

**Utah Center for Water Resources Research
Annual Technical Report
FY 2012**

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 education and 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 12, the UWRL expended a total of almost \$8 million in water research support. USGS Section 104 funds administered through the UCWRR accounted for approximately three 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. Five research projects were funded in FY12 with USGS 104 funds. These projects are respectively entitled, (1) "Drought Index Information System Development for NIDIS," (2) "Reducing the Dangers of Low-Head Dams in Utah", (3) "Estimating Crop Water Use with Remote Sensing: Development of Guidelines and Specifications, (4) "UAV Monitoring and Assessment Applications in Municipal Water and Environmental Management Problems," and (5) "Performance of Stormwater Bioretention Systems in Utah's Climate and Hydrologic Conditions." These projects dealt with the following water management issues: (1) developing a capability to evaluate and implement 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; (2) establishing a classification system for low head dams based on the dangers created at various flow conditions and identifying a potential simple solution to eliminate the drowning hazards presented by such dams (3) developing a framework for estimating crop water use using remote sensing through a standardized approach, thus providing guidelines and specifications for applying certain evapotranspiration (ET) models and producing ET products that are acceptable to the USGS WaterSmart program and the scientific and user community; (4) Investigating the value of using AggieAir, a low-cost, high-resolution multispectral remote sensing platform, as a tool to provide accurate and quality spatial data for municipal applications to help manage water and environmental issues in wetland and riparian areas, landfills, and parks and recreation areas; and (5) Designing a public demonstration bioretention basin to increase public awareness and education of bioretention in Utah and to provide data for determining bioretention infiltration rates for semi-arid climates. The projects all involved collaboration of local, state, and federal water resources agency personnel.

Research Program Introduction

USGS Section 104 funds were used to establish a data server to support the publication of drought index information for the NIDIS Upper Colorado River Basin (UCRB) pilot drought early warning system which aims to enhance access to drought related data and enable custom drought index calculation. A HydroServer using the CUAHSI HydroServer software stack on virtual servers hosted at the Utah Water Research Laboratory (UWRL) data center has been developed to publish drought index values as well as input data used in drought index calculations, with web services for the data sources necessary for drought index calculation. Procedures to aggregate the input data to the time and space scales chosen for drought index calculation have also been developed, and automated data and metadata harvesters that periodically scan and collect new data from the input databases have been created to ensure that the data available on the drought server are kept up to date.

Low-head dams are small structures that have water continually flowing over their crest that are used to impound water for a variety of municipal industrial, and recreational needs. At certain flow conditions, these structures can create strong currents called rollers that rotate in an upstream direction, creating a serious drowning hazard for individuals who venture too close and become trapped in the unrelenting cycle. A project utilizing USGS Section 104 funds is establishing a classification system for these low-head dams based on the dangers created at various flow levels. This system will help recreational water users and dam owners assess hazards and act appropriately in terms of safety and liability. The project also aims to identify at least one simple solution, that when added to a low-head dam will effectively break up the upstream directed current, thereby eliminating the dangers created by the rollers and allowing individuals swept over low-head dams to continue downstream rather than become trapped by the current. Establishing an easy to use and understand hazard classification system for these structures and finding a simple way to reduce the strength of the roller could save lives in the future.

Irrigated agriculture is the largest consumptive water user in the western United States. Estimates of crop water use can be improved through more accurate evapotranspiration (ET) estimates. A research project supported with Section 104 funds this year is developing a framework for estimating crop water use using remote sensing through a standardized approach that will provide guidelines and specifications to be followed in order to apply certain models and produce ET products that are acceptable to the USGS WaterSmart program and the scientific and user community. This research includes reviewing and testing candidate remote sensing – based ET models to establish model performance and determining the uncertainty associated with the application of these models. A set of study sites will be selected from within the 17 western United States representing different climatic regions, and a variety of spatial and point datasets will be utilized. This work will benefit many hydrological modeling and water resources management applications.

Remote sensing can be useful for water and environmental management applications by giving managers accurate, high-resolution spatial data on what they are trying to manage, Even though research has shown that remote sensing can be a very useful tool, the high cost, long processing time and inflexibility discourage its use. Free GIS state services or applications like Google Earth could be used for aerial imagery instead of purchasing the data; however, the imagery from free GIS state services such as Google Earth can be out-of-date, may have poor resolution, and rarely include all spectral information needed for advanced analytic techniques. AggieAir™ is a low-cost, high resolution remote sensing platform developed at Utah State University to deal with these types of problems and to provide remote sensing data to a wider range of managers and stake-holders. AggieAir™ platforms are small, autonomous aircraft (commonly known as “unmanned aerial vehicles,” or UAVs) with multiple on-board cameras to capture aerial imagery during flight, and are capable of capturing visual (red, green, and blue), near-infrared (NIR), and thermal imagery. In this USGS 104 funded project, we will investigate the value of using AggieAir™ as a tool for cities, such as Logan, UT, to help them manage environmental issues by capturing aerial imagery over areas of interest,

Research Program Introduction

including wetland and riparian areas, landfills, and parks and recreation areas.

Bioretention cells are designed to retain stormwater input in the soil storage layers for treatment and consumption by deep-rooting natural vegetation and to reduce pollution loading to receiving waters. However, most bioretention design guidelines focus on systems receiving 30 to 80 inches of rainwater each year. Little progress has been made on quantifying the hydrologic impacts of bioretention facilities on urban environments in semiarid climates, such as in Utah. The final project supported by USGS 104 funds this year is addressing this gap. A new, field-based research facility (the first in Utah) was designed and constructed as a research and demonstration/outreach site to investigate whether bioretention cells are able to reduce stormwater runoff in semiarid climates and to determine the infiltration rates through the bioretention cell and into the natural sub-soils. The cell was planted with a mixture of native grasses, shrubs, and woody vegetation and sensors were installed that monitor groundwater levels and movement. This work will enable more accurate prediction of infiltration rates of the soil types used in bioretention cells and rate changes over 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.

Progress Report: USGS Grant No. G10AP00039 Drought Index

Information System for NIDIS

David Tarboton

Jeff Horsburgh

May, 2013

Project Description

Utah State University has established a data server to support the publication of drought index information for the NIDIS Upper Colorado River Basin (UCRB) pilot drought early warning system. The goals are to enhance access to drought related data and enable custom drought index calculation. The approach has been to first establish a foundation of primary hydrologic information related to drought in the UCRB pilot available through the Consortium of Universities for the Advancement of Hydrologic Science Inc. (CUAHSI) Hydrologic Information System (HIS), then aggregate this data at time and space scales most relevant for drought index calculation and publish it using HIS so that local customized drought index evaluation is enabled.

The CUAHSI HIS is a federated system for sharing hydrologic data. It comprises multiple data servers, referred to as HydroServers, that publish data in a standard XML format called Water Markup Language (WaterML), using web services referred to as WaterOneFlow web services. HydroServers can also publish geospatial data using Open Geospatial Consortium (OGC) web map feature and coverage services and have a web interface for data access. HydroServers use a Microsoft Windows Server operating system and ESRI ArcGIS Server platform to publish data from Microsoft SQL databases and ArcGIS server files. Time series data are stored in SQL Server databases using the Observations Data Model (ODM). HIS also includes a centralized metadata catalog that indexes data from registered HydroServers and a data access client referred to as HydroDesktop.

Accomplishments

This project established the <http://drought.usu.edu> HydroServer using the CUAHSI HydroServer software stack on virtual servers hosted at the Utah Water Research Laboratory (UWRL) data center. The drought HydroServer was developed as a platform to publish drought index values as well as the input data used in drought index calculations. Primary input data required for drought index calculation include streamflow, precipitation, reservoir storages, snow water equivalent, and soil moisture. Before this project began, only streamflow from the USGS National Water Information System (NWIS) was available as a standard WaterOneFlow web service. We have set up the following web services to provide access to the data needed for the computation of drought indices.

WaterOneFlow Web Services for NRCS SNOTEL Snow Water Equivalent Data

The NRCS SNOTEL data service is a flow through web service that retrieves data directly from the NRCS SNOTEL website. The SNOTEL WaterOneFlow web service is available at:

<http://drought.usu.edu/SNOTEL/>

This is registered at HIS Central (<http://hiscentral.cuahsi.org/>) and discoverable from HydroDesktop under data service title "NRCS SNOTEL Standard Variables."

WaterOneFlow Web Services for NCDC Precipitation Data

The NCDC precipitation service is a hold and serve data service that provides access to NCDC precipitation data for sites within a 50 mile buffer around the Upper Colorado River Basin. The NCDC precipitation web service is available at: http://drought.usu.edu/NCDC_Precip/

This is registered at HIS Central (<http://hiscentral.cuahsi.org/>) and discoverable from HydroDesktop under data service title "NCDC Upper Colorado River Basin Precipitation."

WaterOneFlow Web Services for USBR Reservoir Data

The USBR reservoir data service is a flow through data service that provides access to inflow, outflow, elevation, and storage data from US Bureau of Reclamation Reservoirs in the UCRB. The USBR reservoir data service is available at: <http://drought.usu.edu/USBRReservoirs/>

This is registered at HIS Central (<http://hiscentral.cuahsi.org/>) and discoverable from HydroDesktop under data service title "USBR Upper Colorado River Basin Reservoir Data."

WaterOneFlow Web Services for SNODAS Snow Water Equivalent Data

Two web services have been established to publish data from the NOHRSC Snow Data Assimilation System (SNODAS). These web services provide data at different levels of spatial aggregation:

- HUC10: http://drought.usu.edu/SNODAS_HUC10/
- HUC8: http://drought.usu.edu/SNODAS_HUC8/

These are registered at HIS Central (<http://hiscentral.cuahsi.org/>) and discoverable from HydroDesktop under data service titles "SNODAS HUC 8 Model Results," and "SNODAS HUC 10 Model Results."

WaterOneFlow Web Services for Drought Index Data

In order to produce higher level drought index data products from the primary data sources listed above, we developed harvesting and aggregation algorithms that ingest the primary data, aggregate them in both time and space, and then store the results in an ODM database on the drought HydroServer. We then use standard CUAHSI HIS WaterOneFlow web services to serve these higher level datasets in WaterML format. The WaterOneFlow web service that provides access to the time and space aggregated data is available at: <http://drought.usu.edu/NIDISTimeSeries/>

This data is discoverable from HydroDesktop under data service title "NIDIS Upper Colorado River Basin Drought Index Data."

Map Web Services

In addition to the above observational data web services, we have also published the following GIS datasets as OGC map services on the NIDIS HydroServer.

- UCRB Study Area
- NIDIS Monitoring Sites
- USGS HUCs
- UCRB Major Rivers
- ESRI Street Base Map

These underlie the HydroServer map application (<http://drought.usu.edu/nidismap/>) that provides map based display of drought information over the UCRB pilot (Figure 1).

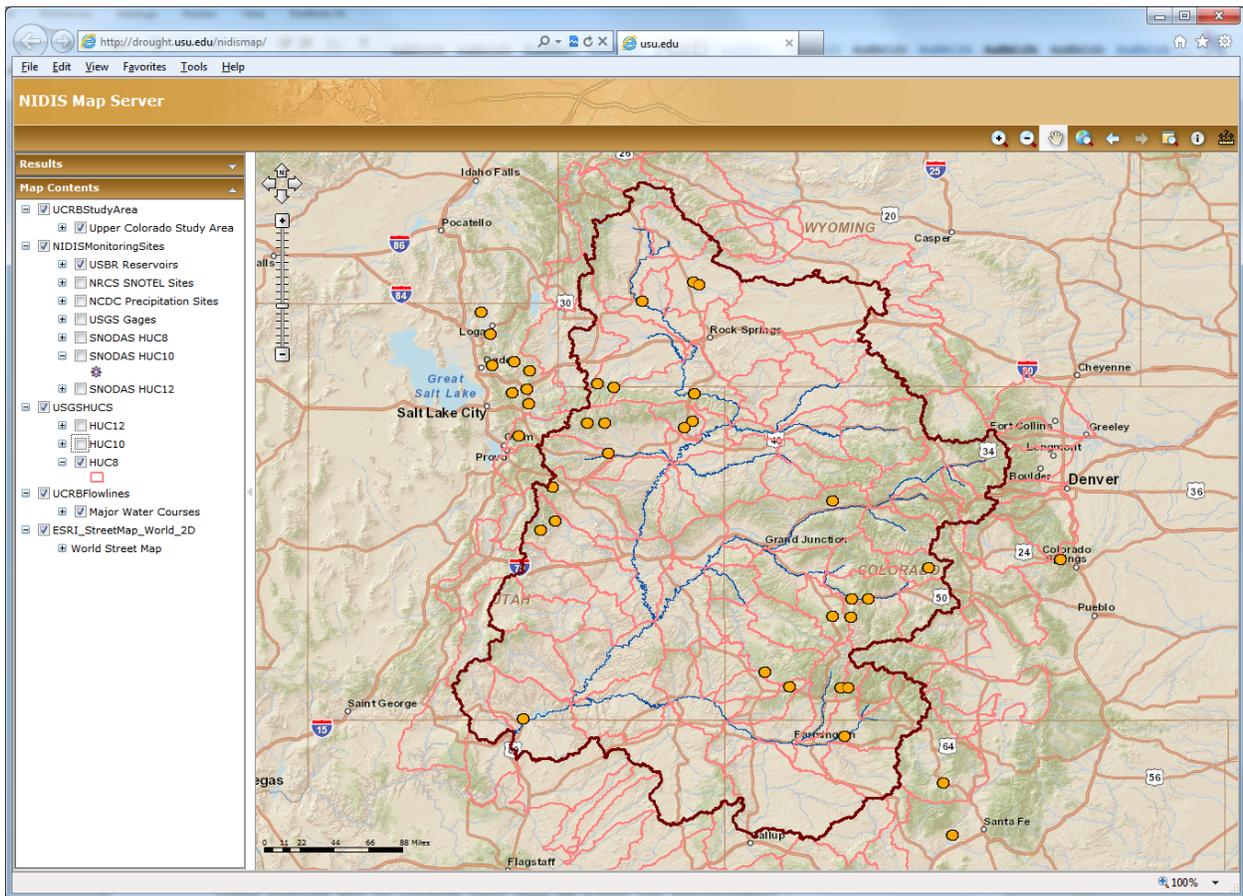


Figure 1. NIDIS Map Server

Work Plan

This project is complete. No further work is planned.

USGS Grant No. G10AP00039 Drought Index Information System for NIDIS

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Congressional District:	
Research Category:	Climate and Hydrologic Processes
Focus Category:	Drought, None, None
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Principal Investigators:	David Gavin Tarboton

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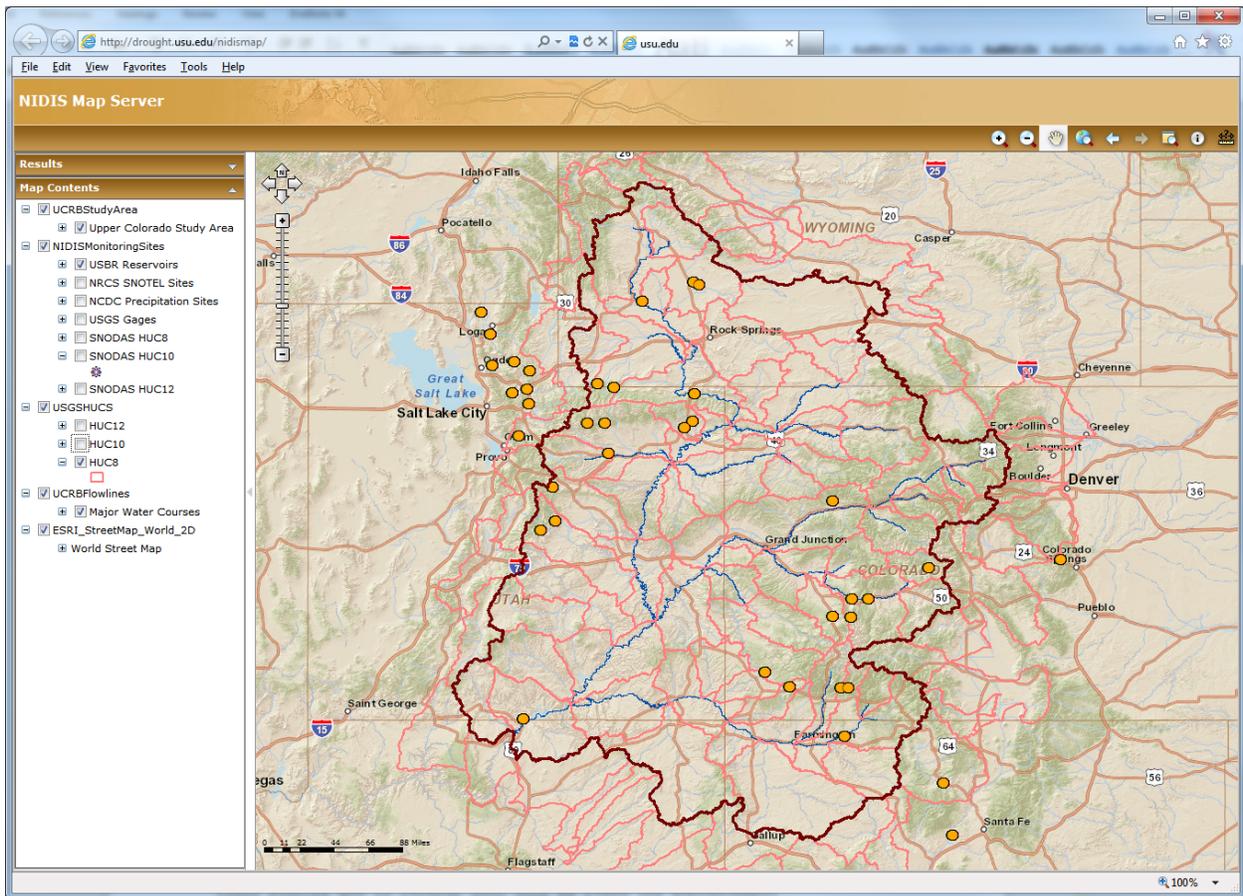


Figure 1. NIDIS Map Server

Work Plan

This project is complete. No further work is planned.

