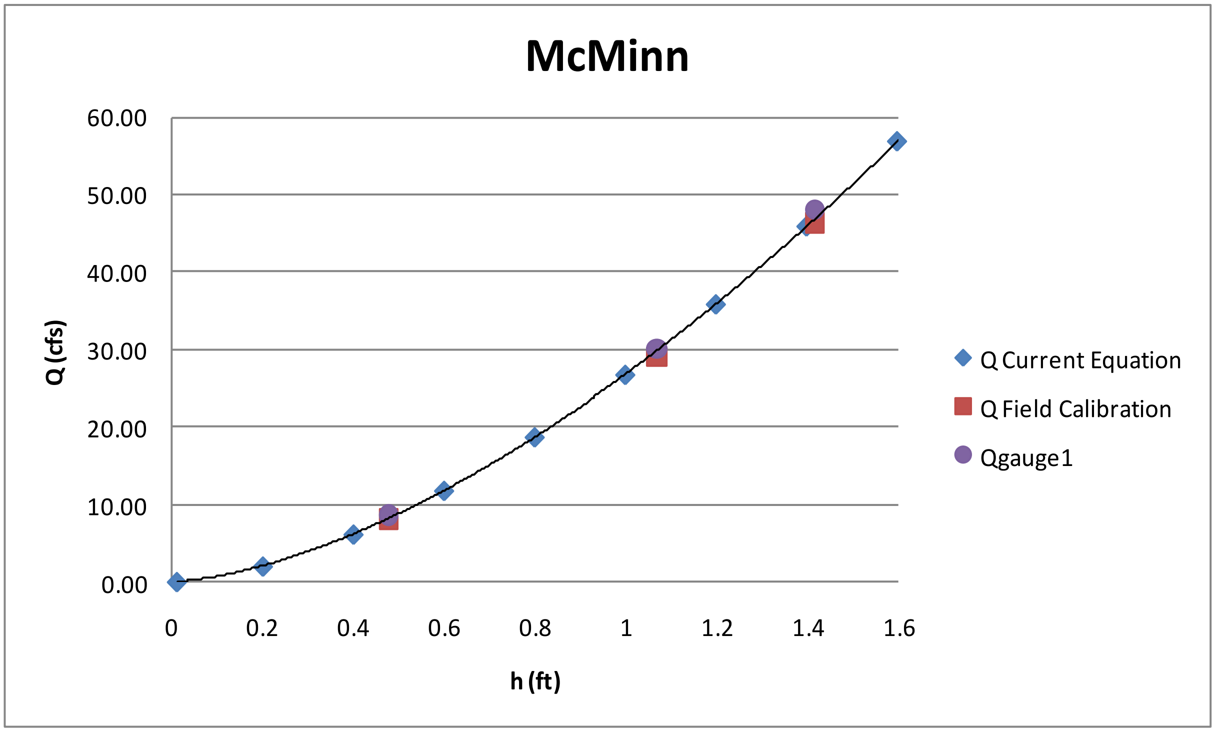
[a] $Q_{actual}$ is the flow measured in the field
[b] $Q_{gauge1}$ and $Q_{gauge2}$ were read off of the flow gauges in the field

| | |
|---|---|
| Name: | McMinn |
| Irrigation Co.: | Upper Bear Distribution |
| Type: | Ramp (Prefabricated) |
| Width (W): | 8 ft |
| Instrumentation: | One flow gauge<br>One head gauge |
| Approach: | Straight Channel |
| Crest Correction Factor ($\Delta Z$): | -0.022 ft |
| Recommended Equation: | $Q = 26.769(h-0.022)^{1.6054}$ |

| | |
|---|---|
| Observations: | • Flume is in good condition.<br>• Approach channel elevation (deviation from average): +0.08”/-0.10”.<br>• Crest elevation (deviation from average): +0.08”/-0.17”.<br>• Ramp is reasonably free from moss and sediment buildup.<br>• The staff gauge offset relative to the crest elevation was small ($\Delta Z$ = -0.022 ft), consequently<br>• $Q_{gauge1}$ ~ $Q_{predicted}$, however both vary slightly from $Q_{actual}$ (up to ~ 9% error at the lowest flow rate). $Q_{corrected}$ is the most accurate with errors up to ~ 2.4%. |

| $Q_{actual}$ [a] | $h_a$ | $Q_{predicted}$ [b] | $Q_{gauge1}$ [c] | $Q_{corrected}$ [d] |
|---|---|---|---|---|
| (cfs) | (ft) | (cfs) | (cfs) | (cfs) |
| 46.32 | 1.44 | 48.07 | 48.00 | 46.90 |
| | *% error for $Q_{actual}$* | *-3.77%* | *-3.62%* | *-1.24%* |
| 29.06 | 1.09 | 30.74 | 30.00 | 29.75 |
| | *% error for $Q_{actual}$* | *-5.77%* | *-3.22%* | *-2.38%* |
| 8.08 | 0.50 | 8.80 | 8.60 | 8.19 |
| | *% error for $Q_{actual}$* | *-8.93%* | *-6.49%* | *-1.36%* |

