WATER ACCOUNTING IN THE TRUCKEE BASIN RIVERWARE MODEL

Jeffrey T. Boyer, TROA Implementation Planning Coordinator, U.S. District Court Watermaster's Office, 290 S. Arlington Ave, Reno, NV 89501, (775)784-5241 X26, jtboyer@troa.net

Abstract

Operation of Truckee Basin Reservoirs and administration of Truckee River diversions requires a complex water accounting system. The water accounting system is used to categorize and quantify stored waters and waters flowing in-stream on a daily basis. A new water accounting system has been developed using RiverWare software to replace a legacy spreadsheet system. The RiverWare water accounting system is one of a set of linked models to be used under current reservoir operating policy and being developed for use in the future under a proposed river and reservoir operating agreement which is expected to be in place in 2007.

INTRODUCTION

Area Of Study

The study area is described in detail in a related paper submitted for the Spring 2006 FIHMC conference (Mann, 2006).

Water Accounting

An interagency effort has been employed to develop a set of closely related models that can be used to improve water management efficiency in the Truckee River Basin. The RiverWare Modeling system is the tool chosen for this effort. RiverWare provides a generalized modeling environment for building basin-specific, river and reservoir models (Zagona et al., 2001) and is ideal for modeling complex river and reservoir operations. The "Current Conditions" RiverWare models apply Truckee Basin reservoir and river management law and policy as it exists today. Current reservoir operating rules and water accounting requirements are based on the 1935 Truckee River Agreement (TRA), the Orr Ditch Decree, subsequent legal agreements, court rulings and flood control requirements, as well as evolved policy that is often undocumented. Developing the "Current Conditions" RiverWare models was planned as a logical step toward building the more complex models that will be required for efficient river and reservoir operation and accounting under the proposed new Truckee River Operating Agreement (TROA). Chronologically first in the series of linked RiverWare models is a water accounting model that uses observed data, operator inputs, and a set of complex logic expressed in the RiverWare rule language to quantify actual reservoir storage accounts and releases by category. Storage and release accounts are quantified by the model along with ownership of flowing waters at specified river reaches to define the current state of the Truckee Basin river and reservoir system. The state of the physical system and water accounts are used in daily reservoir management decision making and to initialize other models in the RiverWare system. Linkage and order of the Truckee Basin RiverWare models is diagramed in Figure 1.

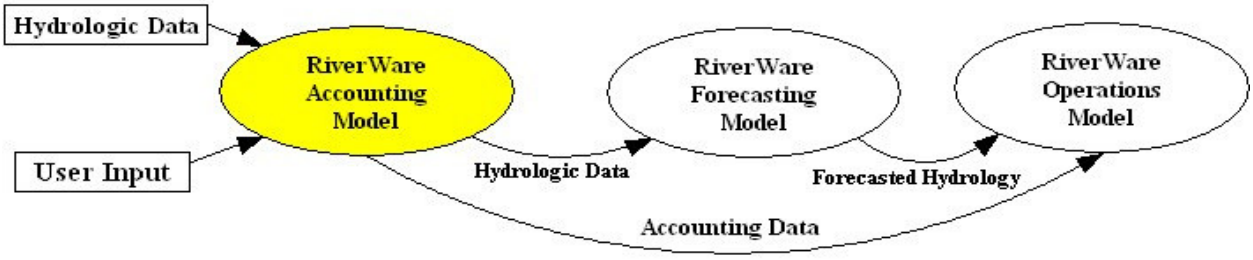

Figure 1. Model Linkages

RIVER & RESERVOIR OPERATING POLICY CURRENT CONDITIONS

Current reservoir operating policy for the Truckee River and Truckee Basin Reservoirs is dictated primarily by the 1935 TRA and the Orr Ditch Decree, completed in 1944. Additional requirements and agreements related to three newer reservoirs built between 1963 and 1971 add elements to the current operating policy. Most significant of these additional requirements include flood control operating criteria, the Tahoe Prosser Exchange Agreement, endangered species rulings, and the Interim Storage Agreement. In addition to legal requirements, operating policy has accommodated changing recreational and environmental interests within the limits of current laws.

The following is a brief summary of some of the legal agreements and operating policies that direct Truckee Basin reservoir and river operation while dictating water accounting logic and requirements.

