Appendix B

Absorption Schedule Technical Memorandum

To: Mike Geary, Squaw Valley Public Services District General Manager
From: Alex Fisch, Placer County Planning Services Division
Date: April 8, 2014
Subject: Village at Squaw Valley Specific Plan Water Supply Assessment

Placer County is the lead agency for the Village at Squaw Valley Specific Plan (VSVSP) project in compliance with the California Environmental Quality Act (PRC 2100 et. seq.). The County is preparing a Program EIR to analyze the environmental effects of project approval and implementation. To comply with the statutory requirements of CEQA, the County will analyze and disclose the impacts of the VSVSP project including analysis of the project's incremental contribution to cumulative effects considered together with other probable future projects. While there is no precise definition in CEQA for what is a probable future project, two approaches are prescribed. A list approach is commonly used whereby the lead agency will generate a list of "past, present and probable future projects producing related or cumulative impacts including, if necessary, those projects outside the control of the agency" (CEQA Guidelines § 15130). When utilizing the list approach Placer County would include approved projects currently under construction, projects that are approved that have not been constructed, and projects that are expected to be approved and constructed for which the County is currently processing an application(s) or has direct knowledge of the project and reasonably expects it to be carried out (including those outside the local agency control). The second approach prescribed by CEQA is to utilize projections contained in adopted local, regional, or statewide plan(s) or which are forecast from such plan(s). When plans do not include quantifiable projections, forecast growth projections can be developed in accordance with the adopted development regulations. Projections are often utilized for projects that are expected to build out over a relatively long period of time and the forecast timeframe will typically match the projected build out of the project.

For the VSVSP project, which is proposed to build out over a 25-year period, the County determined that it was appropriate to use both a list and forecast approach to determine cumulative development within the Olympic Valley study area[1]. The cumulative development projections therefore include approved projects that have not yet been built, such as the Resort at Squaw Creek Phase 2 and the Olympic Estates Subdivision, project applications that the County has on file, and valley-wide development projections forecast out to 25 years[2]. The forecast does not assign development to any specific properties nor grant or restrict any development rights. Rather, the forecast identifies a total development projection for use in the EIR cumulative impact analysis and SB 610 Water Supply Assessment.

The following text and tables details the cumulative list and projections prepared by Placer County.

[1] Regional development projections from neighboring communities such as Truckee, Alpine Meadows and Tahoe City are also included in the cumulative analysis. This memorandum deals specifically with the methodology used to prepare cumulative assumptions for the Olympic Valley study area in support of cumulative impact analysis within that community and the Water Supply Assessment.

[2] This memo does not describe linear utility projects within the Olympic Valley study area that may occur within the 25-year cumulative horizon such as the Squaw Valley Public Service District's Alternative/Supplemental Water Supply & Enhanced Utilities Feasibility Study preferred alternative.

Cumulative Projections

1. Development capacity is expressed in total bedrooms and commercial square footage in accordance with policies of the Squaw Valley General Plan, which is applicable to the entire Olympic Valley study area.
2. Cumulative projections include projects that are approved and are likely to be constructed and projects that the County is processing which have a reasonable expectation of being approved and constructed. This includes the approved Resort at Squaw Creek Phase 2 and the Olympic Estates Subdivision projects, and other projects that the County is currently processing including the Squaw Valley Ranch Estates, the Mancuso Rezone project, and redevelopment of the PlumpJack Hotel.
3. A parcel inventory of the study area was used to determine locations where additional development could be constructed during the 25-year cumulative timeframe and to verify that forecast development would not exceed the holding capacity of the Squaw Valley General Plan. The parcel inventory does not assign any development to any specific parcel. The forecast is a metric defining a number of bedrooms and commercial square-footage only and development could occur anywhere where it is authorized within the Olympic Valley study area. It is intended solely to provide a reasonable basis for predicting cumulative conditions within the 25-year time frame so that an appropriate cumulative impact analysis can be performed. The analysis is not intended to serve as a precise prediction regarding the amount of development that will occur on a particular parcel; rather, the analysis is a forecast of the cumulative, aggregate level of development that will exist in 25 years.

The results of the County's analysis of approved projects, foreseeable projects, and forecast future development for the Olympic Valley study area are shown in the table below.

Cumulative List and Forecast to 2040

Approved Projects			
	Units	*Bedrooms*	*Commercial sq. ft.*
RSC Phase 2	441 condo units	464 bedrooms	--
Olympic Estates	16 residential units	64 bedrooms	--
Foreseeable Projects			
	Units	*Bedrooms*	*Commercial sq. ft.*
Squaw Valley Ranch Estates	8 residential units	40 bedrooms	--
Mancuso	4 residential units	20 bedrooms	--
PlumpJack Redevelopment	--	104 net hotel rooms/condo bedrooms	10,000 sq. ft. net new commercial
Olympic Valley Museum	--	--	14,500
Forecast Development			
	Units	*Bedrooms*	*Commercial sq. ft.*
Single-Family Residential	66	264	--
Resort/hotel/condo units	34	52	--
General Commercial	--	--	56,000
Total Development Outside the Project Boundary			
	569 units	1,008 bedrooms	80,500 sq. ft.
Village at Squaw Valley Specific Plan Project Development			
Resort Residential	600	1,243	--

Hotel	250	250	--
Employee Housing	21	264*	20,000
Net Other Commercial	--	--	200,083
Total Development			
	1,440 units	2,765 bedrooms*	300,583 sq. ft.

*264 employees in dormitory housing and studio units are included in the 2,765 total bedrooms of probable and forecast development. Total employees are utilized as the metric in recognition that demand for new infrastructure and services to serve dormitory employee housing are quantitatively distinct from new infrastructure and service demands created by construction of new hotel, condominium, and residential bedrooms.

Development Absorption

The following table details projected absorption rates for the project and for the cumulative development for the identified 25-year period in 5-year increments. To be conservative, the overall absorption rate is weighted to assume higher development rates in the near term for the VSVSP and for the cumulative projects/development. Absorption rates for the VSVSP assume a slightly higher rate of development in the near term due to the known tentative development schedule for the plan. Absorption rates for the VSVSP utilize increments of 35%, 20%, 20%, 15%, and 10% for each 5-year period and are expressed in units of bedrooms and commercial square footage. Commercial square footage for the VSVSP does not follow this formula precisely due to known amenities that are likely to be constructed in early phases of development, such as the Mountain Adventure Camp. Employee beds are calculated at corollary rates.

Absorption rates for the cumulative projects/development utilize increments of 25%, 25%, 20%, 20%, and 10% for each 5-year period and are also expressed in units of bedrooms and commercial square footage. Due to known commercial projects that are more likely to occur in the near term, commercial square footages do not follow this formula precisely.

Project Plus Cumulative Absorption Schedule

VSVSP Village Area		
Year	*Bedrooms*	*Commercial sq. ft.*
2020	522	104,940
2025	298	30,000
2030	298	30,000
2035	223	20,000
2040	152	15,143
Total	**1,493**	**200,083***
VSVSP East Parcel		
Year	*Beds***	*Commercial sq. ft.*
2020	92	15,000
2025	52	5,000
2030	52	--
2035	39	--
2040	29	--
Total	**264**	**20,000**
Cumulative projects/development		
Year	*Bedrooms*	*Commercial sq. ft.*
2020	252	24,500
2025	252	20,125
2030	201	14,000

2035	201	14,000
2040	102	7,875
Total	**1,008**	**80,500**

*The VSVSP is projected to construct a total of 277,733 square-feet of commercial uses, not including the 20,000 square-feet of commercial planned for the East Parcel. 77,650 square feet of the 277,733 square feet is replacement of existing commercial uses for a net total of 200,083 square feet of new commercial uses.

**Due to the dormitory and studio unit housing proposed for project-generated new employees, employee beds are utilized as the metric in recognition that demand for new infrastructure and services to serve employee housing are quantitatively distinct from new infrastructure and service demands created by construction of new hotel, condominium, and residential bedrooms.

Conclusions

The 25-year *cumulative list and forecast* includes all approved projects that are within the project vesting period, known active projects that are likely to be approved and carried out, and forecasted development for the 25-year planning horizon. The 25-year *project plus cumulative Absorption Schedule* identifies total development in excess of 20% beyond the prior 25 years of development within the Olympic Valley indicating that the quantity of development within the Olympic Valley study area for the identified 25-year period would exceed development that had occurred over the prior 25-year period and that the project development in this analysis would occur at a faster rate than historic levels. Based on observed development patterns, constraints and other factors, these figures will enable an appropriately conservative analysis of cumulative development and related environmental effects in the Olympic Valley and the VSVSP's potential incremental contribution to these cumulative effects. This will also enable an appropriately conservative analysis of the total water demand in order to complete the SB 610 Water Supply Assessment for this project, which will determine the availability of water for this same 25-year period.

APPENDIX B

Squaw Valley Groundwater Model 2014 Recalibration

HydroMetrics, WRI, June 17, 2014

HydroMetrics WRI
1814 Franklin St, Suite 501
Oakland, CA 94612

TECHNICAL MEMORANDUM

To: Mike Geary/SVPSD

From: Stephen Hundt

Derrik Williams

Date: June 17, 2014

Subject: Squaw Valley Groundwater Model 2014 Recalibration

SECTION 1
Background and Purpose

This technical memorandum documents a recent update to the Squaw Valley groundwater model. This model update reassesses and modifies various model inputs. The purpose of this update is to produce an updated model that is better calibrated than the previous model, and is based on more realistic and widely accepted assumptions.

The updated and recalibrated groundwater model accurately simulates groundwater levels in Squaw Valley better than the previous model. In general, the model simulates groundwater levels and the creek/aquifer interaction in the western portion of Squaw Valley better than the eastern portion. This is consistent with the model objectives of providing a tool for managing groundwater pumping in the western portion of Squaw Valley. The updated groundwater model can be confidently used to develop future groundwater pumping plans that minimize impacts on Squaw Creek.

SECTION 2
Model Modifications

2.1 HYDROSTRATIGRAPHY

Elevations of the hydrostratigraphic units that define the groundwater model layers were modified in early 2014. These modifications were based on geologic data from test well borings installed by Todd Groundwater. Todd Groundwater developed new elevations of the three hydrostratigraphic units, using the surface datum of the existing groundwater model. The new mapped surfaces were used to adjust elevations of the three model layers. Some additional adjustments to the surfaces were required to ensure that all observation wells and pumping wells were included in the model without changing their location or depth. The updated extents and bottom elevations for the three model layers are shown in Figure 1.

2.2 RECHARGE

2.2.1 WESTERN RECHARGE ZONE ADJUSTMENT

Two changes were made to the recharge zones that cover the western side of the basin. The first change combined two recharge zones into one zone. The western basin previously included two large recharge zones: numbered 1 and 9. Zone 1 received recharge from rainfall, and zone 9 received recharge from rainfall, irrigation return flows, pipe losses, and sewer inflow and outflow. As development increases, the two zones will include similar land uses and similar impermeable surface percentages. As a result, the zones were combined into single zone that receives recharge from rainfall, irrigation return, pipe losses, and sewer inflow and outflow. The extent of the new recharge zone is shown in Figure 2.

The second change made to this recharge zone was to increase the percentage of rainfall that infiltrates and recharges the aquifer. Most permeable surfaces in the model are assigned a recharge percentage of 10% of rainfall. Most relatively impermeable surfaces in the model are assigned a recharge percentage of 2.5% of rainfall. The percentage of rainfall that becomes recharge in the new zone was increased from 2.5% to 6%. This change was made to acknowledge the general ratio of permeable and impermeable surfaces in the recharge zone.

