ARCSA 2014 – Zero Net Water

#1 – Title, Zero Net Water

Thank you, Mike. The theme of this conference is "Rainwater Harvesting: Solution to U.S. Water Supply Challenges". So let's do some "big concept" thinking about that, and look at something that could create a *quantum leap* in business prospects for rainwater harvesting.

Last summer I wrote a blog post introducing "Zero Net Water", setting it out as a *sustainable water* development concept for the Texas Hill Country – and beyond.

#2 – Quote from blog

And it begins with this …

"Imagine a water management strategy that would accommodate growth and development without unsustainably pumping down aquifers or incurring the huge expense and societal disruption to build reservoirs or transport water from remote supplies to developing areas. Welcome to the concept of Zero Net Water."

As the name implies, it's a management concept that would result in zero demand on our conventional water supplies. Well, *almost* zero, as we'll see here in a bit.

Right here is a good place to interject for *this* audience that I'm presenting Zero Net Water in the context of *my* region, Texas. How applicable it might be to *your* area will depend on your climate and your water supply situation.

#3 – Zero Net Water components

Under Zero Net Water, water supply is centered on *building-scale* rainwater harvesting. Understand this is THE water supply across *whole* developments, perhaps done under *active sponsorship* of the entity that controls the conventional water system in the area.

Then we'd *also* <u>integrate</u> water supply with "waste" water management by centering *that* on *decentralized* reclamation and reuse for *irrigation* supply, and with stormwater management by using Low-Impact Development, green infrastructure and volume-based hydrology methods, to hold water on the land, maintaining hydrologic integrity of the watershed as it's developed.

#4 – The Result …

This *integrated* management results in *minimal* disruption of flows through the watershed, even as water is harvested at the site scale to be used – and *reused* there – to support development, creating a *sustainable water* development model.

#5 – Comparison, building-scale vs. watershed-scale RWH

We do this by taking advantage of the inherent difference in capture efficiency between *building-scale* and *watershed-scale* rainwater harvesting.

#6 – Watershed-scale RWH model

Of course, all our conventional water supplies are *watershed-scale* rainwater harvesting systems. *Which are inherently inefficient*.

A really *big* inefficiency is that only a *minor* fraction of rainfall over a watershed makes it into reservoirs or aquifers, the "cisterns" of that system. Most of it's lost to evapotranspiration, which of course supports plant life in the watershed.

And what *does* get into *reservoirs* is subject to very high evaporation loss.

Then the water from those cisterns must be distributed back to where it's used, losing *more* water. Industry standards say 15% transmission loss is "good practice", and many distribution systems have much higher losses.

There's also what you might call "quality inefficiencies". Water collected in reservoirs is somewhat *impaired* relative to the quality of rainfall, and needs considerable treatment. And even though it's generally considered potable, water in aquifers can be hard, or contain things like sulfur or iron, and *also* need some treatment.

And there's *certainly* a high energy cost. It takes a *lot* to lift water out of aquifers, to run water treatment plants, *and* the distribution system.

#7 – Building-scale RWH concept

The *building-scale* rainwater harvesting system blunts *all* those inefficiencies. The *inherent* capture efficiency off a rooftop into a cistern approaches *100%*. And the *building-scale* distribution system is built, and can realistically be maintained, “tight”, so transmission loss is negligible.

Rainwater captured directly off the roof is very *lightly* impaired, so doesn’t need much treatment.

And with a low lift out of the cistern, a very short run to where the water is used, and typically only a cartridge filter treatment system, the building-scale system uses *far* less energy.

#8 – Which model is more sane?

Now I ask you, which of these models is more sane? Collect *high* quality water, *very* efficiently, *where* it falls and use it there, or collect it at very *low* efficiency, with *impaired* quality, over the *whole* watershed, then *lose* a bunch – and use a lot of energy – running it through a looong loop – *back to where the water fell to begin with*?
[pause]
Okay, rhetorical question. Movin’ on …

#9 – Building-scale RWH “grows” water supply

Now since we install this system one building at a time, it “grows” the water supply in direct proportion with demand.

