The tide is in

Underground, it's not going back out

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FARMERS on the coast near Monterey Bay are noticing that there is something wrong with the tide.

Not the tide on the beach. That continues to rise and fall as always. What concerns the farmers are the slow, seasonal changes in the underground water they pump from wells to irrigate their crops. About 50 years ago, they started to notice that the water turned slightly salty toward the end of the summer growing season, when pumping was highest. When winter rains brought in fresh water, the salt tide receded.

Now, farmers and water experts agree, the tide has stopped going out. Irrigation water as much as four miles inland may be more than 10 times as salty as the tapwater in Watsonville, and it is getting worse.

The source of the problem is obvious: The Pacific Ocean lies only a short walk from the fields. The solution is less clear. To outrun the advancing ocean, farmers are starting to sink new wells, deeper and farther inland.

But deeper wells do not guarantee fresh water. Last year, a new 1,000-foot-deep well in Springfield yielded water too salty to be used. The well cost its owner $150,000 — a ruinous mistake.

"Seawater intrusion hasn't put anybody out of business yet, but it's come damned close," said Craig French, former general manager of the Pajaro Valley Water Management Agency. The agency manages water resources for the Pajaro Basin, which extends along the coast from La Selva Beach to Moss Landing and inland to the mountains. Within that area, French says, there are 1,400 wells. About 85 percent of the water they supply goes to farms and orchards.

To speak of "seawater intrusion" is misleading: The wells are not pumping full-strength seawater. But even a little seawater in irrigation water can seriously damage

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sensitive crops such as strawberries and lettuce. A 2-percent solution of seawater, for example, can cut yields of strawberries in half.

Back in the 1940s

Seawater intrusion in the Pajaro Valley was first noticed in the late 1940s, when it reached about half a mile inland. Today it reaches an average of two miles from the shore. Within that area, well water is getting saltier every year.

What causes seawater intrusion is overdraft, or pumping the underground sources faster than water flows into them. Though the basin's "water budget" is hard to measure accurately, water-management officials and experts now agree that the area has been in the red for years, perhaps decades. And as the area's apple orchards give way to fields of thirstier crops such as lettuce and strawberries, they say, the demand for water will increase.

"It's a regional problem with local consequences," says Joseph Scalmanini, a consulting engineer who has spent several years studying the area's water problems. "You won't get seawater in Watsonville's water supply for a long time ... but you will see a continued loss of agricultural water quality."

According to a hopeful local legend, water flows into the Pajaro Basin underground from sources hundreds of miles away.

"People will tell you that some scientist put a tracer in the Sierra Nevada snowpack and discovered that the water ended up here," Scalmanini said. "That's wishful thinking – or wishful dreaming, I should say."

