Comparison of Simulated and Observed Effects of Pumping from MX-5 Using Data Collected to the End of the Order 1169 Test, and Prediction of the Rates of Recovery from the Test

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Prepared For:

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1.0 INTRODUCTION AND PURPOSE

On behalf of three Department of the Interior agencies (the US Fish and Wildlife Service, National Park Service, and Bureau of Land Management), Tetra Tech (2012a) prepared a three-dimensional model of groundwater flow of part of the Colorado River Flow System. This model is intended to provide information on the effects of current and future groundwater use on the groundwater system, which includes resources that are the responsibility of these three agencies.

Calibration of the model was based in part on the observed responses to pumping of the carbonate aquifer in Coyote Spring Valley (CSV) over the first part of the Order 1169 test, during the period September 2010 through December 2011. Data are now available on the effects of pumping in CSV through December 2012, when the Order 1169 test was declared complete. The first part of this present evaluation is designed to determine how well the modeling results agree with the observed water-level drawdown and spring discharge data collected in 2012. The model was not calibrated to the more recent information. The results can be used to estimate whether the model over-predicts or under-predicts the effects of pumping in CSV. The conclusions of this evaluation should only be applied to the effects of pumping in CSV, and not from other areas of groundwater use.

The model is also used to evaluate what is likely to happen if pumping in CSV were to be reduced. One possible management option for protecting the stream and spring environments in the Muddy River Springs area would be to reduce pumping rates if water levels declined to a mitigative threshold value. However, it is unknown whether a reduction in the pumping rate would cause an “immediate” recovery of water levels and spring flow in the Muddy River Springs area, or if drawdown and water-discharge would continue to decline for some time, and by how much. The second part of this report evaluates the likely recovery effects, using cessation of pumping in MX-5 at the end of the Order 1169 test as the imposed change in pumping stress.

2.0 POST-AUDIT SIMULATION

The post-audit simulation is a comparison of the simulated versus measured changes in water levels and discharge rates in the Muddy River Springs area, based on an additional year of simulation using reported rates of pumping. In order to perform this simulation, reported monthly pumping data were obtained from the Nevada Division of Water Resources' website used to distribute information pertaining to the Order 1169 pumping test. In addition, measured water level and spring discharge data were obtained for comparison with the simulation results. Results are presented in the form of graphs in Section 2.4.

2.1 APPROACH

The simulation was performed with the long-term model described in Tetra Tech (2012a), modified to include an additional 12 months of pumping to cover the period January 1, 2012 through December 31, 2012. [In addition, the model simulation time was extended an additional 15 years to evaluate the time required for the groundwater system to recover from the effects of Order 1169 pumping. These changes and the results are discussed in more detail in Section 3.0.] The Multinode Well package dataset was modified by adding the reported 2012 monthly pumping volumes, converted to cubic feet per day, into additional monthly stress period records. If reported values were not available for a well during 2012, the average of the monthly pumping for the previous three-year period was used for the applicable month in 2012, under the assumption that water needs in 2012 were similar to those in recent years.

Other data sets needed to be extended as well. These included data sets describing recharge, the stage in Lake Mead, evapotranspiration, and streamflow. For recharge, this was done simply by informing MODFLOW to use the information for the previous stress period, as recharge was assumed to remain constant throughout the year. The stage in Lake Mead throughout 2012 was assumed to be the same as it was in December 2011. For evapotranspiration and streamflow, the 12 stress periods representing 2011 were repeated for 2012, so that the seasonally varying stresses were applied for 2012 in the same manner as previous stress periods.

The file for the Head Observation Package was modified to include the additional data for 2012, in order that simulation results corresponding to the dates of the measurements would be printed out.

2.2 PUMPING RATES

Figures 2-1a and 2-1b display the monthly pumping (expressed in gallons per minute, gpm) from wells completed in carbonate rocks, and completed in basin-fill sediments, respectively, in Coyote Spring Valley and the Muddy River Springs Area, for the period 2005 through 2012. While the pumping is expressed in gpm, the values represent the average rate over the month, not the instantaneous rate that was pumped at any time. The pumping from the carbonate rocks began in 1992, when production from Arrow Canyon began. The rate of pumping varies seasonally, with the higher rates occurring during the summer months. During the period 2005 through mid-2009, the seasonal high rates (summer) ranged from approximately 2,000 gpm to 3,000 gpm. The winter usage ranged from zero to approximately 1,000 gpm.

During the summer of 2010 (prior to the start of significant pumping from MX-5), the rate increased more than 3,000 gpm, due to pumping of CSI-3 and CSI-4.

In September 2010, pumping of MX-5 at significant rates (greater than 1,500 gpm on average) began. Smaller volumes were pumped in July and August. The maximum average rates were approximately 3,500 gpm. There were two one to two month periods, in mid-2011 and early 2012, when MX-5 pumping essentially stopped. Pumping continued to the end of 2012, when the State Engineer's Office declared that the test was officially completed, and may have continued in 2013. During the period when MX-5 was being pumped, total pumping from the carbonate aquifer exceeded 6,000 gpm on several occasions during the summer. Thus, the Order 1169 pumping from MX-5 approximately doubled the amount of water being removed from the carbonate aquifer, primarily during the summer months.

Pumping from the basin-fill wells near the Muddy River Springs also followed a seasonal pattern, with the greatest pumping occurring during the summer months. The maximum rate varied from about 3,000 gpm to 4,500 gpm, similar to rates of pumping from the carbonate aquifer. However, there was not an appreciable difference in pumping rates for the periods before and during the Order 1169 test. Average rates during the winter months were typically down to 500 to 1000 gpm.

2.3 OBSERVED WATER LEVEL AND DISCHARGE CHANGES

Figure 2-2 provides water-level measurements for selected wells completed in the carbonate aquifer, over the period 2005 through 2012. The figure also shows the average monthly pumping rate from MX-5, inverted so that increases in pumping rate are downward on the figure, in the same direction as decreases in water level.

The water-level data in many wells show both seasonal changes, caused by seasonal pumping and evapotranspiration in the Muddy River Springs area, pumping in Coyote Spring Valley, and longer term declines caused by general groundwater usage. Significant pumping from MX-5 began in September 2010, although the official start of the Order 1169 pumping was November 2010. The following discussion is divided by geographic area.

Coyote Spring Valley – There are four wells that are located in Coyote Spring Valley that are shown on Figure 2-2.

- MX-4 is located 100 feet from MX-5, and is the closest observation well to MX-5. Water levels in this well showed seasonal effects prior to pumping of any wells in Coyote Spring Valley, indicating that changes in water consumption/pumping in the Muddy River Springs area are transmitted into this part of Coyote Spring Valley. There was also a long-term decline in water levels observed in MX-4 that is likely attributable to greater amounts of pumping from the carbonate aquifer from the Arrow Canyon and Arrow Canyon 2 wells in the Muddy River Springs area. With the onset of pumping at MX-5, the slope of this long-term downward trend increased, as would be expected. It is interesting to note that following the brief periods when MX-5 pumping stopped in mid-2011 and early 2012, there were distinct increases in water levels observed in MX-4 (and also in CSVM-1). [The three plotted measurements for MX-4 during the second half of

2011 with values of approximately 1816.5 feet amsl appear to be a data-entry error, as the transducer data indicate that the water levels were about 2 feet higher during this period.] However, when substantial pumping of MX-5 started in September 2010, a distinct increase in the decline in water levels did not occur in MX-4 or CSVM-1, only a continuation of the same downward trend. Figure 2-1 shows that the pumping rate from the Arrow Canyon well decreased at the same time that pumping increased from MX-5, so that the observed water-level responses may reflect the combined off-setting effect of these two pumping changes.

- CSVM-1 is located east of MX-5 approximately one-half mile. The water levels in this well are very similar to those in MX-4. The slope of the longer-term decline in water levels is similar to that observed in MX-4.

- CSVM-2 is located in the southern part of Coyote Spring Valley, approximately eight miles from MX-5 and MX-4. Water level trends in this well are similar to those in MX-4 and CSVM-1, but the water levels in this well are higher in elevation than those in the other two wells. Seasonal trends are present in the water level record, as are the slow long-term decline in water levels prior to the start of the Order 1169 test, and the more rapid decline in water levels during the test. Even short-term changes are apparent in CSVM-2 water levels that are quite similar to those observed in MX-4, which seem to be visually correlated with changes in MX-5 pumping rates. The water levels in this well are approximately 2.5 feet higher than those in MX-4 prior to the start of MX-5 pumping, but the difference increases to about 3.3 feet when pumping is occurring. The increase in the difference is consistent with pumping of MX-5, as drawdown should be greater near the well being pumped.

Muddy River Springs Area – Two wells, EH-5B and EH-4, were selected to show temporal changes in water levels in the carbonate aquifer.

- EH-5B is located east of the two Arrow Canyon wells, and is expected to respond to pumping from these two wells, as well as from pumping in MX-5. Pumping from shallower alluvial wells and seasonal ET will also have effects. With the beginning of pumping at MX-5, the general rate of decline in water levels increased, as in other wells. One notable difference from the response in the wells in Coyote Spring Valley occurred at the beginning of pumping in MX-5. In the Coyote Spring Valley wells, water levels declined with the start of MX-5 pumping. However, in EH-5B (and EH-4), water levels rose at this time, probably because of the reduction in pumping from the Arrow Canyon wells that occurred at that time. Thus, the responses in EH-5B reflect both MX-5 pumping effects and pumping effects in the Muddy River Springs area, as do responses in Coyote Spring Valley wells. However, the effect of pumping in the Muddy River Springs area has a proportionally greater effect on EH-5B water levels than on water levels in Coyote Spring Valley.

- EH-4 is located south of the two Pedersen springs, and to the southwest of the alluvial deposits which are both pumped and provide natural diffuse groundwater discharge into the Muddy River. The water level responses in EH-4 are very similar to those in EH-5B.

California Wash – Two wells, Paiute M-1 and Paiute M-3, were selected for evaluation of changes in California Wash water levels. Paiute M-1 is located in the northern part of California Wash, about five miles south of the Muddy River Springs area. Paiute M-2 is located 15 miles from the Muddy River Springs area, and approximately eighteen miles from MX-5, on the east side of the Arrow Canyon Range.

- Paiute M-1 water levels show both seasonal effects and an increase in the rate of longer-term downward decline when pumping of MX-5 began. The earlier measurements included in the spreadsheet that was obtained from the State Engineers Office appear to contain a shift in the datum during 2006 and has some time gaps. In contrast, the data reported from 2009 to the present visually correlate well with carbonate water levels measured in Coyote Spring Valley and the Muddy River Springs area. The rise in water levels that was observed in EH-4 and EH-5B at the beginning of the pumping of MX-5, attributed to a reduction in Arrow Canyon pumping, also occurred in Paiute M-1, but was less pronounced than in the wells in the Muddy River Springs area.

- Paiute M-3 water level data are similar to the measurements from Paiute M-1, with the elevation being approximately 1 foot lower.

In summary, the water-level data presented here indicate that seasonal changes in water levels were observed over a large area. The most likely causes are seasonal pumping and evapotranspiration in the Muddy River Springs area, and seasonal pumping in Coyote Spring Valley. The widespread transmission of these effects is evidence of the high permeability and low storage properties of the carbonate aquifer in this region. A relatively slow decline in carbonate water levels was occurring prior to pumping of MX-5. With the increase in pumping from the carbonate aquifer when pumping of MX-5 began, there was a distinct increase in the rate of water-level decline over a large area.

2.4 MODEL SIMULATION RESULTS

The simulation results are presented in the same format as in Tetra Tech (2012a), with minor changes. Figure 6.2-5 of that report provided several graphs of simulated and observed drawdown, from the start of the Order 1169 simulation. The Order 1169 simulation began two years before the start of the MX-5 pumping, and the results were shown for that two-year period. In this report, results are shown starting at the beginning of 2010, or about 9 months before the start of MX-5 pumping. The time axis, located across the plot area of the graphs, shows the calendar year, rather than simulated year, for easier evaluation. In addition, “drawdown” is referenced to the date of the closest measurement relative to September 1, 2010.

