HYDROLOGIC COMPUTER SIMULATION FOR THE UPPER SNAKE RIVER RESERVOIR SYSTEM

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ABSTRACT

A computer software program has been developed to visually simulate and display the daily operation of the Upper Snake River and Reservoir System in eastern Idaho and Wyoming. R*TIME, a real time software system developed by SCIENTECH Inc., has been linked to the water district's database creating a visual display of daily reservoir contents, river discharges, and snow water equivalent graphs and indexes while utilizing color alarms and river widths in proportion to flow. The real time display configuration provides the user and audience with a fast analysis and comparison of previous water years that was previously possible only with meticulous study of charts and graphs, or years of experience. The simulation display includes a time scale with pause, rewind, and fast forward buttons enabling the users to animate the reservoir "teacup" display at variable speeds. The computer simulation is used as a tool for improving future water management and distribution by policy makers, water resource managers and water users. It is also an educational tool for displaying the complexity of a river and reservoir system.

INTRODUCTION

Over the past several years, there has been a gradual shift in the population of Idaho from a rural, agricultural environment to a more urban-based population. As a result, water managers are feeling the needs and demands to provide irrigation water for non-agricultural uses as well. The upper Snake River reservoirs were built primarily for irrigation, power generation and flood control. With the change and increase in population, the demands on how water is managed for agriculture, recreation, minimum fish flows, Indian tribal water rights, endangered species, and managed groundwater recharge projects have also changed. Because of these competing demands for water at various times of the year, there are now more frequent meetings to discuss water issues with more diverse groups and individuals. Many of these individuals come from different backgrounds and may not fully understand the complexity and interaction of the snowpack and streamflow on reservoir management. Better water management tools were needed to illustrate and explain the complex hydrologic processes and how reservoirs and rivers are operated together as one system.

THE VISION AND INVESTIGATION

Over the years, Water District #1 in eastern Idaho and the U.S. Bureau of Reclamation (USBR) have tried different visual media to explain and simulate river and reservoir operations. These presentations included the USBR "Teacup Diagram", which displayed current reservoir storage and streamflow values. This idea lead to the vision of this animated display.

The feasibility of developing this animation idea was discussed with several universities, engineers from the USBR, state water resource engineers, and software programmers, in addition to searching on the Internet. Existing software programs and methods for displaying a schematic on a computer screen were investigated. Some of the

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commercially available software tools analyzed included animation software that connected still pictures into a moving display, morphing software to change from one image to another, and MPEG software that connects digital images. MPEG is the digital software format commonly used to show the movement of clouds and weather fronts by television weathermen. Each of these methods of visual display had some advantages and also some drawbacks. Some of the animation software were good for displaying historical data but are not easily adapted to show current data. Animation of still images takes a lot of pictures per second, which requires a lot of data storage and memory and a lot of human hours to put a short display together. Most of the display methods would need recompiling to append the most recent time period in order to have an up-to-date presentation.

THE SOLUTION

After further research, it appeared that a Human-Machine-Interface software held the most promise of being adapted to produce a reservoir / river simulation. SCIENTECH Inc., a computer software company, was contacted to see if they could develop a computer display screen to depict reservoir and river status. SCIENTECH Inc. used a proprietary real time software package called R*TIME to create a Windows NT computer application. R*TIME is a powerful method of creating near real-time displays through its display builder application which is commonly used in the power generation industry to provide operators with current information on various sensors, gages and processes. The Display Builder, which is one application in the R*TIME product, was used to create a customized graphic display of the Upper Snake Reservoir and River System. A subset of Water District #1's database containing daily reservoir contents and mean daily river discharges for a water year was linked to their respective dynamic components to create their graphical representations. Figure 1 is an example of the Upper Snake River Reservoir simulation display.

