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Silenced Springs?

Great Basin waters face threats big and small.

By J. Madeleine Nash. Page 12.

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SILENCED SPRINGS?

The Badwater playa in Death Valley, where scientists are studying the impacts of groundwater pumping. THOMAS NASH

Big threats loom for the tiny aquatic creatures of the Great Basin

In his right hand, Don Sada clutches a simple kitchen sieve; in his left, he holds a Tupperware container. As I look on, the 58-year-old ecologist from Reno's Desert Research Institute plunges into a thick stand of watercress that obscures the headwaters of Big Springs Creek, an exuberant stream that issues from multiple springs at the southern end of Snake Valley, along the flanks of the Snake Range in east-central Nevada. "Let's see what's here," he says, stooping to part the watercress and drag his sieve through the stream's pebble-strewn bottom. "I've got springsnails," he shouts.

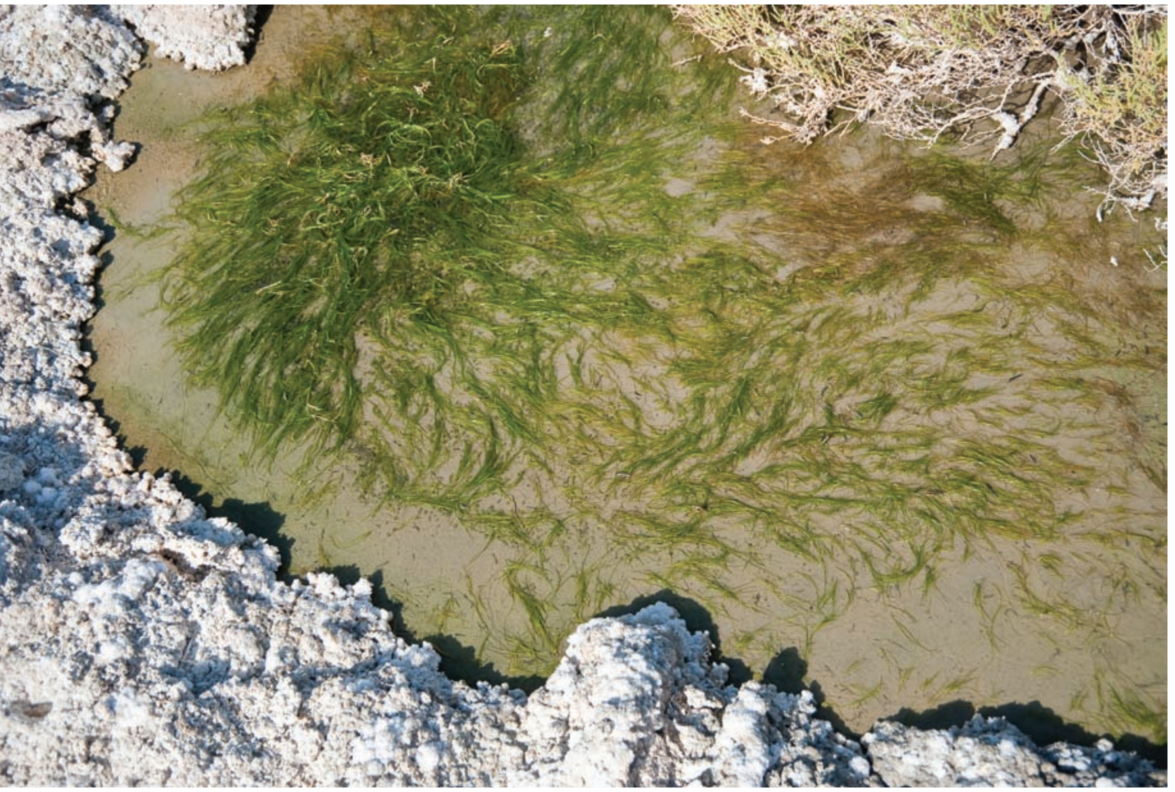
Peering into the container, I see about a dozen dots that appear as animate as baby peppercorns. The dots are snails, so small that the whorls that mark their shells are all but invisible. These diminutive gill-breathers belong to a species — *Pyrgulopsis anguina* — found near the source of just three springs, all of them in Snake Valley.

The snails are part of an ancient assemblage of aquatic organisms found here and in other Great Basin valleys. Fifteen thousand years ago, agile minnows now confined to spring-fed pools and streams swam through the shallows of great lakes and rivers. Springsnails, and the type of habitat they occupy, may have existed here for some 5 to 6 million years, ever since the end of the Miocene, the geological epoch during which Nevada's corrugated basin-and-range began to form. But now many of these little spring dwellers are in trouble, due largely to us, the brash newcomers who, barely two centuries ago, began pushing into the territory west of the 100th meridian.