Reducing the Dangers of Low Head Dams in Utah

Basic Information

Title:	Reducing the Dangers of Low Head Dams in Utah
Project Number:	2011UT154B
Start Date:	3/1/2011
End Date:	2/28/2013
Funding Source:	104B
Congressional District:	UT1
Research Category:	Engineering
Focus Category:	Surface Water, Recreation, Methods
Descriptors:	None
Principal Investigators:	Michael C. Johnson, Steven L. Barfuss

Publications

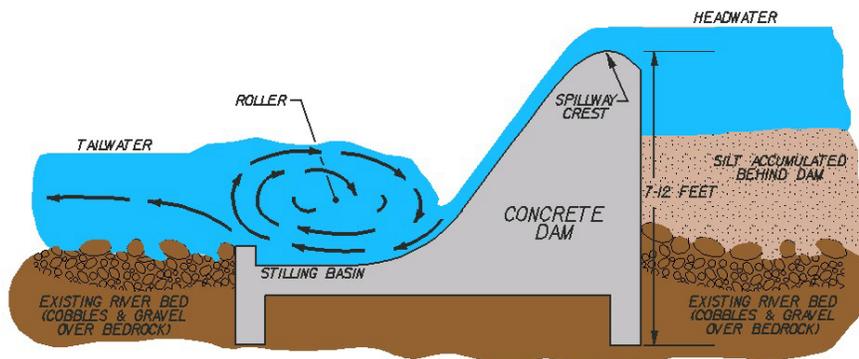
There are no publications.

REDUCING THE DANGERS OF LOW-HEAD DAMS IN UTAH

Michael C. Johnson, Principal Investigator, Riley Olsen, Research Assistant

INTRODUCTION AND PROBLEM

Low-head dams are small structures, usually no taller than 5 to 10 feet, that are designed to have water continually flowing over their crest. They are used for many purposes, including the impoundment of small volumes of water for use by municipalities, industry, and recreational users; water quality improvement; and simply to house and protect utility lines at river crossings. At certain flow conditions, these structures can create serious drowning hazards due to a current created at the downstream face of the dam, as depicted in Figure 1 below. This current, commonly referred to as a roller or hydraulic, features a counterintuitive upstream directed surface velocity. This roller can be strong enough to trap debris, such as trash and tree branches, near the face of the dam for prolonged periods of time. Fooled by the calm appearance of the cascading water often present, many recreational water users have ventured too close to these structures and found themselves caught in the strong current, often struggling to the point of exhaustion, and many times drowning before being rescued or ejected from the unrelenting cycle.



<http://www.overmywaders.com/index.php?belowthemillpond>

Fig. 1. An ogee crested low-head dam featuring a dangerous roller.

OBJECTIVES

One of the main objectives of this research was to establish a classification system for low-head dams based on the dangers created at various flow conditions. It was hoped that this classification system would utilize parameters that are easily measured and obtained in the field,

such as upstream and downstream water depths. This classification system could help recreational water users and dam owners assess hazards and act appropriately in terms of safety and liability.

Another objective of this study was to identify at least one simple solution, that when added to a low-head dam, would effectively eliminate the dangers presented by the roller by breaking up the upstream directed current. By breaking up the dangerous hydraulic, individuals that are swept over a low-head dam would be flushed over the structure and continue on downstream with little chance of being trapped by a current.

RESEARCH METHODOLOGY

This research was performed using primarily computational fluid dynamics (CFD) software to model flow over both 10 ft tall flat-topped and ogee-crested low-head dams at various flow conditions. The numerical solutions obtained from the CFD simulations were analysed and compared through careful examination of upstream directed surface velocities. Easily measured parameters, including upstream and downstream water depths and dam height, were then used to calculate a risk factor that is capable of distinguishing between conditions of high and low-risk, with respect to the presence of a roller.

Once this risk classification had been successfully identified, the next step was to experiment with several possible modifications to both dam shapes in an attempt to eliminate, or at least significantly reduce the size and strength of the roller, therefore reducing the drowning risk to the public. These remediation options were evaluated based on the amount of time that human dummies introduced into the flow remained in the entrapment zone consisting of the extents of the roller. This time was called the entrapment time.

In order to verify the accuracy of the numerical results obtained through the CFD program for both objectives of this project, physical models of several of the simulations were constructed and tested at the Utah Water Research Laboratory. This was done utilizing a gravity fed rectangular laboratory flume (6 ft x 30 ft x 4 ft deep). The physical models were set up so that water depths at specified distances upstream and downstream of the dam matched those at the same distances in the corresponding CFD models. Once these water surface elevations were achieved, a flow meter was used to measure the flow rate. This flow rate, as well as photos and

video, were compared to the numerically obtained flow rate and CFD animations to verify that the physical process was being accurately reproduced by the CFD model. Also, a scaled human shaped model that had a weight and density comparable to a person wearing a life preserver, was constructed and placed into the physical model to test the remediation option effectiveness

RESULTS

Risk Classification

Through comparison of many CFD simulation of flow over flat-topped and ogee-crested low-head dams, a parameter was found that could clearly distinguish between the possible states of flow downstream of a low-head dam, when plotted against a velocity factor used to quantify roller strength. By distinguishing between possible states of flow at low-head dams, this factor is able to predict the presence of a roller, and therefore when high-risk conditions are present. The factor itself is calculated as $(h_u - h_d)/P$, where P is the dam height, h_u is the upstream water depth measured at a distance of $3P$ from the upstream face of the dam, and h_d is the downstream water depth measured at a distance of $6P$ from the upstream face of the dam. Figures 2 and 3 show the results of plotting the risk factor versus velocity factor for the flat-topped and ogee-crested dam shapes, respectively.

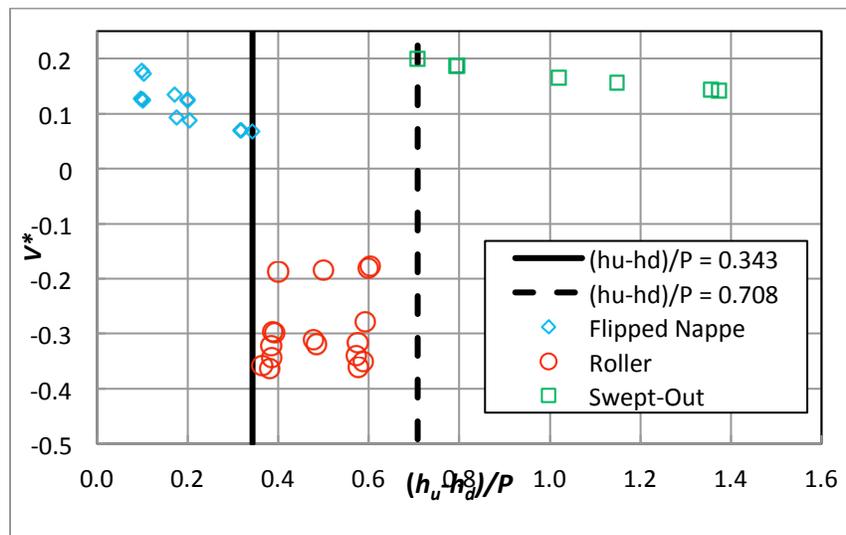


Fig. 2. Flat-topped classification results.

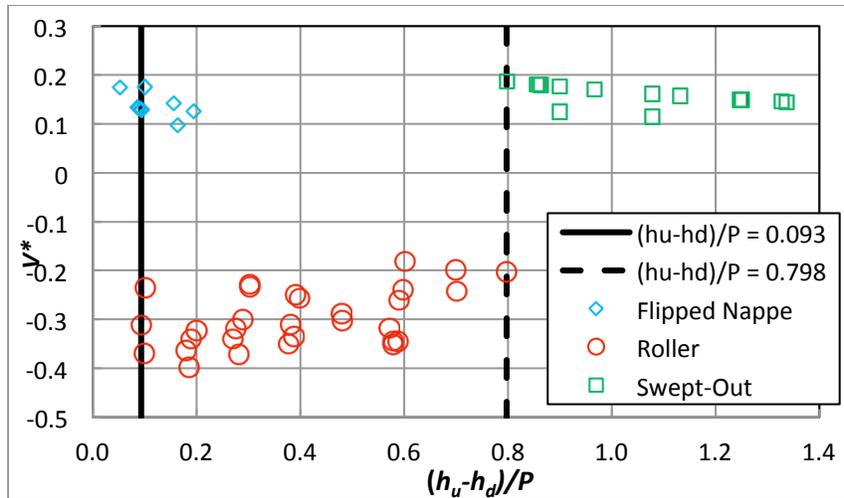


Fig. 3. Ogee-crested classification results.

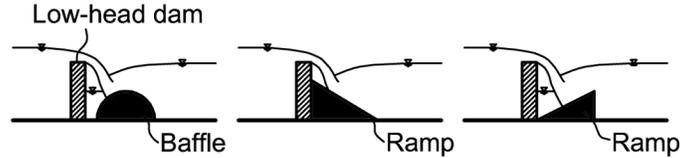
As can be seen in Figure 2, the range of risk factors that was shown to produce a roller consisted of values between 0.343 and 0.708 for the flat-topped dam shape. For the ogee-crested dam shape, conditions that resulted in the formation of a roller were seen to occur between risk factors of 0.093 and 0.798.

Remediation Options

More than nine different remediation option designs were tested during this project using a trial and error process. Some of the non-effective remediation options tested included half circle baffles placed downstream of the dam and spaced along the width of the channel, downstream facing ramps spaced along the width of the channel, and upstream facing ramps spanning the entire channel width. These configurations are shown in Figure 4.

Two designs were found to be capable of eliminating the dangerous current, therefore allowing the human dummies introduced into the flow to be flushed through the entrapment zone under most conditions. The first configurations included upstream facing ramps spaced along the width of the channel, as shown in Figure 5 for the flat-topped dam shape. These designs were also tested on the ogee-crested dams. Three different configurations of this design were tested, each having somewhat different ramp and spacing dimensions, and were designated as R1, R2, and R3.

Cross-Sectional Views



Front Views

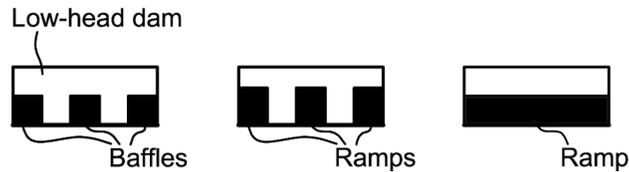


Fig. 4. Non-effective remediation designs.

The R1 configuration had a ramp height (h_r) of $0.5P$, ramp length (L_r) of P , ramp spacing (s_r) of 2 ft, and ramp width (w_r) of 2 ft. The R2 configuration had similar dimensions to the R1 design, with the only exception being h_r , which was increased to $0.75P$. The R3 design shared the same ramp geometry as the R2 design, except that both s_r and w_r were increased to 6 ft in order to allow passage over the structure safer for victims at lower flow rates.

The second design found to show considerable potential for eliminating dangerous hydraulic conditions at low-head dams consisted of spaced horizontal platforms protruding from the downstream face of the dam just below its crest, as shown in Figure 6 for flat-topped dam shapes. Three different configurations of this design were also tested, and were designated as P1, P2, and P3. These same designs were also tested on ogee-crested dams.

The P1 configuration had a platform height (h_p) of $0.8P$, platform length (L_p) of $0.75P$, platform spacing (s_p) of 2 ft, and platform width (w_p) of 2 ft. The only dimension that was changed from the P1 configuration to the P2 configuration was L_p . For the P2 design, L_p was increased to $0.85P$ in an attempt to increase effectiveness at higher headwater depths. The P3 design had identical cross-sectional platform geometry as the P1 design, except with s_p and w_p increased to 6 ft in order to allow safer passage of water users over the structure.

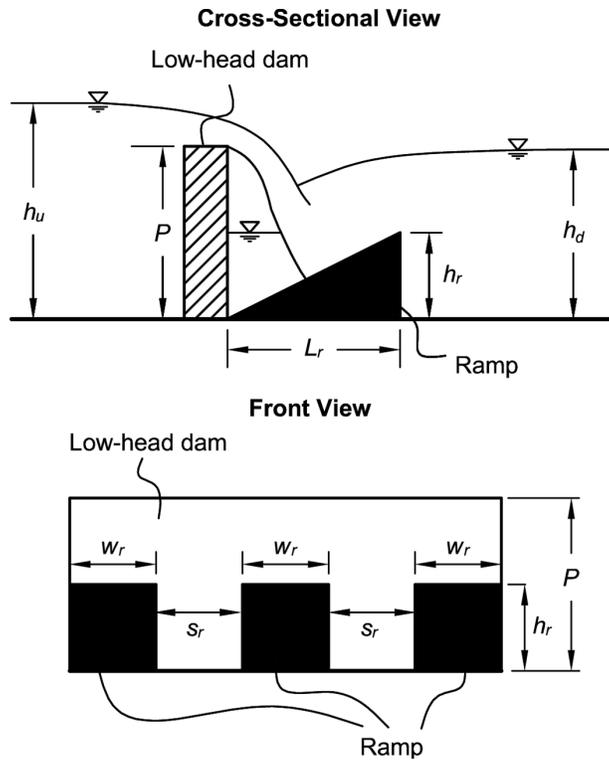


Fig. 5. Flat-topped ramp definition sketch

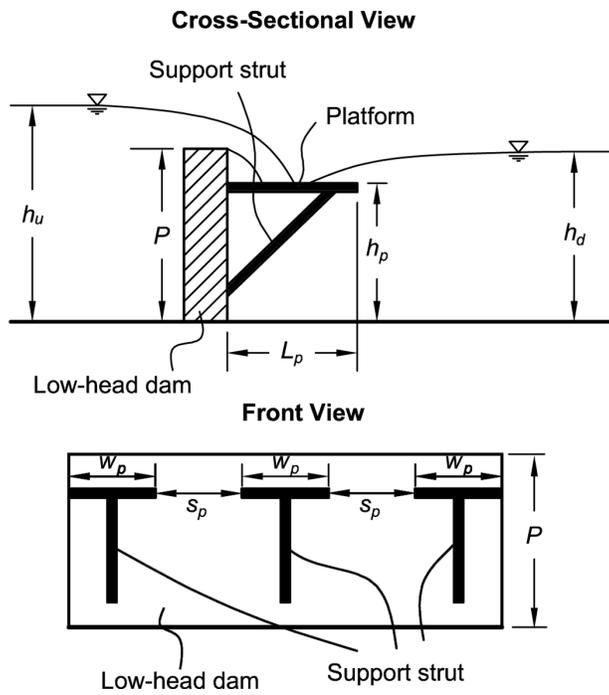


Fig. 6. Flat-topped platform definition sketch

As mentioned earlier, remediation option effectiveness was evaluated based on the time that human dummies introduced into the flow remained trapped in the roller below the dam (entrapment time). Tests were carried out until either 50 seconds had passed, or all dummies had been ejected from the entrapment zone, whichever was shortest. Tests in which the dummies remained trapped by a roller for longer than 50 seconds was considered ineffective. Figure 7 shows the resulting averaged entrapment times for each of the remediation options. Entrapment times were averaged for each of the dam shapes tested, in addition to an overall average that took both shapes into account.

As can be seen in the figure, the best performing option was the P3 design with an average entrapment time of just over 10 seconds. The R3 design also performed well with an average time of about 12.5 seconds. However, due to time constraints, both of these options were only tested on the dams of the flat-topped shape. Therefore, it is unknown for certain how these designs would perform with the ogee-crested dam, although, based on close agreement of results between dam shapes of other remediation options, it is expected that both options would perform well. Regarding options that were tested on both dam shapes, the P2 design showed the most promising results with an average entrapment time of about 17 seconds.

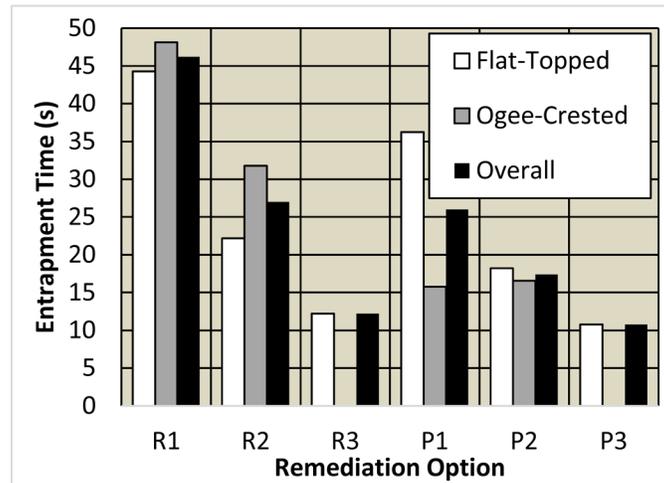


Fig. 7. Average remediation option entrapment times.

