

Appendix

Technical Aspects of “The Story” Compilation of Expert Team Reports

Appendix Sections

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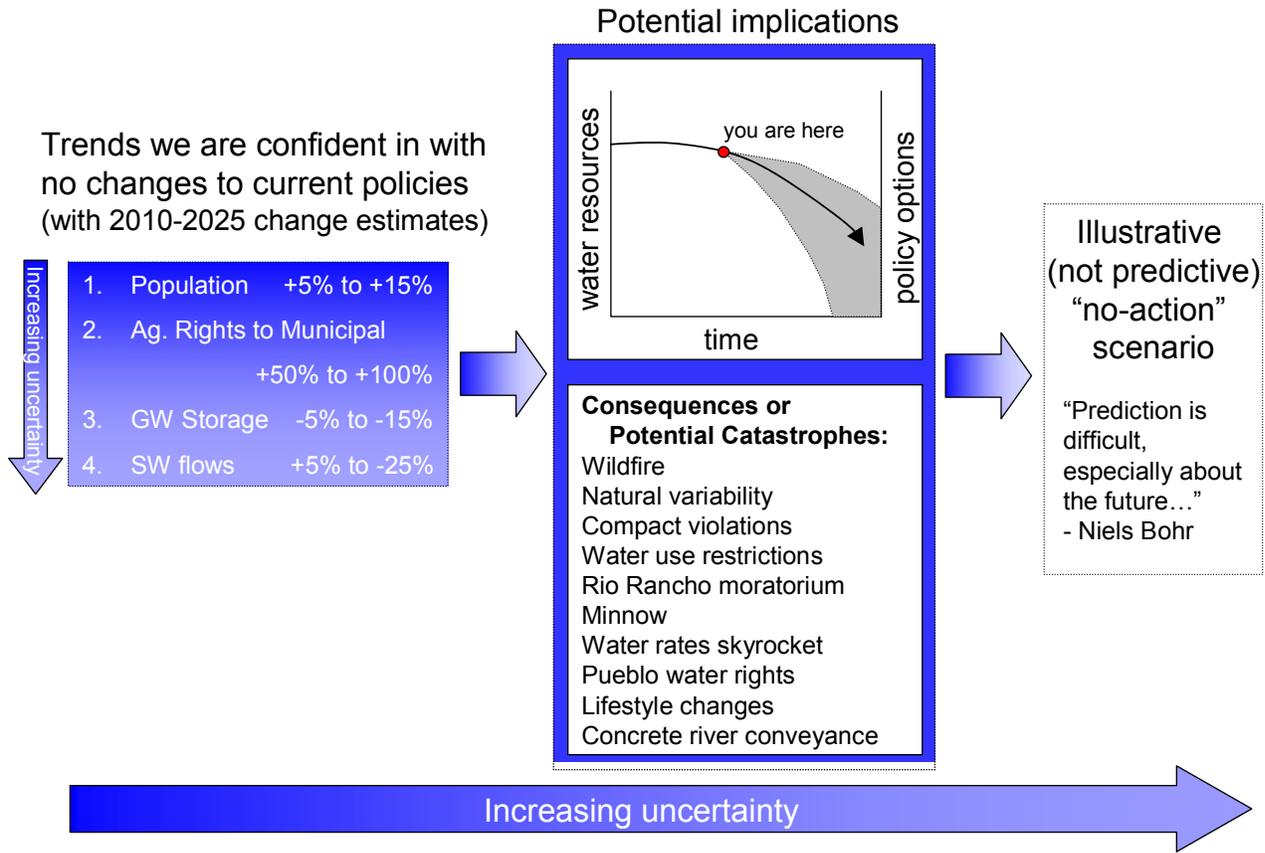
14th Annual Water Assembly
June 12, 2010
UNM / Dane Smith Hall

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1. Overview: Jesse Roach, hydrologist, computer modeler, Sandia National Labs

Setting the stage for the scenario



2. [Climate](#): David Gutzler, climate researcher at UNM

- Inflows will be lower
- Plants will use more water
- Urban demand up because its hotter (Think Phoenix)
- Still within range of variability of water budget
- Back to millennial averages
- Higher variability within historic range
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For at least the past millennium the climate of southwestern North America has been characterized by extreme variability from year to year and decade to decade (i.e. droughts and wet spells). More recently, starting significantly in the latter half of the 20th Century, temperatures have been increasing and are expected to increase further on multidecadal time scales in the 21st Century. The anticipated combination of high variability and gradually warmer temperatures creates special challenges for water management that add to the challenges associated with increased demand for water. Recent studies combining data analysis and climate projections suggest that:

- 1) Streamflows into the middle Rio Grande from snow-fed headwaters will decrease by 2025, due to diminished snowpack and increased evapotranspiration. Different model projections indicate decreases in average annual runoff, relative to late 20th Century average flows, ranging from about 3% to more than 10%. The range of these projections is large, but all the projections trend downward.
- 2) The late 20th Century "average" (often calculated from a 30-year average from 1971-2000) was actually an extraordinarily wet period relative to longer term averages. A reduction of approximately 10% in average flow is roughly equivalent to reverting back to the mean inflow in the Rio Grande over the entire period of record since the Rio Grande Compact was negotiated.
- 3) The specific annual inflow that we will experience in the year 2025 is not predictable 15 years in advance, but a reduction in the average expected flow of 3-10% is still well within the range of variability that water managers are accustomed to seeing. However, long-term reductions in flows gradually reduce the scope of management options for dealing with short-term water shortages (see point 5).
- 4) Demand for water in the summer goes up as temperatures increase. The rise in demand is very hard to quantify, and will depend on how aggressive urban centers choose to be with regard to landscaping, and on future directions in agricultural diversions in the valley.
- 5) Points 1-4 all refer to expected averages. Average values are irrelevant if nature delivers a big drought around 2025. We can't predict whether that will be the case; but we can confidently predict that a 1950s-style drought (or an event even more severe and longer lasting) will occur sometime in the 21st Century. What will we do between now and 2025 to prepare ourselves for this eventuality?

References:

- Gutzler, D.S., and T.O. Robbins, 2010: Climate variability and projected change in the western United States: Regional downscaling and drought statistics. *Climate Dynamics*, submitted for publication.
- Hurd, B.H., and J. Coonrod, 2007: Climate change and its implications for New Mexico's water resources and economic opportunities. Technical Report 45, New Mexico State University Agricultural Experiment Station, 27 pp.