So *besides* more efficiently transforming rainfall into a supply usable by humans, creating a *sustainable* water supply system, it *also* creates a more *economically efficient* system, because supply is built, and paid for, only in response to imminent demand. Again, one building at a time.

10 – Building-scale RWH does NOT rob streamflow

Now before we go on, let’s dispense with a *myth* about this strategy. Some say harvesting off all the roofs would *rob streamflow*, that you *wouldn’t* more efficiently harvest water, you’d just *rob* some from downstream users who depend on that flow. But that’s just not so.

#11 – Hydrologic changes due to development graphic

Remember, we're talking about *new* development, and when we develop *raw* land, we increase this *quickflow* runoff – and decrease infiltration. When we go from a natural site to just 10-20% impervious cover, like in an exurban subdivision, we *double* the runoff, and with housing at more like urban intensity, we *triple* it.

As I said, under Zero Net Water, we'd use LID to mitigate that shift from infiltration to runoff. Development rules typically *require* us to capture and treat runoff, to protect water quality and minimize channel erosion. And we usually have to put in detention so the increased runoff doesn't cause downstream flooding problems.

#12 – Building-scale water cycle

So if we harvest runoff *only* from the *rooftop* portion of *new* impervious cover, we're just *mitigating* ***those*** problems, NOT robbing streamflow. On the developed site, even *with* rainwater harvesting, runoff *increases* over what runs off the native site.

The other thing is, water collected in the cistern does NOT exit the watershed. No one is putting it in a truck and hauling it away. We're just holding it up for awhile.

Most of that water eventually appears as wastewater. Under Zero Net Water, that's used for irrigation, so the water we harvested, *after* being used once in the building, is *still* maintaining plant cover in the watershed.

#13 – Bottom line …

So the bottom line is we capture and utilize some of that *additional* runoff created by development. We do that *instead* of allowing it to become *quickflow*, which if not mitigated in some *other* way creates water quality, channel erosion and flooding problems.

So we *can* fundamentally improve overall yield of water supply usable by humans *without* any significant impact on streamflow.

#14 – The caveat to "Zero"

Now as I said, there's a caveat to "Zero" …

#15 – Cistern is a reservoir

That’s because the building-scale cistern operates just like a reservoir, holding water for future use – indeed, it *is* a “*distributed* reservoir”. So like any reservoir, it’ll produce a “firm yield” of water supply.

Now, considerations of cost efficiency lead to the concept of “right-sizing” the building-scale system – its roofprint and cistern capacity – so, that “firm yield” would cover demands *most* of the time. Instead of spending a lot more upsizing the system to get that last little bit of demand, we’d bring in backup supply to cover that. If, and only if, conditions *do* get bad enough that we’d need it.

#16 – Backup supply from watershed-scale system

Of course, that backup supply would come from the watershed-scale system. So we “right-size” the building-scale systems to *minimize* that draw, because the watershed-scale system would *itself* be most stressed *just* when that backup supply is needed.

Now the total market for development is set by a whole lot of factors other than, “Is there a water supply available?” So we’d presume that *whatever* development is served by building-scale rainwater harvesting would not be *additional* development, it would just *displace* some of the development that would *otherwise* have drawn from the watershed-scale system. Indeed, the *point* is to *off-load* the watershed-scale system, so we can *avoid* costly expansions, like long pipelines from far-away aquifers or expensive new reservoirs.

So we off-load the watershed-scale system *most* of the time, allowing it to *retain* that supply, so it *could* provide a *small* percentage of total building-scale system demand through a drought.

And then, when the rains do come, the watershed-scale system would also *recover* faster, because we *stop* drawing that backup supply for the building-scale systems, again off-loading it.

