Recent Groundwater Trends
Within the Elephant Butte Irrigation District of N.M.

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This presentation is intended to:

1. Offer a brief explanation of the EBID’s basic approach to monitoring groundwater trends, particularly net annual changes in groundwater storage in the shallow alluvium aquifers within the bounds of the EBID.

2. Offer a summary account of supplemental groundwater pumping for irrigation of assessed lands and net annual changes in shallow groundwater storage in recent years (2010 through 2016) in:
   a. The Hatch/Rincon Valley of the EBID.
   b. The Mesilla Valley of the EBID

3. Offer a summary account of the EBID’s perspective on the USBR’s groundwater modeling efforts associated with the USBR’s Record of Decision as per NEPA-EIS proceedings concerning continued implementation of the 2008 Rio Grande Project Operating Agreement.
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• James P. King, Ph.D CE, P.E., NMSU CE Professor and EBID Chief Technical Consultant

Cooperation from area farmers to provide access to wells for surrogate measurements and calibration as needed is also greatly appreciated.
EBID’s approach...

Geospatial modeling using groundwater table elevation measurements with precision instruments to calculate where and to what extent changes in shallow aquifer storage within the EBID are occurring on an annual basis. EBID’s approach accounts primarily for changes in the shallow alluvium in the near term, realizing that the effects of pumping at greater depths are somewhat delayed.

- Thiessen polygons (Thiessen, 1911) utilizing spatial analysis software (ArcGIS® v.10.2, ESRI, 2013) have been chosen for simplicity. This method adjusts for non-uniform sampling point distribution using a weighing factor for each sampling point (each monitoring well). The weighing factor is based on the total area within the drainage basin (respective Valley) within which individual Thiessen polygons are contained.
- Net change in shallow aquifer storage at year-end for each year during the period of review (2010 through 2016) is computed as the sum of the product of change in head (measured change in water table elevation at each year-end at each monitoring well), the storage coefficient (specific yield) reported/known for the shallow alluvium, and each Thiessen polygonal area associated with each monitoring well.
Example of Thiessen polygons created from locations of EBID monitoring wells relative to the spatial bounds of the Rincon Valley.

Other approaches (i.e., geostatistical kriging, inverse distance weighting, etc.) could/would work also and have been explored by the EBID to varying degrees.

Hydraulic Tomographic Mapping (HTM), a relatively new, untested (in the field) subsurface hydrology stochastic modeling approach, may be explored also.
EBID’s approach...

“Keep it simple, but not one bit simpler than necessary.”  -Einstein

Net year-end to year-end change in the shallow alluvium groundwater storage at each Thiessen polygon and associated monitoring well is simply expressed as:

\[ \Delta V_w = S A \Delta h \]

where
\[ \Delta V_w = \text{change in storage, in acre-feet.} \]
\[ S = \text{storage coefficient (dimensionless), established in the literature to be about 0.2 on average for the shallow alluvium (first 80-100 feet or so) throughout the Valley.} \]
\[ A = \text{Thiessen polygonal surface area within which the monitoring well is contained, in acres.} \]
\[ \Delta h = \text{change in head at the monitoring well, in feet.} \]

Potentially conservative in terms of estimated storage losses because assumes that the change in head is uniform across each Thiessen polygonal area.
USGS LC-3C. Located very near Burn Lake in the Mesilla Valley, in close proximity to CLC production well LRG-430-S-44 which was replaced in 2006 and operating as needed ever since.

USGS LC-2F. Located due west of USGS LC-3C, very near the Rio Grande.

Other approaches draw attention to groundwater declines in recent years at a few monitoring sites in a particular area of the Mesilla Valley as representative of “the problem”. While simple and effective in terms of making an impression, this approach is not representative of overall aquifer health. Note that there is nothing necessarily wrong with the exercise of the CLC’s production well in this example, nor anything wrong with the monitoring efforts of the USGS. Interpretations, however, should be with due caution.
Hatch/Rincon Valley

- About 28,000 acres within the EBID of which about 17,000 acres is assessed and in cultivation on average. In 2016, about 15,800 acres irrigated through EBID. About half is under drip irrigation and alternated with flood irrigation as needed (to flush salts).

