

Excerpts from a discussion concerning the water supply of the Albuquerque Basin between Michael Wallace and members of the Middle Rio Grande Water Alliance

This conversation transpired over the summer of 2014

Participants shown include

Michael Wallace: aka Michael Wallace and Associates MWA an Albuquerque hydrologist

Middle Rio Grande Water Alliance: aka **MRGWA:** a taxpayer subsidized consortium focused on climate change and drought

Sunfarm, aka **Lynn Montgomery:** a drought activist and member of MRGWA

Michael Jensen: a leader within Los Amigos Bravos and a member of MRGWA. Also a drought activist involved in rate issues associated with Albuquerque Bernalillo County Water Utility Authority

Michael Campana: Professor of Hydrogeology and Water Resources, College of Earth, Ocean, and Atmospheric Sciences, Oregon State University. Former President of American Water Resources Association. Former Professor of Water Resources at the University of New Mexico.

John Hawley: Stratigrapher and Sedimentologist

William Turner: Water Rights broker

Frank Ward: Professor at New Mexico State University

Formatting guide:

underlined = email header

Italics = text of email

Bold = supporting annotation for time series. Also I've emphasized some of my own key comments in bold.

Subject

Re: (MRGWA) to grow or degrow? A question for the times.

From mwa

To sunfarm@toast.net

Cc mrgwa@waterassembly.org

Date Jun 13 2014 11:50 AM

..Brings up a question of Albuquerque's groundwater supply.

Can someone point me to the most current map or other database which depicts the extent in three dimensions of the potable water supply in the Albuquerque groundwater basin?

On Jun 13 2014 12:21 PM, mjensen@taosnet.com wrote:

I suggest asking the USGS, since they have done most of the studies and currently conduct monitoring on levels.

On Jun 13, 2014, at 3:56 PM, mwa <mwa@abeqas.com> wrote:

Perhaps there is a quick answer.. possibly John Hawley can point me in the right direction. I still wonder, and I have wondered often, where the 3D boundaries lie which define the potable water in this ~20,000 ft deep groundwater - filled natural bathtub (as researchers once characterized it)

I'm familiar with John's work in the 90s and his concerns on sediment fineness and resulting storage capacity - diffusivity issues.

But over the years I have never seen a 3D groundwater water quality map (or map set, or database, or GIS coverage) produced. I just took another idle look at NMBMMR and USGS. NMBMMR doesn't appear to have

anything regarding my search, and although the USGS appears to report water levels, and there are some isolated topics related to arsenic in some areas, there still does not appear to be a comprehensive report that outlines our (Albuquerque's) 3D groundwater quality picture.

But thanks for the suggestion, Mike. If you or anyone else have an insight on a good report, please let me know.

-----Original Message-----

From: Lynn Montgomery [mailto:sunfarm@toast.net]

Sent: Friday, June 13, 2014 7:28 PM

To: mrgwa@waterassembly.org

Subject: Re: (MRGWA) to grow or degrow? A question for the times

Here's something spatial. A few years ago Frank Titus stated that our depletions of the Albuquerque aquifer equaled a half cubic mile. The last time I saw him he said it was a lot more. We know that if we don't pay it back there will be dire consequences to river flows. We don't know if we can pay it back or how long we have before dissolved minerals precipitate out, coating and fusing medium particles. The recharge to the river is the same whether there's little flow or a flood. So it could take a long time for Mother Nature to pay it back. I have little faith we could substitute ourselves for Mother Nature in this case, so it looks like the future of the Rio Grande could very well be dry bank to bank and we will only watch. The much touted "recovery" is a few feet. A tiny deposit towards our arrears, Balance, between surface and groundwater, is a fallacy because surface use is linear and groundwater use is spatial. The effects of groundwater use are exponentially greater by a power, so a linear scale is useless and very misleading, thus the evil of surface to ground transfers. My Spring is drying up. It's never been this bad this time of year. The last of my old apricot, trees are dying. To hear claims of abundant water is more than irritating.
Regards, Lynn

.....

Subject

Re: (MRGWA) to grow or degrow? A question for the times

From mwa

To sunfarm@toast.net

Cc mrgwa@waterassembly.org

Date Jun 15 2014 4:40 PM

...