3. [Fire: Howard Passel; Mike Hightower and Sheldon Tieszen, Sandia National Labs](#)

Fire will most likely have a significant impact in the bosque by 2025. In the west in the last few years 5-10% of forests have been burning annually, with those rates increasing exponentially, and that pattern holds roughly true for the MRG bosque. At those rates, from 2010 to 2025, another 15-30% or more of the bosque may have burned, with a concomitant risk to human property in and around the bosque. Most of the recent fires in the bosque have been fires that began in the overgrown understory but that rose to the crowns, creating extremely hot fires that burn all above ground vegetation. Without extensive clearing of bosque undergrowth, continuing crown fires should be expected. Destructive crown fires along with dropping water tables and increasing temperatures (due to global warming) could lead to wholesale shifts in species compositions in the bosque, and to a shift from the traditional cottonwood-willow bosque to a system more suited to an arid climate.

4. Policies, Permits and Procedures: Elaine Hebard, Michael Jensen, Beth Richards

What the policies of 2010 will produce in 2025

Please note that all numbers are approximate!

Over all

- MRG is continuing to muddle through with neither final adjudication nor effect of any changes coming from adjudication.
- Policies may change but without much effect, unless something happens to cause a crisis. Potential crises include extended drought, renegotiation of the Colorado Basin Compact in ways that diminish Upper Basin supplies, other legal decisions that might impact use of San Juan-Chama (SJC) project water, over-pumping of groundwater that impacts stream flow, or ESA requirements.
- Ultimately, there may be changes in ways the water is administered (such as that Pueblo water is leased for urban uses once quantification occurs).

Local Government Current Policiesⁱ

Urban

- MRG population increased from 788,515 to 1,277,459, of which 85% is urban.ⁱⁱ
- MRG urban water withdrawals increased from 162,721 af in 2005 to 182,000 af.ⁱⁱⁱ MRG urban withdrawals increased from 35.70% to 45% in 2025.^{iv}
- Urban depletions, even with SJC project water, have continued and are increasing now that pumping has nearly resumed at historic levels.^v
- Despite using SJC project water, the regional water table has continued to decline which was predicted in the modeling of the project's impact. In certain places, houses, roads, pipes and other infrastructure in Albuquerque are at risk through subsidence.
- Urban area
 - Has increased in density.
 - Much of the valley floor has been paved over in Bernalillo County.^{vi}
 - GPCD has declined to 140.
 - All residences can use no more than 180 gallons per house.^{vii}
 - Mesa del Sol, one of the four major planned subdivisions outside of the urban cores, is beginning to be built.^{viii}
- ABCWUA, which now includes Rio Rancho
 - will store 10,000 af of SJC project water^{ix}
 - will recycle / reuse 10% of water produced
 - will continue to be bonded to capacity^x
 - will continue to provide water for growth, mostly directed by County development decisions.^{xi}
 - Rio Rancho, because it was unable to obtain sufficient water rights to cover its impacts on the river, became more innovative in its reuse of water before being acquired by ABCWUA^{xii}
- Competing with Santa Fe, MRG urban areas need to purchase more than 35,000 af water to provide for the population increase, transferring usage from Valencia and Socorro County irrigators or pursuing new supplies.^{xiii}

- A desalination treatment facility is under construction, and will supply 15,000 af as a drought reserve.^{xiv}

Agriculture

- Efforts to promote community gardens, increase food production, local foodshed programs have increased during the past fifteen years, resulting in more vegetables being grown in the green fringe along the river and around the urban areas. Drip irrigation is now promoted due to the water table declining and the percentage of irrigation water actually reaching the shallow aquifer is *de minimis* in Bernalillo County.
- Despite the modest reduction of urban use per capita, more water is needed by urban areas. Pressures to transfer water away from agriculture are stronger than agriculture promoters, so land use continues to change, particularly further from the urban areas.^{xv}
- While water is not transferred as quickly as occurred in the 'oughts, the net effect is that there will be less diversion with consequence of less recharge and water consumption (ET) and less return flow through the drains.
- Several ditches have been closed, reducing the number of walking / riding trails and recreation opportunities.
- MRGCD commenced adjudication in Conservancy Court more than ten years ago. Pueblo water claims have not yet been quantified.
- Surface waters have been reduced due to climate change by 5-10% on average, with repeated instances of short-term declines – especially in winter, but increasingly in summer, too – that occasionally dry segments of the MRG.^{xvi} More groundwater depletions are impacting river flows as well

Riparian ET / River Flows

- After spending tens of millions of dollars on bosque restoration, the results did not show a reduction of riparian evapotranspiration in the many acres of bosque in the region. However, such restoration has reduced fires by 25% and has assisted in the increased usage of the area by residents.
- Climate change has increased ET, while reduced river and drain flows have reduced shallow groundwater, making the Bosque drier and more susceptible to fire. The decline of cottonwoods and reduction in restoration efforts means a return of invasives, which has increased ET where invasives occupy the understory and cottonwoods still exist.^{xvii}
- Budget cuts have suspended the restoration program indefinitely.^{xviii} Bosque volunteers, UNM Department of Biology and the six Pueblos help to maintain about two-thirds of the MRG portion.
- In the reach between Paseo del Norte and the ABCWUA wastewater treatment plant, the water table has continued to drop, eliminating cotton woods in certain areas which are now nourished by drip lines.^{xix}

State and Federal Policies

Water Quantity

Flow Dependent - If the flows are reduced enough, then the Biological Opinion and Rio Grande Compact deliveries will be in much bigger conflict than they already are, which could result in more pumping, less diversions, using up the stored water faster and increased river leakage

If flows reduce enough, the WUA cannot fully divert SJ-C water (has to reduce to maintain 500cfs below the diversion), further aggravating groundwater pumping and depleting the river and the related shallow groundwater; if flows go low enough, the WUA cannot use ANY SJ-C water (if cannot maintain at least 250cfs); this starts in Winter when MRG flows are lowest, but extends into the Summer months; if there were a drought, SJ-C diversions might be disrupted year-

round and the upstream storage would disappear really quickly ... And, if the Colorado Compact is forced into upstream re-allocation because the downstream states have exhausted all conservation/efficiency options, then the SJ-C water will become limited (not to mention possible impacts from San Juan Basin settlements when drought hits the CO Basin states ... that is: the MRG is in a bigger watershed than we think of, subject to political calculations we have little influence over

OSE

- Continue to "manage for depletions," "keeping the river whole."
- MRG Administrative Area Guidelines have not been changed, allowing a depletion of ground water to an additional 37'.

