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Climate change is eroding work to clean up the Snake River. Is Summit County snowmaking making it worse?

A warmer, drier alpine is impeding water quality for streams and rivers used for snowmaking, like the Snake River that runs through Keystone



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Snow covers Deer Creek, near the the headwaters of the Snake River on Jan. 29, 2022, in Summit County. (Hugh Carey, The Colorado Sun)

KEYSTONE – The Snake River wends through this resort village, rushing streamside condos, beckoning anglers to cast after rainbow trout and, at some point in the year, funneling into equipment Keystone ski area uses to make snow.

But a few miles upstream, the river is a braid of smaller streams that scour a mineral-rich basin pocked with dozens of abandoned mines. Water flows through mine shafts and heaps

of blasted rock, becoming acidic and laden with heavy metals as it rolls across Summit County and into Dillon Reservoir.

High country hikers and trail runners traversing **Chihuahua Gulch, Argentine Pass and Peru Creek below** Ruby Peak and Grays Peak sometimes pass streams running so thick with these metals that the water appears white, pale green, or rusty orange.

For the last 20 years, the **Snake River Watershed Task Force** has coordinated state, federal and county agencies along with nonprofits on expensive projects to stanch pollution flowing from mines, hoping to improve downstream water quality for aquatic wildlife and recreational users. The coalition has made progress in cleaning up the Snake River, but a warming climate is reversing those gains. Some researchers who have studied water quality in the area worry the backsliding may compound as ski areas use rivers in the area to make snow.

The mines have long been seen as the major contributors in an admittedly dispersed problem — the cannonballs in a spray of buckshot. But a growing body of research suggests climate change is accelerating the pace at which acidic water and heavy metals run out of the basin, including from the mineral belts scattered throughout in the mountains themselves. Forty years of research shows marked increases in metals that are toxic to aquatic life, capable of killing trout and insects that fish live on.

“I’ve seen the data, I’ve seen the various theories,” said Brian Lorch, who worked with Summit County Open Space for 20 years on assessing former mine sites that might be safe enough to join the county’s trail system. “It seems to be pointing toward climate change kind of undoing the effects of the improvements that we’re seeing in water quality.”

Collaboration drives a major project, but results take years to parse

Two recreational interests helped launch the Snake River Watershed Task Force. Summit County was interested in adding open space around towns and began considering old mining claims. But the county aimed to avoid purchasing land that came with downstream liability for pollution leaking from the old mines. (The open space program has since purchased more than 350 former mine sites, including the Golden Horseshoe trail system, about 1,800 acres east of Breckenridge with about 100 miles of trails.) Plus, Arapahoe Basin applied for a snowmaking permit to draw water from the North Fork of the Snake River.

“That’s what led to this concern around water quality, and overall health of the watershed,” said Julie Shapiro, senior policy director with the Keystone Policy Center. The Environmental Protection Agency hired the center to convene the task force in 2000. The policy center was founded in 1975 as a solution-oriented effort for Keystone Ski Resort, similar to the Aspen Institute, but has no formal affiliation with the ski area, Shapiro said.



Arapahoe Basin ski area in Summit County on Jan. 31. The resort draws water from the North Fork of the Snake River for snowmaking. About 80% of that water returns to the basin in spring. (Hugh Carey, The Colorado Sun)

After some work in the 2010s to reroute streams that were running over old tailings piles, picking up toxins along the way, the group landed on a cornerstone project: the Pennsylvania Mine. From 1864 into the 1940s, miners dug silver, gold, lead, copper and zinc from the Pennsylvania Mine, which is perched at about 11,000 feet in elevation on a steep hillside near the Snake River tributary Peru Creek.

When the U.S. Geological Survey studied the Snake River Basin in 2009, the Pennsylvania Mine ranked as the largest human-related source of contaminants, including aluminum,

cadmium, copper, iron, lead, manganese and zinc. Occasionally, water built up behind piles of rock and dirt in partially collapsed mine shafts then broke through, flooding the river below with toxins and killing fish for miles downstream.