The discharge in the Muddy River Springs area is presented in the same format as Figure 6.3-1 in Tetra Tech (2012a), except that the figure starts on January 1, 2010, and the discharge is only shown for the springs.

2.4.1 DRAWDOWN THROUGH TIME

Figure 2-3 shows the simulated and observed water-level changes for several selected monitoring wells in the study area, as described above. The addition of another year of MX-5

pumping to the simulation, and the comparison of simulated and observed drawdown, makes it apparent that the model under-simulates the amount of drawdown that is being caused by pumping of the carbonate aquifer. Tetra Tech (2012a, p. 44) had noted that the model does not simulate short-term (seasonal) variability in some areas where it is observed, and suggested that adjustment of carbonate transmissivity and storage parameters may improve the model fit to observed changes in water levels. It was unclear, based on simulating pumping through 2011, whether the model under-simulated the amount of drawdown caused by pumping at MX-5. The current results clearly indicate that the model under-simulates the amount, and probably the extent, of drawdown. For example, at CSVM-6 (located about 3 miles north of MX-5), the simulated drawdown is approximately 0.6 feet, while the observed drawdown is up to 2.4 feet. At CSVM-2 and CSV-3, approximately eight to ten miles south of MX-5, the measured drawdowns were up to 2 feet, but the simulated values are less than 0.5 feet. In California Wash, the observed drawdown was also about 2 feet (Paiute M-1 and Paiute M-3) but the simulated drawdown is 0.3 feet or less.

2.4.2 SPRING FLOW

Figure 2-4 shows the observed and simulated discharge rates from the springs. In general, the model simulates very little change in the discharges, while there are small observed declines in the measured values during the Order 1169 test period. [The increases in observed discharge at Muddy Spring are believed to have been caused by anthropogenic changes near the spring.] The limited simulated impact on the discharge is, at least in part, caused by the under-simulation of drawdown.

2.4.3 SPATIAL EXTENT OF SIMULATED DRAWDOWN

Maps of the simulated drawdown caused by pumping of MX-5 were developed by first simulating the effects of all pumping (including MX-5), then simulating the effects of all pumping except MX-5, and subtracting the simulated water levels of the second run from those of the first run. The result is a dataset with the simulated drawdown caused by pumping of MX-5. This approach was used to eliminate possible effects that might be caused by non-linear boundary conditions. It isolates the effects of MX-5 pumping.

Figure 2-5 shows the simulated drawdown in model layer 5 caused by MX-5 pumping as part of the Order 1169 test, at three different times. The leftmost panel shows the simulated effects at the end of December 2011, while the central panel shows the simulated effects of an additional year of pumping. The rightmost panel is the predicted drawdown 15 years after MX-5 pumping is turned off in the model at the beginning of 2013; this panel is discussed in a following section. Layer 5 is the model layer exhibiting the greatest drawdown at the location of MX-5. Figure 2-6 is a similar set of maps, for model layer 11. This layer exhibited the greatest extent of drawdown.

In the time interval between the end of 2011 and the end of 2012, pumping continued from MX-5, and the extent of simulated drawdown increased in all directions. The amount of drawdown near MX-5 also increases, in both layer 5 and 11. The area of drawdown has begun to extend more in a north-south direction, reflecting the influence of the geology. To the north, the area of simulated drawdown greater than 0.1 feet has reached Kane Spring Valley (layers 5 and

11). To the south, it has reached the central part of Garnet Valley and nearly all of Hidden Valley (layer 11).

As noted above, the model under-simulates the drawdown caused by MX-5 pumping. Thus, the simulated amount and the extent of drawdown depicted on these maps is less than has been observed.

2.5 DISCUSSION

This post-audit evaluation of the CRFS model indicates that the model under-simulates the amount of drawdown that was caused by the Order 1169 pumping of MX-5 through the end of 2012. As a result of this, the simulated effect of this pumping on the discharge from springs in the Muddy River Springs area is too small. These results indicate that additional calibration of the model using the more recent data would be beneficial. In the interim, the predictive results presented in Tetra Tech (2012b) that pertain to pumping existing and pending water rights from the carbonate rock aquifer in Coyote Spring Valley and Muddy River Springs area should be viewed as conservative, as the impacts are likely to be under-estimated. Specifically, the carbonate water levels that drive the discharge from the springs in the Muddy River Springs area will decline more quickly than simulated, and the flows from the springs and in the Muddy River will decline more quickly.

3.0 RECOVERY SIMULATION

3.1 APPROACH

The model was run using monthly stress periods for a 15-year period, in which no pumping was assumed to occur from MX-5, but other pumping was assumed to occur at the average of the rates in 2010, 2011 and 2012. The simulated pumping rates from carbonate wells in Coyote Spring Valley and the Muddy River Springs area are shown in a plot at the bottom of Figure 3-1. Evapotranspiration was assumed to continue to occur seasonally at the same rates as simulated at earlier times. The stage of Lake Mead was assumed to remain at the level it was in December 2012.

3.2 SIMULATION RESULTS

3.2.1 DRAWDOWN THROUGH TIME

Simulated drawdown at several wells is shown on Figure 3-1. The earlier-time water levels show the effects of MX-5 superimposed on a general downward trend. The effect of stopping MX-5 pumping is very evident in wells close to MX-5 (MX-4, CSV-RW2, CSVM-1, UMVW-1, MX-6) and easily discernible in more distant wells (DF-1, CSVM-6, CSVM-5, CSV-3, CSVM-2, CSV-1, CSI-2, CSI-1), as water levels in these wells begin to rise. The effect is also present (as observable changes in slope) in the simulated responses of Arrow Canyon, Arrow Canyon 2, KMW-1, CSVM-4, CE-VF-2, CSV-2, EH-5B, EH-4, BW-01, Paiutes M-1 and Paiutes M-3.

The time required for recovery is a function of the distance from MX-5 and the criterion used to define when recovery is complete. Figure 3-2a through 3-2h show the drawdown and recovery as a result of MX-5 pumping, after removing the effects of pumping of other wells and seasonal evapotranspiration. For example, at MX-4 (Figure 3-2a), about 75% of the drawdown is recovered very quickly, but after 15 years, the recovery is about 90% complete. At MX-6 (Figure 3-2c), the simulated recovery is about 75% complete after 15 years. At EH-4 (Figure 3-2d), the maximum drawdown is simulated as occurring several months after cessation of MX-5 pumping. The recovery for this well is about 70% complete after 15 years. In areas that are much further away, recovery is simulated as not beginning until after 15 years. Although the simulated drawdown at CSVM-3 (Figure 3-2h) is only 0.03 feet after the 28 months of MX-5 pumping and 15 years of recovery, the drawdown is continuing to increase after cessation of pumping at MX-5.

3.2.2 SPRING FLOW

Because there was no easily observable decrease in the simulated spring discharge, no easily observable increase in simulated spring flow should occur after MX-5 pumping is stopped (Figure 3-3). For example, the decline simulated for Baldwin Spring is less than 2% of the flow in 2010.

3.2.3 SPATIAL EXTENT OF DRAWDOWN

The rightmost panel in Figures 2-5 and 2-6 shows the simulated drawdown after 15 years of recovery. Recovery near MX-5 is nearly complete (recovery was about 90% at MX-4). However, comparison of the results presented in the central and rightmost panels in both figures indicates the area with at least 0.01 feet of drawdown continued to expand after pumping ceased, and has reached the western and southern model boundaries in layers 5 and 11. While the simulated drawdown in these areas is small, the simulation demonstrates that although drawdown has nearly recovered near the pumping well, impacts in other areas might continue to increase a decade or more after pumping has stopped.

3.3 DISCUSSION

There are two significant conclusions from the recovery simulation:

- Recovery from the effect of the 28-month pumping of MX-5 will take longer than the 28 months of pumping, and may take substantially longer depending on the location of interest. Near the Muddy River Springs, approximately one-third of the simulated drawdown remains after 15 years of recovery.

- The model predicts that the drawdown in Coyote Spring Valley and the Muddy River Springs area caused by MX-5 pumping is superimposed on a slower decline of water levels that is likely largely caused by pumping of carbonate aquifer water from the Arrow Canyon and Arrow Canyon 2 wells. However, existing carbonate pumping from wells in Coyote Spring Valley, Garnet Valley and the western part of the Black Mountains Hydrographic Area was also included in the recovery simulation and may be responsible for part of the observed decline in simulated water levels in the vicinity of MX-5.

If additional calibration were to be performed to better match the last year of Order 1169 pumping, it is likely that the hydraulic properties of the carbonate rocks in the western part of the model would change. The transmissivity would likely increase and the specific storage would likely decrease, in order to increase the extent of the drawdown area affected by MX-5 pumping and to increase the amount of drawdown simulated in areas distant from MX-5. These changes would be expected to shorten the period required for complete recovery to occur, but increase the impacts on the discharge from springs in the Muddy River Springs area.

4.0 CONCLUSIONS

The Tetra Tech (2012a) model was calibrated using information available through December 2011. The pumping of MX-5, and the related collection of water-level and discharge information, has provided additional information that was used in evaluating the predictions made with the model pertaining to the effects of pumping in Coyote Spring Valley. The pumping dataset for the model was updated with monthly pumping information for 2012, and the model was run with this revised dataset. Results indicate that the model under-simulates the amount (i.e., calculates less effect) of drawdown and reduction of spring discharge than has occurred as a result of MX-5 pumping during the Order 1169 pumping test period. The observed drawdown is more widespread, and is of greater magnitude, than simulated by the model during this period. The model simulates that the discharge from springs is not affected to a measureable amount, but the real effects are measureable. Thus, predictions that have been made with the model that evaluate the effects of pumping in Coyote Spring Valley should be considered conservative. More specifically, the actual impacts from pumping would be larger and more widespread than simulated by the model.

In addition, the 15-year period after the end of the Order 1169 pumping test on December 31, 2012 was simulated to determine how quickly water level (and spring discharge) recovery is likely to occur. This evaluation indicates that recovery from the 28-month pumping test will occur over years. In the Muddy River Springs area, it was estimated that recovery will be approximately 70% complete after 15 years. In areas that are “distant” from MX-5, results suggest that drawdown can still be increasing 15 years after pumping of MX-5 stopped. If pumping were to occur for longer than 28 months (the total time of the pumping at MX-5 as part of the Order 1169 test), the rate of recovery can be expected to be slower.

The data collected during 2012 could be used to improve the calibration of the model to the observed effects of pumping in Coyote Spring Valley. A revised model would be expected to simulate greater and more widespread drawdown than the current model, more impact on spring flow, and shorter recovery times.