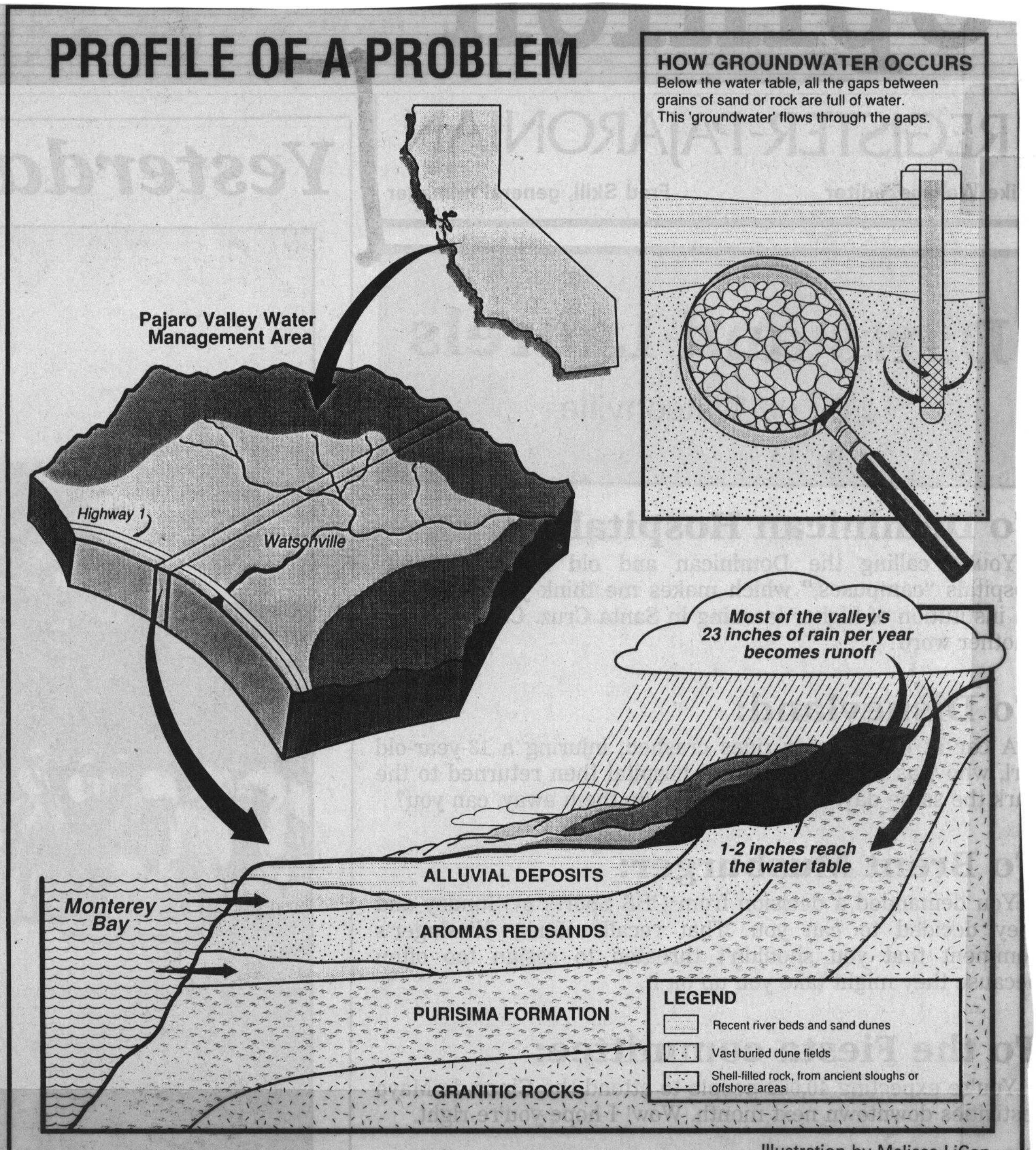

Illustration by Melissa LiCon

The Pajaro Valley Water Management Agency monitors eight wells along the coast, and county agencies monitor about 200. For years, the wells told an encouraging story: Water levels dropped below the critical points during the dry season but sprang back up after winter rains. But now that has changed. Well levels are staying low all year round.

"If the water levels are near sea level, then, pumping or no pumping, intrusion will occur," hydrologist John Mann told the water management agency in 1988. Even if the wells recover, Mann said, it could just show that the ocean is moving farther inland.

Many straws, one glass

Hydrologists say the wells that tap the aquifers are like straws in a single glass. Though seawater intrusion may never reach Watsonville, a gallon of water pumped out of the municipal wells there sucks in just as much seawater as a gallon pumped in Springfield.

Gene Taylor, a hydrologist for the Monterey County Flood Control and Water Conservation District, puts it simply: "Every drop of water out of the bucket adds to the problem. The poor people on the coast just get hit with it first."

Unless something is done to stop it, seawater intrusion will almost certainly hit coast-dwellers harder every year. The only realistic solution, water authorities agree, is to balance the basin's water budget. The supply must rise or the demand must fall.

The search for solutions

The PVWMA is weighing 17 possible ways to combat seawater intrusion. Most of the methods are based on increasing the supply of water, by either finding new sources within the basin, reusing wastewater, or importing water from outside the basin. Some, like desalinization of ocean water, are technically possible but probably too expensive for use here.

Methods that most experts consider likely to play a role in the area's future include the following:

- Pumping water from deep aquifers. The Purisima Formation is vast and so far untouched. Tapping it would let the area continue to use its traditional source of water, wells. But because few wells have penetrated it, this aquifer remains a big question mark. The quality of well water drawn from it has been uneven, and some hydrologists suspect 5-million-year-old seawater still lurks in its depths. The fine-grained rock may also prove to be a relatively poor aquifer. In any case, pumping this aquifer will eventually suck salt water into it, too.

"You can borrow, time-wise, maybe several decades," John Mann said, "but there's going to be a day of reckoning."

- Reusing wastewater from Watsonville, Morgan Hill and Gilroy. After tertiary treatment, the water could be used to irrigate crops or injected into the groundwater.

- Connecting with the California Water Project. In recent years, the most controversial proposal has been the San Felipe Project, a pipeline to carry water from the San Luis Reservoir. Estimated costs for the project run as high as $54 million. Its critics fear that it will hike the cost of water and pave the way for residential development at the expense of the area's farms. Its advocates, however, call it the only way to provide enough water for the valley's needs.

"If you don't bring water in, the only people who can afford it will be industries and bedrooms," says University of California extension agent Norm Welch.

With the population of the Pajaro basin increasing by more than 1,000 people every year, the demand for water seems sure to grow. As a counter-measure, water experts agree, any future program to combat seawater intrusion must include a strong dose of conservation. Other proposals, such as slapping surcharges on pumping and restricting water rights, are more doubtful.