ISC

- By 2025, we have violated the Rio Grande Compact

Water Quality

NMED

Triennial review - Things are going in two opposing directions: huge push back from industry to cut regulations and that will keep happening. Agency budgets will be cut so there won't be as much oversight and regulating. Environmental community is getting more organized and getting more sympathy in legislature.

Concentrations of contaminants in the river will increase because of more contaminants and because of less flow (climate change/drought/more leakage)

One thing that has come up in the last two Triennial Reviews is the NMED setting lower water quality standards as flow drops in rivers and streams, since standards are based on designated uses and DUs change with flow regimes (among other things); we have strenuously resisted this change with some success, but the NMED's SWQB is now considering a new “Hydrology Protocol” whose outcome is focused on just such a scenario and under which 3rd parties (developers, dischargers) can hire a consultant to do a flow analysis and declare that a stream is ephemeral, for instance, and ask for permission to discharge or otherwise impact what might have been (or even is, still) an intermittent stream.^{xx}

EPA

- New pharmaceutical standards are in place (including for endocrine disrupting compounds already found in the river and drains)
- Pueblos will push for more stringent standards, citing Isleta as an example

Federal Agencies

BoR & Army Corps

- Storage rules for the Abiquiu Reservoir was revised to allow for more storage.^{xxi}
- Otherwise, no change in the operation of reservoirs or storage capacity

Fish & Wildlife

- new Biological Opinion is in place

Pueblo and Tribal Water Claims

- Continue to solidify their water claims and assert rights to develop water quality standards

Endnotes for Policies, Permits and Procedures

ⁱ With 18 local governments participating in MRCOG's Water Resources Board alone, not to mention several Soil & Water Conservation Districts, acequia associations, on down to elected neighborhood associations, there are too many policies to be considered individually. The MRCOG Survey of local actions summarized local governments' self-assessments of actions being implemented in accord with the Regional Water Plan. Instead, the focus was on the policies of ABCWUA and MRGCD, in part because their withdrawals represent the majority of the region's total as reported by the OSE.

ⁱⁱ *A Report on Historical and Future Population Dynamics in New Mexico Water Planning Regions*
 Table 4.13 - Projected Population and Annual Average Growth Rate: July 1, 2000 to July 1, 2060
 Middle Rio Grande Region

Projection Year	Total Region Population	Bernalillo	Sandoval	Valencia	Torrance
2000	708,709	553,827	88,560	66,152	169
2005	788,515	611,361	105,512	71,459	183
2010	913,662	709,680	119,868	79,894	213
2015	1,039,695	808,329	142,073	89,045	248
2020	1,161,485	901,664	161,078	98,459	284
2025	1,277,459	989,710	180,137	107,294	318

Source: Population Estimates and Projections Program, Bureau of Business and Economic Research, University of New Mexico, August, 2008, For the New Mexico Interstate Stream Commission, <http://www.ose.state.nm.us/PDF/Publications/TechnicalReports/BBER-WPR-Estimates-Projections-Aug2008.pdf>

Note that the estimated MRG population reported by the US Census for 2009 was 841,428. (Data released March 23, 2010, <http://bber.unm.edu/demo/nmcos.htm>)

Table 29. New Mexico Urban and Rural Population, 2000
<http://www.census.gov/compendia/statab/2008/tables/08s0029.xls>

Total population (1,000)	Urban population (1,000)		Rural population (1,000)
	Number (1,000)	Percent	
1,819	1,364	75.0	456

Source: U.S. Census Bureau, 2000 Census of Population and Housing, Population and Housing Unit Counts PHC-3.

For Census 2000, the Census Bureau classifies as "urban" all territory, population, and housing units located within an urbanized area (UA) or an urban cluster (UC). It delineates UA and UC boundaries to encompass densely settled territory, which consists of:

- core census block groups or blocks that have a population density of at least 1,000 people per square mile and
- surrounding census blocks that have an overall density of at least 500 people per square mile

The Census Bureau's classification of "rural" consists of all territory, population, and housing units located outside of UAs and UCs. The rural component contains both place and nonplace territory. Geographic entities, such as census tracts, counties, metropolitan areas, and the territory outside metropolitan areas, often are "split" between urban and rural territory, and the population and housing units they contain often are partly classified as urban and partly classified as rural.

ⁱⁱⁱ In 2005, GPCD for Bernalillo County was 175. Acknowledging that several assumptions are embedded in the following example calculation, if the GPCD for Bernalillo County were 140 in 2025, approximately 35,000 af in additional water would be withdrawn.

Bernalillo County Public Water Supply and Domestic Self Supplied

		Total Annual Withdrawals			
	Population	af	gallons	gallons / day	GPCD
2005	614,508	120,694	39,328,312,886	107,748,802.4	175
2010	788,515	141,320	46,049,276,000	126,162,400.0	160
2025	989,710	155,206	50,574,182,272	138,559,403.5	140

Based upon: 2005 MRG Public Water Supply and Domestic Self Supplied, OSE Report; Population for 2010 and 2025 from BBER Population projections; Solved from GPCDs of 160 and 140.

New Mexico Water Use by Categories 2005

	Bernalillo County		Sandoval County		Valencia County		MRG	
	af	%	af	%	af	%	af	%
Commercial (self-supplied)	6,555	3.77%	2,642	3.16%	1,592	0.80%	10,789	2.37%
Domestic (self-supplied)	6,037	3.47%	2,754	3.30%	3,926	1.98%	12,717	2.79%
Industrial (self-supplied)	1,130	0.65%	3,880	4.64%	63	0.03%	5,073	1.11%
Irrigated Agriculture	43,920	25.25%	54,382	65.09%	186,216	93.89%	284,518	62.42%
Livestock (self-supplied)	378	0.22%	129	0.15%	911	0.46%	1,418	0.31%
Mining (self-supplied)	917	0.53%	688	0.82%	3	0.00%	1,608	0.35%
Power (self-supplied)	363	0.21%	0	0.00%	0	0.00%	363	0.08%
Public Water Supply	114,657	65.91%	13,861	16.59%	5,624	2.84%	134,142	29.43%
Reservoir Evaporation	0	0.00%	5,215	6.24%	0	0.00%	5,215	1.14%
	173,957	100.00%	83,551	100.00%	198,335	100.00%	455,843	100.00%

Source: Longworth, John W., P.E.; Valdez, Julie M.; Magnuson, Molly L., P.E.; Albury, Elisa Sims; and Keller, Jerry; 2008, <http://www.ose.state.nm.us/PDF/Publications/Library/TechnicalReports/TechReport-052.pdf>

Table prepared by emh

Notes:

- a. The Rio Jemez and Rio Puerco are not split out separately.
- b. Does not distinguish between ground water and surface water withdrawals.
- c. The OSE numbers do not include withdrawals for riparian ET and open water evaporation.