The basin is upstream of the Dillon Reservoir, a drinking water supply for Denver, and while the reservoir's sediment might be collecting some of these contaminants, they don't appear to pose a human health risk. The Colorado Department of Public Health and the Environment reviewed local drinking water system reports and found no water-quality violations.

“Almost all of our concerns are ecologically driven,” said Paul Peronard, the EPA's on-scene coordinator for the Snake River Basin. “The Snake River doesn't really support fish habitat. ... Copper and zinc, while not particularly harmful for humans, smack the crap out of aquatic populations and fish.”

Peru Creek, the stream running right by the Pennsylvania Mine, is unlikely to host a reliable fish population and historically, natural mineralization means that stream may never have provided fish habitat, but there's no proving that now. The goal isn't to see fish in that high-mountain creek, just better water quality downstream.

For the Pennsylvania Mine, the task force settled on a strategy of installing three bulkheads. In 2014 and 2015, 22-foot-long concrete plugs were poured into mine shafts then reinforced with steel and pinned into place by the weight of the mountain above. Nearby tailings piles were capped with dirt and native grass seed, and a pond was lined with limestone to help reduce acidity. The clean-up work cost about \$3.5 million, \$1.8 million of which was from the EPA and \$1 million from the state. The bulkheads would stop the pulses of toxic water that killed fish, in addition to, stakeholders hoped, saturating the surrounding hillside and slowing the weathering process that releases acid and metals and improving water quality.



The Snake River outside Montezuma in Summit County on Jan. 31. Bulkheads in the Pennsylvania Mine are supposed to slow the discharge of toxic metals into the river, which eventually flows into Dillon Reservoir. (Hugh Carey, The Colorado Sun)

“This bulkheading approach is kind of the go-to method of doing things,” said Rob Runkel, a research hydrologist with the U.S. Geological Survey who has studied the Snake River Basin. “They’re definitely safe and engineered like a dam would be engineered. As far as knowing what it’s going to do to water quality, it gets a little tricky.”

Streams are complicated, and this kind of work is messy. Between construction stirring up sediment, the fractured geology inside the mountains moving water in unpredictable ways,

and watersheds drawing from a web of tributaries, each with its own chemistry, it takes a while to find a new equilibrium.

“You can’t definitively say, ‘Oh, it didn’t work’ until you get down the road,” Runkel said.

He **researched** bulkheads in the Animas and Arkansas river watersheds that seemed to produce negligible improvements in the water quality, but it’s too soon to say whether the results would be similar in the Snake River basin.

Bulkheads also are not foolproof. One punctured to release some of the water behind it caused the 2015 spill at the Gold King Mine that colored the Animas River orange and sent heavy metals as far downstream as Lake Powell. In 2018, water that had pooled in the Captain Jack Mine above Boulder was poured into Left Hand Creek, killing fish for **10 miles downstream**. Recently, a mine above Nederland was found to be **violating water quality standards**.

A task force final case study on the Pennsylvania Mine project, based on stream data collected into 2019, reported substantial reductions in copper, iron, and lead and some decreased acidity below the mine.

“We reduced loads — was that good enough to bring fish back into the Snake River? It turns out not yet,” Peronard said in a phone interview. “Hopefully, sometime in the next decade or so we’ll do enough of these projects that you’ll see not only this reduction in load, but an improvement in the overall water quality.”

“I think in most cases we’re seeing improvements, probably not on the scale that most people would hope for,” said Jeff Graves, director of the Colorado Division of Mining, Reclamation and Safety’s inactive mine reclamation program. “Some of that’s a function of

that background geologic effect in association with the pyrite that's distributed throughout the region — so not just associated with the mining activities.”

Mining exposes pyrite, a shiny metal also called fool's gold, to air and water. The pyrite reacts by creating sulfuric acid, which then dissolves metals from surrounding rocks. That process also occurs naturally, even in areas without mining. But now, as **climate change lowers the water table**, oxygen is reaching pyrite deeper underground, and, like mining has, is creating more sulfuric acid.

