State of Idaho Oversight Monitor

The Eastern Snake River Plain Aquifer

March 2006

our changing AQUIFER

On the volcanically unique Eastern Snake River Plain, just like elsewhere, water flows from high country to low, channeled into streams, lakes, and rivers. But in the portion of the plain occupied by the Idaho National Laboratory (INL), rivers don't all flow to the ocean. Instead, something dramatically different happens. Streams like the Big and Little Lost Rivers simply disappear.

Here, where sediments deposited by the actions of wind and water overlay porous layers of basalt, rivers and streams disappear, losing their water to the Eastern Snake River Plain Aquifer. Decades later, the same water will reappear in the Magic Valley, issuing from the "Thousand Springs" stretch of the Snake River along the north canyon wall between Milner and King Hill.

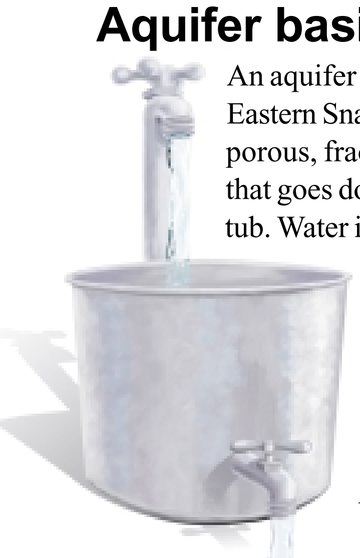
The Lost River and the fascinating springs of the Magic Valley are but two features of the remarkable Eastern Snake River Plain Aquifer, which is not only the focus of this issue of the Oversight *Monitor*, but the primary reason that the INL Oversight Program exists.

Concern about how activities conducted at Idaho's nuclear laboratory affect the aquifer was the driving force behind the formation of a state oversight program. No matter what issue we're considering, we're thinking about the aquifer—when we're talking about building a nuclear reactor at the site, removing waste buried in pits and trenches, closing buildings that aren't needed any more—whatever it is, to Oversight, it is about Idaho's precious resource, the Eastern Snake River Plain Aquifer.

As we struggle to find the appropriate balance between competing demands for our state's finite water resources, it makes sense to begin with the source of much of Idaho's water: the Eastern Snake River Plain Aquifer.

***Lost river found**: Above and below, some of the "thousand" springs in Idaho's Magic Valley. Most are along the north bank of the Snake River between Milner and King Hill. Spring water is used in fish hatcheries, for power production, drinking water, and habitat. © Steve Blyl IdahoStockImages.com*

Aquifer basics: the bathtub concept



An aquifer can be thought of as a bathtub—a bathtub that, in the case of the Eastern Snake River Plain Aquifer, consists of thousands of cubic miles of porous, fractured basalt. Water from the faucet **recharges** the tub, water that goes down the drain (or is splashed on the floor) is **discharged** from the tub. Water in the tub is stored until the drain is opened or water is splashed out. When more water is recharged to the tub than drains, the water level in the tub increases and more water is in **storage**.

The Water Balance for an aquifer is:

Recharge – Discharge = Change in storage

We'll first talk about changes in storage because it helps us understand where the recharge to the aquifer stays before it can become discharge.

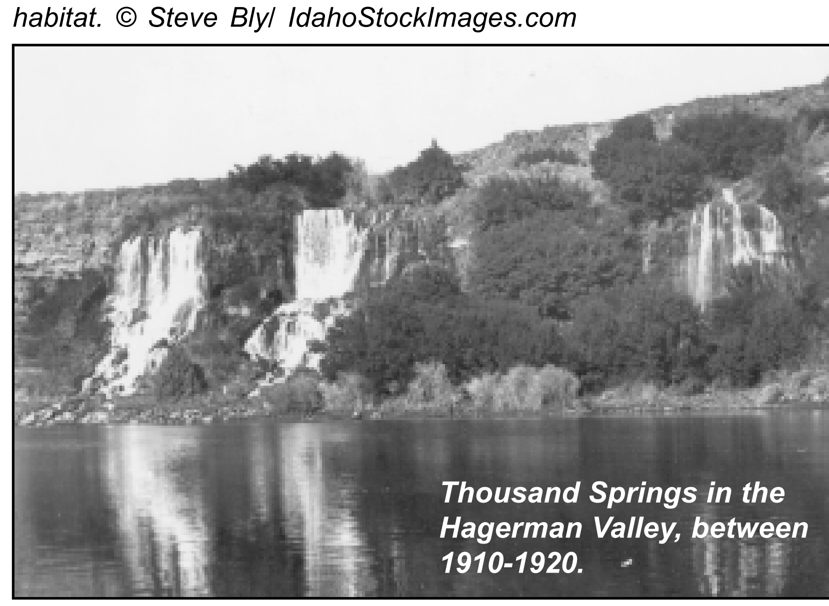
Aquifer Storage

The broken basalt and sediments of the Eastern Snake River Plain Aquifer contain a tremendous amount of water, as much as 1 billion acre-feet. This is enough water to cover the entire 10,800 square miles of the plain with nearly 145 feet of water, about the same amount of water as in Lake Erie.

Though the aquifer can be compared to the volume of Lake Erie, the aquifer is not at all like an underground lake. Water is stored between the grains of sediments and in the open fractures between pieces of basalt of the Eastern Snake River Plain. The water-holding rocks of the aquifer are as much as 4000 - 5000 feet thick. However, not all of that water can be easily used. Only 100 to 220 million acre-feet stored in the top few hundred feet of the aquifer can be easily pumped and used.

Flood irrigation practices (the only way to get water to crops before sprinklers and electric pumps) add much more water to the crop than growing plants can use. The extra water soaks into the ground to add to storage in the aquifer, increasing the aquifer level beneath irrigated areas. An estimated 24 million acre-feet of water was added to the aquifer from 1880s to 1950s, with some places seeing water levels rise more than 100 feet.