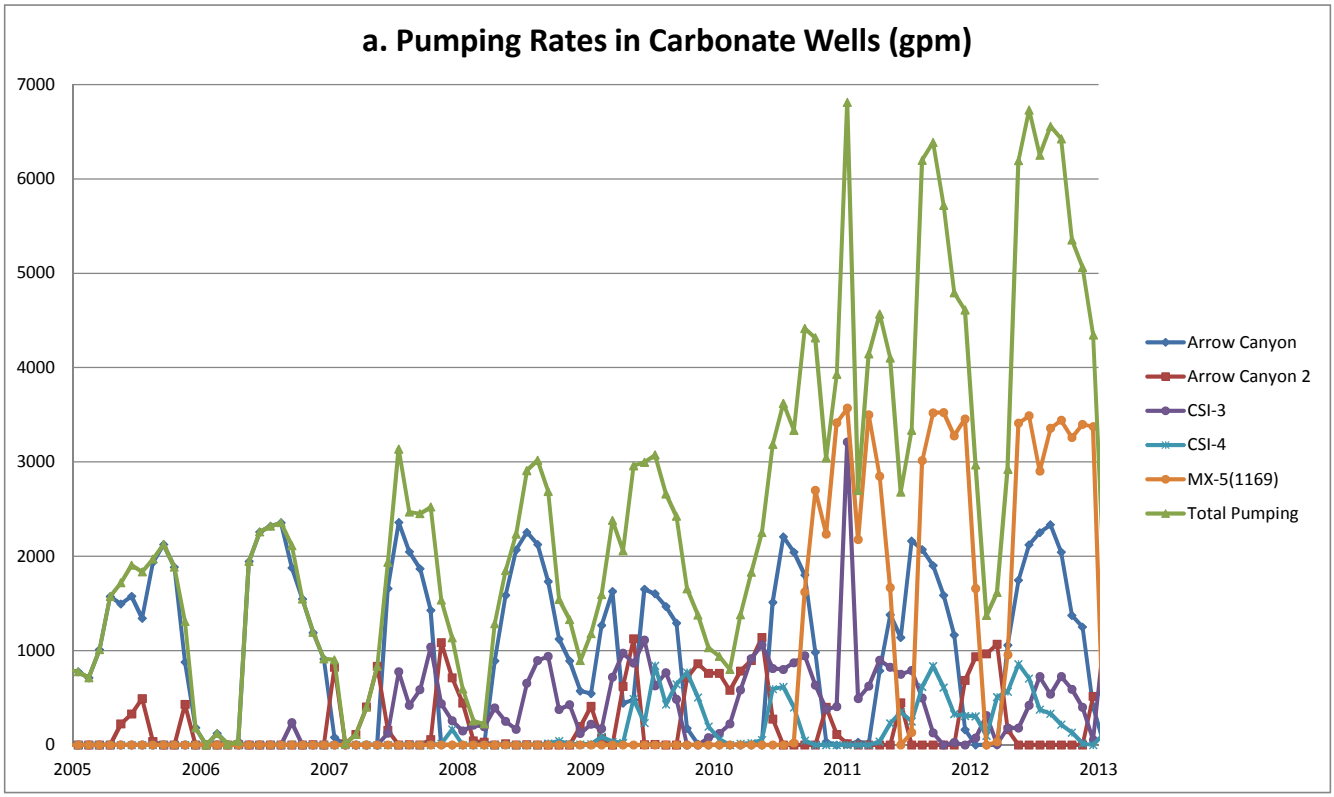
5.0 REFERENCES

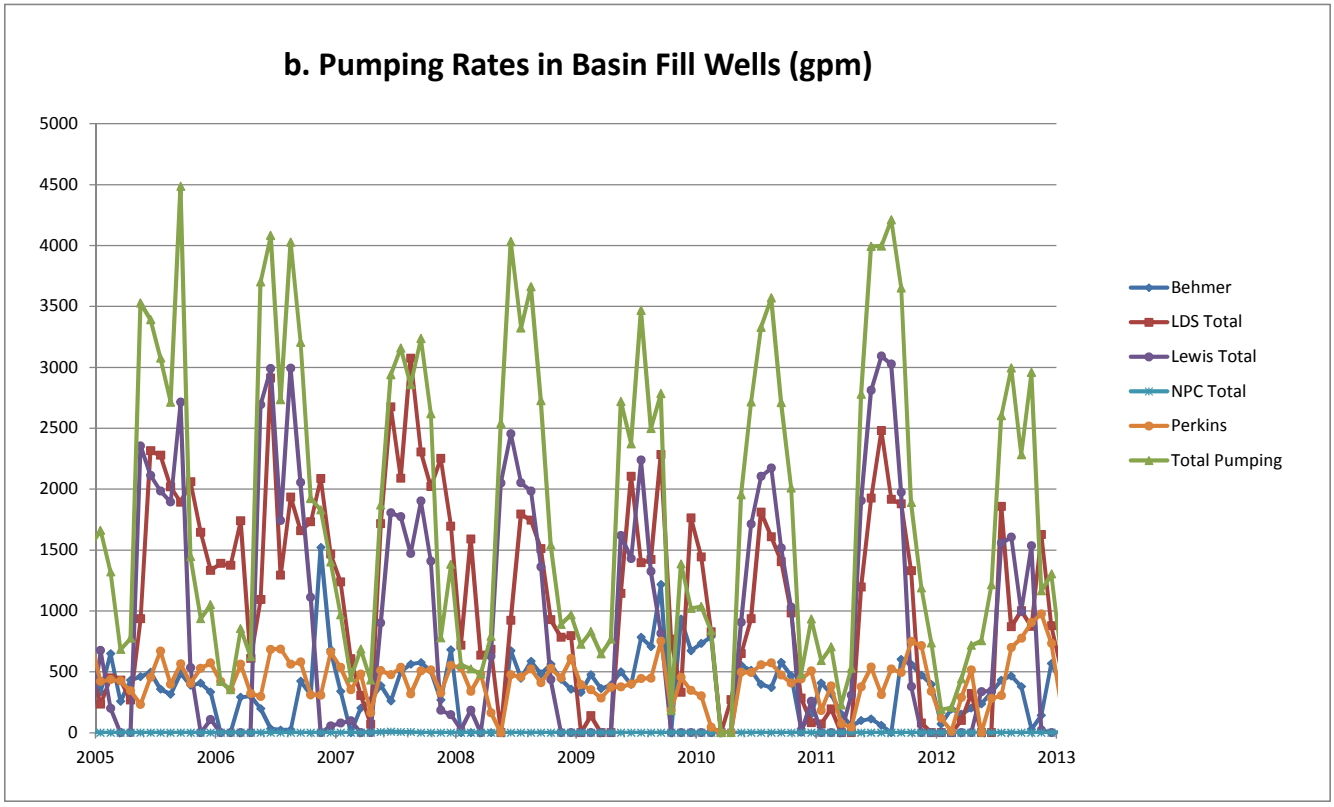
Tetra Tech, 2012a, Development of a numerical groundwater flow model of selected basins within the Colorado Regional Groundwater Flow System, Southeastern Nevada.

Tetra Tech, 2012b, Predictions of the effects of groundwater pumping in the Colorado Regional Groundwater Flow System, Southeastern Nevada.

FIGURES

Figure 2-1. Rates of groundwater pumping in Coyote Spring Valley and the Muddy River Springs area, 2005-2012





Note: Dates on the x-axis represent January 1st of each year

Figure 2-2. Observed water levels in selected wells, and MX-5 pumping rate (inverted), 2005-2012

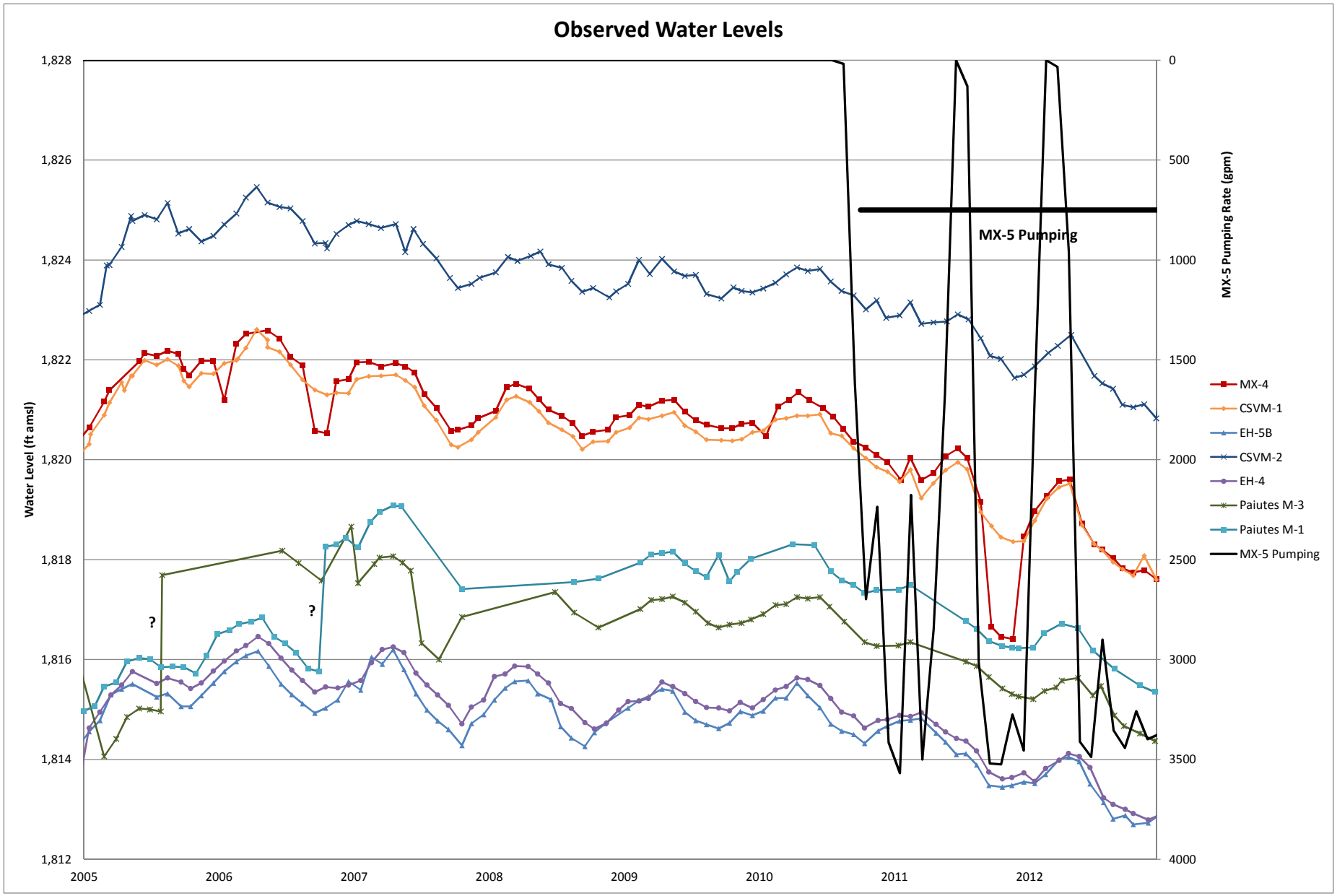


Figure 2-3. Comparison of simulated and observed drawdown in selected wells, 2010-2012

