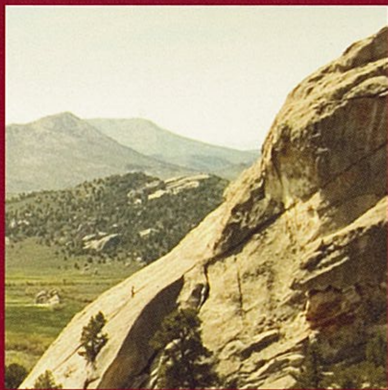

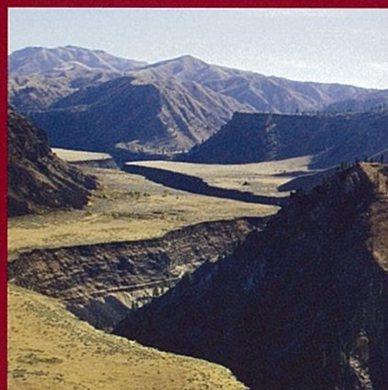

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Idaho Landscapes: History, Science, and Art **continues the proud tradition of *Idaho Yesterdays*, founded in 1957. We debut with mysteries—with a small town murder that leads to an Indian reservation, with mysterious clay tablets in an Idaho archive, with a famous writer's search for the "dark underneath" of the human psyche, and with rivers that flow underground.**

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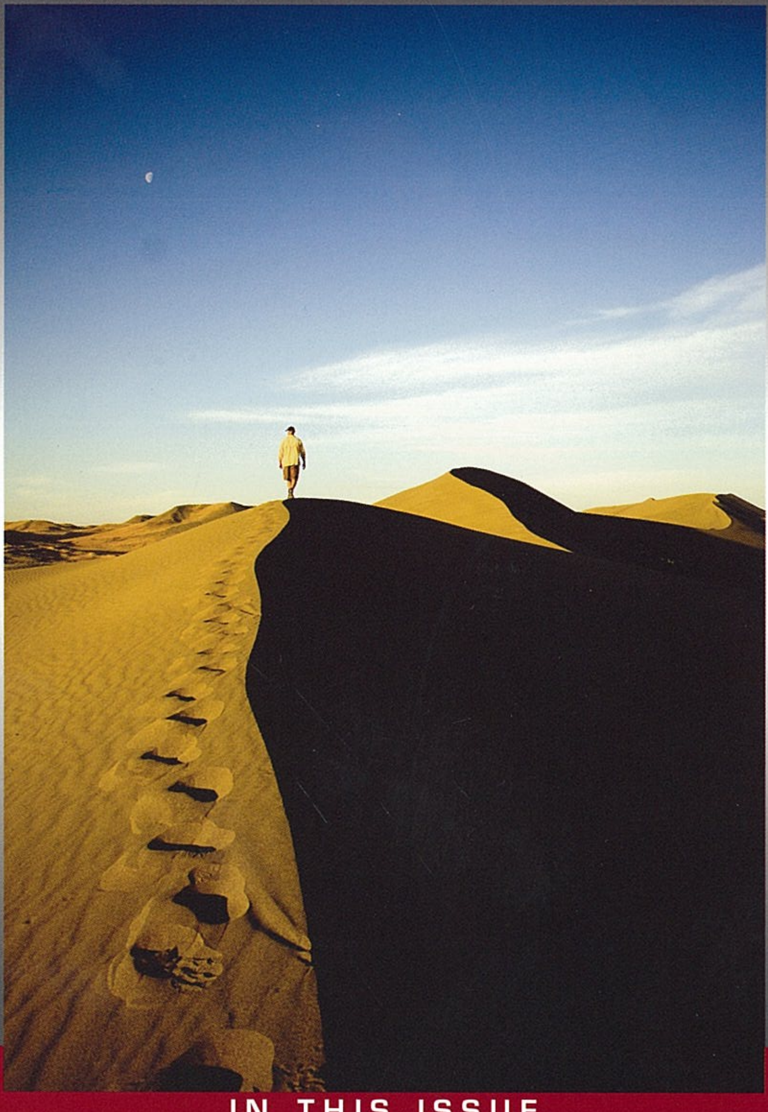