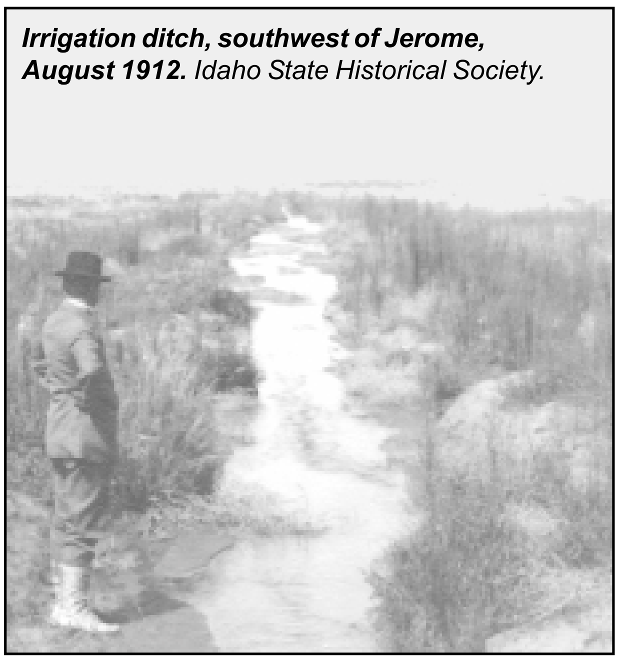
But the longer we irrigated, the better we got at moving water to the places we wanted it. Irrigation methods changed from "flood" irrigation to more efficient sprinkler irrigation, and using only surface water to an increasing portion of pumped ground water. Increased pumping took more water out of the aquifer, and flood irrigation no longer provided as much recharge water. About 6 million acre-feet of water came out of



Thousand Springs in the Hagerman Valley, between 1910-1920.

Idaho State Historical Society, Bisbee collection.

Hagerman Valley, between 1910-1920.

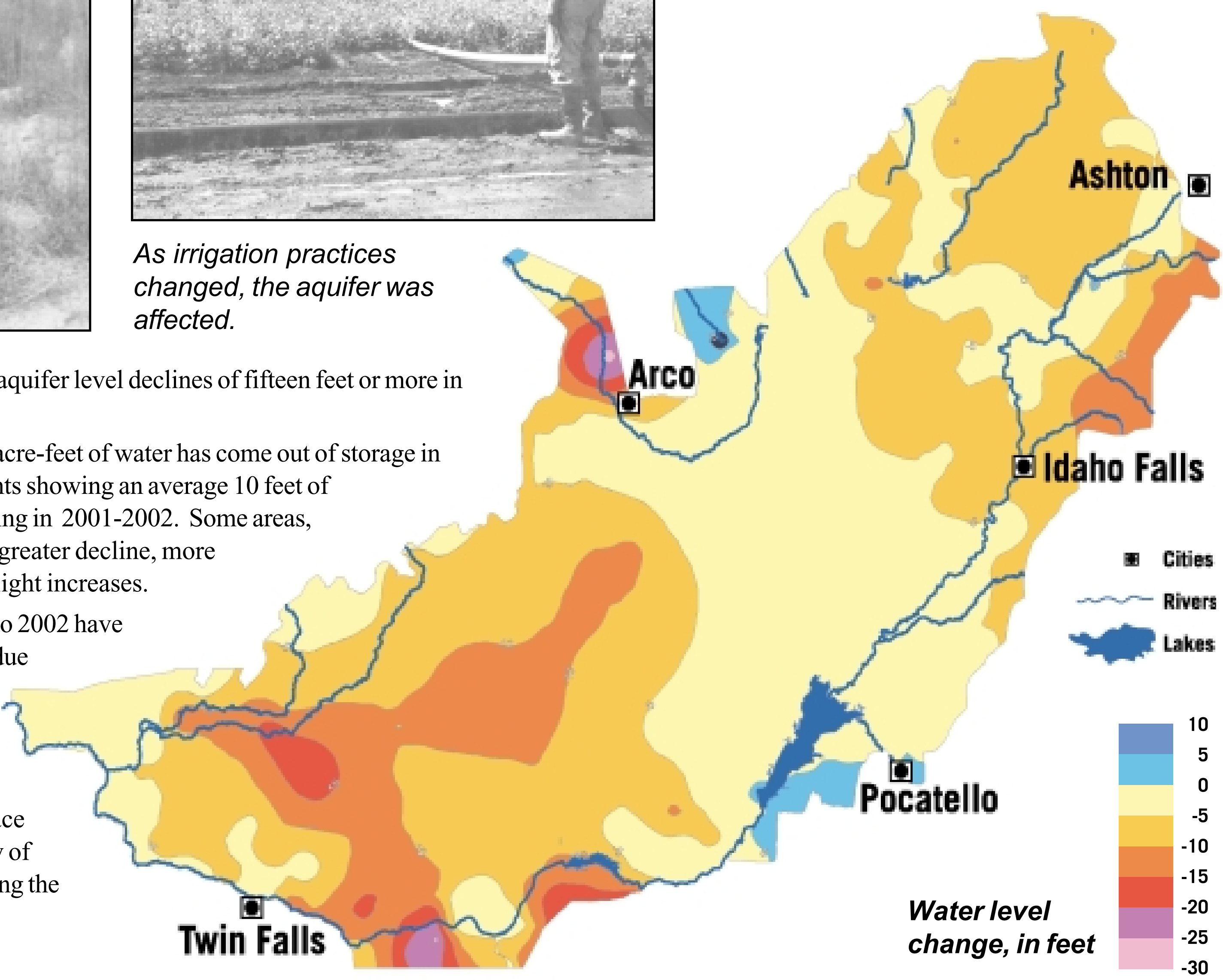


Irrigation ditch, southwest of Jerome, August 1912. *Idaho State Historical Society.*

Bean crop under irrigation from well, September 1950. *Idaho State Historical Society.*

As irrigation practices changed, the aquifer was affected.