The net difference between MRG withdrawals in 2000 and 2005 was 15,750 af which breaks down as follows:

- 21,762 acre feet decrease in agricultural and livestock withdrawals
- 2,722.26 acre feet increase in Commercial, Industrial and Mining withdrawals
- 4,196.06 acre feet decrease in Public Supply and Power withdrawals
- 5,155 acre feet, a reduction of half, in Reservoir evaporation

Of the total reductions of 23,235.49 af, more than ninety percent came from the decrease in agricultural withdrawals. While the population increased by 57,830, water withdrawals decreased by 3,255 acre feet in Bernalillo County. Most urban withdrawals are from groundwater, ultimately impacting surface water flows.

Noteworthy is that 22,846 af more water was withdrawn in 2005 than in 1990 in the MRG according to the OSE.

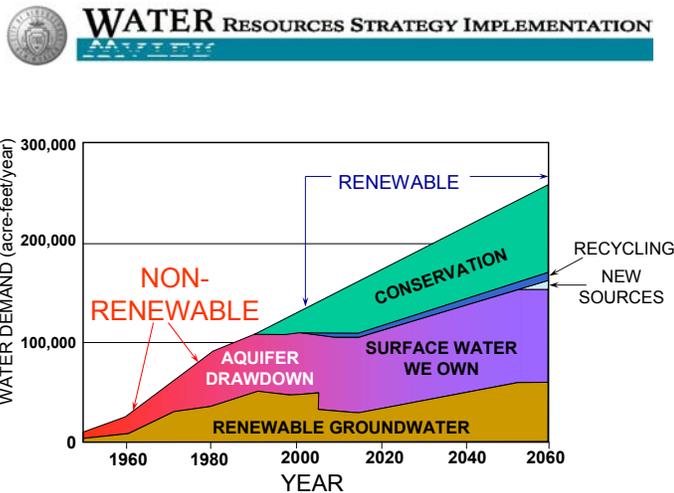
The OSE numbers do not include all of the withdrawals from the system, such as river leakage, riparian ET and open water evaporation. In the *Historical And Current Water Use In The Middle Rio Grande Region* report done for the Regional Water Plan, riparian ET and open water evaporation withdrawals amounted to nearly 25% of the total. Moreover, although depletions are no longer reported by the OSE, in the *Historical* report, riparian ET and open water evaporation accounted for 44% of the regional depletions.

1995	Withdrawals		Depletions	
	%	af	%	af
public water supply	25.30%	151,800	25.20%	85,680
agriculture	46.99%	281,940	27.52%	93,568
riparian vegetation	15.52%	93,120	28.14%	95,676
open water evaporation	9.17%	55,020	16.26%	55,284
mining	0.10%	600	0.05%	170
self-supplied industrial	0.32%	1,920	0.11%	374
self-supplied commercial	0.98%	5,880	1.06%	3,604
self-supplied domestic	1.29%	7,740	1.13%	3,842
livestock	0.29%	1,740	0.48%	1,632
self-supplied power	0.04%	240	0.05%	170
		600,000		340,000

John Shomaker & Associates, Inc. & PioneerWest, June 2000

^{iv} Urban withdrawals include Commercial (self-supplied), Domestic (self-supplied), Industrial (self-supplied), and Public Water Supply. Agricultural withdrawals include Irrigated Agriculture, Livestock (self-supplied). The Other category includes Mining (self-supplied), Power (self-supplied) and Reservoir Evaporation. They break down as follows: Urban = 162,721 af or 35.70%, Agriculture = 285,936 or 62.73%, and Other = 7,186 af or 1.58%.

^v ABCWUA water management policy, as depicted by the following graphic, shows that pumping will begin to steadily increase after 2020.



In a recent submission to the Office of the State Engineer regarding the Bear Canyon ASR Pilot Project, the ABCWUA claimed that modeling in the region "shows the recovery of groundwater elevations starting around 2009 due to the decrease in pumping in the Water Authority production wells. The recovery continues until about 2024, when increases in pumping start to draw the water table down again." (*Data Synthesis Report Bear Canyon Recharge Demonstration Project Underground Storage and Recovery Permit USR-2*, April 2, 2010)

^{vi} "If the trend of dispersed development in the Albuquerque area continues until 2050, approximately 125,000 acres of the Middle Rio Grande Basin landscape will be urbanized, with a resulting population density of 11.8 persons per urban acre." (FOCUS 2050 Regional Plan of the Middle Rio Grande Council of Governments)

^{vii} Current ABCWUA policy is for all new residences to meet this standard.

^{viii} Four major subdivisions have been approved by local governments - Rio West, Sandoval County; Mesa del Sol, Albuquerque; SunCal, Bernalillo County, and Rancho Cielo, Belen.

^{ix} Based upon ASR Proposal, submitted November 30, 2009 and a Policy of the 2007 Water Management Strategy.

^x Stan Allred, April 17, 2009, told the ABCWUA Board that it was bonded to capacity. See 2010 Proposed Budget.