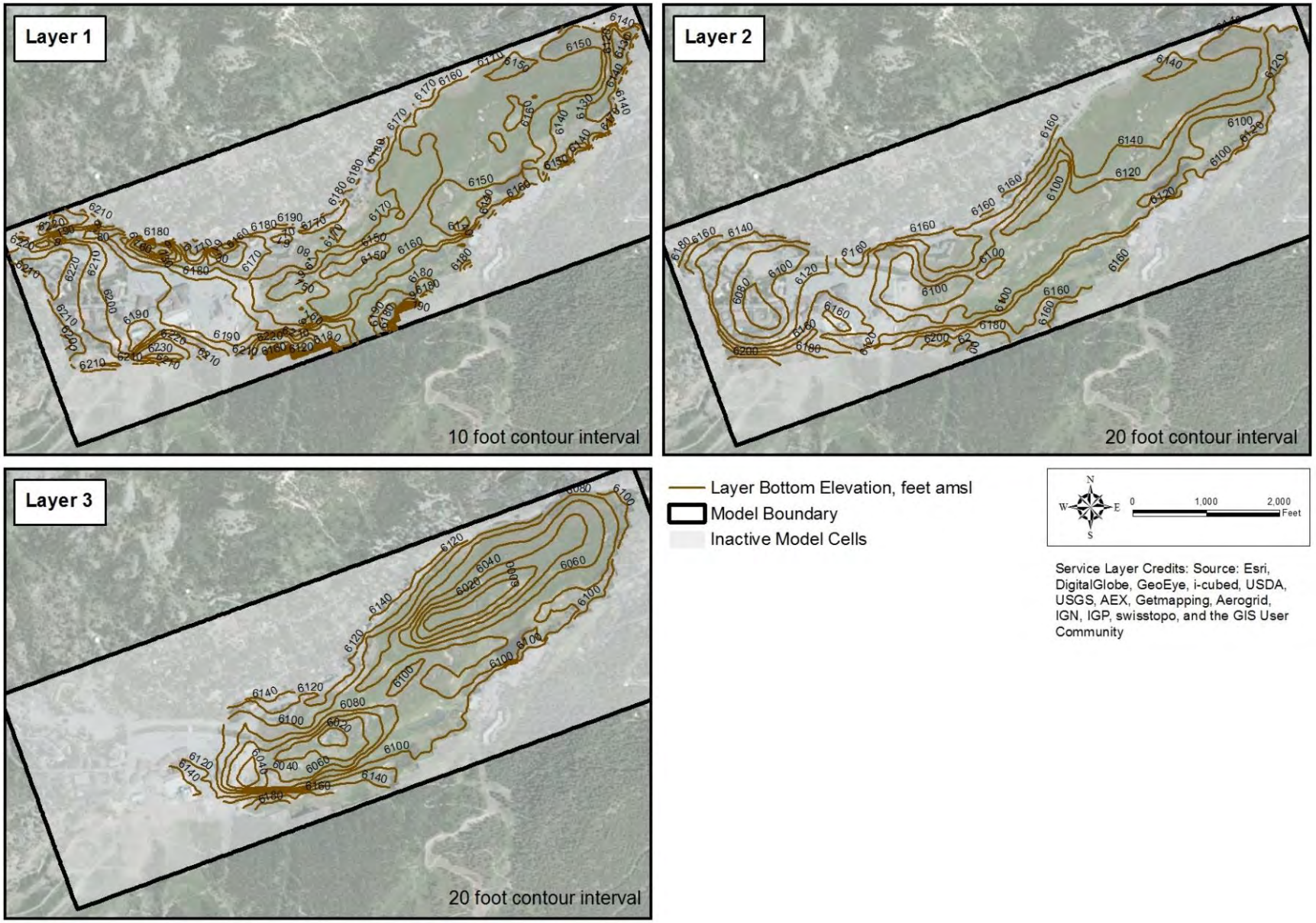


Figure 1: Model Layer Extents and Bottom Elevations

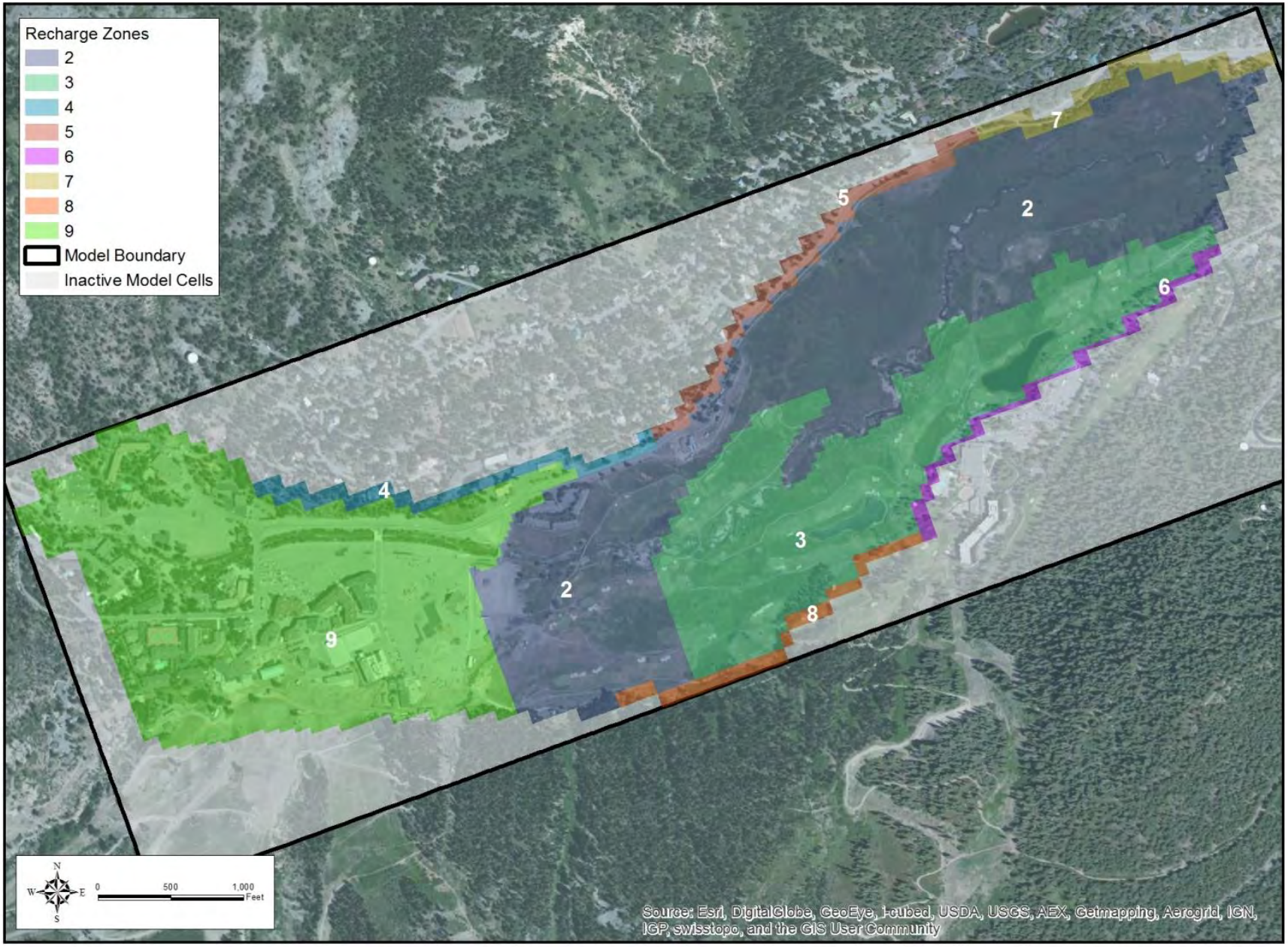


Figure 2: Recharge Zones

2.2.2 PRECIPITATION DELAY

The month in which precipitation infiltrates and recharges the aquifer was modified to approximate snow accumulation and melting. Rather than trying to model the highly complex dynamics that occur in melting snowpacks, a simple and transparent scheme was used to delay the infiltration of precipitation during cold months when it likely falls as snow. We assumed that between December and March, not all precipitation would immediately infiltrate. Instead, some of that precipitation remains as snow which melts and infiltrates in later months. Table 1 shows how precipitation was allocated during winter months.

Table 1: Method of Delaying Precipitation Recharge

Rainfall Month	Average Air Temperature (°F)	Month of Precipitation Recharge		
		Month of Rainfall	1st Month After Rainfall	2nd Month After Rainfall
January	23	50%	25%	25%
February	27	50%	25%	25%
March	31	60%	40%	0%
April	33	100%	0%	0%
May	41	100%	0%	0%
June	49	100%	0%	0%
July	55	100%	0%	0%
August	57	100%	0%	0%
September	52	100%	0%	0%
October	43	100%	0%	0%
November	34	100%	0%	0%
December	23	50%	25%	25%

The adjustment in the timing of precipitation recharge does not change the annual amount of precipitation recharge estimated by the model. The effect of the delay is to somewhat attenuate the spikes in recharge that had previously occurred during December and increase the recharge that occurs during the spring. Figure 3 compares the effective precipitation rate with and without the delay. The blue bars on Figure 3 are the infiltration rates if all infiltration takes place during the same month as precipitation. The salmon bars on Figure 3 show new times when infiltration takes place due to a snowmelt delay. The red bars on Figure 3 show times when infiltration takes place in both situations.

