INTEGRATED WATER MANAGEMENT IN THE BEAR RIVER BASIN

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ABSTRACT

The Bear River basin includes portions of Utah, Idaho and Wyoming and has the largest river in the Americas with no outlet to the ocean. There are water rights to the use of water from Bear River and its tributaries and decrees to distribute between users as well as an interstate compact to regulate between states. Central to the Bear River system is Bear Lake, which is operated as a reservoir to provide water for irrigation and to produce power. Utah Power, irrigators and Bear Lake interests signed a settlement agreement that allocates annual storage releases for irrigation. The power company and the compact states also memorialized historic operation by a signed agreement. Recognizing the interconnection between ground water and surface water, conjunctive management has become the policy of the states. The water rights, policies, decrees, compact and agreements form the foundation of the "law of the river" for Bear River.

Management of the Bear River within these constraints is understandably complex. Interstate delivery of natural flow and accounting of storage allocations below Bear Lake are cooperatively performed by the states using computer models. During the irrigation season, the weekly process of data collection and computer modeling of the river had resulted in a time delay between diversion and decision-making or regulation. Recent automation, however, using telemetered gages and meters has facilitated data collection and sharing, reducing delays and allowing more accurate monitoring and regulation. Through computer models and automated data collection and sharing, water management issues have become more manageable, and decision-making and regulation more timely.

INTRODUCTION

From its headwaters high in the Uinta Mountain range of Northern Utah, the Bear River travels 500 miles and crosses five state lines before entering into the Great Salt Lake, a mere 90 miles from its source (Figure 1). Midway along its course, the river is diverted into Bear Lake, a natural lake, whose level may be increased by as much as 21 feet to hold an additional 1.4 million acre-feet of usable storage. On the north shore of the lake is a natural dike and a pumping plant where stored water may be released into an outlet canal that returns water to the Bear River to produce power and provide supplemental irrigation water to 150,000 acres of cropland and pasture. The river basin above Bear Lake is known as the upper Bear River while the area below Bear Lake is referred to as the lower Bear River.

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Below Bear Lake, tributaries more than double the flow of the Bear River before it passes through the Bear River Migratory Bird Refuge and into the Great Salt Lake, never making it past the Great Basin to the ocean.