#17 – DS modeling results

We can use a historical rainfall model to see what that "right-sized" system should be. My model covers the years 1987 to 2014. We'll look here at the results from the model using rainfalls in Dripping Springs, just west of Austin, which are fairly representative all around Austin and the nearby Central Texas Hill County.

We enter a *roofprint*, a *cistern volume* and a *water use profile*, and the model tells us how *that* system would've performed over the modeling period. Our *goal* is to need only a *limited* backup supply, *only* in the most severe drought years, so that's what we'd *also* expect in the future.

We see here, a 4-person household using water at 45 gallons per person per day, around Dripping Springs would need 45 hundred square feet of roofprint and a 35 thousand-gallon cistern. Out of the 28 years covered by this model, that system would've needed backup only in the severe drought years of 2009, and 2011, which was the *worst one-year* drought on record over most of Texas.

We've been having *chronic* drought there since 2008, and over *that* period, this system would've covered the *vast* majority of the total demand. Again, this system would've "off-loaded" the watershed-scale system *most* of the time, allowing it to retain capacity to provide, in this case, *only 3%* of the total supply <u>over this period of *drought*</u>. So this system meets our definition of "right-sized".

About that usage rate, we don't have time to go through it here today, but *45* is a rate that would satisfy a very *broad* swath of the population, given the efficiency of today's water fixtures. Indeed many people can do *better* than that – and we'll look at that here in a minute.

But first, you may look at that 45 *hundred square foot roofprint* and say, oh my gosh, you're just talking about large, high-end houses here, aren't you?

#18 – Roofprint graphic

No, we're not. Roofprint is not the *living space* in the house, it's the *roof* area, which includes the living area AND overhangs, the garage, and covered porches and patios. And *that* [pointing at porch] …

#19 – Veranda strategy house plan

… is where we could get a lot of additional roofprint, relatively cost efficiently, using what I call the “Veranda Strategy”. The idea is you surround the house with verandas – covered porches or patios – wherever that might be feasible.

I’ve looked at house plans of several builders active in the Hill Country, sketching on verandas like you see here, and determined that with a typical single-story house, you COULD get that 45 hundred square feet of roofprint.

Of course, if we designed the house around this idea from the *start*, we could do that more cost efficiently, and with more attractive designs.

#20 – Veranda strategy profile drawing

So I suggest that architects and builders consider this, and come up with “rainwater harvesting vernacular” house designs.

There’s another advantage to the veranda strategy – we can integrate the cistern into the house design. With a large area of veranda, we wouldn’t need a very deep cistern under its floor to get the storage we need.

So we could build the cistern around the foundation and not take up space on the lot for a free-standing cistern. That’ll be more important on smaller lots, of course.

#21 – DS modeling results, 40 gpcd

Okay, back to the modeling, and considering how *low* our water usage rate could go. As we see here, if we use water at a rate of *40* gallons per person per day, then our backup supply would be trivial.

I can relate from my *own* experience that 40 is *very* doable. My wife and I typically use *35-37* indoors, sometimes even down to <u>*30*</u>, in a 2-person household. We live in the city, on Austin Water. We really have no reason to try to be really highly conservative. It’s just *normal living* for us. Case studies of *other* experiences show *similar* results. So many people *really can* do better than 45.

#22 – DS modeling, 40 gpcd, down-sized system

And if we *can* hit 40, we could *downsize* the system and *still* need backup only in the severe drought years, *still* not putting much stress on the watershed-scale system. We cut the roofprint down to 4 thousand and the cistern to 30 thousand, giving us a considerable savings.

#23 – DS modeling, 35 gpcd

As they say in those TV marketing ads, "But wait! There's more!"

Many rainwater system designers in my area base sizing on an average usage rate of 35! Again, experience shows that *is* quite doable. Here we see, if we *can* do that, even with that *down*-sized system, the backup supply is again trivial.

#24 – DS modeling, 35 gpcd, further down-sized system

So again, we could down-size the system *even more*, and *still* cover the vast majority of demand through the recent drought.