SUMMARY AND CONCLUSION

Because of the dangerous flow conditions that can be present at low-head dams under certain operating conditions, and the resulting deaths that have occurred throughout the years, a study was performed with the hope of making these structures safer for the public. The objectives of the project included establishing a risk classification system that could be used to warn water users of high-risk conditions, and identifying a couple of remediation options that are effective at breaking up the reverse roller that traps water users, therefore allowing them to continue past the dam with less risk of drowning. The research was performed primarily using computational fluid dynamics software, with physical model tests performed to verify the numerical results. Tests were performed on flat-topped and ogee-crested low-head dams standing 10 ft in height.

The first objective was accomplished by establishing a risk factor calculated as $(h_u - h_d)/P$, that was capable of distinguishing between the different states of flow at low-head dams, and therefore able to predict when high-risk conditions are present. It was found that for the flat-topped dams tested, the high-risk scenarios occurred between risk factor values of 0.343 and 0.708. For the ogee-crested dams, high-risk conditions occurred between risk factor values of 0.093 and 0.798. Outside of these ranges, it was found that low-risk conditions were present with respect to entrapment by a roller.

The results of the second objective was the identification of two general remediation configurations which consisted of six actual designs that were capable of breaking up the reverse roller that is known for trapping and drowning recreational water users. The first configuration design consisted of upstream facing ramps spaced along the width of the channel. Three variations of this configuration were tested and were referred to as R1, R2, and R3. The second configuration consisted of horizontal platforms protruding from the downstream face of the dam and spaced along the width of the channel. Like the ramp configuration, three variations of this configuration were tested and were called P1, P2, and P3.

Based on the amount of time that human dummies remained in the entrapment zone below the low-head dam for each of the designs tested, it was found that the most effective option was the P3 design. However because this design was only tested on the flat-topped shape, it should be noted that the P2 design had the best performance of the remediation options tested on both dam shapes.

USGS Award No. G11AP20229 Estimating Crop Water Use with Remote Sensing: Development of Guidelines and Specifications

Basic Information

Title:	USGS Award No. G11AP20229 Estimating Crop Water Use with Remote Sensing: Development of Guidelines and Specifications
Project Number:	2011UT164S
Start Date:	9/19/2011
End Date:	9/18/2012
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Research Category:	Climate and Hydrologic Processes
Focus Category:	Water Use, Agriculture, Methods
Descriptors:	satellite remote sensing, crop water use
Principal Investigators:	Christopher M.U. Neale

Publications

There are no publications.

Estimating Crop Water Use with Remote Sensing: Development of Guidelines and Specifications

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1. Introduction

Irrigated agriculture is the largest consumptive water user in the western United States. Improved estimates of crop water use through evapotranspiration (ET) estimates are important because of the diminishing water resources and competition for water in the 17 western states. Several programs have been established by states and federal government agencies to help monitor water resources in the western US including programs such as WaterSmart by the US Bureau of Reclamation. The key element in estimating crop water use is ET estimates. Also, knowledge of ET is useful for many applications including hydrological modeling and water resources management.

As indicated by the USGS, the aim of this work is to solve the water balance at the 12 digit HUC watersheds scale and eventually the 8 digit HUC level.

2. Statement of Work

Estimating crop water requirements that are acceptable by the community of users and water agencies in the western states, as well as by the USGS WaterSmart, for reporting purposes is a challenging problem. A wide range of ET models are available in the literature, providing different approaches and estimates. The application of some of these models, in particular the remote-sensing based models, can be considered subjective because some of them rely on modeler perception, experience, and understanding on the selection of inputs.

The main research objective is to develop a framework for estimating crop water use using remote sensing through a standardized approach. This framework will provide guidelines and specifications that would need to be followed by different states in order to apply certain models and produce ET products that are acceptable to the USGS WaterSmart program and the scientific and user community. To achieve the main objective the following activities will be followed:

1. Review currently available ET estimation models being used by the different Western States, including remote sensing based models
2. Select candidate models to be tested
3. Review cropland data base and report on its accuracy, availability, and ease of use.
4. Review and investigate the use of thermal and multispectral band imagery from multiple sensors
5. Perform sensitivity analysis of remote sensing based ET models to input error from using gridded forcing weather data.

A conceptual diagram of the statement of work with the suggested activates of the remote sensing of ET framework is shown in Figure 1.

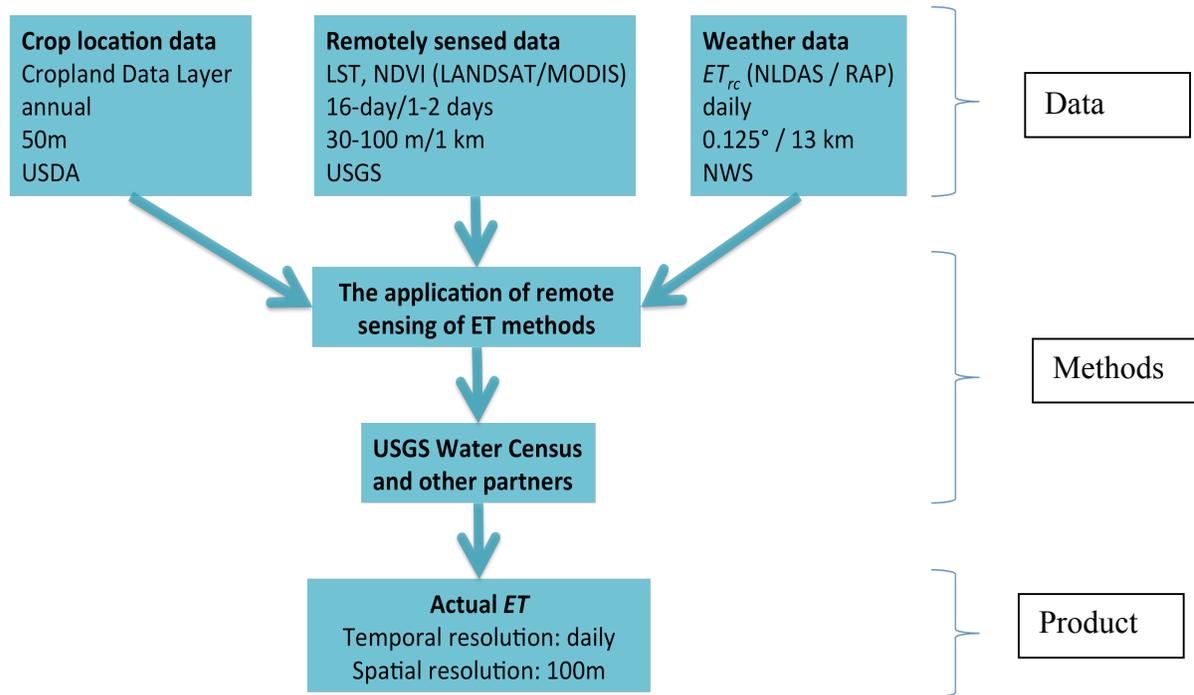


Figure 1: A conceptual diagram of the suggested remote sensing of ET framework.

3. Methodology

An important aspect of this research work is the selection, review and testing of candidate remote sensing-based ET models. This will allow the establishment of model performance over a wide range of agricultural crops and eventually different surface types outside of the irrigated areas. The models will be tested over irrigated cropland sites selected based on the availability, quality, and suitability of ground-based verification data. Considering the need for gridded weather forcing data over areas where there were limited or no such data, the uncertainty associated with the application of these models will be investigated. Forcing data will include, for example, those that are available in the North America Land Data Assimilation System (NLDAS).

3.1. Candidate models

A review of currently available remote sensing of ET models was conducted in order to select candidate models for future comparison. These models provide a broad range of the current practices in this arena and are presently accepted by the scientific community and the users. The selection was based on different criteria but with a particular attention on those models focused on cropland types of surfaces. The following were identified:

- Thermal Remote Sensing based models, which include all those that use the radiometric surface temperature obtained from different sensors as an input for estimating the surface energy balance components. Several models are being considered:

- The Two Source Energy Balance (TSEB) Model by Norman et al. (1995), including its recent improvements and modification ALEXI -DisAlexi method (references). This model was introduced by the group at the - USDA-ARS hydrology and remote sensing lab.
- SEBAL developed by Bastiaanssen et al. (1998), and METRIC by Allen et al. (2007)
- SEBS model (Su et al. 2002)
- SSEB simplified surface energy balance developed by a group from the USGS (Senay et al. 2008)
- Hybrid ET Approach
 - SEBAL and TSEB have been coupled with the reflectance-based crop coefficient method with a recently developed hybrid approach that couples the surface energy balance approach with water balance model. (Neale et al. 2012, Geli et al. 2012 in review).
- Crop coefficient-based approach
 - Traditional crop coefficient and reference ET approach supported by accurate crop layers obtained from the classification of satellite imagery. This is an approach used by the US Bureau of Reclamation through their LCRAS system
 - ET framework developed by Melton et al. - (NASA)
- Penman-Monteith approach
 - MODIS ET Algorithm, which uses Penman-Monteith equation and incorporates spatial data from MODIS to estimate ET (Mu et al. 2007)
- Priestly-Taylor approach
 - Evapotranspiration Priestly-Taylor Jet Propulsion Lab (PT-JPL) by Fisher et al. (2012).

Review report planned completion date is at the end of June 2013. The report will cover the following:

- Types of models based on methodology and application.
- Detailed review of each candidate models' algorithm
- Comments on the required input data of each
- Possible sources of uncertainties and errors for each.

3.2. The study sites

Three study sites were selected to test the candidate models that represent different climate regions and surfaces. These sites are from within the 17 western United States and are representative of the different irrigated and rain-fed agricultural areas as well as natural vegetated surfaces. The sites include (Figure 2):

- The Palo Verde Irrigation District (PVID), California
 - The data for this site were collected by the remote sensing services lab at USU and the Alliance of Universities – Central State University through a project funded by the USBR. The data spans about 3.5 years from 2006 to 2009. It includes flux measurements, irrigation canal and drainage flows, and airborne and satellite images. The main crops are alfalfa and cotton

crops. Data are also available for Salt Cedar forests in the riparian zone of the Colorado River.

- Walnut Gulch Experimental watershed, AZ. The area is naturally vegetated covered mostly with desert shrubs and grassland. Flux and satellite remotely sensed imagery will be used to conduct the analysis.
- Agricultural area in Mead, Nebraska. The area contains irrigated and rain-fed soybean and corn fields.

3.3. Model intercomparison

- Agreement with modelers is reached to apply each model at selected sites.
- Three sites were selected at different regions including
 - The Palo Verde irrigation district (PVID), California (Site 1)
 - The Walnut Gulch watershed, Arizona (Site 2)
 - Mead, Nebraska (Site 3)
 - Data for Site 1 were sent for analysis, data for site 2 and 3 under preparation
- Data distribution
 - Site 1 is currently in the ET modeling stage, expected results by end of June 2013.
 - Sites 2 and 3 are in data preparation and processing stage, will be sent by end of June 2013 and results by end of July.
- Models evaluation
 - Utah State University will implement the model validation stage using ground based measurements, expected results by mid-August, 2013.

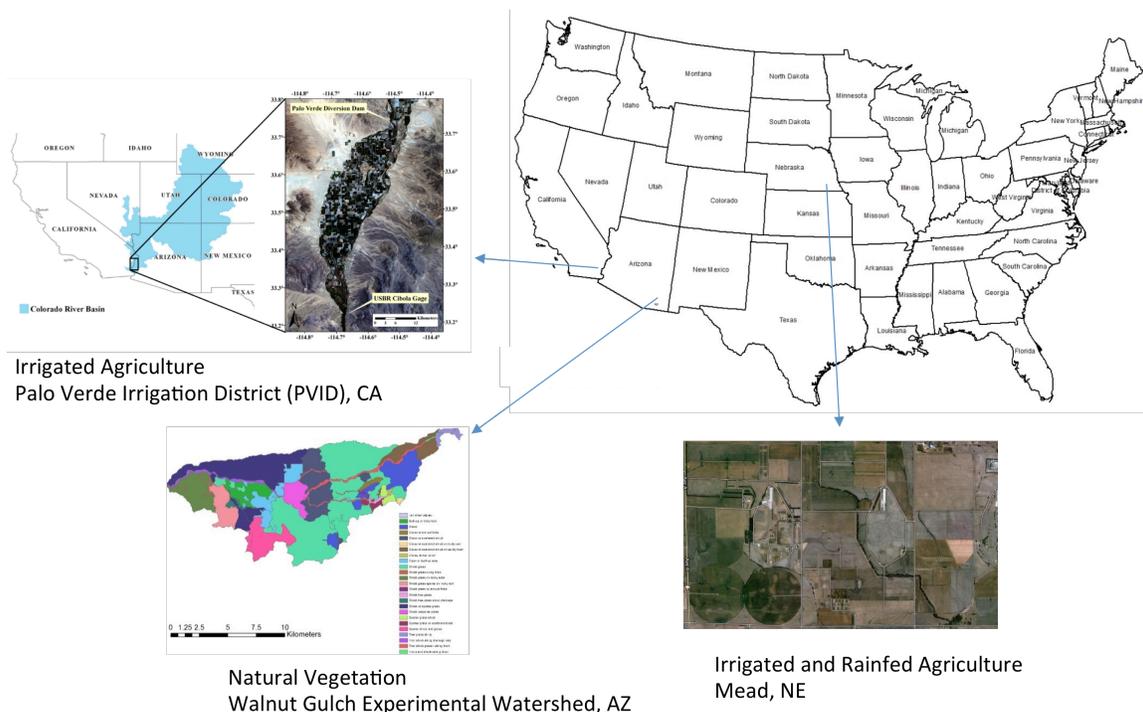


Figure 2: the selected testing sites for the model intercomparison task.

3.4. Remote sensing, weather and spatial datasets

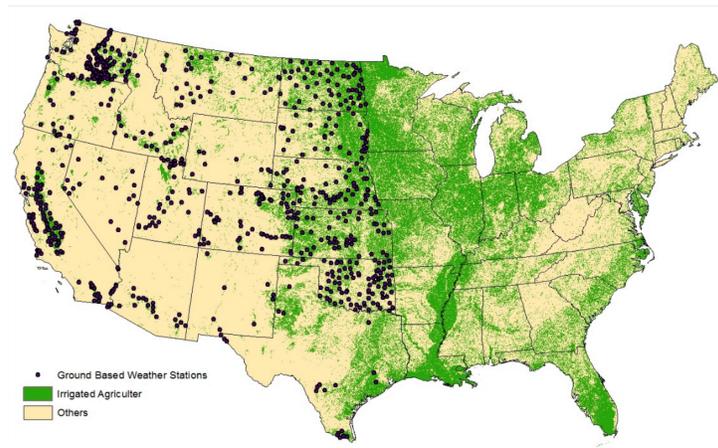
Spatial and point datasets that are being used were identified considering different technical aspects including

- Thermal and multispectral imagery from Landsat TM, MODIS, and GOES
- Cropland Data Layer, produced annually by USDA, and its vector Common Land Units database of parcel boundaries
- Hourly weather data from weather station networks from the different states
- Spatial reference ET and other gridded weather forcing data including, for example, air temperature, wind speed, vapor pressure, and solar radiation

The USGS is currently testing a new algorithm that will eventually provide atmospherically corrected thermal and multispectral Landsat satellite imagery. We are using this product in testing the ET models as a way of standardizing the calibration of imagery. This will ensure the quality of the data, guarantee a single source of data, and remove the uncertainties that could arise from using atmospheric correction from individual users that might apply different models and/or methods.

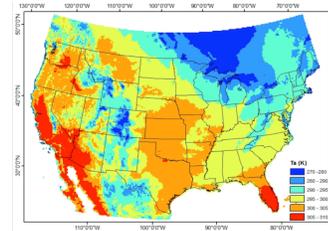
3.5. Comparison of gridded with ground based weather data

The use of ground based weather data might not be appropriate in some situations when applying remote sensing of ET models at regional scales over large areas. The near real-time gridded weather forcing data called NLDAS phase 2 can be a potential source of spatially distributed weather data to be used in these models. However, these data are at a relatively coarse resolution of 14 km, which is not ideal for agricultural studies at field scales or irrigated areas surrounded by desert or semi-arid vegetation. The data need to be compared against ground based measurements to identify errors and biases. Several hundred ground based weather stations were identified over agricultural areas within the 17 western states (Figure2) filtered using the NASS Cropland data set. The main variables being compared are air temperature, solar radiation, vapor pressure and wind speed.

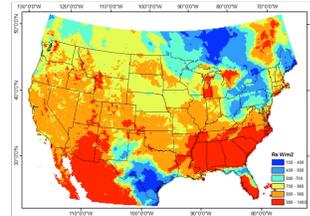


Crop Land Data for 2012 (NASS) is used to identify stations over irrigated areas, 800 stations were located for the western US.

Figure 3: Location of the selected ground stations with over agricultural areas based on the crop land data.



Downward shortwave radiation R_s ($W m^{-2}$) at 18:00 GMT during May 17, 2008



Air temperature T_a at 2 m above surface ($W m^{-2}$) at 18:00 GMT during May 17, 2008

Air Temperature and Solar radiation from NLDAS-2 data, other forcing variables include Wind Speed, Specific Humidity.