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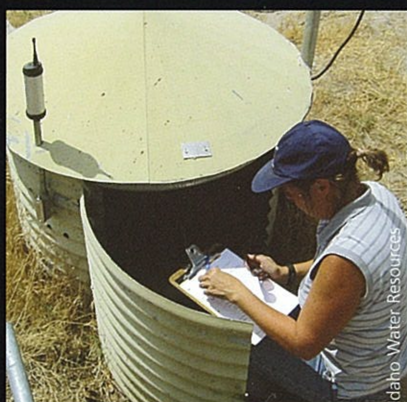
water science goes underground

by **Larry Burke**

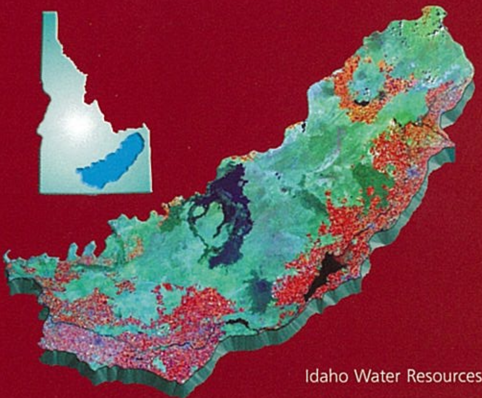
Scientists probe the mystery of water in motion under Idaho's Eastern Snake River Plain

Newly-settled immigrant farmers had hardly punched their first wells into the southern Idaho desert before curious scientists were busily trying to unlock the subterranean mysteries of the aquifer below. The earliest scientific treatise goes back to 1902, when Israel C. Russell wrote "Geology and Water Resources on the Snake River Plains of Idaho" for the United States Geological Survey. Since then, generations of scientists have poked, probed, mapped and measured the plain's every corner in an effort to learn more about subtleties of one of America's largest and most productive aquifers.



Now one group of scientists is taking the quest one step further—they are trying to predict the future. Instead of tea leaves

The Eastern Snake River Plain holds a vast and mysterious strata of water-bearing basalt. This satellite image shows irrigated farming in red, dry rangeland in green, and drier rangeland in blue.



Idaho Water Resources

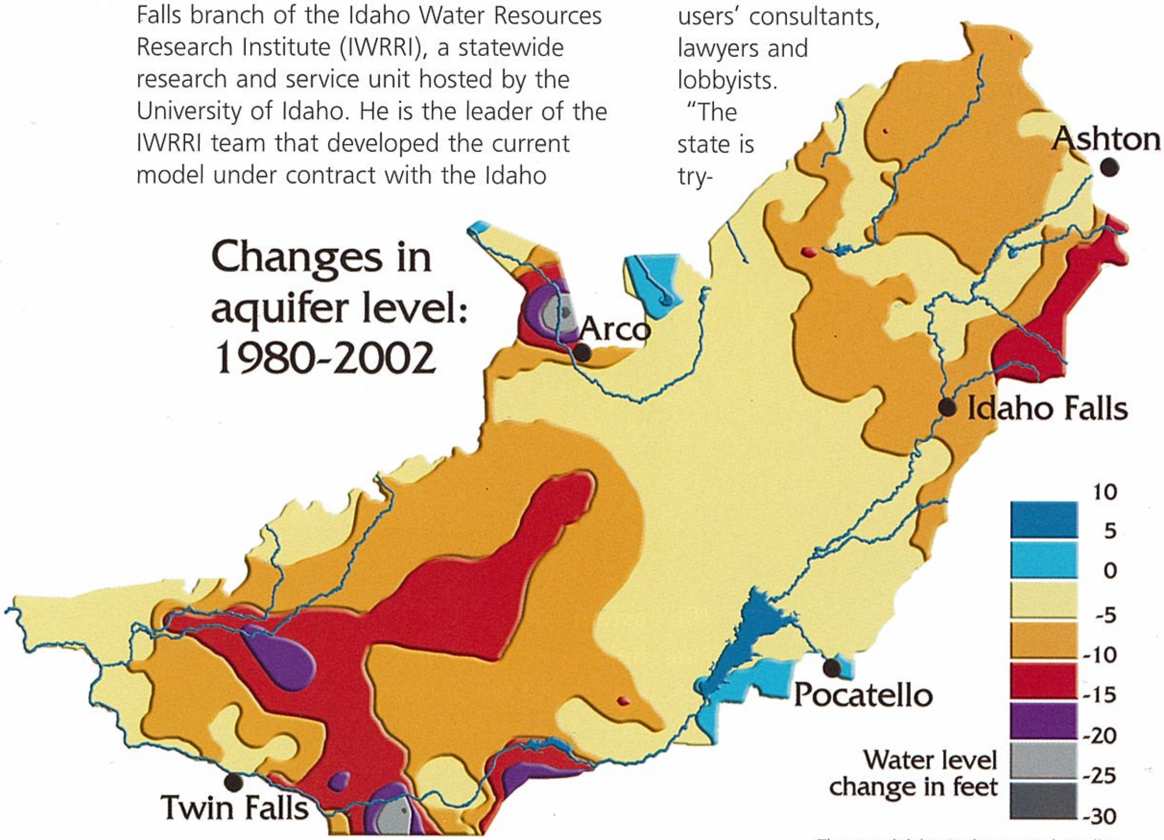
or crystal balls, these scientific seers use powerful computers, mathematical equations, mountains of data and educated suppositions to divine the future. Their version of a crystal ball: the Eastern Snake Plain Aquifer Model, a sophisticated amalgam of math and computer code that is designed to predict how water gains or losses in the Snake River change as water is added or taken away from the aquifer.