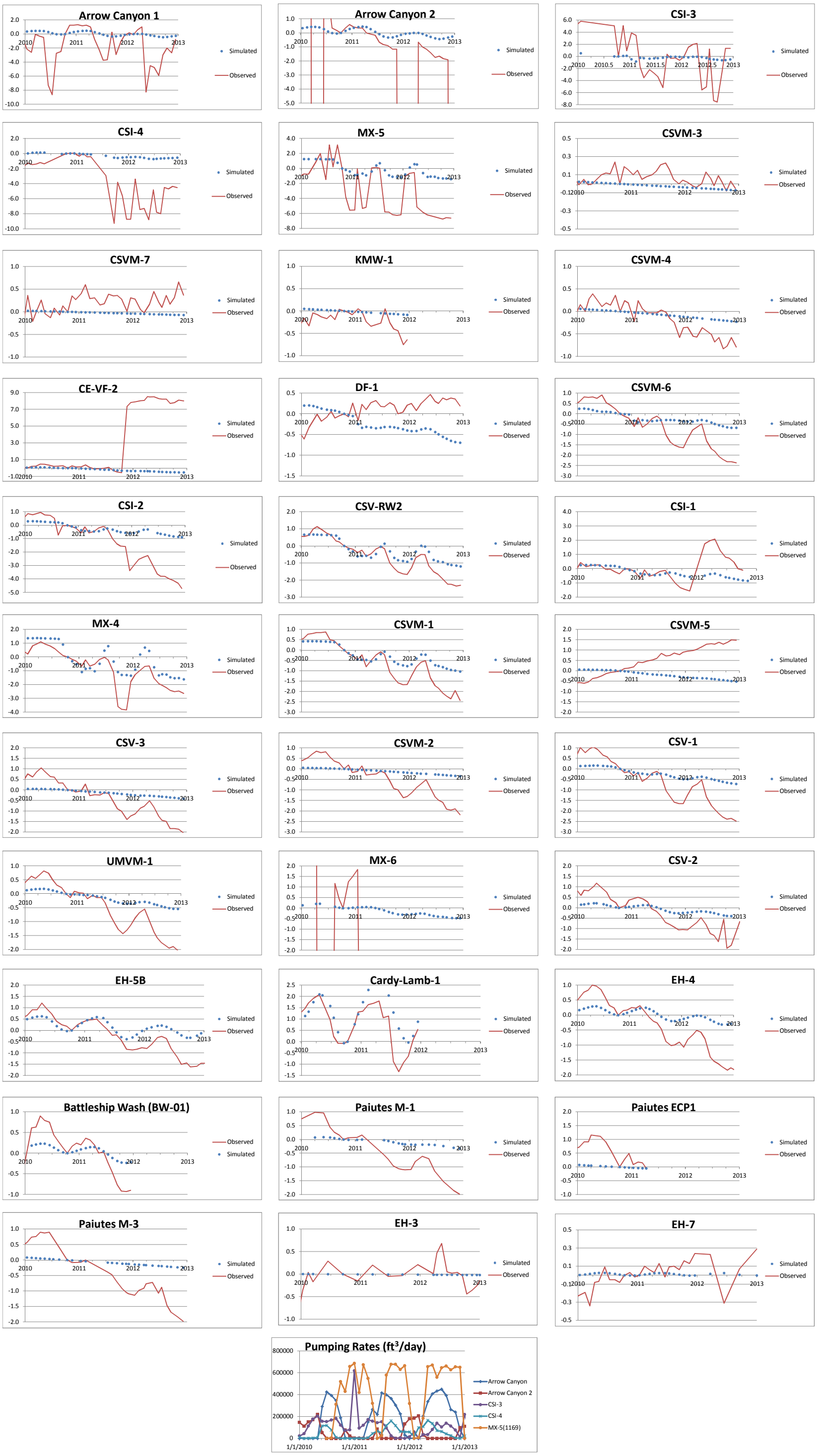
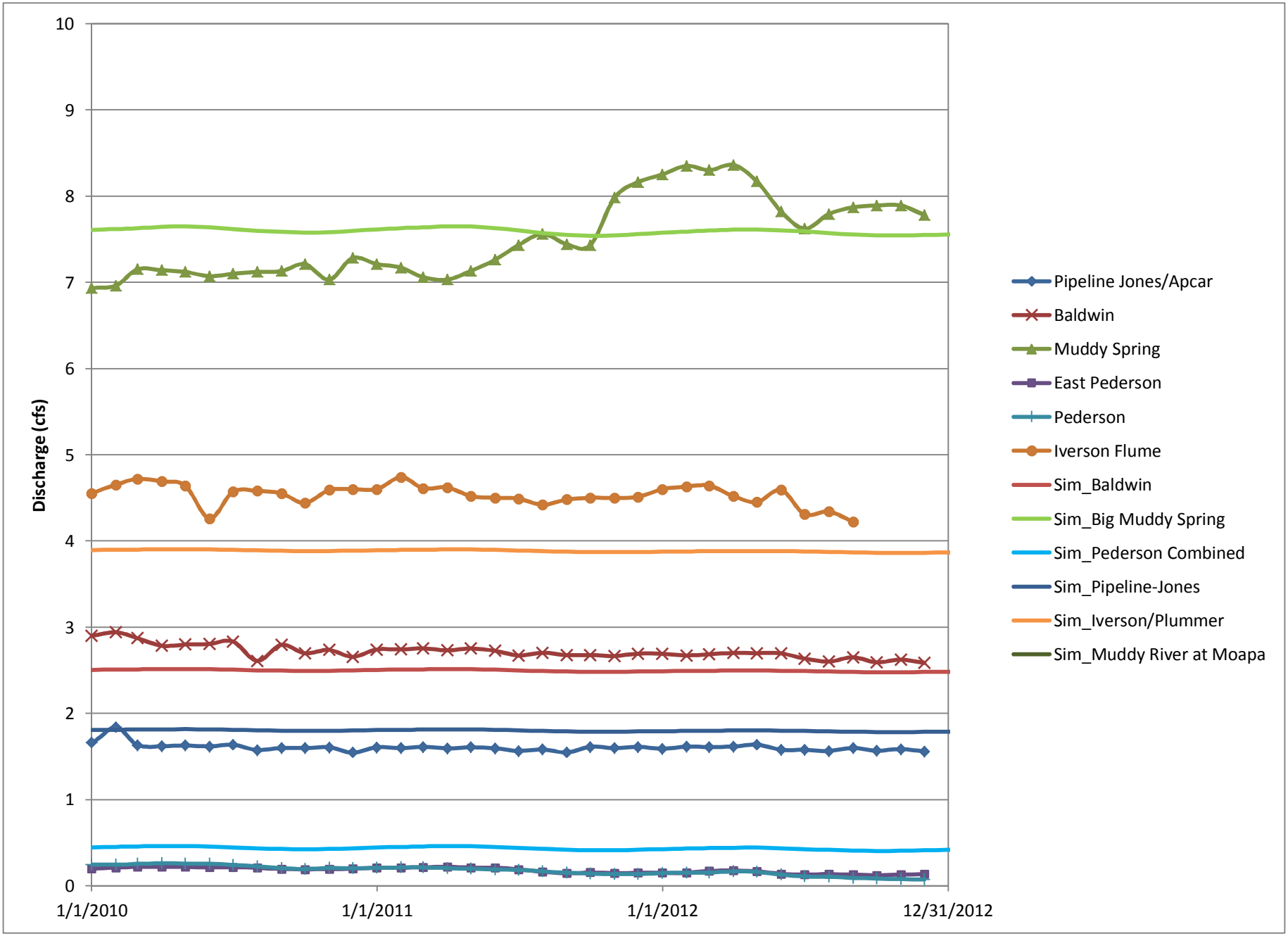
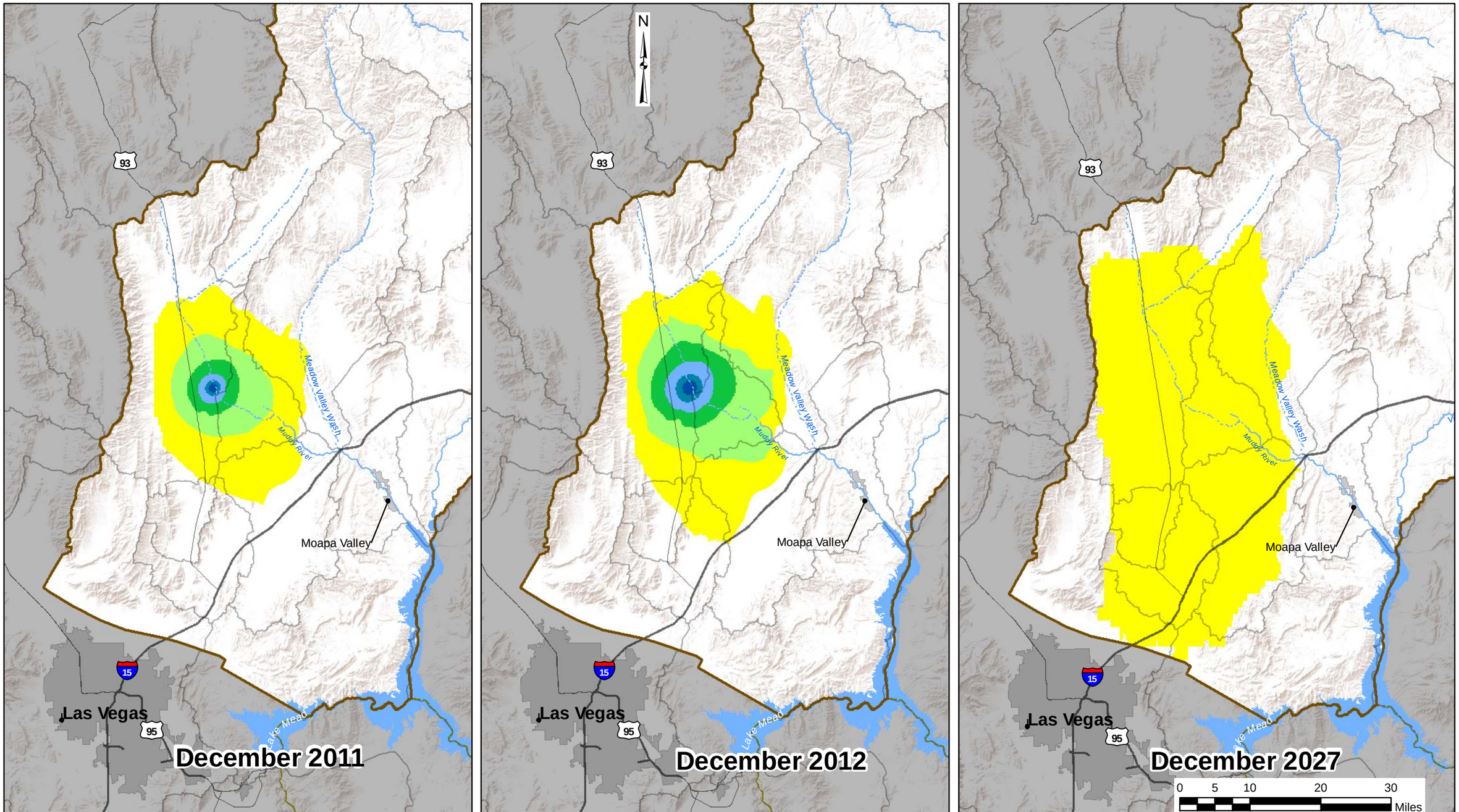


Figure 2-4. Comparison of observed and simulated spring discharge, Muddy River Springs area, 2010-2012





Legend

Active Model Domain

State Boundary

Drawdown (ft)

- 2.01 - 4.00
- 1.01 - 2.00
- 0.81 - 1.00
- 0.61 - 0.80
- 0.41 - 0.60
- 0.21 - 0.40
- 0.01 - 0.20

