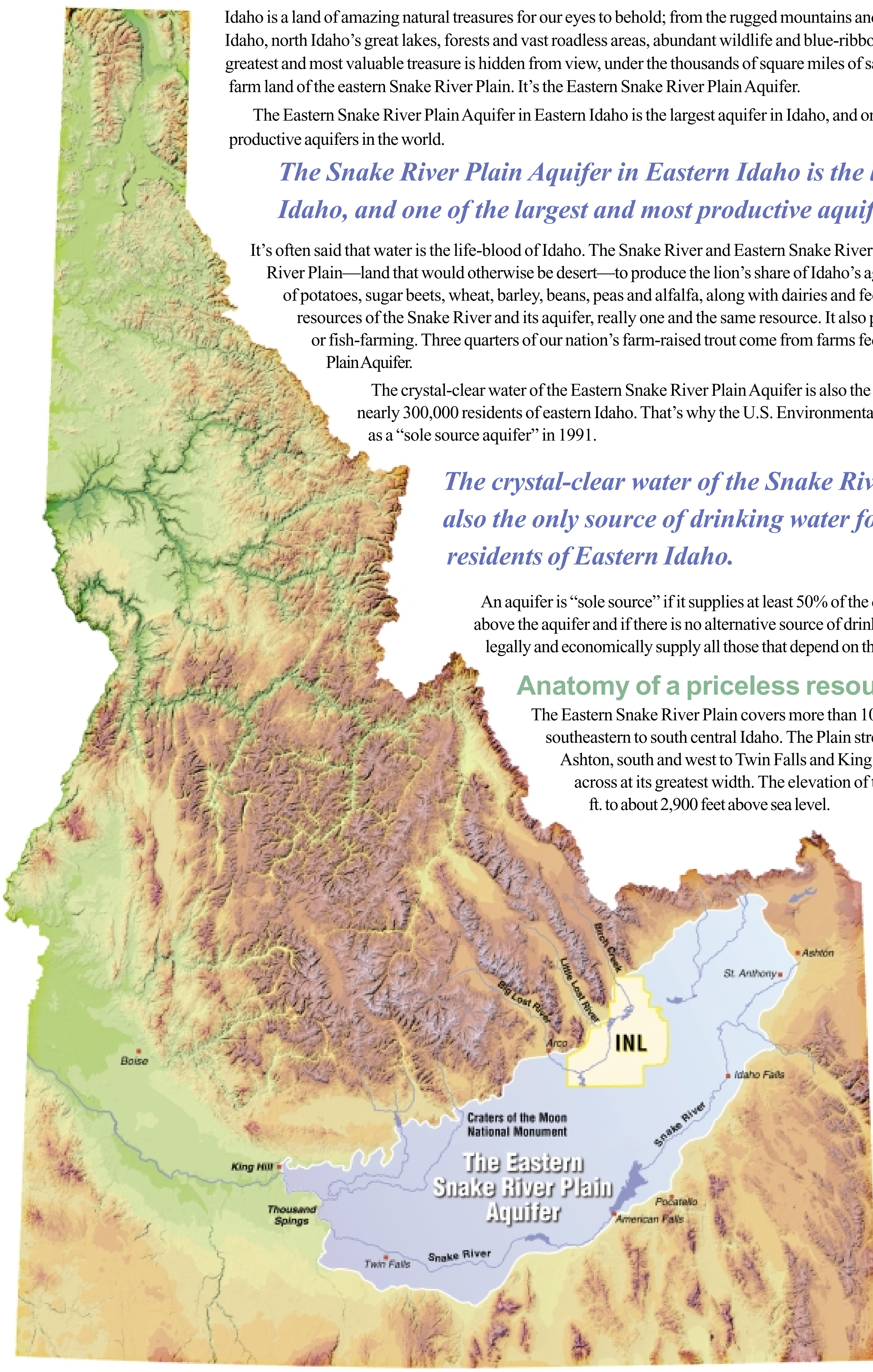
State of Idaho

Oversight Monitor

The Eastern Snake River Plain Aquifer
May 2005

Idaho's treasure; the Eastern Snake River Plain Aquifer



Idaho is a land of amazing natural treasures for our eyes to behold; from the rugged mountains and pristine canyons of central Idaho, north Idaho's great lakes, forests and vast roadless areas, abundant wildlife and blue-ribbon fishing. However, Idaho's greatest and most valuable treasure is hidden from view, under the thousands of square miles of sagebrush desert and irrigated farm land of the eastern Snake River Plain. It's the Eastern Snake River Plain Aquifer.

The Eastern Snake River Plain Aquifer in Eastern Idaho is the largest aquifer in Idaho, and one of the largest and most productive aquifers in the world.

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It's often said that water is the life-blood of Idaho. The Snake River and Eastern Snake River Plain Aquifer allow the Snake River Plain—land that would otherwise be desert—to produce the lion's share of Idaho's agricultural products. Vast fields of potatoes, sugar beets, wheat, barley, beans, peas and alfalfa, along with dairies and feedlots, rely on the combined resources of the Snake River and its aquifer, really one and the same resource. It also provides water for aquaculture, or fish-farming. Three quarters of our nation's farm-raised trout come from farms fed by the Eastern Snake River Plain Aquifer.

The crystal-clear water of the Eastern Snake River Plain Aquifer is also the only source of drinking water for nearly 300,000 residents of eastern Idaho. That's why the U.S. Environmental Protection Agency designated it as a "sole source aquifer" in 1991.

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An aquifer is "sole source" if it supplies at least 50% of the drinking water for people living above the aquifer and if there is no alternative source of drinking water that could physically, legally and economically supply all those that depend on that aquifer.

Anatomy of a priceless resource

The Eastern Snake River Plain covers more than 10,800 square miles of southeastern to south central Idaho. The Plain stretches more than 170 miles from Ashton, south and west to Twin Falls and King Hill, and is more than 60 miles across at its greatest width. The elevation of the Plain ranges from over 6,000 ft. to about 2,900 feet above sea level.

Snow and rain that falls on the 36,000 square-mile upper Snake River Basin, including parts of Wyoming, Utah and Nevada, supply the Snake River and Eastern Snake River Plain Aquifer.

