Idaho Water Resources Research Institute
Annual Technical Report
FY 2014

Introduction

The Idaho Water Resources Research Institute (IWRRI) is housed at the University of Idaho. IWRRI is dedicated to supporting and promoting water and water–related research, education, and information transfer throughout Idaho. IWRRI collaborates with researchers and educators from all Idaho state universities; staff of local, state, and federal agencies; and private water interests. The IWRRI is the only mechanism in the state that provides an autonomous statewide source of support for water research and training without regard to specific topic or discipline area. This is important because Idaho's water problems cross multiple topics and disciplines and compartmental approaches to these problems are less effective. IWRRI is relied upon by state and federal agencies and private water interests to provide the objective expertise to address the needs of the state and region. The Institute has been a strong proponent of education and outreach for both youth and adult audiences. It is through education that the public can make informed public policy decisions concerning water. It is also through education that individual citizens become engaged in the process through adjustments of their own attitudes and lifestyles.

Research Program Introduction

The Idaho Water Resources Research Institutes research program is comprised of the following objectives: (1) To work with state and federal agencies and non−government organizations to identify water research needs of the state and region; (2) To promote water−related research relevant to state and regional needs; (3) To stimulate, coordinate, and provide leadership for water resources research within Idaho universities and collaborate with sister institutions in adjoining states; (4) To cooperate with and assist state and federal agencies and non−governmental organizations for the benefit of the citizens of Idaho and the region; and (5) To develop funding for needed research and encourage cooperation with other research organizations.

The Idaho Water Resources Research Institute was able to support two new research projects during the 2014 Project year addressing approaches to develop improved approaches to reservoir operations to determine optimal water release rules to balance the benefits provided from both flood control and irrigation, and development of improved approaches for defining the Soil Moisture Drought Index (SDOI) to better characterize Hydrologic Droughts in the Pacific Northwest.

Dynamic modeling of rule curve reservoir operations under stochastic climate conditions

Basic Information

Title:	Dynamic modeling of rule curve reservoir operations under stochastic climate conditions
Project Number:	2014ID197B
Start Date:	3/1/2014
End Date:	2/28/2015
Funding Source:	104B
Congressional District:	01
Research Category:	Climate and Hydrologic Processes
Focus Category:	Economics, Floods, Water Supply
Descriptors:	None
Principal Investigators:	Levan Elbakidze, Garth Taylor

Publications

There are no publications.

Project Summary

Water release in multipurpose reservoirs throughout the water year is of utmost concern for water resources management agencies. In this study, a dynamic optimization system, that considers both irrigation demand and flood safety, is used to derive the optimal amount of water release during a water year. The dynamic optimization model maximizes benefits from water release including agricultural irrigation benefit minus flood damage. A partial differential equation resulting from Hamilton-Jacobi-Bellman equation is solved and optimum water release is derived. The empirical model is then developed for the Lucky Peak dam in Idaho as a case study. A nonlinear GAMS model is developed to demonstrate preliminary results for optimum water release. The empirical results are compared qualitatively to engineering operating rule curves used in reservoir operation. Implications of potential earlier run-off due to climatic change are also examined. The model and the results are produced for a deterministic case where average daily inflow amounts during the water year are used without consideration of stochasticity. The purpose of this project is to develop a framework, with corresponding empirical illustration, which can be extended for the stochastic case where water inflow is stochastic throughout the water year. The objective is to propose a framework for modeling optimal reservoir water release for balancing the irrigation water demand and the flood control. None of the previous studies in this field have considered economic trade-offs between irrigation water and flood damage simultaneously.

Data for Lucky Peak Dam inflow is available as daily average values (cubic feet per second) from 1985 (earliest available data) to 2013. The "Water Years" are from October 1st to September 30th. Daily inflow into the reservoir (in acre feet unit) over time is presented in Figure 1. Fitting these daily inflow values as polynomial curves for 27 years using ordinary least squares (OLS) method, we obtain average daily inflow for a representative water year.

