Arizona Department of Water Resources
Hydrology Division

ARIZONA DEPARTMENT OF WATER RESOURCES

Revised Groundwater Modeling Results for the East Valley Water Forum Regional Water Planning Study

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ADWR Hydrology Division

By

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Background

This report presents the revised results of the first East Valley Water Forum (EVWF) model run (ADWR, 2004a). The results presented in this report supercede previously published model results (ADWR, 2004a) and differ from earlier results only due to recent structural modifications that have been made to ADWR's SRV groundwater flow model (ADWR, 2004b). The conceptual water budget simulated in this revised report is unchanged from the original "Chandler Model" budget described in the preliminary report. However, the modifications to the SRV model caused minor changes to the model results that are discussed later in this report.

The intent of this model run is to provide members of the EVWF with preliminary water budget data and modeling results that are based on relatively recent planning data and estimates. It is hoped that these results will be helpful to the members of the Forum as they develop, update or confirm future pumpage and recharge projections for their water service organizations. However, it is important to emphasize that this is a revised model run that is not intended for specific planning purposes, nor are the results intended to serve as a "base case" scenario to compare against other scenarios that are currently under development.

Conceptual Water Budget

The conceptual water budget for this model run was based on assumptions concerning future groundwater pumping and recharge that were developed from the 2002-2003 City of Chandler Shallow Aquifer Management Study (the Chandler Model), and the ongoing Scottsdale/Phoenix Northeast Valley Aquifer Management Plan. These two studies provided pumping and recharge projections for most of the East Salt River Valley (ESRV) sub-basin and the portion of the Maricopa-Stanfield sub-basin of the Pinal AMA [Pinal(MS)] that is included within the SRV model area for the period 2003-2025. Pumping and recharge projections for the West Salt River Valley (WSRV) and portions of the ESRV not covered by the Chandler or Scottsdale/Phoenix studies were provided from ADWR's 1996 Current Trends Analysis (CTA) and the 1997 Assured Water Supply (AWS) municipal provider designation simulations (see Figure 1).

A summary of the projected pumping and recharge totals applied in this model run is provided in the conceptual water budget shown in Table 1. Please note that some figures have been revised from previously published preliminary figures.

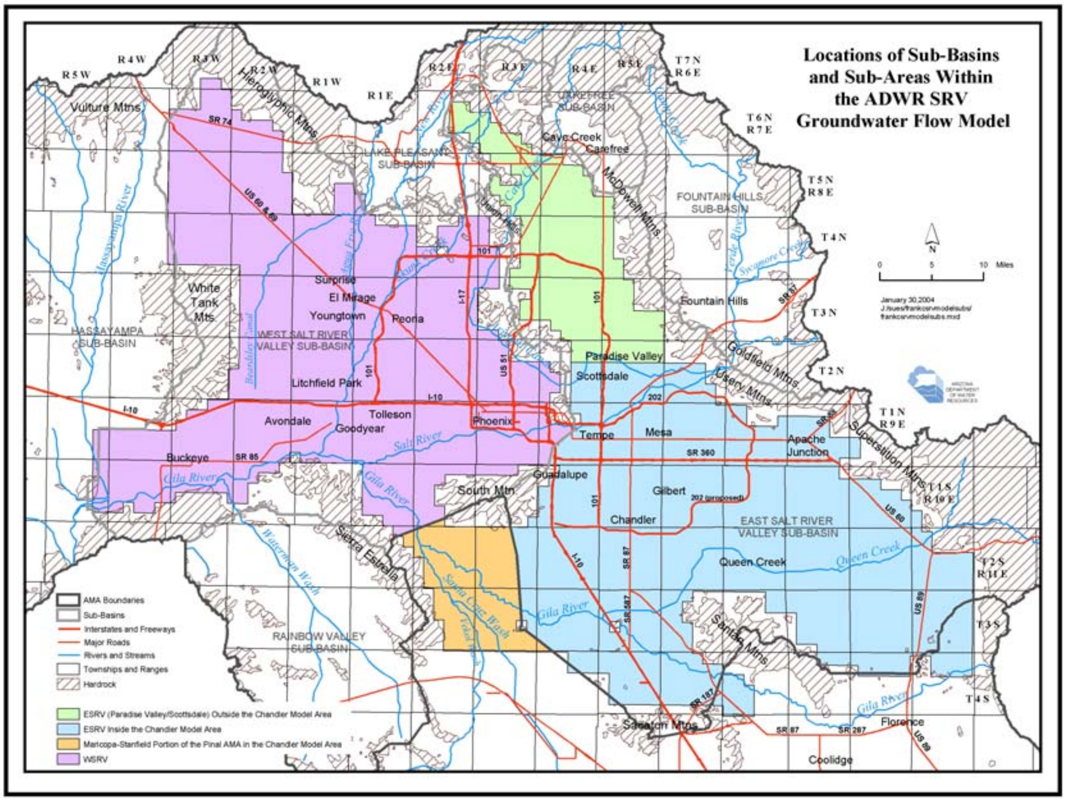

Figure 1. Locations of sub-basins and sub-areas within the SRV model area

ESRV + Pinal (MS)	**2005**	**2010**	**2015**	**2020**	**2025**		WSRV	**2005**	**2010**	**2015**	**2020**	**2025**
Inflows							**Inflows**					
Boundary Flux	24,800	24,800	24,800	24,800	24,800		Boundary Flux	29,700	31,400	31,900	33,000	34,500
Ag Recharge	266,700	255,000	236,700	239,000	240,400		Ag Recharge	245,800	244,400	224,300	199,300	199,300
Urban Recharge	9,700	9,700	9,700	9,700	9,700		Urban Recharge	23,100	23,100	23,100	23,100	23,100
Turf Recharge	11,700	11,700	11,700	11,700	11,700		Turf Recharge	8,000	8,000	8,000	8,000	8,000
Artificial lake Recharge	9,000	9,000	9,000	9,000	9,000		Artificial lake Recharge	4,400	4,400	4,400	4,400	4,400
Canal Recharge	73,200	73,200	73,200	73,200	73,200		Canal Recharge	54,200	49,200	46,000	43,300	43,100
Major river flood Recharge	69,100	69,100	69,100	69,100	69,100		Major river flood Recharge	10,000	10,000	10,000	10,000	10,000
Infiltration of baseflow & effluent on major rivers (stream losses)	50,100	51,500	53,500	56,700	64,200		Infiltration of baseflow & effluent on major rivers (stream losses)	58,000	72,500	75,200	77,800	79,100
Artificial Recharge	145,600	172,200	176,800	181,200	183,400		Artificial Recharge	18,000	23,000	23,000	23,000	23,000
Total Inflows	**659,900**	**676,200**	**664,500**	**674,400**	**685,500**		**Total Inflows**	**451,200**	**466,000**	**445,900**	**421,900**	**424,500**
Outflows							**Outflows**					
Boundary Flux	34,400	37,200	38,700	40,100	41,700		Boundary Flux	6,900	7,900	9,100	10,200	10,500
Pumpage	429,700	461,500	495,300	555,300	562,200		Pumpage	497,400	559,300	559,300	559,300	559,300
Evapotranspiration	1,900	3,000	4,300	5,800	7,500		Evapotranspiration	14,700	22,200	24,500	26,600	28,400
GW discharge to major rivers (stream gains)	46,400	51,500	54,900	57,500	65,500		GW discharge to major rivers (stream gains)	4,600	6,800	7,100	7,300	7,400
Total Outflows	**512,400**	**553,200**	**593,200**	**658,700**	**676,900**		**Total Outflows**	**523,600**	**596,200**	**600,000**	**603,400**	**605,600**
Inflow - Outflow	**147,500**	**123,000**	**71,300**	**15,700**	**8,600**		**Inflow - Outflow**	**-72,400**	**-130,200**	**-154,100**	**-181,500**	**-181,100**

Table 1 Conceptual water budget for EVWF Run 1 (2003-2025)

Model-simulated Water Budget

The model-simulated water budget for the SRV model area is shown in Table 2. Average stress rates are shown in 5-year intervals from 2005 to 2025. It should be noted that some components of inflow and outflow that are listed in Table 2 are described differently in Table 1. This difference occurs because the groundwater model implements some of the boundary fluxes using the well package, so the positive well pumpage and some of the negative well pumpage actually represent boundary fluxes. Differences also exist in groundwater recharge and discharge components listed in Table 1 and Table 2. For example, groundwater recharge and discharge on major rivers (the Salt and Gila) and the Buckeye Canal are handled in the model using the stream routing package, rather than the recharge package.