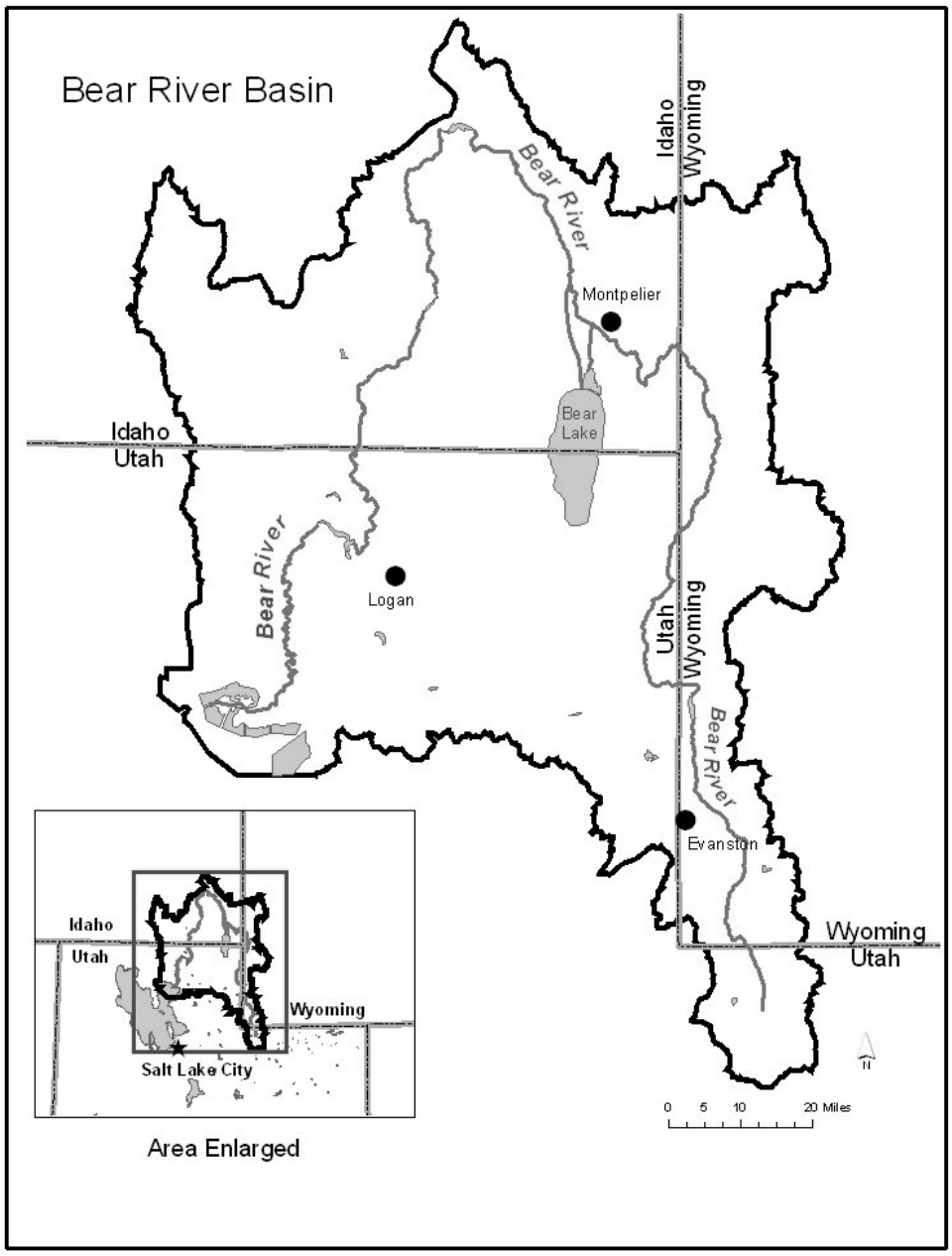

Figure 1. Bear River Basin

The Law of the River

The phrase, "Law of the River," is usually used in reference to the Colorado River with its interstate compact, but every river, to one degree or another, has a "law of the river." It may be as simple as the water rights to a small creek or as complex as interstate or international law on a river. The "law of the river" for Bear River is comprised of state water rights, an interstate compact, court decrees and mutual agreements.

Pioneers began diverting the Bear River in the late 1800s after tapping its tributaries. Several larger canals were constructed around the turn of the century. In 1909, the predecessors to Utah Power began the project that would divert water into and out of Bear Lake and generate power at hydroelectric power plants along the Bear River. Utah Power also bought Wheelon Dam from Utah and Idaho Sugar Co. (predecessor to Bear River Canal Co.) and filed on the hydropower rights. They agreed to deliver a total of 900 cfs to the two canals that head at what is now Cutler Dam, supplementing any deficiencies in natural flow with stored water from Bear Lake. Over time, all the major canals and small irrigation pump owners also signed contracts with the power company for storage water from Bear Lake[2].

In 1920 in Idaho and 1922 in Utah, water rights in the lower basin were adjudicated. The Dietrich Decree[3] is a federal decree in the state of Idaho and the Kimball Decree[4] was a state decree in Utah. The decrees quantified the usage and flow as well as the priority of the water rights to the Bear River and its tributaries. They also established travel times and transit losses for the storage releases from Bear Lake and allow Utah Power to operate the river in the instance of storage water as if the river were a canal. Of particular importance, the federal Dietrich Decree recognized the rights of Utah and Idaho Sugar Co. (Bear River Canal) in Utah and directs that the "…official charged with the administration of the decree, shall see that there is delivered at the Utah state line such quantity of water as is necessary, together with natural increment below said Utah state line, to satisfy said rights in accordance with their dignity and priority as herein recognized."

The Bear River Compact was signed in 1958 and amended in 1980 to regulate the distribution and development of the Bear River between the states of Wyoming, Idaho and Utah. Among other things, it provides a procedure for declaration of a water emergency, in which case water would be delivered by priority without regard to state boundary. The Bear River Commission is charged with the administration of the compact and authorizes an Engineer-Manager to oversee

[2] Jibson, W. N., 1991, History of the Bear River Compact.
[3] Utah Power & Light Company vs. Last Chance Canal Company, Ltd., Et al.
[4] Utah Power & Light Company vs. Richmond Irrigation Company, Et al.

distribution between states. The individual states each have their own river commissioners to distribute water among users and report diversions.

For nearly a century, Utah Power has had a major influence on the operation of Bear Lake and Bear River. Originally, the hydroelectric power produced along the Bear River was the main source of power in the region. Storage releases from Bear Lake have also augmented late summer flows that have made the agricultural region more productive. As other sources of electricity have become available, the main focus of the Bear River system has become irrigation.

More recently, interests concerning Bear Lake other than agriculture and hydropower, such as recreation and environmental interests, have become more significant and a lawsuit challenging Utah Power's plan to dredge an existing channel in Bear Lake was filed. The power company argued that they needed the channel to efficiently pump their storage water when the lake was low during an extended drought. To resolve the matter, a settlement agreement was signed in 1995 by Utah Power, irrigation contract holders and groups and individuals representing other interests around Bear Lake. In the settlement agreement, the lawsuit was dismissed and irrigators agreed to allocate storage releases for irrigation annually, based on forecasted lake levels. By reducing allocations during extended periods of drought and low lake levels, water is reserved for lake recovery. Another key element in the settlement agreement was the acceptance of interstate distribution, by priority, circumventing the need to petition the Bear River Commission for an official declaration of a water emergency.

