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NEW LIFE FOR THE DEAD SEA?

A conduit from the Red Sea could restore the disappearing Dead Sea and slake the region's thirst. But such a massive engineering project could have untold effects, reports **Josie Glausiusz**.

Standing at the rocky shore of the Dead Sea, Itay Reznik raises his arms as high as they will go. Suspended in the air about a metre-and-a-half above his fingertips is a dock to nowhere. "When I started my PhD in 2007, we could sail from this dock," says Reznik, a graduate student in geology at Israel's Ben-Gurion University of the Negev in Beer-Sheva. Now the dock dangles more than three metres above the water.

This super-salty lake on the border between Israel and Jordan is the lowest spot on Earth's surface, and it is getting lower each year. Over the past 50 years, the water level has dropped by almost 30 metres; recently the loss has accelerated to an average of 1.2 metres per year. The Dead Sea's surface area has shrunk by almost one-third over the past 100 years.

In this desert region, more water evaporates from the sea than enters it. The Jordan river once fed the sea with 1.3 billion cubic metres of fresh water per year, but that has shrivelled to less than 100 million cubic metres, most of which consists of agricultural run-off and sewage. Israel, Syria and the Kingdom of Jordan take the river's water for drinking and agriculture. At the southern end of the sea, Israel's Dead Sea Works and Jordan's Arab Potash Company exacerbate the problem by evaporating the mineral-rich water to extract potash and magnesium.

Without action, the Dead Sea will continue to shrink. But a proposal being evaluated by the World Bank could revive the lake with a 180-kilometre-long conduit carrying water from the Red Sea 400 metres downhill to the Dead Sea through a canal, pipeline or some combination of the two. The water's flow would generate electricity to run a desalination plant, providing drinking water for local people — as much as 850 million cubic metres of water annually, the equivalent of just under half of Israel's current consumption (see 'Saving the Dead Sea').

The concept of a Red–Dead canal goes back to 1664, when Athanasius Kircher, a German Jesuit scholar, envisioned it as part of a regional network of transportation canals. Similar schemes have been revived and abandoned over the years, most notably following the 1973 energy crisis, when Israel considered building a hydropower plant on a canal linking the Mediterranean and the Dead Sea.

Lately, however, the Red–Dead plan has gained momentum, mainly because of Jordan's desperate need for drinking water, and because of a desire by Israel, Jordan and the Palestinian Authority to collaborate on a 'peace conduit'. The three governments have developed shared goals for the project and in 2005 they jointly asked the World Bank to investigate its feasibility and environmental impacts. "It's the only place where Israel, Jordan and the Palestinian Authority are publicly working on a project together," says Alex McPhail, lead water and sanitation specialist at the World Bank, who is overseeing the bank's study programme of the plan.

Environmentalists aren't so keen. Friends of the Earth Middle East (FoEME) an Israeli–Jordanian–Palestinian advocacy group with branches in Tel Aviv, Amman and Bethlehem, has questioned the environmental effect of the conduit, which would cost billions of dollars to build. The intake pipe would draw up to 2 billion cubic metres of water each year from the

Red Sea's Gulf of Aqaba, which would have an unknown effect on the sea's 1,000 or so species of fish and 110 species of reef-building coral. And the conduit would run through the Arava Valley, a haven for rare gazelles, hyrax and hares. The valley is also lined with a seismically active fault that could damage the water system. Most significantly, environmentalists argue that this expensive and potentially harmful project is unnecessary, and that Israel and Jordan could at least partially restore the River Jordan by conserving more of their water resources.

Reznik and other researchers in the region are busy resolving these and other issues. Their results will feed into the World Bank's final report in 2011, which will help to determine whether Israel, Jordan and the Palestinian Authority pursue the project, and whether it will attract funding.

The decline of the Dead Sea is obvious on a drive through the region with Reznik and his PhD supervisor, Jiwchar Ganor, a geologist at Ben Gurion. At Ein Fashkha, a nature reserve and freshwater spring on the northwestern shore, small placards mark the shore line in 1968 and 1984. The first is now about two kilometres from the lake; the second sits forlornly beside a set of crumbling stone 'stairs to the sea', which is now nowhere to be seen.

A muddy mess

The lake's retreat has left a wasteland of exposed sediment, which is so salty that few plants can grow. Freshwater springs once fed oases of palm trees and other plants along the former lake shore but the springs' outlets have migrated downhill into the muddy zone along the current shore. Environmentalists worry that the decline of the oases will harm migrating birds that stop in the region to fatten up before crossing the Sahara Desert. Infiltration of fresh water has also dissolved salt layers in the sediments, leading to the formation of some 3,000 sinkholes.

The retreat has also taken a toll on people because the Dead Sea is a tourist destination and home to several farming communities. Its retreat has halted efforts to build hotels and other amenities, and the sinkholes have undermined roads and bridges, and harmed agriculture.

