A Tale of Two Mesas: One High, Dry and Windy; the Other, Somewhat Less So—
A Curmudgeonly* Geologist's Perspective on Current Activity in and Prospects for Future Groundwater/Energy-Resource Development in Rio Grande Valley-Border Uplands of the Albuquerque-Rio Rancho Metro-Area: East Mesa—Mesa del Sol, and KAFB Fuel-Spill Impacts in the SE Heights Area. West Mesa—Santolina, and a Proposed Exploratory Oil Well West of Rio Rancho

John W. Hawley, Ph.D., C.P.G. 02309-American Institute of Professional Geologists
dba HAWLEY GEOMATTERS hgeomatters@qwestoffice.net

Emeritus Senior Environmental Geologist, NM Bureau of Geology & Mineral Resources,
NM Institute of Mining & Technology
Visiting Senior Hydrogeologist, NM Water Resources Research Institute,
NM State University

Summary of PPT Presentation at January 5, 2016 Luncheon Meeting of the Air & Waste Management Association- New Mexico Chapter, Rocky Mountain States Section

Golden Corral - Central and Eubank NE, Albuquerque

Introduction – Hydrogeologic ***reality checks**** (*see list of selected references*) are particularly appropriate in metropolitan districts of arid/semiarid regions with growing population and limited water resources, but seemingly unlimited land availability. Proposed expansion of urban/suburban (residential) and municipal & industrial (M&I) development, and water/energy extraction activity in the "West Mesa" areas of Albuquerque and Rio Rancho certainly merits such appraisal, particularly in light of the need to sustain and enhance existing entities of similar nature within the Rio Grande Valley and on "Mesa" lands of Albuquerque's "East Heights" area. With respect to *Water* (*surface*- and *ground*-), which has that uncanny ability to run uphill to money, please don't forget its essential connection with *Energy*! The latter's sources (hydrocarbon, nuclear, solar, wind, and geothermal) are not an issue here, rather it is the amount and cost of the energy that is potentially needed to move water from subsurface or surface sources to its places of treatment, use, reuse, and disposal. Rights of property owners (individual or institutional) to initiate and implement land and natural-resource development for gainful economic purposes are also not matter of debate here; because I fully support them. From a groundwater and energy-resource perspective, however, prudent behavior dictates that it's always best to: *look deeply (scientifically, technically, environmentally, and socio-economically) before leaping* into the *swamp* of unintended consequences!

In the first group of PowerPoint® slides that illustrate this talk, I'll describe some basic geologic-framework (i.e. *geoplumbing*) components of the northern Albuquerque Basin area that includes the cities of Albuquerque and Rio Rancho. Much of this information is based on recent field and laboratory research by teams of geologists, geophysicists, and geochemists working for NM Bureau of Geology & Mineral Resources at NM Tech, the US Geological Survey, and the UNM Earth & Planetary Sciences Department. Key publications cited herein include: Connell (2004, 2008), Connell and others (2005, 2013), Grauch and Connell (2013), and Plummer and others (2004). Interpretations and opinions related to Basin hydrogeology and related environmental concerns strictly reflect my personal/professional perspective!

*****2016 Caveat on *Reality Checks*: *Ideology* all too often *Trumps Reality* (pun intended)!

In simplest geologic terms, the northern part of the Albuquerque Basin is an east-tilted structural depression (half graben) formed during the past 25 million years by extension of the Earth's crust. It is one of the deepest segments of the Rio Grande rift tectonic province, which extends from northern Colorado to Trans-Pecos Texas and Chihuahua Mexico (Hudson and Grauch, 2013). Most of the rift-basin fill is sedimentary, but igneous-intrusive and interbedded-volcanic rocks are also locally present. Almost all of it is included in the Santa Fe Group, except for Quaternary river-valley fill (including eolian sediments and younger basalts). Basin-flanking structural uplifts comprise the Sandia Mountains to the east and the Colorado Plateau to the west. One of the places of maximum basin subsidence is located immediately west of a broad boundary-fault zone beneath the Sandia piedmont slope between Louisiana and Tramway Blvds. There, tens of thousands of feet of aggregate displacement has occurred and as much as 15,000 feet of Santa Fe Group basin fill has accumulated.