*I'm curious about Dr. Titus's claim. a Whopping .5 cubic mile of water use from the Albuquerque basin over the lifetime of our city?
If my informal calcs are correct (basin volume ~ 2,500 cubic miles, accounting for an assumed porosity of 0.25), that's a drop in the basin's bucket.*

I think this is rather absurd to sound an alarm about. For example, a comparison to the amount of water consumed over that same lifetime by irrigators in the MRG is interesting.

*If my informal calcs are correct, irrigators here have consumed about five to ten cubic miles of H₂O over that same period.
I'll keep in mind that both uses involve return flows.*

Twenty times the urban water consumption. I certainly don't have any problem with that, but I do wonder why there is any animus against urban water users. They deploy a much smaller per capita footprint upon the landscape and waterscape in comparison to most other users.

After a day of no response I wrote:

Subject can anyone disclose this number?

From mwa

To sunfarm@toast.net

Cc mrgwa@waterassembly.org

Date Jun 17 2014 10:58 AM

*What is the estimated volume of potable water stored in the Albuquerque Groundwater Basin?
It is a simple question.*

On Jun 17 2014 11:04 AM, Lynn Montgomery wrote:

The water quality diminishes as one goes deeper. At what point is the water still potable? Matter of taste? How much energy is required to pump the deeper water? Will we have access to such energy in the future? Is this a spacial question, or has the debate reverted back to insufficient linear conceptions? Like I said, the effects of groundwater pumping are exponentially greater by a power than surface water use. Has anyone challenged that? Not so far.

Regards, Lynn

Subject Re: (MRGWA) Re: can anyone disclose this number?

From mwa

To mrgwa@waterassembly.org

Date Jun 17 2014 11:16 AM

Thanks Lynn, but that's not responsive to my question, and a lot of what you say I would certainly dispute.

I think after the tens of millions of dollars of publicly funded research, we all are entitled to know the answer to this question:

What is the estimated volume of potable water stored in the Albuquerque Groundwater Basin?

After another day of no response I wrote:

Subject The Un-Quantified Basin

From mwa

To Mrgwa

Date Jun 18 2014 9:05 AM

*Can this be true? After all of the publicly funded studies and projects, and all of the urgency to conserve, **that NO ONE knows how much potable water exists in the Albuquerque Groundwater Basin?***

It is as if, as an urban dweller, I went to the Bank of Water to make a withdrawal, but was told "Sorry we cannot allow you to withdraw any more of your funds, the balance is too low". If I then asked what they indicate my balance to be, and they replied that they didn't know, does anyone think this can be acceptable?

..

On Jun 18 2014 11:44 AM, mjensen@taosnet.com wrote:

Michael:

.. I haven't come across anything that assigns a number to the amount of potable water in the Basin. That doesn't mean that people can't have reasonable understanding of what's going on, what the future holds, etc.

If you've read the studies, then you are surely aware that the Basin has not been studied in its entirety, so there are unknowns (but probably not "unknown unknowns"). However, the Basin has been studied enough to realize that very large areas of the Basin are either: 1) contaminated with things like arsenic and/or are brackish (making their use highly improbable or only with treatment) or 2) in formations that make removing the water impossible (or not economically viable). Most studies I have seen that deal with potable water show (in two dimensions) a significantly constrained area of potable water that represents a small fraction of the width and depth of the entire basin.

If you've followed events recently, then you also know that when the CABQ/ABCWUA was pumping 80k, 90k, 100k acre feet annually - in that area of constrained potability - that there was major draw down in the potable sections of the aquifer (within the metropolitan area). There was significant land subsidence detected, in some places almost to the point where it could become irreversible. Now that the ABCWUA is pumping about 55-60kafy, there is some rebounding, although this level of pumping is still somewhat above what pre-development recharge has been estimated at (but isn't any longer due to hard urban surfaces and water channeling).

In other words, there are limits to what can be pumped in any given year, regardless of what the total amount might be. The CABQ/ABCWUA realized that there were these limits to GW pumping and turned to the San Juan Chama water as the way to "save" the urban users. Within a year of the start of the SJC Drinking Water Project, the ABCWUA was talking about desalination as the way to "save" the urban user (despite very large technical, environmental, and economic issues). They now talk about Aquifer Storage and Recovery in the same way.

So, who knows. Maybe there are centuries of potable water in the Basin somewhere. I don't think so. But, regardless, for the time being, we can only pump - on a regular basis - enough to supply about 55-60% of our total demand, even with the large reduction in per capita daily use.

