ON-LINE AND REAL-TIME WATER RIGHT ALLOCATION IN UTAH'S SEVIER RIVER BASIN

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ABSTRACT

The Sevier River Basin in central Utah is one of the state's most critically water-short areas. The Bureau of Reclamation and Utah State University have had a long-term partnership with the Sevier River Water Users Association to automate the river and implement real-time water right allocations. The Bureau has now automated nearly all of the key canal, reservoir, and stream gauging stations along the main stem of the river. Utah State University has implemented the water rights allocation procedures. Both efforts have substantially assisted the River Commissioners in the day to day regulation of the river. For the users, this system has reduce the information time lag from about 45 days to a single day, thereby allowing them a substantially greater water management capability.

HISTORICAL CONTEXT

Utah's pioneers understood the need for irrigation and were aware of its rudiments long before their initial entry to the Salt Lake Valley in July 1847. It is therefore not surprising that these pioneers diverted water from City Creek the day after their arrival. What is surprising are the ways water rights evolved over the next half century to accommodate water management needs in an arid environment. Substantial innovation and adaptation were necessary to avoid severe economic loss and community conflict. The water rights of the Sevier River Basin in central Utah (Figure 1) are among the most imaginative and effective of these adaptations.

The early settlement of the Sevier River Basin began in 1849. However, irrigation development was effectively halted in the 1850's and 1860's by the Walker and Black Hawk Indian wars. When the Black Hawk War was concluded in 1868, settlement and irrigation development resumed in earnest, and simultaneously, from Panguitch in the headwaters to Delta at the mouth of the river.

The early irrigation developments were interesting. Most were located on tributary streams where the relatively high gradient and rocky bottoms allowed the irrigators to divert water by simple rock and brush dams into short right or left bank ditches. Where the settlers were forced to divert the river itself, the

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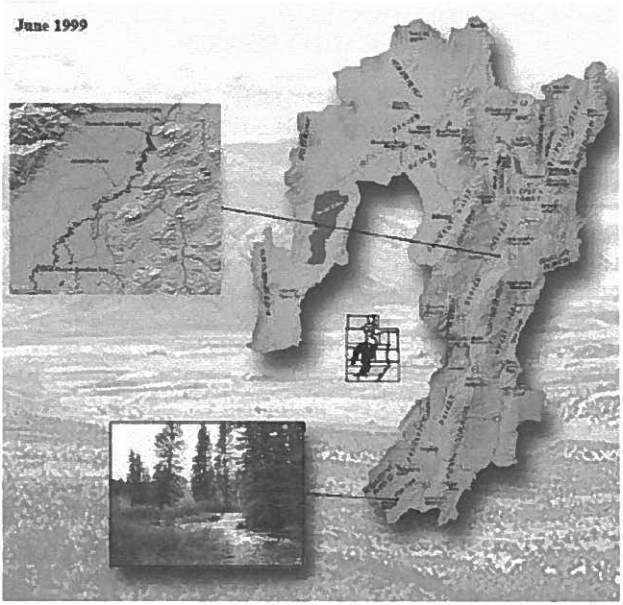

Figure 1. Location and Setting of Utah's Sevier River Basin. (Source: State Water Plan, Sevier River Basin, Utah Board of Water Resources, June 1999)

makeshift dams were easily destroyed during the high runoff periods. For instance, what is now Gunnison Bend Reservoir near Delta is the result of nine failures between 1860 and 1983.

The struggles to stabilize a water supply have had significant effects on the structure of local water rights. No central civil authority existed during the first 30 years of these developments to resolve conflict, allocate water during shortages, or coordinate water uses. However, since the developments were small and the runoff adequate, there were few such needs until the drought years of the 1890's. And, at about the same time, nearly all arable land that could be supplied water by these small direct diversions had been developed. Plans were moving ahead rapidly to expand irrigation by constructing reservoirs to capture high, unused flows and winter water. Interestingly, the lands already developed were sufficient to utilize nearly all of the water in the dry years. In fact, in the late 1890's there was a period when no water reached the town of Deseret at the end of the river and litigation began in earnest. By 1903 when Utah had enacted its major water law, the Sevier River was still critically short of water, and more than 40 lawsuits were in progress to establish water rights.

PRIMARY RIGHTS

Two institutional distinctions emerged by the 1890's which defined early water rights. The first is that while water management was primarily treated as small community enterprises, the communities along the river had essentially formed two camps, the "upper basin" and the "lower basin". As water rights were perfected, this division point became the river gauging station immediately below the canal diversion to the Vermillion Canal Company. This point is called Vermillion Dam and will be noted again later.