[a] $Q_{actual}$ is the flow measured in the field
[b] $Q_{predicted}$ is calculated using $h_a$ and the current equation
[c] $Q_{gauge1}$ was read off of the flow gauges in the field
[d] $Q_{corrected}$ is calculated using $h_{corrected}$ and the current equation

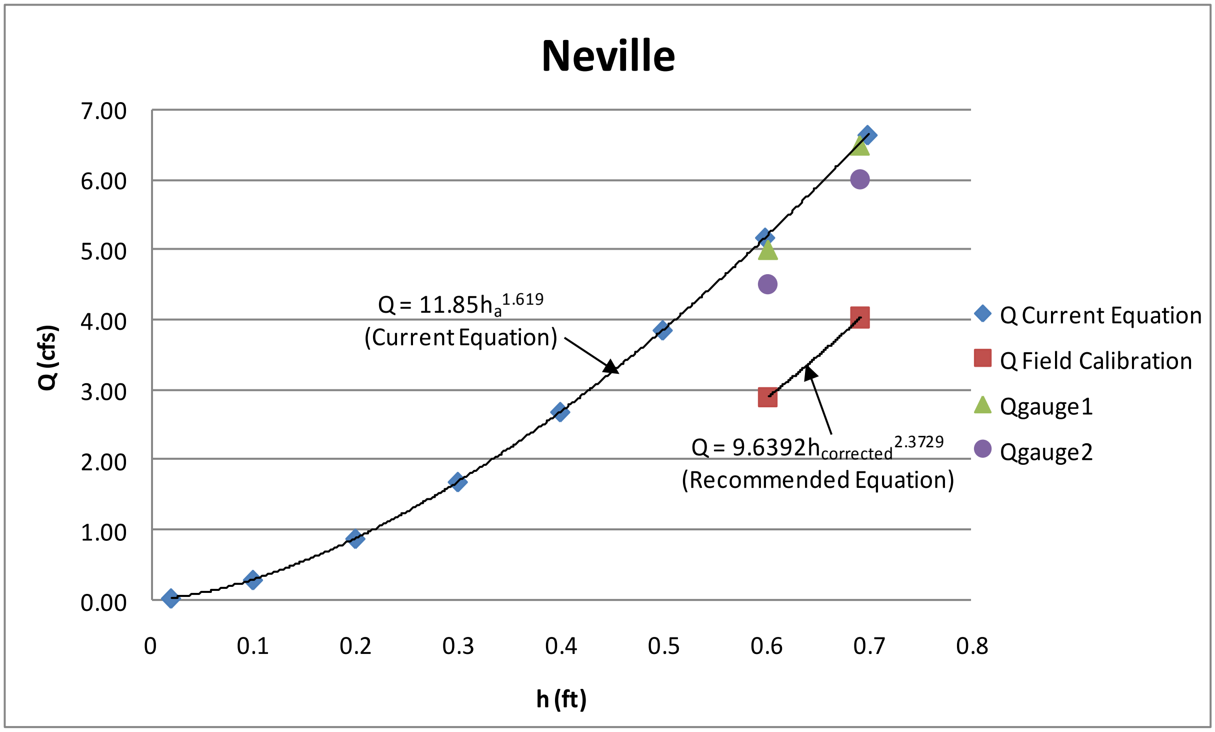


| | |
|---|---|
| Name: | Neville |
| Irrigation Co.: | Upper Bear Distribution |
| Type: | Ramp (Prefabricated) |
| Width (W): | 3 ft |
| Instrumentation: | Two flow gauges<br>One head gauge |
| Approach: | Straight Channel |
| Crest Correction Factor ($\Delta Z$): | + 0.002 ft |
| Current Equation: | $Q = 11.85h^{1.619}$ |
| Recommended Equation: | $Q = 9.6392(h + 0.002)^{2.3729}$ |

| | |
|---|---|
| Observations: | • Flume is in good condition.<br>• Approach channel elevation (deviation from average): +0.09”/-0.09”.<br>• Crest elevation (deviation from average): +0.05”/-0.08”.<br>• Ramp is reasonably free from moss and sediment buildup.<br>• The staff gauge offset relative to the crest elevation was small ($\Delta Z$ = +0.002 ft), consequently $Q_{corrected} \sim Q_{predicted}$. $Q_{corrected}$, $Q_{gauge1}$, and $Q_{gauge2}$ all varied significantly from $Q_{actual}$ (up to ~ 80%). A new head-discharge relationship is presented based on the limited data collected. This recommended equation is accurate only up to the highest flow measured (4.03 cfs). A more extensive field calibration should be performed to better understand the behavior across the full range of flow rates.<br>• Flume has problems with submergence. The recommended equation should be used when operating under a submerged condition.<br>• Using the recommended equation and the current staff gauge, the flow rate can be calculated with minimal error. |