Between the late 1800s and the start of the 21st century, Sada says, habitat destruction and the introduction of non-native species caused the extinction of a dozen genetically unique Great Basin fishes along with at least three mollusks. Still other extinctions have been but narrowly averted. Of some 4,000 springs Sada and his colleagues have examined, barely 60 can be considered remotely pristine. The rest have been subjected to unremitting abuse, notably by cattle and wild horses, which have trampled riparian margins, and by ranchers and farmers, who've canalized spring brooks and diverted their water.

"This spring looks pretty healthy," Sada says of Big Springs, "but if you look, you can see it's been disturbed. All those grasses over there are non-native, as is this clover. And over there, it looks like it's been dug out." Not far from Big Springs is Needle Point Spring, which used to spill into a trough and pond used by cattle and wild horses. Its flow faltered in 2001, shortly after nearby wells started withdrawing groundwater for irrigation.

Now, Snake Valley's springs face a new threat: the



In Death Valley, Badwater springsnails live under the edge of the travertine in spring-fed pools, where despite the 120 degree air temperatures, the water remains a cool 70 degrees (above left). The springsnails — the tiny black dots — are barely visible to the naked eye (center). At right, Don Sada collects snails at Travertine Springs. THOMAS NASH

Southern Nevada Water Authority's controversial plan to pump groundwater from Snake and other remote valleys and ship it south, to the Las Vegas metropolitan area. A decade or so from now, a 285-mile-long pipeline could carry more than 100,000 acre-feet of water south each year — more than enough to flood a city the size of Las Vegas to the depth of one foot.

In another era, a project this stunning in scale might have been hailed as smart, imaginative, even visionary. But that was before the environmental consequences of extracting large amounts of water from arid Western lands became so apparent. Across the region nowadays, rivers are in trouble, as are many aquifers. In extreme cases, water tables have dropped by several hundred feet, causing streams to dwindle, spring flow to wane, trees and shrubs to wither. Many rural and urban areas now suffer from land subsidence. As groundwater is removed, surrounding sediments can compact and slump, undermining buildings and highways. Parts of the Las Vegas Valley have sunk as much as six feet, and areas in Arizona and California have dropped anywhere from 15 to 30 feet.

This dismal track record casts a long shadow over the planned water diversion and lends credibility to those who question its eventual costs. The concern is further magnified by the size of the planned withdrawal. According to hydrological models submitted to the Nevada state engineer by project opponents, the utility's pumps will likely cause a severe water table drop across a very large area, extending well beyond the targeted valleys. And yet the full picture of the impacts may not emerge for decades, even centuries.

Where springs are concerned, what worries Sada most is the potential for harmful synergy — the cumulative impact of all the strain being placed on the small, vulnerable ecosystems he has spent the past quarter-century studying.

THE TEMPERATURE IS starting its climb towards 123 degrees when I catch up with Sada at Death Valley National Park. As the raven flies, Death Valley is around 225 miles from Big Springs. It's a world apart on the surface, but the geology and the hydrology are surprisingly similar. Sada, a trim, athletic-looking man with short-cropped gray hair, is dressed in his work clothes: shorts, T-shirt, a wide-brimmed hat and Teva sandals. "Let's go!" he says. We stop first at Badwater Basin, which, at 282 feet below sea level, qualifies as the lowest spot in North America. There we walk around the rim of a pool whose water shines like burnished copper. Save for floating mats of algae and a border of salt-tolerant pickleweed, it seems devoid of life.

Then Sada removes a chunk of salt-encrusted travertine and flips it over. On the moist underside, a freckling of snails clings to the rock. On a whim, I touch the water. At just over 70 degrees F, it seems cool compared to the air, which feels like it's been roasted in a blast furnace. At Sada's suggestion, I bring a drop to my lip. While not as salty as seawater, it's definitely brackish, which explains how Badwater got its name. "I still don't know how these things do it," Sada says of the snails. "For me, finding these snails here, in this harsh environment, is just a humbling experience."

The Badwater snail was first described in 1948. It provided one of the first hints of the arcane world that Sada and his longtime collaborator, Smithsonian Institution zoologist Robert Hershler, went on to discover some four decades later, when they set out to look for springsnails in several hundred Great Basin springs. "We didn't know what we would find," remembers Sada. "We ended up with a whole new fauna." In less than 10 years, the number of known North American springsnail species more than doubled. Among the additions was Snake Valley's *Pyrgulopsis anguina*, whose name combines *pyrgos*, Greek for tower, with *anguinus*, Latin for snake-like.