- Features the best chili on the planet and world-class onions, but no significant aquifer to speak of. About 55 feet on average of saturated thickness developed essentially exclusively for irrigated ag pumping.

- Apart from some neighboring dairy, no other industry exists in the Rincon/Hatch Valley.

- EBID maintains 13 instrumented shallow monitoring wells with RTU’s in this area. Program being expanded to include specific conductance to estimate TDS.
Total annual pumping for EBID assessed lands (aka combined rights) in the Hatch/Rincon Valley correlates VERY closely with the total annual surface water allotment for the EBID as a whole. Extensive drip irrigation in the Hatch/Rincon Valley alternated with flood irrigation has considerable influence over on-farm efficiency. Drip irrigation does reduce net diversions and increases on-farm efficiency, but also reduces net return flows.

Summary annual pumping data, 2009-2015 provided by NMOSE. Further analysis by EBID.
• Bars show elevation change per year at each monitoring well. Net annual storage change is tabulated separately.

• Beginning in 2014 and persisting through 2016, net gains in shallow alluvium groundwater storage in the Rincon/Hatch Valley were observed, helping to moderate an otherwise losing trend in previous years.

• Cropping patterns and distribution of pumping, as well as total pumping, apparently changed as of 2014, likely by necessity.
• Gains throughout for 2016.

• Trending toward stabilization, mostly due to changing cropping patterns (less alfalfa) since 2014, and moving from triple or double crop scenarios to a single crop (mainstays of chile and onions, some cotton).

• Some acreage recently planted in young pecan trees could eventually lead to additional stress on an already very limited aquifer system.

• Local arroyo and tributary flows are helping.

• Impeded drainage also a factor. Lack of river channel maintenance is a real problem, but isn’t EBID’s fault or responsibility.
A deficit situation remains, particularly between Garfield and Salem.

- But, note that the area between Garfield and Salem saw among the greatest gains in 2016.

- Salts are accumulating in some areas and tending to concentrate downstream as drainage is impeded.

- USGS NAWQA monitoring site H26, very near EBID monitoring well RIN_12R revealed specific conductance of groundwater at 4,260 uS/cm in 2014. In 2016, the site tested at 3,850 uS/cm. Reflects a range of about 2,811 to 2,541 mg/L TDS.
Hatch/Rincon: Quick to lose, quick to gain, but not much groundwater to lose regardless of fluctuations in the EBID surface water allotment. Losses hurt more because not much of a groundwater buffer. Limited aquifer is highly dependent on the surface water allotment delivered to farms, and flow in the river/canal system.

Established annual rate of loss remains greater than annual rate of gain to date, but currently gaining.

Total net gain is 55% of total net loss over the last 7 years, so the glass is presently about half full (relative to end of 2009).

Salt accumulations remain a concern.

Not out of the woods...
• Hatch/Rincon: System response to total annual release from Caballo is in part reflected by Rio Grande Project operations and related downstream delivery obligations, but primarily by ongoing regional drought limiting annual release, and the fact that there is relatively little groundwater in storage in the Hatch/Rincon Valley to lose to begin with.
• The aquifer in the Hatch/Rincon Valley is basically no more than a limited extension of the riverbed itself and the immediately adjacent floodplain, which is relatively narrow.
• Even in the near term, net loss of groundwater from storage in the Hatch/Rincon Valley is a critical management consideration. Hope that another year like 2011 or 2013 doesn’t happen again anytime soon.
• Effective forecasting/modeling is difficult given many other variables (agronomic, economic, alternating drip/flood, etc.).
• Trends over the last seven years of enduring severe drought suggest that if 2017 delivered a full EBID surface water allotment (not likely), a gain of about 10,690 acre-feet in the shallow alluvium aquifer in the Rincon Valley might be expected.
• If so (not likely), the total net loss from shallow aquifer storage in the Rincon Valley incurred in recent years could be almost extinguished, and the Valley could be about 1.2 years away from full recovery (relative to end of 2009) if a consecutive full allotment the following year (2018) could be expected.
Mesilla Valley

• About 108,000 acres within the EBID, about 71,000 acres assessed of which about 63,000 acres on average is in cultivation. Very little drip. In 2016, about 51,740 acres irrigated through EBID, of which over half is producing premium pecans for which world-wide demand persists.