Year →	**2005**	**2010**	**2015**	**2020**	**2025**
Inflows					
Recharge	926,531	911,648	895,776	881,543	859,963
Wells In	34,458	34,319	34,311	34,311	34,311
Constant Head In	11,078	9,431	7,986	7,633	7,580
Stream Leakage In	123,897	155,556	175,652	175,715	178,629
Total Inflow	**1,095,965**	**1,110,954**	**1,113,726**	**1,099,202**	**1,080,484**
Outflows					
Pumpage	956,445	1,032,950	1,063,820	1,122,590	1,139,578
Constant Head Out	10,216	11,076	12,365	13,394	13,565
Stream Leakage Out	27,736	6059094	80,691	83,330	86,917
Evapotranspiration	22,140	28,463	29,903	30,922	31,264
Total Outflow	**1,017,478**	**1,133,397**	**1,186,779**	**1,250,235**	**1,271,327**
Simulated (Inflow – Outflow)	**79,428**	**-22,443**	**-73,054**	**-151,033**	**-190,843**
Conceptual (Inflow –Outflow) *	**75,100**	**-7,200**	**-82,800**	**-165,800**	**-172,500**

*Determined by subtracting total outflows from total inflows for ESRV, Pinal(MS) and WSRV in Table 1

Table 2 Model-simulated water budget for EVWF Run 1 (2003-2025)

The model-simulated change in storage for the period 2003-2025 was –1,948,587 acre-feet. Model-simulated pumpage, recharge and head-dependent fluxes (Table 2) generally compared favorably with the conceptual estimates (Table 1). For example, review of the model-simulated pumpage (Table 2) indicates that about 99% of the conceptual projected pumpage and negative boundary flux to the Maricopa area (Table 1) was actually simulated by the model. This result indicates the fact that few model cells "dewatered" during the simulation period (a problem that has occurred in previous long-term modeling studies, such as the CTA study). About 98% of the projected conceptual recharge was actually simulated by the model (some recharge was applied to "inactive" model cells that were generally located along the margins of the active model area).

Comparison of ADWR-SRV and Chandler Model Results

The projected change in water level from 2003 to 2025 for the Upper Alluvial Unit (UAU, SRV model Layer 1), and the Lower Alluvial Unit (LAU, SRV model Layer 3) are shown in Figures 2 and 3, respectively. The various color patterns indicate areas where water levels are projected to rise (the green to blue colored areas) and areas where water levels are projected to decline (the yellow to red areas). The pattern of predicted water level change in the southern portion of the ESRV and Pinal(MS) area shows similarities and also some differences (Figure 4).

Similarities noted include:

1) Projected changes in water levels from both simulations show similar tendencies.

2) The degree of change in projected water level increase or decrease is very similar. Areas that display a significant increase of predicted water level – up to 150 feet in both simulations are delineated by: T1N R6E, T1N R7E, T2S R6E, T2S R8E (see Figure 3 and Figure 60). The predicted increases are mainly attributed to the artificial recharge sites.

3) Other areas in which the two simulations project similar increases in water level are: the Mesa and Gilbert areas, most of the Tempe area and the area covered by the Salt River Pima Maricopa Indian Community (SRPMIC). Most of the rest of the central and east parts of the model area (with the exception of a small portion of Apache Junction area and east of Queen Creek) show similar predicted water level change patterns. Both simulations predict declining water levels in the western portion of Chandler.

Differences between the model results are attributed to several factors that include, but are not limited to:

1) Differences exist between the two models' initial conditions (starting water level configurations in 2000 for the CM model and 2003 for the ADWR-SRV model). Some differences also exist between the two models' hydraulic conductivity distributions. Although the ADWR-SRV model was modified to include the latest hydraulic conductivity data in the Chandler area, the SRV model's hydraulic conductivity distribution has been modified in other areas since the original calibration (see memo from Lou Bota and Phil Jhanke to EVWF on SRV model updates, 12/4/03). The modified version of the SRV model that was used for the Chandler Shallow Aquifer Management Feasibility Study (CM study) was developed prior to some of the more recent changes.

2) Differences exist between the each model's simulated groundwater fluxes to the Scottsdale-Paradise Valley area and to the WSRV sub-basin west of Tempe and through the gap between the southwestern tip of South Mountain and the Sierra Estrella (Figures 2 and 3). These fluxes were simulated as constant "cut-

boundary" conditions in the Chandler model at about –32,200 AF/yr, which for the period 2003-2025 represents a total boundary outflow of 740,600 AF. On the other hand, these areas are not boundaries in the ADWR-SRV model and therefore groundwater flux varied over time. Zone-budget analysis of groundwater underflow in the ADWR-SRV model indicated that the combined simulated outflow through "cut-boundary" areas was –32,447 AF/yr in 2003 and –43,041 AF/yr in 2025, with a total for the period 2003-2025 of 899,456AF.

3) Differences between simulated evapotranspiration (ET) exist between the two models. The Chandler model simulated time varying ET volumes that averaged out to about 1,000 AF/yr. The ADWR SRV model-simulated time varying ET that averaged out to about 2,700 AF/yr in the Pinal(MS) and ESRV portions of the model area.

4) Differences exist between the two models' simulation of groundwater discharge and recharge along the Gila River. These differences occurred because the Chandler model utilized the "Drain" package to simulate groundwater discharge along the Gila River, while the ADWR-SRV model-simulated both groundwater discharge and infiltration (recharge of baseflow) along the Gila River using the "Stream-flow routing package".

   Moderate differences were noted between the simulated volumes of annual groundwater discharge between the two models (the CM model-simulated about 42,400 AF/yr of average annual groundwater discharge to the Gila over the 23-year projection period, while the ADWR-SRV model simulated about 38,500 AF/yr of average annual groundwater discharge). However, these differences had far less impact on model results than the infiltration of baseflow along the Gila that was also simulated by the ADWR-SRV model. The ADWR model-simulated groundwater discharge (baseflow) along the upper 20 miles of the Gila in the model area (from the southeastern portion of the GRIC near Coolidge to Gila Butte, a few miles northwest of Sacaton). Subsequently, the baseflow infiltrated back into the aquifer along the Gila's reach from Gila Butte to the confluence with the Santa Cruz River.

   These simulation results are consistent with historical accounts of the "gaining and losing" reaches of the Gila during predevelopment times when the Gila was perennial throughout the model area (USGS, 1991) (ADWR, 1993). The downstream infiltration of Gila River baseflow in the ADWR model resulted in the simulation of larger water level rises in the western portion of the GRIC than simulated in the Chandler model (Figures 2-4).