Many springsnails are confined to extremely small habitats. At Badwater they occupy the rocky strip at the water's edge, close to the source of the spring, where the freshest, coolest water wells out. In places this biotic zone is no more than 6 inches wide. Visitors to Badwater were unwittingly trampling it, Sada says, until the National Park Service protected the site with an elevated viewing platform.

Working our way up in biological complexity, we continue on to Travertine Springs, whose water supplies the Death Valley resort of Furnace Creek. There we walk alongside a fast-flowing brook clogged with non-native palms that have taken root right in the water. Even so, the brook continues to host an assemblage of endemic invertebrates — a springsnail, two amphipods (which are small crustaceans) plus a beetle and a bug. About the size of a flattened pea, the bug, a naucorid or creeping water bug, is the largest predator in the system. "Welcome to my world, the world of minutiae," Sada says.

The day has all but dissolved in a heat-shocked haze by the time we head across the Nevada state line, arriving mid-afternoon in the Amargosa Desert, a grim expanse of sand dunes, alkali flats and sun-scoured scrublands. In this drear setting, the deep aquamarine pools we find at the Ash Meadows National Wildlife Refuge seem more exquisite than gemstones. Among the pools' inhabitants are pupfish, which dart to and fro, nipping at tasty diatoms and small aquatic invertebrates. The females of this endangered minnow species are green; the males, vivid blue, so blue they would appear at home swimming round a tropical reef.

Like the pupfish, the water is always in motion. Where it bursts from the rock, it stirs up puffs of sediment and causes strands of filamentous algae to sway, as if in a gentle breeze. In spots you can even see the plumbing — the limestone caves from which the water streams. Sada recalls diving down to the cave at the bottom of Crystal Pool to search for springsnails. "The water was coming out with such force, it was hard to swim against it," he says.

The pools of Ash Meadows seem idyllic, until Sada points out some of the non-native intruders — the school of mosquitofish swimming near the surface, a diaphanous mass of bullfrog eggs. The mosquitofish were no doubt introduced for mosquito control, the bullfrogs probably for food. "People like to move bullfrogs around," Sada says, "probably because they like to catch 'em and eat 'em." Unfortunately, mosquitofish are extremely aggressive, harrassing other fish and eating their offspring. And bullfrogs are not harmless, either: Not far from here, Sada collected one that had a half-dozen partially digested pupfish in its gut.

Sada ticks off a list of other exotics that have invaded Ash Meadows over the years, including crayfish, mollies and an aquarium snail believed to prey on the eggs of fish, springsnails and other aquatic invertebrates. This snail, the Malaysian trumpet snail, is highly resistant to desiccation. It can easily hitch a ride in the beaks of birds or the shoes and clothing of waders. It can also reproduce asexually; one snail is all it takes to start a population explosion.

Less obvious than the exotics are the healed-over scars left by would-be developers, one of whom tried to turn Ash Meadows into a cattle ranch with irrigated forage crops and another — Jack Soules — who envisioned building a 20,000-home subdivision. "This is still a deeply traumatized landscape," Sada says, pointing out the row of Native American grinding stones arrayed along a fast-flowing spring brook. "Soules was planning to put his own house right here, with the brook running through his living room," Sada recalls. In the early 1980s, backhoes were already at work here, ripping into mesquite-lined brooks and redirecting their flow into a series of artificial ponds.

"There were dead pupfish all around," remembers Sada, who, at the time, was the U.S. Fish and Wildlife Service's endangered species expert in Nevada. He was one of the Fish and Wildlife Service officials who walked into Soules' office and informed him that he was violating the Endangered Species Act. Construction stopped soon thereafter, rendering further action unnecessary. A short time later, Soules' company, Preferred Equities, sold Ash Meadows to The Nature Conservancy, which, in turn, sold it to the Fish and Wildlife Service in 1984. Today, the refuge protects two-dozen endemic species, including the Ash Meadows Amargosa pupfish and four other species now considered officially endangered.

Before leaving Ash Meadows, Sada takes me to visit nearby Devils Hole, a limestone cavern whose roof collapsed long ago, opening a window to the aquifer below. In 1968, water levels began to plummet here, in response to pumping from irrigation wells sunk into Ash Meadows. Eight years later, a landmark decision by the U.S. Supreme Court effectively shut down the pumping, saving the gravely endangered Devils Hole pupfish. As I stand on a metal viewing platform, suspended high above a pea-green pool, I understand the rationale for the 50-mile road trip we've just taken. Devils Hole, Ash Meadows and Travertine Springs in Death Valley all tap the same subterranean lode.