So, if you want to use your bank analogy, then maybe the better scenario is this:

You invested your money, but your financial advisor made investment decisions based on a bunch of faulty assumptions. You started to realize this and hired a new one. But those past decisions are hurting your cash flow. Lots of the funds aren't liquid; they're tied up in long-term investments that need to run their course before you can pull from them. Some were so badly conceived, you'll probably never get your funds out. You have some liquidity, but if you start drawing it down too quickly, your account gets flagged because the underlying investments aren't generating enough cash flow to transfer in. You are now on a budget and have only limited ability to increase your withdrawals and only on a temporary basis. In the meantime, you're trying to restructure your investments and look for new investments that will contribute to your liquidity. But, it's a bad investment climate - funds are drying up all over. Its going to take some creative thinking.

..

*Michael Jensen
Middle Rio Grande Projects Director*

Subject Re: (MRGWA) The Un-Quantified Basin
From mwa
To mjensen@taosnet.com
Cc mrgwa@waterassembly.org
Date Jun 18 2014 7:13 PM

Thanks Mike ..

*In the past I never systematically explored these issues for Albuquerque groundwater basin. **But it seems odd, and of concern, that even after your descriptions below, the Basin remains un-quantified.** For most other basins that I'm aware of, there is typically a simple summary: Basin X has ## acre feet of potable groundwater in storage, along with # af/year in recharge, etc. etc.*

I'll keep reading, and to follow up:

Can you point to a specific reference regarding your description of the significant subsidence due to pumping in metro Albuquerque?

And also can you point to a specific reference regarding the "very large areas of the Basin ..(which are) contaminated" ?

*I would like to read those reports if they can be obtained.
thanks*

From: Mike Wallace [mailto:mwa@abegas.com]
Sent: Thursday, June 19, 2014 1:16 PM
To: mrgwa@waterassembly.org
Subject: Re: (MRGWA) The Un-Quantified Basin

It would not surprise me if an estimate of thousands of years of extractable potable water supply were derived, even after every caveat were factored in.

I hope the MRGWA family will seek candid and cost-free answers from those who where already paid to develop these estimates.

***The initial question will ideally remain simple:
What is the estimated volume of potable water in the Albuquerque Groundwater Basin?***

If those scientists expect even more funding to provide a simple answer to this simple question, I hope any such future work goes out for competitive bid.

From: Frank Ward <fward@nmsu.edu>
Sent: Thursday, June 19, 2014 2:53 PM
To: mrgwa@waterassembly.org
Subject: Re: (MRGWA) The Un-Quantified Basin

Mike,

I like the challenge you've posed by stating your question. But I'd guess that the question as stated may not be answerable. To make it answerable, it might need to be re-posed to state something like:

What is the estimated sustainable volume per year that can be taken from the Albuquerque Groundwater Basin?

That sustainable volume would come from the river and precip falling on various places.

How much is legal for the City and surrounding areas to take from the basin for urban or ag use in light of existing water rights is, of course, a much different question.

end Frank Ward (add header from in box)

Sent from my Verizon Wireless 4G LTE smartphone
Date:06/19/2014 from Mike Wallace

Thanks Frank. My question is answerable and it is a standard and fundamental one to address.

The other questions you pose are good to ask as well of course, but I don't know how they can be addressed without some initial resolution of the foundational question.

It seems that we have for the most part only received a narrative about implied scarcity. Since the fundamental question was apparently never addressed, I have to wonder now about the credibility of any assertions we have recently received regarding basin supply forecasts and related scarcity.

It seems like deja vu, since the narrative is a little bit like that of GHGs and drought: plenty of alarming forecasts but little if any hard evidence

As Alex Proyas once asked: How do I get to Shell Beach?

Subject Re: (MRGWA) RE: The Un-Quantified Basin
From mjensen@taosnet.com
To mrgwa@waterassembly.org
Date Jun 19 2014 5:27 PM

I guess you can ask the ABCWUA and Rio Rancho why they are so hard at work looking for other sources of water besides the Albuquerque Basin's potable water.

Subject Re: (MRGWA) RE: The Un-Quantified Basin
From Mike Wallace
To mjensen@taosnet.com, mrgwa@waterassembly.org
Date Jun 19 2014 9:25 PM

Those questions seem redundant to the fundamental one.