• Features a deep, robust aquifer which has been readily developed for all uses and has historically buffered periods of surface water shortage.

• EBID maintains 45 instrumented (with RTU’s) shallow monitoring wells in this area. Average well depth about 12.2 meters (40 feet). Also manage 7 ISC piezometers along border with TX.

• Two new sites (MES_46R-B and MES_46R-C) using existing EBID wells added this last year. Two additional sites using existing EBID wells planned this year. At least one new piezometer needed.
Total annual pumping for EBID assessed lands in the Mesilla Valley correlates VERY closely with the total annual surface water allotment for the EBID as a whole. At zero surface water allotment and given 51,740 acres irrigated in the Mesilla Valley through the EBID (2016), it can be seen that an average on-farm delivery of 4.37 acre-feet per acre of groundwater might be expected.

Summary annual pumping data, 2009-2015 provided by NMOSE. Further analysis by EBID.
Bars show elevation change per year at each monitoring well. Net annual storage change tabulated separately.

Modest net gain in shallow alluvium storage observed in 2015, and substantial gain in 2016. Effects at greater depths (below about 150-200 feet and beyond) where aquifer storage properties are different may not be realized at the water table for a number of years, but will tend to persist much longer.

Groundwater table elevations at MES_10R, MES_14R, MES_46R, and MES_47R have dropped below the measurement range of sensors in the last 2-3 years, however measurements from wells immediately nearby and related elevation survey loops have served as surrogates. At least one, preferably two, deeper piezometers with stacked sensors are needed eventually. Cost about $30K per piezometer.
• Virtually all areas exhibiting slight to moderate gains at the end of 2016.

• Notably, the heart of “Pecan Land” has apparently gone to considerable effort (and surely expense) to lease and concentrate surface water in place of some amount of groundwater pumping. Proactive, organized farming to weather drought! Capture and use of stormwater whenever and however possible is helping too.

• Migration of groundwater from parts of the West Mesa by induced hydraulic gradients is contributing also, but suspect to be minor relative to the farming community’s efforts to adapt (i.e., fallowing, reduced pumping, leasing/concentrating surface water, opportunistic use of stormwater, etc.).
A deficit situation clearly remains.

- But, note that the area where the greatest cumulative losses to date are observed is also the area where among the greatest gains occurred in 2016.
• Mesilla: Quick to lose and much to lose, given significant groundwater buffer. Not as quick to gain (relative to the Rincon Valley).
• Established annual rate of loss remains MUCH greater than annual rate of gain to date, but currently gaining.
• Linear response to gradual increases in the EBID surface water allotment in recent years is encouraging, tending to reinforce the argument that migration of groundwater downgradient from the West Mesa remains minor relative to agronomic adaptation in the Valley.
• Total net gain is only 16% of total net loss over the last 7 years, but clearly on the right track.
Mesilla: System response to total annual release from Caballo is reflected primarily by ongoing regional drought limiting annual release, but certainly also Rio Grande Project operations and related downstream delivery obligations. Project performance expressed as the Diversion Ratio (DR) will take time to recover (assuming drought conditions don’t intensify).

- **DR** = Sum of Diversion Charges / Release from Caballo. **EBID Allotment** = DR x Release from Caballo - MX - EPCWID No.1.
- Not “cratering the aquifer” as yet; the Operating Agreement is working; EPCWID No.1 is being kept whole; gains in the aquifer at present are unmistakable; so far successfully enduring the worst drought in the history of the Rio Grande Project.
- BUT, could be some while yet before consecutive full or even close to full surface water allotments can be expected.
Better forecasting/modeling potential in the Mesilla relative to Rincon, in part due to significant groundwater buffer, but still many agronomic and economic variables make effective prediction difficult.

