PLANET TEXAS 2050
A UT Grand Challenge

Tracing Water

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By Mary Huber

Bull Creek at Loop 360 in Austin, Texas. Photo credit: Roy Niswanger

As Texas's population is expected to nearly double in the next 30 years, Planet Texas 2050 grand challenge researchers find it important to understand what effect rapid urbanization will have on the natural environment.

Jay Banner, a professor in the Jackson School of Geosciences, has spent the past several years studying the evolution of Austin's watersheds, tracing water as it moves from the Colorado River, to treatment plants and into people's homes. Banner and his student research team found that some of that municipal water, including wastewater, is leaking into Austin's rain-fed springs and streams. In fact, in some places, municipal water makes up the majority of water flowing in springs and streams. This raises concerns about the future of the delicate ecosystems nearby. You can read more about their findings in a recent report titled Stream and Spring Water Evolution in a Rapidly Urbanizing Watershed, Austin, TX, published in the journal Water Resources Research.

You and your team discovered something interesting about Austin-area springs and streams. What did you find?

We studied the chemical composition of a watershed in Northwest Austin called Bull Creek to try to understand the effect urbanization is having on the natural water system. In doing so, we found a significant amount of municipal water ending up in area springs and streams.

By municipal water, I'm referring to the city-supplied water that comes to and from our homes — the water that comes out of our taps and faucets. We hypothesized that this was because of failing infrastructure. We wanted to know exactly how bad it was: how much leakage was happening, where it was happening, and how this leakage might impact the sensitive aquatic ecosystem. Our concern is that the amount of municipal water getting into these springs and streams — namely wastewater — will degrade the habitat for many species, endangered and otherwise.

Why this location?

A watershed is essentially an area of land where all the water drains to a certain point. It’s a feature of the land because of its topography.

If you look at Bull Creek watershed, there’s an interesting pattern: the southwest portion is almost entirely undeveloped, but the northeast part that runs along the spine of Highway 183 is densely urbanized. There was this stark contrast. That was one reason we picked this watershed. We wanted to see processes that result from urbanization at their most fundamental level, and the way to do that is to do it in a watershed where there are very few variations aside from the extent of urbanization. The soil types, the bedrock geology, the rainfall are all the same. Any differences we determine are likely the result of urbanization.

The Bull Creek watershed comprises both rural and urbanized areas in Northwest Austin and drains into the Colorado River.

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What did you look at to determine if the water was municipal water or rainfall?

We started by using the element strontium as a natural tracer — looking for it in rainfall, the soil, the bedrock, and dissolved in the spring and stream water. We do this by measuring the amounts of the different isotopes of the strontium contained in these waters. Isotopes are naturally-occurring forms of the same element that have a different number of neutrons. It turns out that the amounts of the different isotopes vary depending on the original source of the water. So, in this sense, the strontium isotopes in a water sample gives it a "signal," something we can use to trace the water back to its original source.

Strontium-87 is an isotope produced by natural radioactive decay, and in general it's present in high levels in really old rocks. The Llano River northwest of Austin drains into the Colorado River, which serves as Austin's municipal water supply. When a river like the Llano drains a terrain with such old rocks, it dissolves strontium that carries a signal of this high strontium-87.

We can deduce, therefore, that municipal water has relatively high levels of strontium-87. By comparison, water in Austin's local creeks, which drains a terrain comprising younger limestones, bears a lower level of strontium-87.

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> this leaking infrastructure — that may be an unintended positive consequence of the failure of the municipal infrastructure because water stays available to these plants and animals even in times of drought.”

This high-versus-low level of strontium-87 is a valuable tool. It can be used to infer how much water is derived from natural water flow and how much is municipal water leakage and irrigation. The more developed parts of the Bull Creek watershed showed higher levels of strontium-87 because of leaking municipal water and irrigation, and both are a result of urbanization.

Should we be concerned that strontium is in our soil and water?

Strontium is merely an element, and it’s there all the time. It’s not harmful in the amounts that we find it in these streams. We shouldn’t be concerned about it. What we should be concerned about is that it indicates that municipal water — including wastewater — is getting into these streams, which can degrade the ecosystem and recreational areas.

How is municipal water ending up in our springs and streams?

In the Austin area, we rely on Austin Water utility for our drinking water, and that comes from the Colorado River. We pump it from the river to a treatment plant to clean it and make it drinkable, then we pump it from the plant to our homes. On both the supply and return side — so when it comes to our homes and when it makes its way back to the wastewater treatment plant — significant amounts of water leak from the pipes and get into the natural environment. Almost every infrastructure system anywhere in the United States, and the world, has some leakage associated with it.

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> water quality, so this is something we should really be taking a careful look at when we decide how we design the residential and industrial development of watersheds."

When there's a major leak, like a broken water main, it will flood the streets and we can watch it happen. But for every one of those floods that we see, there are many more that we don't see leaking slowly underground. The losses are on the order of about 10 or 15% of the municipal system a year, and that's not unusual for a large city in North America. This is something very common to urban environments, but it's a problem because the losses are costly, and wastewater at least is harmful to the environment.

According to your findings, more than half of spring and stream water at some urbanized sites in the Bull Creek watershed originates from municipal water. That seems like a lot of leaks — a lot of water getting out.