5) Differences were noted in the projected water level changes for the Chandler and the south Scottsdale areas. Both models predicted declining water levels in the Chandler area, however the Chandler model predicted water level declines over a larger area covering almost the entire city with the exception of a small portion situated in the south–east corner. The ADWR-SRV model predicts declines only

in the western portion of the city. The Chandler model predicted rising water levels in the south Scottsdale area while the ADWR-SRV model predicted rising water levels in a very small portion of south Scottsdale which borders Tempe, and declining water levels in most of the rest of the south Scottsdale area that was included in the Chandler model area (Figures 2-4).

Differences in simulated groundwater underflow to the Paradise Valley area and to the WSRV probably account for most of the difference. However, other factors undoubtedly also contribute to the difference.

6) Differences between model results in the east Queen Creek area were also noted. Inspection of Figure 4 reveals that the Chandler model simulated water level decline in a very small portion of the Queen Creek area, while the ADWR-SRV model simulated greater decline over a much larger area. The explanation for this difference is not readily apparent, however it is probably due to a combination of many factors, some of which have been previously mentioned.

General Discussion of Model Results

Based on the projected stresses, the ADWR-SRV model results indicate that large areas of the southeast ESRV and Pinal(MS) areas would experience rising water levels over the next two decades. Rising water levels were predicted primarily in areas where substantial future artificial groundwater recharge was projected. The projected artificial recharge for the ESRV that was included in this model scenario ranged from about 145,000 acre-feet per year in 2005 to about 183,000 acre-feet per year in 2025. For comparison purposes, there were 15 permitted artificial recharge facilities in the ESRV in 2002 that had a combined total permitted annual recharge volume of about 260,000 acre-feet per year. Actual reported artificial recharge at those facilities in 2002 was about 109,000 acre-feet.

Model projections indicate rising water levels over most of the GRIC in the ESRV and Pinal(MS) areas. The predicted rise in water levels on the GRIC occurs mainly in areas where new farming or more intensive farming is projected. In these areas the volume of projected incidental agricultural recharge is generally greater than the projected pumping volume. Water levels in the northern part of GRIC (south and southeast of South Mountain) and in the far northwestern portion of GRIC are projected to follow the same general decline trend predicted for most of the WSRV.

The model results indicated declining water levels in Queen Creek, Apache Junction, west Chandler, south-west Scottsdale and Phoenix (Paradise Valley) areas. The declines in these areas are primarily attributed to increases in projected pumpage

The model predicts significant declines in water levels for most of the WSRV with the major exception of the Buckeye area. However, the predicted declines in some portions of the WSRV are probably over-estimated because the projected recharge assumptions for the WSRV were based on ADWR's 1996 CTA planning study, which only included an average of about 23,000 acre-feet per year of artificial recharge for the two artificial recharge facilities that were permitted in the WSRV at that time. Since 1996, an additional 11 artificial recharge facilities have been permitted in the WSRV that have a combined annual permitted recharge volume of approximately 175,000 acre-feet per year. Reported recharge at the 13 permitted facilities in the WSRV in 2002 was about 50,000 acre-feet. The over-projection of water level decline in some portions of the WSRV probably has only a minimal impact on the predicted water levels in the ESRV because of the limited hydraulic connection between the two sub-basins. However, future model runs will include updated artificial recharge projections for the WSRV sub-basin.

The projected depth to water in 2025 is shown in Figure 5. This map was prepared by subtracting the model projected water level change from 2002 to 2025 from the average measured depth to water in each model cell in 2002. Areas where the projected depth to water exceeds 600 feet below land surface are shown in yellow to brownish colors. Areas where the projected depth to water is above land surface are shown in blue (Buckeye and GRIC areas). It should be noted that the current depth to water is shallow in the Buckeye "water-logged" area and in many parts of the western GRIC, so these results are not unexpected based on current conditions and in recognition of the large projected increases in agricultural recharge that were simulated on the GRIC. Although the projected water logging in these agricultural lands is not unexpected, it seems likely that there would be reductions in agricultural activity and/or drainage activities commenced if significant water logging actually occurred.

Water logging was also projected for the south Gilbert/west Queen Creek artificial recharge site (Figure 5). Shallow groundwater conditions were also predicted at the GRUSP and CAGRD sites. The model projected groundwater discharge (baseflow) to begin to occur in the channel of the Salt River at the GRUSP site by the year 2010. The projected baseflow on the Salt infiltrated back into the aquifer within a mile downstream of the GRUSP site. Based on current water levels and projected artificial recharge volumes these results are not totally unexpected. However, it's a certainty that there would be reductions in recharge at these sites if water levels actually approached the land surface.

The projected water level elevation in 2025 is shown in Figure 6. Examination of this figure reveals the persistence of regional groundwater flow patterns and regional cones of depression. Groundwater mounding in the vicinity of artificial recharge sites, such as GRUSP and the CAGRD site is also indicated. Hydrographs of model-simulated water levels are compared to measured water level data for selected "index" wells in Figure 7. These hydrographs show the general correspondence between simulated and measured water levels over the 1983 to 2003 calibration period and also show simulated projection trends through 2025 for both east and west SRV areas.

Recommendations for Future Model Scenarios

The preliminary model run for the EVWF has been useful for a variety of reasons. The simulation results have identified some areas where improbable assumptions concerning future groundwater recharge and/or pumpage seem likely. Additionally, some of the difficulties that have already been encountered in developing this preliminary model run reflect the overall complexity in conducting a combined planning and modeling study of this magnitude. This experience suggests the need for careful coordination and communication between all parties to ensure that each future projection scenario is developed with clearly understood assumptions and accurately translated into model data sets. Based on the model results and experience thus far obtained, the following recommendations are made.

- Projected groundwater pumpage and recharge on the Gila River Indian Community (Figure 5) should be carefully evaluated. The large projected water logged areas in the western portion of the GRIC suggest drainage pumpage would be necessary if agricultural activity occurs at projected levels.

- Projected groundwater recharge at the Gilbert/Queen Creek, GRUSP and CAGRD (Figure 5) recharge facilities should be evaluated as the projected water level rises near or above land surface at these sites.

- Projected recharge for Gilbert vadose zone wells (Figure 2 and 3) should be evaluated. The projected uniform blanketing of the Gilbert area with these wells should be confirmed.

- Projected pumpage by small water providers, industrial users and agricultural users not supplied by a major municipality, water company, the SRP or the RWCD should be carefully evaluated. This was the “other” category of pumping in the Chandler model. This category of pumping may have been double counted with projected municipal or irrigation district pumping in some areas, and remains an uncertainty in other areas.

- Projected M&I pumpage in the Apache Junction area, the Arizona Water Company Service area and the Johnson Ranch area should be carefully evaluated. These areas have changed greatly since the CTA study and updated projections are required.

- Projected agricultural pumpage and/or groundwater savings facility water use in the New Magma and Queen Creek areas should be evaluated. Again, much has happened since the CTA study in these areas and the projections need to be updated.

- Projected SRP pumpage needs to be carefully compared to projected municipal pumpage to ensure that there is no “double-count” of pumping if SRP supplies a portion of a municipal provider’s water supply.

- Although this modeling study is primarily intended to evaluate future groundwater conditions in the ESRV, it is still important to include updated artificial recharge projections for the WSRV in future scenarios.

- Model results in the Paradise Valley area should be compared to results from the Scottsdale/Phoenix Northeast Valley Aquifer Management Plan.

- Projected flood recharge along the Salt and Gila should be compared to recent ADWR estimates.

- Projected groundwater pumpage and recharge on the SRPMIC should be evaluated.

- Recharge assigned to "inactive cells" should be evaluated.