In 2000, Utah Power signed an operational agreement with the basin states to memorialize its historic operation of Bear Lake. It agreed to only release storage from Bear Lake to fulfill its irrigation contracts or for flood control and generate power at downstream hydropower plants as a secondary benefit.

Groundwater – Surface Water Interaction

As the compact states were grappling with administration of the decrees, compact and agreements, the issue of dealing with the effect of groundwater on the Bear River always came up. Certainly, a call on the river would have to consider groundwater impact and the states were committed to addressing it. To that end the Bear River Commission requested the states of Utah and Idaho investigate the impact of groundwater development and that the Commission's Technical Advisory committee review their findings[5].

The US Geological Survey, in a report on the hydrology of Cache Valley[6] identified the interconnection of the surface water and ground water systems and

[5] Bear River Commission, 2002.
[6] Kariya, K. A., M. D. Roark and K. M. Hanson, 1994.

created a groundwater flow model to simulate flow in the unconsolidated basin fill in that portion of the lower Bear River basin. The report found that there was generally a 1:1 relationship of groundwater depletion to surface water depletion in the Bear River basin. The state of Utah took the groundwater flow model and applied it on a monthly time step and analyzed where the depletions would occur. It found that much of the depletion would occur to tributary streams that were fully appropriated by senior rights, which could "dry dam" the tributary during water shortages. Below these senior tributary diversions, the impact to the main stem of the Bear River in Utah, on the average, is only 4.1 cfs. Similarly, Idaho found that their impact to the main stem of the Bear River is only 4.9 cfs. The total estimated average depletion of 9.0 cfs is less than one percent of the average annual discharge at the Idaho-Utah state line, smaller than an acceptable measurement error. The resulting decision was to not include groundwater in the interstate accounting and distribution of the lower Bear River.

Because of the need to conjunctively manage groundwater to protect surface water rights, the State Engineer in Utah adopted an Interim Groundwater Management Plan for Cache Valley[7] in 1999. In 2001, the Director of the Idaho Department of Water Resources similarly created a Ground Water Management Area[8] to protect surface water rights and limit new groundwater development.

MANAGEMENT

There is an axiom that if you want to manage a resource, you must first measure it. The flows of the Bear River have been measured and records kept for close to 100 years by the USGS and by Utah Power. There are also records of diversions by some of the major canals that have been kept for almost as long. Lately, records of diversions by smaller diversions and pumps have also been kept. Interstate computer models have been developed and used for the past 15 years to distribute natural flow and account for storage diversions.

Data Collection

To properly distribute and manage the operation of the Bear River system, the river commissioners in each state collect diversion data weekly. This data is cooperatively shared between states and includes canal diversions and pump diversions. In addition to the five major canals, there are over 90 pumps and small diversions in Utah and close to 30 in Idaho. Measurements of river flows and reservoir contents are reported by Utah Power and the USGS and are obtained by the river commissioners as well.

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[7] Utah Division of Water Rights, 1999.
[8] Idaho Department of Water Resources, 2001.

In the upper Bear River, above Bear Lake, diversions are reported by the river commissioners to the Engineer-Manager of the Bear River Commission who administers provisions in the compact to distribute between states if there is a call on the river. For the lower Bear River, the diversion, reservoir and stream flow data are input to computer models that facilitate distribution between users.

Interstate Modeling and Delivery

Both Idaho and Utah have computer models to perform the interstate distribution of the Bear River below Bear Lake. Each state has their own operating system and the models are separate and distinct but conceptually and realistically the same. The redundancy also provides a check on operation. The general approach is a reach-gain analysis to determine natural flow available and a distribution by priority of that natural flow with deficiencies made up by storage water. Following is a description of the Utah model.

The Lower Bear River Distribution Model (LBRDM) is a daily accounting model that utilizes WATMODEL[9], a water accounting software model developed by the Utah Division of Water Rights. WATMODEL facilitates the handling of numerous diversion sets over the length of a river. Each diversion variable represents an array of daily values. The river may be divided into reaches with reach variables that are connected such that a diversion in one reach will affect downstream reaches. WATMODEL also has functions that help in distribution, such as the "distribute" function that can take each diversion, in priority and effectively call water down from upstream reaches.

The natural flow reach-gain calculation for a reach is given by the following mass balance equation:

$$NF^r = Out - In + Div\ (+/-)\Delta Res + NF^{r-1} \quad (1)$$

Where: NF^r is the natural flow in a reach
Out is the measured flow leaving the reach
In is the measured flow entering the reach
Div is the diversions within the reach
ΔRes is the change in reservoir contents (+ storing, - releasing)
NF^{r-1} is the natural flow entering the reach.