HYDROLOGICALLY SPEAKING, NEVADA IS A SINGULAR PLACE. The driest state in the U.S., it sits at the heart of the Great Basin, an undulating expanse of mountains and valleys that resembles a rumpled carpet. The name stems from a geological insight made by the great pathfinder John Fremont, who recognized that water in this vast region is trapped in the equivalent of a bathtub, "having no connexion whatever with the sea."

The precipitation that falls on this rugged landscape has a couple of options. If it stays on the surface, it may briefly collect in an ephemeral playa or join a stream or a river that empties into a terminal sink or lake. The best-known example of the latter is Utah's Great Salt Lake, whose waters, due to high evaporation rates, are more saline than seawater. Or, it could seep into the ground and end up beneath the surface, in the vast freshwater reservoirs that underlie the valleys of this arid region.

The water in those reservoirs comes from snow and rain in the mountains, which percolates down into near-surface sediments and gravels and seeps beneath them, through porous layers of carbonate rock laid down by ancient seas. For the most part, these subterranean reservoirs are invisible, but here and there, their hidden waters well up through fissures and faults, spilling onto the surface as springs. Early explorers carefully noted the locations of these life-sustaining oases, both within the Great Basin and along its edges. In 1844, for example, when Fremont visited the Las Vegas Valley, he remarked on "two narrow streams of clear water, 4 or 5 feet deep, with a quick current, from two singularly large springs." These springs stopped their year-round flow decades ago, dooming the Las Vegas dace, a native fish, but in Fremont's day they supported a lush growth of vegetation, explaining the name Las Vegas, which is Spanish for "The Meadows."

Both physically and chemically, the springs that draw from the deeper carbonate are different from springs that tap aquifers in the valley or basin-fill. Their waters are older and carry higher concentrations of dissolved minerals. They are also warmer, a sign they have passed

What worries Don Sada most is the potential for harmful synergy — the cumulative impact of all the strain being placed on the small, vulnerable ecosystems he has spent the past quarter-century studying.

Vegas forges ahead on pipeline plan

BY MATT JENKINS

When Marc Reisner updated his landmark book *Cadillac Desert* in 1992, he mistakenly referred to the "forceful woman" who heads the Las Vegas-based Southern Nevada Water Authority as Patricia Mulwray. Her name is actually Patricia Mul*roy*.

Reisner's mistake might have been a Freudian slip: *Hollis* Mulwray is a character in the movie *Chinatown* who is based on William Mulholland, the powerful founder of the Los Angeles Department of Water and Power. Mulholland occupies a special place in the pantheon of Western water honchos, as both visionary and villain. He is best remembered for his audacious, and very secret, plan in the 1920s to buy up water rights in the Owens Valley and ship the water to L.A.

Mulroy understandably bristles at any reference to *Chinatown*. Yet she has achieved a degree of power that might even make Mulholland envious. Mulroy has largely set the terms of Western water over the past two decades. She has challenged what she calls the conservative "belt-and-suspenders" mindset that has traditionally prevailed among Colorado River water bosses. And, most controversially, she has led a two-decade-long effort to build a massive groundwater project that will tap huge aquifers lying beneath the Great Basin in eastern Nevada and pipe billions of gallons of water to Las Vegas.

This August, the state governments of Nevada and Utah announced that they had put one more piece of the project into place. They released an agreement that divides the water beneath the Snake Valley, on the Nevada-Utah line, between the two states, and that also delays for a decade the legal formalities needed to complete that final part of the groundwater project.

The announcement touched off a furor in Snake Valley. "We only got about a week's notice, and it left us scrambling to try to understand the agreement," says Mark Ward, an attorney for the Utah Association of Counties.

The agreement apportions the remaining water in Snake Valley 7-to-1 in Nevada's favor and "practically eliminates future development in Snake Valley," says Kathy Walker, the chairman of the Millard County Commission. Since the agreement was released, she says, "we've been racking up some serious miles" in an effort to change the terms of the deal.

Some pipeline opponents, however, see the agreement as a reprieve of sorts. Denys Koyle, who owns the Border Inn casino on a lonely stretch of Highway 50 on the Nevada-Utah border, says, "When I saw it, I thought, 'Oh my gosh: We've got 10 more years.' I've been saying every day we buy is a big victory."

The hoopla over the most recent development in the groundwater saga obscures a larger reality. Patricia Mulroy has tackled the groundwater project with far less secrecy than William Mulholland would have used. Still, over the past three years, she has moved to lock in the water she needs for the project with remarkable finesse. The Southern Nevada Water Authority now has at least 37 billion gallons of water lined up for the project, which will span seven valleys on the east side of Nevada, from Coyote Springs Valley to Spring Valley, and Snake Valley on the Nevada-Utah line.