As the law suits noted above were settled, two major river decrees were issued. The first was the Higgins Decree of 1901 covering the lower river and the second was the Morse Decree of 1906, covering the upper. Both decrees delineated the rights of various users to directly divert and use the flows of streams or the river as they flow past their point of diversion. These are called "primary" rights. The aggregate flows consisting of groundwater inflows, tributary inflows, and irrigation return flows within a reach are called "the primary".

The Appropriation Doctrine of "first in time, first in right" governed the development of Sevier River water rights. However, most of the rights diverting directly from the river or its tributaries initiated prior to formal government structure and the interruption of development due to the Indian wars produced almost simultaneous water development all along the river. Thus, the courts could not firmly establish priorities in time. Instead, the Higgins Decree adopted the unusual approach of setting nearly all of the direct flow rights below Vermillion Dam on a common priority. It also recognized some rights were clearly aimed at high water flows so it defined several "classes" of right. In effect, the decree recognized essentially the maximum claim of each user.

The Higgins Decree added one more interesting feature by requiring that whenever the supply of water was insufficient to meet all of the rights within a class, that these rights would each prorate the flow and thereby share equally in the shortage. When water was available above the flows of a given class, it was allocated to the next class with the same prorating feature. The class priorities are based on what was considered a basic supply and then on succeeding levels of surplus. In other words, the Higgins Decree allocated the river below Vermillion Dam on the basis of supply frequency and need. These features were adopted in form in the later Morse Decree with different definitions of right classes. For instance, the classes in the lower basin are called A, B, C, D, E, and F rights whereas in the upper basin they are called first , second , and third class rights.

Neither the Higgins Decree nor the Morse Decree dealt with the rights to water for storage and neither dealt with the allocation of water between the two river zones. Further, neither included resources for personnel to measure and regulate flows. They were thus generally ignored during periods of low flow. Nevertheless, the critical concepts of staged class and prorating shortages were

established and the quantitative needs of each water user were outlined. In later litigation when a more general water right system was defined, the primary rights defined by the Higgins and Morse Decrees were essentially adopted in total.

STORAGE RIGHTS

Primary rights are defined by discharge at a specific place and time, and ultimately by the day to day needs of the area they are applied to. Water in excess of these requirements is appropriated to various storage rights and accumulates in the reservoirs of the Sevier River. The users in the river system had been aware for many years that substantial water was escaping during the high flow periods of May and June and throughout the winter months. Another source of "excess" water available for the storage rights was the unused primary flows.

Gunnison Bend Reservoir at the end of the river had been built and destroyed since the 1860's with the structure in use today being finalized in 1895. In 1897 construction of Otter Creek Reservoir was initiated followed by Sevier Bridge in 1902. These reservoirs had the capacity to store all excess water during a typical "dry' year, but in 1906 and 1907 the water supply was relative large and plans were made to enlarge Sevier Bridge and construct Piute Reservoir. Piute Reservoir was completed in 1908 and the Sevier Bride enlargement was completed in 1918. With the construction of these reservoirs came major developments for literally hundreds of thousands of new acres.

When the inevitable dry cycle returned so did the lawsuits over water rights. The river was defined by two water decrees neither of which were reconciled with each other and neither or which resolved the question of where the primary rights ended and the storage rights began. In 1925, the Utah State Engineer used one lawsuit as a vehicle to adjudicate the entire river system. Local and regional committees of water users were formed to negotiate and stipulate water rights because the costs of resolutions in the courts were too high and unpredictable. Amazingly, they succeeded after nine years and their agreement was adopted by the courts as the Cox Decree. In addition to almost verbatim inclusion of the Higgins and Morse Decrees, the Cox Decree linked the two halves together and defined the relationship between the primary and storage rights. A number of lawsuits have ensured to refine, clarify, or correct the Cox Decree, but it remains today as the Sevier River's fundamental water right instrument.

Perhaps as important as the allocations of the Sevier River flows were the provisions for two "River Commissioners" to monitor and regulate the river through a series of river gauging stations and monitored flows into each canal. Specifically, the Commissioners were charged with implementing the Cox Decree and collecting sufficient data to do so accurately. Funds for their salary and expenses come from all the users of the Sevier River, but they reported directly to the Utah State Engineer. Hence, the data acquisition and control functions performed by the Commissioners are in effect the basis of water management in the Sevier River Basin.