Water levels have slowly declined since the 1980s as groundwater pumps replace surface irrigation. Previous: a scientist at a test well; North Menan Butte near Arco, rising from the ancient magma that created the Snake River Plain.

"The model is a mathematical representation of a physical system," says Gary Johnson, an associate director for the Idaho Falls branch of the Idaho Water Resources Research Institute (IWRRI), a statewide research and service unit hosted by the University of Idaho. He is the leader of the IWRRI team that developed the current model under contract with the Idaho Department of Water Resources (IDWR).

"The ground-surface water exchange is what we are trying to model. If you pump or draw down the aquifer in other ways, what is the impact on the Snake River?" asks Johnson. The model is much more than an academic exercise. It has evolved into an important tool that Idaho's water managers at IDWR rely on as they try to balance conflicting rights claims on the Eastern Snake Plain, where ground and surface water are highly interconnected and managed together under conjunctive rules adopted in 1994. The model's scientific, objective analysis of the aquifer's behavior has become an important part of the public policy process. Scientists now hold a place at the discussion table alongside the water users' consultants, lawyers and lobbyists.

"The state is try-

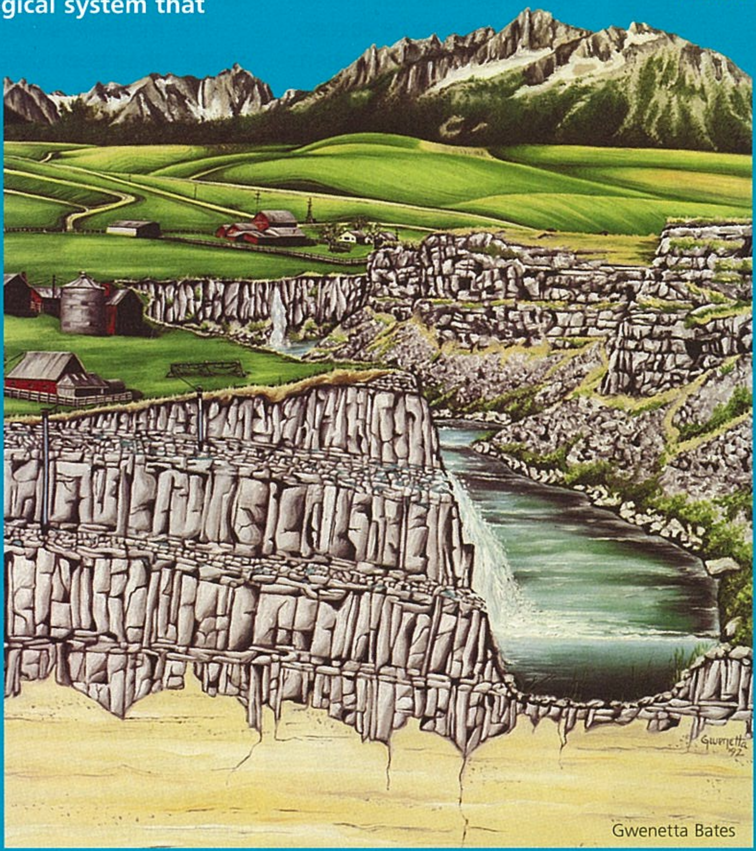


Thomsen/Idaho Environmental Quality

A vast underground sponge

The Eastern Snake River Plain aquifer is an intricate Massachusetts-sized hydrological system that covers 10,000 square miles stretching from Ashton to King Hill. One of its enduring mysteries is the quantity of water hidden within its nooks and crannies. Some say it holds a volume equal to Lake Erie, but no one knows for sure.