The Dead Sea will probably never vanish completely — as its surface shrinks, its salinity increases and evaporation slows. "The Dead Sea will not die," says Ittai Gavrieli, acting director of the Geological Survey of Israel in Jerusalem, who is leading a series of modelling studies on the impact of the proposed conduit. But if nothing changes, the lake is likely to drop a further 100–150 metres from its current level of 423 metres below sea level, Gavrieli says.

"The Dead Sea is the only place where Israel, Jordan and the Palestinian Authority are publicly working on a project together."

Aside from arresting further ecological damage, the conduit could provide crucial help for the Kingdom of Jordan, says Mousa Jama'ani, secretary-general of the Jordan Valley Authority in Amman. Jordan is one of the world's poorest countries in terms of freshwater resources. The Gulf States are even more parched, but they use their oil for electricity production to power the desalination of seawater. "Here in Jordan, there is no oil, also no water," Jama'ani says.

A desalination plant on the Red–Dead conduit would supply some of that badly needed drinking water to Jordan. "The population here increases and increases, water resources are limited, and demands increase," says Jama'ani. "What we can do? The government has a responsibility to the people."

The desalination plant would also supply clean water to the Palestinians, says Shaddad Attili, head of the Palestinian Water Authority in Ramallah. Palestinian water sources are limited to a mountain aquifer beneath the West Bank (part of which borders the Dead Sea) and a coastal aquifer — heavily contaminated with seawater and sewage — that supplies Gaza.

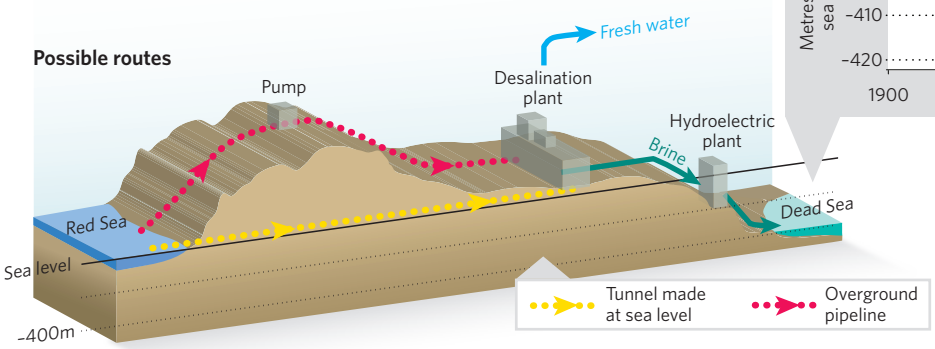
"Palestinians haven't had access to the Jordan river basin since 1967," Attili says. Nor are they permitted to develop the northwestern shore of the Dead Sea. Attili believes that the agreement to cooperate on the Red–Dead project with Israel is a big achievement — a view reiterated by Uri Shor, spokesman for the Israeli Water Authority. Israel obtains about one-third of its water from the Sea of Galilee and most of the rest from underground aquifers; it also desalinates some 165 million cubic metres of sea and brackish water per year, about 9% of the country's annual consumption of 1.8 billion cubic metres. "Such a project is a platform for international co-operation, and therefore it's in our interest as well," Shor says.

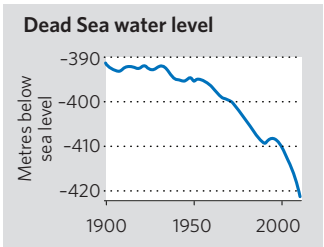
In 2008, with US$16.7 million in aid donated by eight countries, including the United States, France and Sweden, the World Bank launched a study programme to examine the feasibility of constructing the Red Sea–Dead Sea Water Conveyance and its social and environmental impact. The programme has released a series of interim reports[1,2] over the past 18 months, examining such factors as the best route for the conduit (most likely through Jordanian territory) the form it will take (canal, tunnel, pipeline or some combination thereof) the type of intake on the Red Sea, where to site the pumping stations, desalination plant and hydropower facility, and the allocation of desalinated water.

The World Bank also recently started two

SAVING THE DEAD SEA

With the Dead Sea shrinking, plans are developing to refill it by connecting it with the Red Sea. Various routes are being considered, but all of them would flow downhill, providing an opportunity for hydropower. The electricity could be used to run a desalination plant that would supply the region with fresh water.





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studies looking at the impact of the conduit on both the Red Sea and the Dead Sea. Last October, under pressure from FoEME, the World Bank initiated a 'study of alternatives', conducted by a trio of British, Jordanian and Israeli experts to examine other options, such as building a water pipeline from Turkey or restoring the flow of the River Jordan.

One important factor is the risk of earthquakes. The Dead Sea Fault, an active seismic zone, runs the length of the Arava Valley and forms the border of two tectonic plates. According to the interim feasibility study[1] commissioned by the World Bank, there is high risk of a major earthquake occurring within the operating life of the project, endangering pumping stations and the desalination plant. Gavrieli says that such damage could be forestalled if geologists can identify the fault location and engineers design the conduit and related facilities well enough. "If you know where the fault line is, you prepare for it; you reinforce it, you allow for some flexibility," he says.