HISTORIC DATA ACQUISTION AND CONTROL

The Cox Decree defined all the water rights in the Sevier River system, but the interpretation of such by the Commissioners is the reality of the rights. Procedures were devised to quantify each right using the stream, reservoir, and canal diversion measurements. Most gauging stations were eventually equipped with stage recorders and measurements by the commissioners formed the basis for local calibrations. The timeframe chosen for accounting each right was one day, but the records were collected and "worked" each month.

It is easy to imagine the operational problems of administering daily rights on a monthly interval. The users didn't know of their rights until a month or more later and were continually over-diverting in violation of their rights or under-diverting at the expense of their irrigated acreage. The Commissioners and the users devised a number of practical remedies by which the primary users would be allowed temporary storage in the reservoirs. In some cases they were allowed to "over-draft" their rights from the reservoir rights for short periods. A short case study here will demonstrate the concepts of Sevier River water rights and their management.

The Rocky Ford/Willow Bend Case Study

The Rocky Ford Canal Company and the Willow Bend Irrigation Company jointly divert water from the main stem of the Sevier River just below Vermillion Dam. (See Figure 1 for its general location and Figure 2 below for an enlarged view.) The rights of these users are defined as all the irrigation return flows, groundwater inflows, and tributary inflows to the Sevier River between Vermillion Dam and the Rocky Ford Reservoir Dam. The right has an upper limit of 24,000 acre-feet during the April 1 to October 15 period of each year. In addition, the two companies are entitled to fill their reservoir with up to 2,000 acre-feet of the accumulated flow in the reach during the month of March, but they do not have an irrigation right until April 1. This water is charged against their maximum right of 24,000 acre-feet and is also limited for use to the April 1 - October 15th period.

All flows escaping the upper basin or being transferred to the lower basin as recorded at Vermillion Dam are allocated to the storage rights. Thus commencing March 1st, the flow passing over Vermillion Dam must be delivered through Rocky Ford Reservoir into Sevier Bridge Reservoir as a right segregated from any of the primary flows that may be used by the Rocky Ford/Willow Bend right. Based on many years of experience, the Commissioners and the users have agreed that any flow over Vermillion Dam would experience a loss of 2% through this section of river.

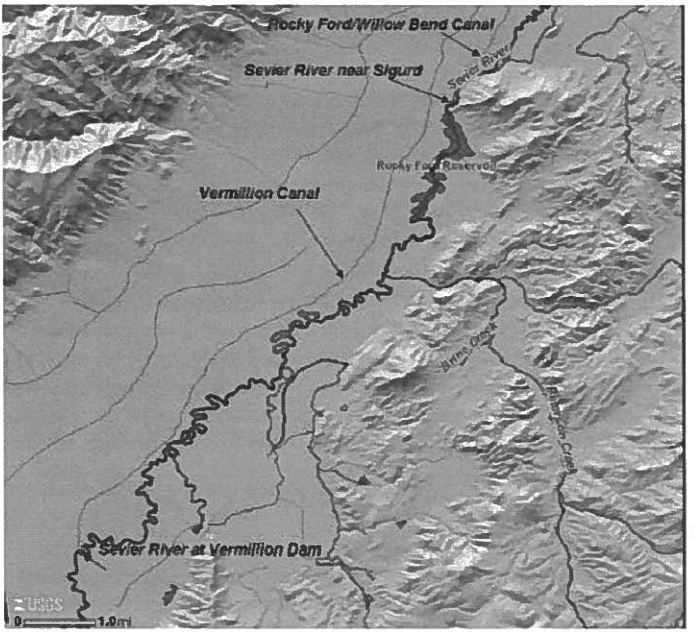

Figure 2. Location and Setting of the Rocky Ford/Willow Bend System. (Source USGS)

Since the records and computations of the Rocky Ford/Willow Bend right lag actual daily used by as much as a month, these users have had no effective way to determine and then divert their right. Working with the Commissioners, an agreement has been reached in which these users are allowed to overdraft their right so long as the overdraft is made up by October 1st. In other words, they are able under this agreement to overdraft during the high demand periods of July and August and repay the overdraft when the demand is low in September. The effect is to increase the irrigated acreage under this right, and as such, use more water than the right was allowed by decree.

None of these management features are outlined in the river decrees. Clearly the right has been enlarged beyond it original intent to accommodate the needs of the Commissioners to manage the water effectively. This is a common problem faced by those trying to implement a legal description in a physical setting and many special arrangements are implemented to accommodate the day to day reality of water management in the field.