4. Principal findings and significance

4.1. Comparison of gridded weather data

Preliminary results about the comparison of NLDAS gridded weather forcing with ground based data are shown in Figure 4. The results indicated that there can be large discrepancies between NLDAS forcing and surface values over irrigated areas. This suggests that the use of these data without adjustment or bias correction could lead to large errors when applying remote sensing of ET models at large spatial scales. A peer review manuscript is being prepared to present these results along with some suggested bias correction methodologies.

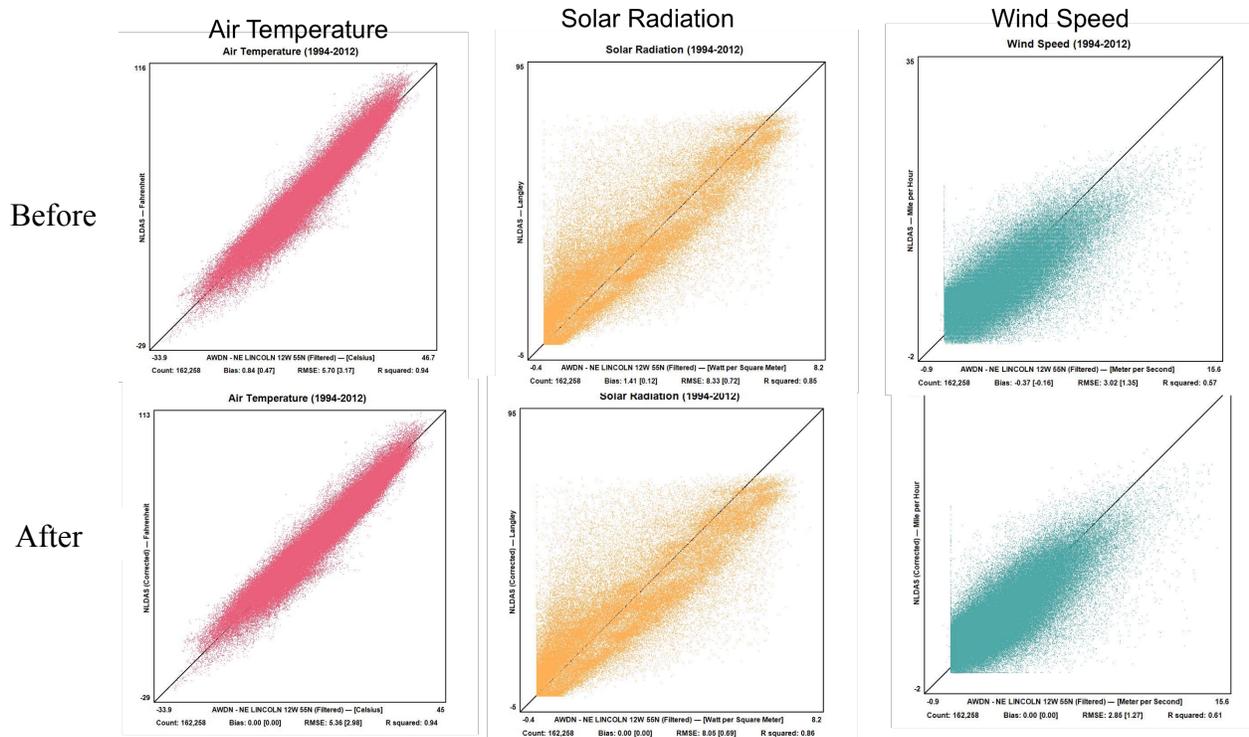


Figure 4: Scatterplot of T_a , R_s , and U comparisons between NLDAS and ground weather forcing before and after suggested bias correction NE Lincoln station (12W 55N) 1994-2012 .

4.2. Application of TSEB over PVID

A preliminary analysis was conducted to study of the effect of using NLDAS weather forcing and ground based data in the application of the two source energy balance model (TSEB) to estimate ET. This study was carried out over the PVID, CA. Figure 5 depicts the size of the NLDAS pixel with respect to the study area.

The preliminary results (Figure 6, 7 and 8) indicated that:

- The statistical comparison of the estimated fluxes with ground measured data using the TSEB model were typical of similar studies in irrigated agricultural areas.
- Generally, estimated discrepancies at the individual flux level based on NLDAS-2 forcing were slightly higher compared to those estimates using ground based weather station data but with similar overall behavior.
- The estimated R_n values based on NLDAS-2 are slightly lower than those based on ground forcing.
- The estimated H based on NLDAS-2 are slightly lower than those based on ground forcing that might be due to a slightly higher T_a resulting from the use of NLDAS-2.
- LE based on NLDAS-2 were slightly lower compared to those based on ground data.
- Daily ET estimates based on NLDAS-2 were slightly lower but not significant.

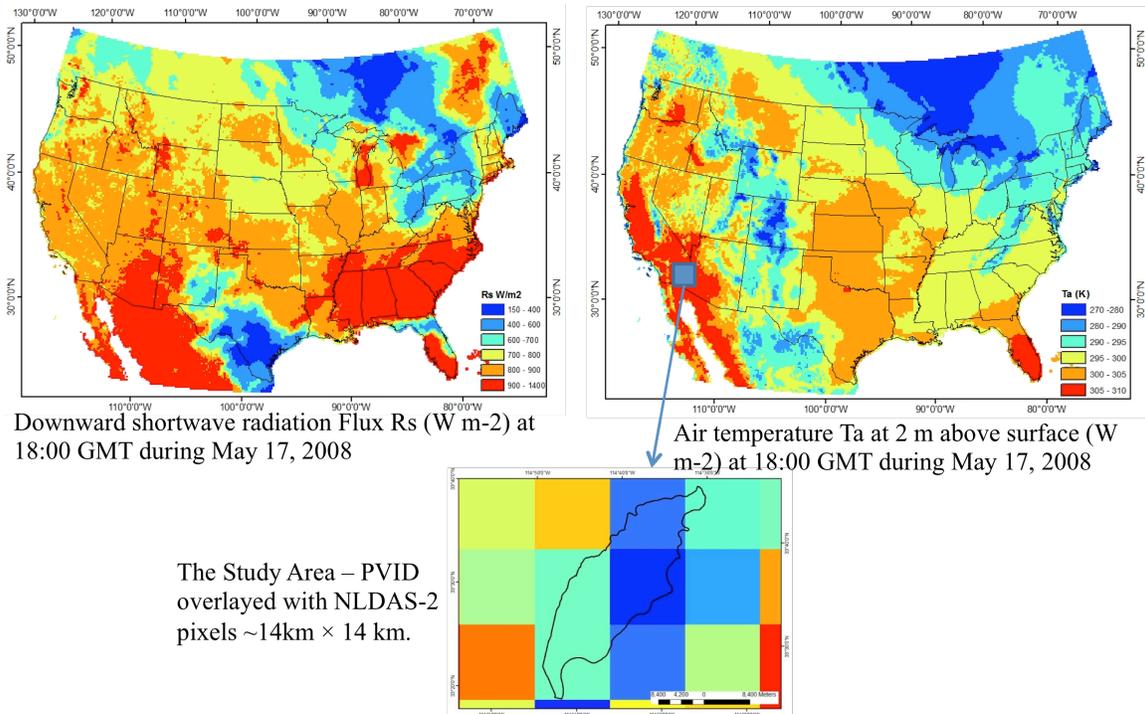


Figure 5: depiction of the NLDAS pixel size with respect to the study area at the PVID, CA.

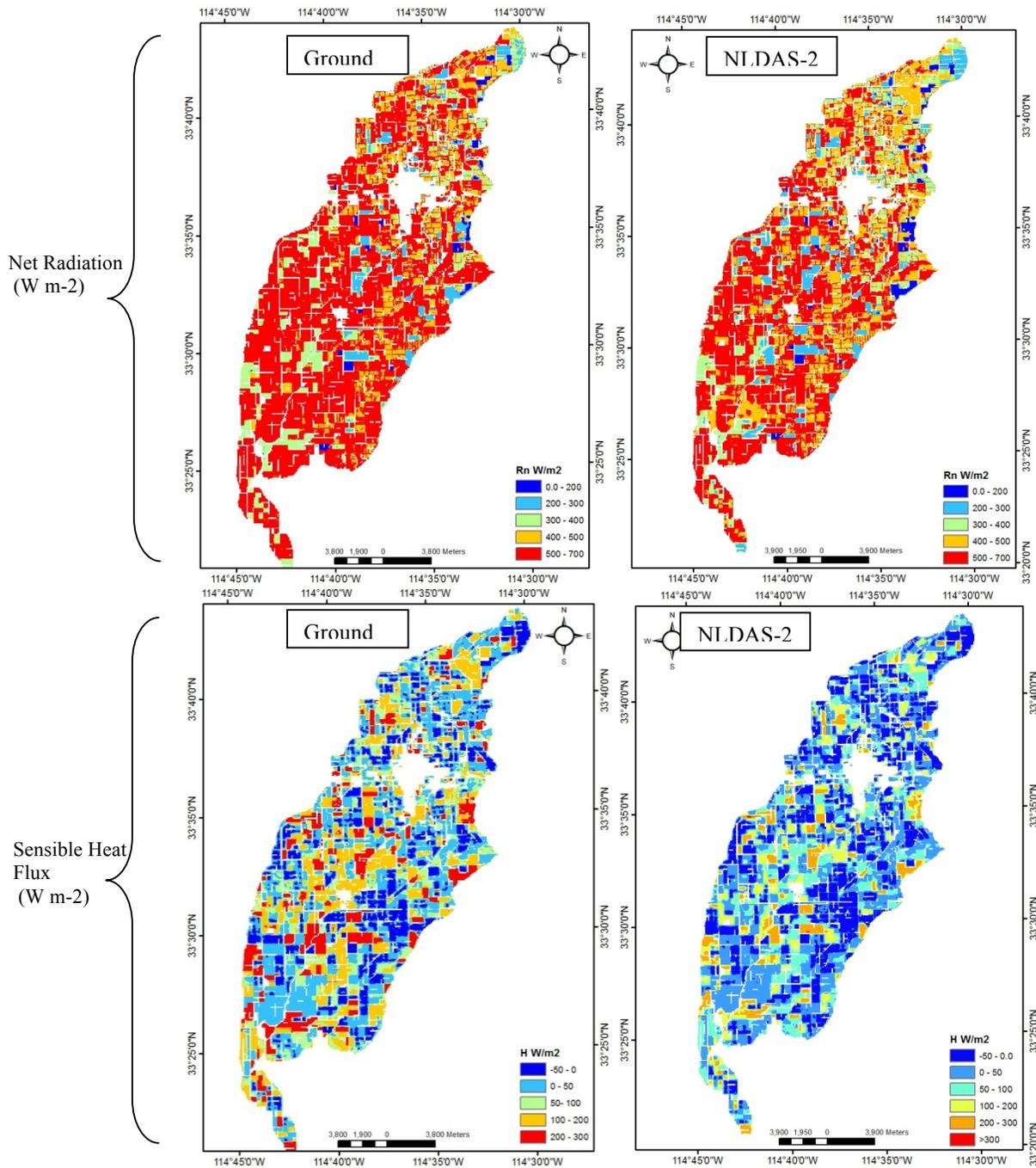


Figure 6: Comparison of Net Radiation R_n and Sensible Heat flux ($W m^{-2}$) during May 17, 2008 based on TSEB estimates with a) ground and b) NLDAS-2 weather forcing data.

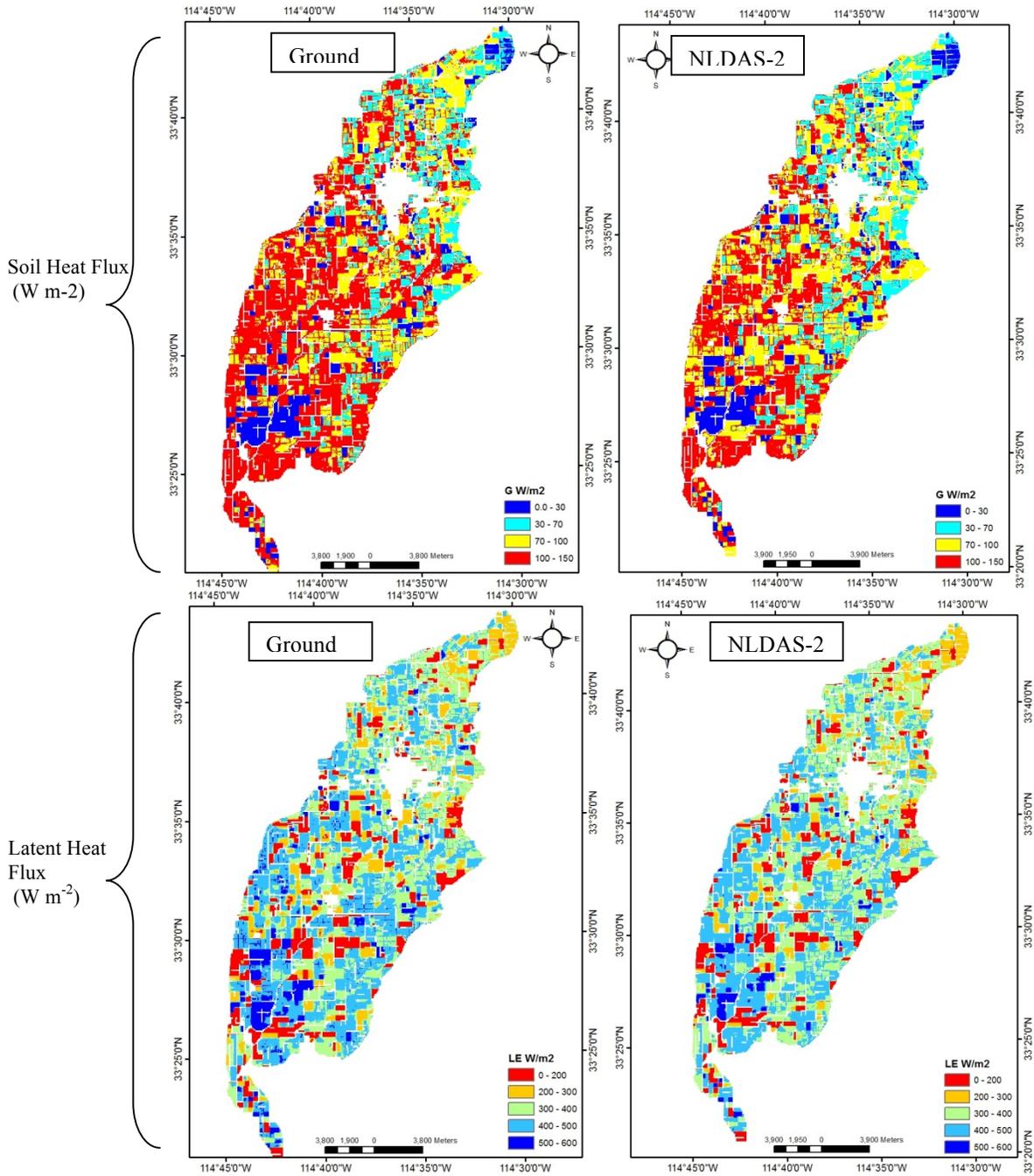


Figure 7: Comparison of Soil latent G and latent heat flux (W m⁻²) during May 17, 2008 based on TSEB estimates with a) ground and b) NLDAS-2 weather forcing data.

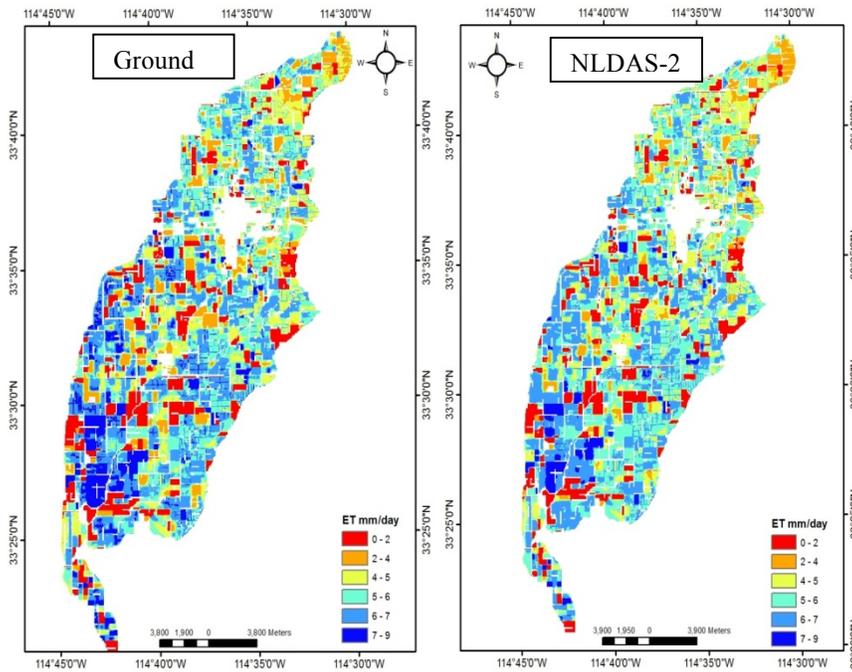


Figure 8: Comparison of daily ET (mm) during May 17, 2008 based on TSEB estimates with a) ground and b) NLDAS-2 weather forcing data.