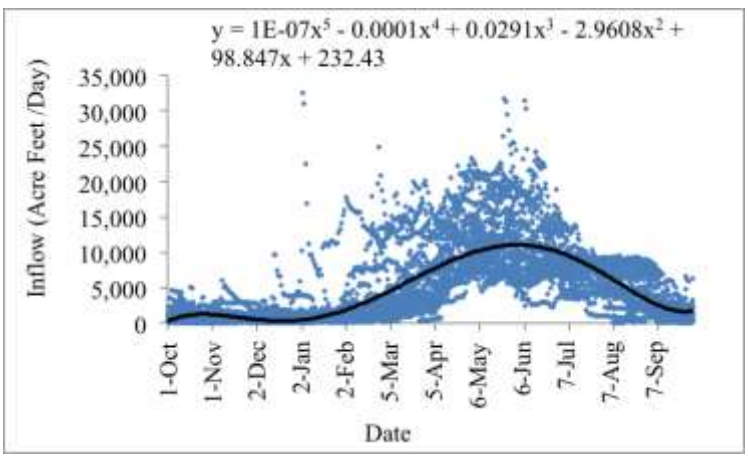

Figure 1. Lucky Peak Dam daily inflow from 1985 to 2013

The empirical model was solved using the non-linear programming optimization routine in GAMS to derive the optimal water release during a water year. Figure 2 presents the water inflow (blue curve) and the optimized path of water release (red curve). The preliminary simulation results show that the water inflow and the optimal water release start to rise in the beginning of the water year (October 1st) and show a small peak at late-October. From mid-November to the end of March there is no release of water from the reservoir. The reason is that there is no agricultural water demand in this period and water volume in the reservoir in that period is far below the maximum reservoir capacity because of relatively low inflow (very low flood risk). In April until mid-May, inflow and release curves are identical and rising. In other

words the amount of released water is equal to the amount of inflow. The two curves separate from beginning of June until the end of July. During this time period, water release peaks to satisfy high irrigation demand. The optimal release goes up to 17,000 (Acre Feet / Day) in mid-summer. Beginning August, the release matches the inflow again until the end of the water year.

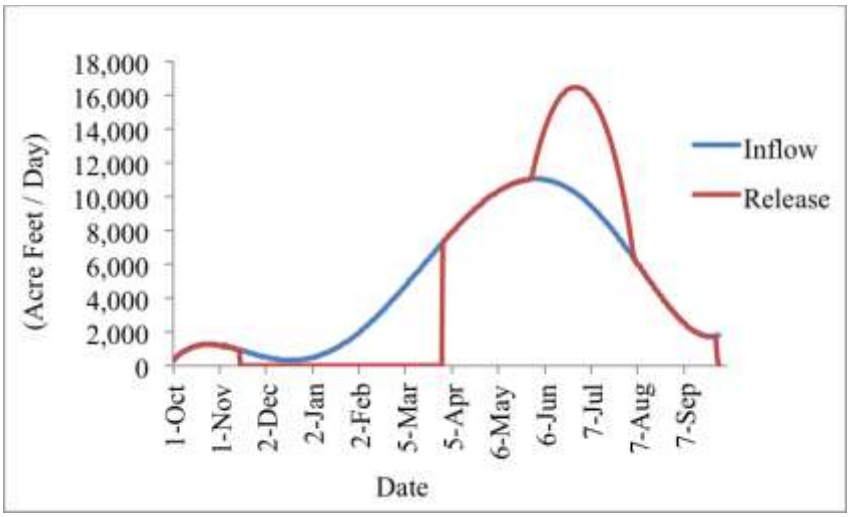

Figure 2. Water inflow and optimized water release path

The model was used to examine the effect of climate changes in the form of earlier precipitation and runoff on optimal water release during the water year in a deterministic context. The results showed that earlier runoff reduced the amount of water released for irrigation in the summer. Thus, agricultural benefits are affected adversely by earlier runoffs because of the water shortage (smaller peak) in high water demand months.

The next steps are to a) develop an empirical model for Boise Reservoir System including high and low value crops and multiple reservoirs, and present a comparison between the programming system results and Boise Reservoir System rule curves, and b) develop a stochastic optimization model for daily operation by adding a stochastic component to the inflow.

Development of Soil Moisture Droght Index (SODI) to Characterize Hydrological Droughts in the Northwest

Basic Information

Title:	Development of Soil Moisture Droght Index (SODI) to Characterize Hydrological Droughts in the Northwest
Project Number:	2014ID199B
Start Date:	3/1/2014
End Date:	2/28/2015
Funding Source:	104B
Congressional District:	02
Research Category:	Engineering
Focus Category:	Drought, Surface Water, Management and Planning
Descriptors:	None
Principal Investigators:	Jae Ryu