Floriston Rate

The 1935 TRA was a negotiated agreement between major water right holders on the Truckee River. The Agreement was designed to reduce the frequency of drought-induced water shortages especially for agricultural irrigation and power generation, the two dominant water uses of the time. Establishment of "Floriston Rates" was the key provision of the TRA. Floriston Rates are a set of required flows at Floriston, as measured currently by the USGS gage, Truckee River at Farad. When Floriston Rates are met, established irrigation and power generation rights as adjudicated by the Orr Ditch Decree are satisfied. Floriston Rates vary seasonally and with the level of Lake Tahoe. The Floriston Rate system makes it unnecessary for water users to schedule diversions or call for release of water to which they are entitled. The system is supply driven ie the Floriston Rate must be met whenever the supply is available and when the Floriston Rate is met there is adequate water to supply existing water rights for agricultural users and power generation. The Floriston Rates are outlined in Table 1.

Lake Tahoe Elevation	OCT	NOV - FEB	MAR	APR - SEP
Less than 6225.25 Feet	400	300	300	500
6225.25 to 6226.0 Feet	400	350	350	500
Over 6226.0 Feet	400	400	500	500

Table 1. Floriston & Reduced Floriston Rates (CFS)

Pooled Water

The TRA called for construction of Boca Reservoir and the "pooling" of water stored in Boca Reservoir with Lake Tahoe storage to reduce the frequency of water shortages. Runoff could be captured in Tahoe and Boca when Floriston Rates are met by other sources contributing to the Truckee River above Farad and "Pooled Storage" would be released from Tahoe and/or Boca Reservoir when necessary to meet Floriston Rates. There are two subcategories of "Pooled Storage" captured in Boca as defined in the TRA, these are known as "Supplemental Water" and "Additional Supplemental Water". Each has different rules for storage and release.

Privately Owned Stored Water

The TRA recognized Privately Owned Stored Water (POSW). Today, POSW is owned by the Truckee-Carson Irrigation District (TCID) and the Truckee Meadows Water Authority (TMWA) in Donner Lake, and by TMWA in Independence Lake. POSW can be released when ordered for direct use by the owner, usually on top of available Floriston Rate sources. Alternatively, Donner Lake POSW can be released by the owner and voluntarily used to meet the Floriston Rate. TMWA has the additional option to exchange its POSW from Donner Lake by releasing it to meet the Floriston Rate. This exchange is completed by an equivalent reduction in release of Pooled Water from Boca that would have been made to meet the Floriston Rate if the Donner POSW had not been used for that purpose. The reduction in the Boca Floriston Rate release is followed by the transfer of an equivalent amount of Boca Pooled storage to TMWA POSW in Boca. This is referred to as an "in-lieu" exchange. This voluntary exchange, based on current policy, has the advantage of allowing TMWA to build a drought supply for possible later use rather than being forced to spill its water to meet dam safety requirements.

Tahoe Prosser Exchange Water

With the construction of Prosser Reservoir in 1963 additional categories including "Uncommitted Water" and "Tahoe Prosser Exchange Water" (TPX) were recognized. TPX Water is stored directly in Prosser or converted from Uncommitted Water in Prosser. Purpose of the Tahoe Prosser Exchange is to replace Lake Tahoe Floriston Rate Water when the Tahoe release is made solely to meet instream flow requirements. There are two subcategories of TPX Water, Type A TPX is accrued as new storage and Type B TPX is accrued by conversion of Uncommitted Water that was stored previously. This mandatory exchange ensures maintenance of instream flows below Lake Tahoe which were not required by the 1935 TRA or prior existing water rights.

Stampede Fish Water

Stampede Reservoir was completed in 1969. Originally designed to store water for municipal and industrial uses, Stampede storage water was designated as "Fish Water" upon completion of the reservoir and following one of the first endangered species court rulings. By current policy, a portion of Little Truckee water which should legally be passed through Stampede to Boca as "Pooled Water", is routinely captured and stored in Stampede Reservoir during winter and spring seasons. This block of Pooled Water is later released to meet instream flow targets in the Little

Truckee River between Stampede and Boca Reservoirs during the summer. In late summer and fall it is often necessary to release Stampede Fish Water to meet the same instream flow targets. Fish Water released for this purpose is recaptured in Boca and retains the "ownership" label of Stampede Fish Water. The Stampede Fish Water exchange is completed when Pooled Water belonging to Boca Reservoir is captured in Stampede during the next runoff period as Fish Water, while a like amount of Fish Water in Boca is converted to Pooled Water.