- Review of recent satellite imagery for the Phoenix AMA has revealed substantial decreases in cropped acreage over the last several years. This trend is also confirmed by review of Arizona Agricultural Statistics Reports (2003) that reveal that cropped acreage in Maricopa County for major crops (alfalfa, cotton, corn, wheat and barley) has dropped by about 35 percent from about 259,200 acres in 1997 to 169,100 acres in 2003. Comparison of current cropping levels to projected cropping levels that were developed from the 1996 CTA run (which were the basis for projections of future agricultural recharge used in this model scenario) indicate a substantial over-projection of agricultural acreage and agricultural recharge for future years. Future projections of agricultural recharge must take the new estimates of current agricultural activity into account.

- All water providers and irrigation districts that are participating in the EVWF planning/modeling study should review their pumpage and recharge projections and confirm and/or modify those projections accordingly.

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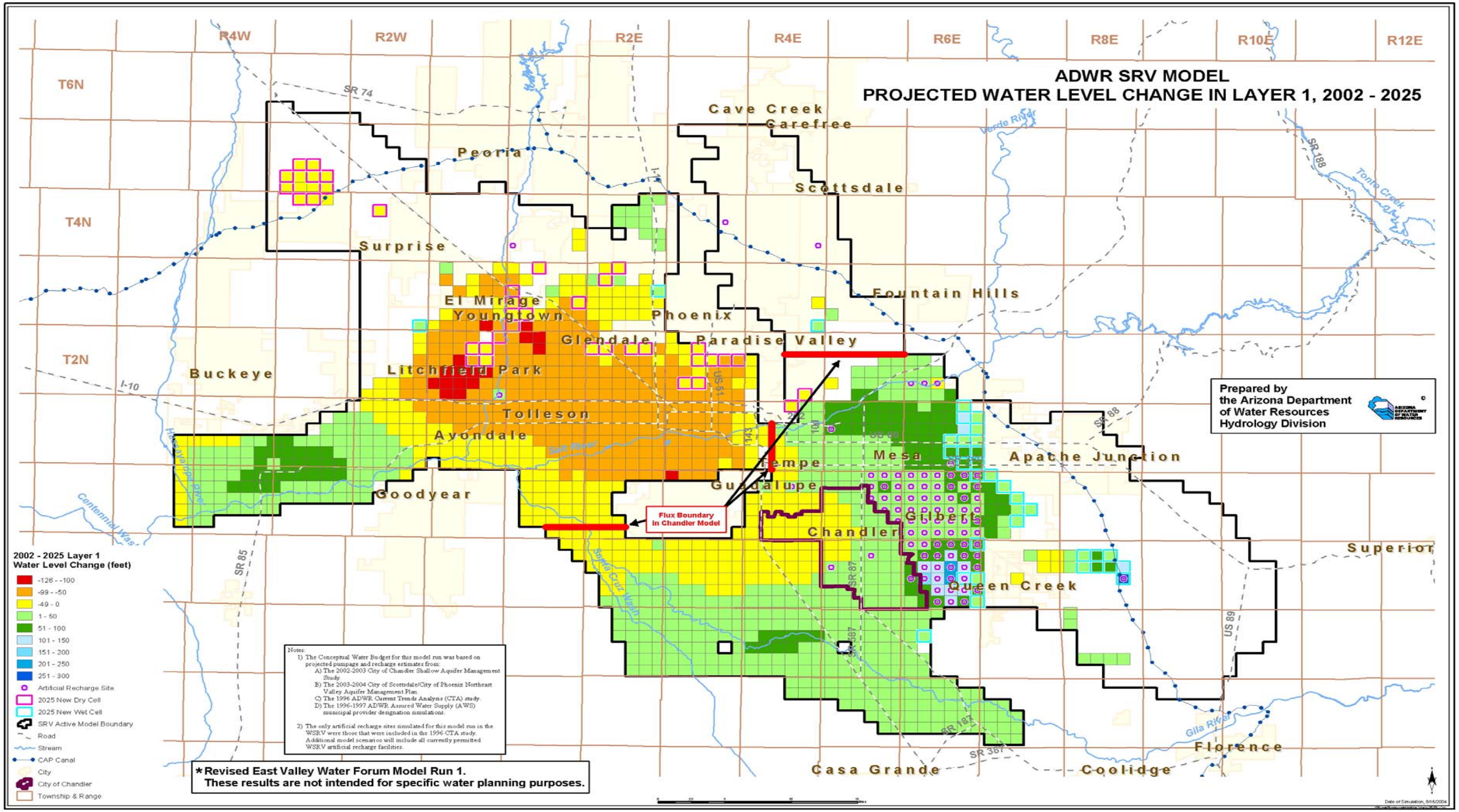