| $Q_{actual}$ [a] | $h_a$ | $Q_{predicted}$ [b] | $Q_{gauge1}$ [c] | $Q_{gauge2}$ [c] | $Q_{corrected}$ [d] | $Q_{new\ equation}$ [e] |
|---|---|---|---|---|---|---|
| (cfs) | (ft) | (cfs) | (cfs) | (cfs) | (cfs) | (cfs) |
| 4.03 | 0.69 | 6.50 | 6.50 | 6.00 | 6.54 | 4.03 |
| | *% error for $Q_{actual}$* | *-61.23%* | *-61.26%* | *-48.86%* | *62.17%* | *0.00%* |
| 2.90 | 0.60 | 5.18 | 5.00 | 4.50 | 5.22 | 2.90 |
| | *% error for $Q_{actual}$* | *-78.91%* | *-72.61%* | *-55.35%* | *80.12%* | *0.00%* |

[a] $Q_{actual}$ is the flow measured in the field
[b] $Q_{predicted}$ is calculated using $h_a$ and the current equation
[c] $Q_{gauge1}$ and $Q_{gauge2}$ were read off of the flow gauges in the field
[d] $Q_{corrected}$ is calculated using $h_{corrected}$ and the current equation
[e] $Q_{new\ equation}$ is calculated using $h_{corrected}$ and the recommended equation

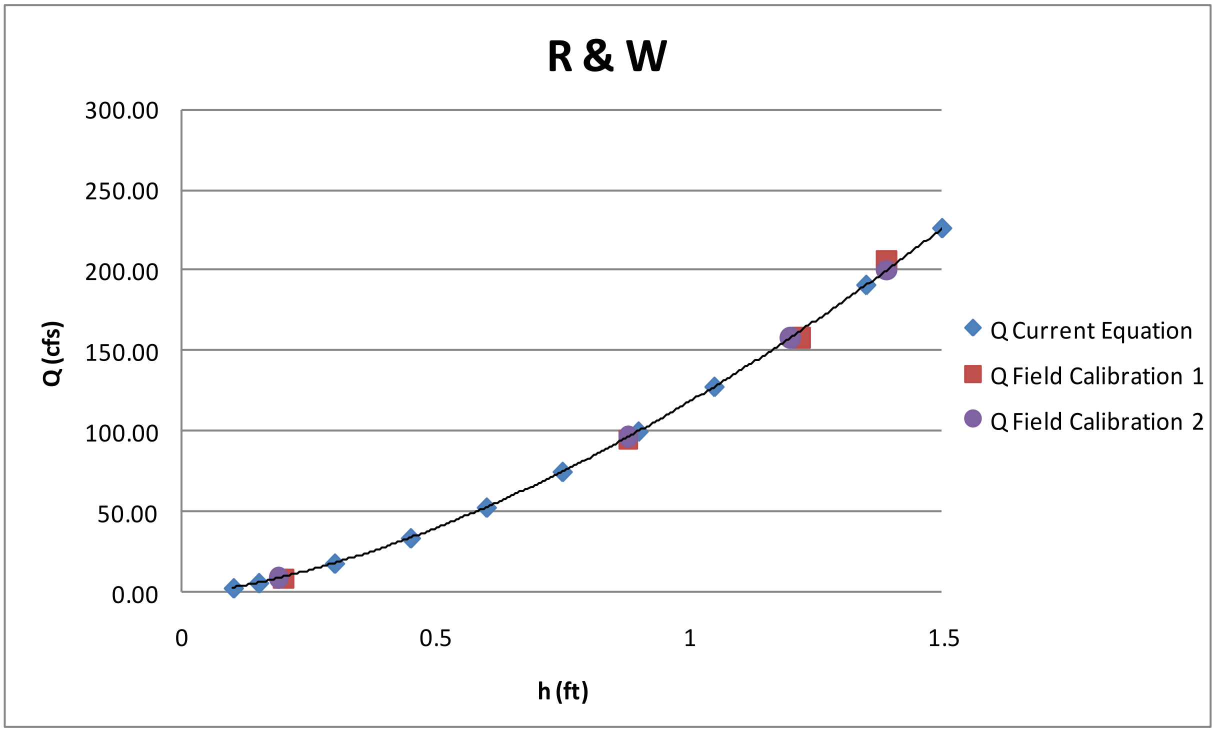


| | |
|---|---|
| Name: | R & W |
| Irrigation Co.: | Upper Bear Distribution |
| Type: | Ramp (Concrete) |
| Width (W): | 36 ft |
| Instrumentation: | Two flow gauges |
| Approach: | Straight Channel |
| Crest Correction Factor (*ΔZ*): | + 0.004 ft |
| Recommended Equation: | $Q = -2.6732 + 41.066h + 94.815h^2 + -19.108h^3 + 4.3149h^4 - 0.463h^5$ |