Water Exchanges

Current policy allows for specific, limited water exchanges such as the Stampede Fish Water exchange and the Tahoe Prosser Exchange which are used to improve instream flows and the Donner to Boca Floriston Rate exchange used to improve M&I drought supply, as previously described. Water exchanges require specific reservoir operating practices and sophisticated accounting procedures. Water exchanges have been used to meet some of the newer water demands and interests that are significantly different from those recognized in the 1935 TRA and to make storage of water more efficient in a reservoir system that is also significantly expanded from the system envisioned when the TRA was negotiated.

Flood Control Space Requirements

In managing physical storage, seasonal flood space requirements are observed at the three combination flood control and water supply reservoirs, which include Boca, Stampede, and Prosser. Current reservoir capacity as limited by the flood space requirements is strictly applied in the allocation of inflow based on storage priorities. For example when the combined total of Pooled Water stored in Boca and Stampede is equivalent to Boca's current flood control capacity, Boca's storage entitlement is considered satisfied. If additional inflow is captured in Boca or Stampede after Boca's storage entitlement is satisfied, new storage is credited to the next most senior storage priority. This accounting practice is necessary to ensure that water exchanges are not used to manipulate storage priorities to the advantage of one water category over another.

Interim Storage Agreement

Another example of a recent agreement with water accounting requirements is the Interim Storage Agreement. This agreement allows TMWA to store POSW from Donner and Independence Lakes in Boca or Stampede and provides for carry over storage from one year to the next. The agreement dictates that POSW storage on September 1 in excess of 5,000 AF be converted to Fish Credit Water. Accounting requirements incorporated in the RiverWare model include separating the POSW portion of Stampede inflow, tracking the Donner to Boca POSW exchange, tracking storage volume compared to limits, applying turnover dates, spill priorities, and evaporation losses. Storage fees for the water categories created by this agreement could also be tracked by the RiverWare water accounting model.

Storage Licenses

Truckee Basin reservoirs store water as allowed by California storage licenses and according to rules specified in the TRA or subsequent agreements. A central concept in the current operating

system is that a reservoir can only store water for its licensed purpose or purposes. These authorized categories are referred to as "Project Waters". Storage of additional water categories in some of the reservoirs does occur, sometimes by intentional policy and sometimes as an incidental and temporary result of imperfect application of the reservoir operating rules or due to some other temporary limitation in reservoir outflow regulation.

RIVER & RESERVOIR OPERATING POLICY TROA

The proposed TROA is expected to replace current operating policy for the Truckee River and Truckee Basin Reservoirs as early as 2008. Although TROA will replace the TRA as the "law of the Truckee River", TROA will maintain the key provisions of TRA while adding another layer of policy on top of the current conditions policy. TROA is an attempt to update the 1935 TRA by providing for a highly coordinated operation of the Truckee Basin Reservoirs addressed by TRA with the reservoirs added after TRA. Coordination of reservoir storage and release as provided by TROA is designed to satisfy increased M&I water demands along with recreational and environmental interests that were largely unrecognized during the negotiation of the 1935 TRA. This is accomplished through TROA's reservoir operating and accounting provisions.

TROA will create new challenges for river and reservoir management and will impose extensive additional requirements for water accounting and forecasting of daily hydrology and reservoir operations. Two of the key operating and accounting processes proposed by TROA are briefly described below. These two processes are "Credit Storage" and "Exchange". Detailed explanation of river and reservoir operation and accounting under TROA can not be covered in a paper of this length.

Credit Storage And Release

TROA will provide for some of the changed demands by adding a system of "Credit Storage and Release". Nevada water law has allowed for the purchase and transfer of water diversion rights from agricultural to M&I uses to meet changing demands. However, storage and release management of those waters remain as originally required by the 1935 TRA, primarily to meet agricultural and power generation needs. TROA will partially change reservoir operations from the supply driven Floriston Rate system to one that is more demand driven by allowing a Credit Storage option which will divide some of the Pooled Water into separate ownership categories.
Under the TROA Credit Storage option, a party may request that a portion of Floriston Rate Water that it has a right to but no current demand for, be held back as Credit Storage in that party's name for later use at its discretion. The process of Credit Storage and Release converts the Pooled Water system created by TRA and the Floriston Rate to a system with numerous separate ownership accounts that must be tracked. The establishment of Credit Water requires that the TROA water accounting system define the theoretical source reservoir and release rate that would have been required to meet the Floriston Rate before the specific establishment request was made. This change also requires significantly increased interaction between the reservoir operator and water users. Stakeholder interaction will be handled through a scheduling process in which water owners will specify their request for Credit Water Establishment or Release.