Figure 2. Water level change Layer 1 2002-2025

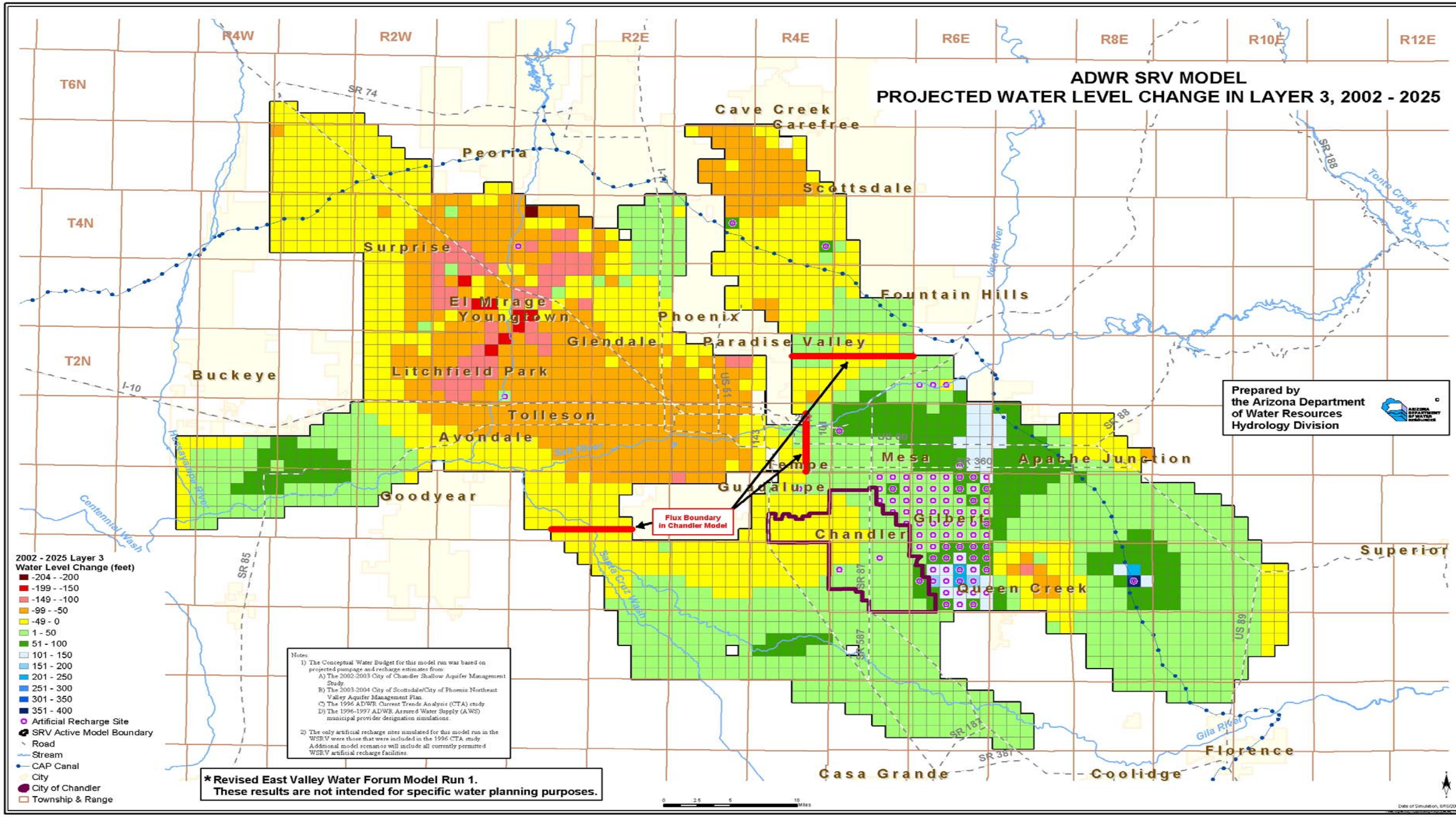


Figure 3. Water level change Layer 3 2002-2025

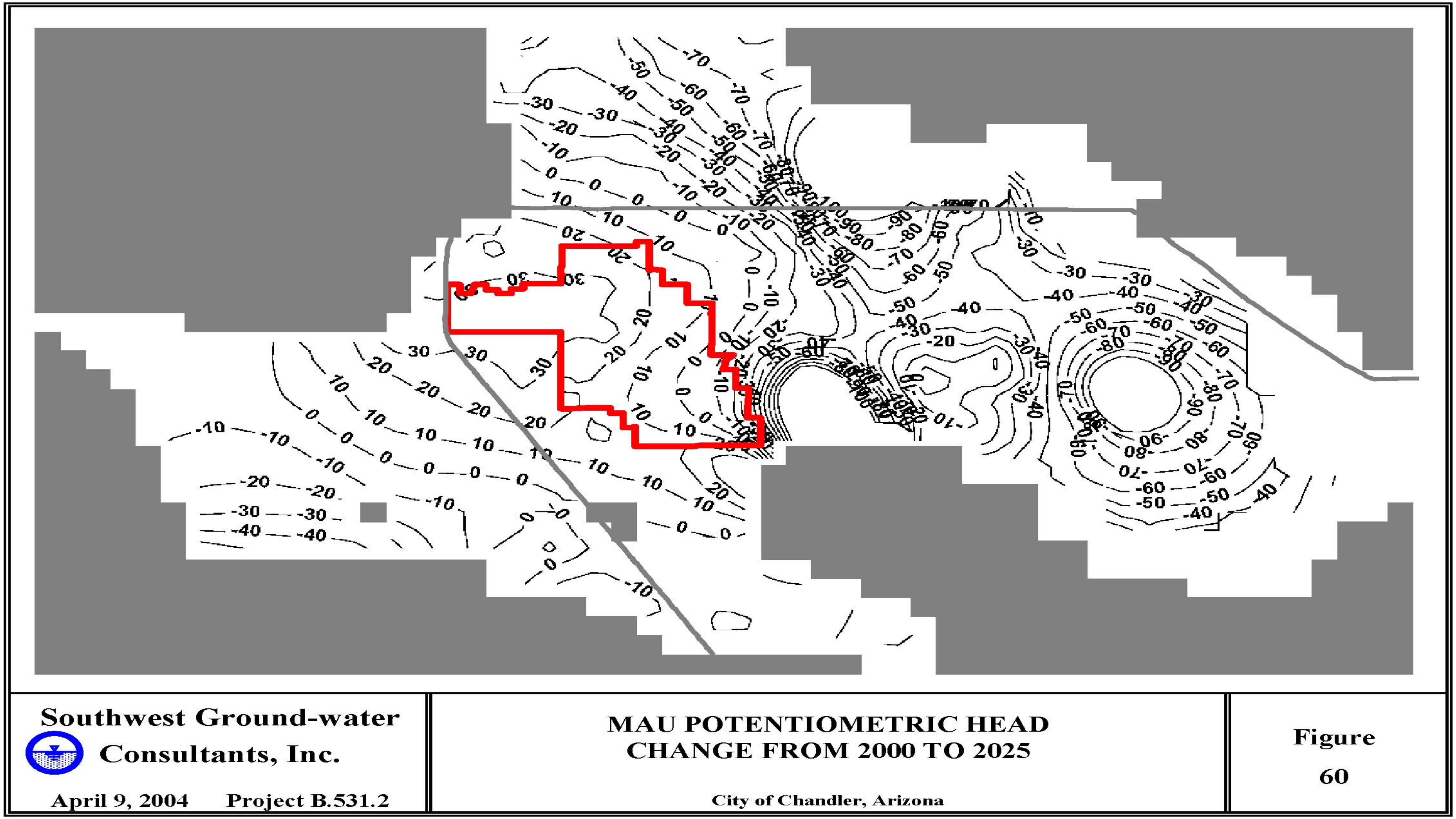


Figure 4. Chandler Model MAU head change 2000 to 2025

(Figure shown with the permission of SWG. Negative values indicate water level rises, positive values represent water level declines)