Each year, about 8 million acre feet of water flow past King Hill, the western boundary of the Eastern Snake River Plain. This is enough water to cover all of the Eastern Snake River Plain with about 16 inches of water.

In contrast, the entire Eastern Snake River Plain Aquifer is thought to contain as much as a billion acre feet of water, enough to cover the Plain with about 140 feet of water, creating a lake more than twice as deep as Lake Erie.

ANATOMY of an AQUIFER

It's the Rocks!

Our aquifer is composed of basalt lavas intermixed with sediments from lakes and rivers, and wind-blown dust. Most of the aquifer (about 90%) is basalt, and it's the broken basalt of the Eastern Snake River Plain that makes our aquifer so productive. The depth to which these broken basalts extend determines the thickness of our aquifer. From St. Anthony and Ashton at the northeastern edge of the aquifer to the Snake River at Thousand Springs and Hagerman, water-saturated basalt is as much as four thousand feet deep. Water flows more easily in the upper few hundred feet of the aquifer. The depth to the aquifer is as much as a thousand feet in the center of the Eastern Snake River Plain.

The large, broken blocks and columnar joints seen in places like this box canyon on the usually dry bed of the Big Lost River near Arco are features that help us see how water can travel so easily through the basalt of the Eastern Snake River Plain Aquifer.

Contrast in permeability is most obvious in the Snake River Canyon. The older basalt (brown in this picture) marks the base of the aquifer (the grey basalt in this picture). The elevation of the springs along the canyon wall is controlled by this older, less permeable basalt.

The Secret Life of Snake River Plain Volcanoes

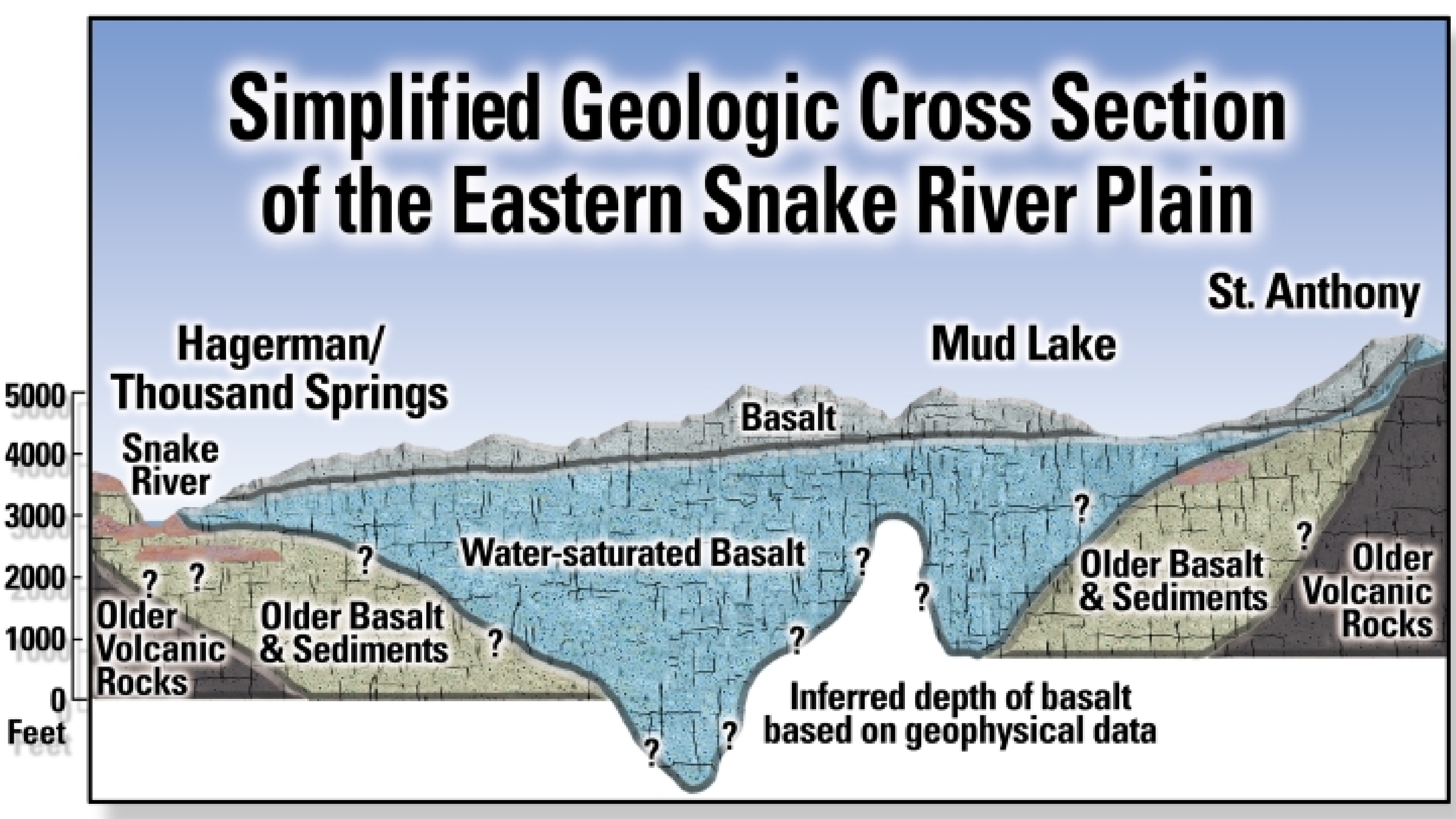
The Eastern Snake River Plain is so unique that it represents it own "Plains-style" volcanism. The Plain's relatively flat landscape is composed of a distinctive combination of broad, gently-sloping mounds of lava ("shield" volcanoes or "hubcaps"), basalt flows fed by lava tubes that can stretch for miles, and flows fed by long fissures filling in the spaces between the shield volcanoes. A few, relatively small basaltic cinder cones also dot the landscape.

Eruptions began along tension cracks in the Plain, as southeast Idaho was being stretched from northeast to southwest, along with the mountain ranges on either side of the Plain. Groups of these open fractures, stretching for several miles, can be seen on the Plain today.