During early stages of Albuquerque Basin filling (25 to about 8 million years ago), closed-topographic basin (bolson) conditions existed. As a result, alluvial flats and ephemeral-lake plains comprised the dominant basin-floor environments of deposition, and sediments are typically fine-grained and include some evaporites. During the past 8 million years, however, much of the basin floor was occupied by a major fluvial system, the Ancestral Rio Grande (ARG), which included the ancestral upper Rio Puerco. The ARG system ultimately contributed as much as 3,000 ft of sand-dominated fluvial sediment to the most actively subsiding parts of basin between the west-frontal fault zone underlying the Sandia piedmont east of Louisiana Blvd. and present site of the inner Rio Grande Valley. Between about 5 and 1 million years ago, the ARG fluvial system expanded to one of regional extent that connected Rio Grande rift basins between Taos and El Paso. Moreover, it continued as the major contributor to basin aggradation and the source of sediments that comprise our primary aquifer until entrenchment of present river-valley was initiated. That latter feature, which now separates our "East" and "West Mesas," has existed as an erosional river-valley landform only for the relatively short span geologic time (probably less than 800,000 yrs). This interval was marked by the culmination of the Pleistocene Ice Ages, and expansion of the Rio Grande drainage basin from Colorado to the Gulf of Mexico.

The major complicating factors in this fluvial-geomorphic history involve millions of years of differential uplift/subsidence between mountain and basin structural blocks, evolution of the Jemez volcanic field, and continental-scale climate change. For example: 1) Rio Grande-rift basins were not nearly as deep, nor mountains as high 8 million years ago; 2) upper Rio Grande drainage terminated in the Socorro area until about 5 million years ago; 3) the onset of Pleistocene alpine glaciation in Southern Rocky Mountains and large pluvial-lake expansion started about 2.6 million years ago; 4) the first extensive of basaltic-volcanic fields in the Albuquerque Basin formed at about the time; and 5) highlands of the Jemez Mountain caldera complex only appeared on the Basin's northern horizon about 1.8 million years ago.

Emphasis of the second slide group is on residential-community/M&I developments in two parts of the Albuquerque-Rio Rancho Metro-Area: 1) The existing, relatively small Mesa del Sol development on the "East Mesa" between the Sunport and the Pueblo of Isleta Reservation, and 2) the proposed, large Santolina development on the West Mesa, which is located mainly south of I-40 between the valleys of the Rio Puerco and Rio Grande. I'll also touch on relevant hydrogeologic/environmental-geologic aspects of the subsurface parts of the Albuquerque SE Heights potentially impacted by the KAFB Fuel Spill. In addition, my review of the general hydrogeologic framework of the "West Mesa" area north of Santolina allows a brief introduction to known deep-subsurface conditions (to about 10,000 ft below mean sea level) and some environmental concerns at a site west of the City of Rio Rancho where “SandRidge Exploration and Production” Company proposes to drill an exploratory oil well. The proposed drill site is located near the intersection of 24th Ave. and Encino Rd. (about 15 miles west of Bernalillo).

East-Mesa: Mesa del Sol-Hydrogeologic and environmental assets and challenges
In terms of both groundwater production capacity and quality, the existing development (elevation-about 5,400 ft amsl) is underlain at relatively shallow depths of (about 400 ft) by the world-class, Santa Fe Group aquifer system of the Albuquerque East Heights.

1. Configuration of groundwater flow toward the major ABCWUA pumping centers located north of the Sunport and KAFB precludes any anthropogenic contamination of the underling aquifer from sources on KAFB or SNL. Moreover, recent initiation of effective decontamination of parts of the upper-aquifer zone affected by the KAFB fuel-spill plume (by NMED, USAF, et al.), is now an additional very positive factor in long-term management of the entire East Heights aquifer system.
2. In marked contrast to the West Mesa-Santolina locality, there are excellent opportunities for artificial aquifer recharge, and water storage and recovery (ASR) operations.
3. While on-site wells have yet to be constructed, water-supply pipeline (ABCWUA), surface-runoff capture, and highway-access infrastructure is in place.
4. A non-geohydrologic personal observation: Even with some obvious growing pains, Mesa del Sol is an area where people currently live (about 150 homes), work and play; and all parts are within a 10 to 20 minute drive from the Sunport and central Albuquerque.