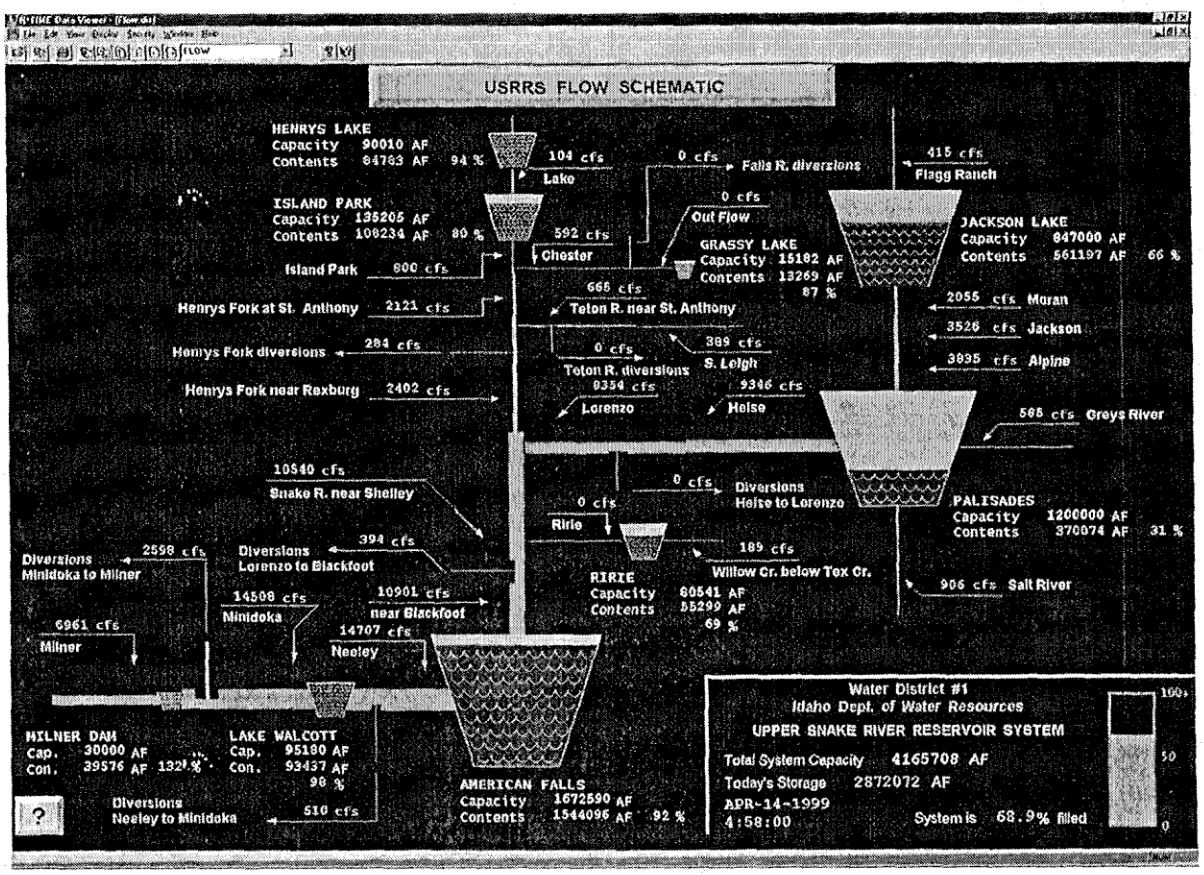

Figure 1. Schematic of Upper Snake River Reservoir Simulation.

R*TME is a Microsoft Windows-based application designed to operate on IBM compatible personal computers using Windows NT and Windows 95 operating systems. The data can be dynamically displayed in a textual or graphical form in a window on a color display screen attached to a computer workstation. Display elements on the computer screen are updated as the data change.

LOCATION

This computer simulation was developed for Water District #1 jurisdiction in eastern Idaho. The watershed includes the Snake River and its tributaries in Idaho and Wyoming, except for the Blackfoot and Portneuf rivers, from the Wyoming border to Milner Dam. Milner Dam is located in south central Idaho near the town of Burley. The irrigated lands that receive water distributed by the district cover an area of approximately 320 kilometers (200 miles) long and up to 100 kilometers (60 miles) wide. It includes 1,280 kilometers (800 miles) of river and major tributaries. More than 300 canals and pumps divert water to irrigate approximately 4,850 square kilometers (1,875 square miles). There are 8 major reservoirs with a capacity of more than 5,050 cubic hectometers (4,100,000 acre-feet) of storage water. Water District #1 monitors the delivery of approximately 9,860 cubic hectometers (8,000,000 acre-feet) of natural flow and storage water to irrigation diversions each year.