| | |
|---|---|
| Observations: | • Flume is in good condition.<br>• Approach channel elevation (deviation from average): +0.04"/-0.02".<br>• Crest elevation (deviation from average): +0.31"/-0.17".<br>• Ramp is reasonably free from moss and sediment buildup.<br>• The staff gauge offset relative to the crest elevation ($\Delta Z$ = +0.004 ft) did nothing to improve the accuracy over the range of flows. $h_{a1} \sim h_{a2}$, with $h_{a2}$ being more accurate (up to ~ 2% error for $Q_{predicted2}$ vs. up to ~ 11% error for $Q_{predicted1}$). |

| $Q_{actual}$ [a] | $h_{a1}$ | $Q_{predicted1}$ [b] | $h_{a2}$ | $Q_{predicted2}$ [c] | $Q_{corrected1}$ [d] | $Q_{corrected2}$ [e] |
|---|---|---|---|---|---|---|
| (cfs) | (ft) | (cfs) | (ft) | (cfs) | (cfs) | (cfs) |
| 8.26 | 0.20 | 9.19 | 0.19 | 8.43 | 9.51 | 9.51 |
| | *% error for $Q_{actual}$* | *-11.17%* | | *-1.97%* | *-15.06%* | *-15.06%* |
| 94.82 | 0.88 | 96.21 | 0.88 | 96.21 | 96.94 | 96.94 |
| | *% error for $Q_{actual}$* | *-1.46%* | | *-1.46%* | *-2.23%* | *-2.23%* |
| 158.05 | 1.22 | 162.16 | 1.20 | 157.92 | 163.05 | 163.05 |
| | *% error for $Q_{actual}$* | *-2.60%* | | *0.08%* | *-3.16%* | *-3.16%* |
| 206.03 | 1.39 | 199.99 | 1.39 | 199.99 | 200.95 | 200.95 |
| | *% error for $Q_{actual}$* | *2.93%* | | *2.93%* | *2.46%* | *2.46%* |

[a] $Q_{actual}$ is the flow measured in the field
[b] $Q_{predicted1}$ is calculated using $h_{a1}$ and the current equation
[c] $Q_{predicted2}$ is calculated using $h_{a2}$ and the current equation
[d] $Q_{corrected1}$ is calculated using $h_{corrected1}$ and the current equation
[e] $Q_{corrected2}$ is calculated using $h_{corrected2}$ and the current equation