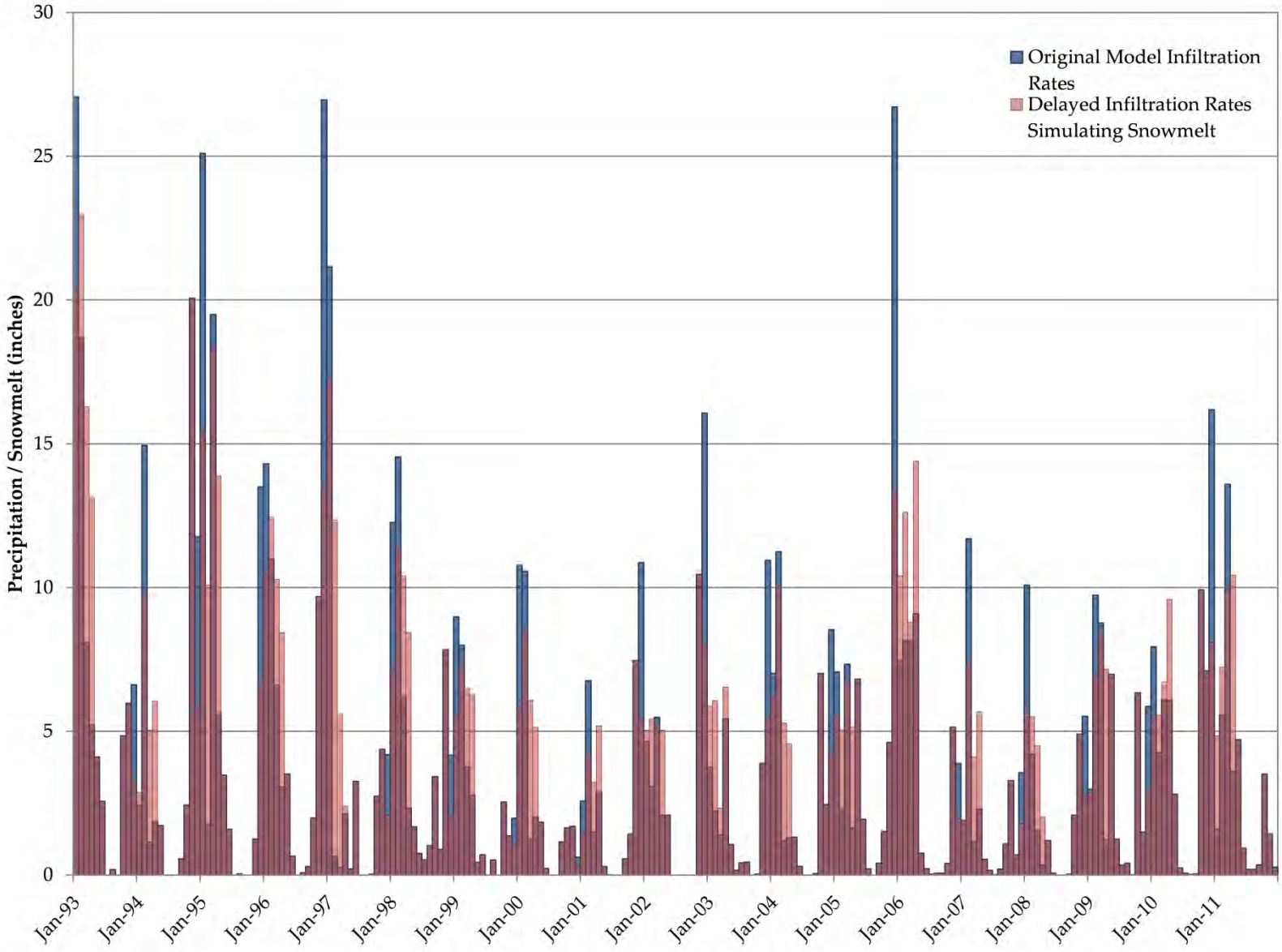


Figure 3: Precipitation and Delayed Precipitation

2.2.3 RESORT AT SQUAW CREEK-PHASE II PIPE AND SEWER LOSSES

Distribution pipe losses from the planned Resort at Squaw Creek (RSC) Phase II development were added to recharge zone 6 (Figure 2). The sewer losses from the development were combined with all other sewer losses that take place in the Valley.

2.2.4 LIMIT SEWER INFILTRATION AND EXFILTRATION

A limit was placed on the amount of groundwater that flows into and out of sewer lines in the Valley. Monthly sewer infiltration and exfiltration rates were originally calculated by comparing measured sewer flows with measured water deliveries (Williams, 2001). These calculations resulted in estimated sewer losses and gains by month, based on water delivery. In general, the aquifer gains water from the sewers during summer months when groundwater levels are lower than the sewer, and the aquifer loses water to the sewer during winter months when groundwater levels are elevated.

As projected water deliveries increased from future development, the corresponding projected amount of sewer infiltration and exfiltration became unrealistically large. To ensure that sewer infiltration and exfiltration does not become unrealistic, the total gains and losses to sewer lines were capped. The maximum amount of sewer infiltration during summer months was set to 7.9 acre feet per month; the maximum amount of sewer exfiltration during winter months was set to 5.1 acre-feet per month. These rates were the highest sewer gains and losses calculated during the calibration period.

Groundwater gains and losses from sewer infiltration and exfiltration remain a minor component of the Valley's water budget. Figure 4 shows total recharge contributed by sewers throughout the model period alongside the contribution of rainfall, pipe losses, and irrigation return flows. Rainfall dominates groundwater recharge. Irrigation return flow is the second largest recharge component, and becomes the dominant component during summer months when rainfall ceases. Recharge from sewer exfiltration remains a small component of recharge throughout the simulation.

The annual net sewer gains and losses can be derived by summing annual sewer exfiltration with total annual sewer infiltration. Figure 5 shows the annual net sewer gains and losses as a percent contribution to total recharge under the WSA scenario. The net sewer gains and losses average 0.94% of all recharge.

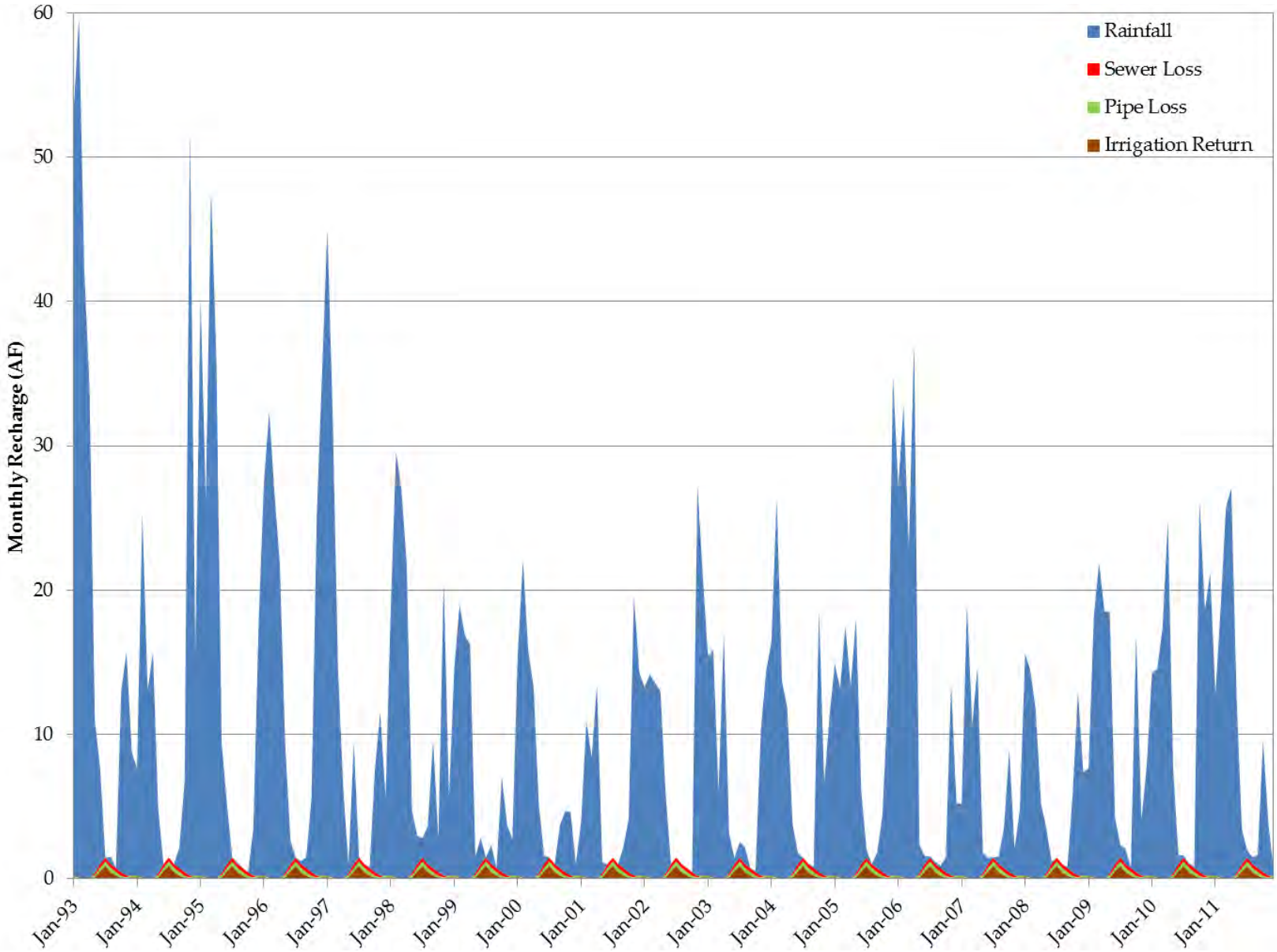


Figure 4: Monthly Recharge by Source for WSA Scenario

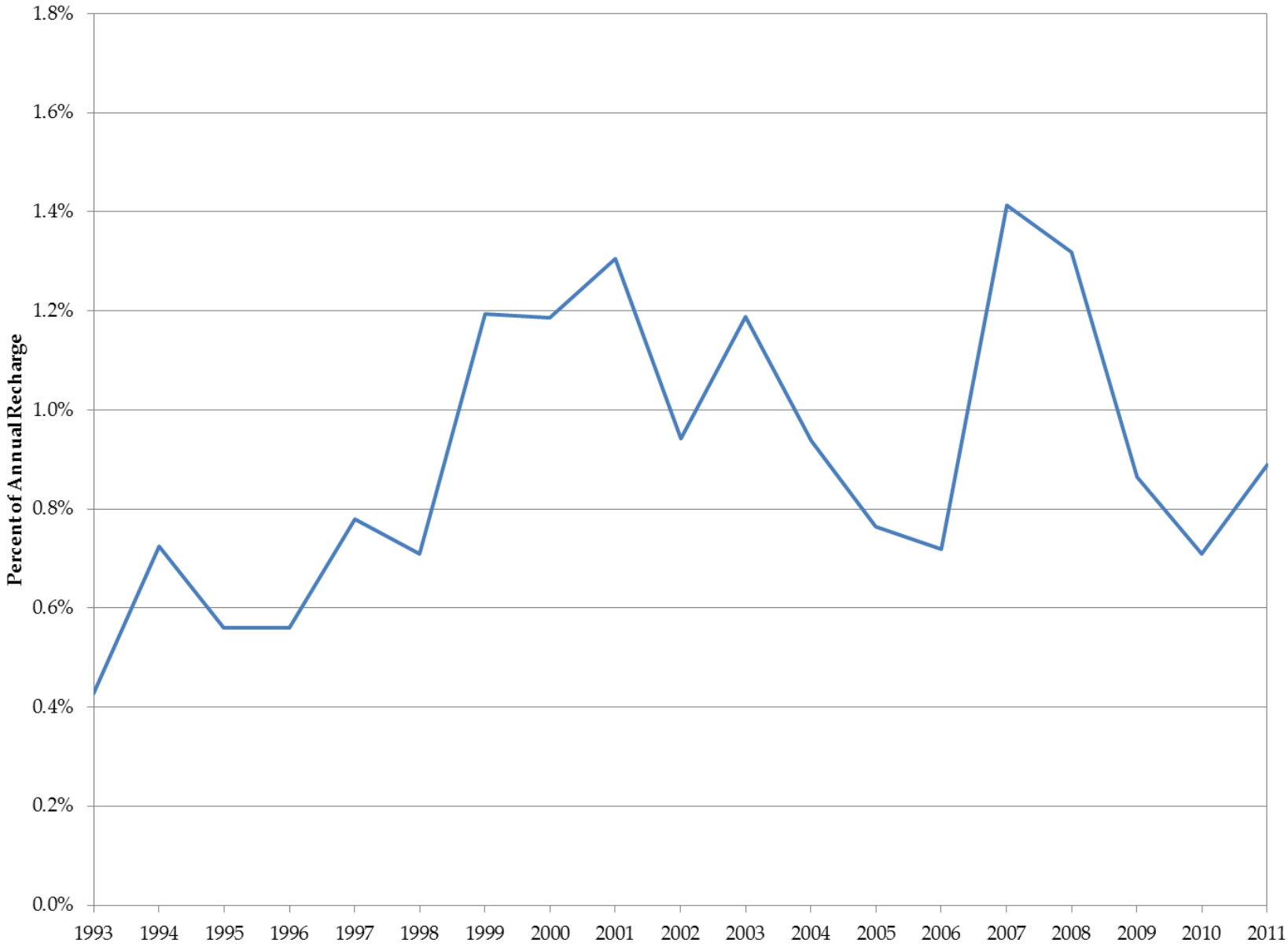


Figure 5: Sewer Leakage Percent of Annual Recharge for WSA Scenario

SECTION 3
Model Calibration

3.1 APPROACH

Calibrating the regional groundwater flow model involved successive attempts to match model output to measured data from the calibration period. Simulated groundwater elevations were compared against available observed groundwater elevations. The model was considered calibrated when simulated results matched the measured data within an acceptable measure of accuracy, and when successive calibration attempts did not notably improve the calibration statistics. Calibration was conducted by varying relatively uncertain and sensitive parameters such as horizontal and vertical hydraulic conductivities, over a reasonable range of values. Parameters varied during calibration included:

- Horizontal conductivity
- Vertical to horizontal conductivity
- Specific yield
- Specific storage
- Stream leakage
- Fault conductance

3.2 CALIBRATION PERIOD

The primary criterion for choosing the appropriate calibration period was the availability of a relatively complete set of data. The necessary data included complete pumping data, recharge data, streamflow data, and groundwater elevation data from the network of groundwater monitoring wells. Taking into account these criteria, we chose the period from May 1992 through December 2011 for calibration.