"We already have the necessary water rights to go all the way to Spring Valley," says Mulroy.

But even as the Water Authority has amassed the permits it needs to fill the pipeline with water, unsettling questions have emerged regarding the project's impacts on desert springs ecosystems *(see main story, page 12)*. And one of Mulroy's own scientists says her agency is hiding the effects that groundwater pumping will have on the Great Basin.

WHEN MULROY ANNOUNCED her plan in 1989, the proposal drew a round of more than 4,000 legal protests from ranchers, as well as from the federal government. Since then, the Water Authority has adroitly moved to head off many of those challenges. Mulroy has spent $79 million in eastern Nevada buying up ranches and related water rights. (The Water Authority acquired several thousand cows and sheep as a result of those deals, and now has a sideline called Great Basin Ranch, and its own cattle brand.)

In 2006, Mulroy neutralized the most significant source of opposition when she struck a deal with the U.S. Department of the Interior, which was worried that the project could harm springs in three national wildlife refuges and Great Basin National Park. The government agreed to drop its protests in exchange for a promise from the Water Authority to fund a program that is now monitoring groundwater levels and the project's potential effects on wildlife.

In Snake Valley, another potential source of opposition came from the state of Utah, which shares the aquifer there with Nevada. But the Lincoln County Conservation, Recreation and Development Act, introduced by Sen. Harry Reid, D-Nev., and approved by Congress in 2004, required Nevada and Utah to negotiate a division of the water in Snake Valley.

That's the agreement released this August. "The purpose of the agreement is to build some kind of cooperative management of Snake Valley so we don't have a pumping war in the West Desert," says Boyd Clayton, Utah's deputy state engineer.

The deal is also an important part of a bigger bargain between Utah and Nevada. In the past, Mulroy has said that if Utah doesn't support her quest for groundwater from the Great Basin, she would respond by monkey-wrenching Utah's plans to build a pipeline from Lake Powell to St. George, the fastest-growing part of the state. Boyd Clayton, the deputy Utah state engineer, says that the recent Snake Valley water-sharing agreement reduces the risk of interference. "Clearly, if Nevada perceives that we're not trying to deal with them equitably on this issue," he says, "they're less likely to be helpful and equitable as Utah tries to develop the Lake Powell pipeline."

That has left Millard County in a delicate position. "Sen. (Bob) Bennett's (R-Utah) office has contacted us a few times, saying we need to be a little careful," says Walker, the Millard County chairman. "We're sort of stuck in the middle."

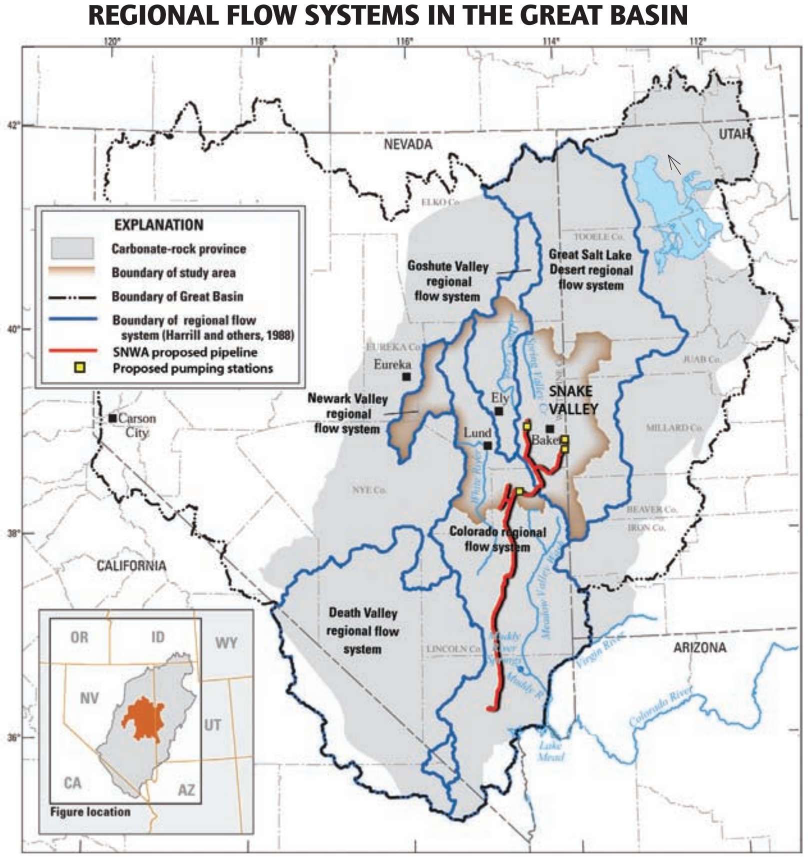
But with its potential hurdles out of the way, the Water Authority has received approval from the Nevada state engineer, the state's top water regulator, for 114,755 acre-feet of water from Delamar, Dry Lake, Cave, Spring and Snake valleys — enough for more than 1.5 million people in Las Vegas.