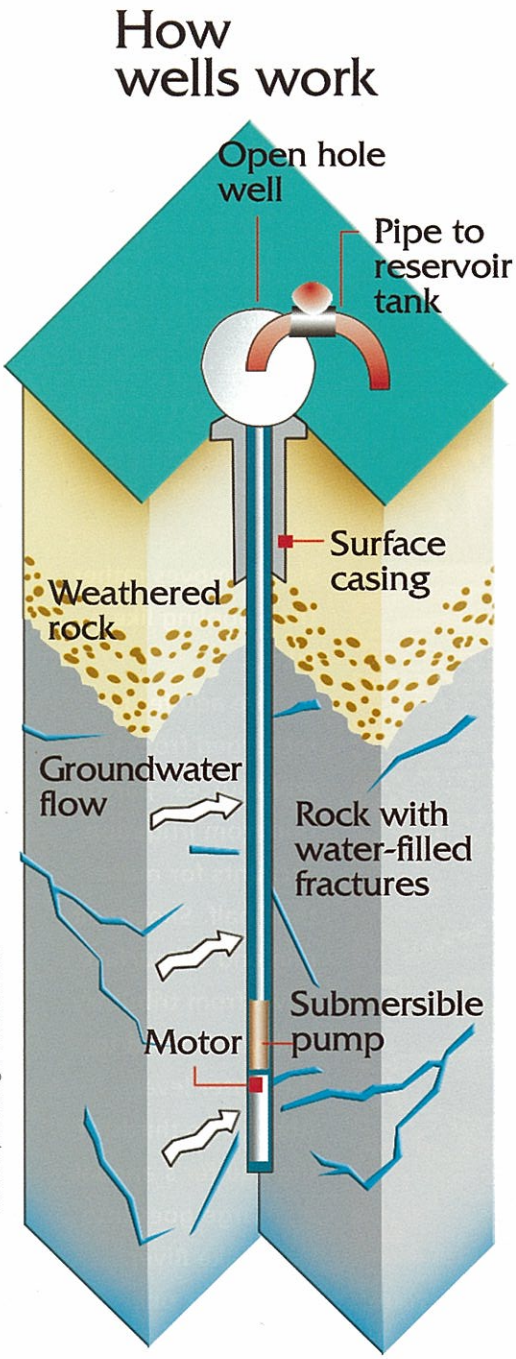
The aquifer is a product of Idaho's geologic past. Ancient volcanic eruptions left a succession of basalt lava flows that built upon each other. Between eruptions, now-buried sediments accumulated from rivers, lakes and windblown sand, building up thick layers that were topped by other basalt flows thousands of years later. These layers formed a vast underground sponge capable of holding an immense volume of water as it seeped into the earth's surface over the centuries.



Gwenetta Bates

There are some misconceptions about the aquifer. Its water doesn't flow like an underground river—there is no upstream or downstream —and it isn't an enormous lake. Rather, the subsurface is a maze of cracked rock, caverns and rubble, so water slowly moves rather than pooling like a lake.

The aquifer is recharged from several sources—percolation from irrigation accounts for more than half. Snowmelt, rain and subsurface flows from tributary valleys also add to the water level. About two-thirds of the aquifer's annual discharge goes into the Snake River. Groundwater pumping accounts for the other one-third.



Thomsen/*San Diego Union-Tribune*

ing to base water management on science. It can't all be science, but that has to be a piece. Models incorporate the best scientific information we have available. We consider ourselves to be objective. I think most people share that perspective," says Johnson.

The stakes are high, very high. The last 25 years have seen a succession of disputes between spring and surface water users with older or "senior" rights and groundwater users with newer or "junior" rights. At issue in many of the arguments, some of which have been settled by the courts, is the claim that groundwater pumping from within the aquifer is a major factor in reduced flows to numerous springs used by the Magic Valley's aquaculture industry or reduced Snake River flows that are used for electric power generation or irrigation. Spring and surface users with senior rights have asked IDWR to curtail junior groundwater users, a process known as making a "call."