The LBRDM utilizes the hydrologic factors decreed in the Dietrich and Kimball decrees. Transit losses and travel times were set for storage releases. From Bear Lake to Cutler Dam, transit losses were decreed to be a total of 4½% with 1½% in the first reach and an additional 1% in each reach down to Cutler Dam. For simplicity, the losses from the previous day are added in, rather than computed by

[9] Utah Division of Water Rights, 2005.

iteration. Similarly, travel time was decreed to be 24 hours in each reach, and is accepted to be 4 days from Bear Lake to Cutler Dam. A decreed adjustment for the natural gain of Bear Lake and Mud Lake is also in the model.

Reach-by-reach in downstream order, the gain is calculated and the natural flow is accumulated. Once the natural flow is determined in each and all reaches, it can be distributed, sequentially, by priority. WATMODEL reach variables, connected in downstream order, have the effect of distributing up and down the river, regardless of reach boundaries. When natural flow is distributed to a diversion it reduces the natural flow available in that reach and in downstream reaches. When the natural flow in a reach is all distributed, no more natural flow may be distributed in that reach nor in upstream reaches.

Decision-making and Communication

During the irrigation season stakeholders have bi-weekly conference calls to stay on top of the operation of the river. Utah Power has sponsored the calls and representatives of the irrigators, Utah Power and the states have participated. Information discussed in the conference calls includes reservoir levels, flow at gaging stations, available natural flow, storage releases, diversions and projected diversions. Decisions are then cooperatively made to maintain a "balance" on the river, balancing demands with resources. Coordinated management of the river system requires data sharing between stakeholders with the objective of efficient use of the resource.

Conference calls have proven to be valuable to the operation of the river. Utah Power has been able to coordinate decisions on storage releases based on projected diversions and "balance" of the river. Irrigators have been able to make decisions on diversions based on updated natural flow calculations. The states and their river commissioners have been able to provide information on river modeling and accounting and projections of regulation. This was evident during July and August of 2004 when storage allocations were greatly reduced, natural flow was limited by drought, and storage allocations were close to being used up.

DATA AUTOMATION

Although the data collection and river modeling by the states has greatly enhanced the management of the Bear River, there has been a time delay between diversion and regulation or decision-making. This posed a problem in 2004 when an irrigator on the lower Bear River refused orders of the State Engineer to curtail diversion. The river commissioner and state officials had to monitor and regulate his diversions at a remote location on a daily basis. Since then, automated data collection systems have been installed on both the upper and lower Bear River and similar systems are being installed in Wyoming and on major canals in the lower basin portion of Idaho.

Through a cooperative project with the US Bureau of Reclamation, an automated system of telemetered gages was installed in 2004 in the upper basin area of Utah. The data are displayed on the Bear River Basin web site[10]. Canals in Wyoming are now also automated and displayed at the same location. The monitoring and displaying of diversion data has made the jobs of the river commissioners for the states as well as the Bear River Commissioner Engineer-Manager easier and has proven beneficial for the irrigators as well. There have been times when interstate regulation has been unnecessary.

With the success in the upper Bear River basin in hand, attention was turned to automating the lower Bear River basin. Most of the system was installed and operational in the 2005 water year. Where the upper system used mostly gages in canals, much of the lower system includes meters on pumps.

The task of monitoring 93 pumps on the lower Bear River had proven to be time consuming and resulted at times, in delays and use of estimated data. With another grant from the Bureau of Reclamation, along with funding from the state legislature to provide the telemetry, irrigators paid to install meters on their pumps. Pressurized systems chose between ultrasonic meters and inexpensive on/off sensors on rated pumps. Flood systems chose between on/off float sensors and sonar sensors. Every effort was made to make an effective yet low-cost system. Each site also has a radio and an antenna to transmit diversion data to the central computer at the Logan Regional office of the Utah Division of Water Rights. All data storage is on the central computer and is displayed on the Division web site.[11]

CONCLUSION

As in many river basins, management of the Bear River within institutional constraints is complex. Like the string that holds the kite up in the wind, though, the institutions that form the "law of the river' have held water management up through some difficult drought cycles. Interstate delivery of natural flow and accounting of storage allocations below Bear Lake have been cooperatively performed by the states using computer models. Recent automation has facilitated data collection and sharing, reducing delays and allowing more accurate monitoring, regulation and operational river balance. Conjunctive management of groundwater and surface water has become the policy of the states and has resulted in limitations on additional groundwater development. Integrated water management using computer models, automated data collection and sharing and communication has made decision-making and regulation timelier, developing more trust and cooperation amongst competing interests.

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[10] www.bearriverbasin.org/canals

[11] http://waterrights.utah.gov/cgi-bin/dvrtview.exe

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