Changes in aquifer level: 1980-2002

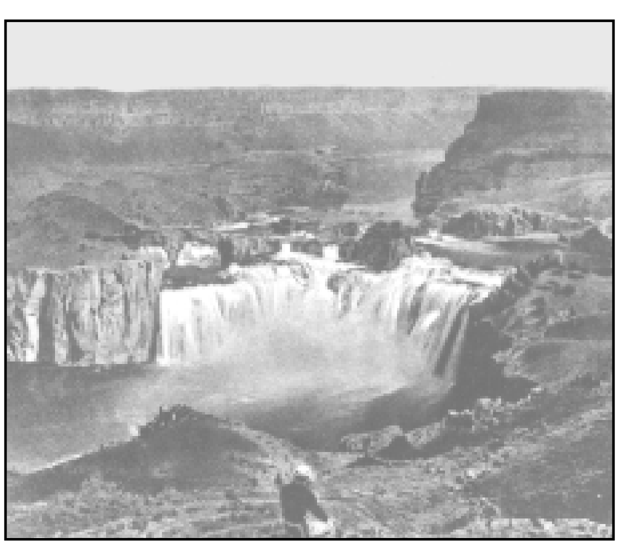


storage from the 1950s to 1980, leading to aquifer level declines of fifteen feet or more in some areas.

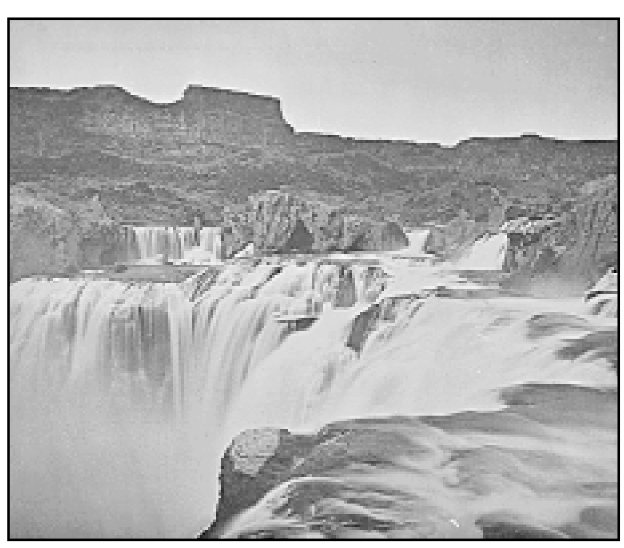
From 1980 to 2002, another 6 million acre-feet of water has come out of storage in the aquifer, with aquifer-wide measurements showing an average 10 feet of decline since 1980, with half of that occurring in 2001-2002. Some areas, such as near Arco, have experienced even greater decline, more than 60 feet, while other areas have seen slight increases.

Water level measurements from 2001 to 2002 have shown decreases in aquifer levels, largely due to the current drought. Less snow in the mountains means less water in the river to irrigate with, less water to recharge the aquifer, and greater reliance on ground water. In many years the demand for surface water consumes most, if not all, of the flow of the Snake River above Shoshone Falls during the irrigation season. The result, first seen in 1905, is a dry "Twin Falls."

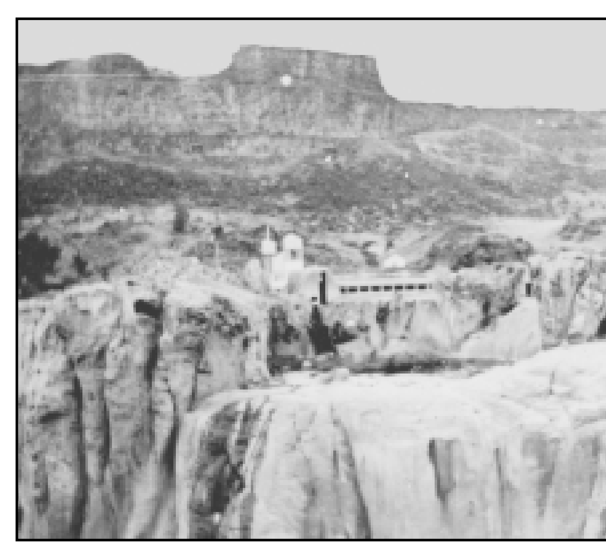
***Shoshone Falls**: Nicknamed "the Niagra of the West," Shoshone Falls drops 50 feet farther than Niagra-- 212 feet. It is 1200 feet wide. You'll note in the historical and present day photos of Shoshone Falls on this page and the next that the flow of water over the falls varies. Like the water in the aquifer, it is affected by the amount of water used for irrigation.*



Drawing from REPORT OF THE GEOLOGICAL EXPLORATION OF THE 40TH PARALLEL, 1870-1880. Idaho State Historical Society.



1871. Settlers are arriving in Idaho, but few acres are irrigated. Surface water irrigation began to increase in the 1880s.



Irrigation diversions temporarily dried up the Falls for the first time in 1905. This photo was taken in 1941. Idaho State Historical Society

Aquifer Recharge

The water that fills the aquifer comes from a number of sources. The amount of water recharging the aquifer varies from year to year; however, the proportion of recharge from each source stays about the same. An estimated 8.06 million acre-feet of water recharged the Eastern Snake River Plain Aquifer in water year 1980. Because a great deal of measuring and sampling took place that year, it provides a good benchmark for comparison.