All groundwater elevation data from the calibration period were not treated equally. Squaw Creek flow monitoring began in 2004. Therefore post-2004 streamflow data are more accurate than the pre-2004 streamflow estimates, and the model will likely perform better for the time period after 2004. To reflect the improvement in the data beginning in 2004, groundwater elevation observations after 2004 were given a ten times larger weight than observations prior to 2004.

3.3 STRESS PERIODS

Stress periods define time periods in the groundwater model over which hydraulic stresses such as pumping and recharge are held constant. Stress period selection depends on the model objectives and the time frame of interest. The primary objective of the model is to assist with groundwater management strategies and simulating impacts from potential water projects. Because seasonal fluctuations in groundwater elevations are important in groundwater management, the stress periods must be at least seasonal. Based on the existing data and model objectives, monthly stress periods were chosen. These stress periods allow adequate resolution of seasonal groundwater level fluctuations while performing the simulations in a reasonable amount of time.

3.4 PILOT POINT METHOD FOR MODEL CALIBRATION

A pilot point approach, rather than a zoned conductivity approach, was used to distribute aquifer parameters during calibration. The pilot point approach results in a smoothly varying hydraulic conductivity field. Doherty (2003) describes the methodology for the use of pilot points in groundwater model calibration. Using this method, the values of aquifer hydraulic properties are estimated at the locations of a number of points spread throughout the model domain. Hydraulic properties are then assigned to the model grid through spatial interpolation from those points (Doherty, 2007).

Prior to estimating any hydraulic parameters, the pilot points were selected manually based on following criteria (Doherty, 2002):

1) More pilot points were placed where there are more data;
2) Pilot points were placed between data points in order to calibrate to head difference between wells;
3) Pilot points were placed in between wells and outflow boundaries.
4) Pilot points were placed to eliminate big gaps between adjacent pilot points;

In addition, pilot points for horizontal hydraulic conductivity were placed at locations with estimated hydraulic conductivities derived from aquifer tests.

Between 18 and 78 pilot points were selected for each layer. The pilot points are used to estimate horizontal hydraulic conductivity, ratio of horizontal to vertical hydraulic conductivity, specific yield, and specific storage. Layer 1 was treated

as homogeneous with respect to specific storage and layer 3 was treated as homogenous with respect to specific yield. The values in these two instances were specified and omitted from the parameter estimation process.

The pilot point methodology results in 480 parameter values that can be varied during calibration. PEST software, with its Singular Value Decomposition (SVD)-assist functionality (Watermark Numerical Computing, 2004, 2008), was used to help update the full set of parameter values and improve the calibration.

3.5 CALIBRATION RESULTS

3.5.1 MODEL PARAMETER MODIFICATIONS

Model calibration consisted of modifying the distribution and magnitude of horizontal hydraulic conductivity, ratio of horizontal to vertical hydraulic conductivity, specific yield, and specific storage values using the pilot point method discussed above. The final distributions of aquifer parameter values for horizontal hydraulic conductivity, vertical anisotropy ratio, specific storage, and specific yield are shown on Figure 6 through Figure 9.

Streambed conductance values for Shirley Canyon and the South Fork of Squaw Creek were included as adjustable parameters in the calibration. The final values obtained from calibration equate to average streambed hydraulic conductivity values of 1.1×10^{-3} feet per day and 1 foot per day. These values are similar to the values of 1.9×10^{-4} feet per day and 1 foot per day that were used in the previous version of the model.

The calibrated value for the fault hydraulic conductivity is 0.16 feet per day, assuming a one-foot thick fault. This value is lower than the surrounding aquifer material and higher than the previously used value of 0.010 feet per day.