Basalt lava flowed from some of these cracks, taking different forms due to the type and length of eruptions. Shield volcanoes formed when eruption activity lasted for years in the same vent area. Lava-tube fed flows formed as eruptions lasting from months to years cooled to form a crust on top while a lava stream continued to flow, forming a tube underneath. Fissure-fed flows resulted from eruptions that lasted for shorter periods, days to months. Increases in the amount of dissolved gas, new surges of lava, or lava encounters with groundwater caused more explosive eruptions, forming cinder cones.

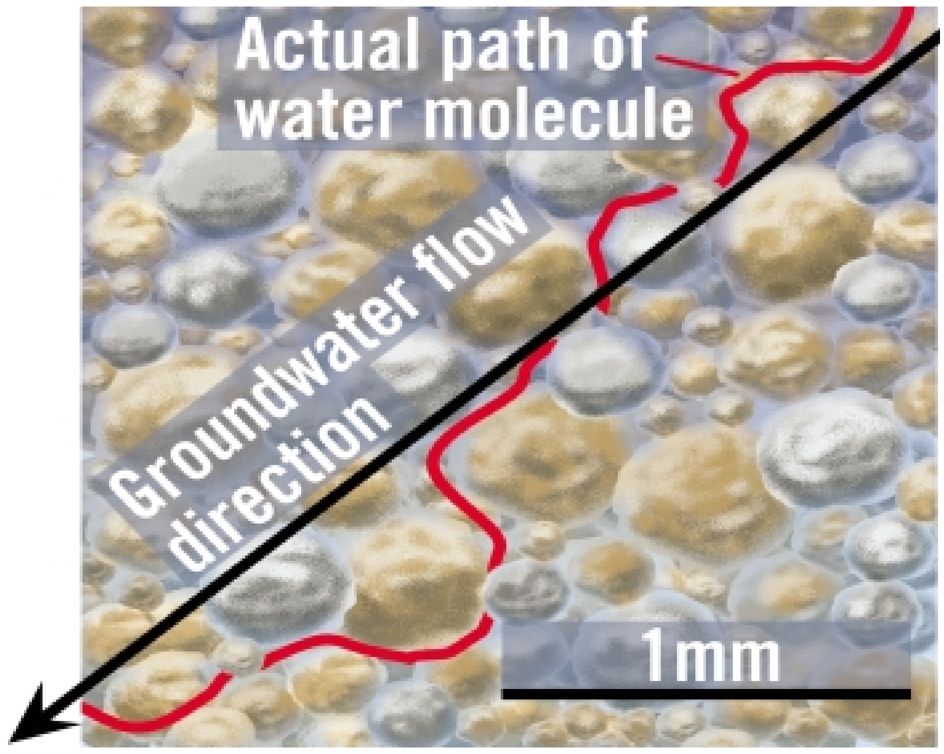
Another kind of lava, rhyolite, is found in a few places on the surface of the plain. It is thicker and more viscous than basalt and typically has more explosive eruptions. Rhyolite can form thick "domes," like Big Southern Butte along INL's southern boundary, from quiet eruptions. It can also form widespread sheets of ash from violent eruptions, like those forming Yellowstone Park.

Overall, the lives of individual Snake River Plain volcanoes were short, probably days to years, with hundreds to thousand of years between eruptions.



Deep wells and remote sensing tools like the travel time of seismic waves tell us the basalt lavas are as much as 4,000 to 5,000 feet beneath the surface across the Eastern Snake River Plain, with other lava rocks and sediments below. Due to the age of the rocks (meaning more time for dissolved minerals to clog up water flow), most of the deeper basalt is saturated with water. The most permeable rocks, where water flows easily, are those in the upper 200-300 feet of the aquifer.