Drawdown is in feet

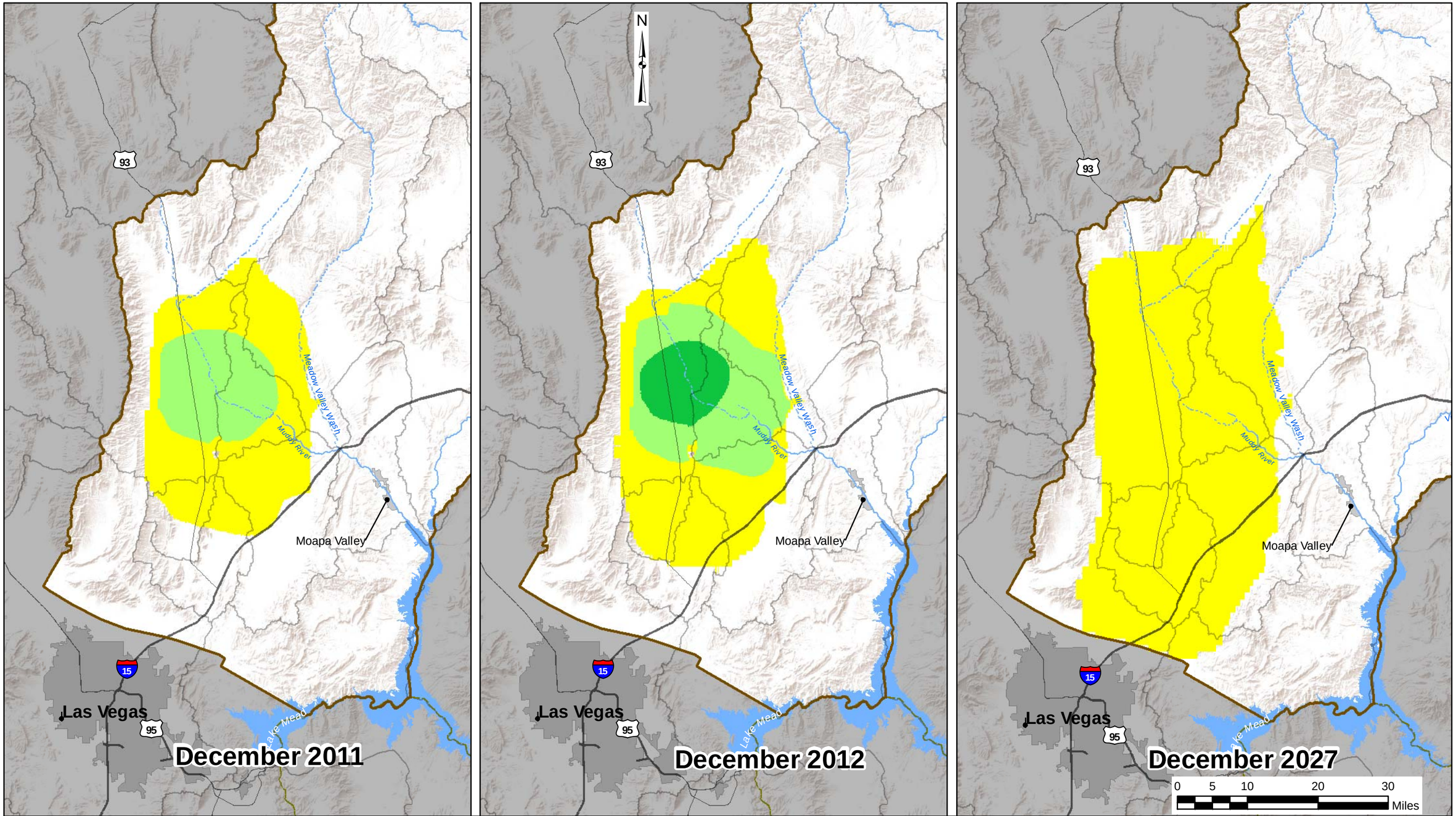
Drawdown calculated based MX-5 pumping

TITLE:
Simulated Drawdown from MX-5 Pumping, Model Layer 5

LOCATION: **Colorado Regional Groundwater Flow System Southeastern Nevada**

TETRA TECH

FIGURE
2-5



Legend

Active Model Domain
State Boundary

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- 0.21 - 0.40
- 0.01 - 0.20

Drawdown is in feet

Drawdown calculated based MX-5 pumping