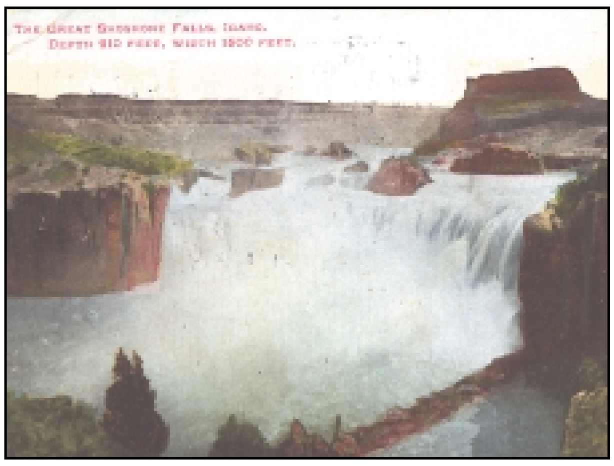
The largest source of water recharging the aquifer is irrigation. This leftover water seeps into the ground, and works its way to the aquifer. For the 1980 water year, this was 4.84 million acre-feet, or 60% of all recharge.

The next largest source of recharge to the aquifer is tributary basin underflow. That's ground water that flows to the aquifer from the tributary valleys along the margins of the plain. This includes recharge from the Henry's Fork and South Fork of the Snake River, and the valleys of Birch Creek, Big and Little Lost Rivers, Big and Little Wood Rivers, Portneuf and Raft River valleys, and other smaller valleys. This source added 1.44 million acre-feet, or 18% of recharge.

While the climate of the Eastern Snake River Plain Aquifer is semiarid, with less than 10 inches of precipitation each year, the timing of the rain and snow (snow cover melting and rain occurring in times of the year when there is less evaporation), and the scant soil cover over much of the basalts of the plain allows a significant amount of precipitation to recharge the aquifer in some areas. Direct precipitation on the plain accounts for 0.70 million acre-feet, or 9% of recharge.

Water infiltrating from the bed of the Snake River is also a significant source of recharge. Along some lengths ("reaches") of the Snake River, the riverbed is above the aquifer level; and therefore, water from the river seeps through the river bed to recharge the aquifer. These are called "losing reaches." Since aquifer levels can change during the year, some reaches of the river can "lose" during times of the year that the aquifer level is lower, and "gain" when the aquifer level is above the bed of the river.

In 1980, 0.69 million acre-feet, or 9% of recharge was from Snake River losses. Just like the Snake River, other rivers and streams, as well as canals, that flow out on to the Eastern Snake River Plain can recharge the aquifer. This recharge from tributary stream and canal losses added 0.39 million acre-feet, about 5% of the recharge for the 1980 water year.



This postcard published in 1909 and these two pictures taken in 2005 show how the level of water going over Shoshone Falls rises and falls.

Aquifer discharge

Just like the bathtub metaphor, what goes into an aquifer as recharge is reflected in changes in aquifer levels and in water discharged. Water can be discharged as springs in the walls of the Snake River Canyon, or seep into the bed of the Snake River in “gaining reaches,” or be pumped out of the aquifer for use on the land.

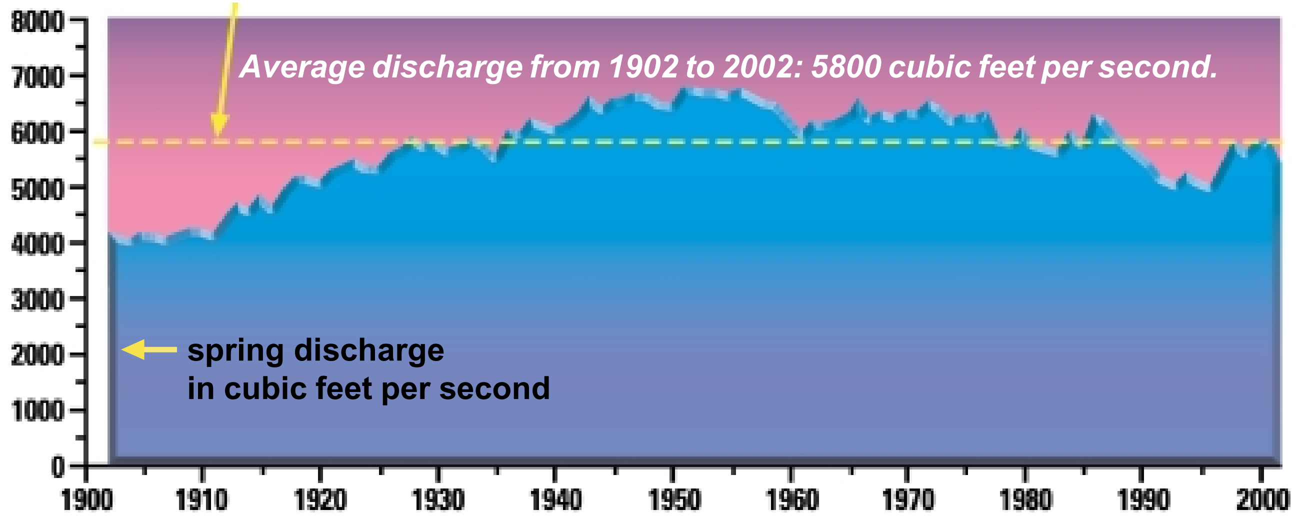
In 1980, 8.22 million acre-feet were estimated to have been discharged from the aquifer. Most of this discharge, 7.1 million acre-feet or 86%, occurred as seepage and spring flow to the Snake River. Major springs occur along three stretches of the Snake River, near St. Anthony, from Blackfoot to American Falls, and Milner to King Hill.

Most of the spring flow and seepage occurs from Milner to King Hill, often called the Thousand Springs reach. Here, 4.83 million acre-feet or 68% of the spring flow and seepage occurs. Seepage and springs from Blackfoot to American Falls account for 1.99 million acre-feet, or 28% of discharge. The remaining 0.28 million acre-feet, or 4% occurs near St. Anthony.

Ground water pumped from the aquifer accounts for 1.14 million acre-feet, or 14% of discharge. Nearly all of this ground water is pumped for irrigation (95%), about 3% is pumped for drinking water for cities and rural homes. The remaining 2% is pumped for industrial and livestock use.