4.3. List of presentations

Introduction of the suggest project framework and dissemination of preliminary results was achieved through presentation in professional conferences and workshops. A list of presentations is provided below:

- Geli, H. M. E., Neale, C. M. U., Lewis, C. S., Verdin, J., & Senay, G., 2012, Comparison of NLDAS weather forcing data with ground-based measurements in Utah, presented at 2012 Fall Meeting, AGU, San Francisco, California, 3-7 Dec.
- Neale, C. M. U., Geli, H. M. E., Verdin, J., & Senay, G., 2012, Using NLDAS weather forcing data on remote sensing of ET using a two source energy balance model, presented at 2012 Fall Meeting, AGU, San Francisco, California, 3-7 Dec.
- Lewis, C. S., Geli, H. M. E., Neale, C. M. U., Verdin, J., & Senay, G., 2012, Comparison of NLDAS weather forcing data with ground-based measurements for the Western US, presented at Spring Runoff conference Logan, Utah.
- Geli, H. M. E., Neale, C. M. U., Verdin, J., & Senay, G., 2013, Estimation of Crop Water Use with Remote Sensing: Development of Guidelines and Specification, presented at the USCID conference, Phoenix, AZ.

- Geli, H. M. E., & Neale, C. M. U., 2013, The use of a Hybrid Evapotranspiration Model with Multiple Source Remote Sensing Data, ASA meeting, Tampa, Florida

4.4. Summary of progress

The project is presently in its second year. A summary of the project progress is shown in Table 1.

Items					0	20%	40%	60%	80%	100%
1	Identification and review of currently available remote sensing of ET models									
		Identification and selection of models for testing								
2	Defining a common Framework	Summary Review (report) of Existing Practice								
		a	Models Review Report							
		b	Input Data							
		1	Cropland Data							
		2	Weather Data							
		3	Standardized Imagery							
		c	Modeling Process							
d	Evaluation of ET									
3	Final Framework									
4	Community review									

References

Allen, R. G., M. Tasumi, and R. Trezza, 2007: Satellite-based energy balance for mapping evapotranspiration with internalized calibration (METRIC)-Model. *J. Irrig. Drain. Eng.*, **133(4)**, 380–394.

Bastiaanssen, W., M. Menenti, R. Feddes, and A. Holtslag, 1998: A remote sensing surface energy balance algorithm for land (SEBAL) 1. Formulation. *J. Hydrol.*, **212–213**, 198–212.

Bausch, W. C. and C.M.U. Neale. 1987. Crop coefficients derived from reflected canopy radiation: A Concept. *Trans. ASAE* 30(3):703-709

Geli, Hatim M. E., 2012: Modeling Spatial Surface Energy Fluxes of Agricultural and Riparian Vegetation Using Remote Sensing, Ph. D. Dissertation, Department of Civil and Environmental Engineering, Utah State University.

Mu, Q., Heinsch, F. A., Zhao, M. S., and Running, S. W. (2007). Development of a global evapotranspiration algorithm based on MODIS and global meteorology data. *Remote Sensing of Environment*, 111, 519–536.

- Neale, C. M. U., Bausch, W., Heermann, D., 1989. Development of reflectance based crop coefficients for corn. *Trans. of ASAE*, 32(6), 1891-1899
- Norman, J. M., W. P. Kustas, and K. S. Humes, 1995: A two-source approach for estimating soil and vegetation energy fluxes in observations of directional radiometric surface temperature. *Agriculture and Forest Meteorology*, 77, 263–293.
- Su, Z. 2002. The Surface Energy Balance System (SEBS) for estimation of turbulent heat fluxes, *Hydrol. Earth Syst. Sci.*, 6, 85–100, 2002
- Senay, G.B., Verdin, J.P., Lietzow, R., Melesse, A.M., 2008. Global daily reference evapotranspiration modeling and evaluation. *J. Am. Water Resour. Assoc.* 44, 969–979

UAV Monitoring and Assessment Applications in Municipal Water and Environmental Management Problems

Basic Information

Title:	UAV Monitoring and Assessment Applications in Municipal Water and Environmental Management Problems
Project Number:	2012UT167B
Start Date:	3/1/2012
End Date:	2/28/2013
Funding Source:	104B
Congressional District:	UT1
Research Category:	Engineering
Focus Category:	Conservation, Floods, Hydrology
Descriptors:	None
Principal Investigators:	David Rosenberg, Austin Jensen

Publications

There are no publications.

State: UT
Project Number: 2012UT167B
Title: UAV Monitoring and Assessment Applications in Municipal Water and Environmental Management Problems
Project Type: Research
Focus Category: Conservation, Floods, Hydrology
Keywords: Remote sensing, UAV, Unmanned Aerial Vehicle, UAS, Unmanned Aerial System, Thermal Infrared, Near Infrared, Landfill Management, Management of Parks and Recreation, Wetlands, Riparian, Wetland Management, Flood Management, Flood Debris
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Abstract: There are many benefits in using remote sensing and aerial imagery for water and environmental management problems. One of these benefits includes having more accurate, distributed, and complete spatial data than is possible with ground surveys alone. However, many water providers and environmental managers are not able to take advantage of these benefits due to the high cost and limited flexibility of conventional remote sensing technologies. Motivated by these issues, we have developed a series of remote sensing platforms at Utah State University (USU) collectively called AggieAir™. The AggieAir platforms are small, autonomous unmanned aircraft which carry multispectral onboard cameras to capture aerial imagery during flight. The multispectral cameras available on AggieAir include a visual (red, green blue) camera, a near-infrared (NIR) camera, and a thermal infrared camera. AggieAir enables users to gather aerial imagery at a lower price and a greater spatial and temporal resolution than most manned aircraft and satellite sources. In addition since AggieAir is not dependent on runways, the user can launch the aircraft and gather aerial imagery when and wherever they want. This project will investigate the use of AggieAir for municipal applications specifically in water and environmental management problems. We will collaborate with the city of Logan, UT and use AggieAir to capture aerial imagery over various types of municipal areas including a wetland, a riparian area, the city landfill and the city golf course. The imagery will be processed in various ways to generate data that Logan City can use to help manage these areas.

UAV Monitoring and Assessment Applications in Municipal Water and Environmental Management Problems

Problem Description

For water and environmental management applications, remote sensing can be useful by giving managers accurate and quality spatial data on what they are trying to manage. Sriharan et. al. (Sriharan, Everitt, Yang, & Fletcher, 2008) used aerial imagery to map invasive plant species in a wetland to help managers remove them effectively. In a riparian area, Everitt and Deloach (J. Everitt & Deloach, 1990) used aerial imagery to map Chinese Tamarisk. Even though research has shown that remote sensing can be a very useful tool, many do not use it due to high cost, long processing time and inflexibility (Pinter et al., 2003). Free GIS state services or applications like Google Earth could be used for aerial imagery instead of purchasing the data. However, the imagery from these sources can be out-of-date, may have poor resolution, and rarely include all spectral information to allow for the use of modern classification software or other advanced analytic techniques. To deal with some of these problems and provide remote sensing data to a wider range of managers and stake-holders, a new series of remote sensing platforms, collectively called AggieAir™, has been developed at Utah State University (see Figure 1). AggieAir platforms are small, autonomous aircraft (commonly known as “unmanned aerial vehicles”, or UAVs) with multiple on-board cameras to capture aerial imagery during flight. AggieAir is capable of capturing visual (red, green, and blue), near-infrared (NIR), and thermal imagery. For this project, we will investigate the value of the use of AggieAir to cities, such as Logan, UT, to help them manage environmental issues by capturing aerial imagery over areas of interest. The types of areas in which Logan City are interested include wetland and riparian areas, landfills, and parks and recreation areas such as a golf course.

In order to reduce the human footprint on the environment and protect people and property from natural disasters such as floods, cities should carefully manage their environmental resources. This includes is wetlands resources. Logan City operates 240 acres of polishing wetlands for wastewater treatment and 35 acres of land used for leachate treatment, stormwater runoff, and wetland mitigation. The City has a UPDES permit, which allows treated wastewater to be discharged into the backwaters of a local reservoir located on a major tributary to the Bear River. The permit requires the city to maintain pollutant levels in discharged wastewater below a threshold standard. The polishing wetlands help remove the regulated contaminants. To ensure that the wetlands are effective at removing the contaminants, the vegetation must be managed to promote native species and remove invasive plant species. It would be of great benefit to the treatment plant, landfill, and wetland mitigation to have aerial photography of the wetlands to identify plant species, growth patterns, and dead spots where re-planting and maintenance is needed. The use of small UAVs to accomplish these tasks has not been previously explored.

Cities are also concerned with managing riparian areas. Each spring, employees from the Logan City Street department walk the banks of the Logan River to look for debris in and near the river. On average, Logan city uses 14 employees over 5 days to identify locations of collected flotsam and deadfall trees. Once these debris piles are located, the city removes the debris to allow the spring runoff water in the river to flow freely without debris collecting on bridges and irrigation head gates or otherwise creating flood hazards. The average cost for these activities includes

\$10,000 in labor and \$10,000 for equipment and fuel. Quick and efficient identification of debris piles could significantly reduce the cost by reducing the manpower and equipment needed for this project. Aerial photography could reduce removal costs if it could be accomplished at a sufficient geographic and temporal resolution at a competitive cost.

Many cities must also manage landfills to properly dispose of waste collected by the city. Logan City operates 90 acres of landfill. To prevent the contents in the landfill from affecting the surrounding environment, frequent inspections of the landfill surface are critical to monitor signs of seeps, leaks, or erosion. It is also necessary to monitor stormwater management systems to properly control stormwater run-off and run-on. If stormwater comes in contact with landfill refuse it becomes leachate and must be treated properly. It would be of great benefit to landfill operations to have aerial photography to monitor unwanted changes in the landfill surface to minimize leachate. It would also be of benefit to record changes in elevation as materials are compacted into the landfill.

Parks and recreation are an important part of a city that must also be managed. Logan City maintains a golf course within in its jurisdiction to enhance and provide a high quality of life for local citizens. Each year groundskeepers for the Logan City golf course spend many hours driving and walking the course to identify areas of the course which develop dry or dead vegetation due to lack of consistent watering or inadequate application of fertilizers. Aerial remotely sensed imagery could help groundskeepers to quickly identify areas of the golf course that need additional water or fertilizers, improve grass maintenance, and save money on manpower and equipment to walk the golf course.

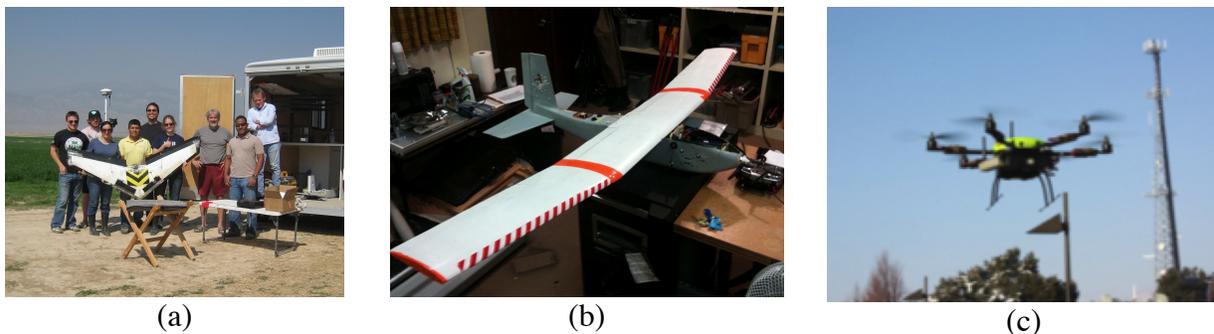


Figure 1: Current AggieAir UAV Platforms; (a) the older flying wing; (b) Minion and Titan class aircraft (Minion shown in the photograph); (c) AggieAir vertical-takeoff-and-landing platform

AggieAir vehicles are specifically designed as low-cost, scientific-grade remote sensing platforms. Using on-board navigation sensors, each aircraft is able to navigate according to a preprogrammed flight plan without a human operator. Since AggieAir aircraft were designed to be used in remote areas for field work applications, only an open field is required for takeoff and landing, not a runway or road. To launch the fixed-wing aircraft (Figure 1.a and Figure 1.b), a bungee is staked into the ground, attached to the aircraft, pulled back and released. For the landing, the aircraft simply lands on its belly. AggieAir platforms weigh from 3 to 25 pounds, depending on the class, and have wingspans from 72 to 144 inches. Again, depending on class of aircraft, they can fly for 30 to 90 minutes, and all are battery powered.

The imagery acquired by AggieAir is multispectral. Currently, visual (red, green and blue), near-infrared (NIR), and thermal infrared imagery is available. After each flight, hundreds of individual images must be retrieved from the cameras and processed. For processing, each image is tagged with the position and orientation data of the UAV when the image was exposed. This data can be used to automatically georeference each image immediately after the flight. To stitch all of the images together into a mosaic, third-party software called EnsoMOSAIC is used. EnsoMOSAIC stitches all the images together and creates an orthorectified mosaic. EnsoMOSAIC can also be used to generate digital elevation models (DEMs).

AggieAir has been used in many different types of water-related and environmental projects by researchers at USU. Some of these projects include wetland and riparian applications (Jensen et al, 2011; Zaman, McKee, and Jensen, 2011).

Scope of Work

Four tasks were identified for data collection and analysis that will be of value to Logan City:

1. Acquisition of multi-spectral imagery for nine square miles of a wetland area within Logan City in the visual, NIR, and thermal bands of the spectrum. The imagery will be classified for different types of wetland vegetation. This data will be used by Logan City to help manage mitigation wetland areas and to find out which areas are suitable for fill.
2. The Logan River will be flown by AggieAir from the mouth of Logan Canyon to the city boundaries to capture aerial imagery of the river in the visual and NIR bands. The imagery will be used to assist workers in identifying where to find debris in the river so that it can be removed before spring runoff.
3. AggieAir will be used to fly over the Logan City Golf Course. Aerial imagery in the visual, NIR, and thermal bands will be captured and used to map water stress of the grass. This data will be given to the groundskeepers to help them water the grass more efficiently. This will be done two times over the summer.
4. A detailed, high-resolution flight will also be made over the Logan City Landfill. Visual, NIR and thermal imagery will be captured and used to generate a digital terrain map (DTM), and to investigate the possibility of using aerial imagery to detect seeps, leaks and erosion. This will be done two times over the summer.

After the imagery is captured from AggieAir, it will be stitched together into orthorectified mosaics. If further image processing is needed, the mosaics will be converted to reflectance mosaics. After all the imagery is collected and processed, an evaluation will take place with Logan City to determine whether AggieAir was able to provide them with better data. This will include comparing the processed data with sample points taken on the ground, evaluating any time and cost savings to Logan City, and whether there was an overall improvement in water and environmental management.

All of the data acquired by AggieAir will be stored on a server at the Utah Water Research Laboratory (UWRL). Access to this data and its metadata will be given to Logan City and other interested parties through Secure File Transfer Protocol (SFTP). The mosaics can also be served via Google Earth.

Accomplishments to Date

Imagery has been acquired and processed from flights over the Logan City wetlands and the Logan City Golf Course. Figure 2 shows the orthorectified mosaic of the Logan City wetlands in the visual spectrum, including the Logan City sewage lagoons and, to the south, the farm land that is used as a polishing treatment facility to improve nutrient removal from the effluent released from the lagoons. Also shown to the south of the lagoons are wetland areas along the Little Bear River, which Logan City manages. These are shown in greater detail in Figure 3.

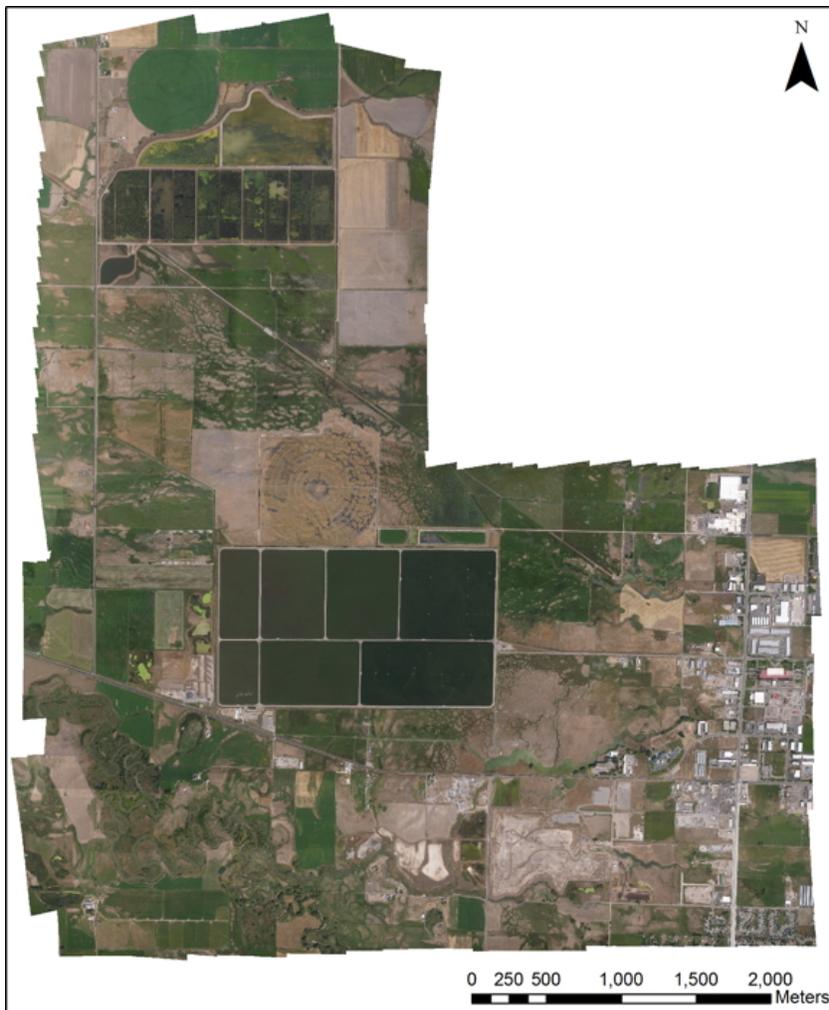


Figure 2: Logan City Wastewater Treatment Lagoons and Managed Wetlands (imagery acquired with AggieAir)



Figure 3: Logan City Managed Wetlands along the Little Bear River

Flights over the Logan City Golf Course produced imagery in the visual, near-infrared, and, as shown in Figure 4, thermal bands. From the golf course thermal imagery it is easy to identify locations on fairways and greens where higher temperatures indicate greater need for attention to irrigation and/or nutrients.