Reducing the cistern down to 25 thousand will save you a bundle. And at 35 hundred, the roofprint is *now* in the vicinity of what you'd have with a more "normal" area of covered porch or patio. Making the system more cost efficient.

Highlighting that water use efficiency is *so* key to this whole strategy.

#25 – DS modeling, seniors oriented development

A prime market for building-scale rainwater harvesting are *seniors developments*, where you'd expect the house to be occupied by only *2* people. That's a *growing* market as the population ages, and really it's an even *broader* market than just seniors, as demographics show a trend toward *smaller* households generally.

So if we *do* have only *2 people* using water at 45 gallons, then we'd need only 25 hundred square feet and 15 thousand gallons for a "right-sized" system. Much less costly, so rainwater harvesting houses for *this* market would be more cost competitive.

#26 – San Antonio

Now looking around at other areas of Texas. San Antonio is interesting, because they're looking at a 142-mile pipeline across several counties, to tap the Simsboro Aquifer. That'll be VERY high cost water, which brings up social equity issues, *and* it takes a *big* risk on the *long-term* sustainability of pumping that aquifer as much as *they're* planning, along with several *others* who *also* want to export that water. Which has the people *living* in that area, who see *their* water future being compromised, *very* much up in arms.

San Antonio says they *need* that water to support their projected growth, but at the *end* of their 50-year planning horizon, isn't that population *still* going to be there, *still* needing water for another 50 years, and so on beyond that? So if you *deplete that aquifer* to grow that population, *then what*?

That's a question I asked in another blog post I titled "One More Generation", because that's when groundwater models show they'll have sucked it down pretty far. But long-term depletion just *doesn't* seem to enter their thinking. It's like they're *saying*, "Screw the future generations, they're on their own!"

But, back to *rainwater harvesting* in San Antonio. As we see here, the worst period *there* was 2008-2009, rather than 2011. And even with a bit larger systems than we'd need in Dripping Springs, we see a fairly high backup in those years. Still, those "right-sized" systems would've covered well over 90% of demand since 2008. Again, <u>this is through a period of *drought*</u>.

#27 – Collective conjunctive use schematic

To broaden the use of rainwater, they might integrate it into their overall system with collective, conjunctive-use systems, maximizing whatever roofprint *is* installed. While this'll get you into public water supply permits, we *should* look at this concept, to maximize rainwater harvesting in more *intense* development.

But *however* they'd do it, water supply can be grown *sustainably* with Zero Net Water, and *directly proportional* to increases in demand. So perhaps San Antonio should consider *broadscale* use of *building-scale* rainwater harvesting, *instead* of paying a *huge* cost, *all well in advance* of any need for that water, to drain a far-away aquifer.

#28 -- Brownwood

Brownwood is another interesting case because they said they “almost ran out of water in 2011”. Well, I look at this and it seems to me they didn’t “almost run out of water”, they just didn’t have the right infrastructure to capture and use the water they *actually had*.

We see here the right-sized systems in Brownwood are SMALLER than in Dripping Springs, and *still* would’ve covered an even *higher* percentage of demand since 2008. With only minimal backup supply *in 2011*.

So maybe Brownwood *too* should consider broadscale pursuit of building-scale rainwater harvesting. Maybe they should do that *instead* of the direct potable reuse system they’re planning. Can’t you see the marketing campaign for this – *Drink rainwater, not poop water!*

#29 – DFW, Ferris

Now a couple places around the Dallas-Fort Worth Metroplex. Ferris is on the southeast edge of the area, and there we see the right-sized systems would be VERY modest relative to what we saw in Dripping Springs, but *still* would’ve covered almost the *entire* demand through the drought since 2008. Note *these* right-sized roofprints are *small* enough that houses with a “normal” area of covered porch or patio should get it, so these systems would be relatively cost efficient.

#30 – DFW, Denton

Denton is on the northwest edge of the area, and there the right-sized systems are a little bigger, but still fairly modest, and would’ve again almost *completely* covered demand, through the drought, since 2008.