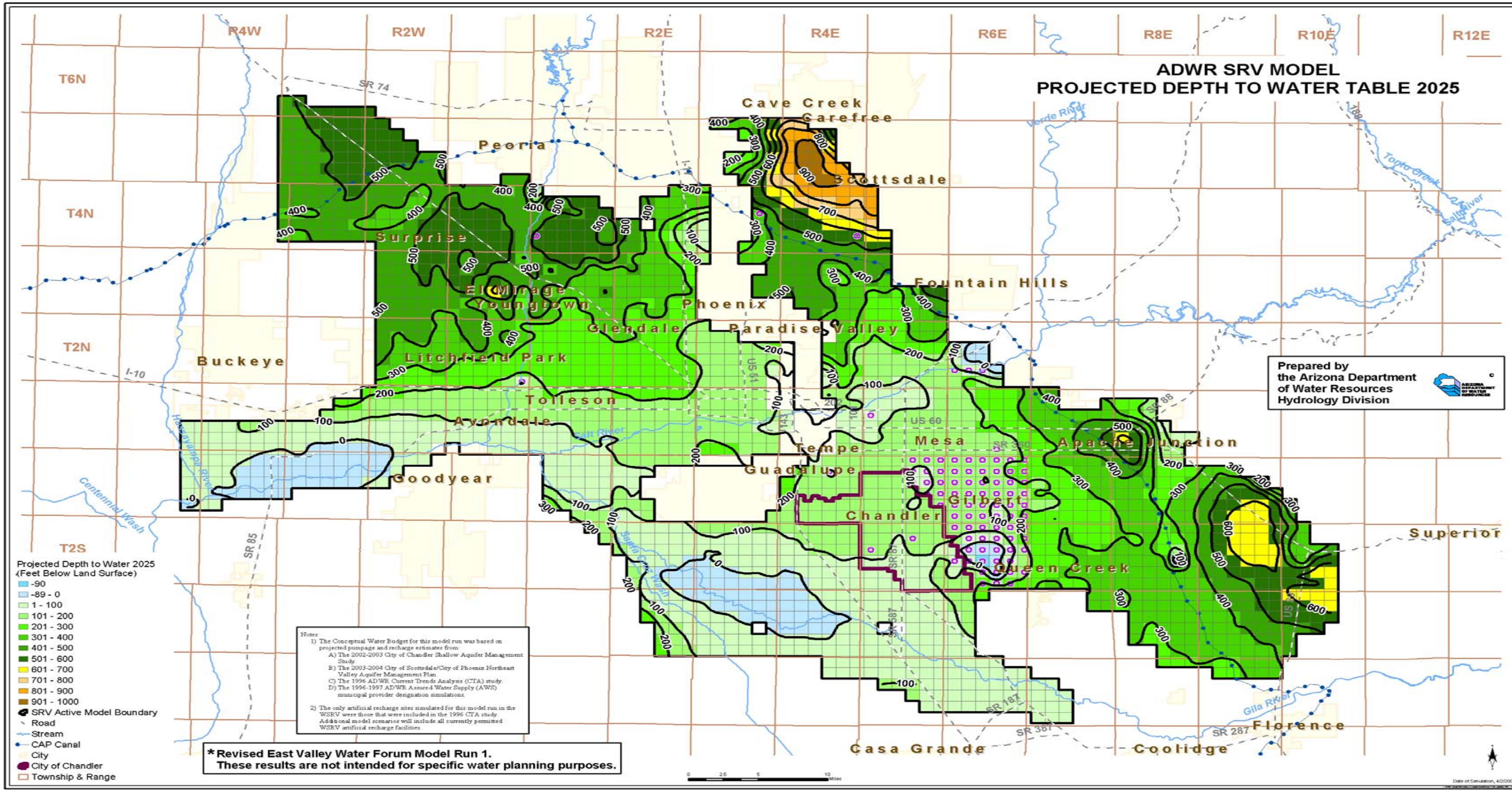


Figure 5. Projected Depth to Water 2025

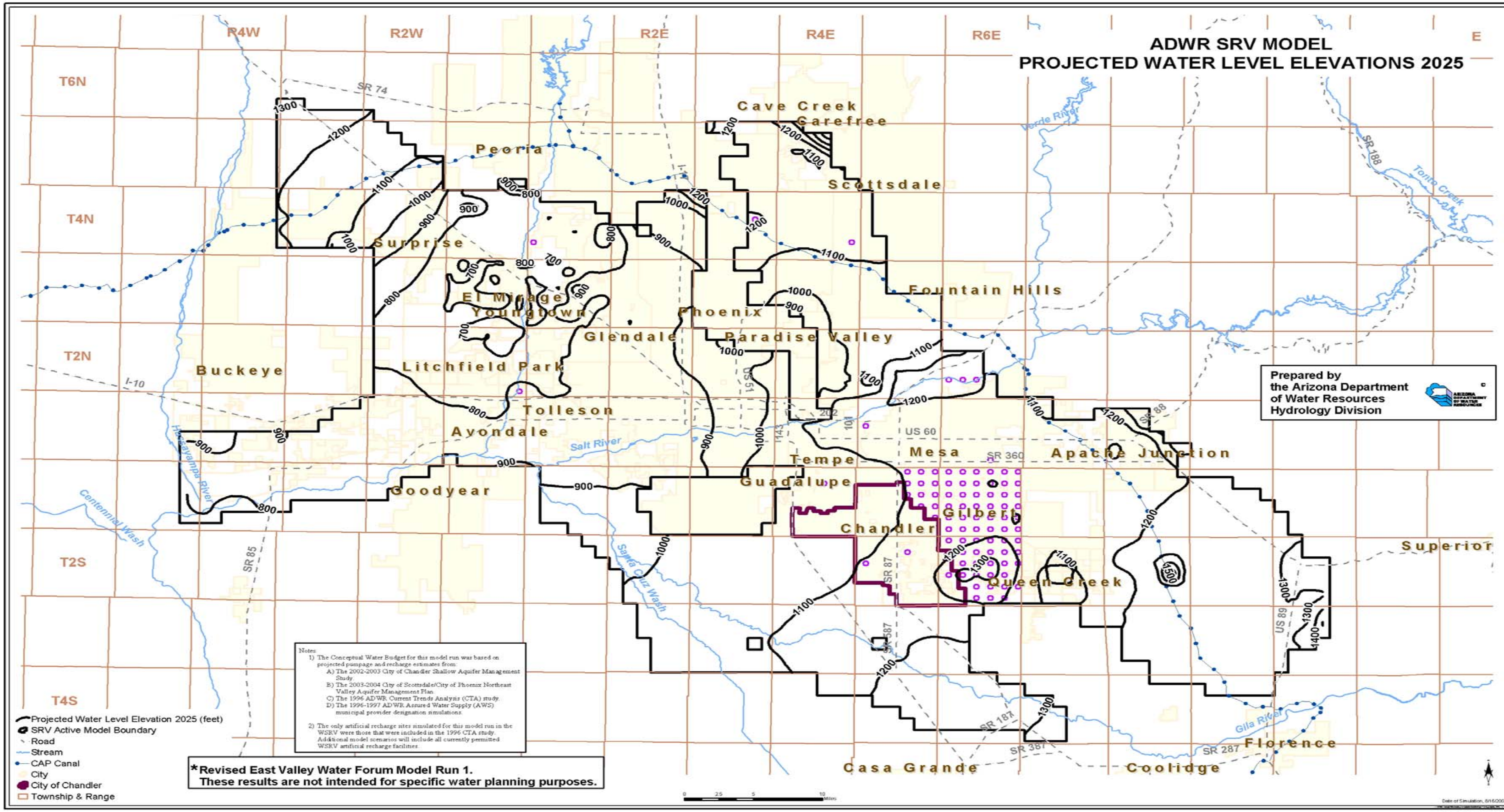


Figure 6. Projected water level elevations 2025

1. East SRV

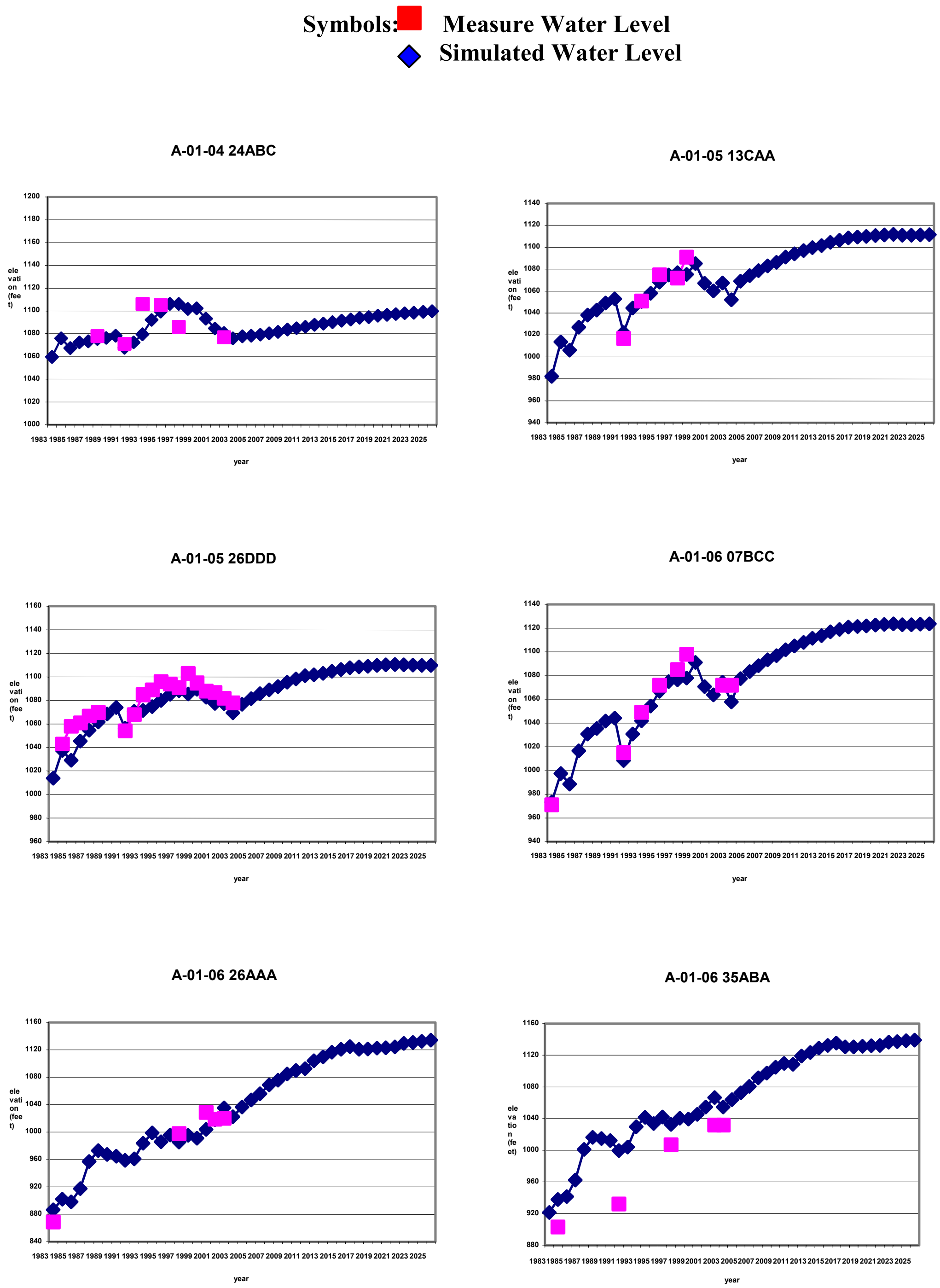