Water-based recreational activities are also important to the economy in this area and continue to grow. Reservoirs and rivers are used by river runners, boaters and fishermen through out the year. Wise water management to meet the diverse water uses and changing and competing water demands is important in this watershed.

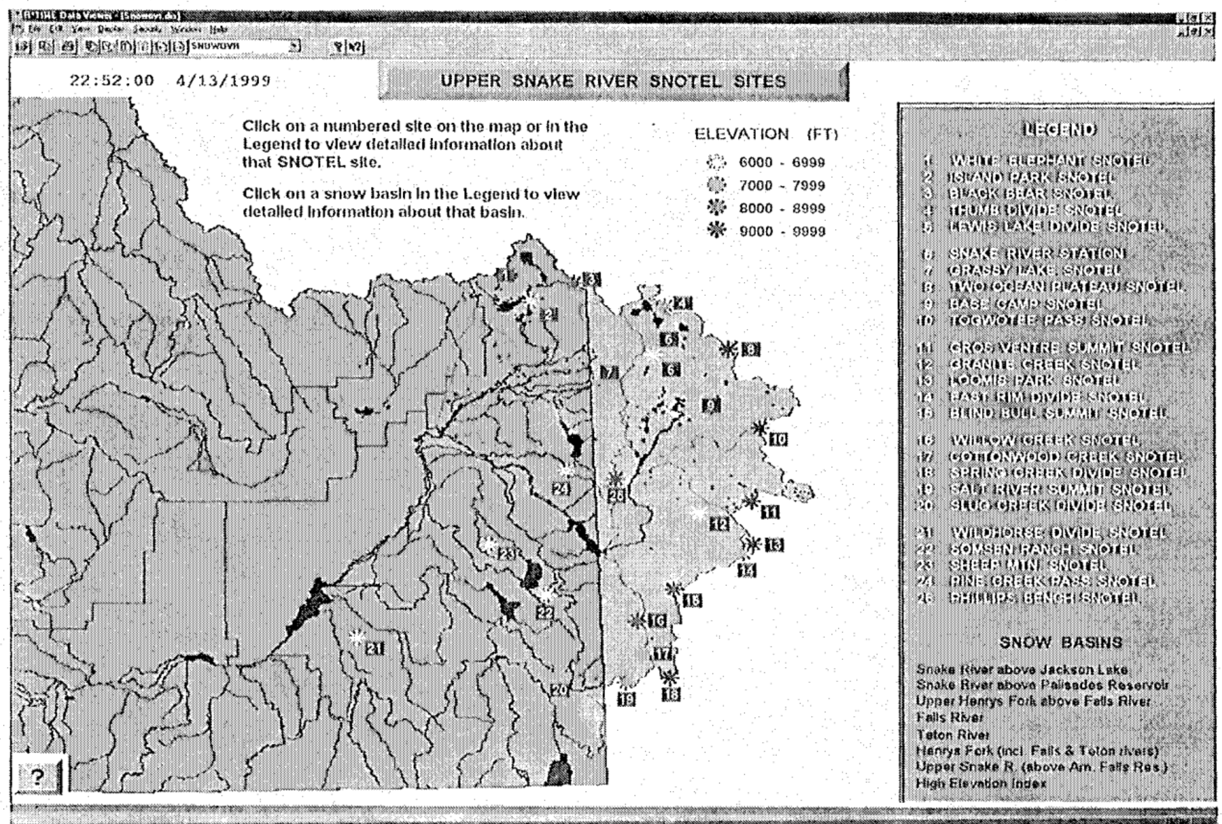

Figure 2. Illustration of map-based interface used to select snow, river, reservoir or diversion station.