Water Exchanges

TROA attempts to better coordinate use of the Truckee Basin reservoirs by adding a process of voluntary and mandatory water exchanges between reservoirs. Exchanges can be described as trades where water from a specific storage category is released from a reservoir to meet a purpose other than that category's normal purpose in exchange for a similar volume of water in another reservoir. These exchanges could be made to improve instream flows, maintain desired minimum storages, or to decrease the risk of spill for a specific storage category. TROA exchanges, while similar to the limited exchanges used in current operating policy will formally allow storage of virtually all water categories in any Truckee Basin reservoir. Implementing and documenting these water exchanges will greatly add to the complexity of the TROA water accounting system in RiverWare. Changes to the storage licenses of each reservoir will be required to allow the storage of most water categories anywhere in the Truckee Basin reservoir system.

CURRENT CONDITIONS DAILY RESERVOIR OPERATION & WATER ACCOUNTING

A Federal Watermaster is charged with making daily reservoir storage and release decisions in the Truckee River Basin. To the extent possible, the Watermaster's operating decisions follow existing legal requirements and policy as partially covered in this paper. However, a significant challenge in the water management process is applying the operating rules to real world conditions. Real world conditions often present circumstances that were not anticipated by the governing laws, including facility maintenance requirements and response to emergencies. Everyday real world challenges include inaccuracy of reservoir inflow calculations and the limits of storage and release data accuracy and availability. They also include permanent and temporary physical limitations of reservoir outlet facilities as well as timing and accuracy of manual release adjustments. Water accounting is used in the Truckee River Basin to help the Watermaster make reservoir release and storage decisions that comply with Basin policy and to compensate for the real world limitations which make perfect operation impossible.

The following three factors are key to understanding water accounting and its importance; 1) water accounting is backward looking, it is done at the end of the day after release decisions are made, 2) water accounting goes hand in hand with operations because categorization of releases often requires knowledge of the decision maker's intent which in turn requires manual input of some data before other calculations can be completed, and 3) storage account status from the previous day's accounting and other numbers calculated for the current day are often used in making daily water release decisions.

Currently, a spreadsheet based water accounting system developed and maintained by Watermaster staff is used as a vital tool in the Watermaster's daily decision making. This spreadsheet water accounting system requires input of physical data and some scheduled releases while using many logical, "IF-THEN-ELSE" type statements to generate an accounting of storage and release by categories at the end of each day. Entry of the scheduled release data often requires knowledge of the reservoir operator's intent.

Riverware Accounting Model

A more sophisticated water accounting system will be required for operation of the Truckee Basin Reservoirs under the very complex, proposed new TROA. RiverWare is the tool chosen for the TROA water accounting and reservoir operation models. Since the proposed TROA adds many new operating and accounting requirements on top of the existing policy, the modeling team chose to begin by modeling current basin policy using the RiverWare tool and then to build TROA requirements on top of the models developed for current policy.

The Truckee Basin RiverWare models include the physical objects of the Basin such as reservoirs, river reaches, diversions, etc. The objects are connected by supplies which are pathways for inflows, outflows, and transfers. Rules written in the RiverWare accounting model breakdown and categorize the components of reservoir inflow and release, referred to in RiverWare terminology as "supplies". Similarly, RiverWare rules are used to govern accumulation in and withdrawal from reservoir storage accounts. The physical objects are set up to include appropriate water accounts and sub accounts. The Accounting model and the operations models both include the same physical objects, connections, and accounts. The accounting rules in the forward looking operations model are very similar to those in the accounting model but the operations model relies on additional logic to set the releases, before applying the accounting logic. The operations model is summarized in a related paper submitted for the Spring 2006 FIHMC conference (Coors, 2006).