TITLE:
Simulated Drawdown from MX-5 Pumping, Model Layer 11

LOCATION: **Colorado Regional Groundwater Flow System Southeastern Nevada**

TETRA TECH

FIGURE
2-6

Figure 3-1. Simulation of water levels in selected wells, 2010-2027

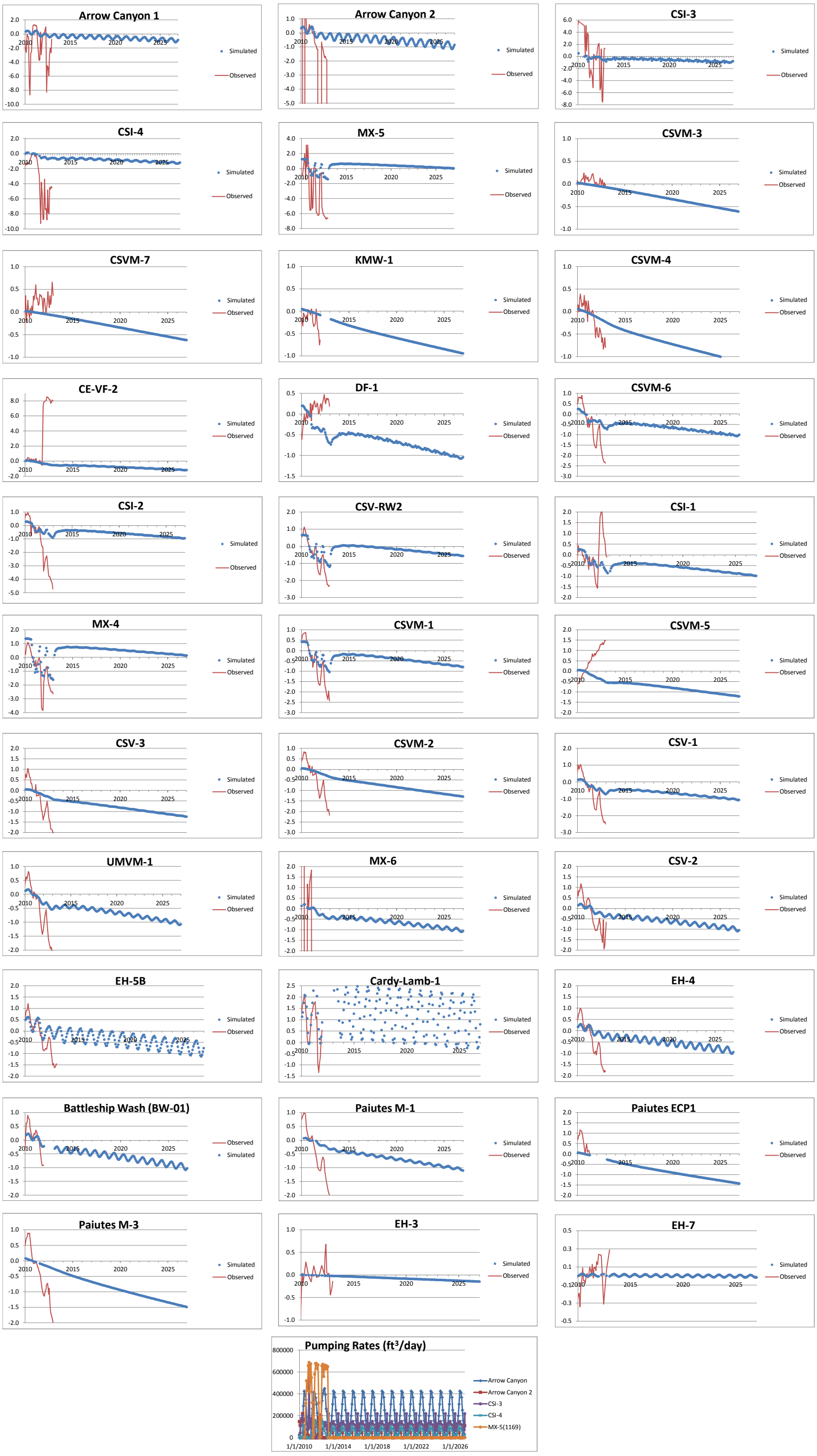
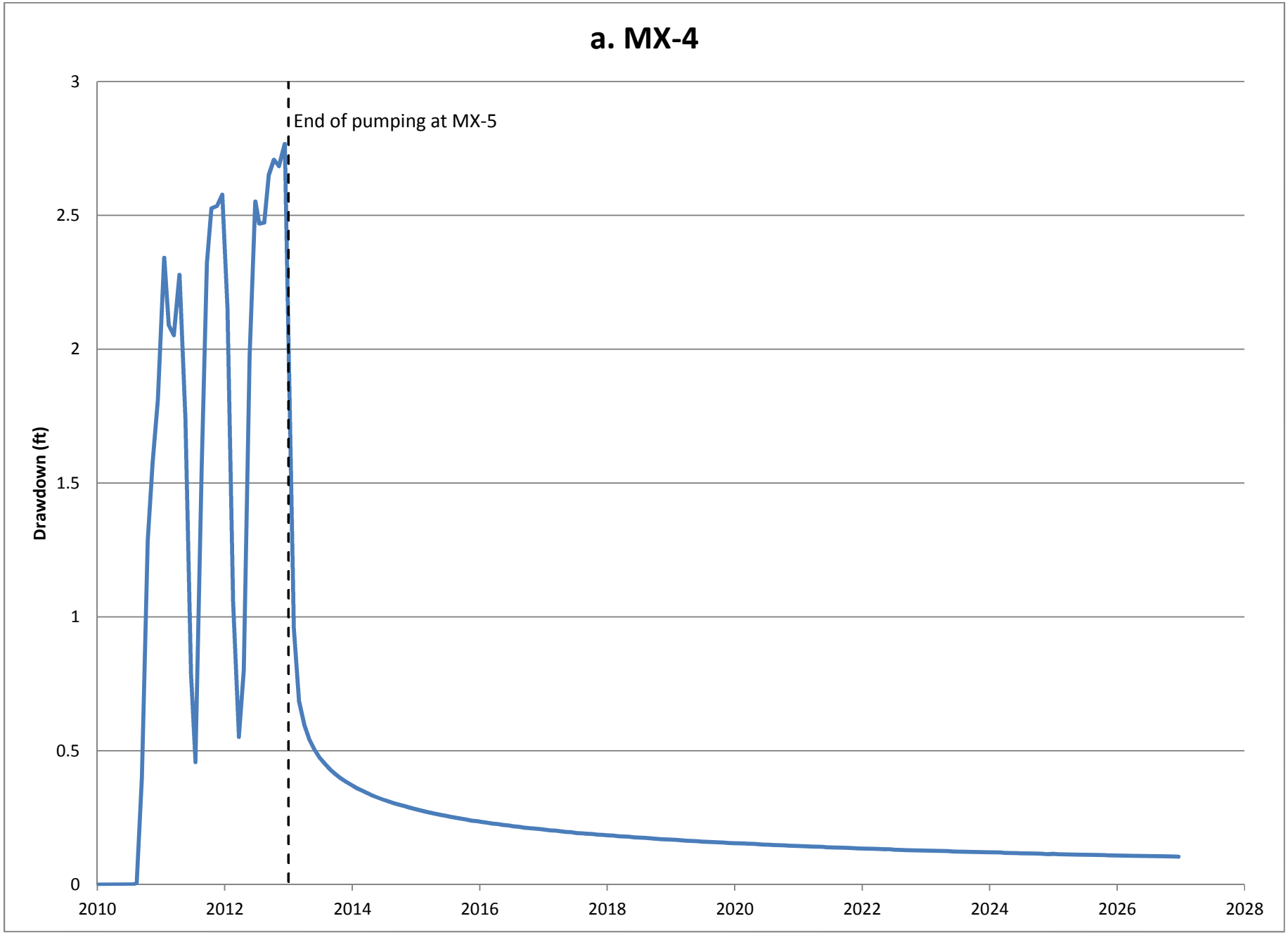
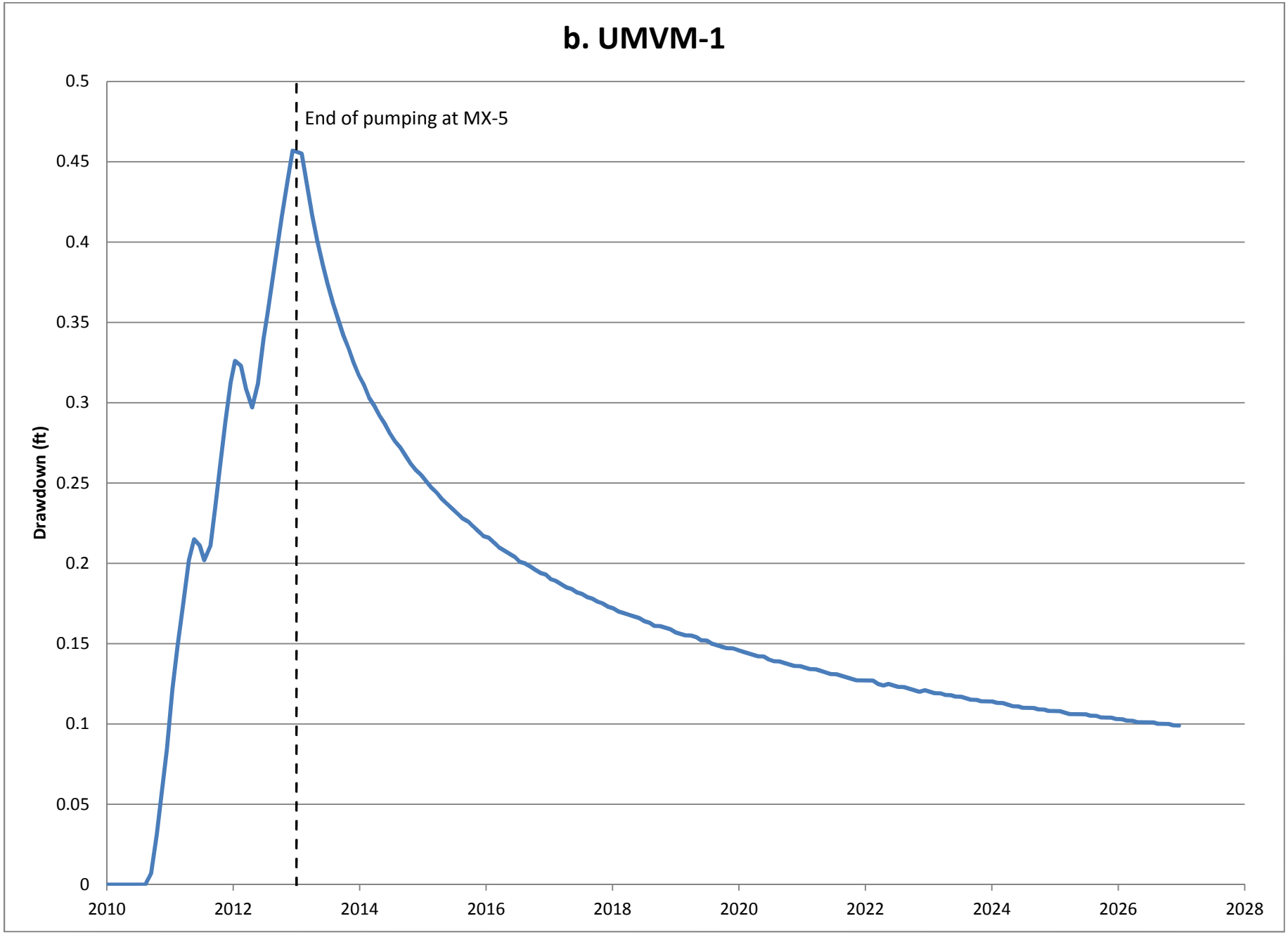
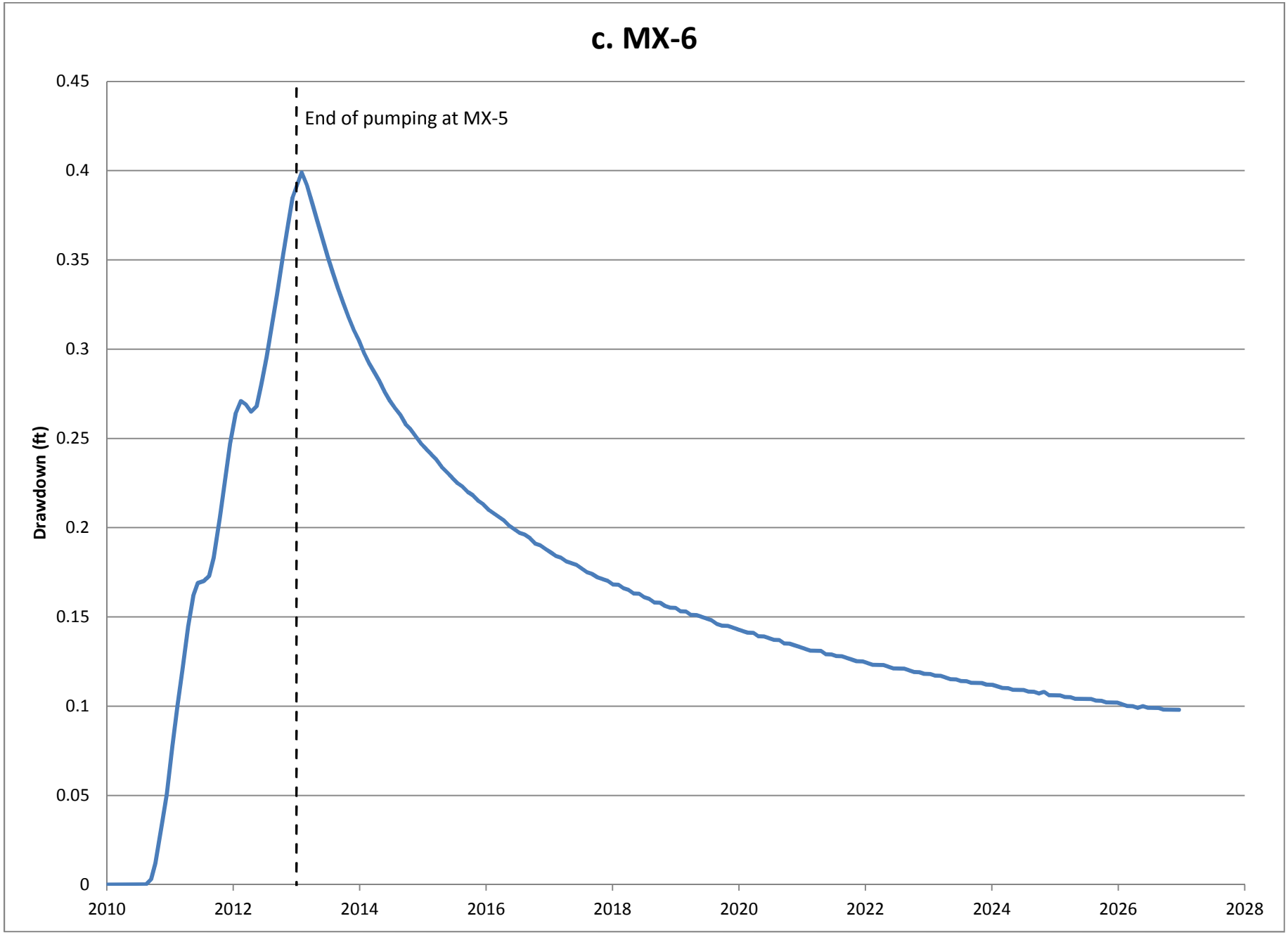
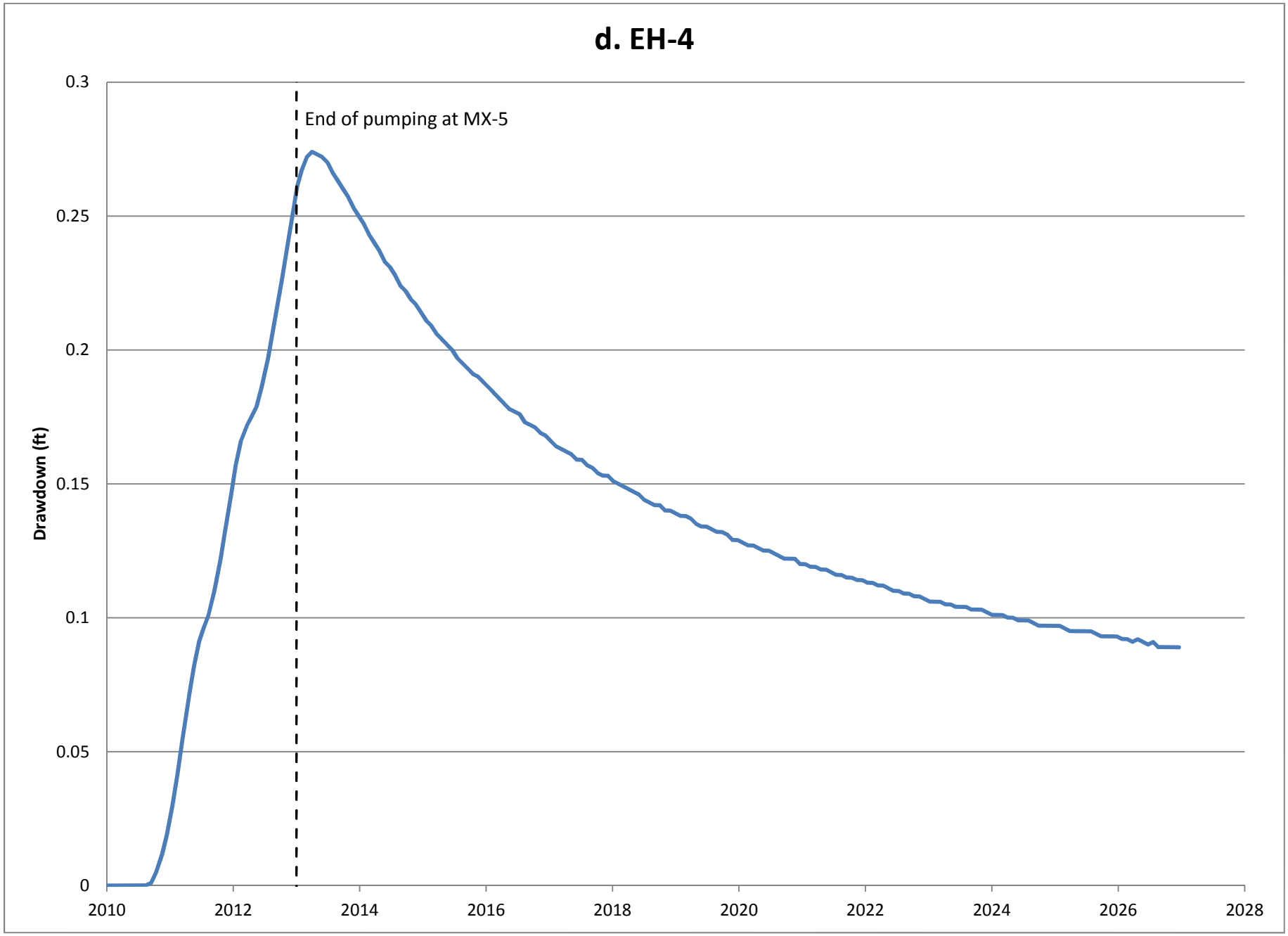