THE SIMULATION --- SOFTWARE PRODUCTS AND MAIN FEATURES

The Human-Machine-Interface (HMI) software is used to link a database to a computer graphical display. The package of software programs and applications that make up the R*TIME software has several capabilities, and multiple ways of displaying data in different formats. After data is processed by the HMI software, the Data Viewer is used to view near real-time data, historical data or run a simulation display. The Upper Snake River Reservoir Information Display System (USRRIDS) provides the operator with the ability to replay historical data for a specific water year onto a color graphical computer display. This graphical display shows the reservoir contents, river and diversion discharges for the Upper Snake River and Reservoir System as illustrated in Figure 1.

A fast and easy to use menu driven interface allows the computer operator to quickly retrieve the pertinent data. A map-based interface is used to select the snow, river, reservoir, or diversion station for a comparison of the present year to an appropriate reference year and a long-term (30-year) historical average. Figure 2 is an illustration of the map-based interface used to select snow measuring stations. A similar map is available for selection of river, diversion or reservoir station.

The R*TIME software uses a custom designed graphical schematic display to continuously update the near real-time data display screen with the latest available data automatically. Data can also be displayed in a tabular format. Short or long-term trend displays can be selected, with several data stations plotted on a common scale or individually with either trends or bar graphs.

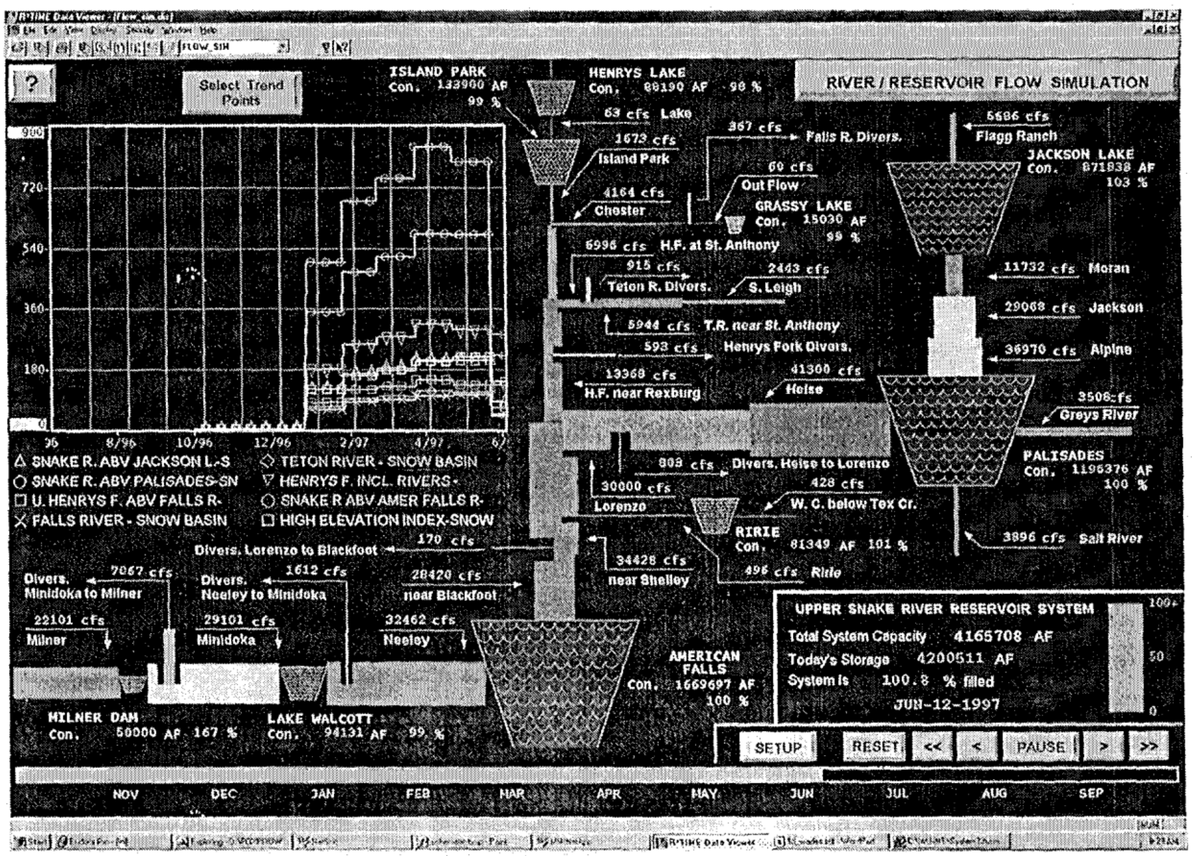

Figure 3. Schematic display of pseudo-proportional river and diversion widths.