Accounts and supplies necessary for implementing basin policy were mapped as a starting point for development of the Truckee Basin RiverWare models. The "accounts map" provides a useful view of accounts and supplies included in the Truckee Basin models. Figure 4 is a piece of the "accounts map" showing Prosser Reservoir storage accounts as well as inflow and outflow supplies in the model.

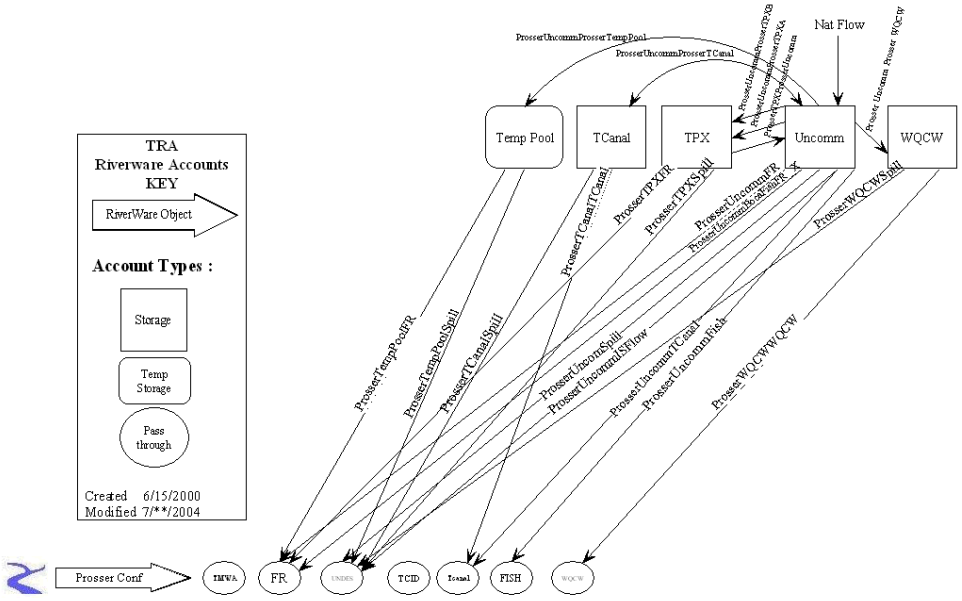

Figure 4. Prosser Reservoir Accounts and Supplies

In the Accounting model, rules are written to look backward and categorize releases after they have been made by the Watermaster. Similarly, in the Accounting model reservoir net inflows are calculated from observed data (+- Storage Change + Release) and allocated to appropriate storage accounts based on logic applied in the RiverWare rules.

SUMMARY

In the Truckee River Basin updated operating policy and water accounting has been used to a limited extent to improve the ability of the existing reservoir system to meet an increased and changing set of demands on the water supply. Water accounting has been used to facilitate some coordination between Truckee Basin Reservoirs built before and after the 1935 TRA, to assist with the day to day operation of the system, and to document that original legal requirements are still being met with the updated operating policy. A proposed new river and reservoir operating agreement (TROA) will add significantly more complex layers of operating policy to existing policy. The TROA policy will create many new water accounts and allow greatly increased flexibility in water management. The proposed changes will require sophisticated daily forecast and reservoir operating models to maximize potential benefits of the new flexibility. A water accounting model will be required to track the status of numerous water accounts created by TROA, to assist in making reservoir operating decisions allowed by TROA, and to document that the reservoir system is operated according to the complex legal requirements of TROA.

REFERENCES

Coors, A. S., (2006). "Truckee-Carson Basin RiverWare Operations Model" Proceedings of Federal Interagency Hydrologic Modeling Conference, pp 1-2.

Ickes, H. L., (1935). "Truckee River Agreement" United States of America Interior Department.

Mann, M. P., (2006). "Hydrologic Forecasting In The Truckee-Carson RiverWare System" Proceedings of Federal Interagency Hydrologic Modeling Conference, pp 1-2.

United States of America v. Orr Ditch Water Company Equity No. A-3 (D. Nev. 1944). "The Orr Ditch Decree".

Zagona, E. A., Fulp, T. J., Shane, R., Magee, T., and Goranflo, H. M. (2001). "RiverWare: A Generalized Tool for Complex River System Modeling," Journal of the American Water Resources Association, 37(4), pp 913-929.