Well, this all suggests the Metroplex might *also* consider building-scale rainwater harvesting to expand *their* water supply. Instead of things like the Marvin Nichols reservoir. That’s a very *high* cost watershed-scale rainwater harvesting project that’s *very* much opposed by the folks in northeast Texas, where it would be located, because of the economic and ecological impacts it'll have there. And even under the *best* case it wouldn't deliver a *drop* of water to the Metroplex for *at least* a couple decades, while they can start growing their water supply RIGHT NOW with building-scale rainwater harvesting.

#31 – Introduce irrigation supply

Okay, now to look at water for irrigation. As I said, under Zero Net Water, we'd maximize wastewater reuse for *that* supply.

#32 – "Waste" water reuse high value to RWH

And indeed, "waste" water reuse is *highly* valuable to rainwater harvesters, if they want to maintain an irrigated landscape.

That's because, as we've seen, a "right-sized" system *just* for interior use is already "large". So to also supply irrigation *directly* out of the cistern, you'd have to make the system larger, and that'll be costly, of course. *Or* bring in a MUCH larger backup supply, as we'll see here in a bit.

But we have a flow of water sitting *right there* we could use for irrigation, that we've *already paid* a hefty price to gather – that's the "waste" water flowing from the house. *Don't lose it, reuse it*.

#33 – Headwaters neighborhood collective system plan

If needed, we can do this on a collective basis – and you *would* need a collective wastewater system in Texas if the development has lots smaller than a half acre. This is a sketch plan for a neighborhood in a project near Dripping Springs, from a blog post I wrote trying to convince developers to pursue *this* infrastructure model – to save water AND money, which of course makes *great* sense no matter *where* the water supply comes from. Do this, I argue, instead of continuing to centralize the wastewater to one *far-away* location, and then discharge it. *Throwing away the water we need for irrigation!*

This "decentralized concept" of wastewater management, if done right, can deliver many fiscal, societal and environmental benefits, and I could talk about all *that* for hours. But, for this discussion, just note that, *to do it right*, all these dispersal areas would be *subsurface* drip irrigation fields, for two reasons. One is to prevent exposure to the reclaimed water. Even though it would be treated to high quality and disinfected, exposure might still be a concern if we're irrigating right up around the houses, so we keep it underground.

But more importantly for *water management*, because drip provides *much* higher irrigation efficiency than spray. So we'd maximize the benefit we get from this reclaimed water *resource*. Again, we need peak efficiency in *all* our water uses.

#34 – Building-scale water cycle

We could *also* do this ON each lot with an on-site system, if the development has larger lots.

#35 – Schematic of HPBS/drip

This can be done with a highly robust, low-maintenance, energy efficient recirculating biofilter treatment unit, *reliably* delivering a very high quality effluent, again to a subsurface drip irrigation field.

#36 – Collage of drip fields

We'd array that field to serve our *highest* value landscaping. This is nothing new; I've been designing this system for over a quarter century. These are drip fields in some of those systems, and as we see here, drip can serve any type of landscaping.

#37 – DS modeling, irrigation without reuse

Okay, now let's look at the impact on our rainwater system of reusing wastewater – or not – to defray irrigation demands. We give the model an irrigated area, and an irrigation demand profile through the year, and tell it whether or not to apply the wastewater to irrigation.

Here we see that system we'd "right-sized" for *just* the interior use, *now* having to supply irrigation water too. I've used an irrigated area of 24 hundred square feet here for illustration, just because that's the size of drip field we'd have under *our* on-site rules for a three-bedroom house.

As we see, to supply irrigation for conventional turf over *that* area, we'd have to bring in backup in many years, and a WHOLE LOT in the worst drought years.

But, you know, in my area, water systems all have drought contingency plans, and irrigation is the *first* thing they curtail. So could you really bring in truckload after truckload for *irrigation*, even if you wanted to?