To sort out the tangle of proposed policies, the Pajaro Valley Water Management Agency has commissioned a consulting firm to draw up a master plan for meeting the area's water needs. Hydrologists with James Montgomery Consulting Engineers Inc. are using computers to model the basin's water budget.

The PVWMA's new director, Michael Armstrong, says the model was expected to be finished by early March. The consultants will modify it by adding different combinations of the 17 proposed policies, to see which ones might succeed in driving back the invading ocean.

"It's very complicated," said Young Yoon, the project's head modeler. "We have to consider so many aspects: financing, institutions, people's perceptions, environmental concerns. All of them need to be interrelated and weighed. Maybe there is no best solution. Maybe the best we can do is second best."

Actually, almost all of the water pumped from wells in the Pajaro Valley fell as rain within 10 miles of Watsonville. The San Andreas Fault and Santa Cruz Mountains block the flow of water from the east.

On the average, the Pajaro Basin gets about 23 inches of rain per year. Most of it immediately evaporates or is sucked up into the roots of plants.

The surviving rain trickles down through the soil. Within a few days or weeks, it hits the water table. It merges with an immense body of water and flows toward the ocean.

The groundwater seeps between grains of sand and gravel and right through solid rock. It creeps along at a rate that can make a snail's pace look like the Concorde: only a few feet a year in some places. Even if water from the Sierra Nevada could reach the coast, it would take thousands of years to arrive.

Wishful thinking

Hopeful talk about vast uncharted underground lakes and rivers makes hydrologists wince.

"I wish we could lay that myth to rest," French said, shaking his head.

The groundwater in the Pajaro Basin has no real bottom, and it does not flow between banks. Wherever people stand, it is beneath their feet. Wherever they drill, they will hit it.

The secret of drilling a good well is to hit the right layer. A well that ends in a plug of clay will never suck in enough water to be of use. Granite bedrock is only a little better, though some low-yield wells in the mountains pump water out of it.

A thick layer of sand or gravel, however, acts as a groundwater duct. Such a layer is known as an aquifer – literally a "water-carrier" in Latin. To understand the aquifers in the Pajaro Valley, it is necessary to start with a little geology.

A geological cross-section of the Pajaro Valley looks like a side-view of a slice of lemon meringue pie. The crust of the pie is an enormous ramp of granite rock. Its edge sticks up to form the Santa Cruz Mountains, while its bottom slopes westward into the ocean.

The granite has spent most of the last five million years slowly and unsteadily sinking beneath the Pacific. Atop it lie thousands of feet of rock – the lemon filling – and on top of that, loose sediments such as gravel, sand and clay – the meringue. Among these layers, hydrologists generally recognize three main aquifers:

- An upper aquifer made of river gravels and dune sands. Only a few thousand years old, this formation is still being deposited. Shallow 19th century wells tapped it, but salts and nitrates have made its water largely unusable today.
- The Aromas Red Sands. Between 200 and 600 feet thick, these supply water to almost all of the wells in the Pajaro Valley. Their red-orange color tells geologists that they originated on land, not underwater. Between 100,000 and 200,000 years ago, they formed a massive dune field flanking the mountains.
- The Purisima Foundation. This tan, fossil-filled sandstone makes up the cliffs on beaches near Capitola. In the Pajaro Valley, it lies 800 feet below sea level and is at least 1,000 feet thick. Only a few wells are deep enough to reach it. The sand from which it formed accumulated over millions of years in shallow waters like those just offshore from Elkhorn Slough.

The aquifers are separated by layers of clay and other fine-grained sediments that hold water tightly. The whole sequence of layers, from granite upward, juts out into Monterey Bay.

Under natural conditions, fresh water flows through the aquifers and into the ocean. A little seawater may enter the aquifers, but the pressure of the fresh water keeps the seawater far offshore.

Pumping water from wells, however, lowers the pressure in an aquifer. When it falls too far, seawater moves upstream through the "ducts." Because the salt in the seawater makes it heavier than fresh water, it sinks to the bottoms of the aquifers. There it forms huge tongue-like wedges that slide slowly inland.

Testing for saltwater

Just as a dipstick is used to check the oil pressure in a car, a hydrologist uses a monitoring well to check the water pressure in an aquifer. Roughly speaking, if the pressure of the seawater pushes well water up to sea level, then it balances the pressure of the seawater pushing into the aquifer.

Actually – again because the seawater is heavier than fresh water – the critical well level is a little higher. One hydrologist estimates that well levels in the Aromas aquifer have to be at least five feet above sea level to prevent intrusion. Well levels in the Purisima aquifer have to be at least 15 feet above sea level.