Joint Water and Sewer System Improvement Revenue Bonds for \$55,630,000, Series 2008A "The Authority believes that water received pursuant to the contract for San Juan-Chama water and the rights to Rio Grande Basin water will be sufficient to support, in perpetuity, population of more than 900,000 using 150 gallons per capita per day with 50% consumptive use and 50% return flow." (March 2008, RBC Capital Markets, www.fpr.net/fulfillment/pdf/post_os_albuquerque_nm_water_utility.pdf)

^{xi} If implemented, the Planned Growth Strategy is only a City of Albuquerque plan. Bernalillo County is currently paying ABCWUA to run a water line to Cordero Mesa at Paseo del Volcan. The pipe line is to assist SunCal in attracting jobs, a requirement for them to construct more housing. ("The Bernalillo County Commission's approval of bonds to pay for a new waterline would put taxpayers on the hook for an \$8 million project for which West Side developer SunCal Cos. had already agreed to pay." *Taxpayers May Foot \$8M Bill for Waterline*, By Sean Olson, Journal Staff Writer, Wednesday, April 15, 2009, <http://www.abqjournal.com/news/state/152317272627newsstate04-15-09.htm>; "Bernalillo County Manager Thaddeus Lucero said SunCal could not meet a Solar Array Ventures, or SAVe, timeline to acquire the land, forcing the county to take on both the land acquisition and water-line construction responsibilities at a cost of about \$8.5 million." *County Jumps in To Save Solar Deal*, By Sean Olson, Journal Staff Writer, Monday, June 22, 2009, <http://www.abqjournal.com/news/state/22231819state06-22-09.htm>)

^{xii} Larry Webb re Rio Rancho current policies

^{xiii} Tom Turney & Rolf Schmidt Petersen's conclusions

^{xiv} Recommendation 6, Policy G - Develop and Implement Long-Term Water Acquisition Plan of the 2007 Water Management Strategy. (<http://cabq.legistar.com/View.ashx?M=F&ID=449430&GUID=FA611AF3-2104-44B8-8F4F-6C91F5156C4B>)

The Kay Bailey Hutchison Desalination Plant in El Paso, Texas currently produces 15.5 MGD of permeate (desalted water) and 12 MGD from new wells to blend the water for a total of 27.5 MGD. About 3 MGD of waste is produced. (http://www.epwu.org/water/desal_info.html). According to Guy Bralley, the TDS in the Rio Puerco, however, is roughly 4 times the concentrate that is being re-injected!

^{xv} The additional 35,000 af to supply urban demand mentioned in Endnote 2 translates into 16,700 acres of irrigated lands being dried.

Based upon the OSE 2005 Water Use report, irrigated acres in the MRG were reduced by 3,709 acres between 2000 and 2005. Applying that change to the next fifteen years to 2025, 11,127 additional acres would be taken out of irrigation. Additional irrigated acreage was reduced in Socorro County with water transfers into the MRG.

MRG	2000	2005
Irrigated Agriculture, af	296,559	284,518
Acres	41,043	37,334

(includes Rio Puerco & Rio Jemez)

^{xvi} Climate Change Group

^{xvii} This is the highest ET scenario, with invasives alone least and cottonwoods alone in the middle per a presentation I saw in Julie Coonrod's seminar a couple of years ago (mj)

^{xviii} MRG Bosque Initiative funding is gone after FY2010.

^{xix} See for example, the 1942 photograph of a reach of the Santa Cruz River south of Tucson, Arizona, which shows stands of mesquite and cottonwood trees along the river. The photograph of the same site in 1989 shows that the riparian trees have largely disappeared, as a result of lowered ground-water levels. <http://pubs.usgs.gov/fs/fs-103-03/images/fig3.JPG>.

^{xx} Hydrology Protocol (<http://www.nmenv.state.nm.us/swqb/hydrology/>). The NMED's rationale is based on CWA and EPA requirements and rules. Basically, the Protocol would apply to all currently unclassified streams and rivers (ie, unclassified as to perennial, intermittent, or ephemeral). The issue is that standards have to be "attainable", so if flows diminish, a standard might no longer be attainable, such as temperature, which tends to rise with lower volume, or "aquatic life" criteria, which almost by default wouldn't apply to ephemeral streams. It's been argued that there are many examples of aquatic life that inhabit ephemeral or intermittent streams as part of their life cycle, etc in an attempt to prevent negative "Use Attainment Analysis" (UAAs) from being carried out, especially by third parties that might have a vested interest in a less stringent set of criteria and related standards.

^{xxi} "The Water Authority is diligently working towards obtaining the necessary permanent easements and has requested a modification to our existing storage contract. Currently, there is no agreement between the Water Authority and the Corps related to discretion for storage and how that relates to future native water storage for the Water Authority, Rio Grande Compact or endangered species. Upon completion of easement acquisition, the Water Authority will need federal authorization to increase storage in Abiquiu." San Juan-Chama and Native Storage in Abiquiu, 2010 Federal Legislative Priorities for the Water Authority (<http://cabq.legistar.com/View.ashx?M=F&ID=802600&GUID=1D7896A9-B1A3-4B8F-A9DD-12E2117FD15A>)

5. Economy: Lee Reynis, economist

The severity of the three years of drought seems obvious. The main questions are: (1) whether one may expect serious droughts to recur time and again -- a persistent pattern of limited precipitation and drought; (2) whether other areas are similarly affected by drought or by weather extremes (e.g., intense storms with flooding, which seems to be one of the indicators of climatic change/global warming); (3) the nature of the policy responses here and elsewhere (burying one's head in the sand is hardly likely to inspire confidence).

Assuming that we face a period of prolonged and serious drought that is more serious than the situations elsewhere and/or that the policy response here is to dither while other communities face up to the challenges, the economy of this area -- so blessed by climate, by scenic vistas, and by an abundance of opportunities for outdoor recreation -- will suffer. The natural environment is a major amenity that makes this area attractive to tourists as well as a desirable place to live and to locate a business. The choice to stay here is an expensive one for many, as the average wage is less than 85% of the national, and as the public education system (k-12) is underfunded and generally inferior to those available in other states.

It is not just that "business importation became more difficult." Rather,

Some homeowners seeing the deterioration of their New Mexico paradise put their homes on the market and headed for greener pastures. New housing construction slowed to a trickle and homeowners stopped pouring money into additions and alterations. For sale signs went up in neighborhoods across the area and homes sat vacant for months, often encouraging vandalism. Rather than appreciating, housing prices in the area began to decline, a phenomenon not seen since the Great Recession of 2008-09.