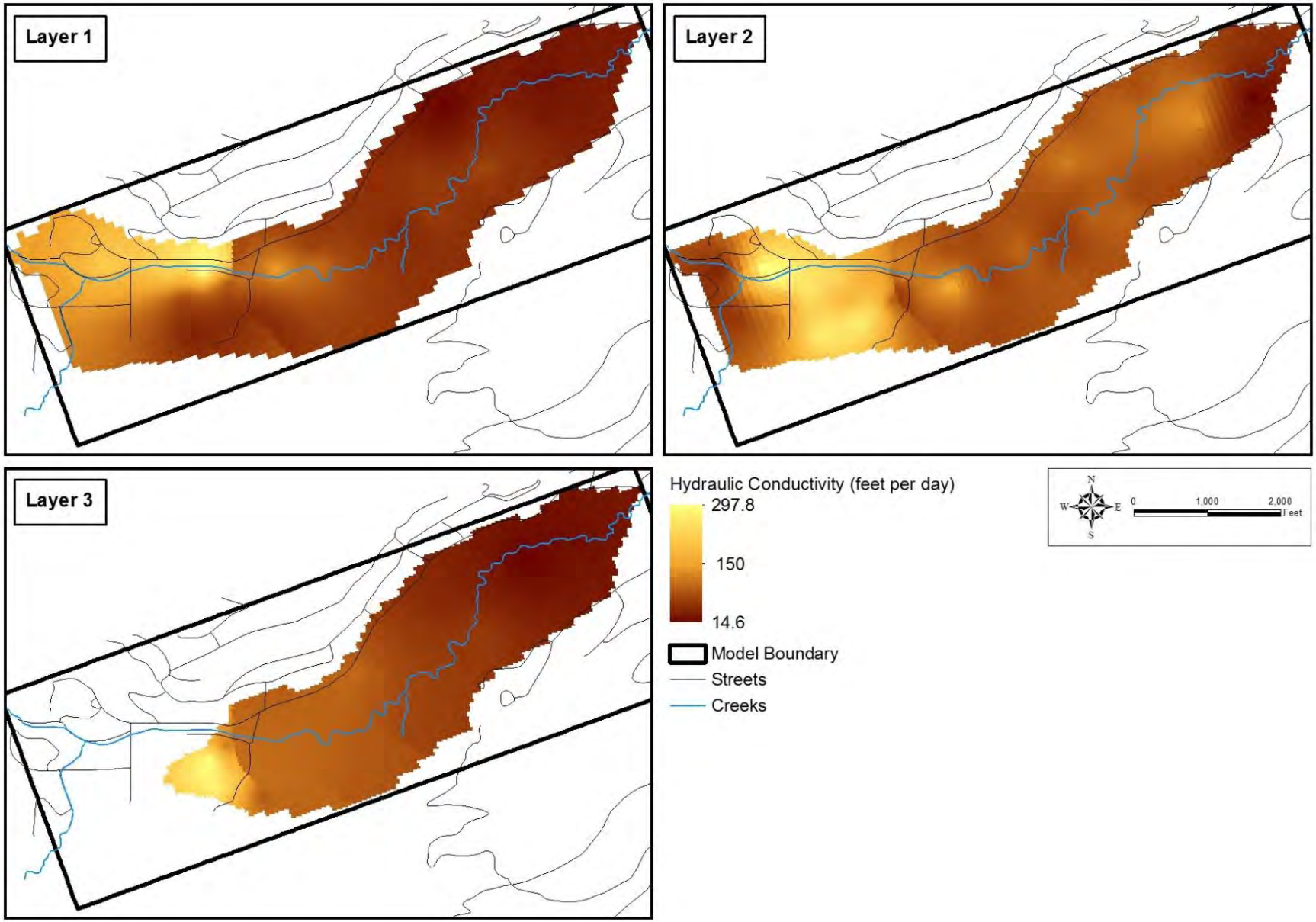


Figure 6: Distribution of Hydraulic Conductivity

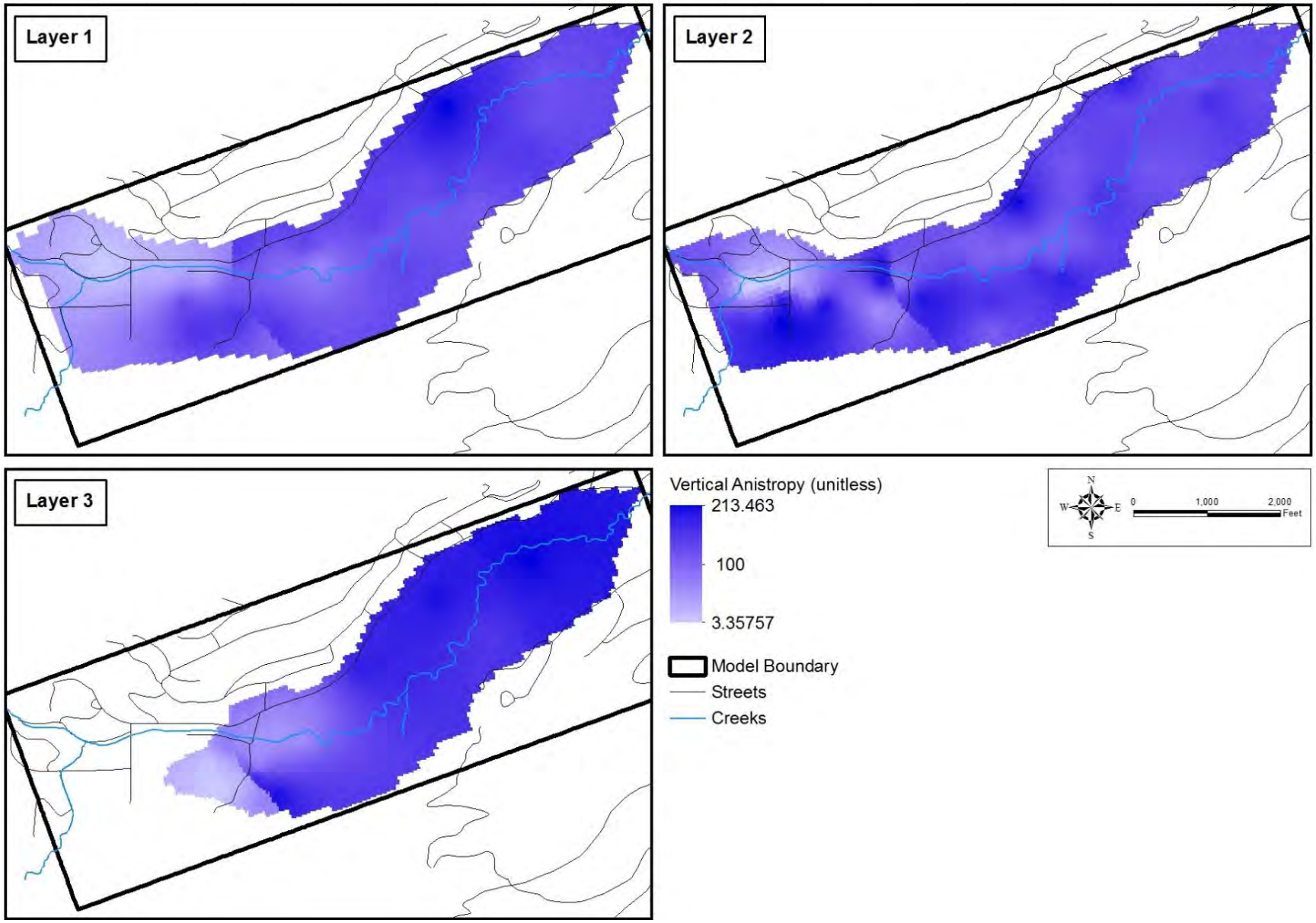


Figure 7: Distribution of Vertical Anisotropy Ratio

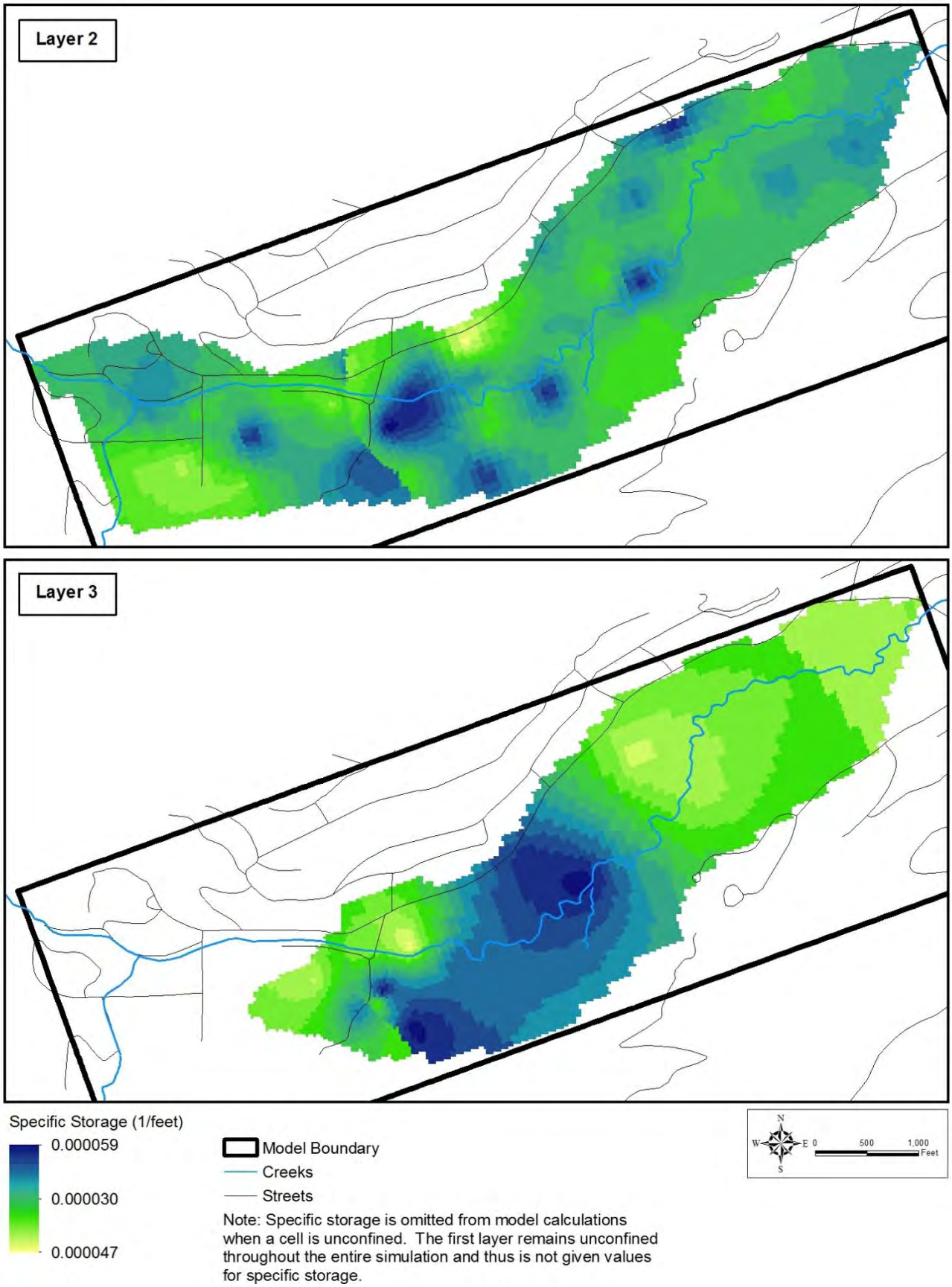


Figure 8: Distribution of Specific Storage

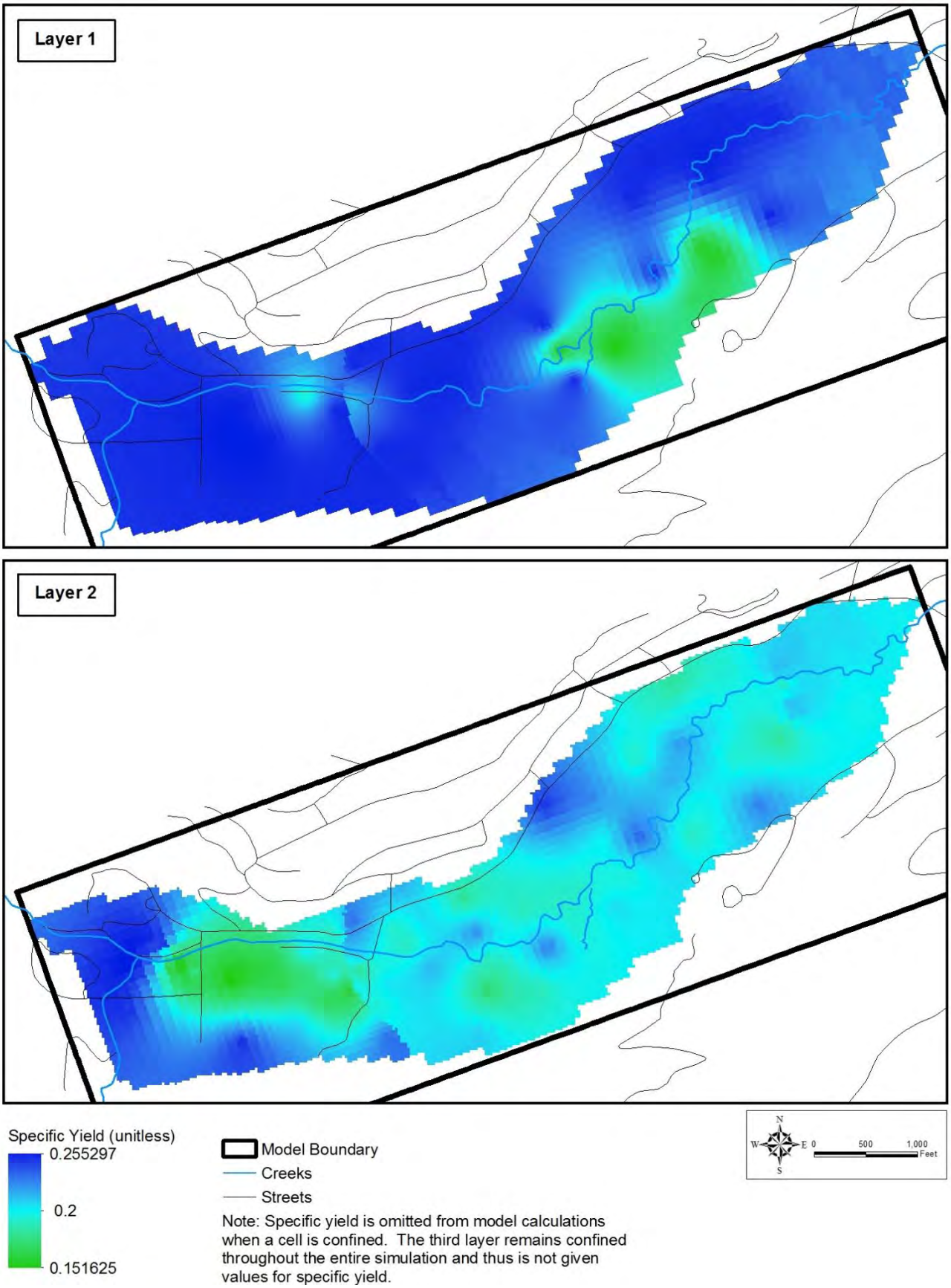


Figure 9: Distribution of Specific Yield

3.5.2 GROUNDWATER ELEVATION CALIBRATION

Flow model calibration is commonly evaluated by comparing simulated groundwater elevations with observed groundwater elevations from monitoring and production wells. Hydrographs of simulated groundwater elevations should generally match the trends and fluctuations observed in measured hydrographs. Furthermore, the average errors between observed and simulated groundwater elevations should be relatively small and unbiased. The well locations used for calibrating the groundwater flow model are shown on Figure 10.