West-Mesa: Hydrogeologic challenges facing developers in the Santolina area, which still can be met if 1) substantial economic resources are available, and 2) there are no legal/institutional constrains on paper/wet-water transfers

1. The underlying Santa Fe Group basin-fill aquifer system has low production potential; and the top of the zone of groundwater saturation is 500 to 800 ft below the land surface.
2. Groundwater quality is generally poor (e.g. high arsenic and corrosivity).
3. In marked contrast to the Albuquerque East Heights (Mesa) opportunities for artificial aquifer recharge, and water storage and recovery (ASR) operations are limited.
4. A supply system adequate for the projected domestic and M&I water requirements would, therefore, require first: a well-field in the river-valley area (pumping level ~4,700-ft amsl elev.) or surface-water diversion system (~4,900-ft elev.), and second: an 8 to 10-mile trunk pipeline, with pump stations and storage tank facilities at elevations ranging from about 5,500 to 5,600 ft amsl.

Selected References on Albuquerque-Rio Rancho Area Hydrogeology and Related Environmental Concerns

Allen, B. D., Connell, S. D., Hawley, J. W., and Stone, B. D., 1998, Core drilling provides information about Santa Fe Group Aquifer beneath Albuquerque's West Mesa: New Mexico Geology, v. 20, no. 1, p. 8-13.

Connell, S.D., 2004, Geology of the Albuquerque Basin and tectonic development of the Rio Grande rift in north-central New Mexico, *in* Mack, G.H., and Giles, K.J., eds., The Geology of New Mexico: A geologic history: New Mexico Geological Society, Special Publication 11, p. 359-388.

Connell, S.D., 2008, Geologic map of the Albuquerque-Rio Rancho metropolitan area and vicinity, Bernalillo and Sandoval Counties, New Mexico: New Mexico Bureau of Geology and Mineral Resources, Geologic Map 78, scale 1:50,000, 2 sheets. http://geoinfo.nmt.edu/publications/maps/geologic/home.html

Connell, S. D., Allen, B. D., and Hawley, J. W., 1998, Subsurface stratigraphy of Santa Fe Group from borehole geophysical logs, Albuquerque Area, New Mexico: New Mexico Geology, v. 20, no. 1., p. 2-7.

Connell, S.D., Hawley, J.W., and Love, D.W., 2005, Late Cenozoic drainage development in the southeastern Basin and Range of New Mexico, southeasternmost Arizona and western Texas, *in* Lucas, S. G., Morgan, G., and Zeigler, K.E., eds., 2005, New Mexico's Ice Ages: New Mexico Museum of Natural History & Science Bulletin No. 28, p. 125-150. http://nmnaturalhistory.org/bulletins

Connell, S.D., Smith, G.A., Geissman, J.W., and McIntosh, W.C., 2013, Climatic controls on nonmarine depositional sequences in the Albuquerque Basin, Rio Grande rift, north-central New Mexico, *in* Hudson, M.R., and Grauch, V.J.S., eds., New Perspectives on Rio Grande Rift Basins: From Tectonics to Groundwater: Geological Society of America Special Paper 494, p. 383-425. doi: 10.1130/2013.2494(15)

Grauch, V.J.S., and Connell, S.D., 2013, New perspectives on the geometry of the Albuquerque Basin, Rio Grande rift, New Mexico: Insights from geophysical models of rift-fill thickness, *in* Hudson, M.R., and Grauch, V.J.S., eds., New Perspectives on Rio Grande Rift Basins: From Tectonics to Groundwater: Geological Society of America Special Paper 494, p. 427-462. doi: 10.1130/2013.2494(16)

Hawley, J.W., 2005, Five million years of landscape evolution in New Mexico: An overview based on two centuries of geomorphic conceptual-model development, *in* Lucas, S.G., Morgan, G., and Zeigler, K.E., eds., New Mexico's Ice Ages: New Mexico Museum of Natural History & Science Bulletin No. 28, p. 9-93. http://nmnaturalhistory.org/bulletins

Hawley, J.W. and Haase, C.S., compilers, 1992, Hydrogeologic framework of the northern Albuquerque Basin: New Mexico Bureau of Mines and Mineral Resources, Open-file Report OF-387, 74 p.