Worried about prolonged drought in the area and disappointed by the government response, some companies considering investments in Albuquerque looked elsewhere, and some of the corporations here shut down their Albuquerque operations or, with little encouragement from local managers, decided against making needed plant and equipment upgrades. Private nonresidential construction activity withered as capital investment in new plant and equipment, in new office and commercial structures, and in alterations and additions slowed. The Albuquerque area experienced disinvestment and falling real estate values

The downturn in construction resulted in a fall-off in gross receipts tax revenues for communities throughout the area. Declining property values ultimately impacted property tax revenues as well. Indeed, the most important local government revenue sources declined in real terms, precipitating something of a fiscal crisis. Governments were hard pressed to maintain service levels much less to make investments that could have helped to ameliorate the impacts of the drought.

Another note, "welfare costs escalated" is probably not the best way to phrase the increased use of unemployment insurance (temporarily and only if eligible employees), foodstamps and Medicaid. NM still has TANF, which is what most people think of as "welfare" but it is now a temporary program for families and has work requirements. These are all safety net programs; income maintenance programs would be another way to describe them. The need for these programs will surely rise under the scenario presented. Some are federal programs or have a large federal subsidy. NM may have difficulty meeting the required match.

6. [Infrastructure](#): Lora Lucero, urban planner, land use attorney, editor

from the Planned Growth Strategy report prepared for Bernalillo County about 10 years ago, with a 25 year horizon:

The consultants determined that the city-county has serious rehabilitation and deficiency needs for water, sewer, storm drainage and streets. “Rehabilitation” is the substandard physical condition of existing infrastructure without increasing capacity for new growth. “Deficiency” is related to the costs to expand infrastructure capacity to conform to engineering standards.

The consultants projected \$2.4 billion in rehabilitation/deficiency costs over a 25-year period, noting that the cost burden falls mainly on the public sector (about 90%). A high percentage of the rehab needs are located within Albuquerque’s 1960 city limits. Main water line breaks have occurred in older neighborhoods, in areas annexed prior to 1960, but water service line failures have for the most part taken place in newly developed areas. There were 2,602 main line breaks in 1996 and 1997. Of those, 2,060 (79%) were within the 1960s boundary.

The anticipated costs --- in millions:

Rehabilitation Associated Costs

Water	\$505.4
Sewer	\$347.0
Storm Drainage	\$35.0
Streets	\$912.3
TOTAL	\$1,800.0 million

Deficiency Associated Costs

Water	-----
Sewer	\$15.3
Storm Drainage	\$221.5
Streets	\$463.2
TOTAL	\$699.9 million

The identification of the level of public spending needed for infrastructure rehabilitation and deficiencies is only part of the picture. It is important to compare this to the average level of spending occurring.

Annual Public Rehabilitation Needs and Expenditures - Difference between need and spending

Water	- \$11.1 million (-55%)
Sewer	- \$6.7 million (-48%)
Streets	- \$3.8 million (-12%)
Hydrology	.5 million (+36%)
TOTAL	-\$20.4 million per year (-31%)

The shortfall in public funding is significant --- nearly \$20 million per year or 31% less than the total requirement. The situation is more pronounced in water and sewer where actual spending is 55% and 48% lower than needed.

The consultants opine that this problem is directly related to the city's reactive mode to new development. Rather than directing new development to locations where it would be most efficient based on existing infrastructure, the city has followed development wherever and whenever the developer wanted to build. This has serious long-term consequences for the public sector that pays for the lion's share of the infrastructure.

I have seen no indication from a policy perspective that the city-county has altered this "reactive mode" approach in the 10 years since this report was issued. The current economy might have slowed new development for a while, but it won't change the bottom line.

Take away message: Albuquerque and Bernalillo County are growing inefficiently and, arguably, inequitably. Existing residents are subsidizing the short-term needs, while long-term rehabilitation and deficiency needs are left unmet.

7. [Energy](#): Bruce Thomson, hydrologist, director, UNM Water Resources Program

Impacts of Energy Supply Changes on the Middle Rio Grande Water Resources

Overview: The Energy-Water Nexus

While much attention on the interdependency between water and energy (DOE 2006), most of this attention is focused on energy generation, and specifically thermoelectric processes (fossil fuel and nuclear power plants) and hydroelectric plants. The links between water and energy are compelling and are illustrated conceptually in Figure 1 (DOE, 2006). A more complete list and general summary of the nature of the linkage between energy development and transport is presented in Table 1 (DOE, 2006). The statistical linkage between water and thermoelectric power generation is especially impressive.

- Thermoelectric plants diverted 132×10^9 gal/d (1995), but return 97% to source.
- Thermoelectric power generation accounted for 3.3% of total freshwater consumption in 1995 at 3.3×10^9 gal/d.
- Energy demand will more than double consumptive use to 7.3×10^9 gal/d by 2030.
- Nation's demand for electric energy will increase by 53% by 2030