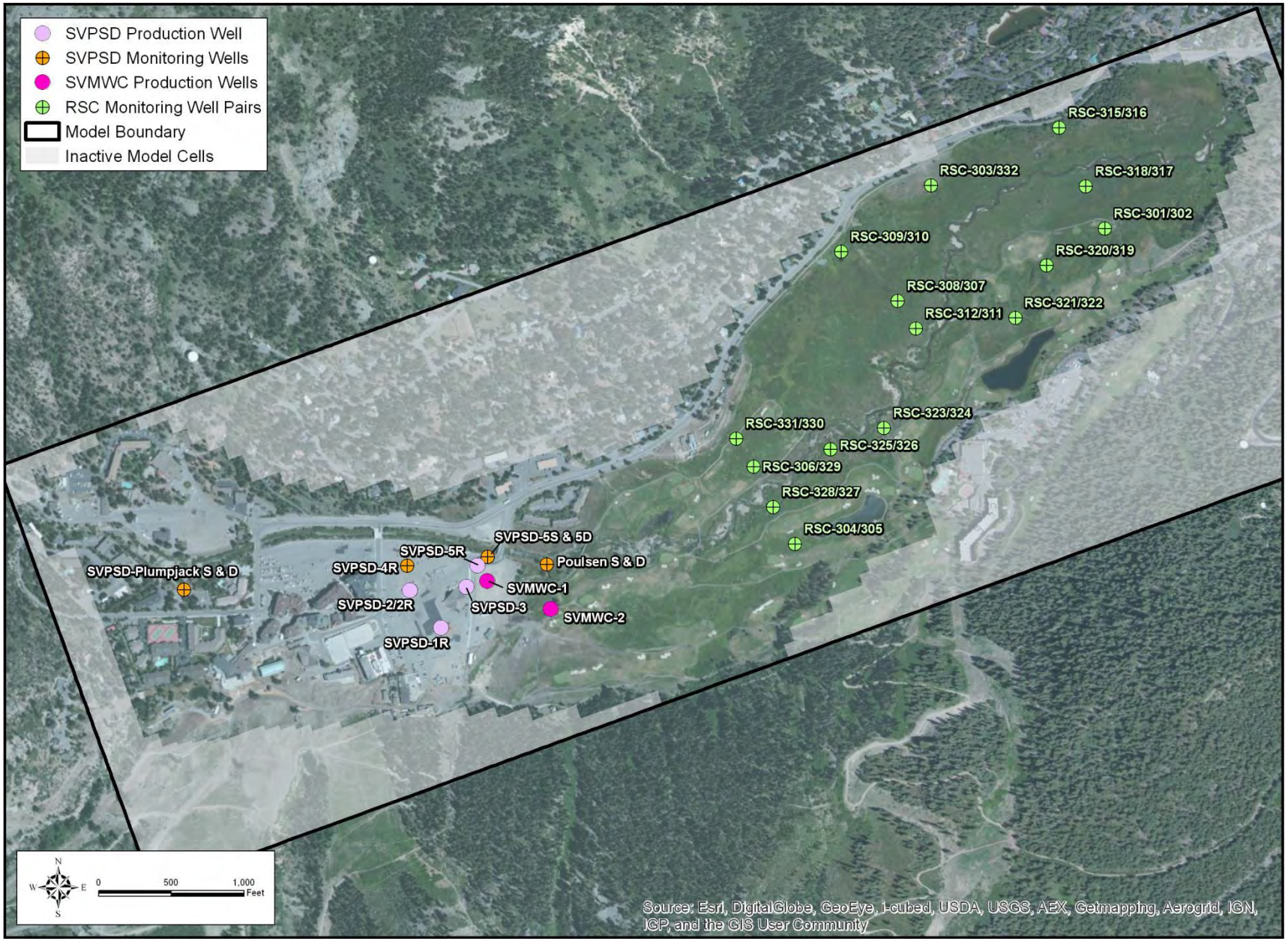


Figure 10: Target Well Locations

A complete set of hydrographs showing both observed and simulated groundwater elevations are included in Appendix A. These hydrographs show that the simulated groundwater elevations track measured groundwater elevations well.

Various graphical and statistical methods can be used to demonstrate the magnitude and potential bias of the calibration errors. Figure 11 shows all simulated groundwater elevations plotted against observed groundwater elevations. Results from an unbiased model will scatter around a 45° line on this graph. If the model has a bias such as exaggerating or underestimating groundwater levels, the results will diverge from this 45° line. Figure 11 demonstrates that the results tend to lie close, but slightly below, a 45° line. This suggests that model has a minor bias towards underestimating average groundwater levels. This is likely due to the fact that the model cannot simulate the measured groundwater elevations that are above ground surface in the meadow area.

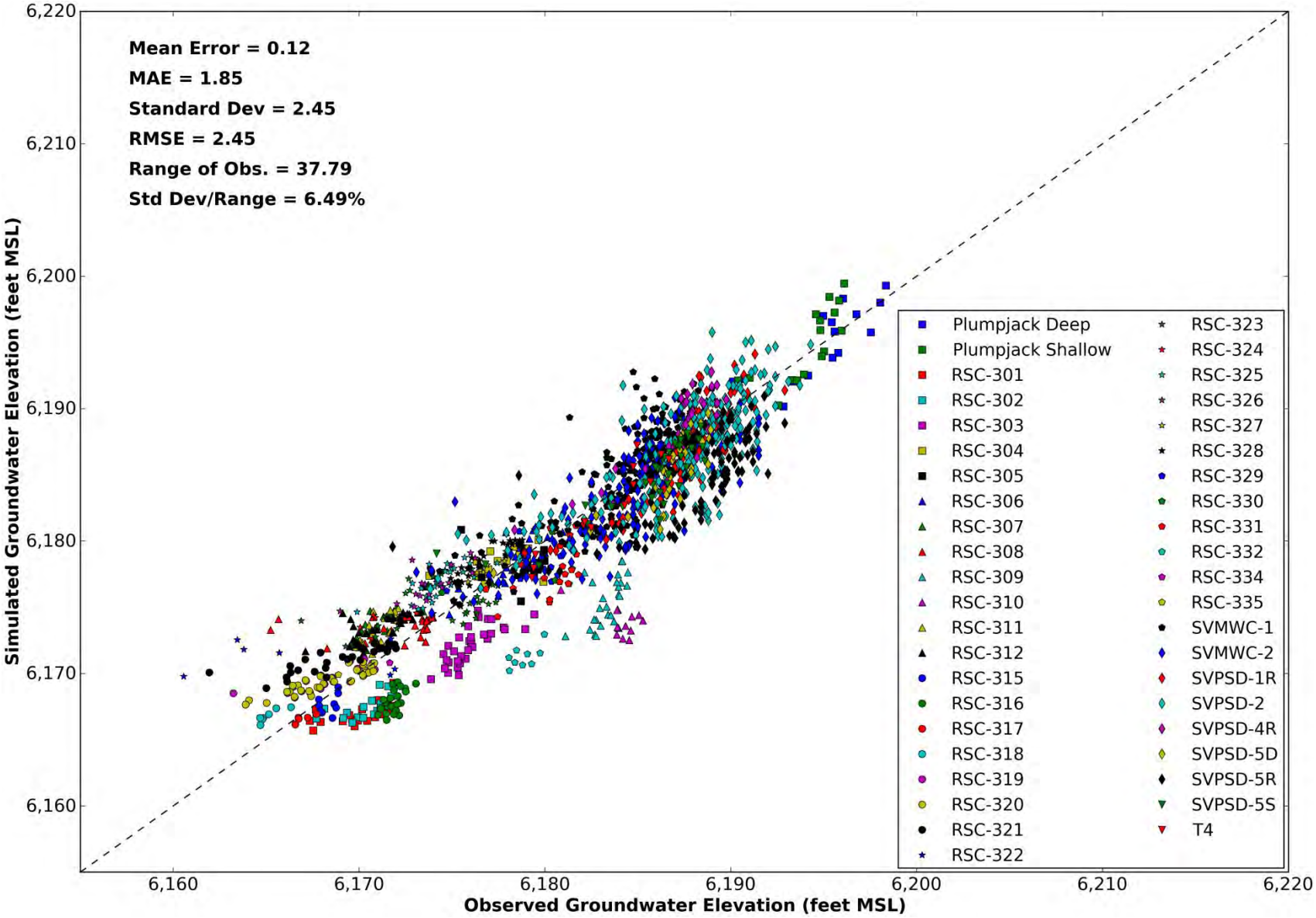


Figure 11: Simulated Versus Observed Groundwater Elevations

Figure 11 also includes various statistical measures of calibration accuracy. The four statistical measures used to evaluate calibration are the mean error (ME), the mean absolute error (MAE), the standard deviation of the errors (STD), and the root mean squared error (RMSE). Each of these statistical measures was calculated using weighted measurements, where all weights have been normalized such that the sum of all weights is equal to one.

The mean error is the average error between measured and simulated groundwater elevations for all data on Figure 11.

$$ME = \sum_{i=1}^{n} w_i \left(h_m - h_s\right)_i$$

Where h_m is the measured groundwater elevation, h_s is the simulated groundwater elevation, w_i is the normalized observation weight and n is the number of observations.

The mean absolute error is the average of the absolute differences between measured and simulated groundwater elevations.

$$MAE = \sum_{i=1}^{n} w_i \left|h_m - h_s\right|_i$$

The standard deviation of the errors is one measure of the spread of the errors around the 45º line on Figure 11. The population standard deviation is used for these calculations

$$STD = \sqrt{\sum_{i=1}^{n} w_i \left(h_m - h_s\right)_i^2 - \left(\sum_{i=1}^{n} w_i \left(h_m - h_s\right)_i\right)^2}$$

The RMSE is similar to the standard deviation of the error. It also measures the spread of the errors around the 45º line on Figure 11, and is calculated as the square root of the average squared errors.

$$RMSE = \sqrt{\sum_{i=1}^{n} w_i \left(h_m - h_s\right)_i^2}$$

As a measure of successful model calibration, Anderson and Woessner (1992) state that the ratio of the spread of the errors to the total head range in the system should be small to ensure that the errors are only a small part of the overall model response. As a general rule, the RMSE should be less than 10% of the total head range in the model. The RMSE of 2.45, shown on Figure 11, is approximately 6.49% of the total head range of 37.8 feet. A second general rule that is occasionally used is that the mean error should be less than 5% of the total head range in the model. The mean error of 0.12 is approximately 0.32% of the total head range. Therefore, on average, the model errors are within an acceptable range.

These calibration statistics are better than the calibration statistics shown in the *Squaw Valley creek/aquifer study model update report* (HydroMetrics WRI, 2013). Table 2 compares the calibration statistics from the 2013 calibration effort with the current calibration effort. This table shows that the modifications, along with additional calibration efforts, improved the model's ability to predict groundwater elevations and impacts from proposed pumping.

Table 2: Comparison of Calibration Statistics

	November 2013 Calibration	Current Calibration
Mean Error	1.38 feet	0.12 feet
Mean Avg. Error	2.31 feet	1.85 feet
RMSE	2.92 feet	2.45 feet
RMSE/Range of Obs.	7.72 %	6.49 %

A second graph used to evaluate bias in model results is shown on Figure 12. This figure is a graph of observed groundwater elevations versus model residual (simulated elevation minus observed elevation). Results from a non-biased simulation will appear as a cloud of data points clustered around the zero model residual line. Results that do not cluster around the zero residual line show potential model bias. Results that display a trend instead of a random cloud of points may suggest additional model bias.