ON-LINE, REAL-TIME DATA ACQUISITION AND CONTROL

Today, all of the river, canal, and reservoir stations used by the commissioners to determine and allocate Sevier River water rights along the main stem are equipped with electronic sensors and telemetry systems. Data are record at hourly and daily intervals, transmitted to computers and published on the Internet. Each day, the data are also transmitted to USU where software computes and allocates the water rights. This information is also available on the Internet.

In addition to the data acquisition systems, many of the reservoir and canal controls are connected to the same telemetry system but not to the Internet for security reasons. Consequently, the River Commissioners now have access to instantaneous flows and water levels, daily estimates of individual water rights, and instantaneous capability to remotely control key system structures. A detailed summary of the development and nature of this system is provided by Sevier River Water Users, et al. (2004)[3].

The transition from the historical monthly based management system to today's hourly and daily system occurred over the period of 1991 to 2004. Beginning with the automation of canal and reservoir gates and eventually reaching a system status involving a number to equipment and software innovations.

SIMULATING THE WATER RIGHT ALLOCATION PROCESS

Beginning in 1975 and continuing through 2003, an effort was made to simulate the processes used by the Commissioners to define and allocation primary and storage rights along the main stem of the river. This evolved three components: (1) segregation of total primary and storage flows in the system; (2) allocating primary and storage to individual rights; and (3) developing right by right accounting mechanisms.

Computing Primary and Storage Flows

Primary is comprised of irrigation return flows, groundwater inflows, and tributary inflows. It does not include water bypassed in an upstream section because of non-use. For instance, the primary in the lower zone is comprised of primary "make" along the river between the Vermillion Dam and the end of the river at Delta. Figure 3 shows the total primary for the month of June 1970.

The primary calculations are of a single type – ***outflow-inflow = primary***. There are two special provisions in the Cox Decree that bear on the primary computations. The first is that since primary flows were being used before the reservoirs were built, there were some primary flows that were available within the reaches that were later inundated. With the reservoir construction, these flows

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[3] Sevier River Water Users, StoneFly Technology, Inc., Utah State University, and U.S. Bureau of Reclamation. (2004). Sevier River Basin Water Resource Management Network: Evolving Toward Sentience. Final Report to the Department of Commerce's Technology Opportunity Program.

could no longer be identified and were "stipulated" in the decree as fixed amounts based on average estimates prior to the reservoirs.

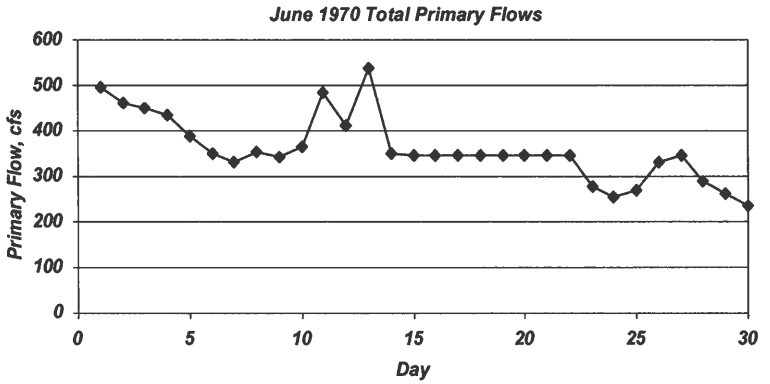

Figure 3.

The second special provision the decree imposed was that primary flows occur without diminution. In other words, all steam losses are charged to storage flows. Thus, storage flows must be determined day by day just as primary flows are to account for stream losses. Otherwise, storage rights could be simply determined by monthly water balances of the systems' reservoirs.

Daily Water Rights Allocation and Accounting

Detailed water rights in the Sevier River systems are modeled by a software package called ***SEVIER III***. The various algorithms have been verified and are now in use by the River Commissioners. Real-time data from river, canal, and reservoir gauging stations are now automatically loaded to a server at midnight of each 24 hour period and then processed by the ***SEVIER III*** software to provide real-time information to the varied individual rights. The accounting system for each right shows the accrual of the rights as well as the use and balances for each major user.

Figure 4 shows the allocation of the primary shown in Figure 3 among the primary right classes in the lower river zone. This figure allows any user or manager to determine what components of the overall rights are accruing at any point in time. This information is then allocated to each right holder as illustrated in Figure 5. As a result of the real time capabilities in the Sevier River Basin and the data processing capabilities, the entire river system is now operated much like a commercial bank, in this case a water bank.