Using the groundwater model, IDWR can issue those curtailment orders knowing it has a more objective, defensible source of information about the causes of the water shortages, the "injury" that users might suffer and the impact of proposed plans to mitigate them. "The model provides underlying technical support for our decisions," says Hal Anderson, administrator of IDWR's Technical Services Division. "We can minimize the arguments about the scientific tool we are using and spend more time on the difficult policy discussions."

The model has had its day in court, where it has been used as a non-biased, scientific source of information in disputes over water calls issued by IDWR. Twice the courts have relied on the science produced by the model. "The model has met the acid test in the courts. The experts agree there is no better tool; the court has determined that it is a viable, defensible way to manage ground and surface water," says Anderson.

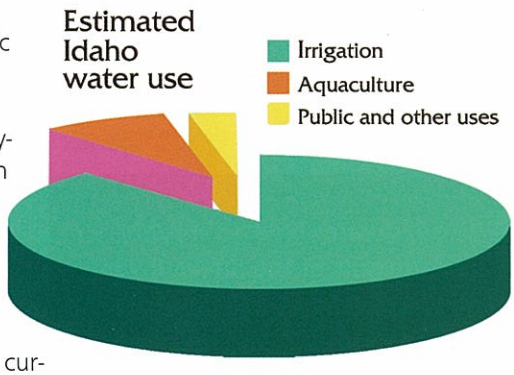
Wells as deep as 400 feet tap the aquifer's subsurface of saturated basalt. Opposite: a blackish band of water-bearing basalt, exposed in the Snake River.

Most parties agree that groundwater pumping is one of the reasons for the lower flows, and that some redress is in order. The question is how much of the impact to the senior users is actually injury and how to mitigate those losses without shutting off junior users' pumps, an action that affects the livelihood of individual farmers and collectively could put southern Idaho's thriving agriculture industry—including the state's famous potatoes—at risk. Solving these problems is a priority for the state, explains Anderson.

Recognizing that the entire state has a vital stake in restoring water to the aquifer, the governor and legislature tasked the Idaho Water Resource Board to come up with a plan, which was released in draft form this November. The board initiated a committee that brainstormed a selection of proposals to increase the amount of water in the aquifer and therefore the amount that eventually discharges into the Snake River. Called the Comprehensive Aquifer Management Plan (CAMP), the proposals cover a gamut of ideas—recharging the aquifer with more water; converting groundwater-irrigated fields to surface irrigation; or paying farmers to let their land go fallow or plant less water-consumptive crops.

The aquifer model was a valuable tool in the CAMP process as a variety of "what-if" scenarios were put on the table, says Anderson. What would be the impact if water were recharged into the aquifer? Or how would conversion from groundwater to surface water irrigation impact flows in the Snake River? Or what would be the benefits if fields were left fallow? "The model helped quantify various management options. We asked what might have happened if we had implemented the CAMP options from 1980 to 2005 based on what we know about the aquifer and river flows from those years. This provided us with a better understanding of how much we might realistically expect," says Anderson.

The Eastern Snake Plain Aquifer Model is the only one devoted to water management on the eastern plain, but there are others in use, including one used by the Idaho Nuclear Laboratory to monitor contaminant plumes and another that guides scientific investigations by the U.S. Geological Survey.



Aquifer models with varying degrees of sophistication have been around for decades. The earliest were actual water systems replicated in sand tanks. Later, room-sized circuit boards charted water using electric current that was manually adjusted according to the conditions at the time. It wasn't until 1977 that Idaho's first mathematical model was produced by a team lead by University


Idaho Water Resources

of Idaho civil engineering research professor Charles Brockway, then based in Kimberly. Jos de Sonniville, a graduate student from the Netherlands under Brockway's tutelage, wrote the first code that made the model possible.

"Jos started from scratch ... the USGS hadn't developed its code yet," says Brockway. Written and run on computers that seem archaic by today's standards, it took twenty-four hours to retrieve data that current computers can produce in minutes. The early model, also commissioned by IDWR, was designed to provide data for a revision of the Idaho State Water Plan. Updated with new information several times, it was used into the 2000s, but, as Brockway says, "it wasn't friendly; it was difficult to move numbers in and out." IWRRI reformatted and recalibrated the model in response to IDWR's need for an updated version that was, as Brockway puts it, "more defensible."