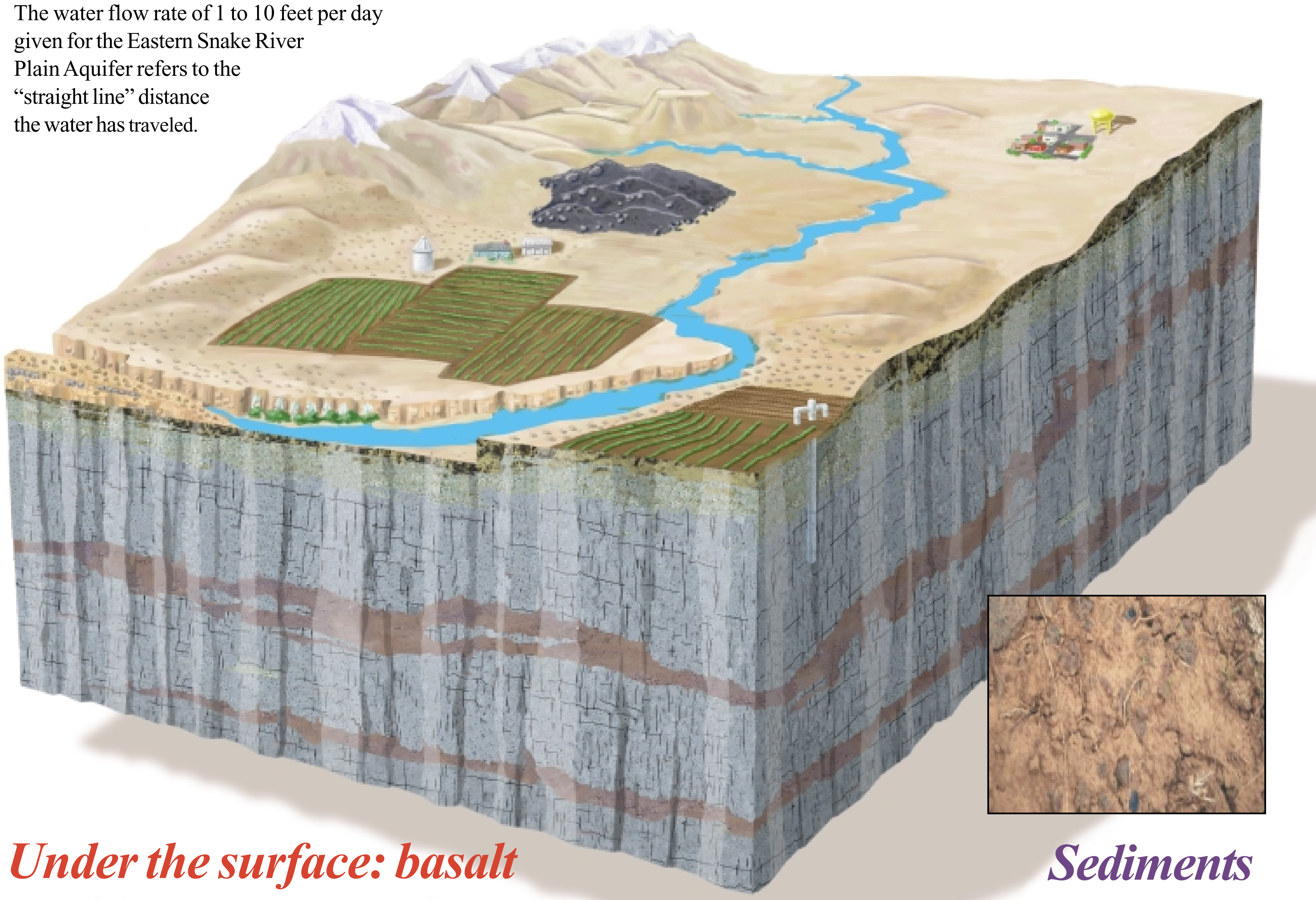
ANATOMY of an AQUIFER



Convoluted path

The shortest distance between two points is a straight line, but the easiest path for water flow in an aquifer is usually anything but straight. Tortuosity is the word used to describe the convoluted path water molecules take to weave in and out, above and below the grains and broken pieces of rock in an aquifer.

The water flow rate of 1 to 10 feet per day given for the Eastern Snake River Plain Aquifer refers to the "straight line" distance the water has traveled.



Under the surface: basalt

Our aquifer is composed mostly (about 90%) of basalt lavas. The basalt layers are not like cake layers, even and uniform from one side of the plain to the other, but more like a pile of pancakes thrown across a table. The basalt lava flows are typically just a few feet to tens of feet thick, and can vary considerably in thickness across short distances. The highly fractured basalt is often broken in blocks. It can also form distinctive "columnar" joints.

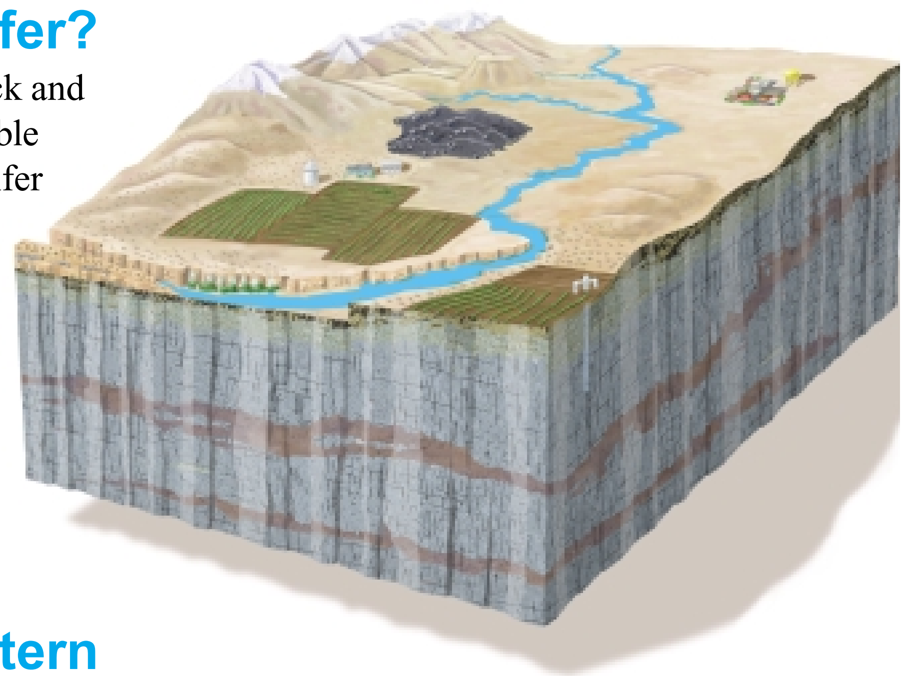
Sediments

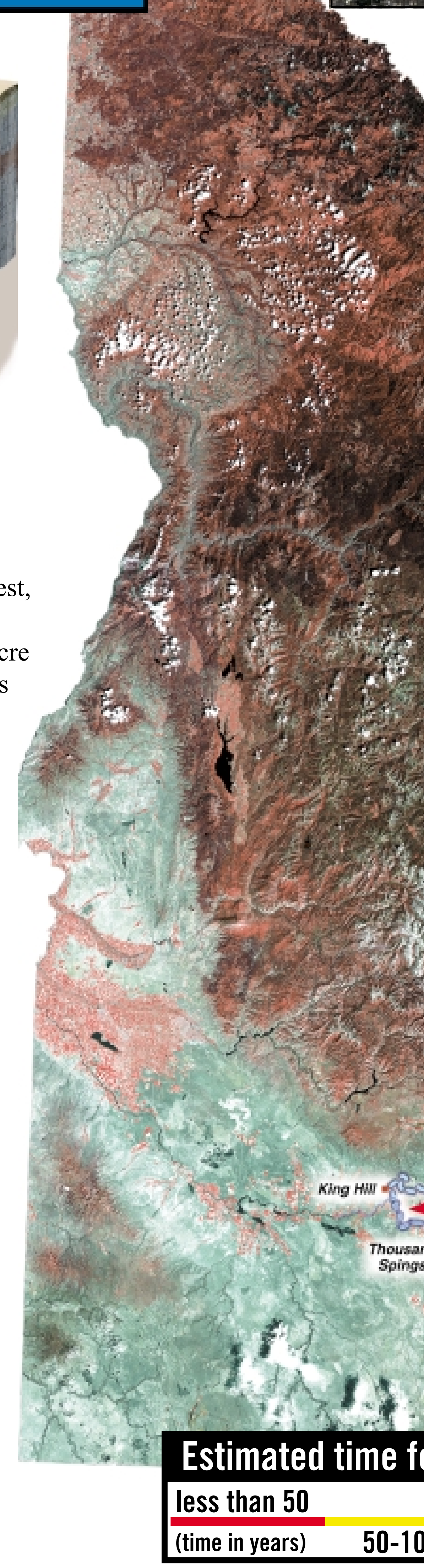
Sediments of the Eastern Snake River Plain fill in the gaps between lava flows, making up about 10% of our aquifer. Sand and gravels from rivers flowing across parts of the plain and silt from lakes formed at different times in the past slow down aquifer water and can trap or "perch" water above the aquifer. There are also thin layers of wind-blown silt formed when other rock layers were exposed to the surface.