Figure 7. Hydrographs of selected wells

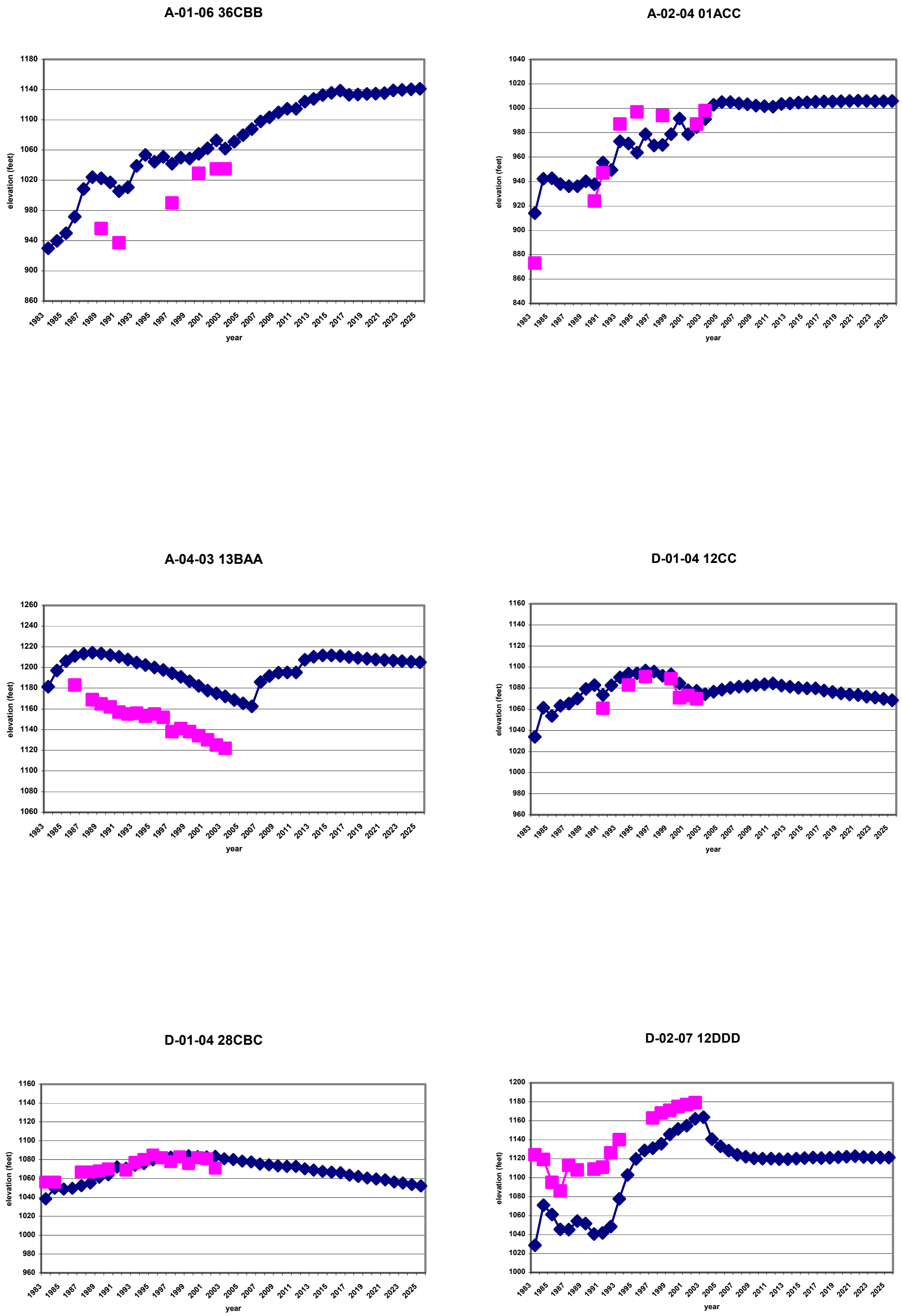
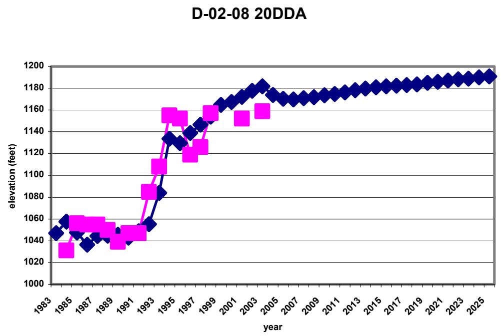
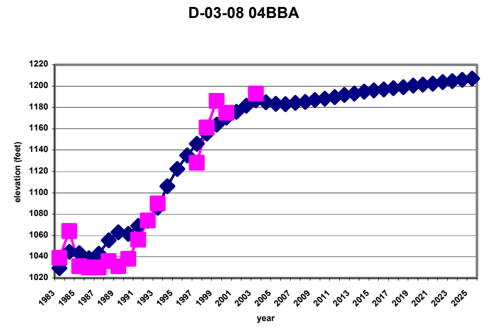
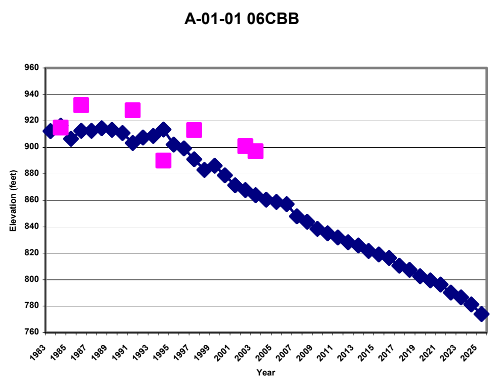