Thousand Springs photo from an old postcard negative, date unknown. Idaho State Historical Society.

Changes in spring discharge: 1900-2000



The pulse of the aquifer

Spring discharge is like the pulse of the aquifer; changes in aquifer levels result in changes in spring flow. Measurements in some of the springs between Milner and King Hill began as early as 1902.

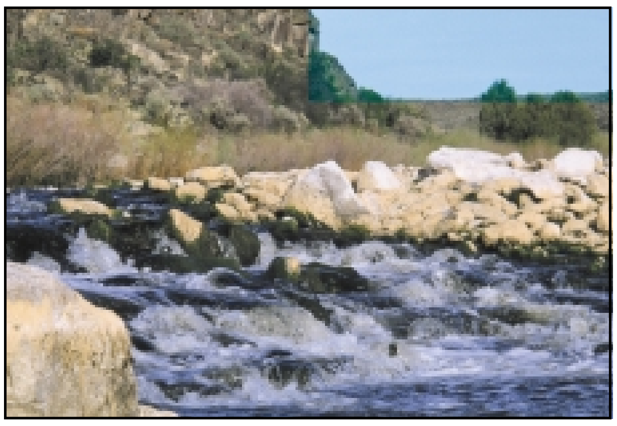
As irrigation began in the Eastern Snake River Plain, spring flows from springs along the north side of the canyon increased. Estimates of spring flow (based on analyzing the water budget for years prior to 1951) were 4,200 cubic feet per second or about 3 million acre feet per year in 1902, and continued to grow until the early 1950s. At the peak flow in 1951, the discharge was estimated at 6820 cubic feet per second, and 4.94 million acre-feet.

Between 1902 and the 1950s, irrigation with surface water spread across the Eastern Snake River Plain. The increased recharge and aquifer levels resulted in a substantial increase in discharge from these springs. From the 1950s through 1980, the measured discharge from these ten springs decreased to about 6000 cubic feet per second, or 4.42 million acre-feet per year.

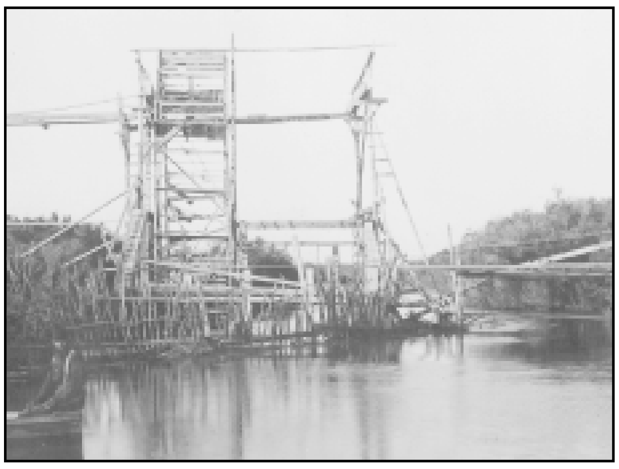
Flow measurements made through 2002 show a continued decline to about 5400 cubic feet per second and 3.9 million acre-feet per year. The average spring flow from 1902 through 2002 is about 5800 cubic feet per second, or 4.2 million acre-feet of discharge.

The increase in spring discharge from 1902 through 1951 appears to be relatively constant, however, the decline from 1951 through 2002 is not. The fluctuations correspond to drought years that had less water available for surface water irrigation and wet years of higher flows in the Snake River, while the overall trend of decreasing flow from the springs is due to more acres being watered from sprinklers and less by traditional flood irrigation.

Water users who designed their spring-dependent fish farms when flows were at their highest are now being affected by the decline in spring flows. However, the decline in spring flows, outside of weather patterns that can’t be changed, is due to the irrigators on the Eastern Snake River Plain becoming more efficient with their water in some portions of the aquifer, and in other areas by irrigators pumping ground water for their crops.

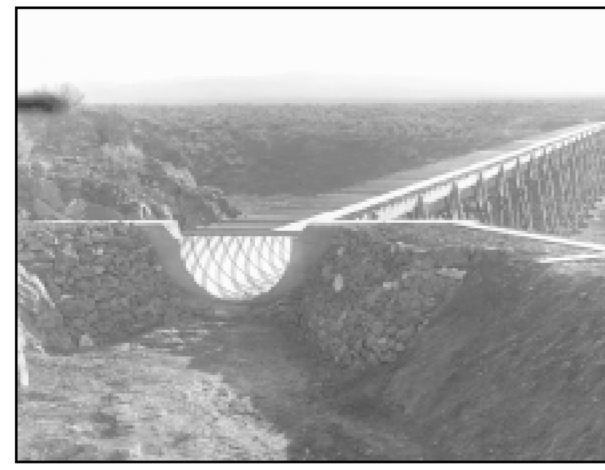


An **acre-foot** is the amount of water which would cover one acre of land with water one foot deep. An acre is a little less than a football field from goal line to goal line. To be precise, from one goal line to within a football-length from the nine yard line at the other end of the field. This is 326,000 gallons. Discharge of one **cubic foot per second** is the same as 449 gallons per minute. One cubic foot per second would fill a foot- ball field one foot deep in 12 hours and 8 minutes. One cubic foot per second flowing from a spring for a year is 724 acre-feet.



Moving water: *irrigation wheel on Snake River about 8 miles below Montgomery Ferry. July 1908. Idaho State Historical Society.*

Moving water for irrigation in the Magic Valley, between 1910-1920. Idaho State Historical Society, Bisbee collection.



Improved: *over time, we got better at getting water where we wanted it. Idaho State Historical Society, Bisbee collection, around 1910-1920.*

Irrigation *on the Eastern Snake River Plain Aquifer*

In the century and a half since Idaho water was first used to water crops, irrigation has changed the landscape of the Eastern Snake River Plain. Water in its many forms shapes Idaho's economy, culture, politics, and society. In recent years it has come to dominate the state's legal landscape as well.