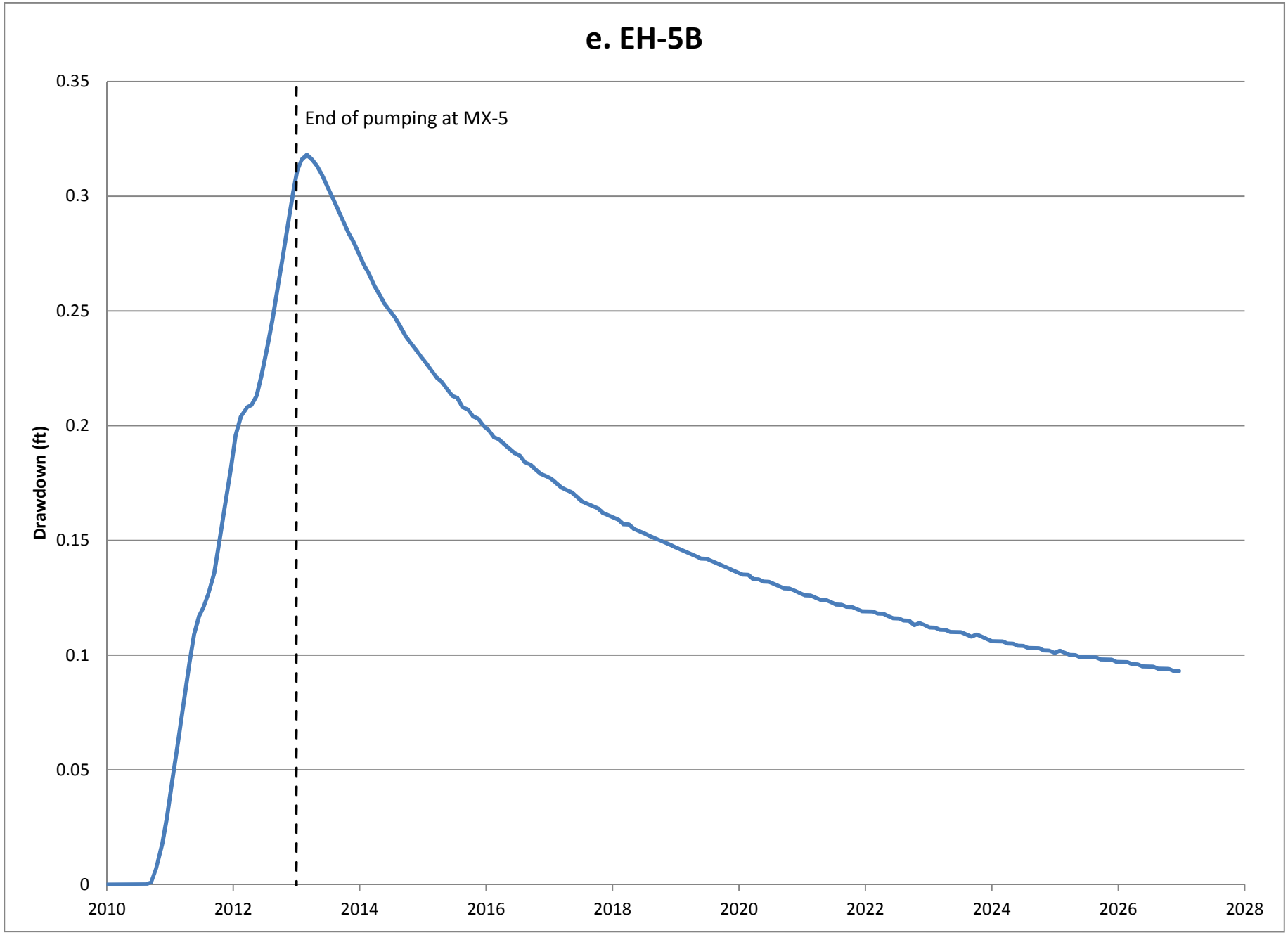
Figure 3-2. Simulated drawdown and recovery caused by pumping of MX-5, at selected wells

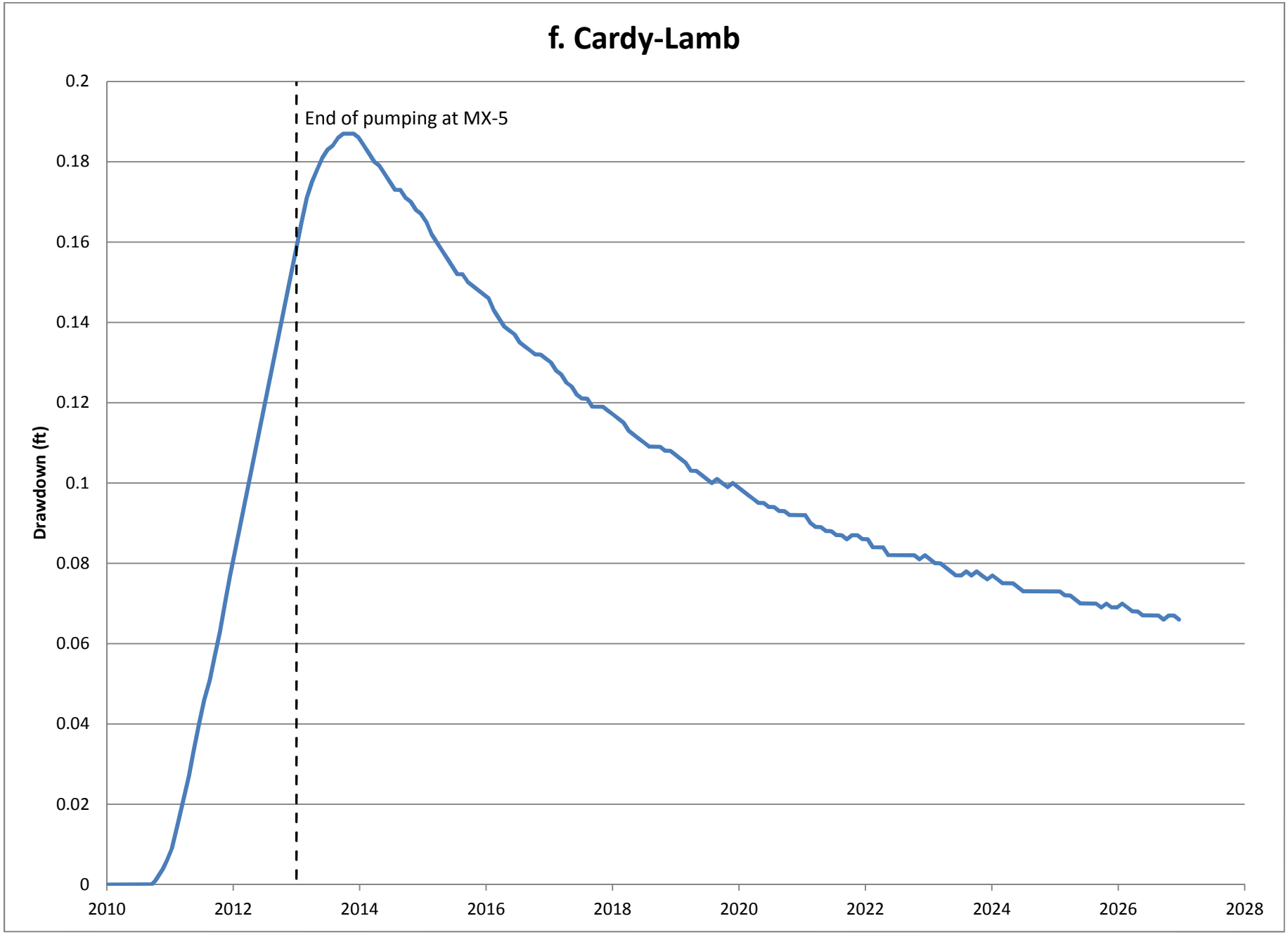


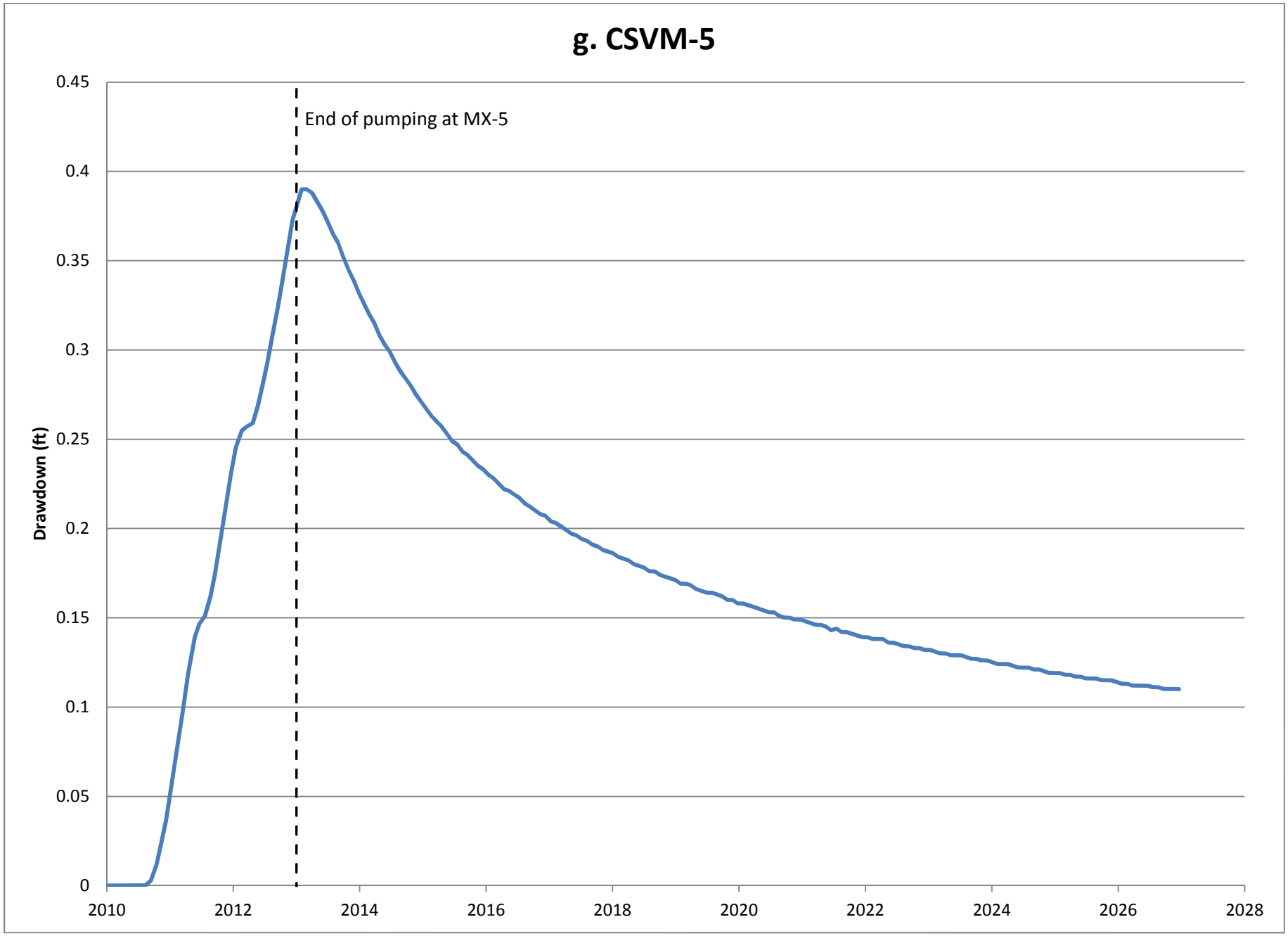

b. UMVM-1
End of pumping at MX-5
Drawdown (ft)
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
2010
2012
2014
2016
2018
2020
2022
2024
2026
2028