Probably the most innovative feature of this system is the ability to “animate” a similar water supply year and use the database to run various what-if scenarios. By adding a water year time-scale and VCR style buttons, the analyst can pause, rewind or fast-forward the display. The most frequent display rate is at a one second per day rate, which replays a year in 365 seconds or about six minutes. This display system can then be used by reservoir operators and canal managers to plan operations, provide training, educate the public, and improve understanding of the river and reservoir system to diverse interest groups. It has helped policy makers to understand the trade off of different water management decisions. The visual understanding of how the reservoirs, rivers, diversions and snowpack operate together as a system is enhanced by having animated reservoir contents, pseudo-proportional river and diversion widths combined with the snow water content onto a common display screen. Figure 3 is a streamflow/diversion and reservoir level schematic display illustrating the pseudo-proportional river capabilities. Attention or alert levels are accentuated by use of yellow or red color alarms when river flows exceed National Weather Service flood stages, or when streamflows decline below a low level of concern.

DATA SOURCES

The water data presented in this simulation is originally collected by several federal agencies. Daily or more frequent data is transferred from the USBR HYDROMET computer system to Water District #1’s computer. From here the data is copied into the simulation for processing and display. The USRRIDS displays two types of water data, current values and historic data. Current water data is provided by an automatic data feed from the USBR HYDROMET system. Once an hour a text file is transferred to the USRRIDS system from the HYDROMET system. The current values are rewritten with archived data after the final edits are complete. Historical data of the most recent extreme wet and dry years are available for display on the USRRIDS.