If 2017 delivered a full EBID surface water allotment (not likely), a gain of about 34,509 acre-feet in the shallow alluvium aquifer of the Mesilla Valley might be expected. If so, still would likely have a considerable deficit in terms of cumulative net loss from aquifer storage in recent years, but could be about 4.0 years away from full recovery (relative to end of 2009) if consecutive full allotment years could be expected thereafter (not likely). One or two wet years is highly unlikely to fill the void in aquifer storage that has been established in the Mesilla Valley to date, but of course would help tremendously.
Recent Surface and Groundwater Flow Modeling Efforts Concerning the EBID

- Based on an integrated, refined version of OSE 2007 (SSPA 2007) using the MF-OWHM (Hanson et al., 2014) code, but retains virtually all major model parameters of OSE 2007.

- Developed with the Rio Grande Project Operating Agreement in mind. Technical basis for the OA-EIS.

- Simulation period begins November 1, 2007 and runs through October 31, 2050.


- Our focus: P50 (central tendency) future climate scenario. Assume future climate is between wetter and drier predictions, but likely not as wet as the 1980’s.
Major Assumptions in the Model

• Cropping pattern and distribution of irrigated lands derived from 2000 data.

• All lands irrigated as of 2000 remain in production for entire duration of simulation. No fallowing.

• All irrigated lands have legally and physically unrestricted access to sufficient supplemental groundwater to fully meet the CIR of all crops. No well capacity issues, wells never fail.

• All pumping for irrigation comes from the upper layer of the model (strictly the shallow alluvium).

• All non-irrigation (M&I, etc.) pumping for the duration of the simulation assumed to be consistent with historical average uses over the period 1995-2004.

• Locations of all wells adopted from previous model version (OSE 2007).

• Non-Project releases from Caballo to the Bonita Private Lateral are preserved at full amounts for the duration of the simulation period.

• Storm runoff as inflows to the Project below Caballo are ignored for purposes of the model for lack of available data.
Record of Decision
Continued Implementation of the 2008 Operating Agreement for the Rio Grande Project, New Mexico and Texas

Model results used by USBR to support continued implementation of the Operating Agreement between USBR, EBID and EPCWID No. 1.
- Model output data included in USBR Technical Memorandum (Reclamation, 2015) appendices files was extracted and analyzed by EBID Groundwater Resources to construct charts not otherwise explicitly shown.
- All other things being equal (relative to the model assumptions), likely variation in regional climate impacting Project surface water potentially in storage is a much more important variable, with or without the Operating Agreement.
- EBID efforts based on monitoring and calculated change in storage to date (2010 – 2016) for the Rincon and Mesilla Valleys combined reveal that USBR modeling scenarios with or without the Operating Agreement are probably irrelevant.
- Basically impossible to effectively model by way of traditional numeric methods the resiliency and adaptive capacity of EBID farmers to deal with the reality of protracted drought. EBID farmers are not on track to “pump the aquifer dry”.
• Expressed cumulatively, a theoretical numeric modeling argument might be made that the OA could result in greater aquifer depletions in the long term.

• If downstream delivery obligations were not a consideration, such an argument might have merit.

• Regardless, modeled cumulative net loss from aquifer storage in the long term (as soon as about 2020) would mean very bad news for us all, with or without the OA under such theoretical circumstances.

• Potential variation in regional climate impacting storage in Elephant Butte Reservoir is and should remain a much greater concern for all.
• Expressed cumulatively, EBID efforts based on monitoring and actual measurements to date (2010 – 2016) for the Rincon and Mesilla Valleys combined reveal that the future, while undoubtedly the subject of many challenges, may not be so bleak.

• Tremendous potential exists to sustainably manage our groundwater resources, as a water use community and for all uses, on our terms.

• Local solutions to local problems!
Questions?

Metering of groundwater diversions is required by OSE anyway, but Remote Telemetry Unit (RTU) real-time metering and reporting of pumping from all irrigation wells as offered by/through the EBID would be very useful. Likely will be a critical component of managing a depletion reduction program (also many benefits to understanding on-farm efficiency, etc.).