It is a simple question.

The estimated volume of potable water in the Albuquerque Basin is X cubic miles

Constituents deserve to know X, and they have a right to consider everything X implies, before activists or others take the entire population on their own preferred path

The same goes for all of the GhG drought business. By your logic i should stop questioning GHG promotions because govt entities are already taking mitigation actions

..

It seems to me that any municipality should have roughly as good of an estimate of their portfolio of water resource assets as they do of other tangible assets such as real estate

Each type always has unique aspects and challenges etc., but our basin groundwater asset remains unquantified. There doesn't seem to be a reason

After a two week pause in the discussion:

From: William Turner [wturner@waterbank.com]
Sent: Monday, July 07, 2014 8:53 AM

To: mrgwa@waterassembly.org
Cc: mrgwa@waterassembly.org
Subject: RE: (MRGWA) We Need to Talk About Water Supply

One must understand how our universities divided up water programs. Back in the 60's NMTech had some extremely well known ex US Geological Survey scientists. Two of the brightest and best known were Carl Jacobs and Mahdi Hantush. They undertook to first quantitative work in the Roswell Basin. At the time it was recognized that water was going to become very important and because NM Tech already had to jump start that all fundamental water resource research should be centered on NM Tech. On the other hand, UNM Geology Department was headed by Vin Kelley. Vin was a grass roots geologists geologist and wanted nothing to do with water and insisted that the University with primacy over geology should be UNM. NMSU of course being the land grant school concerned with water pitched hydrology from an irrigation point of view that was eschewed by NM Tech. So that is the way it ended up until about 1983 when RCRA was enacted and the need for hydrologists to deal with ground and surface water pollution became evident. So, UNM hired Mike Campana from the Desert Research Institute and UNM Civil Engineering hired Bruce Thompson. Even so, a good deal of money went to NM Tech which hired Lynn Gelhar, Dan Stephens and later Fred Phillips. UNM has basically lost the hydrological sciences race to NM Tech. And, that is the way it is today.

On Jul 7 2014 11:56 AM, Campana, Michael wrote:
Hi, all.

I have been listening to the complaints of NM university hydrology and 'unquantified' GW (talk to USGS folks about the GW model) for weeks it seems.

Thanks, Bill, for clarifying things.

UNM geology hired a hydrogeologist (me) because even then it realized that like it or not, groundwater was becoming a big thing in geology. God forbid that a hydrogeologist be hired to 'pollute' geology! That was the attitude of many US geology departments. It is interesting to note that one of the brilliant hydrogeologists of our time - John Bredehoeft - is in the National Academy of Engineering, not the National Academy of Sciences.

When I arrived at UNM in 1989, I was told (by a UNM VP) that this is the way it was vis-a-vis water:

- 1) NM Tech did the groundwater, some quantitative surface water hydrology, vadose zone hydrology, aqueous geochemistry.*
- 2) NMSU did the ag water (including soil physics (some overlap with NMT) irrigation, etc), some surface water, watershed management.*

3) UNM was tagged as the 'water policy & management' school - folks like Lee Brown, Chuck Dumars & Al Utton (law), Chris Nunn, and others.

The explanation was that NM was a small state and did not want competing programs at the 3 'major' state universities. UNM Civil Engineering was allowed to hire water people (Bruce Thomson in 1981 and Richard Heggen around the same time) because they were relevant to 'modern' CE. I am unsure this condition still exists - UNM CE has some dynamite water people - Julie Coonrod, Mark Stone, Ricardo González-Pinzón (OSU PhD!).

This 'division of water' was apparent to me when I tried to get (early) support from the NMWRRI. I was supposed to do 'policy and management' not groundwater and did not get funded (told to me off the record). In fairness that had changed by the time I left UNM.

When Lee Brown and others started UNM's Master of Water Resources Administration (MWRA) program in the late 1980s, they had to convince NMSU to let them do it. How Lee did that has always baffled me (pictures?). Later, in the mid-1990s, I altered the MWRA Program to an MWR - Master of Water Resources - program,. Some people think this is a hydrology degree - it is not. There is a difference between 'hydrology' and 'water resources'.