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This dock was level with the Dead Sea in 2007.

The World Bank reports also examine other potential hazards of the project. For example, pumping water from the Gulf of Aqaba could change currents, damaging corals or sea grasses. Sea water could leak from the conduit and contaminate groundwater. It could harm wildlife and archaeological sites in the Arava Valley, including ancient settlements, aqueducts and reservoirs, copper smelting sites and cemeteries.

The Arava ecosystem potentially faces further threat from a plan by the Israeli real estate billionaire Yitzhak Tshuva to build a 'valley of peace' along the conduit, a Las Vegas-style city filled with parks, lakes, waterfalls, hotels and a botanical garden.

"What's the big deal if the Dead Sea is red? What's worse, having it drop, or having it red?"

Extreme inhabitants

The Dead Sea itself could be transformed, with unknown long-term consequences. Despite its name, the sea is home to a variety of microorganisms, including a salt-tolerant unicellular green alga called *Dunaliella* and red Archaea from the family Halobacteriaceae. *Dunaliella* thrives when the sea is slightly diluted, as in rainy years such as 1992, when the lake level rose by two metres. A new conduit could also stimulate growth of the alga because the Dead Sea is much saltier than either the Red Sea or brine from a desalination plant.

Experiments conducted at the Dead Sea Works by Gavrieli and Aharon Oren, a microbiologist at the Hebrew University of Jerusalem show that such an influx of less-salty water would trigger algal blooms. The effect would be enhanced by the addition of phosphate-based fertilizer, which enters the Dead Sea from the River Jordan[3]. A bloom of *Dunaliella* would in turn feed Archaea that could turn the sea red, says Gavrieli. Whether that is a problem is a matter of opinion. "What's the big deal if the Dead Sea is red?" Gavrieli asks. "What's worse, having it drop, or having it red?"

On the other hand, a change in the Dead Sea's chemistry might turn the surface water white. Currently, the sea is supersaturated with gypsum, a form of calcium sulphate, which barely precipitates because the kinetics of the reaction are too slow[4]. But gypsum will precipitate into white crystals if Red Sea water, which contains ten times more sulphate, is pumped into the Dead Sea as reject brine from a desalination plant. In a ten-cubic metre tank at the Dead Sea Works, Reznik, Ganor and Gavrieli have mixed equal parts of Dead Sea brine and desalination reject brine, and seen little white gypsum crystals bob on the surface. The large-scale, long-term consequences of such a change are unknown, says Gavrieli. Gypsum might sink to the lake bed, or it might form crystals that remain suspended in the upper water layer, turning it milky. A film of crystals on the surface could make the Dead Sea more reflective and slow evaporation; but if they remain in the top of the water column, the gypsum clumps could scatter light within the Dead Sea, raising its temperature and increasing evaporation.

The Dead Sea Works and the Arab Potash Company are important players in the fate of the Sea, as their evaporation ponds account for some 30–40% of the water-level decline. According to the Dead Sea Works, their evaporation ponds help the region by preserving the southern end of the Dead Sea, which dried up in 1977. They also provide employment for some 1,000 workers and support a large complex of hotels at Ein Bokek.

But Gidon Bromberg, Israeli director of FoEME, is not impressed. The potash companies, he says, could switch to extracting minerals by forcing Dead Sea water through membranes under high pressure. That would take more money and energy, but it would cause significantly less water to evaporate.

A set of studies recently completed by FoEME suggests that countries in the region could restore 400 million to 600 million cubic metres of water per year to the River Jordan, at a smaller cost than desalination, by managing demand through measures such as switching to compost or vacuum toilets, or flushing toilets with 'grey' water recycled from the shower. FoEME claims that more sustainable farming practices could also conserve water.

Working together

In the end, it will be the need for desalinated water that is most likely to drive the conduit's construction. Despite the considerable political tensions, all three governments need to cooperate, says Attili. "We don't have another choice," he says, because future generations will depend on new sources of water.

At the moment, the future looks uncertain in the desert beside the Dead Sea. At the end of a long, dusty day, Ganor and Reznik drive high above the lake to a rock bearing a faint red line, which marks the water level measured by British surveyors between 1900 and 1913. The Dead Sea now lies 35 metres below.

If nothing is done, the situation will only get worse, but a Red–Dead conduit would carry with it some real risks. The decision to stop the sea's decline, says Gavrieli, "is a matter of choosing between bad and worse. But the question is, what is bad and what is worse?" ■

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1. *Red Sea–Dead Sea Water Conveyance Study Program Feasibility Study. Options Screening and Evaluation Report. Executive Summary* (Coyne et Bellier, 2009).
2. *Red Sea–Dead Sea Water Conveyance Study, Environmental and Social Assessment. Preliminary Scoping Report.* December 2008 (ERM/BRL/Eco Consult, 2008).
3. Oren, A. *et al. J. Mar. Syst.* **46,** 121–131 (2004).
4. Reznik, I. J., Gavrieli, I. & Ganor, J. *Geochim. Cosmochim. Acta* **73,** 6218–6230 (2009).