#38 – DS modeling, irrigation with larger system

Or would you have to "right-size" this system so it *too* would need backup supply *only* in the most severe drought years? That would add 25 hundred square feet of roofprint, upping it to *7 thousand*, and 10 thousand gallons of cistern, up to 45 thousand, *greatly* increasing the cost of the system. And even then, you'd *still* have to curtail in a year like 2011.

#39 – DS modeling, irrigation with WW reuse

But like I said, we've got that supply of water sitting *right there*, the wastewater. After using it once in the house, *don't* throw it away, use it again.

So going back to that smaller, *less expensive*, system, right-sized *just* for interior supply, and reusing the *wastewater* for irrigation, we *now* need backup for *that* system *only* in severe drought years.

Demonstrating, like I said, the *high* value of wastewater reuse to rainwater harvesters.

#40 – Street view of my house

Now on to how broadly building-scale rainwater harvesting could be applied.

With the roofprints we need to be right-sized around my region, you might question if this strategy is only for large-lot developments, or could be used on urban-sized lots too. Let's look at that, and we'll use my house as an example. Here's a street view of it. A single-family neighborhood, in Austin.

#41 – Lot plan, existing roofpring

And here's the lot plan. A one-fifth acre lot, 15 hundred 80 square foot, 3-bedroom, 2-bath house with a 2-car garage. Pretty typical in my neighborhood.

We see the *existing* house roof, *plus* a patio cover, gives us almost 27 hundred square feet of roofprint. Recall that's *more* than enough for a 2-person household, which is what we are, along with a 15 thousand gallon cistern, that we might fit in here, using buried tanks.

But that's just for 2 people. What about a 4-person household?

#42 – Lot plan, expanded roofprint

Well, there's some existing *trellises* out here that we could put a *hard* roof over. And, following the "veranda strategy", we could add shed roofs around the house, pretty much like the *existing* patio cover, as we see here. With all that, we're bumping up against that 35 hundred square feet we need for 4 people, if the water usage rate were 35.

Now, of course, it's really pretty clumbsy to retrofit a 60's-era house like this. But you can see, if you *designed a house* for rainwater harvesting from the *git-go*, you could readily fit *at least* 35 hundred square feet of roofprint on a lot this size. As for the cistern, we might put it under the veranda floor, like I illustrated earlier.

#43 – Front yard landscaping, with driveway in view

But what about irrigation, if we max out the roofprint just covering interior use?

Well, in my case, I don't need much irrigation water, because I've taken out the turf and installed a native plant landscape. I note this here *just to highlight* that part and parcel of Zero Net Water, we *need* to adopt a *regionally appropriate landscaping ethic*, using plants that *need less* irrigation. Again, we go for *efficiency* in every practical way.

But if you *do* need irrigation, look – every lot like this comes with a ready-made *pavement* area we could *also* use for water catchment – the driveway.

#44 – Lot plan, driveway collection

I’ve got about 625 square feet of driveway. It slopes toward the street, of course, so we could put an inlet grate here to catch the water and run it into an underground tank.

Or, the driveway could be permeable pavement. The rain would ooze through it into a storage space below. There’s *all sorts* of products on the market that are *made* to provide water storage below pavements. So we could *also* gather quite a bit of *irrigation* water on a lot this size.

Bottom line, we see Zero Net Water *could* be done in my region even on urban-intensity housing.

#45 – Minimum net water

Very briefly, I want to note a variant of this we might call “minimum net water”. If the development *will* get water service from a watershed-scale system, we can still pretty much take *irrigation* off the potable supply. In my region that would typically lop off *40%* of annual demand. And of course it would *greatly* reduce peak demand, which drives a *lot* of water system investment.

We could do this with a combination of that neighborhood-scale wastewater reclamation system, using *that* water to cover the *public* areas – front yards, parkways, parks and such – and rainwater harvesting to cover the *private* spaces, the back yards.