It's not surprising that much of Idaho's concern relating to the INL centers around the Eastern Snake River Plain Aquifer. If activities at the lab were to result in irreparable harm to the aquifer, it could be a devastating blow to Idaho's economy and way of life.

The history of the aquifer is inexorably tied to the history of irrigation. A prime example is the difference between the Magic Valley being a semi-arid desert with farms along the river, and the extraordinarily productive agricultural area it is today. Because irrigation is the primary agent of change to the Eastern Snake River Plain Aquifer, the history of irrigation on the Eastern Snake River Plain provides vital insight into the factors that shape Idaho's concern over operations at the Idaho National Laboratory.

Agricultural "Growth"

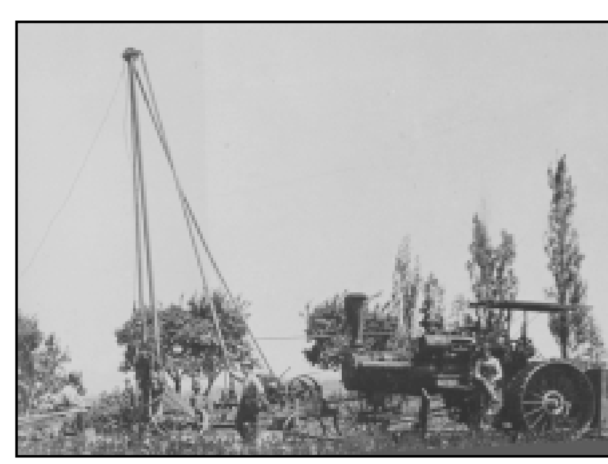
In 1890, the newly-admitted state of Idaho feared that all the land that could be developed for agriculture was already under the plow. Many miles of canals were already being used to take the natural flow of Idaho's waterways to fields. But serious and expensive efforts were needed to store and transfer the huge volumes of water that flowed down the Snake and other rivers throughout the year to the many acres of rich volcanic soils that were beyond the reach of canals or could be supplied with just the low river flows during southern Idaho's dry summers. It was feared that without these great efforts, Idaho's growth would run out of momentum. It could not have been imagined that just ten years later, total irrigated acres across the State topped 550,000, more than double that at the time of Idaho's statehood.

Development of the arid Snake River Plain was encouraged by the Carey Act (1894) and other federal legislation that provided government land at bargain prices to those that could bring that land under irrigation and into production. Private investment provided the capital to buy the lands and build canals. Among the first projects were canals near American Falls, and Milner Dam and associated canals near Burley and Rupert. Familiar landmarks such as Milner Dam, Perrine Bridge, Buhl, and Kimberly remind us of those that helped to finance these early projects. Still, the limiting factor for further development was how to store the melting snows and high spring flows for irrigation in the hot, dry Idaho summers.

Even with the help of wealthy investors, it became clear that the astronomical cost of building dams required more assistance from the federal government. The 1902 Newlands Reclamation Act allowed the Federal Government to finance the work of constructing dams and irrigation works beyond the ability of private investment. From this grew the Minidoka Project that eventually resulted in the Minidoka, American Falls, Palisades, Jackson Lake, and other major dams of the Upper Snake River Valley, as well as dams on other southeast Idaho streams. In addition to storing water for irrigation, these dams helped to tame the floods that often came with spring's melting snow.

Irrigation on the Eastern Snake River Plain was underway by 1880, on lands immediately adjacent to the Snake River and other eastern Idaho streams. By 1899-1900, about 330,000 acres were under irrigation. From 1903 through 1938 Mindoka, Jackson Lake, Milner, American Falls, Henrys Lake, Island Park, and Grassy Lake Dams were constructed. Acres irrigated increased to about 1.54 million in 1929, and 1.7 million acres by 1945.

From 1945 to 1959, acres irrigated increased to 1.83 million acres. Although ground water had been used for irrigation since the 1920s in some areas on the Eastern Snake River Plain, the development of powerful and efficient electric pumps allowed significant ground water usage, with 400,000 acres irrigated from this "new" source. Surface water irrigation accounted for 1.43 million acres. By 1966, acres irrigated by ground water grew to 640,000, and by surface water, to 1.56 million acres, for a total of 2.20 million acres. Irrigated acres totaled 2.27 million in 1979. The source for irrigation water for some lands switched from surface water to ground water, with surface water the source for irrigation of 1.23 million acres, and ground water the source for 930,000 acres. Both surface and ground water resources were used to irrigate 110,000 acres.



From surface water to ground water: *Core drilling for water at an Idaho farm in 1916. Idaho State Historical Society.*

Irrigation wells at Artesian City in Twin Falls County, around 1910-1920. Idaho State Historical Society, Bisbee collection.

Resource from "Waste"

Flooding fields with water is a relatively inefficient means of providing water to crops. The amount of water applied to the fields and furrows prior to more modern irrigation methods was sometimes as much as 7 times what the crop could use. All that extra water, as much as 12 feet of water applied during the course of an irrigation season,
recharged the aquifer. This "waste" became water stored for later use, just like water stored behind a dam.