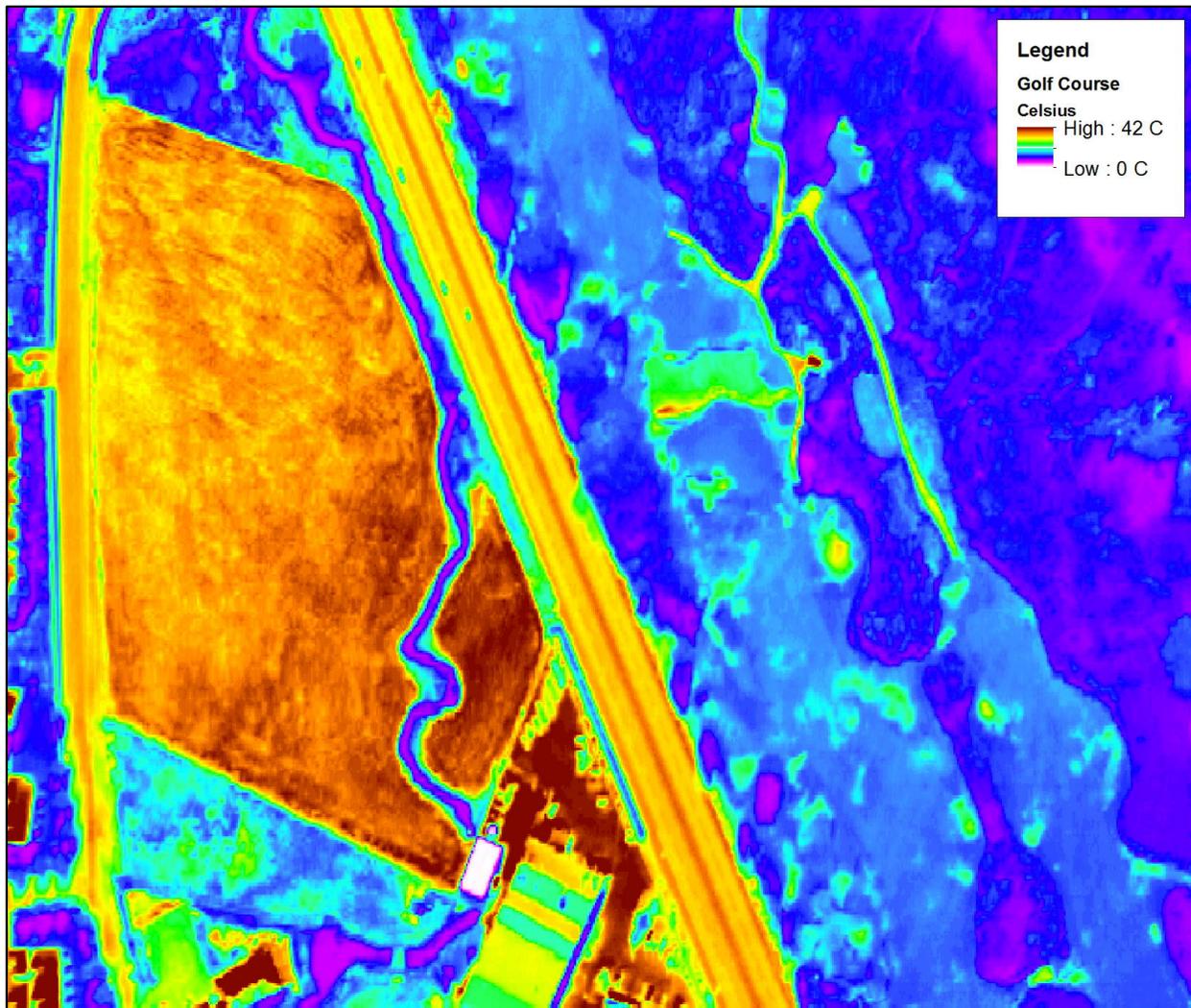


Figure 4: Thermal Imagery of a Portion of the Logan City Golf Course. Areas to the right of the highway indicate hotspots on fairways needing greater amounts of irrigation water.

Work Remaining

The work will continue into the next Section 104-b funding cycle. During next year, flights will be completed over the Logan City landfill and along the Logan River prior to the onset of spring runoff. Subsequent to flights and data processing, the evaluation meeting will be held with Logan City resources managers to assess the value of the UAV technology in the resources management questions examined.

Benefits to the State of Utah

The objective of this project is to investigate the use of AggieAir toward municipal water and environmental management problems. If AggieAir proves useful and is able to save Logan City water, money and time then this could be applied to other cities in Utah. Therefore Utah as a whole would also be saving more water, money and time while effectively managing the environmental resources contained within its cities and counties.

References

- Everitt, J. and C.J. Deloach, (1990). Remote Sensing of Chinese Tamarisk (*Tamarix chinensis*) and Associated Vegetation. *Weed Science*, 38(3):273-278.
- Jensen, A.M., T. Hardy, M. McKee, and Y.Q. Chen (2011). Using a Multispectral Autonomous Unmanned Aerial Remote Sensing Platform (AggieAir) for Riparian and Wetland Applications. *Proc. IEEE Int. Geoscience and Remote Sensing Symp.* (IGARSS).
- Pinter, P.J., J.L. Hatfield, J.S. Schepers, E.M. Barnes, M.S. Moran, D.S.T. Daughtry, and D.R. Upchurch (2003). Remote sensing for crop management. *Photogrammetric Engineering Remote Sensing*, 69(6), 647–664.
- Sriharan, S., J.H. Everitt, C. Yang, and R.S. Fletcher (2008). Mapping Riparian and Wetland Weeds with High Resolution Satellite Imagery. *Proc. IEEE Int. Geoscience and Remote Sensing Symp.* (IGARSS).
- Zaman, B., M. McKee, and A. Jensen (2011). Use of High-Resolution Multispectral Imagery Acquired with an Autonomous Unmanned Aerial Vehicle to Quantify the Spread of an Invasive Wetland Species. *Proc. IEEE Int. Geoscience and Remote Sensing Symp.* (IGARSS).

Performance of Stormwater Bioretention Systems in Utah's Climate and Hydrologic Conditions

Basic Information

Title:	Performance of Stormwater Bioretention Systems in Utah's Climate and Hydrologic Conditions
Project Number:	2012UT168B
Start Date:	3/1/2012
End Date:	2/28/2013
Funding Source:	104B
Congressional District:	UT3
Research Category:	Water Quality
Focus Category:	Surface Water, Water Quality, Water Quantity
Descriptors:	None
Principal Investigators:	Steven J. Burian, Christine A. Pomeroy

Publications

There are no publications.

Performance of Stormwater Bioretention Systems in Utah's Climate and Hydrologic Conditions



Final Report Submitted to Utah State University Water Lab

by

Dr. Christine Pomeroy and Dr. Steven Burian
Department of Civil and Environmental Engineering
University of Utah

USU Subaward Number: 11059101
Total Award: \$24,037

May 15, 2013

Problem and Research Objectives

Currently, a small number of bioretention design guidelines are available as references for planners and designers; however, these consist of bioretention design focusing on mesic systems, which receive 30 to 80 inches of rain each year, and address traditional stormwater engineering approaches, such as facility sizing and hydraulics design (Prince George's County, 2001; USEPA, 2006, Low Impact Development Center, 2009). Quantifying the hydrologic impacts of bioretention facilities on urban environments in semiarid climates, such as in Utah, is a field of study to which little progress has been made (NRC, 2008; Houdeshel et al., 2011).

Bioretention cells are designed such that the stormwater input to the systems is retained in soil storage layers for treatment and consumption by deep-rooting natural vegetation. Pollution loading to receiving waters can be reduced with bioretention components, including vegetation (i.e. nutrient removal) and the soil properties (i.e. adsorption). Infiltration and potential groundwater recharge can be studied through design and monitoring of topsoil, reservoir layers, and in-situ soils. As such, objectives of this study included monitoring total stormwater inflows to the bioretention cell through a single inlet, monitoring depth of water in the gravel storage reservoir, and identifying rates of infiltration into the natural sub-soils over a one year study period. Thus, this research project provided the ability to address the following questions: Are bioretention cells able to reduce stormwater runoff in semiarid climates? What are the infiltration rates through the bioretention cell and into the natural sub-soils?

Overall, the proposed project met the following objectives:

1. Designed and constructed a new bioretention facility, the first field-based research facility in Utah, to be used for the purposes of this research and as a demonstration and outreach site.
2. Assessed the ability of bioretention cells to reduce stormwater runoff volume in Utah.
3. Determined the infiltration rates through the bioretention cell and into the natural sub-soils over the project duration.

Methodology

In the fall of 2011 a bioretention basin was designed for the newly constructed Mountview Park, located in Cottonwood Heights, Utah. Construction of the bioretention basin was completed in May 2012. The project was executed in cooperation with the City of Cottonwood Heights, Gilson Engineering, and Miller Paving. Funding for the project was provided by a 104b grant through the U.S. Geological Survey (USGS) with matching funds from the City of Cottonwood Heights and Gilson Engineering.

The purpose of the site is to serve as a public demonstration of bioretention in Utah and to provide data for future research studies. The site has a sign installed near the walking path of the Mountview Park which increases public awareness and education of bioretention in semi-arid climates such as Utah. The sign also details the purpose, design, and cooperative efforts of all the parties which have participated in the design and construction of the bioretention system. Stormwater inflow data, soil moisture data, stormwater levels in the bioretention storage layer, and rainfall data have been continuously collected from August 2012 to December 2012 and from April 2013 to the present (May 2013). This data is currently being used to determine bioretention infiltration rates for semi-arid climates. Data collection will continue for the indefinite future which will provide additional research opportunities.

Schematics of the park and analyses of the watershed hydrology were obtained from the Cottonwood Heights City Engineer (Mr. Brad Gilson) for use in the design process. Plans of the final design, including all appropriate dimensioning, placement of wells, and locations of plants were supplied to the Cottonwood Heights City Engineer for approval prior to construction of the site in May, 2012. The research team coordinated material selection and well drilling, and provided personnel for construction activities including well installation, planting, and installing instruments. The contracted construction company (Miller Paving) provided in-kind assistance in the form of heavy equipment, personnel, gravel and soil spreading, and time for excavation.

Five drainage basins flow to an outfall at the northwest corner of the parking lot, as shown in Figure 1. The bioretention cell was sized to fit in available space near the outfall of the drainage area. A 0.3 m (12 in) diameter concrete storm sewer connected the cell at the surface level to a nearby overflow basin to allow drainage in an emergency overflow scenario. The cell area was approximately 229 m² (2470 ft²).

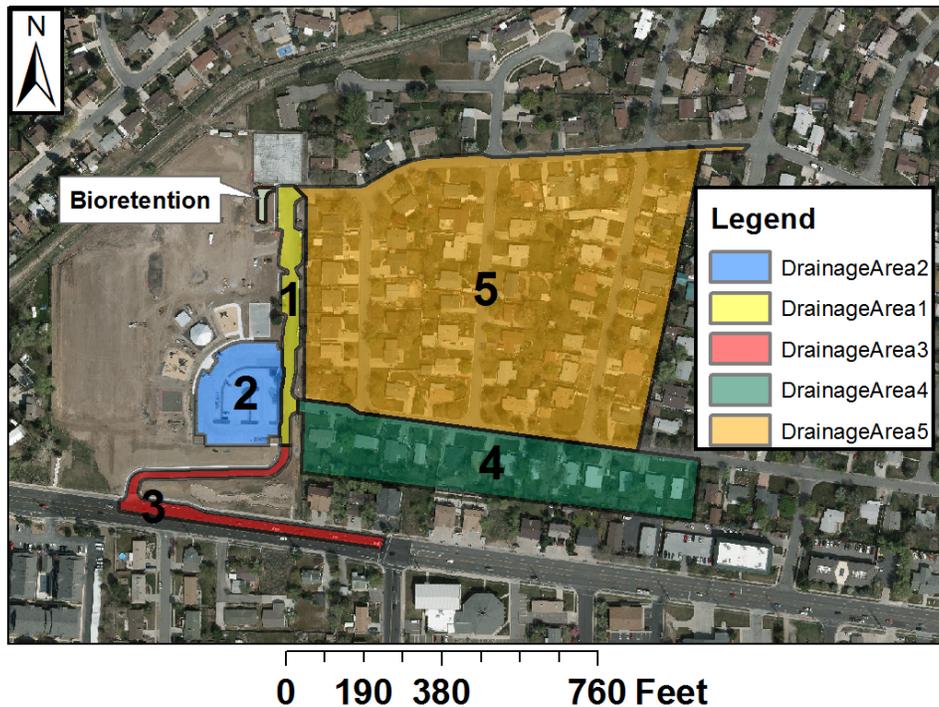


Figure 1: Drainage Area for Mountview Park Bioretention

The cell was excavated to a depth of 1.2 m (4 ft) and subsequently backfilled with storage and soil layers up to the preexisting level. The design included a 0.6 m (2 ft) top soil layer above a 0.6 m (2 ft) subsurface reservoir layer which is ¾" gravel. A cross-sectional view of the design is shown in Figure 2.

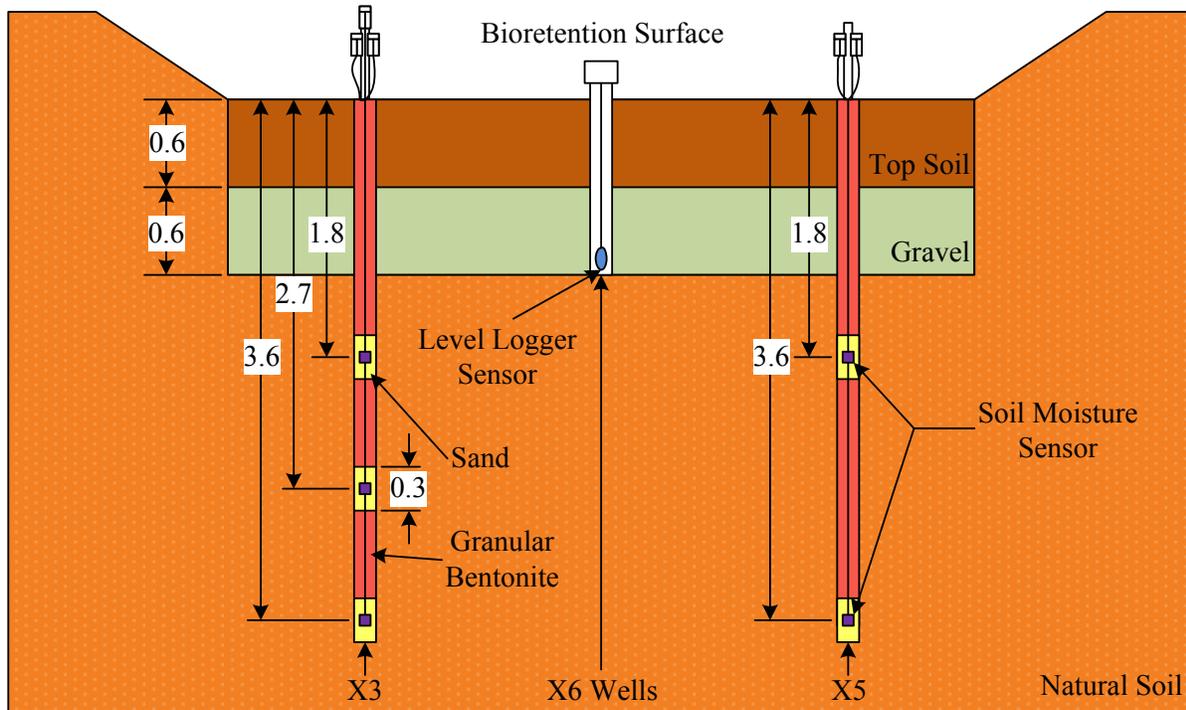


Figure 2: Cross Section of Mountview Park Bioretention

The design also includes a gravel forebay that allows water to rapidly percolate to the storage reservoir. The forebay extends laterally 1.5 m (5 ft) from the cell inlet, and extends vertically to the reservoir layer.

Combined, the underground gravel reservoir and surface depression storage of the overflow retention pond have a capacity of approximately 212.1 m³ (56,029 gal). Overflow is diverted into traditional infrastructure and discharged into a nearby canal on the northwest side of the park.