Funny thing - in the mid-2000s I was developing a curriculum for a DWR - Doctor of Water Resources. One week after mentioning that to a UNM official, another UNM official received a call from 'someone' at NMSU saying that they were the 'water school' and they would never allow such a degree. That contributed to my decision to leave UNM for OSU because I had hit the 'water glass ceiling'. I also like the land-grant status of OSU (like NMSU) since it is more in line with what I am interested in doing. I don't expect UNM to have that viewpoint.

It is interesting to note the situation here in Oregon. UO has absolutely no engineering/hydrology at all. OSU has all that, but PSU - since it is located in the major metropolitan area (70% of the population) - is being allowed to develop such programs. Other states have this division as well. Purdue and IU are similar, as are UNC and North Carolina State U.

Sig, if you think hydrologists are not quantitative then you have been hanging around the wrong hydrologists. And there are very good reasons why petroleum folks and economic geologists can peg the amount of developable resources at a given price. I don;t need to explain this to you. We don't value water in the same way.

Speaking of assessing water supply, I have been waging a campaign against those organizations that discount groundwater when it comes

to
available water (similar to some of the complaints voiced about NM
but
on a global scale). Since I am over 65, I am now a curmudgeon, and
that is fine with me. See <http://is.gd/eymoFr>

I will be back again in a few months.....returning to my hole in the
soggy soil.....

I enjoy the discourse, BTW.

Michael

....

From: mwa [mwa@abeqas.com]
Sent: Monday, July 07, 2014 2:43 PM
To: Campana, Michael
Cc: mrgwa@waterassembly.org
Subject: Water Supply - MEC's' 10 Cents - short changed

*Who cares about university hydro-drama-histories when that **discussion doesn't answer this question of Albuquerque Groundwater Basin potable volume? It's a simple question that is worth a straight answer.** It is not to be dismissed so easily as changing the subject, or by simply placing the question in mock quotation marks.*

Given this lack of official estimates, it may be that the older 1960's era USGS estimates were not so far off as the contemporary narrative. This forum would surely benefit from a straightforward reflection about that from the hydros in the room or outside experts that could be queried, but when will that ever be?

I also wonder how it is even possible to have a fully productive discussion or negotiation about water in this basin and river reach without an honest estimate of that groundwater asset as a key foundation component to work from. The tools are there, and I'm surprised that others suggest they are not, since I've worked and/or collaborated with many who do exactly this.

Mike W.

*...Ok and I think I do care about that academic history. It's interesting to hydros at least
Sorry serially Mike*

*And your estimation method seems reasonable to start from. I had done a set of similar exercises but used a variety of areas and thicknesses of the potable 'layer' with a wide range of answers
When I work from a limited area estimate and conservative storage factor I still see something like 76 cubic miles of potable Albuquerque Basin groundwater.
My value is unofficial. Is there an official estimate to compare to?
If even roughly true, it might serve a useful purpose for future related discussions*

from: "Michael Campana" <Michael.Campana@oregonstate.edu>
To: mrgwa@waterassembly.org
Cc: mrgwa@waterassembly.org
Sent: Tuesday, July 8, 2014 4:54:00 PM
Subject: (MRGWA) Replies: 1) How to estimate GW volume..

1) Hi, Mike,

Your estimate strikes me as being in the ball park (order of magnitude); 76 cubic miles = 260 MAF (FYI: double the volume of Lake Tahoe). I do not know of any official estimates of the volume of potable groundwater in the basin. I would guess the following might have some: USGS, NM Bureau of Mines, ABCWUA, OSE. I would put my money on the first two. I recall a student of mine, Skip Hohweiler, in the mid-1990s estimated something on the order of 100 MAF+. I don't believe it's in print anywhere. He used some geophysical log estimates of porosity and the Hawley & Haase report.

Too bad Kelly Summers is not still with us. He could probably answer your question.

From: John Hawley [mailto:hgeomatters@qwestoffice.net]
Sent: Tuesday, July 08, 2014 5:19 PM
To: mrgwa@waterassembly.org
Subject: RE: (MRGWA) How to estimate GW volume

The historical-background items .. are very appropriate and much appreciated, especially in terms of such methane-rich debate on how many angels can sit on a virtual geohydrologic pin (with apologies to St. Tom Aquinas). ..