TIM DURBIN is a former United States Geological Survey hydrologist who for about a decade did contract work for the Water Authority. In 2001, he began designing a model that the Authority could use to predict the effects of pumping on the Great Basin aquifers. The computer model was a crucial piece of evidence presented to the state engineer during hearings about whether to grant water rights for the project. Yet when Durbin ran the model, he says, it became clear that *any* amount of pumping would have an effect.

"Southern Nevada Water Authority, for years, has been claiming that somehow they can

Please see **Pipeline**, *page 18*

REGIONAL FLOW SYSTEMS IN THE GREAT BASIN



Huge underground water-flow systems underlie much of the Great Basin, as shown on this map. A study published in 2007 by the United States Geological Survey, which focused on the areas outlined in brown, was intended to better understand how the systems work — and how the proposed Southern Nevada Water Authority pumping project would affect them. SOURCES: USGS; SNWA

through depths heated by the earth's core. At Ash Meadows, for example, the temperature of the larger springs is a balmy 90 degrees. Still, the flow through the carbonate is not completely cut off from the basin-fill. There are zones of convergence. In Death Valley, for example, groundwater is thought by some to cascade through a carbonate spillway beneath the Funeral Mountains, then plunge deep into the basin-fill before resurfacing at Travertine Springs.

For a time, scientists believed that Nevada's valleys, with few exceptions, harbored geologically isolated reservoirs of water. Around 50 years ago, however, evidence began accumulating that the carbonate blocks in multiple valleys are hydrologically connected. (Connections also run through the basin-fill. According to a recent study by the U.S. Geological Survey, at least some water from the basin-fill in Spring Valley may be leaking into Snake Valley through a limestone formation that spans the adjacent Hamlin Valley.)

Today, scientists recognize a number of large regional flow systems. In the Death Valley system, for example, water streams south from the Nevada Test Site, across the Amargosa Desert, right through the Funeral Mountains. In the Great Salt Lake Desert system, it falls from the crest of the Snake Range into Snake Valley, then flows north into Utah. The White River/Muddy River Springs system, for its part, starts not far from the city of Ely and flows south, towards the Colorado River. Because everything is so connected, critics say, the Southern Nevada project has the potential to affect springs at surprising distances, not only in Nevada but also in neighboring Utah.

For a couple of days, Sada and I follow the carbonate, leaving the Death Valley flow system to pick up the White River/Muddy River system northeast of Las Vegas. Then, in Snake Valley, we shift to the Great Salt Lake Desert system. It is a singular fact that these flows through the carbonate underlie surface features carved by ancient waterways. Today, for example, the White River flows only intermittently, but before the last Ice Age ended, around 10,000 years ago, it gurgled its way through a good half-dozen grassy valleys, ultimately joining with the Colorado River. Lake Bonneville, the Pleistocene predecessor of the Great Salt Lake, was once 135 miles wide, 325 miles long and up to 1,000 feet deep, making it a tad larger than present-day Lake Michigan. At its maximum, Bonneville reached far into Snake Valley, where traces of its shoreline can be seen today.

As we drive along, Sada tells me a little about himself. He grew up in Bishop, Calif., not far from Owens Lake, which famously went dry after Los Angeles commandeered the flow of the Owens River. Perhaps that's one of the reasons why, for as along as he can remember, he's been drawn to water. At first, he says, he dreamed of working in the ocean as a marine biologist; then he switched to the study of freshwater lakes and streams. Eventually, he became enchanted by the small, improbable upwellings of water scattered across the Great Basin, one of the driest landscapes on earth. An applied ecologist, he frequently conducts research for government agencies and public utilities, including the National Park Service and the Los Angeles Department of Water and Power.