The cell was planted with a mixture of native grasses, shrubs, and woody vegetation. Sensors that monitor groundwater levels and movement were installed in the bioretention. There are six level logger sensors which measure the head of water in the engineered storage layer of the bioretention. In addition, there are 19 soil moisture sensors ranging from 1.8 (6ft) to 3.6 m (12 ft) which track water movement through the soil. Two inflow sensors were placed at the inlet structure to record incoming flows and a rain gage was placed to the north of the Configuration of the vegetation, wells, soil moisture sensors, and rain gage within the cell is shown in Figure 3.

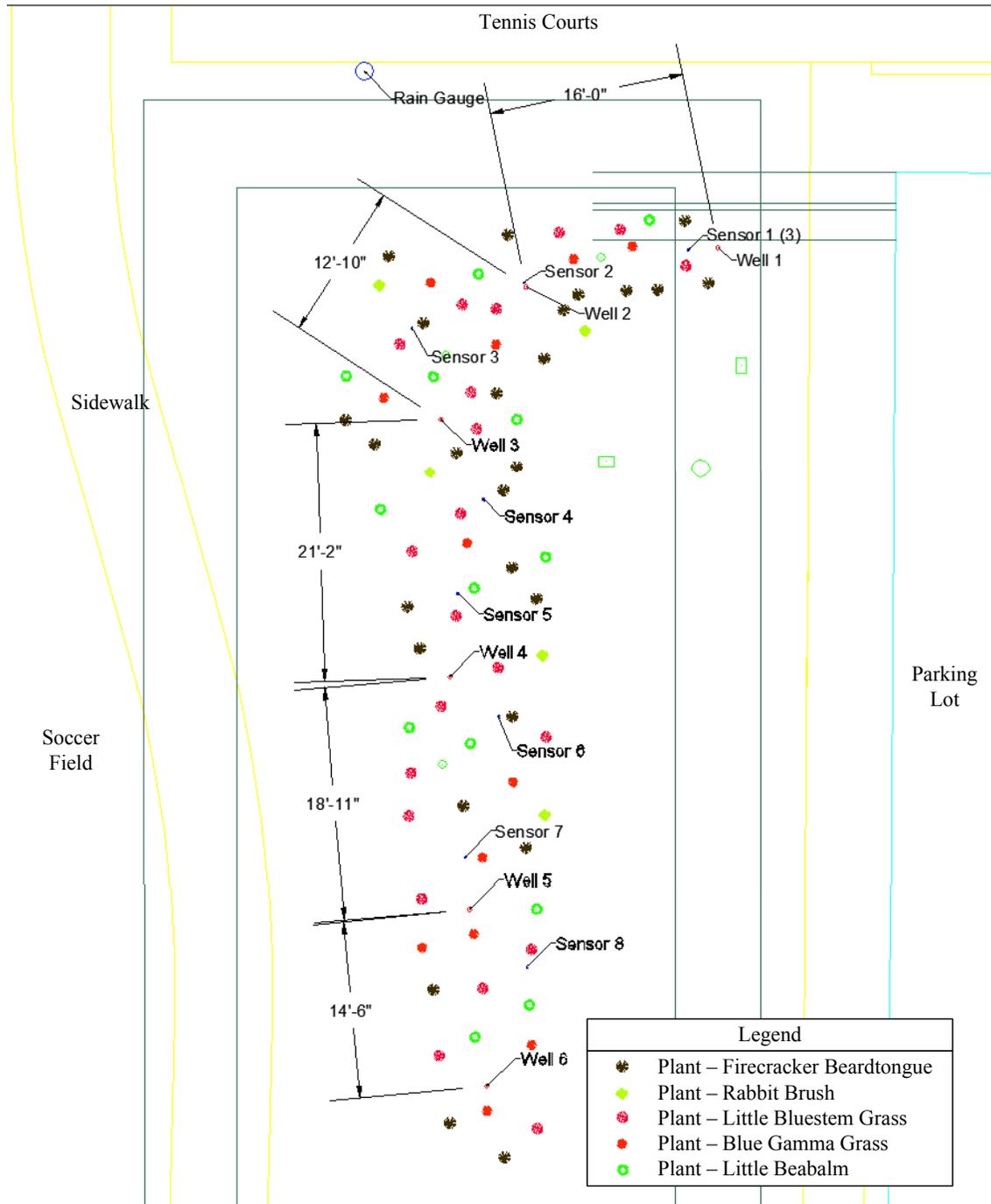


Figure 3: Aerial View of Bioretention

Principle Findings and Significance

Currently work is being performed to develop an algorithm which can process the raw data received from the soil moisture sensors and level loggers and determine the steady state value as well as peak value as a result of water passing by the sensor. Rainfall data has been compiled into daily precipitation plots and this is then used to determine when the sensors are at steady state (no rainfall) and when they have peak values (rainfall). The daily precipitation plot can be seen below in Figure 4.

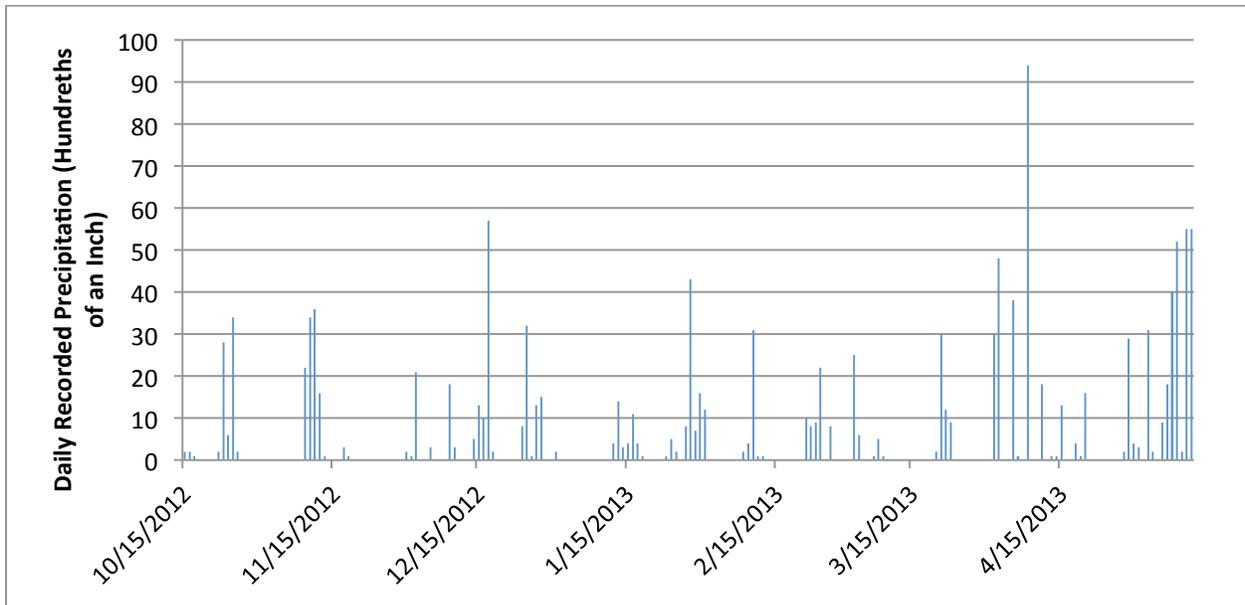


Figure 4: Daily Precipitation Mountview Park, Cottonwood Heights, Utah

At this time some of the data has been processed to determine the vertical infiltration rate for the bioretention. The results thus far have been inconclusive and the rates determined for the natural soil are much lower by the order of two to three magnitudes than are to be expected. While this may be the case for this area, further research is required to accurately determine the vertical infiltration rates of the bioretention located in Mountview Park.

Future Work

The next step of this research is to continue to quantify the vertical and horizontal infiltration rates of bioretention cells in semi-arid climates. Prior research has shown that bioretention is effective in reducing the amount of stormwater discharge as water is able to infiltrate into the natural soil. Continuing this research will enable more accurate prediction of infiltration rates of the soil types used in bioretention cells and if there is any rate change overtime as the site ages due to clogging or other factors.

The horizontal and vertical infiltration rate will be determined using the data from the level logger and soil moisture sensor data. The data will be processed through Microsoft Excel using an algorithm which can determine the steady state values and the peak values for each of the sensors. The infiltration rate can then be determined by taking the time between the peaks of the different sensors to see how the water is infiltrating through soil.

Once the infiltration rates have been calculated for the bioretention, the watershed for the bioretention will be modeled using the EPA's Storm Water Management Model. The model will be calibrated using the collected field data and the long term performance of the bioretention will be determined. The findings of this research will be presented in a Master's Thesis to be finalized in May of 2014.

References

- Houdeshel, C.D., Pomeroy, C.A., Hair, L., Moeller, J. (2011). "Cost estimating tools for low-impact development best management practices: Challenges, limitations and implications." *Journal of Irrigation and Drainage*.
- Low Impact Development Center (2009). *Rain Garden Design Templates*. Retrieved October, 2011 from: http://www.lowimpactdevelopment.org/raingarden_design/index.htm.
- National Research Council (NRC) Committee on Reducing Stormwater Discharge Contributions to Water Pollution. (2008). *Reducing Urban Stormwater Management in the United States*. The National Academies Press. Washington, DC.
- Prince George's County, Maryland PGCo. (2001). *The Bioretention Manual*, Dept. of Environmental Resources, Prince George's County, Md.
- U.S. EPA (2006). Bioretention (Rain Gardens) Information Sheet. Accessed October 2011 from: http://www.epa.gov/npdes/pubs/gi_action_strategy.pdf.

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), the State Engineer's Office, and numerous municipal water supply and irrigation companies 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 in 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.

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

Basic Information

Title:	Information Transfer in Support of the Utah Center for Water Resources Research (UCWRR)
Project Number:	2011UT159B
Start Date:	3/1/2012
End Date:	2/29/2013
Funding Source:	104B
Congressional District:	UT1
Research Category:	Not Applicable
Focus Category:	Education, None, None
Descriptors:	None
Principal Investigators:	R. Ivonne Harris, Carri Lyn Richards

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. This project is in the process of disseminating semi-annual 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 Pages

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 have been developed to make information available, thus creating a tool wherein interested parties can find solutions to water problems. The design of the web pages is developed with Adobe "Dreamweaver" software and CSS. Pictures are 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 works-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.

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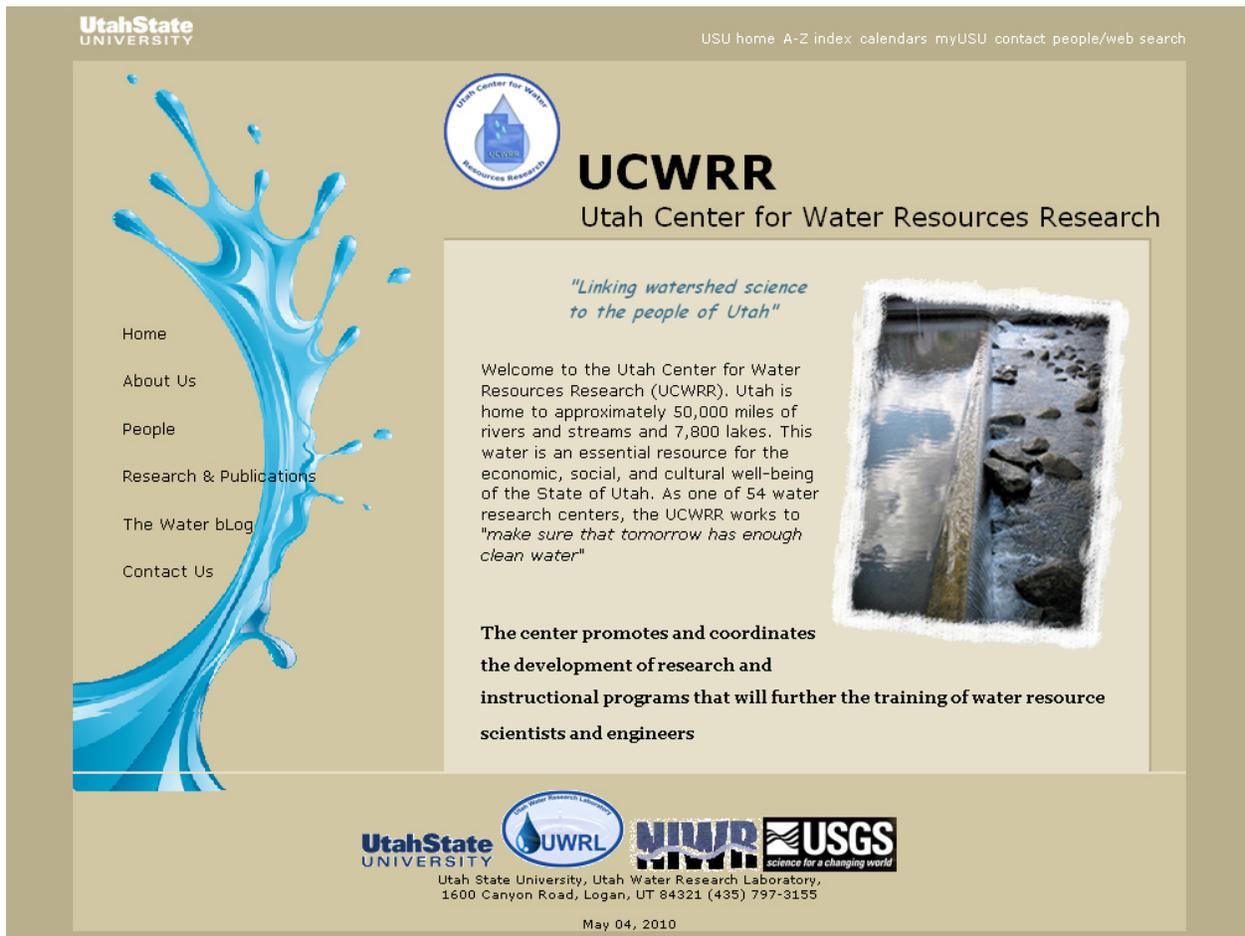


Figure 1. Home page for the UCWRR.

UtahState UNIVERSITY

USU home A-2 index calendars myUSU contact people/web search

Utah Center for Water Resources Research

UCWRR

Utah Center for Water Resources Research

Home
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Research and Publications

2009 UCWRR Summary
2008 UCWRR Summary

Research Reports

- Bioprocess Engineering
- Fluid Mechanics and Hydraulics
- Ground Water and Contaminant Hydrogeology
- Hazardous, Toxic Waste, and Air Quality Management
- Hydrology
- Water Education and Technology Transfer
- Water Quality Engineering
- Water Resources Planning and Management

Photo Gallery

UtahState UNIVERSITY UWRL NIWR USGS science for a changing world

Utah State University, Utah Water Research Laboratory,
1600 Canyon Road, Logan, UT 84321 (435) 797-3155

May 07, 2010

Figure 2. Research and Publications page for the UCWRR.

Newsletter

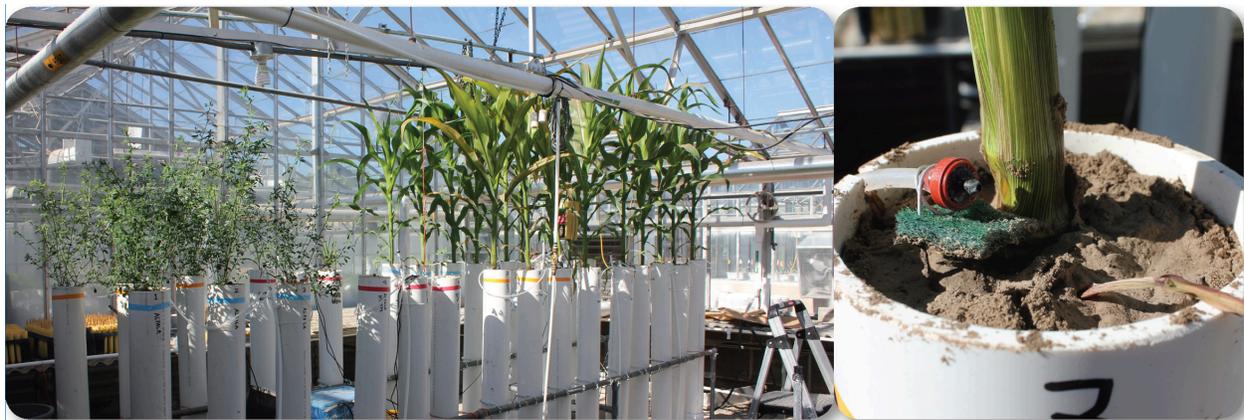
A semi-annual newsletter *The Water bLog* continues to be published. *The Water blog* is disseminated electronically at the UCWRR web site and through e-mail. The newsletter is e-mailed to approximately 350 readers. The main purpose of the newsletter is to highlight research projects and their findings. These will be of great interest and value to the State of Utah, as well as nationally and internationally.

A recent copy of the newsletter was sent out November 2012. One of the research projects featured in the newsletter was “Effect of Deposition from Static Rocket Motor Test Fires on Corn and Alfalfa” where UCWRR researchers have completed a study to determine the impacts of test fire soil (TFS) from static tests of solid rocket motors on the germination, biomass production, and plant composition of corn and alfalfa exposed to TFS deposition. One of the benefits to the State of Utah is that this research will contribute information regarding the potential impact of test fire soil from static test fires on crop production.