The current iteration of the model, put into service in 2004, plots the entire Eastern Plain aquifer onto a grid divided into square mile increments—more than 11,400 interconnected cells in all. Each cell includes data such as the number of irrigated acres, the presence of rivers or canals and simulated

Groundwater bursts through basalt walls of the Snake River canyon in the 40-mile stretch called Thousand Springs. Pure, cold and oxygenated, the water is ideal for trout.

Charles Knowles

Probing the Earth

Researchers at Boise State University are developing new methods to understand what lies beneath the crust of the earth's surface. Eight faculty members in the Center for Geophysical Investigation of the Shallow Subsurface (CGISS) use a technological toolbox—radar, seismic or sound waves, and electromagnetic current—to study the upper crust's geologic characteristics. With these techniques, scientists can locate water or oil deposits, trace contaminants or evaluate possible hazards. "Similar methods have been used by the oil industry ... we are applying the same concepts to solve other problems," says CGISS director John Bradford.

Chemistry professor Dale Russell has patented technology that embeds tiny sensors into a semiconductor chip that can be immersed in groundwater to test for harmful chemicals or minerals. The sensors "trap" molecules, which are then electronically probed to reveal their composition. The sensors can be placed at the source of underground contamination and also at remote sites to detect any migration.

A research team led by Molly Gribb, a civil engineering professor and director of the Center for Environmental Sensing, has developed a new tool, the Ion Mobility Spectrometer (IMS), that can analyze gases under the earth's surface. Lowered into a borehole and placed in the soil, the stainless steel, pencil-shaped sensor can detect gases emitted by a variety of contaminants. The vapors are collected and then analyzed in real-time by the sensor.

John Kelly

aquifer water levels. Because water follows certain natural laws as it moves through the aquifer, the model is based on mathematical equations that are solved through the use of computer code developed by the USGS. Those equations come into play tens of thousands of times and are solved simultaneously when applied to the whole grid.

Basically, the equations include the volumes of water that go in and out of each cell as well as the physical properties of the aquifer, such as porosity and permeability. Since modelers don't know precisely the physical properties on a cell-by-cell basis, they adjust, or calibrate, the physical properties to obtain the best match they can between model output and field observations. In order to determine the inflow and outflow of water in the cells, modelers collect voluminous amounts of data from the Department of Agriculture, local water masters' records, weather information from Oregon State University and USGS water-level measurements from approximately 1,000 wells.

Modelers then crunch this potpourri of variables through the equations to produce data about the possible behavior of water and water levels in the aquifer. The current model uses water data over a 22-year period beginning in 1980 and ending in 2002. The intent is to coax the model into replicating the Snake River's water gains and losses for each of those years and then compare those numbers against the actual observed data. If they match—or come close—the model is then reliable enough for water managers to use to analyze today's questions. By using historic data, modelers can determine how proposed management actions, such as the curtailment of some groundwater pumping, would have impacted the aquifer in the past. The theory is that if the model can successfully replicate historic observations, then it will accurately predict the aquifer's response to proposed or observed changes.

John Kelly

Chemist Dale Russell inspects microscopic sensors. Opposite: Engineer Molly Gribb and Boise State University masters student Ivan Geroy hold a transparent model of a probe used to detect gaseous contaminants below ground.

The model does have its limitations. It is good at making regional assumptions—the impact of thousands of wells, for example—rather than providing localized assumptions—the impact of one well on neighboring wells. It can be used to predict impacts on a "reach" of the Snake River, but not flows to specific springs. And there is always an unquenchable thirst for new data to enhance its precision. "The biggest challenge is to keep it updated. It impacts people's ability to make a living, so it should incorporate the best technical information on the aquifer and how it operates," explains Allan Wylie, an IDWR hydrologist who works on the model and explains its intricacies before the court.

"We can never have enough data, some that we need hasn't been measured yet. So the model will never be perfect, but we want it to be as good as it can be," adds IWRRI's Johnson. At the current time the model is being brought up to date with new technologies and more data, which includes new measurements of water levels that will be taken at approximately the same time to give scientists a snapshot of aquifer levels at 1,000 sites.

IDWR made sure all sides had their say in the development of the present model as well as the update now in progress. A group of water professionals representing various users and agencies meets quarterly to oversee the model's design, construction and calibration. Johnson says the process is designed to gain consensus on a potentially contentious model. "Model development is very transparent ... everything we do is scrutinized," he says.