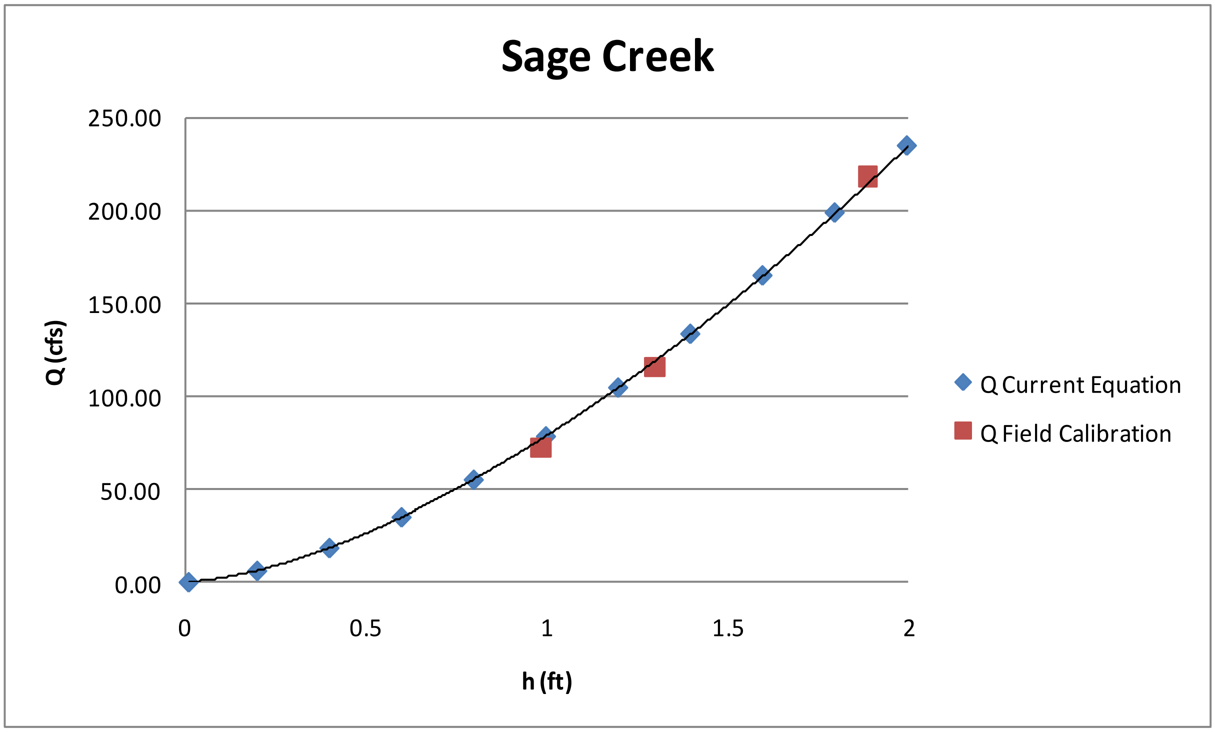


| | |
|---|---|
| Name: | Sage Creek |
| Irrigation Co.: | Upper Bear Distribution |
| Type: | Ramp (Concrete) |
| Width (W): | 24 ft |
| Instrumentation: | Two head gauges |
| Approach: | Straight Channel |
| Crest Correction Factor (*ΔZ*): | + 0.02 ft |
| Recommended Equation: | $Q = 78.338h^{1.5812}$ |

| | |
|---|---|
| Observations: | • Flume is in good condition<br>• Approach channel elevation (deviation from average): +0.32”/-0.28”<br>• Crest elevation (deviation from average): +0.34”/-0.26”<br>• Ramp is reasonably free from moss and sediment buildup<br>• The staff gauge offset relative to the crest elevation ($\Delta Z$ = +0.02 ft) did not improve the accuracy except at the highest flow rate. $h_{a1} \sim h_{a2}$, with $h_{a2}$ being more accurate at the lowest flow rate (1.5% error for $Q_{predicted2}$ vs. 3.2% error for $Q_{predicted1}$). |

| $Q_{actual}$ [a] | $h_{a1}$ | $Q_{predicted1}$ [b] | $h_{a2}$ | $Q_{predicted2}$ [c] | $Q_{corrected1}$ [d] | $Q_{corrected2}$ [e] |
|---|---|---|---|---|---|---|
| (cfs) | (ft) | (cfs) | (ft) | (cfs) | (cfs) | (cfs) |
| 115.45 | 1.28 | 115.74 | 1.28 | 115.74 | 118.62 | 118.62 |
| | *% error for $Q_{actual}$* | *-0.26%* | | *-0.26%* | *-2.74%* | *-2.74%* |
| 72.32 | 0.97 | 74.65 | 0.96 | 73.44 | 77.10 | 75.88 |
| | *% error for $Q_{actual}$* | *-3.22%* | | *-1.55%* | *-6.61%* | *-4.91%* |
| 218.17 | 1.87 | 210.77 | 1.87 | 210.77 | 214.35 | 214.35 |
| | *% error for $Q_{actual}$* | *3.39%* | | *3.39%* | *1.75%* | *1.75%* |

[a] $Q_{actual}$ is the flow measured in the field
[b] $Q_{predicted1}$ is calculated using $h_{a1}$ and the current equation
[c] $Q_{predicted2}$ is calculated using $h_{a2}$ and the current equation
[d] $Q_{corrected1}$ is calculated using $h_{corrected1}$ and the current equation
[e] $Q_{corrected2}$ is calculated using $h_{corrected2}$ and the current equation



# Information Transfer Program Introduction

The individual research projects documented in the Research Project section of this report have information and outreach components integrated within them. These include research findings published in the technical literature and findings and water management models and tools provided 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 the 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 our two newsletters, “The Water bLog” (http://uwrl.usu.edu/partnerships/cwrr/newletter/index.html), which highlights research projects and their findings, and “The Utah WaTCH” (http://uwrl.usu.edu/partnerships/training/utahwatch.html), which addresses on-site and wastewater issues; and reports such as the Mineral Lease Report (http://uwrl.usu.edu/documents/index.html), which is submitted 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.

**List of Workshops**

”Quantitative Risk Assessment Workshop for UK Reservoir Safety,” March 2009, Epsom, Surrey, England. A. Hughes, David S. Bowles, M. Morris.

Utah On-Site Wastewater Treatment Training Program. “Level 3: Renewal of Certification: Design, Inspection and Maintenance of Alternative Systems,” March 19, 2009, N. Logan, Utah. Judith L. Sims and Brian Cowan.

USSD Workshop on The Future of Dam Safety Decision Making: Combining Standards and Risk,” April 2009, USSD Annual Meeting, Nashville, Tennessee. David S. Bowles.

Utah On-Site Wastewater Treatment Training Program. “Level 1: Certification: Soil Evaluation and Percolation Testing,” April 21-22, 2009, N. Logan, Utah. Judith L. Sims, Peg Cashell, and Brian Cowan.