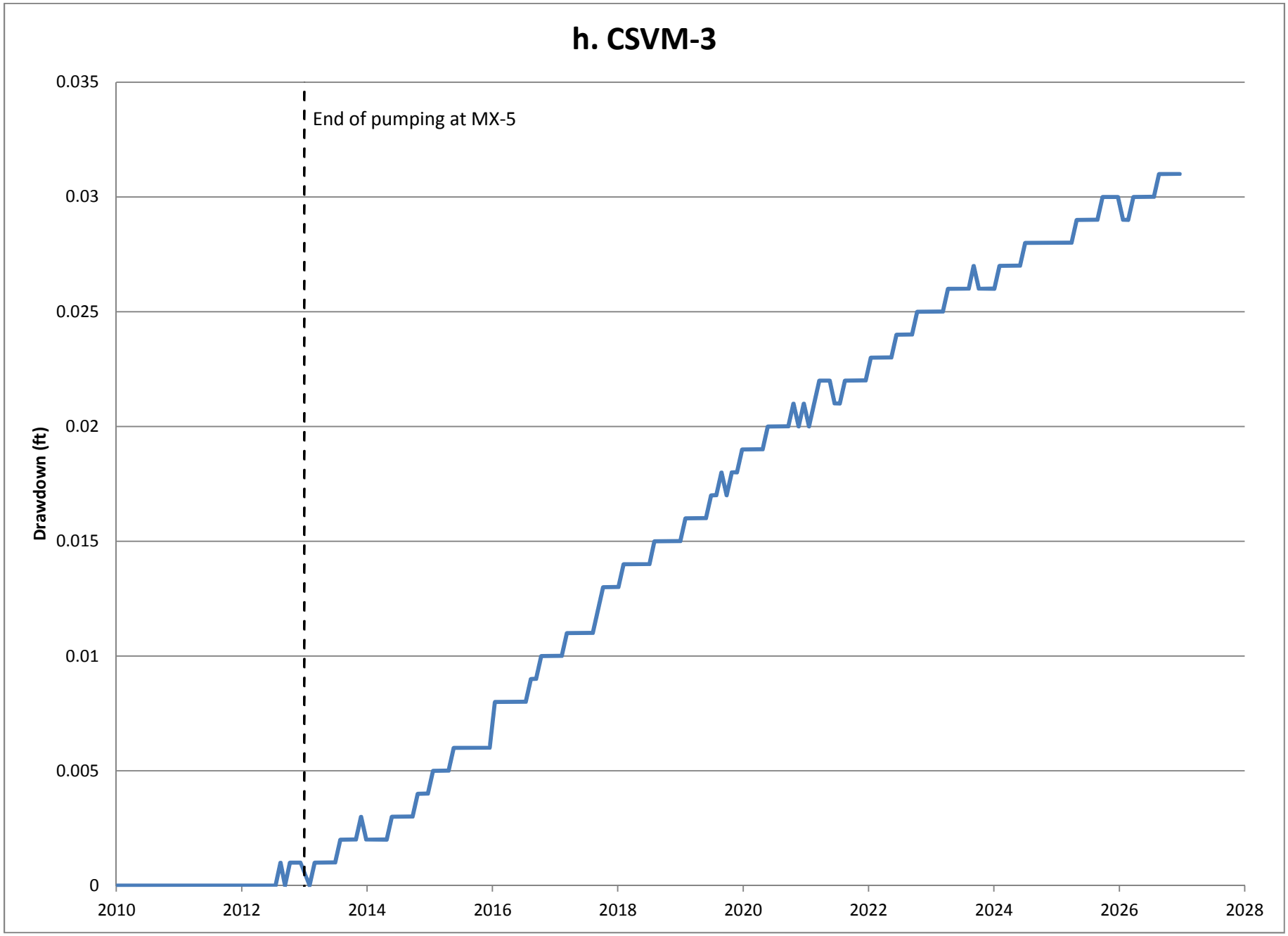

c. MX-6
End of pumping at MX-5
Drawdown (ft)
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
2010
2012
2014
2016
2018
2020
2022
2024
2026
2028

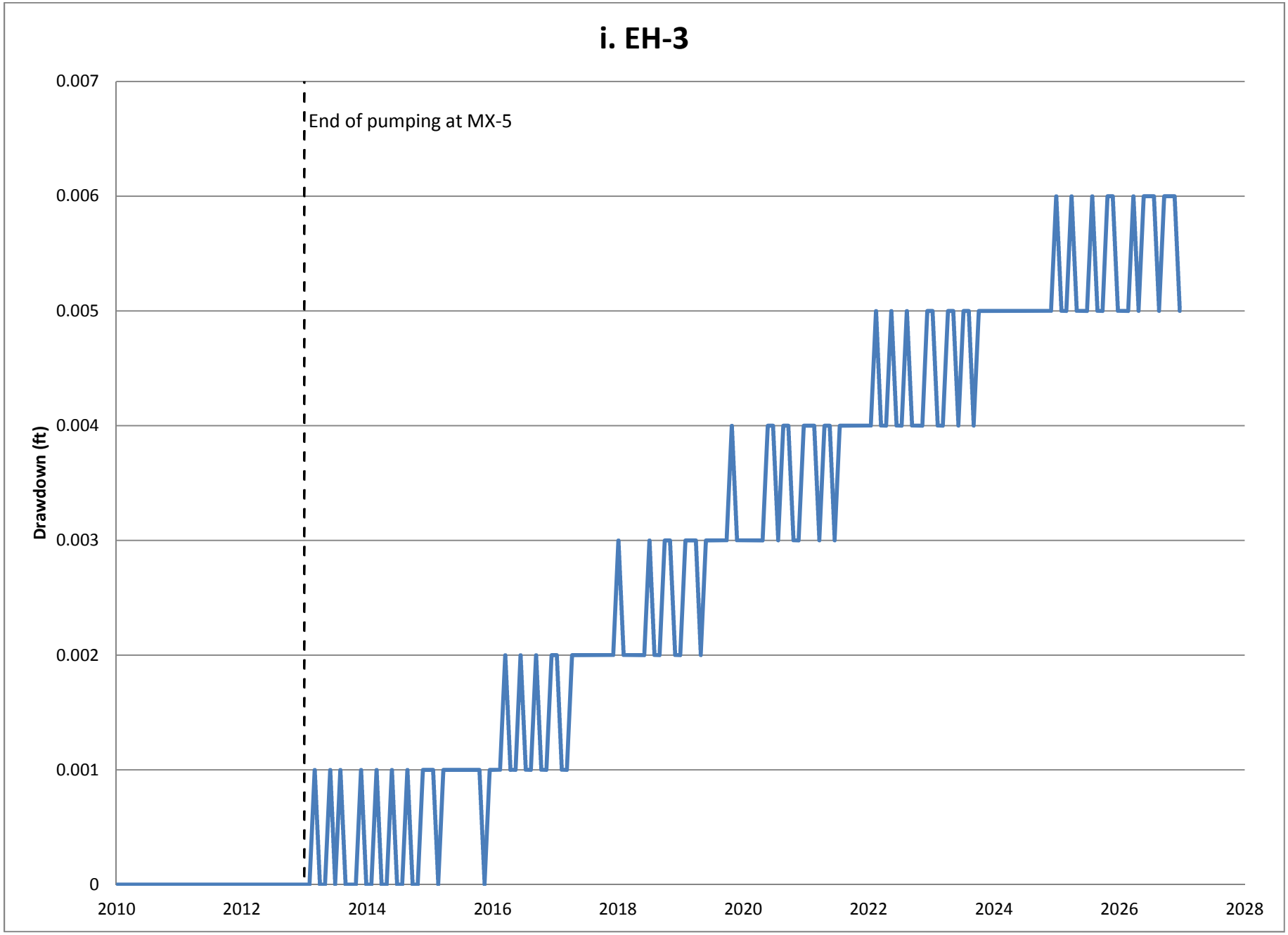

d. EH-4
End of pumping at MX-5
Drawdown (ft)
0.3
0.25
0.2
0.15
0.1
0.05
0
2010
2012
2014
2016
2018
2020
2022
2024
2026
2028


e. EH-5B
End of pumping at MX-5
Drawdown (ft)
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
2010
2012
2014
2016
2018
2020
2022
2024
2026
2028


f. Cardy-Lamb
End of pumping at MX-5
Drawdown (ft)
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2010
2012
2014
2016
2018
2020
2022
2024
2026
2028


g. CSVM-5
End of pumping at MX-5
Drawdown (ft)
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
2010
2012
2014
2016
2018
2020
2022
2024
2026
2028


h. CSVM-3
End of pumping at MX-5
Drawdown (ft)
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
2010
2012
2014
2016
2018
2020
2022
2024
2026
2028


i. EH-3
End of pumping at MX-5
Drawdown (ft)
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0
2010
2012
2014
2016
2018
2020
2022
2024
2026
2028

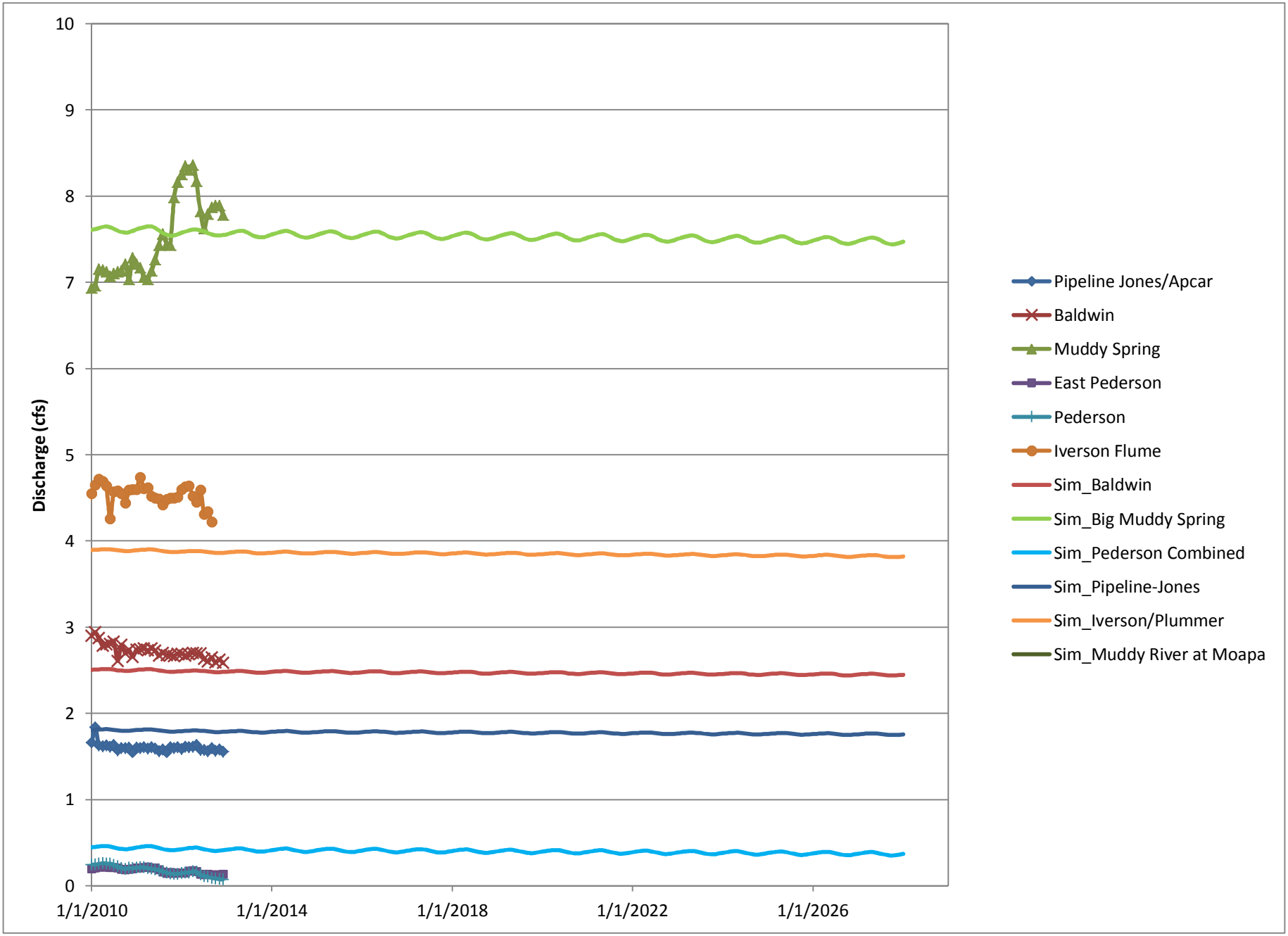



Figure 3-3. Simulated spring discharge rates, Muddy River Springs area, 2010-2027