The Eastern Snake River Plain AQUIFER

What is an aquifer?

An aquifer is a body of rock and sediment that will yield usable quantities of water. An aquifer isn't like an underground river or lake, but more like a giant sponge or a network of tiny interconnected pipes that can hold and transport water.



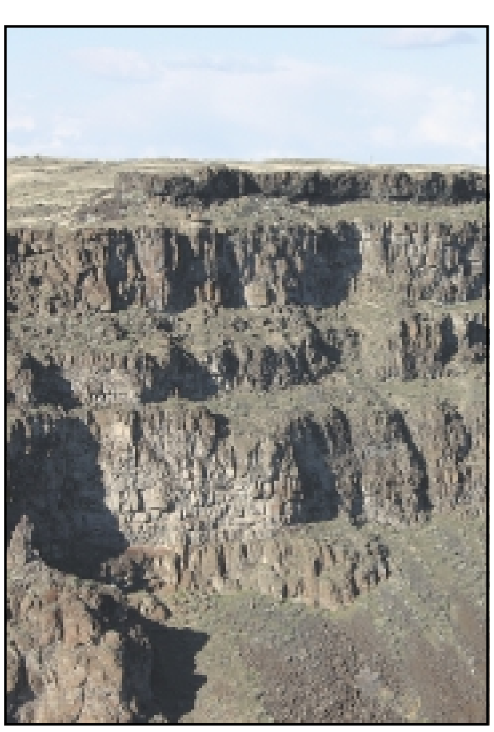


What is the Eastern Snake River Plain Aquifer?

The Eastern Snake River Plain Aquifer is one of Idaho's treasures. It's one of the largest, most productive aquifers in the world. It covers over 10,800 square miles of southern Idaho, stretching from Ashton to King Hill. The aquifer contains an estimated billion acre feet of water, about as much as Lake Erie and 600 times the capacity of American Falls Reservoir.

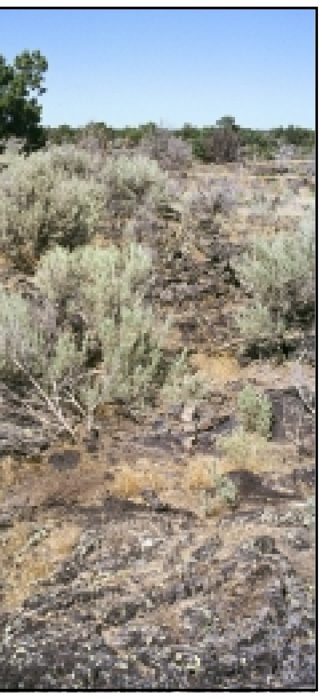
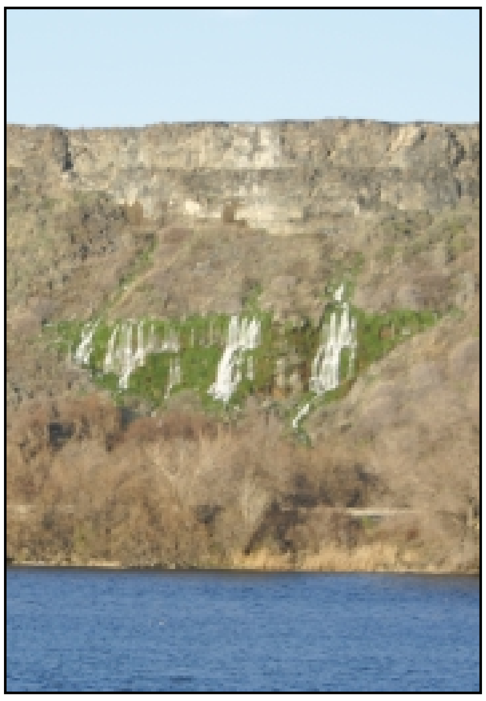
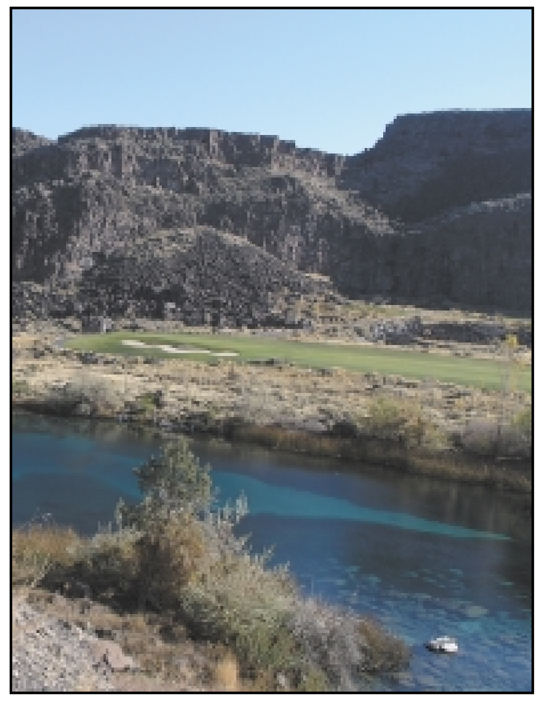
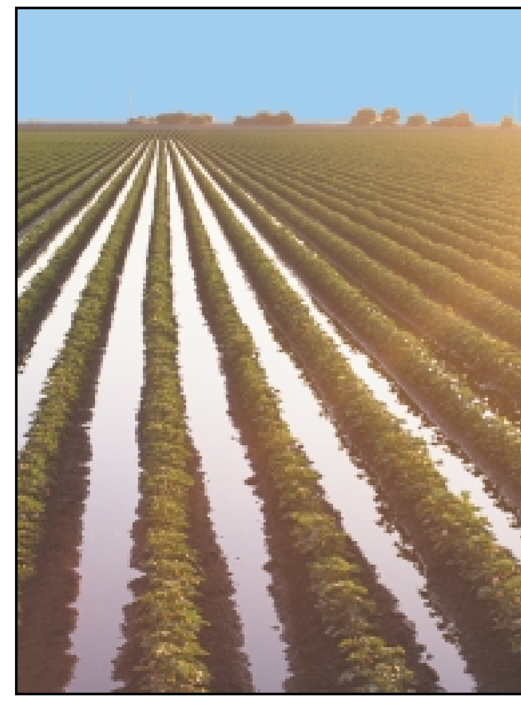
What is the aquifer made of?