Utah On-Site Wastewater Treatment Training Program. “Level 1: Renewal of Certification: Soil Evaluation and Percolation Testing,” April 23, 2009, N. Logan, Utah. Judith L. Sims, Peg Cashell, and Brian Cowan.

Utah On-Site Wastewater Treatment Training Program. “Level 2: Renewal of Certification: Design, Inspection and Maintenance of Conventional Systems,” April 24, 2009, N. Logan, Utah. Judith L. Sims, Brian Cowan.

”Instream Flow Modeling – Physical Habitat Modeling (PHABSIM),” May 4-8, 2009, Utah State University, Logan, Utah. Thom B. Hardy.

Utah On-Site Wastewater Treatment Training Program. “Level 2: Certification: Design, Inspection and Maintenance of Conventional Systems,” May 20-21, 2009, N. Logan, Utah. Judith L. Sims, Brian Cowan.

”Water and Irrigation Training for Ministries of Agriculture and Water Resources” - Government of Iraq, one-week short course on May 25, 2009, Erbil, Kurdistan, Iraq. Jagath J. Kaluarachchi, Mac McKee, Wynn Walker.

Utah On-Site Wastewater Treatment Training Program. “Level 3: Certification: Design, Inspection and Maintenance of Alternative Systems,” May 26-28, 2009, N. Logan, Utah. Judith L. Sims, Brian Cowan, Richard Jex.

”User Group and Training Workshop for DAMRAE (DAM safety Risk Analysis Engine) Software for US Army Corps of Engineers,” September 2009, Logan, Utah. David S. Bowles, A. Srivastava, Sanjay S. Chauhan, Loren. R. Anderson.

Utah On-Site Wastewater Treatment Training Program. “Level 1: Certification: Soil Evaluation and Percolation Testing,” September 22-23, 2009, Heber City, Utah. Judith L. Sims, Peg Cashell, and Brian Cowan.

Utah On-Site Wastewater Treatment Training Program. “Level 1: Renewal of Certification: Soil Evaluation and Percolation Testing,” September 24, 2009, Heber City, Utah. Judith L. Sims, Peg Cashell, and Brian Cowan.

Utah On-Site Wastewater Treatment Training Program. “Level 2: Renewal of Certification: Design, Inspection and Maintenance of Conventional Systems,” September 25, 2009, Heber City, Utah. Judith L. Sims, Brian Cowan.

”Water and Irrigation Training for Ministries of Agriculture and Water Resources - Government of Iraq,” six-week short course September 20-October 30, 2009, Utah State University, Logan, Utah. Said Ghabayen, Jagath J. Kaluarachchi, Mac McKee, Beth Neilson, Wynn Walker.

Utah On-Site Wastewater Treatment Training Program. “Level 2: Certification: Design, Inspection and Maintenance of Conventional Systems,” October 14-15, 2009, N. Logan, Utah. Judith L. Sims, Brian Cowan.

Utah On-Site Wastewater Treatment Training Program. “Level 3: Certification: Design, Inspection and Maintenance of Alternative Systems,” October 20-22, 2009, N. Logan, Utah. Judith L. Sims, Brian Cowan, Richard Jex.

Utah On-Site Wastewater Treatment Training Program. “Level 3: Renewal of Certification: Design, Inspection and Maintenance of Alternative Systems,” October 29, 2009, N. Logan, Utah. Judith L. Sims, Brian Cowan.

Utah On-Site Wastewater Association. “10th Annual Conference,” February 10-11, 2010, Lehi, Utah.

# 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:** | 2009UT131B |
| **Start Date:** | 3/1/2009 |
| **End Date:** | 2/28/2010 |
| **Funding Source:** | 104B |
| **Congressional District:** | UT1 |
| **Research Category:** | Not Applicable |
| **Focus Category:** | Education, None, None |
| **Descriptors:** | None |
| **Principal Investigators:** | R. Ivonne Harris |

## Publications

There are no publications.

# 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. A recent project objective has been the dissemination of 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 UCWRR 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. Photographs from the various on-going projects have been added to the web pages. The address for the UCWRR website 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 "Home" page explains the center's purpose and directs you to specific areas of interest < http://uwrl.usu.edu/partnerships/ucwrr/>.

2. The “About Us” gives an overview of the center and its affiliations and its mission statement <http://uwrl.usu.edu/partnerships/ucwrr/aboutus.html>.

3. The “People” page gives an overview of the governing body of the center as well as key contact staff <http://uwrl.usu.edu/partnerships/ucwrr/people.html>.

4. The “Research and Publications” page guides the reader to the various projects and reports. This page is updated periodically <http://uwrl.usu.edu/partnerships/ucwrr/research.html>.