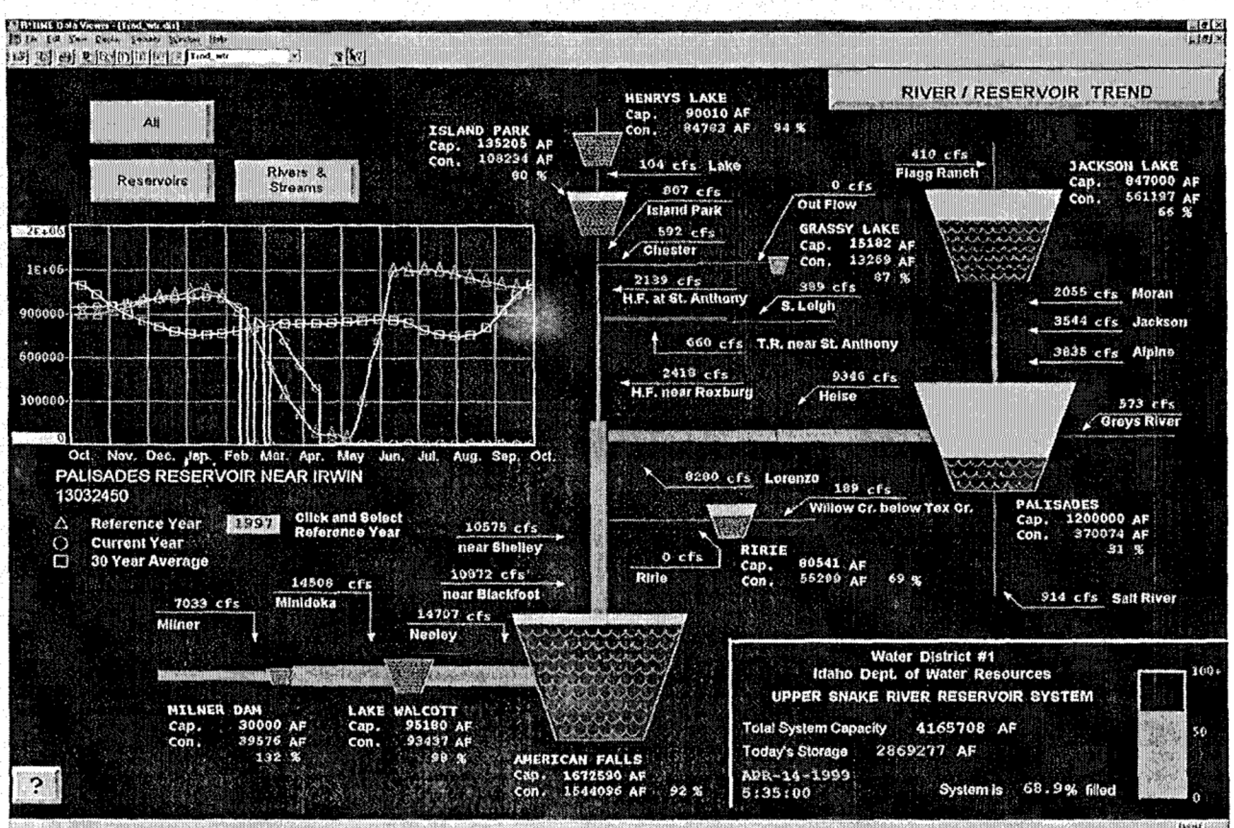

Figure 4. Graphical display of river or reservoir trend and water levels.

Reservoir storage and streamflow data is originally collected by the USBR HYDROMET Data Collection System. Reservoir data is collected for the eight major reservoirs in the basin. Streamflow data is collected for 30 US Geological Survey gaging stations via the HYDROMET system. Irrigation diversion data is available for 57 diversions. This includes the major diversions and represents over 90% of water diverted in the basin. Historic daily streamflow, canal flow and reservoir storage data are available on the USRRIDS system for these stations since the early 1990s. Figure 4 is a graphical trend example of an individual streamflow station while displaying other current water levels. This trend analysis is also available for the other reservoir and diversion stations.

Snow water equivalent data is originally collected by the Natural Resources Conservation Service (NRCS) via the SNOTEL (SNOw TELemetry) Data Collection Network. Current snow water equivalent data for 25 SNOTEL sites is transferred to the USRRIDS system via the HYDROMET system. Historic daily snow water equivalent data are available on the USRRIDS system for most SNOTEL stations since the early 1980s. Snow indexes were also developed for selected basins and elevation zones to provide more basin specific detail information. Figure 5 is a graphical trend example of snow water equivalent data for a single snow measuring station and illustrates how quickly and easily snow trends can be compared to current streamflow, diversion and reservoir contents. Similarly, snow indexes of several snow measuring stations can also be displayed and compared to current water levels.