About 90% of our aquifer is basalt, lava erupted from fissures and volcanoes during the past few million years. The remaining 10% of the aquifer is sediments from rivers, lakes, and wind-blown dust. The fractured nature of the aquifer's basalt is what allows our aquifer to hold and transport so much water. Basalts saturated with water are as much as 4,000 feet deep in the center of the Eastern Snake River Plain.



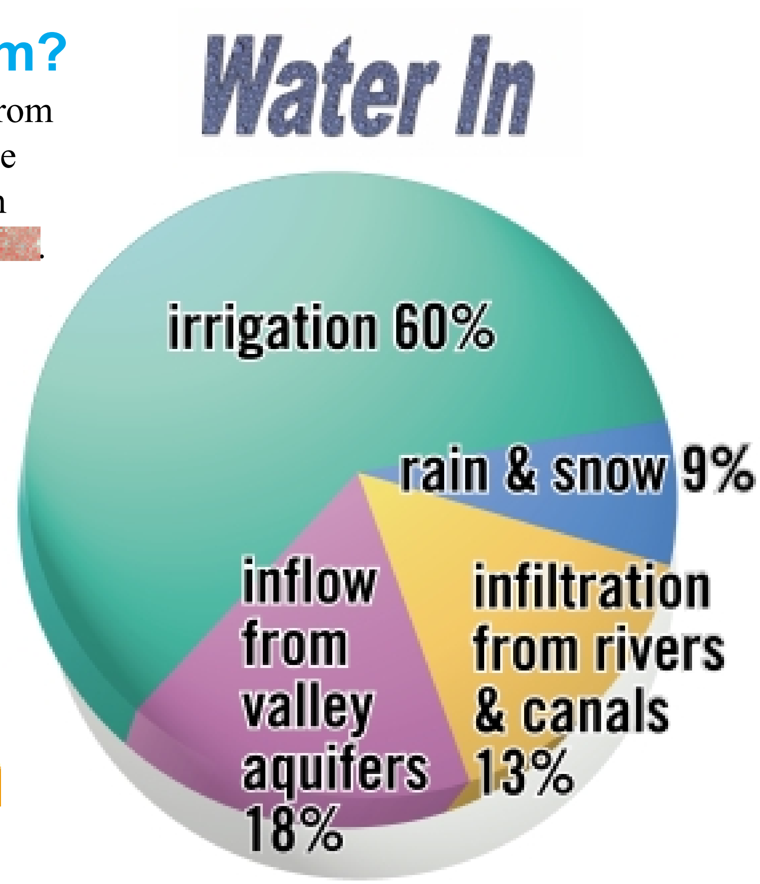
How does water flow?

Water flows through the aquifer via spaces in rocks and sediments, through larger cracks in rocks and tiny holes between rock grains. Water can take a convoluted path as it zigs and zags around rock grains. It travels more quickly through permeable areas—rock layers containing lots of connected spaces. Water flows most easily through the upper 200 to 300 feet of our aquifer.

Where does water in the aquifer come from?

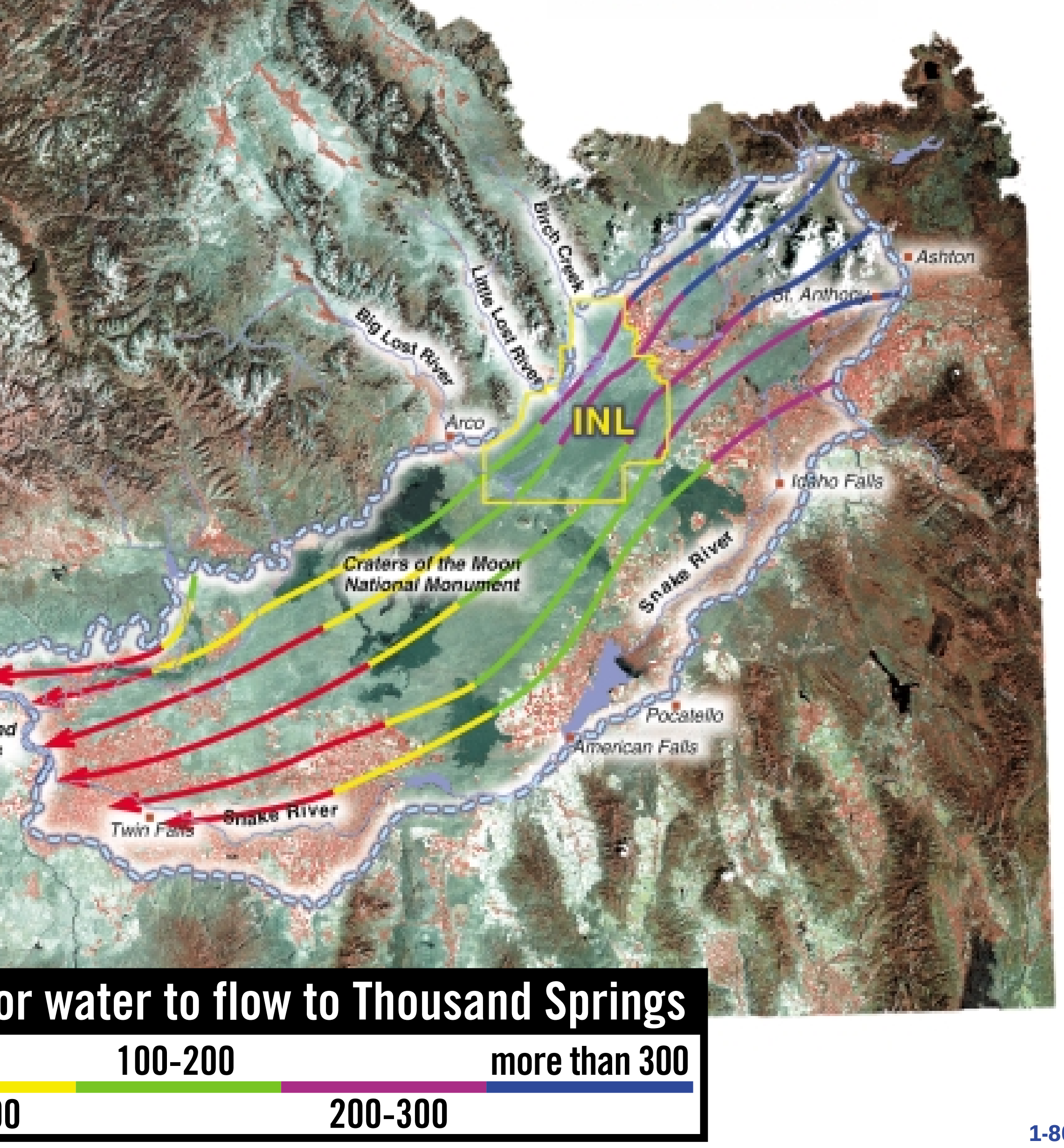
About 60% of the water going into the aquifer (called *recharge*) comes from irrigation. Other recharge comes from small aquifers in valleys along the edge of the plain, infiltration from rivers and canals, and precipitation (rain and snow). On the image below irrigated fields appear as ▒.