Note also that the oft-cited Hawley and Haase (1992) document was primarily a NM Bureau of Mines [now Geology] compilation of work by many institutions and individuals (notably the USGS, NMOSE, many private consultants, and a bunch of geoscience grad students at UNM and NM Tech. Kelley Summers instigated the project, and Norm Gaume insured that it was adequately funded and enthusiastically supported by the ABQ Public Works Department and the USBOR-ABQ Office (Hansen and Gorbach 1967). Steve Haase and I simply provided a new conceptual framework (originally developed for NMWRRRI-NMSU research in the Mesilla Basin) for organizing the existing enormous hydrogeologic database on the ABQ Basin that dated back to the seminal work of Kirk Bryan and C.V. Theis in the late 1930s.

..

..John Hawley

On Thu, July 10, 2014 7:54 am, mwa wrote:

Looks like the time is long overdue for a message to all constituents and Journal readers. That message should hopefully be that the early USGS claims of abundant groundwater were right all along. One could conceivably convert the entire City to turf for centuries without causing much of a dimple in the resource.

I hope NM State and City boosters get the message to Tesla and others, who might otherwise shy away from our area based on incorrect representations of water scarcity.

It's far and away nothing like an arcane scholastic debate. It is a principal asset of our city and State.

From: mjensen@taosnet.com </div><div>Date:07/10/2014 8:22 AM To: mrgwa@waterassembly.org Subject: RE: (MRGWA) How to estimate GW volume & TESLA

Michael:

I don't know what posts you were reading, but most of the ones I read

qualified the total estimated potable groundwater estimates with impacts such as land subsidence and increased river depletions (and attendant impacts to the Bosque) and the fact that "potable" water - narrowly defined - in many locations has high levels of arsenic, for example. There is a difference between water being there and water being there at a cost that is acceptable to the suppliers and their customers. If potable water is as abundant and accessible as you seem determined to have it be, I repeat my question to you: why is the largest water utility in the state continually looking for other sources of sustainable water supply and not just pumping the basin? Why is Rio Rancho spending tens of millions of dollars exploring the feasibility of deep brackish water & desalination? Why has every proposed development of the Atrisco land grant - Westlands, SunCal, the Atrisco Oil & Gas Co, and the current Santolina project - explored deep brackish water development with desalination - Atrisco O&G and SunCal were fighting over who owned those rights? Is it your belief that all of these entities - private and public sector - are idiots? If so, seems to me that voters, the Legislature, and investors all have some grounds for action here ...

Subject RE: (MRGWA) How to estimate GW volume & TESLA
From Mike Wallace
To mjensen@taosnet.com, mrgwa@waterassembly.org
Date Jul 10 2014 9:28 AM

*Mike, I would be happy to explore your concerns. Perhaps MRGWA could sponsor a dialog that includes a talk from me or the like and we could raise awareness on the problems that you perceive and the ones that I perceive. I have plenty of experience in subsidence and groundwater quality to draw from for my part. **The short answer is there are no show stoppers to sustained extraction of the Abq groundwater resource.***

With regard to some of your other comments, I don't always know why other people do other things. It is possible that they look for more water because they didn't get the message that Abq gw supply is abundant

----- Original Message -----

Subject: (MRGWA) Lower Colorado River Basin Groundwater Disappears: Where is Mike Wallace?
Date: Jul 25 2014 9:06 PM
From: "Campana, Michael" <Michael.Campana@oregonstate.edu>
To: mrgwa@waterassembly.org
Reply-To: michael.campana@oregonstate.edu

Hi, John and MRG friends,

I thought of Michael Wallace and his 'unquantified groundwater basins' when I read this quote from Stephanie Castle:

"We don't know exactly how much groundwater we have left, so we don't know when we're going to run out," Stephanie Castle, a water resources specialist at UC Irvine, and the study's lead author, said in the statement. "This is a lot of water to lose. We thought that the picture could be pretty bad, but this was shocking."

So the CRB lost 41 MAF of GW in 10 years. Is that a lot? How much of the groundwater stock is that? 5%? 10%? No one knows for sure. Perhaps we should try to find out. Ya think?

Jay Famiglietti's a smart guy so he knows all this (lack of gw stock data) and I am sure the lack of knowledge of GW stocks is mentioned in the report. I hope so - I have not read it.

Upshot: You have to take the GRACE data with a grain of salt. it doesn't tell you the groundwater stock, just the flows, as net water gain or loss. Helpful but incomplete.

Kudos to Mike Wallace!

Michael