“It's really difficult to distinguish between those manmade impacts and natural impacts,” Graves said. “You think you have a good handle on how much the manmade impacts are, so you try to reduce those, and you expect a one-for-one reduction — so if you take out 5 pounds of zinc at one location, you expect there to be 5 pounds less of zinc at another location downstream, because you took it out, and it doesn't always work that way.”

The reductions in zinc and copper — particularly tough on fish because they asphyxiate on it — range from 20% to 80%, Runkel said. The pH also headed in the right direction, at least until other streams join the Snake. Those other tributaries, some of which are in areas where there was less mining, are still releasing metals and acidic water — largely from natural sources. A neutral pH is 7, coffee is around 5, lemon juice, 2, and the water from these streams is sometimes close to 4. These streams also contain enough zinc to kill aquatic life.

“The task force has grappled with recent data that indicates large natural sources of metals may mean water quality standards for most of the metals will never be met in the watershed,” the final task force case study reads.

And now, as Peronard said, climate change “is screwing everything up.”

How climate change confounds an already complicated issue

In the alpine, warmer, drier conditions brought on by a changing climate seem to be releasing more heavy metals and acidity both from the former mine sites and from untouched bands of mineralized rock. These added contributions could mute gains made by the Pennsylvania Mine project and others like it, said Diane McKnight, a University of Colorado engineering professor and one of a team of researchers who have contributed to ongoing research in the Snake River Basin for decades.

“That doesn’t mean this approach for the Pennsylvania Mine wasn’t successful,” McKnight said. “The Penn Mine may be a great success. That doesn’t change what’s happening in Warden Gulch.”

In Warden Gulch, another Snake River tributary, levels of heavy metals in the water have dramatically increased. But unlike the Pennsylvania Mine, there’s nothing there to plug. Those findings have her looking downstream and asking questions: What happens when water loaded with heavy metals is used to make snow at Keystone? Could it accumulate on the slopes to the point that grass won’t grow there? Could it concentrate zinc, lead, cadmium, and other metals on the mountainside, then send a pulse downstream with spring runoff that kills fish?

“The direct runoff may have metal concentrations that exceed aquatic life criteria,” she said. “That’s what makes it not OK.”

In 2003, she worked on a paper that aired some of these concerns for water quality and fish around Keystone.

“We were just saying, ‘Look, this could be a problem,’” McKnight said. “And this was 20 years ago — before we knew the metal concentrations would be increasing due to climate

change.”

That research, **published in the journal Eos**, saw a swift **reply** from the consulting company Keystone ski area hired to assess water issues, clarifying that nothing indicated “severe” water-quality concerns and that the Snake River supported a viable “put-and-take” fishery, where **fish are stocked for anglers to catch**. True, McKnight and her co-authors’ **reply** read, but that left open other questions, like where the line was drawn for “severe” and whether “put-and-take” was a concession that fish had to be stocked because they couldn’t survive in the Snake River. Even decades later, McKnight said, those answers remain tough to find.

“I don’t see the ski resorts as being up front about what the issues are,” McKnight said in a recent interview.

Communications staff for Vail Resorts, which owns Keystone, did not respond to multiple requests for an interview for this story.

Ongoing research in the two decades since has marked growing concentrations of metals in the Snake River Basin. **The latest study** looked at rare earth elements — so new as water contaminants that there is no safe drinking water standard for them — and reported those elements at orders of magnitude higher than typically found.

“Metal concentrations are high throughout the watershed in various places and based upon that, this is not habitat for fish, and never will be,” said Garrett Rue, who co-authored the study with McKnight. “It’s high enough to asphyxiate fish.”

The data show bulkheading the Pennsylvania Mine has not improved water quality, Rue argues, and he sees the task force as backing away from that reality by pausing meetings and removing much of the detail from its website. Shapiro, with the Keystone Policy Center, said

the information on the website had simply become outdated and that meetings to discuss possible next steps are continuing. Asked if those meetings are open to the public, she pointed toward public field trips to the Peru Creek area, the last of which was held about three years ago.