Absolutely. It kind of surprised us that it was that high.

Based on what you found in Bull Creek, can you infer that other Austin-area watersheds have similar levels of municipal water in them?

You can infer that. In other watersheds in the city, where we see similar extents of urbanization, we see high strontium-87 levels from municipal infrastructure leakage and irrigation. These data are consistent with the hypothesis that with increasing extents of urbanization, more municipal water is getting into these natural water systems.

Why should we care about this? What is the impact of having this municipal water in our springs and streams?

That's a really important question to consider. One can make the case that, if we were just looking at municipal supply water leaking, well, that water is good enough to drink, so it might not be too harmful to the plant and animal life in the watershed. But waterfront or 'riparian' ecosystems depend on the water resource of the stream and springs.

Visiting undergraduate research student Rosemary Burkhalter-Castro collects water samples from Bull Creek. Photo courtesy of Jay Banner.

If the quality of that water degrades, then the plants and animals that live in the ecosystem along the water will be endangered. If we introduce harmful levels of bacteria that come from wastewater — the water that runs down the drain in our sinks and toilets that may include human waste, cleaning chemicals or other toxins — that will degrade the habitat dramatically.

It’s really the wastewater part of it that is most concerning. The last thing we want to do is degrade water quality, so this is something we should really be taking a careful look at when we decide how we design the residential and industrial development of watersheds.

Interestingly, though, we also find some potential positive unintended consequences. Projections for Texas in the 21st century are that we will have longer and more intense droughts than those that we’ve seen historically, which is a real cause for concern. If that happens, those riparian ecosystems could face a real struggle to survive. If there’s a way to actually keep the water flowing — like through this leaking infrastructure — that may be an unintended positive consequence of the failure of the municipal infrastructure because water stays available to these plants and animals even in times of drought. With these positives and negative results from leaking municipal infrastructure, the question is, “How do we weigh which is more important?” It really depends on what we value.

How so?

As long as we’re thinking big, perhaps we can design a municipal water system that’s more leak-proof and that includes valves so that, at the discretion of people who manage the watersheds, we can actually open those valves during times of drought and have what might be the biggest drip irrigation system in the world. And still be able to go out in our streams and creeks without fear of being exposed to health hazards.

For citizens, is there a way to notice just by sight how much water entering the stream is wastewater or clean municipal water? How do we know if the water we’re swimming is the same water we’d drink at home or something dangerous?

Right. If I knew in Waller Creek, say, that all the leakage was just drinking water, I would be in there having a good time! So it’s a really important question: can we tell the difference? The strontium isotope tracers I mentioned give us a way to know how much of a watershed is municipal water, but that doesn’t tell us how much is safe, drinkable water — the water coming into our homes — or wastewater — the used water leaving our homes. We could use a number of other tracers to determine that, though. For example, we could look at bacteria in the water — things like fecal coliform and *E. coli*. Also, we do measure high levels of chloride and sodium in wastewater. We did see these wastewater signals in our study, so we know there are components of both — waste and supply water — leaking into these natural systems. But no, unfortunately, it's not something you can see with your eyes in otherwise clear, running water.

We're working on a new project now looking at the rings of the trees that grow along these creeks to determine when, exactly, the municipal infrastructure failed — was it sudden, or did it happen slowly and steadily over time? To reconstruct such a history, we will examine individual tree rings, which act as a sort of visible and chemical record of the water amount and water quality over time.

Jay Banner and UT geoscience student researchers core baldcypress trees along Austin's Waller Creek to see how municipal water runoff and leakage is affecting the local ecosystem.

What's the solution to this? Could this research help design the water system of the future?

We know there are two areas where we can take action. One, we could take existing leaky watersheds and restore them, and that's a very significant undertaking. You have to investigate the entire network, which is a real engineering challenge. It can be done, but it would take a lot of time and resources.

The second area where this knowledge can potentially be applied is looking at all the new landscapes and watersheds that will be developed in the future. By new, I mean not previously extensively urbanized or built out. We are going to have to build a lot to accommodate twice as many Texans by 2050. So, perhaps knowing the impacts of urbanization ahead of time, we can design the infrastructure to be more leak-proof and to be monitored more carefully. In the most ideal scenario, it could be made to be much more resilient.

In either the case of restoring existing watersheds or planning the development of new watersheds, it's an important consideration. A leaky system costs us money. If our municipal water supply is leaking, that means we have to pump even *more* water to our homes to account for the amount that leaks out before it gets to our taps. That means we're using more water and more energy, and that's a bigger carbon footprint. A tighter municipal pipe network is more resilient. It saves us resources and money and also protects our watershed habitats and recreational areas.

> The full paper, Stream and Spring Water Evolution in a Rapidly Urbanizing Watershed, Austin, TX, can be found in the journal Water Resources Research.

Please join us on this journey.

Planet Texas 2050 is a research grand challenge at The University of Texas at Austin. We're a team of more than 150 researchers across all disciplines working together over the next decade to find ways to make our state more resilient in the face of extreme weather events and rapid population growth. Follow us on Twitter, visit our website, and come back to our blog for updates.

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