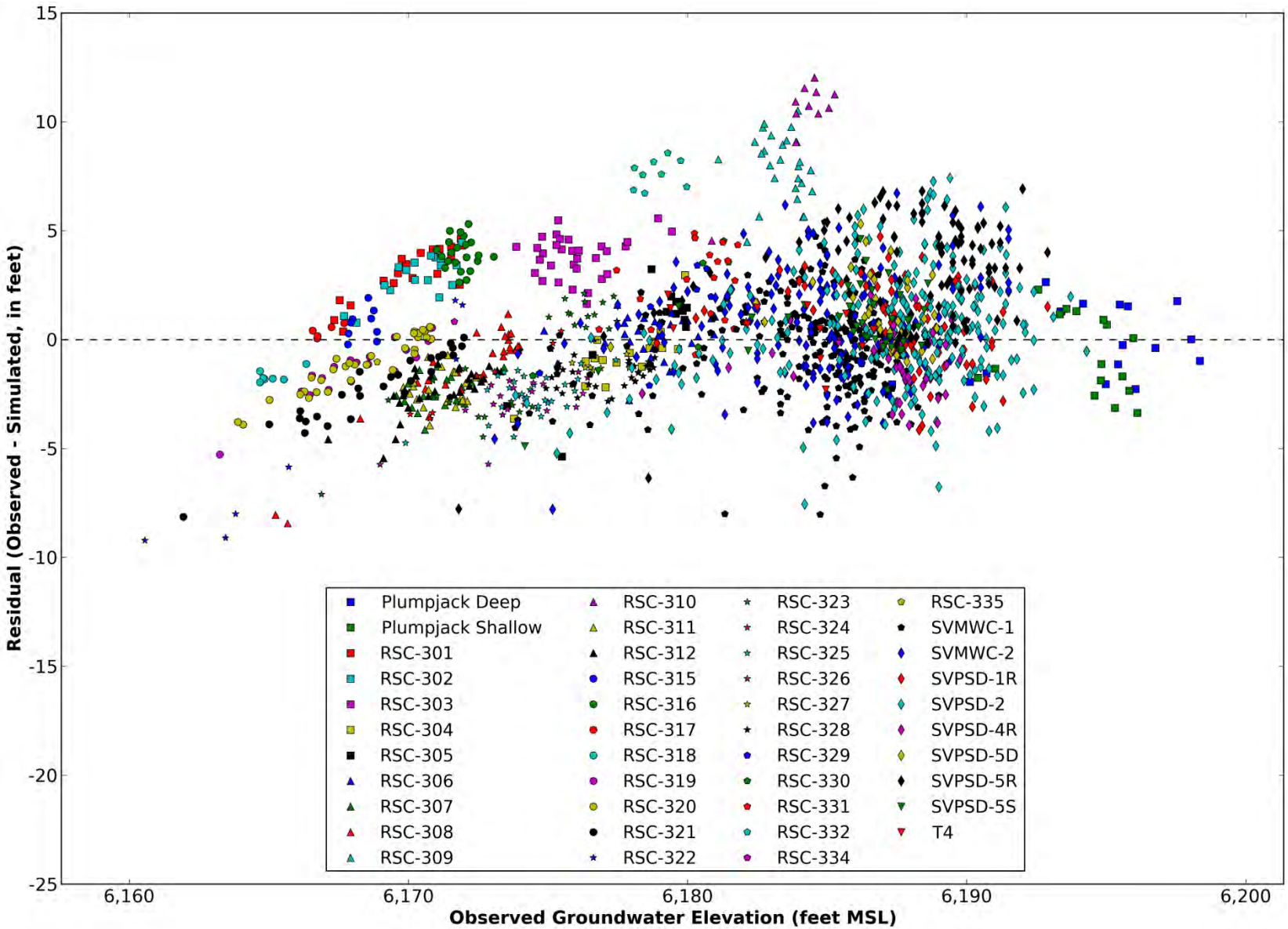


Figure 12: Observed Groundwater Elevations versus Model Residual

SECTION 4
Conclusions

Assumptions in the Squaw Valley groundwater model were strengthened and updated to produce a more accurate and justifiable groundwater model. Four model assumptions were modified:

- Depth and extent of aquifers in Squaw Valley;
- Percentage of precipitation that becomes recharge in the western end of Squaw Valley;
- Timing of precipitation recharge; and
- Maximum sewer infiltration and exfiltration rates.

The updated and recalibrated groundwater model accurately simulates groundwater levels in Squaw Valley quite well. The updated groundwater model continues to be an accurate and dependable tool that can be confidently used to develop future groundwater pumping plans.

SECTION 5
References

Anderson, M.P., and W.W. Woessner. 1992. *Applied groundwater modeling, simulation of flow and advective transport,* Academic Press, Inc., San Diego, California, 381 p.

Doherty, J. 2003. Groundwater model calibration using pilot points and regularization. *Ground Water*. 41 (2): 170-177.

———, 2007, *PEST groundwater data utilities*, Watermark Numerical Computing, Australia, August.

HydroMetrics WRI. 2013. *Squaw Valley creek/aquifer study model update report*, prepared for Squaw Valley Public Service District, November, 49 p.

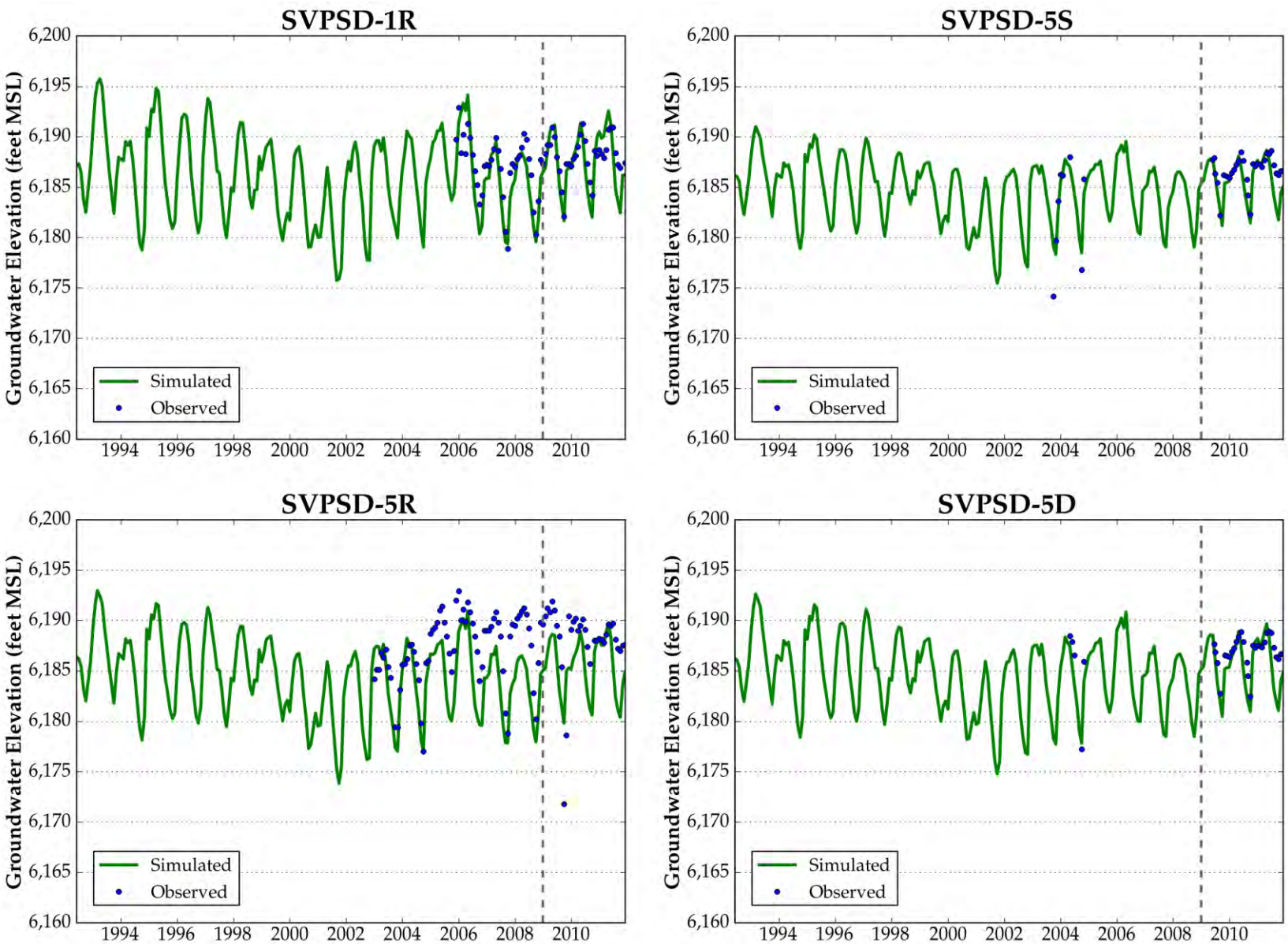
Todd Engineers, 2012, *Independent analysis of groundwater supply; Olympic Valley groundwater basin*, prepared for Squaw Valley Real Estate, December,

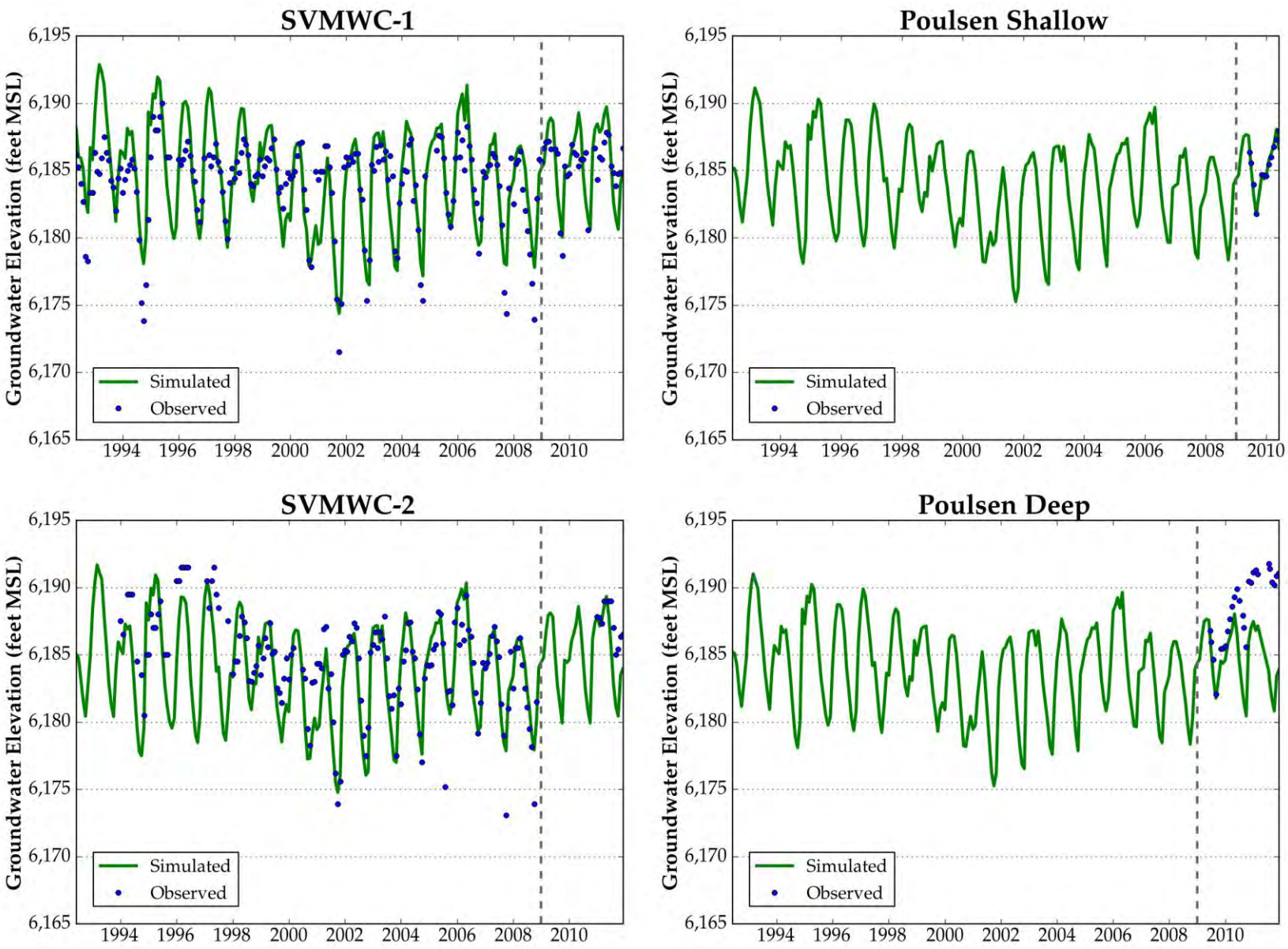
Watermark Numerical Computing. 2004. *PEST Model-Independent Parameter Estimation User Manual: 5th Edition*, July.