#46 – Roof runoff WQ/irrigation plan

We don’t have time to detail all this here – that’s covered in another blog post if you’re interested – but we’d *integrate* water quality management of this *rooftop* runoff with rainwater harvesting. Doing this, we’d get *superior* water quality management of that runoff, we’d restore the hydrologic integrity of this patch of ground *now* covered with the rooftop, and we’d provide irrigation water for the back yard. And by taking rooftops out of play like this, we’d *downsize* the green infrastructure needed to treat runoff from the *rest* of the site. Saving MONEY as well as water.

#47 – Commercial and institutional buildings

All right, so far we've just been talking about houses. But commercial and institutional buildings are a MAJOR opportunity for Zero Net Water.

The ratio of roofprint to water use in *those* buildings typically favors rainwater harvesting. And condensate capture could also provide a significant water supply, in our climate. We could do project-scale wastewater reuse for *irrigation*, and our LID/green infrastructure *stormwater* management scheme would harvest runoff from *paved areas* of the site too, and feed it into landscape elements, rain gardens, that don't *need* routine irrigation.

So commercial and institutional buildings, or *whole campuses* of these buildings, could readily be *water-independent* – "off-grid", not drawing *any* water from the *conventional* water system. That could save *a lot* of water, AND a lot of *money* for conventional water and wastewater infrastructure you *don't* have to build.

#48 – Cost … and VALUE

And finally, *about* cost. Of *course*, that's always going to be a *major* factor in whether *any* of this happens. But I suggest we frame the discussion in terms of VALUE.

As Oscar Wilde famously said, this society knows the *price* of everything and the *value* of nothing. That just might be the case here.

Because, by *conventional* accounting, water supply we get from building-scale rainwater harvesting WILL be quite expensive per unit of yield, mainly because of the high relative cost of cisterns, our distributed reservoir. So our mainstream institutions tend to dismiss it out of hand.

But there are many reasons to consider if it delivers VALUE that we shouldn't ignore. Here's just a few of them, very briefly, because *each* of these could be a *day-long* discussion themselves:

It minimizes the depletion of local groundwater, and loss of springflow. That's *very* important in some places.

It would blunt the "need" to suck down remote aquifers, or take land to build reservoirs, and all their attendant societal issues. Like the water war brewing over the Simsboro, or in northeast Texas over Marvin Nichols.

As we've noted, it's sustainable over the long term, since we live on the water that's falling on us, not by depleting water that's been stored in aquifers over centuries, or from reservoirs that'll silt up.

And again, it's an economically efficient strategy, since you *only* build, and pay for, the supply that's imminently needed.

It also minimizes public risk. Since it's *designed into* the site as it's developed, the cost of creating water supply is *largely* borne by those who benefit directly from *that* development, rather than by *all of us* through public debt. That's another long-term risk that I pointed out in "One More Generation".

That's because the growth projections for our region are *not* manifest destiny. You know, large water infrastructure projects just have this, if you build it, they will come, sort of "justification". But those projections depend on a *continuation* of trends the projections are based on. And that might be disrupted by *any number* of circumstances. So I asked, what if they built it and no one came? Or just, not enough to pay for it came? You may think the projected growth is *indeed* inevitable, and so that's a *remote* risk, but still it's one we could *avoid* by shifting to a *sustainable water* infrastructure model – Zero Net Water.

#49 – Zero Net Water end slide

Okay, that was a whirlwind tour through that concept. Really we only skimmed it – there were any number of topics we could've gone off on for hours. But I hope you got out of this that Zero Net Water takes rainwater harvesting *way* beyond how most people here today think about it, beyond *individual* decisions by a homeowner or business or builder, focused on their own *micro* situation.

It's about society *collectively* saying, *this* is how we will secure our water supply. Instead of, say, sucking the down the Simsboro and telling future generations, we got ours, good luck to you. Or telling the people in East

Texas, we don’t care about your economy or your ecology, we’re going to make you our *water colony*, because we’ve got the political clout to do that.

So really, it’s as much about *ethical living* as it is about water supply. I guess we’ll watch and see if this society is up to that.