Big Spring in Ash Meadows National Wildlife Reserve, Nevada (above left). The endangered Ash Meadows Amargosa pupfish (above right) in Crystal Pool Spring. THOMAS NASH

THE BORDER INN SPRAWLS across the Utah-Nevada state line like a mirage. It's a frequent gathering place for locals opposed to the Southern Nevada Water Authority's water-export plans. It's also a convenient stopover for visitors to nearby Great Basin National Park, which is dominated by the snow-streaked face of 13,167-foot-high Wheeler Peak, the highest mountain in the Snake Range. Here, Sada meets up with Krissy Wilson, the native aquatic species coordinator for Utah's Division of Wildlife Resources. "I am so pleased to meet you," she exclaims. "It's like you're the king of mollusks, the god of snails!"

The next day, Wilson takes Sada and me on a day-long tour of the major springs on the Utah side of Snake Valley. With her quick sense of humor and master's degree in biology, she proves an excellent guide. The distance we cover is great: Snake Valley is nearly 100 miles long and, in places, well over 15 miles wide. It's not yet known how sensitive the springs here may be to the withdrawal of water on the Nevada side. But already the Utah Geological Survey has placed monitoring wells along the flow-path groundwater takes through Snake Valley. The objective is to keep an eye on water levels at increasing distances from the pumping stations, watching for declines that could impact not only springs but also agricultural and domestic wells.

Wilson first stops at Gandy Warm Springs, where crystalline waters gush from hidden caverns on the shoulders of the northern Snake Range. Lush vegetation (including purple loosestrife, a colorful invasive) grows along the water's edge while damselflies and dragonflies swoop overhead. Unstrapping his sandals, Sada wades in, with Wilson directly behind him. A minute or so later, the two stop beside a waterfall that cascades down a ferny wall. Sada scoops up a few springsnails, all exemplars of the species, *Pyrgulopsis saxatilis*. "They're so small!" Wilson exclaims. They are also rare. Like *Pyrgulopsis anguina*, the species Sada found at Big Springs, *Pyrgulopsis saxatilis* appears to be restricted to Snake Valley. In August, to the delight of the pipeline's opponents, the Fish and Wildlife Service indicated it would consider both species for endangered or threatened status, which could raise an additional hurdle to the pipeline project.

Before its brook was diverted, Wilson says, Gandy Warm Springs used to flow into the Gandy Salt Marsh, a spring-fed wetland that sprawls across the valley floor below. Each spring, this small oasis, supplied by water from the basin-fill, connects with a seasonally flooded playa. In response to this ephemeral expansion, little fish known as least chub swim into the playa to breed. The females are lemony in color; the males, green and blue, with a gold racing stripe painted on each side. Once widely distributed across northwestern Utah, the species today exists in just six locations, three of them in Snake Valley. It, too, is a candidate for federal protection.

A springs complex resembles a grove of trees in a discontinuous forest. It is only when you piece the fragments together that the extent of biodiversity is revealed. Thus, the least chub at Gandy may be the same species as those found at the Leland Harris complex around 30 miles away, but they are genetically distinct. Their DNA reveals their geographical isolation. The last time least chub from the Gandy Salt Marsh and neighboring Bishop Springs mingled their genes with those at Leland Harris was around 10,000 years ago, Wilson says, at the end of the last ice age. Left alone for long enough, these chub could give rise to new species.

The Gandy Salt Marsh illustrates a point Sada has been making. While the

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Don Sada collecting snails at Kershaw Canyon Spring in Kershaw-Ryan State Park near Caliente, Nevada.
THOMAS NASH

springs that tap the carbonate tend to be the largest and most spectacular, those with sources in the basin-fill are also biologically important. And, says Sada, "They may well be more vulnerable." In apparent response to a recent multi-year drought, for example, a number of Gandy's 50 or so small, cool-water springs slowed their rate of flow, and some stopped altogether.

FROM GANDY, WE SPRING-HOP OUR WAY NORTH, and at each stop Sada whips out his sieve. Splashing through water sprinkled with duckweed, Sada retrieves a detritus-eating leech, a largish pond snail and a creeping water bug, which he takes care not to touch. "Its bite is extremely painful, like being stuck by a red-hot needle," he matter-of-factly volunteers. Sada also finds a springsnail known as *Pyrgulopsis kolobensis*. It isn't rare, but its presence is a sign of hydrological stability. "You always find *kolobensis* near a spring's source," he says. "They don't like variable environments."

Springsnails are sometimes referred to as the "guardians" of springs, which suggests that they perform some vital function. And no doubt they do; among other things, their appetite for algae and microbes probably helps keep benthic communities healthy. "But to us humans," Sada says, "their most important role may be as indicators of environmental conditions." The presence of springsnails means that water flows have remained constant for a very long time. In addition, springs with springsnails are biologically richer, supporting a larger number of endemic species than springs without snails. When a springsnail population starts to decline, says Sada, it's time to pay attention.