5. **Newsletter**. “The Water bLog” page contains links to electronic copies of current and past issues of the UCWRR Newsletter. The “Water blog” is disseminated electronically via email and the UCWRR website. The newsletter is sent to approximately 350 readers through e-mail. The main purpose of the newsletter is to highlight research projects and their findings. These will be of great interest and value to the State of Utah, as well as the national and international community. Figure 3 shows the first page of the “Water blog.” An electronic copy can be viewed at <http://uwrl.usu.edu/partnerships/ucwrr/newsletter/>.

6. The “Contact Us” page has the center’s address and mode of contact <http://uwrl.usu.edu/partnerships/ucwrr/contact.html>.

**Data Base**

Another concern of the UCWRR is making available electronic copies of research projects and reports. These are gradually being converted to PDF format and added to a database to make them available on-line. This is a work in progress, and some of the publications can be found in our website at <http://uwrl.usu.edu/publications/>.

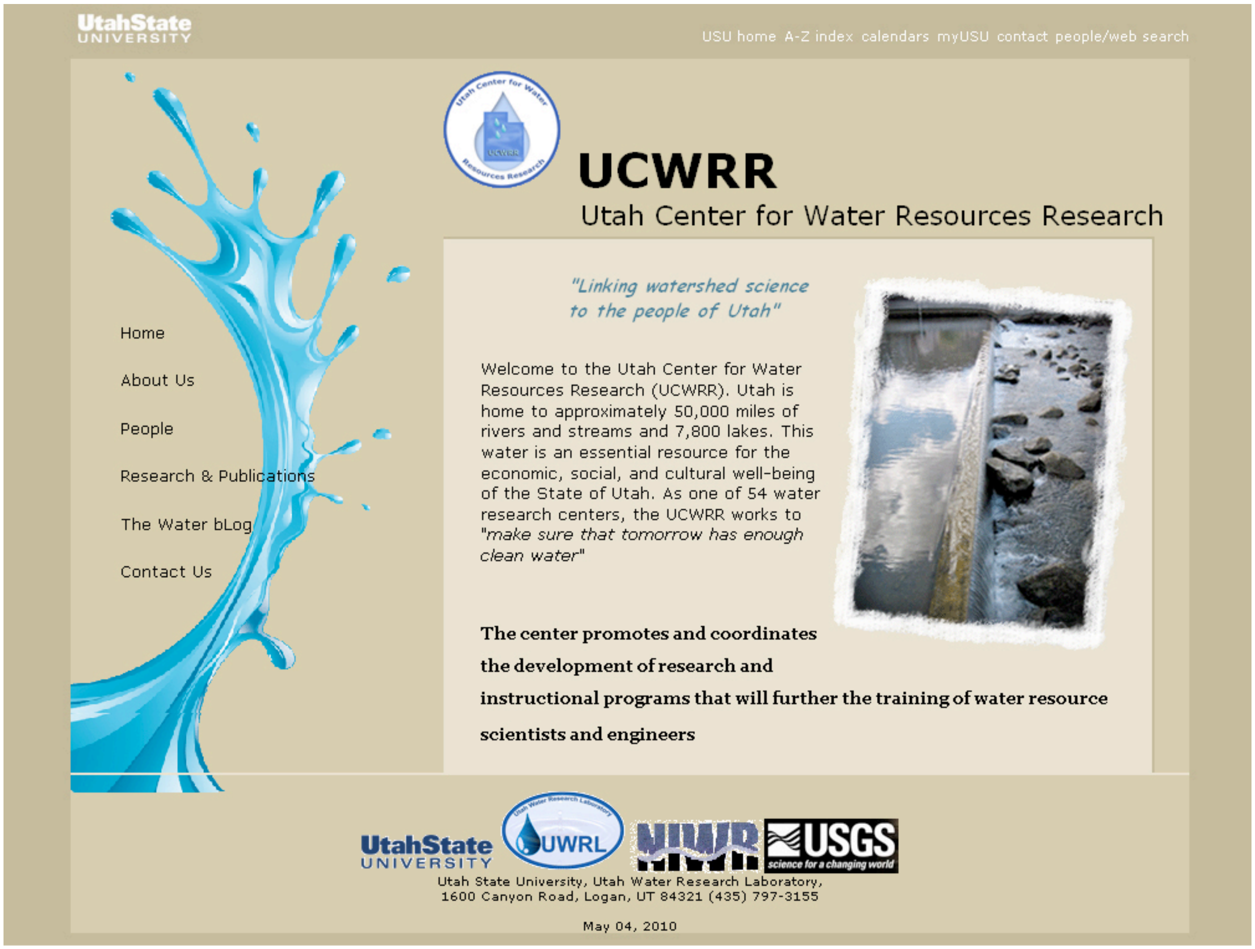



Figure 1. Home page for the UCWRR.