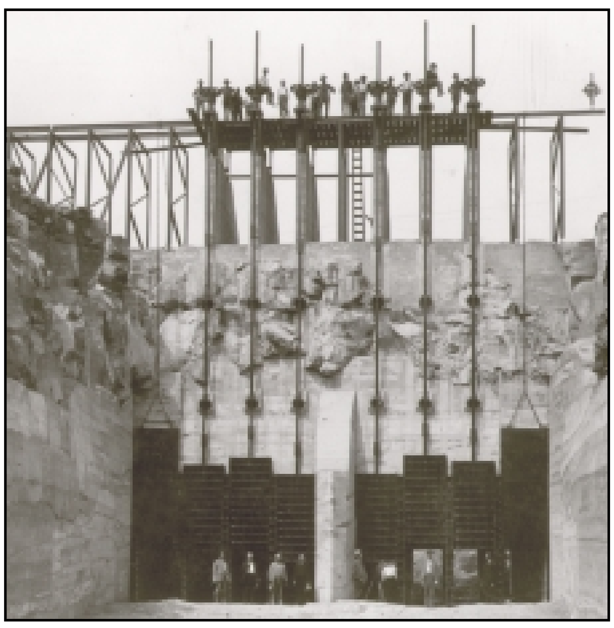
Water levels rose substantially in some areas, for example, ground water levels rose 60-70 feet from 1907 to 1959 in areas near Kimberly and Bliss, and as much as 200 feet in areas near Twin Falls. Across the whole of the aquifer, the average aquifer rise was about 50 feet. This rise in aquifer levels became most evident by the increases in discharge from the major springs along the Snake River. With the transition to irrigating with ground water and more efficient means of applying surface water to fields, less water was added to storage.

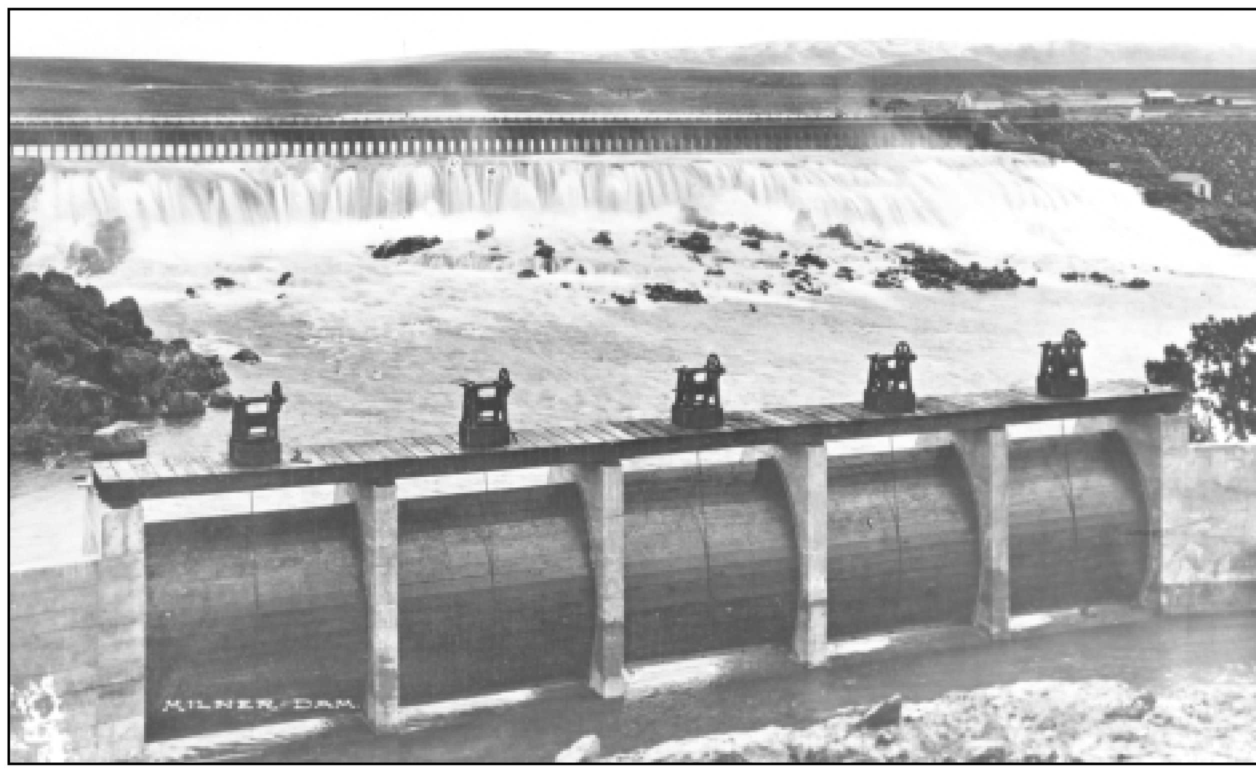
Breaking ground: *Early stages of construction at the Milner Dam, June 1903. Idaho State Historical Society,*

Diversion at Milner. Milner water first reached crops in 1905.