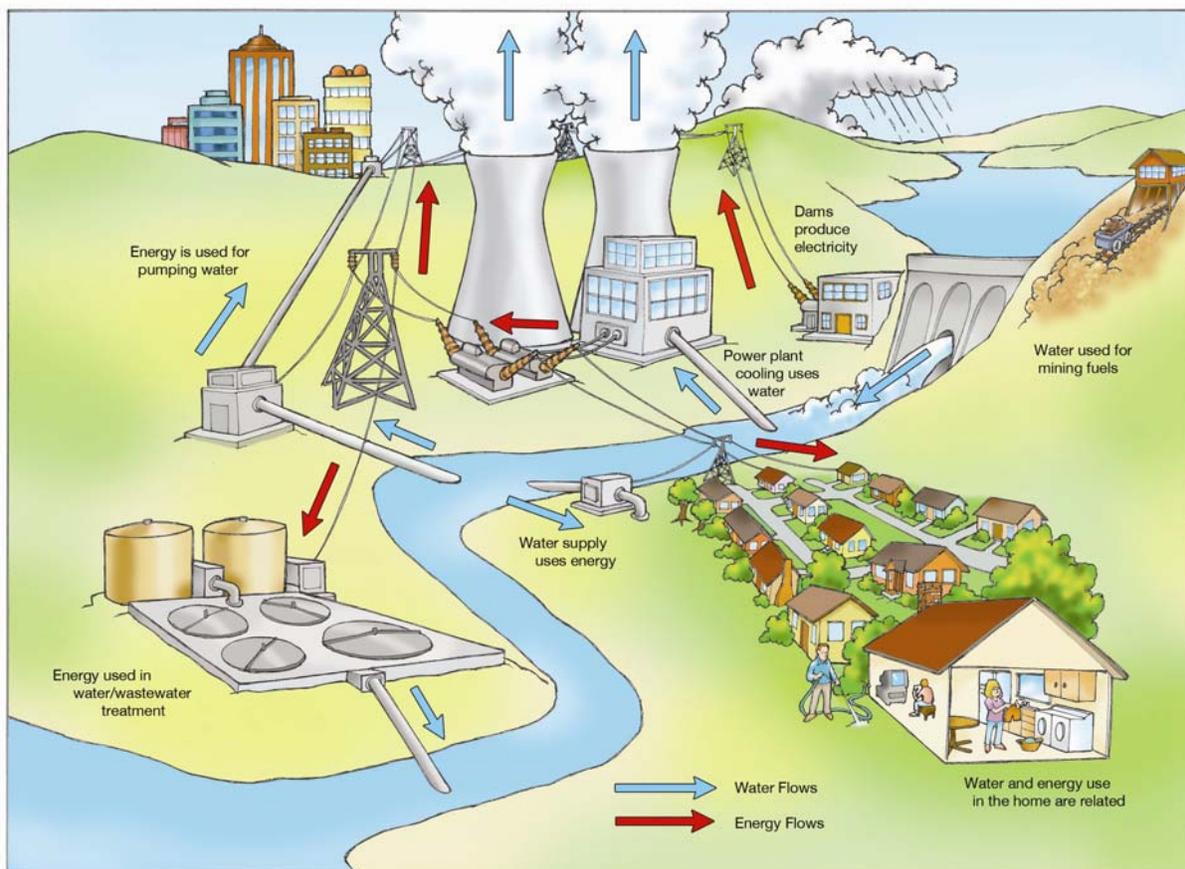


Figure 1. Examples of the interrelationships between water and energy (DOE, 2006).

However, the watershed of the upper Rio Grande (CO, NM, TX) has very few energy related projects that impact water use; there are no large thermoelectric power plants and no significant projects of the other sectors described in Table 1 (extraction, production, refining, or transportation). It is interesting to note that there are three small hydroelectric power plants at El Vado dam (8 MW), Abiqui dam (13.8 MW) and Elephant Butte dam (28 MW) but they are located on reservoirs whose principal purpose is not power generation and are not managed to optimize production and thus have relatively little impact on the region's water supply. The principal provider of electric power to the Middle Rio Grande planning region is the Public Service Company of New Mexico. PNM's PNM's power plants are fueled by coal (41 percent of total), nuclear power (16 percent), natural gas (22 percent) and wind (8 percent).

Table 1. Connections between energy sector and water availability & quality (adapted from DOE, 2006)

Energy Element	Connection to Water Quantity	Connection to Water Quality	Energy Element	Connection to Water Quantity	Connection to Water Quality
Energy Extraction & Production			Refining & Processing		
Oil & Gas Exploration	Water for drilling, completion & fracturing	Impact on shallow groundwater quality	Traditional Oil & Gas Refining	Water needed to refine oil & gas	End use can impact water quality
Oil & Gas Production	Large volumes of produced, impaired water	Produced water can impact surface & ground water	Biofuels & Ethanol	Water for growing & refining	Refinery wastewater treatment
Coal & Uranium Mining	Mining operations can generate large quantities of water	Tailings & drainage can impact surface & ground water	Synfuels & Hydrogen	Water for synthesis or steam refining	Wastewater treatment
Electric Power Generation			Energy Transportation & Storage		
Thermoelectric (fossil, biomass, nuclear, solar)	Surface & ground water for cooling & scrubbing	Thermal & air emissions impact surface waters & ecology	Energy Pipelines	Water for hydrostatic testing	Wastewater requires treatment
Hydroelectric	Water lost to evaporation	Can impact water temperatures, quality, ecology	Coal Slurry Pipelines	Water for slurry transport, water not returned	Final water is poor quality, requires treatment
Solar PV & Wind	None during operation; minimal water use for panel & blade washing		Barge transport of Energy	River flows & stages impact fuel delivery	Spills or accidents can impact water quality
			Oil & Gas Storage Caverns	Slurry mining of caverns requires large quantities of water	Slurry disposal impacts water quality & ecology

Energy & the Rio Grande Basin

In contrast to other states such as California and Arizona, there are no large pumped diversions of water along the Rio Grande in NM except the ABC WUA San Juan Chama diversion, the non-potable reuse diversion, and a new drinking water diversion under construction by the City of Santa Fe at the Buckman arroyo site. In contrast, 19% of California's electric use and 32% of its natural gas is water-related (California Energy Commission, 2005). The trans-mountain diversion of water from the San Juan watershed to the Rio Chama is all by gravity. Furthermore, all agricultural diversions for the MRGCD and other irrigation districts is also by gravity flow.

Thus, unless future energy development projects occur in the Rio Grande basin, the only impacts of future changes in the cost and/or availability of energy will be experienced by water and wastewater utilities. The Electric Power Research Institute has conducted an extensive study of the energy requirements for water supply and treatment (EPRI, 2002). Nationwide, roughly 4% of the nation's electricity use is for moving (80%) and treating water and wastewater (20%). Water supply, treatment, and distribution together typically constitutes about 80% of a community's energy demand. The energy demand in communities which rely upon wells typically require about 30% more electricity than communities which rely upon surface sources, due primarily to the higher raw water pumping costs.

8. [Endangered Species Act](#): Mike Matush, biologist, water quality division, NM Environment Dept.

The Endangered Species Act remains a formidable force in shaping the riparian community, but small isolated refugia have taken the place of widespread plantings formally referred to as riparian restoration. Bosque fires have created a mosaic in the middle Rio Grande and residents are now protected by the adoption of fire breaks (buffering) that are now populated by mass plantings of grassy and wetland herbaceous plant materials. Prescribed fires have been reintroduced to maintain the buffering plant community that many refer to as ‘more natural’, others call it ‘broken’. Controversy remains with the state of the riparian condition but riparian landowners consider it aesthetic versus a means of catastrophic fire protection. Fire protection has become the priority over specie concern. The fire buffering, mosaic and increased diverse community tends to agree with the greater public. To offset specie concerns the state and federal government purchase agriculture lands with sufficient attached water rights and have created manufactured wetlands to maintain the alluvial hydrology, that irrigated crops used to provide, and in addition return water rights back into the Rio Grande via constructed wetland channels which helps satisfy compact obligations. State and federal government continues to create high-flow channels for the silvery minnow and use heavy equipment to lower channel banks to increase the use of the adjoining floodplain. The increased sediment transport becomes cost prohibitive for the state due to constant dredging and the increased threat of lowering the holding capacity of Elephant Butte Lake (EBL) surpassing design specifications. Increasing sediment has created a bank overflow problem by raising channel height and during high discharges also intensifies debris accumulation in EBL. Maintenance and EBL design specs forced the state into a situation where isolated refugia and manufactured wetlands become the most economical and biological viable answer to maintaining specie status with a self sustaining geomorphological channel condition.