Hawley, J.W. and Longmire, P.A., 1992, Site characterization and selection, *in* Reith, C.C. and Thomson, B.M., eds., Deserts as Dumps? The disposal of hazardous materials in arid ecosystems: Albuquerque, University of New Mexico Press, p. 57-99.

Hawley, J. W., Haase, C. S., and Lozinsky, R. P., 1995, An underground view of the Albuquerque Basin, New Mexico, *in* Ortega-Klett, C. T., ed., Proceedings of the 39th Annual New Mexico Water Conference, New Mexico Water Resource Research Institute Report 290, p. 37-55. http://wrri.nmsu.edu/publish/watcon/proc39/contents.html

Hudson, M.R., and Grauch, V.J.S., 2013, Introduction, *in* Hudson, M.R., and Grauch, V.J.S., eds., New Perspectives on Rio Grande Rift Basins: From Tectonics to Groundwater: Geological Society of America Special Paper 494, p. v-xii. doi: 10.1130/2013.2494(00)

Phillips, Fred M., Hall, G. Emlen, and Black, Mary E., 2011, Reining in the Rio Grande—People, Land, and Water: Albuquerque, The University of New Mexico Press, 252 p. (*p. 176*[1]**)**

Plummer, L.N., Bexfield, L.M., Anderholm, S.K., Sanford, W.E., and Busenberg, E., 2004, Geochemical characterization of ground-water flow in the Santa Fe Group aquifer system, Middle Rio Grande Basin, New Mexico: U.S. Geological Survey Water-Resources Investigations Report 03-4141, 369 p., CD-ROM.

Shroba, J.R., Thompson, R.A., Schmidt, D.L., Personius, S.F., Maldonado, and Brandt, T.R., 2003, Geologic map of the La Mesita Negra SE Quadrangle, Bernalillo County, New Mexico: U.S. Geological Survey Miscellaneous Field Studies Map MF-2416, scale 1:24,000. http://pubs.usgs.gov/mf/2003/mf-2416/

Thorn, C.R., McAda, D.P. and Kernodle, J.M., 1993, Geohydrologic framework and hydrologic conditions in the Albuquerque Basin, central New Mexico: U. S. Geological Survey Water-Resources Investigations Report 93-4149, 106 p.

[1] "….Based on hydrogeologic studies conducted in the late 1950s, Albuquerque was thought to sit on top of a gigantic bowl of clean sand and filled with fresh water. One of the earliest sceptics was John Hawley, a *curmudgeonly*[2] geologist who had worked for decades in the New Mexico Bureau of Geology and Mineral Resources. By the late 1980s and early 1990s, Hawley increasingly realized that the idealized model of the basin in vogue in the 1950s and 1960s did not correspond to the sediments he saw actually coming up the hole when new wells were drilled. In 1992 he and his colleague Steve Haase put out a report that laid the hydrogeologic evidence on the table. The 'Lake Erie' of fresh water under the city was a desert mirage, revealed now to be a briny sea. The coarse sands filled with, fresh, pure water were just a ribbon running down the middle of the basin; most of the rest had abundant fine sediment mixed in, and the water in these sediments was often salty." **Phillips et al., 2011, p. 176.**

[2] Winokur, Jon, compiler and editor, 1987, The Portable Curmudgeon: New York, New American Library, a division of Penguin Books USA, Inc. (1992 Plume Paperback Edition), 299 p. ISBN 0-452-26668-8. *See p. iii*: **Cur·mud·geon\,kər-´məj-ən** *n* [origin unknown] **1** *archaic*: a crusty, ill-tempered, churlish old man [*The speaker!*]. **2** *modern*: anyone who hates hypocrisy and pretense and has the temerity to say so; anyone with habit of pointing out unpleasant facts in an engaging and humorous manner.