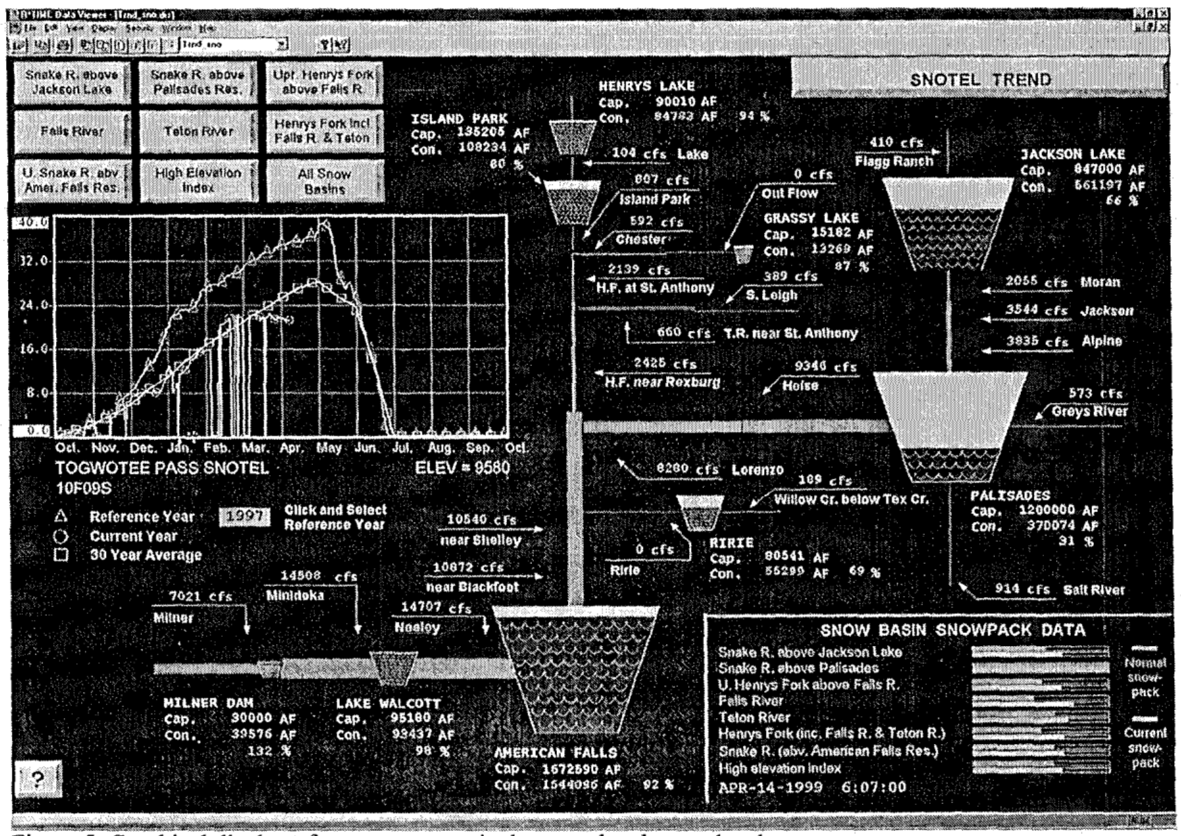

Figure 5. Graphical display of snow water equivalent trend and water levels.

SUMMARY

The Snake River and Reservoir Simulation Display project has successfully created a useful display tool for Water District #1. The simulation is presented at public meetings and allows data to be displayed in a graphical simulation format that could not be done before. The display allows the most current data to be presented without spending an excessive amount of staff time. The software graphically displays data that are dynamically linked to the database and greatly expands the potential use of the historical database. In the future, as more years are linked to the database, the analysis will allow comparison of the present year to a statistically similar year from 20, 30 or 40 years ago.

The computer simulation is used as a tool for displaying the complexity of a river and reservoir system. The simulation provides a visual picture that shows the interconnection between the snowpack and river reservoir levels. It provides a visual image as to the relationship between the snowpack melt phase and increase river levels and resulting change in reservoir storage levels. Through this evaluation it is possible to increase the understanding of what type of reservoir operation is needed to manage the water in order to maximize the water supply and minimize flooding. It can quickly display reservoir operations for a full year, and it is flexible to be able to pause at a certain date, or rewind to a designated time period.

This type of display can provide a new employee, canal manager, news media, or general public a quick way to understand river and reservoir operations and the decisions that were made. It will help policy makers, and elected officials improve their overall understanding of the complexity of the river and reservoir system in Water District #1's jurisdiction. This is a new educational tool that is used at consensus-building meetings to raise the participants understanding to a certain base level, in a shortened time frame, and help reduce conflicts through that increased understanding. In the past, water policies were often formed in a crisis, favoring supply side solutions. Policy makers and water resource managers are now faced with managing existing resources better for the numerous competing demands. This new display will help Water District #1 accomplish this goal.

ACKNOWLEDGMENTS

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