Publications

1. *Sohrabi, M., Ryu, J. H., Abatzoglou, J., Tracy, J., 2015. Development of Soil Moisture Drought Index (SODI) to Characterize Hydrological Drought , Journal of Hydrological Engineering, (in press)
2. Ryu, J. H., *Sohrabi, M., #Acharya, A. 2014. Toward mapping gridded drought indices to evaluate local drought in a rapidly changing global environment , Water Resources Management, 28(11), 3859-3869
3. *Kim, J. J., Ryu, J. H., 2014. A threshold of basin discretization levels for HSPF simulations with NEXRAD inputs , Journal of Hydrological Engineering, 19(7), 1401-1412
4. #Acharya A., Ryu, J. H. 2014. Simple method for streamflow disaggregation , Journal of Hydrological Engineering, 19(3), 509-519
5. Ryu, J. H., Kim, J.J.. 2014. Runoff and nonpoint sources control using LID for the Boise River Watershed, Idaho , Advances in Flowing Waters, 12(1), 1-11
6. *Sohrabi, M., Ryu, J. H., Alijani, B., 2013. Spatial and temporal analysis of climatic extremes over the mountainous region of Iran , The International Journal of Climate Change: Impacts and Responses, 4(4), 19-37
7. *Hoekema, D., Ryu, J. H., 2013. Evaluating Economic Impacts of Water Conservation and Hydrological Forecasts in the Salmon Tract, Southern Idaho , Transaction of the ASABE, 56(4), 1-12
8. *Sohrabi, M., Ryu, J H.., Abatzoglou, J., Tracy, J. 2013. Climate extreme and its linkage to regional drought over Idaho, USA , Natural Hazards, 65:653-681

Project Summary:

Drought brings about profound hydrological, ecological, agricultural and economic impacts. Recent droughts in the United States has resulted in the enactment of emergency drought plans to mitigate dwindling water supplies in the Colorado River basin and crop failure in the many states [Manuel, 2008]. The historic drought in the state of Texas in 2011, in particular, had significant economic impacts on agricultural sectors and other food business at nearly $7 billion in economic losses reported by Texas A&M University's AgriLife Extension Office. Although economic losses affected by drought are prevalent across the country, drought mitigation exercises are still challenging due to a unique characteristic of drought. Because of their slow onset and typically wide spatial domain, it is difficult to define the beginning or end of a drought [Dracup et al., 1980; Ryu et al., 2004; Wilhite and Glantz 1985; Yevdjevich 1967].

Many studies have been done to address the intertwined nature of drought by means of drought indices, such as the Standardized Precipitation Index [SPI; McKee et al., 1993], Palmer Drought Severity Index (PDSI) [Palmer, 1965], the Standardized Precipitation Evapotranspiration Index (SPEI) [Vicente-Serrano et al., 2010], Surface Water Supply Index (SWSI: Shafer and Dezman, 1982; Dezman et al, 1982) and other types of hydrological drought index [Ryu et al., 2010]. PDSI, in particular, defined as a function of precipitation, temperature, and the available water content of the soil has been widely applied to characterize agricultural and/or hydrological drought (e.g., Palmer Hydrological Drought Index), although its applicability and versatility was often criticized by scientists due to its drawbacks [Alley, 1984; Guttman et al., 1992; Karl, 1983]. Poor performances of the PDSI in the western United States where complex terrain and landscape is prevalent led to the revised PDSI known as self-calibrated Palmer Drought Severity Index [sc-PDSI: Wells et al., 2004]. Unlike PDSI, the sc-PDSI accounts for the expected variability of weather conditions between locations so that the climatic characteristic and the associated factors can be adjusted automatically based on local information.

Despite of theses development to sc-PDSI, the index still has some deficiencies. For instance, Dai [2011] and Van der Schrier et al. [2011] reported non-Gaussian histogram of sc-PDSI at many locations. They showed the low frequency of sc-PDSI at near normal category ($-0.5 \leq$ sc-PDSI ≤ 0.5) at many locations. In addition, sc-PDSI is still very sensitive to climatic characteristic and the other local adjustment factors, which can result in drought misdetection and misleading, especially in the northwest.

As such, the goal of this project is to develop a new drought index better representing hydrological conditions in the northwest. Thus, the proposed index, Soil Moisture Drought Index (SODI), will capture variations in precipitation and temperature and account for soil moisture characteristics over time. Since the SODI will meet all the requirements for a robust drought index indicated by the previous study [Keyantash and Dracup, 2002], the results will reveals that SODI can detect and quantify extended severe drought precisely. By highlighting several discrepancies among drought indices based on drought reports, the performance of the new drought index, SODI, will be further evaluated for many real-world applications in the final report.

Information Transfer Program Introduction

The Idaho Water Resources Research Institutes Outreach and Information Transfer program is comprised of the following objectives: (1) To encourage and facilitate public involvement in water resource programs within the state; and (2) To promote water education within the state at the K−12, undergraduate and graduate levels. During the 2014 Program Year, 104B program and state funds were used to support the Idaho Water Resources Outreach and Engagement Effort, which is described in more detail below.

Idaho Outreach and Engagement Project FY2014

Basic Information

Title:	Idaho Outreach and Engagement Project FY2014
Project Number:	2014ID198B
Start Date:	3/1/2014
End Date:	2/28/2015
Funding Source:	104B
Congressional District:	02
Research Category:	Not Applicable
Focus Category:	Education, Hydrology, Water Supply
Descriptors:	None
Principal Investigators:	John C. Tracy, Julie Scanlin

Publications

There are no publications.