Acequia users become an important part of increasing habitat through constant wetting of conveyance easements for irrigation, livestock watering and alluvial support to the tributaries of the Rio Grande. Conveyance easements become a method of maintaining agriculture and channel low flow in localized areas. The NM State Engineer assigns a use to acequia tailwater. The Acequia Association becomes the largest geographic and political player managing isolated refugia and maintaining critical fish and avian habitats through the use of alluvial storage.

If drought condition forces agriculture rights over channel use refugia become habitat priority.

9. [Possible “Cataclysmic” Events: titles from team; text by Bob Wessely, VP Water Assembly](#)

In developing its 2025 MRG Prophecy, the expert team chose to guess that a number of potential cataclysmic events would not yet have come to pass. The team wanted to picture the best possible environment resulting from the Middle Rio Grande’s current policies. The following subparagraphs identify and briefly describe a dozen possible cataclysmic events, each of which could occur within 15 years, but all of which were assumed not to have occurred.

- **Rio Rancho – out of water rights**

In 2010 Rio Rancho was pumping water just below the full amount of their water rights. Because of the City’s high growth rate in population/demand, the City applied for a permit to pump more. The OSE required that the City buy sufficient offsetting water rights prior to pumping on the new permit. The problem occurs if the increase in demand outraces the City’s ability to find/buy/transfer the needed water rights. The expert team’s conjecture was that the OSE caved in to allow a Rio Rancho a reprieve from the rules.

- **Compact default**

The Rio Grande Compact (among Colorado, New Mexico and Texas) requires New Mexico to deliver an amount of water each year to Elephant Butte Reservoir for downstream users. The amount is roughly proportional to the amount of inflow at Otowi gage (at the Los Alamos highway). Should there be a protracted or intense delivery shortfall (due to weather conditions, increased water draw, or increased river leakage), Texas would sue New Mexico. The U.S. Supreme Court would then decide who in the Middle Rio Grande region must stop using water so as to correct the shortfall. The State New Mexico (taxpayers) would have to pay the costs to make that happen. The best estimates of those costs are ten times the several hundred million dollar experience on the Pecos.

- **Call on Colorado basin water by downstream states**

The Albuquerque Bernalillo County Water Utility Authority has determined that their aquifer has been pumped nearly to its practical limit. Accordingly, ABCWUA is switching most of its source water to a Colorado River Tributary, the San Juan River (which gets delivered via tunnel to the Chama River and then the Rio Grande). Upstream States on the Colorado River are required to deliver a fixed amount of water to the populous downstream states (AZ, NV and CA). Should delivery shortfalls occur (upstream demands and/or weather), those downstream States could require (via the U.S. Supreme Court) a curtailment of upstream uses, in particular, Albuquerque’s, Santa Fe’s and MRGCD’s uses of that San Juan/Chama water source.

- **LANL nucleotides into Rio Grande**

There is a risk, albeit exceedingly small, of an accidental substantial radionuclide release from LANL. With LANL arroyos being upstream, such a release would impact the ability of downstream uses of Rio Grande water.

- **Unified Pueblo “action”- claim on water rights**

The substantial senior Pueblo water rights in the Middle Rio Grande are not adjudicated (i.e., the amount of those water rights is unknown). Pueblos could, through individual or collective action, sue to quantify those rights. While such a suit would likely take a long time, interim and/or final judicial decisions could cause a major reduction in the non-Pueblo water uses.

- **Mexico demands more Rio Grande water**

The United States’ treaties with Mexico currently allocate a certain quantity of Rio Grande water to Mexican uses. There is some risk that the United States federal government negotiates an increase in that treaty allocation. Such an increase would, of course, be a further drain on the already over-allocated river.

- **Boyd prevails on Elephant Butte suit**

A gentleman named Scott Boyd has made a claim in the Lower Rio Grande adjudication lawsuit that the Bureau of Reclamation took illegal actions relative to Elephant Butte in the early 20th century. The claim actually seems to be getting at least a little bit of traction with the Court. Should he prevail, there would have to be a major realignment of water rights and the Compact affecting both the Lower and Middle Rio Grande.

- **Act of terrorism**

There is the possibility of terrorist acts that could impact the quantities and/or qualities water supplies.

- **Sudden spike in oil prices**

"Peak Oil", the perception that our demand for fossil fuel will soon exceed the world's ability to mine oil would cause a substantial increase in fossil energy prices. Such an increase would making long distance transportation of foodstuffs less practical. The result could be a resurgence of the need for locally grown produce. That would impact the ease and/or desirability of converting agricultural land to residential development and/or of transferring water rights from agriculture to municipal and institutional uses.

- **Upstream users arbitrarily appropriate**

There is the possibility in times of severe shortages that users upstream from the Middle Rio Grande (e.g., San Luis valley in Colorado) will choose to appropriate more than their rightful allocation of water, which would exacerbate the severe shortages in the Middle Rio Grande.

- **Extended drought**

During the past two millennia there have been half and whole century periods averaging substantially less precipitation than the long term average. The twentieth century (our recent memory) averaged substantially more precipitation than the long term average. An extended drought, relative to what we have grown accustomed, could have intense social and economic impacts.

- **DWP Diversion Protest is Successful**

A protest of the Albuquerque Bernalillo County Water Utility Authority's diversion of San Juan Chama water from the Rio Grande is pending in the Courts. Should the protest prevail, the ABCWUA would have to revert to its pumping of the already drawn-down aquifer until it could meet its demand by finding another (now unknown) source of wet water.

10. [List of Contributors](#)

The following people participated in varying degrees in the development of The Story and its technical appendices. It is important to note that the affiliations are listed for informational purposes only. The participants served as volunteer individuals, not as representatives of their respective organizations.

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