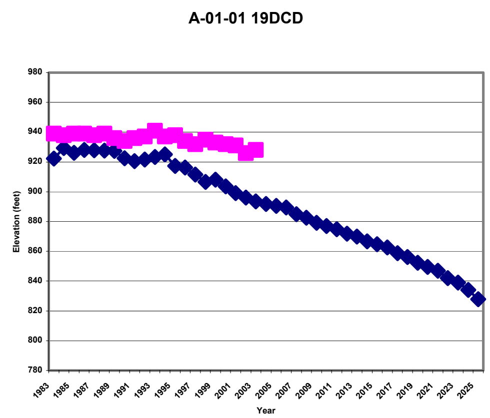
Figure 8. Hydrographs of selected wells

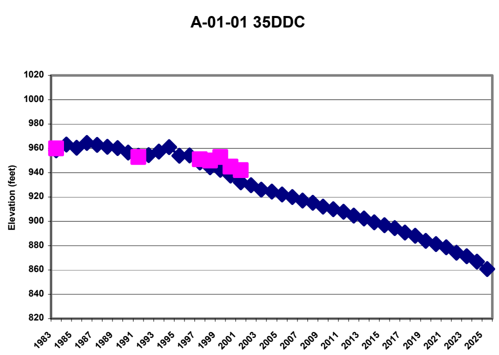




2. West SRV







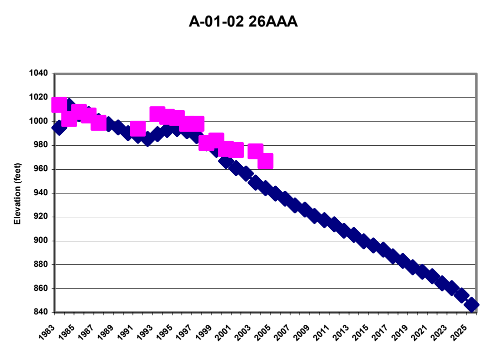


Figure 9. Hydrographs of selected wells

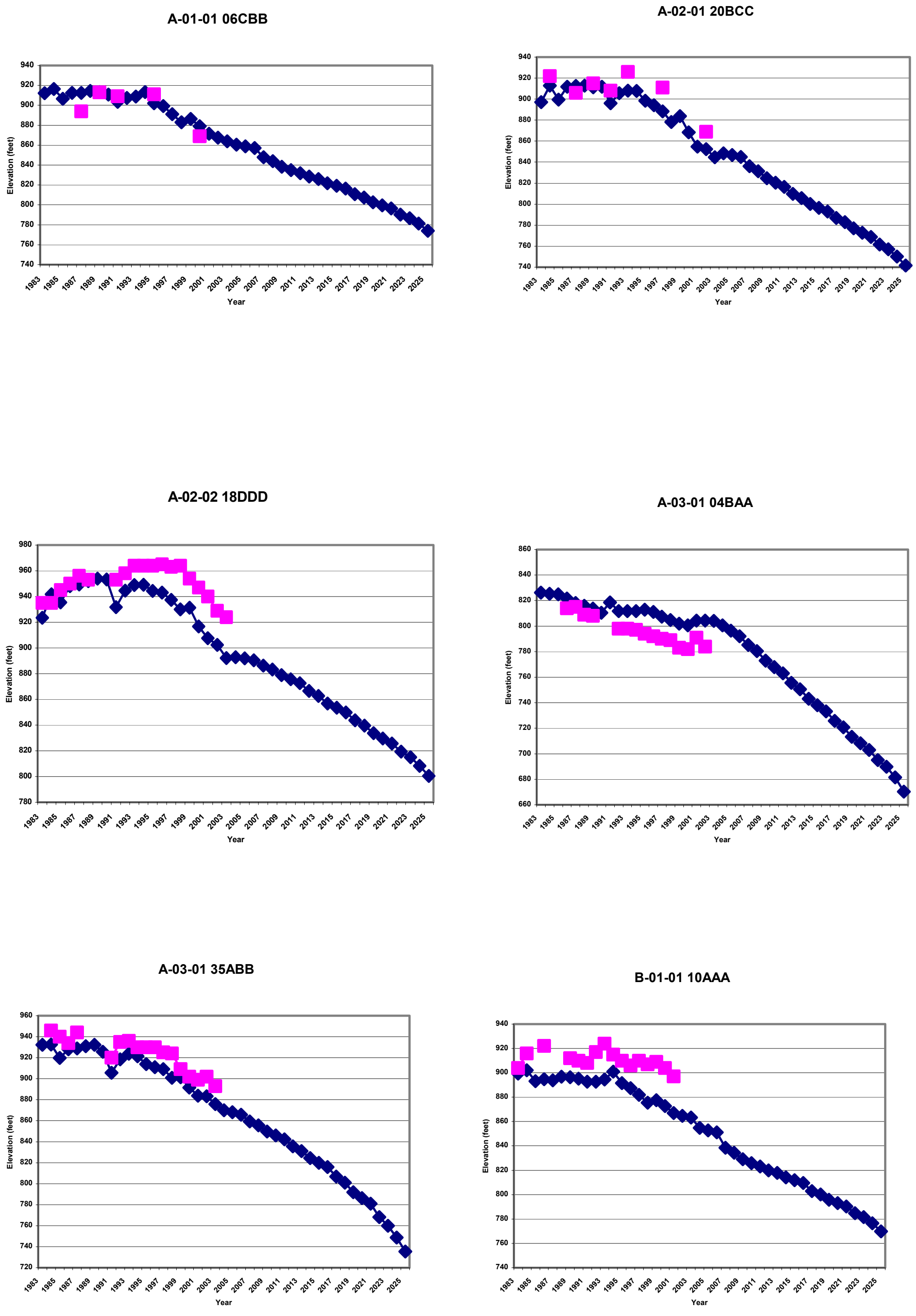


Figure 10. Hydrographs of selected wells

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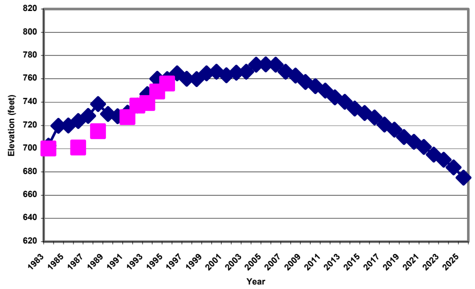

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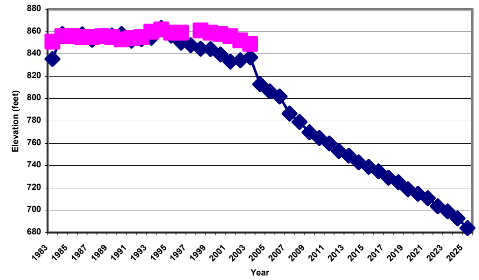
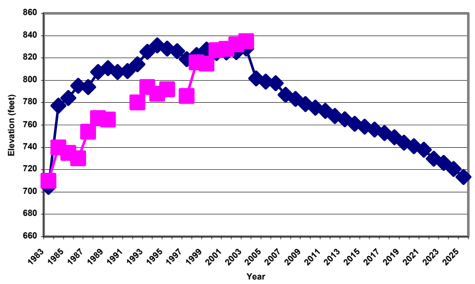


B-02-02 25CBB



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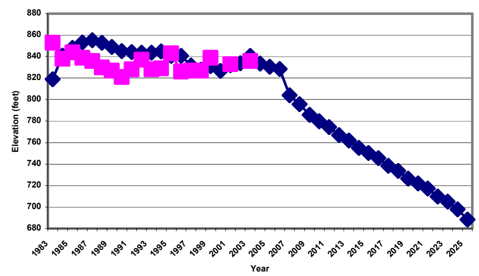

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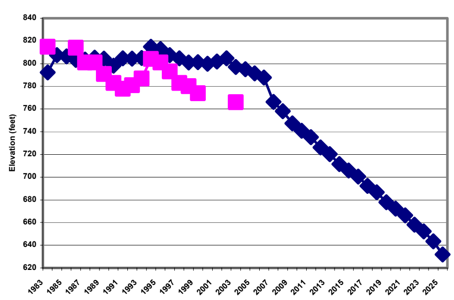

Figure 11. Hydrographs of selected wells