Idaho Water Resources Outreach and Engagement Project Summary

Project Summary

Bringing Water Resources Education to the K-12 Classroom

Approximately 240 teachers were trained during 12 accredited Water Education Workshops that were delivered at locations across Idaho. In addition, IWRRI participated as an i-STEM provider at the Idaho i-STEM summer institutes in Twin Falls and Boise and continued coordinated efforts with the Boise WaterShed, Idaho Water Education Foundation and the Idaho Department of Environmental Quality on various K-12 education and outreach efforts. IWRRI also trained 12 Project WET Facilitators, participated in the training and development for Climate Science coursework and made presentations to teachers at the annual Idaho Science Teachers Conference, the Idaho Environmental Education Conference and Teacher's Night Out, with an estimated 240 teacher contacts.

Providing Water Resources Experiential Learning to K-12 Students

IWRRI participated in youth outreach efforts across the state, including the Water Awareness week (over 7,000 attendees) events and provided materials and support for the Youth Water Festival in Moscow, Idaho.

The Idaho Water Resources Research Seminar Series

Beyond supporting K-12 education, IWRRI provided a state wide water resources seminar series during the Fall semester of 2014, delivered via a compressed video system to Boise, Moscow, Pocatello, Idaho Falls and Coeur d'Alene (11 seminars during the year with an average attendance in all locations of 20 people per seminar). During project year 2014, IWRRI expanded its reach across the state of Idaho, through increasing its seminar and professional outreach activities in Northern Idaho through collaborations with the University of Idaho, Coeur d'Alene Center with the opening of the Northern Idaho Community Water Resources Center on the University of Idaho campus in Coeur d'Alene, ID.

The Idaho Travel Grant Program

During Project Year 2014, travel support was provided to the Director of the Idaho Water Resources Research Institute, faculty and researchers at the University of Idaho. Support was provided for travel to attend: the 2014 AWRA Summer Specialty Conference on Integrated Water Resources Management in Sparks, NV on June 29 to July 2, 2014 (Director and one faculty member); the Spokane River Forum in Spokane, WA in November, 2014 (IWRRI Associate Director); the 2014 Annual AWRA Conference, November 2 to 6, 2014, in Washington, DC (Director and one faculty member); and the 2015 Annual National Institutes of Water Resources meeting (Director).

Support for the Idaho Floodplain Workshop

The Eyes on Insurance: Idaho Floodplain Workshop was held at the Bureau of Reclamation Snake River Office in Boise, ID in September of 2014, with support from the Northwest Regional Floodplain Management Association (NORFMA) and the Idaho Water Resources Research Institute. The goal of the workshop was to provide information to the Idaho property insurance industry, local governmental officials and flood plain managers on updates to the National Flood Insurance Program (NFIP). This was a one day event, held on the 19th of September, and included sessions on: updates to the NFIP as a result of the Biggert Waters Act and the Homeowner Flood Insurance Affordability Act; a primer on the NFIP; a discussion of operation of Boise River reservoirs to mitigate flood risk during high flow periods; and a field trip to the New York Canal.

Additional Activities

The Idaho Water Resources Research Institute also provided support to the Boise River Enhancement Network (BREN) during the project year. BREN was formed through a grant from the US Bureau of Reclamation 2013, with the purpose of the grant being to help form a network of water resource professionals and engaged citizens to share information regarding the condition of the Boise River watershed, forward ideas to sustain the ecological services provided by the watershed and identify resources to help manage and restore watershed function. The IWRRI Outreach Coordinator (Julie Scanlin) serves on the BREN Coordinating Team and helped developed the grant application, as well as aided BREN in organizing field trips and workshops throughout the 2014 project year.

During the 2014 Program Year, training opportunities for water professionals were continued through interactions with the Boise Watershed Center. The Institute has continued its support of the annual Idaho Environmental Education Conference. IWRRI also has the capacity to provide statewide distribution of professional short courses and professional development workshop as available to statewide water professionals. IWRRI continues to network and coordinated to work on a regional level with other institutes and water research entities. Finally, the IWRRI continues its support of the Idaho State Chapter of the American Water Resources Association by recruiting members and providing sponsorship and publicity for several of its events.

During the current project year, IWRRI also sponsored the Palouse Water Summit, held in Palouse, WA in October of 2014; and the Idaho Water Users Conference, held in Boise, ID in January 2015.

USGS Summer Intern Program

None.

Student Support					
Category	**Section 104 Base Grant**	**Section 104 NCGP Award**	**NIWR-USGS Internship**	**Supplemental Awards**	**Total**
Undergraduate	0	0	0	0	0
Masters	1	0	0	0	1
Ph.D.	2	0	0	0	2
Post-Doc.	2	0	0	0	2
Total	5	0	0	0	5

Notable Awards and Achievements