DISCUSSION

Water rights in the Sevier River Basin which have been determined on a daily basis but managed monthly are now managed hourly and daily thanks to system-

wide application of SCADA technology and water right allocation software. The monitoring system allows every user a view of the water flows and reservoir storage, thereby presenting a holistic picture of water management in the basin. Conflicts that have historically resulted in over diversion can now be remedied as day today enforcement of right limitations can now be made.

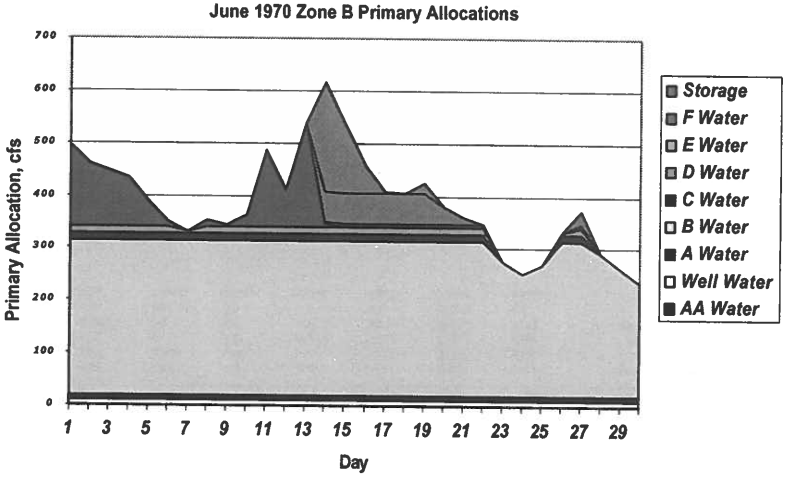

Figure 4.

The new system has a number of features that will be invaluable in coming years. The flooding of 1983 and 1984 when the river could not be controlled as a unit, with the consequent loss of two reservoirs, will now be a thing of the past. Water management is being improved as less and less water is by-passed in the system resulting in a more stable water supply throughout the system. In short, the implementation of advance monitoring, control, and water right software has raised water management in the Sevier River Basin in an entirely new level.

	May	Apr	May	Jun	Jul	Aug	Sep	Oct
Beginning Credits, af	9500.0	21259.0	22715.1	23034.4	23025.0	21449.0	21981.3	1284.0
Primary Credits, af								
AA - Wells, af	0.0	257.0	268.9	357.0	268.9	268.9	257.0	0.0
A Water, af	3531.9	2783.2	3496.9	3395.4	2498.9	2691.1	2896.7	0.0
B Water, af	266.0	37.9	244.6	236.0	0.0	0.0	0.0	0.0
C Water, af	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
D Water, af	0.0	69.1	3399.2	838.3	0.0	0.0	0.0	0.0
E Water, af	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
F Water, af	380.9	0.0	0.0	125.3	0.0	0.0	0.0	0.0
Total Primary	4180.6	3225.6	7493.6	4958.1	2868.8	3060.0	3253.8	0.0
New Storage Credits, af								
1st Increment (184,000)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2nd Increment (132,000)	6900.6	753.2	180.4	191.0	78.3	69.0	102.2	0.0
3rd Increment (>236,000)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Exchange Water	0.0	0.0	0.0	0.0	29.0	9.5	10.1	0.0
Winter Water	2900.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DWAD Wells	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Miscellaneous	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Transfers	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
New Storage	10575.5	253.2	180.4	191.0	109.1	68.4	112.3	0.0
Uses and Losses, af								
Canal Diversions	1311.1	1578.3	5311.0	5132.5	4347.9	3165.7	769.9	754.0
@A Diversions	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sevier Bridge Losses	670.1	0.0	0.0	0.0	0.0	0.0	23094.8	0.0
River Transit Losses	251.8	30.5	795.5	1035.0	67.7	173.5	82.9	2.9
DWAD Losses	377.9	257.6	-242.1	417.6	186.5	-676.7	165.7	-248.4
Gunnison Bend Losses	446.5	149.0	20.4	98.2	-9.1	-65.2	-70.1	-122.6
Total Use & Losses	3057.4	2062.5	5784.8	6684.4	4587.9	2597.2	24063.3	382.8
Ending Credits, af	21298.8	22705.1	24934.4	23050.0	21449.0	21981.3	1284.0	901.2

Figure 5. Typical water right account for a "storage" right in the Servier River Basin