Peer review improves stakeholders' trust and understanding. The anticipated outcome is an improved model that is as accurate as possible and free of technical bias.

The process has worked well, according to members on the committee. "The users

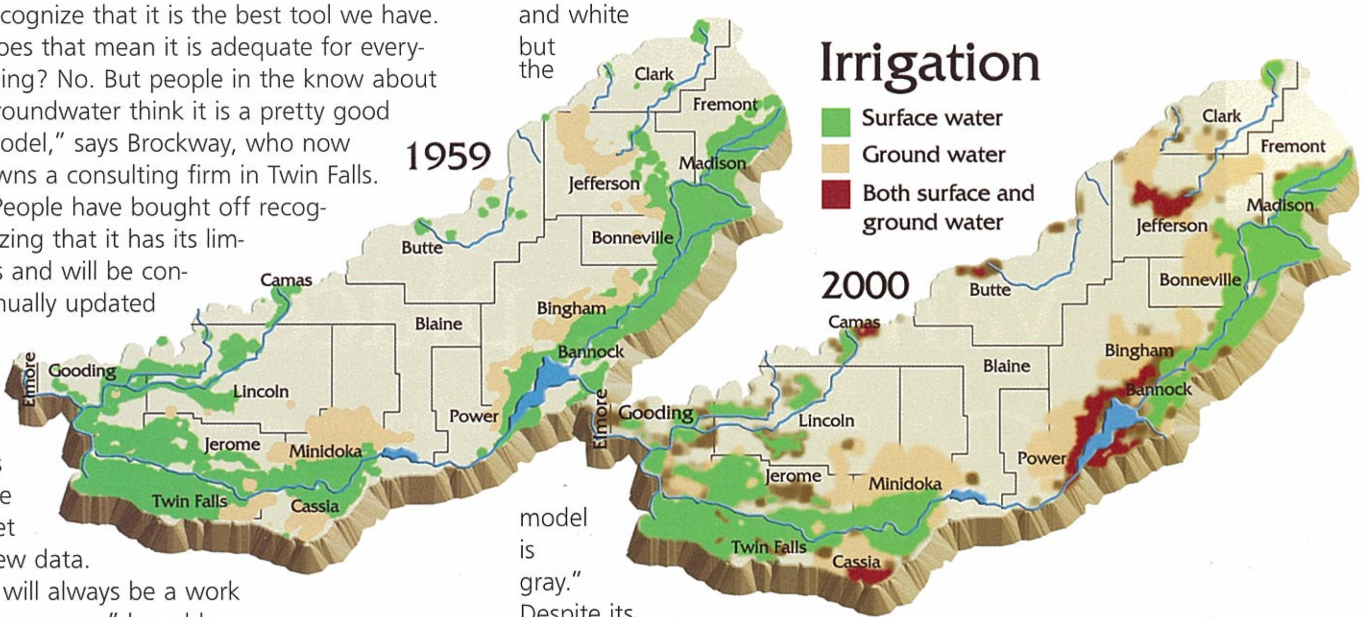
Daren Oswald/*Idaho Statesman*

recognize that it is the best tool we have. Does that mean it is adequate for everything? No. But people in the know about groundwater think it is a pretty good model," says Brockway, who now owns a consulting firm in Twin Falls. "People have bought off recognizing that it has its limits and will be continually updated as we get new data. It will always be a work in progress," he adds.

Charles Bendecke is a former civil engineering professor who is now a consultant for groundwater users in several states, including Idaho. "The model provides a framework for solving problems. ...It doesn't itself solve problems. It tells you about the hydrology and the physics of the aquifer; it doesn't tell you what is feasible for people to do," he says.

"It is a simplification of reality, so there are some uncertainties associated with its predictions. People see water rights as black and white but the model is gray."

Despite its shortcomings, Bendecke says Idaho water management is better off with it than without it. "The model has reduced the level of conflict. What are the alternatives to using it? Either you have none and there is even more arm-waving and arguing or everyone has their own model and we argue about the arithmetic they use," he says.



Thomsen/Idaho Water Resources

Pumping redistributes 14 percent or 1.1 million acre-feet of the aquifer's discharge. Nearly all is for agriculture. Opposite: Clayton Fetzer, foreground, moves water lines in a field of alfalfa near Paul in Minidoka County.

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