Sada tells Wilson about an experiment he and a colleague recently conducted at Travertine Springs in Death Valley. In essence, the two scientists turned one of the spring brooks into an outdoor laboratory, mapping out the microhabitats occupied by aquatic invertebrates. Then, using the pipes and valves in a nearby springhouse, they throttled back the brook's flow for a few hours at night, measuring changes in ecologically important indicators like the velocity of the current and the depth, temperature, and chemical composition of the water. Once they analyze the data they collected, Sada says, they hope to start answering the question now on everyone's mind: What is likely to happen biologically as a spring's flow slows?

Everyone knows what happens when a spring dries up completely, Sada continues; springsnails and other aquatic organisms die. But what happens to these organisms if the water flow drops by, say, 10 percent? What about 20 percent, 40 percent, 60 percent? "At present," Sada says, "no one knows."

Beneath the shade of giant cottonwoods, we lunch at Miller Spring, where Wilson reminisces about the battles fought here against non-native species — for a time, the spring was overrun by rainbow trout — and the agreement with the landowner to control cattle access with fencing. The springsnails and least chub should now have an improved chance at survival, Wilson says, as long as their habitat stays wet. "These are truly aquatic species," she adds. "They are basically trapped in this system, so if the water goes, they go."

Before we leave, Sada makes a final pass with his sieve while Wilson and I stare into the spring pool, hoping to spot a least chub. Thanks, in large part, to the ruckus kicked up by the Southern Nevada Water Authority, these sprightly fish and other small spring dwellers are beginning to intrude into public consciousness. The question remains: Will that matter? Like all creatures, Sada observes, "Humans must make use of water and other resources to survive. The problem is, we have a penchant for using these resources to depletion. The challenge is to use them in a sustainable manner. Sustainable is an overused word, but there's just no good substitute for it. ... " □

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WEB EXTRA
For an audio interview with author Madeleine Nash and accompanying slide show featuring more Thomas Nash images, see **hcn.org**

Pipeline

continued from page 16

develop this with no impacts, and that is just absolute total nonsense," he says. "There is absolutely no way of developing groundwater in these valleys without having impacts."

But when Durbin testified before the state engineer in 2006, "A lot of pressure was put on me to, in some ways, disown my own work," he says. "The report I prepared was, in effect, taken away from me and rewritten by (the Water Authority) to remove anything that suggested impacts."

Durbin no longer works with the Water Authority; he now has a contract with the National Park Service to help analyze the project's potential impacts. The only way that the project's impacts can be reduced, he says, is to pursue targeted pumping that avoids the most sensitive springs. "The extractions can be designed to focus the impacts on certain parts of the hydrologic system and away from others," he says.

For her part, Mulroy says that Durbin's model was less sophisticated than another one that the Water Authority is now developing. And, she says, her agency will finesse its pumping to minimize impacts on the desert springs. "If you follow Durbin's line of thinking, no groundwater can be touched, period," says Mulroy. But a more flexible approach can prove more sustainable. "You change your pumping strategies, year to year. You move pumping around. You let basins rest. And you artificially recharge."

Under an artificial recharge program, annual snowmelt from the mountains can be channeled into infiltration basins in the desert valleys to "recharge" the aquifer with water. "That's why we bought the ranches," says Mulroy. "If you put infiltration basins at the base of those mountains, you can get that runoff into the ground rather than have it run off and evaporate on the playa."

The one thing that could derail the project now is money. Four years ago, the price tag was pegged at $2 billion. Today, that number stands at $3.5 billion. And when it comes to how the Water Authority will finance the project, Mulroy is keeping her cards close to her vest. "At this point, we're spending only the money that we absolutely have to spend," Mulroy says. "The combination of a very effective conservation plan" — with correspondingly reduced water sales — "and a crashed economy with no connection charges" — the hookup fees for new homes through which the Authority generates most of its revenue — "have left revenues pretty stressed."

Even if the Water Authority is in a thrifty bent of mind right now, Mulroy says her agency is prepared to reach for the underground water when the moment is right. Much depends on the now-more-than-decade-long drought on Colorado River, and on yet another agreement. Three years ago, the seven states that draw water from the river negotiated a set of ground rules for how to share shortages if Lake Mead and Lake Powell, the river's two main reservoirs, continue to shrink.

Thanks to those rules, 1,075 is now the most important number in Vegas. The water level in Lake Mead — one of the key indicators of the state of the system — is now at 1,093 feet. When it drops below 1,075 feet, the first round of shared shortages will kick in on the renewed series of negotiations between the seven states — and, Mulroy says, the Water Authority will launch construction of the groundwater project.

"We need to start," she says, "the minute we hit 1,075." □