Where does the water go?

About 86% of the water going out of the aquifer (called *discharge*), about 7.1 million acre feet, eventually flows into the Snake River. Groundwater pumping accounts for 14%, or 1.1 million acre feet, of the aquifer's discharge.

Of the groundwater pumped, 95% is for irrigation, with the rest for drinking water and commercial or livestock use.



How fast does water flow in the aquifer?

Water in the aquifer generally flows from recharge areas on the northern and eastern border of the plain to the Snake River at Thousand Springs.

Water in the aquifer flows probably between 1 to 10 feet per day, much slower than a river, but fast for an aquifer. Water beneath the INL probably takes about 150 to 250 years to travel to Thousand Springs.

References:

Ackerman, D.J., *1995, Analysis of steady-state flow and advective transport in the eastern Snake River Plain aquifer system, Idaho*. USGS Water Resources Investigations Report, 94-4257, 25 p.

Linholm, G.F., 1993, *Summary of the Snake River Plain Regional Aquifer System Analysis in Idaho and Eastern Oregon*. USGS Open File Report, 91-98, 62 p.

Idaho Department of Water Resources, 1999, *Feasibility of Large-scale recharge of the Eastern Snake River Plain aquifer system*, 260 p.

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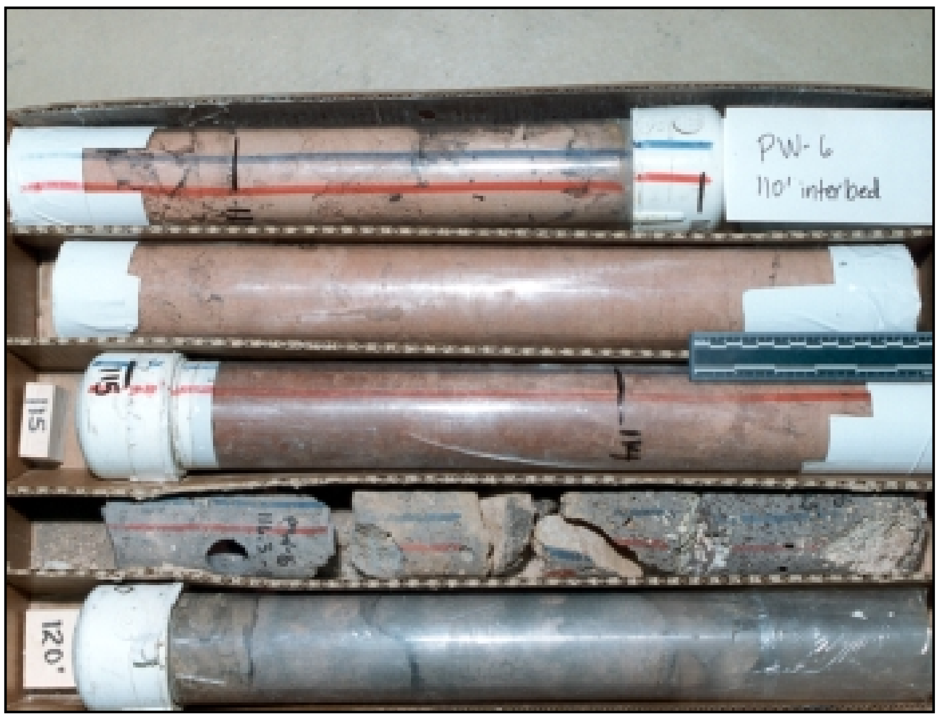


Samples of aquifer rocks can be collected when wells are drilled. This core, which can be hundreds of feet long, is a record of what the aquifer looks like and can help understand contaminant and water flow. The core samples here show sedimentary layers between basalt flows. Beneath the INL are several sedimentary layers tens of feet thick that can slow water and contaminant movement to the water level in the aquifer.

It's like trying to assemble a huge three-dimensional puzzle without having all of the pieces...

Decoding the Aquifer

Understanding the anatomy of our aquifer, how water travels through it, and the impacts of contamination from times past gives us clues to how the aquifer and contaminants might behave in the future. Our aquifer doesn't give this information up easily; we have to sift through evidence and decode its mysteries. We use what we learn to improve how we monitor the aquifer, make decisions about how to best clean up contamination, such as places beneath the INL, and ensure ongoing activities protect the aquifer.

To understand the aquifer, scientists use many different tools and make a wide range of measurements. These tools and measurements produce small pieces of the aquifer puzzle, and these smaller pieces must be brought together to see the whole picture. Scientists often must devise new tools or make new measurements to fill in holes left by "missing pieces."

Measurements are made of the quantity of water soaking into the Eastern Snake River Plain (from irrigation, rivers, canals, and snow and rain) to recharge the aquifer, and water leaving the aquifer, discharged from springs and pumped from wells. Also measured are changes in aquifer water levels in wells, and concentrations of minerals and contaminants dissolved in samples of aquifer water.