“My read on the situation was, based on the writing on the wall, this problem is not getting better, it was not going to get better, and (the Keystone Policy Center) sort of pumped the brakes on having these meetings anymore and they weren’t really being very forthwith about letting this information get out,” Rue said.

Runkel, with the USGS, said runoff from snow made with water carrying heavy metals doesn’t seem to dramatically impact downstream water quality.

“Nothing at Keystone jumped out as a big loader relative to these other mine sites,” Peronard, from the EPA, said. “I can’t tell you, no, it doesn’t have an impact. Intuitively, it’s got to. But is it big enough for us to worry about now? It’s not on anybody’s list right now.”

Snowmaking and concerns for fish

Resorts make snow to even out the edges on an increasingly unpredictable winter. This season, Summit County’s resorts welcomed their first skiers on a surface of almost entirely machine-made snow.



Snow stick guns spew finely misted water into the freezing air to create snow as skiers and snowboarders enjoy the slopes at Keystone on Thanksgiving Day 2021. (Hugh Carey, The Colorado Sun)

“Snowmaking is a physical and metaphorical foundation of the ski season,” said Alan Henceroth, Arapahoe Basin’s chief operating officer. It covers high-traffic areas and allows for some level of certainty both for guests and for local employees, who count on ski areas for seasonal income. “Snowmaking is a real stabilizing factor. Even though we have snowmaking on less than 10% of our terrain, it’s really important that we have it.”

Ski resort representatives from Arapahoe and Keystone initially attended some of the Snake River task force meetings, then stopped. Shapiro attributed that to conversations shifting to a technical focus.

“There wasn’t really a good role for us there,” Henceroth said.

Arapahoe Basin draws water from the North Fork of the Snake River, a cleaner source. The ski area is restricted to using no more than 25% of that river at a time, in part to mitigate pollution downstream in the Snake River.

“If you have a clean stream that runs into a bigger stream that’s polluted and you take some water out of that, theoretically, you are reducing the effects of dilution when you do that,” Henceroth said. For five years, Arapahoe Basin contracted water quality monitoring that he said showed little discernible effect, in part because about 80% of the water used to make snow melts back into the river in spring.

Jon Ewert, an aquatic biologist with Colorado Parks and Wildlife, routinely surveys the fish population in the area, looking for effects of that upstream reclamation work.

“The general gist of what I’ve found is that it has not resulted in a benefit to the fish population up there, but that is not at all to say there haven’t been beneficial things done,” Ewert said. “It’s just that the fish are going to be the very last thing to recover.”

That’s because fish rely on a functioning, healthy ecosystem that provides plenty of insects for food. So far, the water quality in the area appears marginal for that. And upstream of the North Fork, he said, “we have never found a fish in that reach. It’s uninhabited. So, it’s the dilution from the North Fork that makes it livable.”

Keystone's snowmaking operations have presented a problem for fish living in the Snake River since its permit was granted in the 1980s.

"At that time, the state said, 'Well, OK, if you're going to take the water down that low, we don't expect there to be any over-winter survival of fish,'" Ewert said.

To mitigate that, the wildlife department required Keystone to annually stock 2,000 pounds of catchable-sized rainbow trout, he said, which they have done for many years, typically right before the busy summer holidays. Between the habitat and the water levels, he's found few, if any, living out the year.

"We're a long way from seeing healthy trout populations in that area, and I don't know if we'll get there, but we will certainly work for the rest of our careers to improve it," said Lauren Duncan, abandoned mine restoration project manager for Trout Unlimited. "Climate change — we'll see challenges associated with that from here and into the future."

The Snake River Task Force has quieted down since the Pennsylvania Mine work was done. Assessing how well that worked and what challenges the basin is now coming up against will require ongoing monitoring, Runkel said, and that's a chronically underfunded piece of reclamation projects.

"Do we have a clean-up project on the next to-do list? Not a big one," Peronard said. "It's death by a thousand cuts. ... That's not unique to the Snake River. That's all these mining sites. We are generations off — at best — from having fixes in place."