Results can be used to develop Best Management Practices and test fire protocols that will reduce impacts of static test fires on crop growth. Further research could examine the potential impact of TFS on various other crop growth stages.



View of exhaust cloud containing TFS from static rocket motor test



Greenhouse study evaluating the potential impact of TFS on corn

Another research project featured in the November 2012 Newsletter was “Pineview Reservoir Phosphorus and Mineral Nitrogen Processes and Algae/Cyanobacterial Bloom Ecology” where Nuisance blooms of algae and cyano-bacteria occur annually in Pineview Reservoir due in part to excess nitrogen and phosphorus loading, and previous studies have called for management actions to limit these nutrient loads to the reservoir. Pineview has been on Utah’s list of impaired waters since 2000, and a Total Maximum Daily Load (TMDL) study has recommended actions designed to reduce these nutrient loads.

In response to concerns over the potential effectiveness of the proposed reduction actions, UCWRR researchers have collaborated with the Weber Basin Water Conservancy District to provide empirical information for managers so that Pineview Reservoir water quality can be preserved or improved in the most cost-effective way.

While ground water flow into Pineview Reservoir is small relative to surface water flows, the concentration of phosphorus in certain ground water locations far exceeds those anticipated. Future efforts will use ground water quality monitoring near the reservoir to determine the chemical characteristics and possible sources of soluble phosphorus entering the reservoir.



Pineview Reservoir, Utah in early fall. A phytoplankton bloom, dominated by algae, occurs during this period each year



Researchers measuring light penetration through the ice

In the past year our UCWRR faculty members and researchers have traveled around the globe conducting and presenting their research and enhancing and sharing their extensive water resources expertise.

UCWRR faculty member, Blake P. Tullis, spent 6 weeks during summer 2012 as a visiting professor at the Hydraulic Construction Laboratory of École Polytechnique Fédérale de Lausanne (EPFL) in Switzerland. He participated in collaborative research related to piano key weir debris handling and the characteristics of sediment exchange between coupled reservoirs utilized for pumped-storage hydroelectric schemes.



Grande Dixence Dam in Hérémence, Switzerland, the tallest concrete gravity dam in the world at 285m (main photo). Dr. Tullis's experimental piano key weir model spillway set up for a debris handling study at EPFL (inset).

Figure 3 shows the first page of *The Water blog's* May 2012 issue. For an electronic copy of current or past newsletters, please go to <http://uwrl.usu.edu/partnerships/ucwrr/newsletter/>.



Welcome!

The Water bLog is the semi-annual newsletter of the Utah Center for Water Resources Research (UCWRR), housed at the Utah Water Research Laboratory at Utah State University. 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 online at:

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

INSIDE:

Research Highlight:

- ▶ Pineview Reservoir Phosphorus and Mineral Nitrogen Processes
- ▶ Optimizing Phosphorus Reduction in Echo Reservoir
- ▶ ATK Static Test Environmental Assessment Plant Study

In the News

Far Afield

UtahStateUniversity

Message from the Director



Mac McKee, Director

Managing complex water resources systems can be very challenging, especially when the science behind the behavior of the system is incompletely understood. Understanding such systems can require a multi-faceted approach of monitoring, modeling, and management. For instance, managing nutrient loads can require merging a variety of measurement, laboratory, and modeling techniques in order to understand how a watershed operates.

Similarly, various industrial activities can result in unpredictable effects that are difficult to understand and manage, requiring innovative research approaches.

This edition of the *Water bLog* focuses on some of the creative research currently underway at the UCWRR that involves monitoring, modeling, and ultimately managing the effects of nutrients in reservoir systems, as well as the potential downstream effects of static rocket motor tests on field crops. These projects represent only a fraction of the active research at the UCWRR that is designed to find practical solutions to natural resources challenges throughout the state. ■



RESEARCH HIGHLIGHT

Nutrient Management in Utah Reservoirs

UCWRR researchers are engaged in a variety of research designed to address the problem of nutrient loading in Utah's reservoirs, streams, and wastewater treatment facilities. Two such projects are highlighted below.

As demands for clean water for municipal, agricultural, industrial and other uses rapidly increase, it is becoming more and more important to care for and protect the quality of water entering water collection and storage systems. Increasing human activities such as agriculture, urban development, and recreation in and around Utah's freshwater lakes, reservoirs, and watersheds are introducing more pollutants into water supply systems.

Of particular concern are excess nutrients such as nitrogen (N) and phosphorus (P) because these nutrients stimulate algae growth, reduce dissolved oxygen,



Pineview Reservoir near Huntsville, UT

The Water bLog November 2012, Vol. 3, No. 2

Figure 3. *The Water bLog*, the Newsletter for the UCWRR.

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 have been 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>.

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Project Number:	2012UT170B
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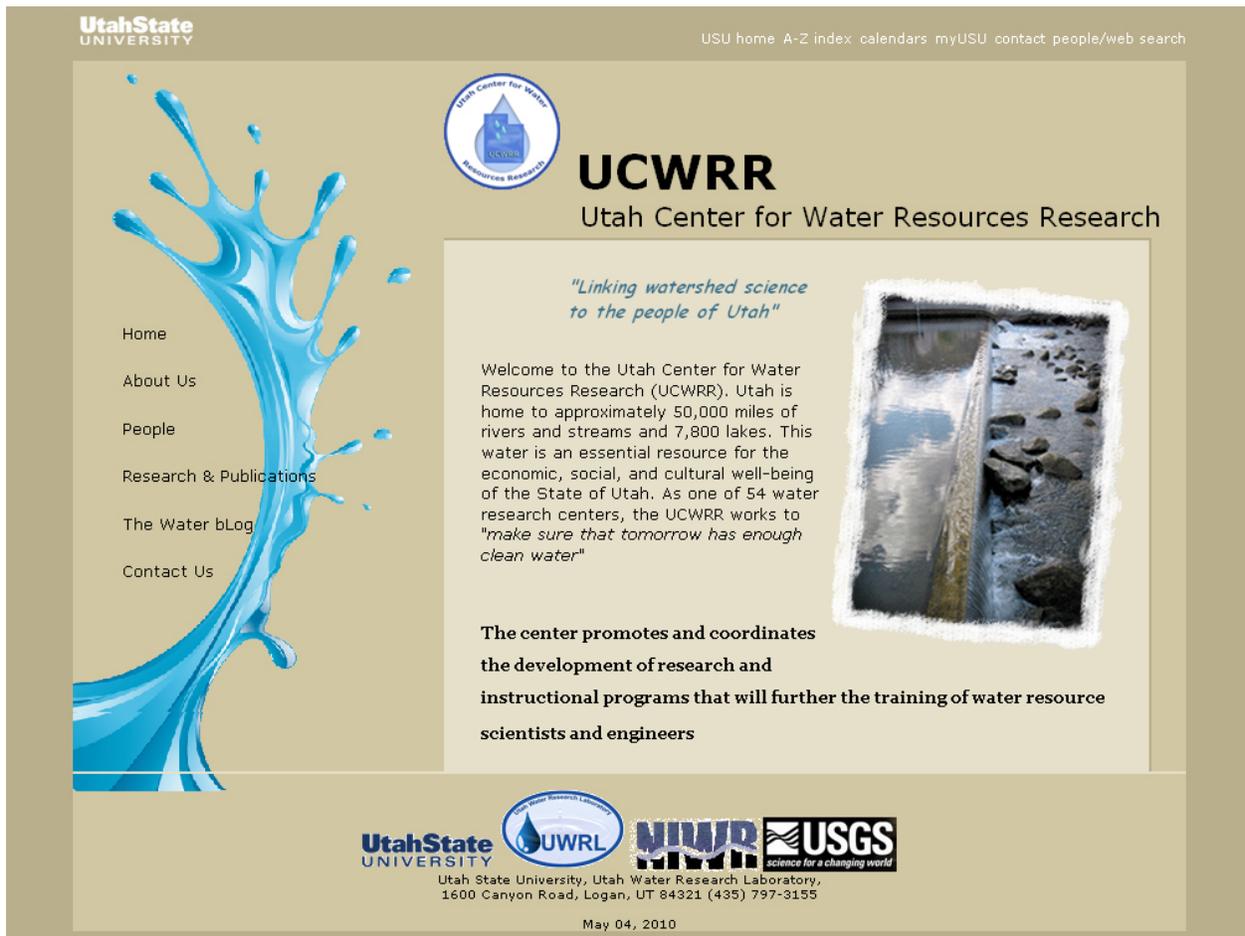


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Utah State University, Utah Water Research Laboratory,
1600 Canyon Road, Logan, UT 84321 (435) 797-3155

May 07, 2010

Figure 2. Research and Publications page for the UCWRR.

Newsletter

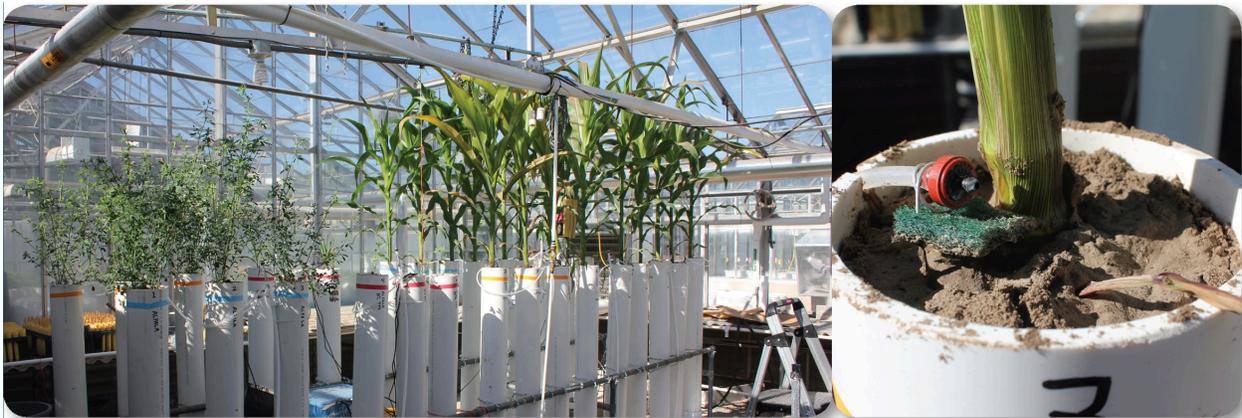
A semi-annual newsletter *The Water bLog* continues to be published. *The Water blog* is disseminated electronically at the UCWRR web site and through e-mail. The newsletter is e-mailed to approximately 350 readers. The main purpose of the newsletter is to highlight research projects and their findings. These will be of great interest and value to the State of Utah, as well as nationally and internationally.

A recent copy of the newsletter was sent out November 2012. One of the research projects featured in the newsletter was “Effect of Deposition from Static Rocket Motor Test Fires on Corn and Alfalfa” where UCWRR researchers have completed a study to determine the impacts of test fire soil (TFS) from static tests of solid rocket motors on the germination, biomass production, and plant composition of corn and alfalfa exposed to TFS deposition. One of the benefits to the State of Utah is that this research will contribute information regarding the potential impact of test fire soil from static test fires on crop production.

Results can be used to develop Best Management Practices and test fire protocols that will reduce impacts of static test fires on crop growth. Further research could examine the potential impact of TFS on various other crop growth stages.



View of exhaust cloud containing TFS from static rocket motor test



Greenhouse study evaluating the potential impact of TFS on corn

Another research project featured in the November 2012 Newsletter was “Pineview Reservoir Phosphorus and Mineral Nitrogen Processes and Algae/Cyanobacterial Bloom Ecology” where Nuisance blooms of algae and cyano-bacteria occur annually in Pineview Reservoir due in part to excess nitrogen and phosphorus loading, and previous studies have called for management actions to limit these nutrient loads to the reservoir. Pineview has been on Utah’s list of impaired waters since 2000, and a Total Maximum Daily Load (TMDL) study has recommended actions designed to reduce these nutrient loads.

In response to concerns over the potential effectiveness of the proposed reduction actions, UCWRR researchers have collaborated with the Weber Basin Water Conservancy District to provide empirical information for managers so that Pineview Reservoir water quality can be preserved or improved in the most cost-effective way.

While ground water flow into Pineview Reservoir is small relative to surface water flows, the concentration of phosphorus in certain ground water locations far exceeds those anticipated. Future efforts will use ground water quality monitoring near the reservoir to determine the chemical characteristics and possible sources of soluble phosphorus entering the reservoir.



Pineview Reservoir, Utah in early fall. A phytoplankton bloom, dominated by algae, occurs during this period each year



Researchers measuring light penetration through the ice

In the past year our UCWRR faculty members and researchers have traveled around the globe conducting and presenting their research and enhancing and sharing their extensive water resources expertise.

UCWRR faculty member, Blake P. Tullis, spent 6 weeks during summer 2012 as a visiting professor at the Hydraulic Construction Laboratory of École Polytechnique Fédérale de Lausanne (EPFL) in Switzerland. He participated in collaborative research related to piano key weir debris handling and the characteristics of sediment exchange between coupled reservoirs utilized for pumped-storage hydroelectric schemes.



Grande Dixence Dam in Hérémence, Switzerland, the tallest concrete gravity dam in the world at 285m (main photo). Dr. Tullis's experimental piano key weir model spillway set up for a debris handling study at EPFL (inset).

Figure 3 shows the first page of *The Water blog's* May 2012 issue. For an electronic copy of current or past newsletters, please go to <http://uwrl.usu.edu/partnerships/ucwrr/newsletter/>.



Welcome!

The Water bLog is the semi-annual newsletter of the Utah Center for Water Resources Research (UCWRR), housed at the Utah Water Research Laboratory at Utah State University. 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 online at:

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

INSIDE:

Research Highlight:

- ▶ Pineview Reservoir Phosphorus and Mineral Nitrogen Processes
- ▶ Optimizing Phosphorus Reduction in Echo Reservoir
- ▶ ATK Static Test Environmental Assessment Plant Study

In the News

Far Afield

UtahStateUniversity

Message from the Director



Mac McKee, Director

Managing complex water resources systems can be very challenging, especially when the science behind the behavior of the system is incompletely understood. Understanding such systems can require a multi-faceted approach of monitoring, modeling, and management. For instance, managing nutrient loads can require merging a variety of measurement, laboratory, and modeling techniques in order to understand how a watershed operates.

Similarly, various industrial activities can result in unpredictable effects that are difficult to understand and manage, requiring innovative research approaches.

This edition of the Water bLog focuses on some of the creative research currently underway at the UCWRR that involves monitoring, modeling, and ultimately managing the effects of nutrients in reservoir systems, as well as the potential downstream effects of static rocket motor tests on field crops. These projects represent only a fraction of the active research at the UCWRR that is designed to find practical solutions to natural resources challenges throughout the state. ■



RESEARCH HIGHLIGHT

Nutrient Management in Utah Reservoirs

UCWRR researchers are engaged in a variety of research designed to address the problem of nutrient loading in Utah's reservoirs, streams, and wastewater treatment facilities. Two such projects are highlighted below.

As demands for clean water for municipal, agricultural, industrial and other uses rapidly increase, it is becoming more and more important to care for and protect the quality of water entering water collection and storage systems. Increasing human activities such as agriculture, urban development, and recreation in and around Utah's freshwater lakes, reservoirs, and watersheds are introducing more pollutants into water supply systems.

Of particular concern are excess nutrients such as nitrogen (N) and phosphorus (P) because these nutrients stimulate algae growth, reduce dissolved oxygen,



Pineview Reservoir near Huntsville, UT

The Water bLog November 2012, Vol. 3, No. 2

Figure 3. *The Water bLog*, the Newsletter for the UCWRR.

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 have been 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>.

USGS Summer Intern Program

None.

Student Support					
Category	Section 104 Base Grant	Section 104 NCGP Award	NIWR-USGS Internship	Supplemental Awards	Total
Undergraduate	1	0	0	0	1
Masters	3	0	0	0	3
Ph.D.	0	3	0	0	3
Post-Doc.	1	0	0	0	1
Total	5	3	0	0	8

Notable Awards and Achievements

Publications from Prior Years

1. 2007UT87B ("Two-Zone Temperature and Solute Model Testing and Development in the Virgin River") - Articles in Refereed Scientific Journals - Bingham, Q.G., B.T. Neilson, C.M.U. Neale, M.B. Cardenas. 2012. Using high resolution remotely sensed data to estimate parameters for transient storage modeling. *Water Resources Research*, 48(8).
2. 2007UT87B ("Two-Zone Temperature and Solute Model Testing and Development in the Virgin River") - Articles in Refereed Scientific Journals - Heavilin, J. and B.T. Neilson. 2012. An Analytical Solution to Main Channel Heat Transport with Surface Heat Flux. *Advances in Water Resources*, 47:67-75.
3. 2007UT87B ("Two-Zone Temperature and Solute Model Testing and Development in the Virgin River") - Articles in Refereed Scientific Journals - Bingham, Q.G., B.T. Neilson, C.M.U. Neale, M.B. Cardenas. 2012. Application of high-resolution, remotely sensed data for transient storage modeling parameter estimation. *Water Resources Research*, 48(8).
4. 2007UT87B ("Two-Zone Temperature and Solute Model Testing and Development in the Virgin River") - Articles in Refereed Scientific Journals - Heavilin, J. and B.T. Neilson. 2012. Approximation of inverse Laplace transform solution to heat transport in a stream system. *Water Resources Research*, 48(9).