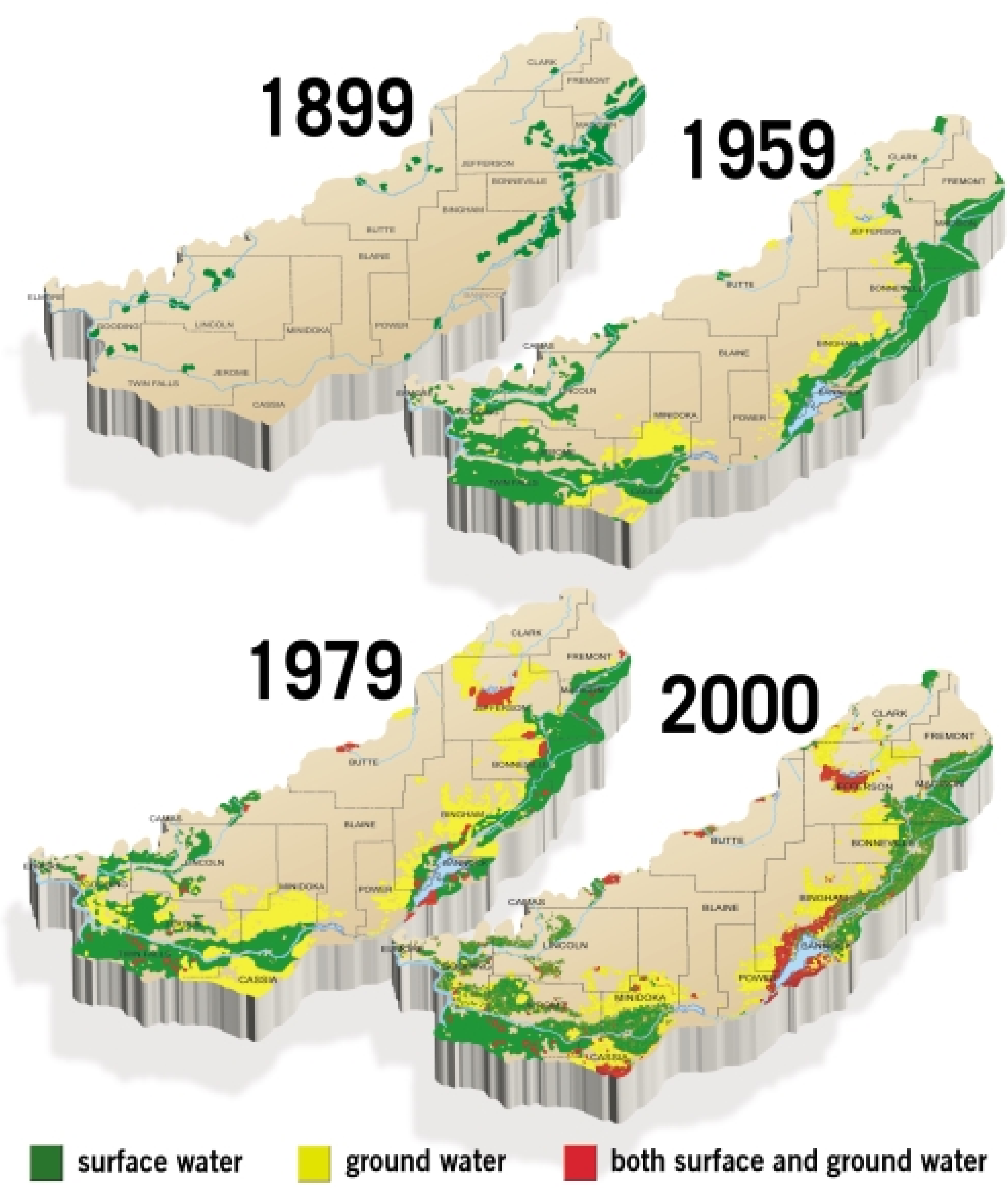
Building wood pipeline, *March, 1912. Part of the Milner project. Idaho State Historical Society.*

Below, late stages of construction on the Milner project. Idaho State Historical Society, Bisbee collection. Right, Milner Dam from old postcard negative. Idaho State Historical Society.





A century of irrigation on the Eastern Snake River Plain Aquifer



Prize-winning potatoes: *in 1910, this farm a mile east of Twin Falls produced 645 bushels per acre, winning $500.00. Idaho State Historical Society.*

Over time, the primary source of irrigation water changed from diverted surface water to pumped ground water.

The primary method of irrigation also changed, from flooding fields to sprinkling. This allowed more acres to be farmed, but also resulted in less water available for recharge.

Modern agricultural methods deliver precise amounts of water at carefully timed intervals.

our changing AQUIFER

It's said that biology is destiny. For humans, that may be true. But for Idaho, geology is destiny, and much of that destiny is defined by the presence of the Eastern Snake River Plain Aquifer.

Rich mineral deposits brought miners to the area. Abundant water and fertile soil attracted homesteaders and farmers. Dams—many built in canyons—provide the hydroelectric power that fuels our homes, businesses, and economy. Majestic mountains and stunning landscapes lure those whose souls are fed by beauty. Idaho's history, and its destiny, have been shaped by these resources.

Lured west with the false promise that "the rain follows the plow," homesteaders traveling the Oregon Trail crossed the Snake River Plain. Some decided to stop, gravitating to the areas where water was plentiful—next to the Snake River and its tributary streams.

In time, Idahoans developed the technology and the infrastructure to thrive whether the rain followed or not. With the addition of pumps, canals, and dams, they tapped the aquifer and farms spread out. No longer tethered to just those areas adjacent to surface water, land was cultivated throughout the Eastern Snake River Plain, molding the arid stretch into one of the most productive agricultural regions in the world.

Today, the pure, cold spring water that flows from Thousand Springs supports a thriving aquaculture (fish-farming) industry; sixty-nine percent of the trout farmed in the United States come from Idaho. Twenty-nine percent of the nation's potatoes are grown in Idaho, and the state ranks sixth in the number of cattle produced. The Eastern Snake River Plain, once little more than a dry passage to the west, now helps feed people all over the world.

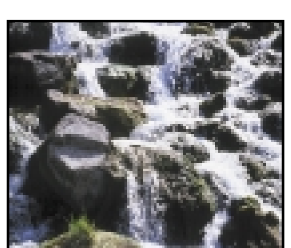
Balancing Water

Unfortunately, the rain still doesn't follow the plow. Nor does it follow the increasing demands for drinking water, habitat, agriculture, industry, production of electricity, fishing and boating, landscaping, or water left in rivers and lakes for its beauty. Demands on this vital resource continue to grow, but the amount of water available, much of it stored up in the aquifer, does not.

Some want more water for consumptive uses, such as industry, agriculture, or drinking. Others want water for production of electricity, for habitat, for recreation, or for other downstream uses.

The demands for water continue, defining Idaho's political landscape now just as surely as geology and hydrology have always defined the Gem State's destiny. An understanding of the way the aquifer gains and loses water can help us understand the conflicts inherent in the use of water and help define that balance.

Whether you are going to define the right balance for water users or understand the complexities of contamination, it is helpful to know how the aquifer works: the principles of storage, recharge, and discharge.



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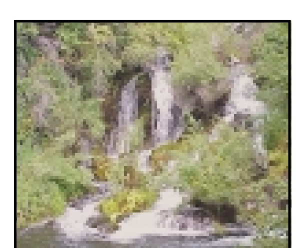

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