To learn about the pieces of the puzzle beneath our feet, scientists drill wells to collect samples of the aquifer rocks and make measurements of their characteristics. Different basalt and sediment layers can also be detected by measuring how seismic waves travel or magnetic and gravitational fields vary across the Plain.

By assembling these pieces, we can create a model of how the aquifer works. If something happens the model didn't predict—like when concentrations of the radioactive element technetium appeared near the INTEC Tank Farm where they weren't expected—we revise the model.

It's a cycle of collecting data, revising models and reviewing decisions to achieve our goal—protecting the aquifer and the people who depend on it.

If something happens the model didn't predict—like when concentrations of the radioactive element technetium appeared near the INTEC Tank Farm where we didn't expect them—we make changes to the model.

Read between the lines–of basalt

Basalts of the Eastern Snake River Plain range from the 2,000-year-old flows at Craters of the Moon to three-million year old flows buried beneath the surface. Where the Craters of the Moon lava field includes hundreds of cubic miles of basalt from a series of eruptions dating back to around 15,000 years ago, the much smaller lava fields at King's Bowl and Hell's Half-Acre likely came from shorter-lived eruptions, maybe just days long.

In the years between lava flows on the Plain, sediments accumulated—wind-blown dust, and deposits from the many rivers, lakes and streams flowing onto the Plain from the mountains to the north and south. Sediments from rivers and lakes have formed deposits up to several hundred feet thick in some areas, while basalt lies bare at the surface elsewhere.

Sediments are intermixed with the basalt flows. At times, basalt flows and eruptions changed the course of streams and rivers, eventually separating the Big Lost River, Little Lost River, Birch Creek and Camas Creek from the Snake River.

During times of wetter climates, lakes formed on the Snake River Plain. One such now-dry lake, Lake Terreton, left sediments found at the north end of the INL. Lakes have also existed along the Snake River, when lava flows dammed the river. Sediments and the remnants of a dam of basalt near American Falls show a large lake existed there once.

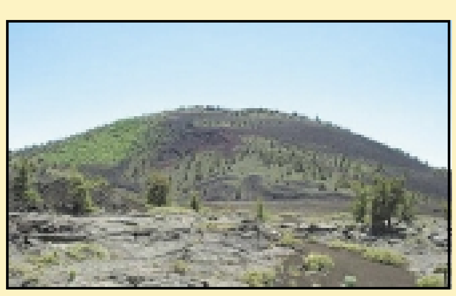
Away from the recent deposits of the Snake River and streams that flow onto the Plain, the Plain is covered with deposits of wind-blown dust (also known as loess) in layers from a few inches to nearly six feet thick. This sediment was deposited as dusty winds blew across the Plain, primarily during the last Ice Age, more than ten thousand years ago.

Craters of the Moon geology offers insight into aquifer

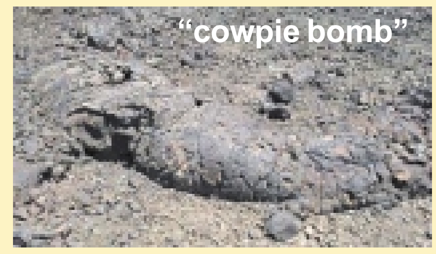
The well-preserved volcanic features of the Craters of the Moon National Monument and Preserve give us an idea of the complexity of the basalt flows beneath the surface that form most of the Eastern Snake River Plain Aquifer. Craters of the Moon National Monument contains three major lava fields covering almost half a million acres. A series of eruptions formed these lava fields between 2,000 and 15,000 years ago.

“Aa” lavas, named after the Hawaiian word meaning burn, are basalt flows that typically cool as massive bodies of rock with rough, jagged surfaces. Water typically travels more slowly through the massive cores of aa lava flows, but fairly easy through the jagged surfaces. Water flows more quickly through areas of the aquifer where there are series of thin lava flows and more slowly through thicker lava flows.

“Pahoehoe” lavas, named after the Hawaiian word for paddle, are basalt flows that make smooth wavy ropes. Pahoehoe lava flows rapidly and tends to spread out. Because of the wavy, ropy nature of the lava, series of pahoehoe flows tends to have lots of open spaces or voids. These spaces allow water to flow more easily through the aquifer. Lava closer to vents tends to be pahoehoe, grading to aa farther from the vent.



Cinder cones form when a vent erupts and accumulates cinders (light, gas-filled rock fragments), bombs and lava spatter around a central crater. The Craters of the Moon lava fields contain over 25 major cinder cones. The photo shows one of them, Big Cinder Butte. Water can move relatively easily through cinder and broken lava deposits.



“cowpie bomb”

“bread crust bomb”

“spindle bomb”

Lava bombs form during explosive eruptions when globs of lava are ejected into the air and start to solidify in flight. The “spindle” bomb shown here is named because of points created from twisting of the glob during flight. Bombs form several kinds of shapes—”cow pie” bombs from when bombs don’t completely solidify during flight and flatten on landing.

Lava tubes form when lava flows long enough to cool and form a crust on top while continuing to flow underneath. If the molten lava drains out, it leaves an empty tube under the crust. Water can move easily through lava tubes, which can vary from one to 50 feet in diameter and up to several miles long.

The Craters of the Moon Lava Field is an example of many of the types of basalt lava flows buried beneath the surface of the Eastern Snake River Plain. The fractured nature of the rocks seen at the surface helps us see how water can travel so easily in our aquifer.

Photos courtesy of the National Park Service. The Craters of the Moon National Monument and Preserve’s web site at www.nps.gov/crmo/ features a wealth of information about geology and related issues. The web site is particularly useful for teachers, parents, and others interested in teaching or leaning more about geology, geological processes, and the high desert environment.

State of Idaho Oversight Monitor

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Cross-section graphic on page 2 is based on *Geohydrologic Story of the Eastern Snake RIver Plain and the Idaho National Engineering Laboratory,* prepared by Bill Hackett, Idaho State University, Jack Pelton, Boise State University, and Chuck Brockway, University of Idaho, for the United States Department of Energy, Idaho Operations Office Idaho National Engineering Laboratory, November 1986, pg 7.”

ANATOMY of an AQUIFER

Idaho National Laboratory
Oversight
a state agency that monitors activities and cleanup at the INL on behalf of the citizens of Idaho

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