Figure 2. Research and Publications page for the UCWRR.

April 2010, Vol. 1, No. 1

# The Water bLog

a newsletter of the

Utah Center for Water Resources Research

at Utah State University

## Welcome!

**The Water bLog** is the semi-annual newsletter of the Utah Center for Water Resources Research (UCWRR), which is housed at the Utah Water Research Laboratory. The center supports the development of applied research related to water resources problems in Utah and promotes instructional programs that will further the training of water resource scientists and engineers. Each issue of The Water bLog reports on a small selection of the current or recently completed research projects conducted at the center. More information is available on-line at:

http://uwrl.usu.edu/partnerships/ucwrr/

## Message from the Director

Mac McKee, Director

Water related challenges continue to emerge in an increasingly complex society. The Utah Center for Water Resources Research (UCWRR) has a rich tradition of leadership in applied research on the world's water resources problems. This tradition continues today with internationally renowned UCWRR faculty and their students engaged in cutting-edge research in such areas as water quantity and quality management, real-time operations of large water delivery systems, dam safety, design of hydraulic structures, groundwater contamination clean-up, creation of new information systems to support the data needs of resource management agencies, and many others. This newsletter highlights a tiny fraction of the research and service activity provided by the Utah Center for Water Resources Research. ■

# INSIDE:

**Research Highlight:**
"UAVs for Remote Sensing in Water Resources Management"

"Identification of Potential Risks to Utah Drinking Water from Chlorinated Solvents"

**Far Afield:**
Projects and Visitors

**State Activities:**
UCWRR projects in all 29 counties in the State of Utah

UtahStateUniversity

RESEARCH HIGHLIGHT

## UAVs for Remote Sensing in Water Resources Management

*Recent research at Utah State University has led to the development of ultra light, autonomous aircraft for use in capturing high resolution aerial imagery for application in irrigation management*

Water use in agriculture is typically very inefficient, yet represents approximately 85% of Utah's water use. Small improvements in efficiency would provide additional water availability for agriculture or municipal supply. to achieve greater efficiencies, however, better and timelier information regarding soil moisture and evapostranspiration is needed by canal and reservoir operators, farmers, and other water managers. Current technologies for remote sensing (satellite- and aircraft-based sensors) are too expensive and provide information too infrequently to be of practical use to farmers or managers of large irrigation systems.

Raven

The Water bLog April 2010, Vol. 1, No. 1

Figure 3. "The Water blog", the Newsletter for the UCWRR.

# USGS Summer Intern Program

None.

| Student Support | | | | | |
|---|---|---|---|---|---|
| Category | Section 104 Base Grant | Section 104 NCGP Award | NIWR-USGS Internship | Supplemental Awards | Total |
| Undergraduate | 2 | 0 | 0 | 0 | 2 |
| Masters | 1 | 0 | 0 | 0 | 1 |
| Ph.D. | 0 | 0 | 0 | 0 | 0 |
| Post-Doc. | 0 | 0 | 0 | 0 | 0 |
| Total | 3 | 0 | 0 | 0 | 3 |

# Notable Awards and Achievements

Dr. Ryan Dupont received the 2009 Undergraduate Research Mentor Award for the College of Engineering, Utah State University.

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.

This year marks the completion of our new $2 million, 11,000 square-foot Hydraulics Modeling Lab in which large (close to prototype) physical models can be tested indoors at a constant head and steady flows in excess of 140 cfs. This building was constructed without use of either State or Federal tax money. Physical models as large as 60 by 140 feet with model reservoir depths of up to 6 feet are possible. With the latest Lidar instrumentation and remote video technology to correlate physical and numerical model investigations, and a 300,000 pound weigh tank, the laboratories at the UCWRR are able to offer the highest level of quality control possible for model studies.

# Publications from Prior Years

1. 2004UT46B ("Data Fusion for Improved Management of Large Western Water Systems") - Dissertations - Khalil, A.F. (2005). Computational and Data-Driven Modeling for Water Resources Management and Hydrology. "Ph.D. Dissertation," Civil and Environmental Engineering, College of Engineering, Utah State University, Logan, UT, 161 pages.
2. 2004UT46B ("Data Fusion for Improved Management of Large Western Water Systems") - Dissertations - Asefa, T. (2004). Statistical Learning Theory: Concepts and Applications in Water Resources Management. "Ph.D. Dissertation," Civil and Environmental Engineering, College of Engineering, Utah State University, Logan, UT, 142 pages.
3. 2006UT69B ("Irrigation Demand Forecasting for Management of Large Water Systems") - Dissertations - Kaheil, Y.H. (2007). Automatic Processing of Multi-Resolution Data for Use in Water Management and Hydrologic Modeling. "Ph.D. Dissertation," Civil and Environmental Engineering, College of Engineering, Utah State University, Logan, UT, 161 pages.
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