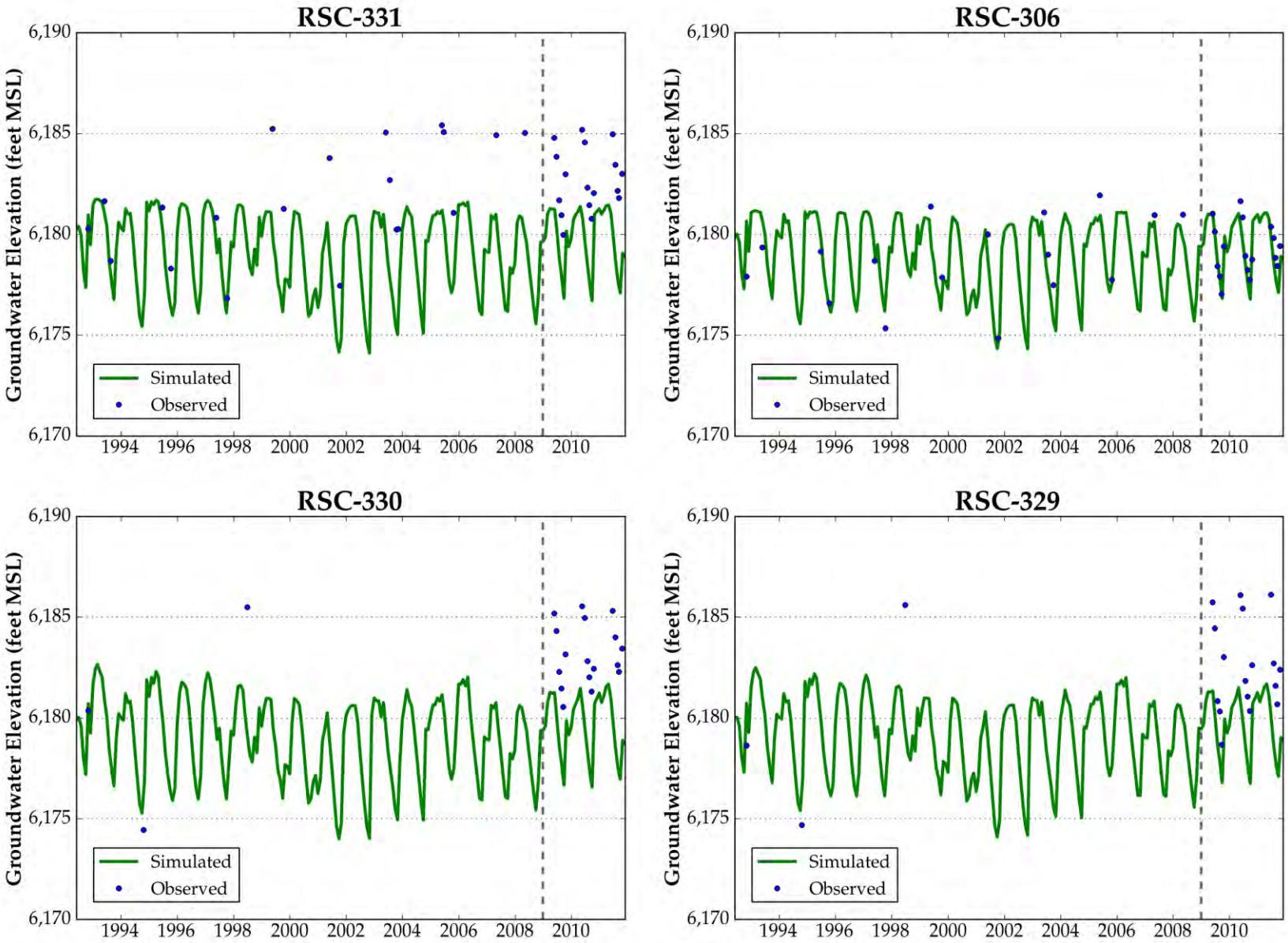
———. 2008. *Addendum to the PEST manual*, November.

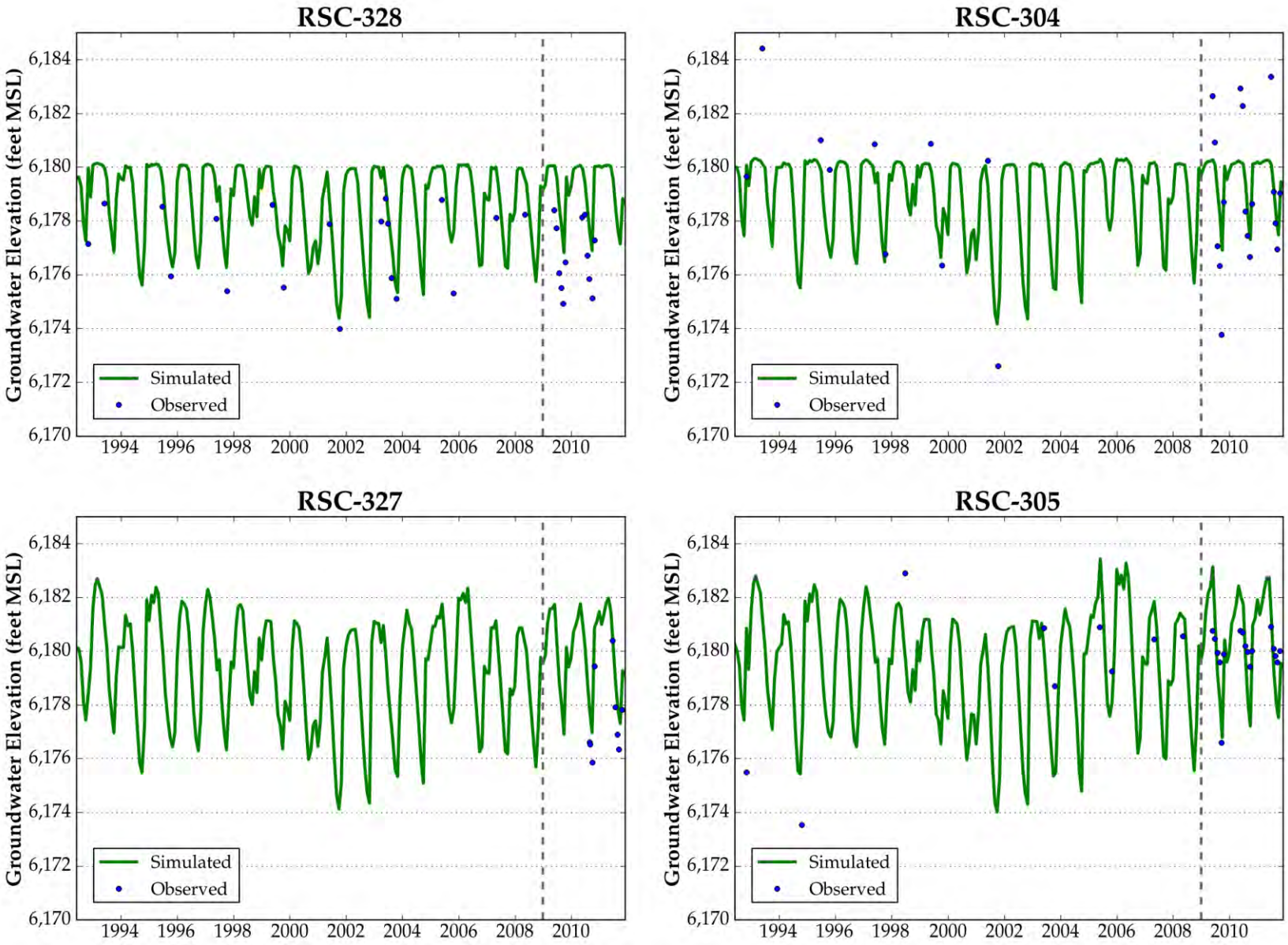
Williams, D., 2001, *Groundwater Development and Utilization Feasibility Study, Groundwater Model Report*, prepared by Derrik Williams, R.G. for West Yost Associates, June 67 p.

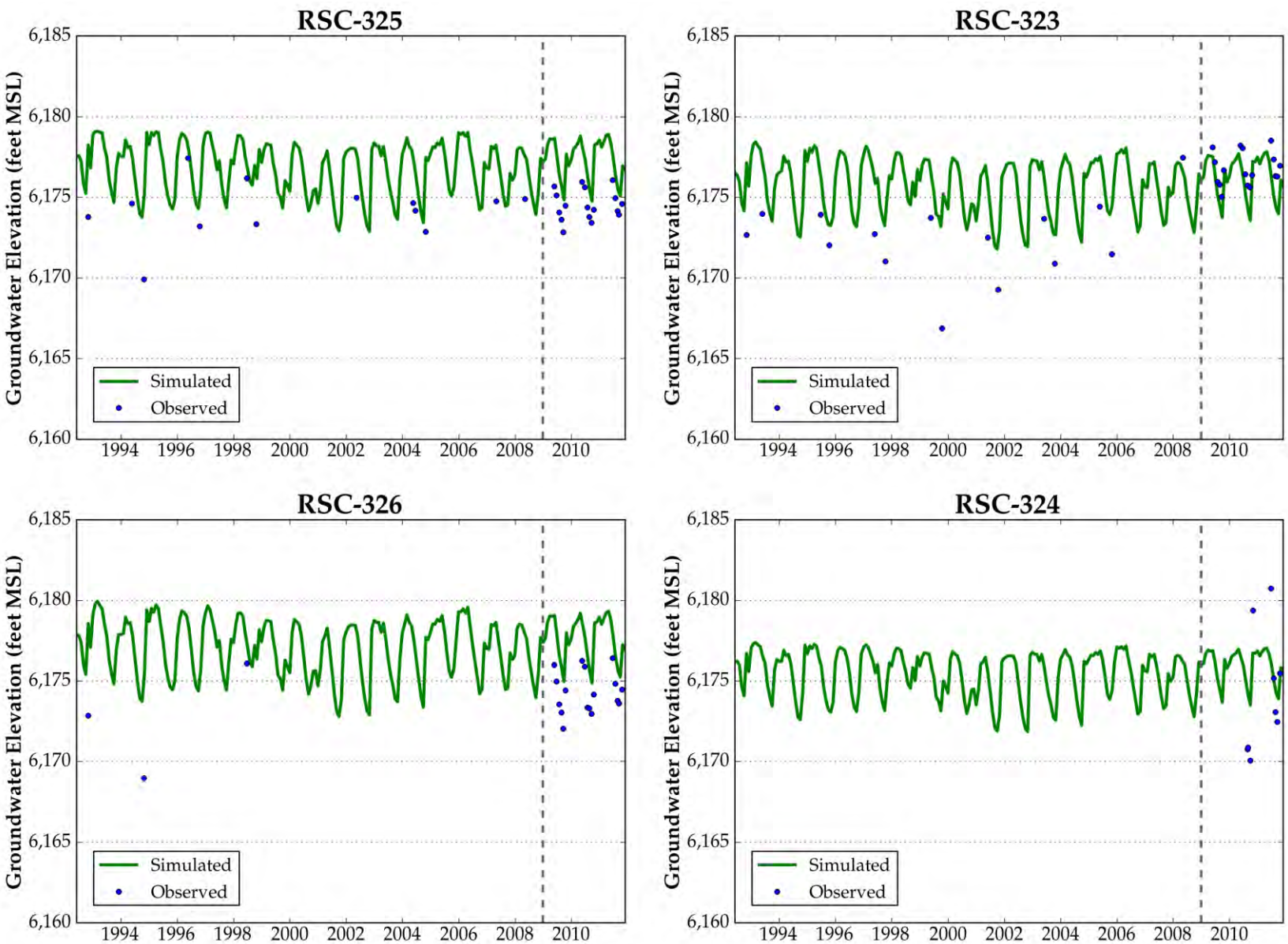
Appendix A: Measured and Simulated Hydrographs

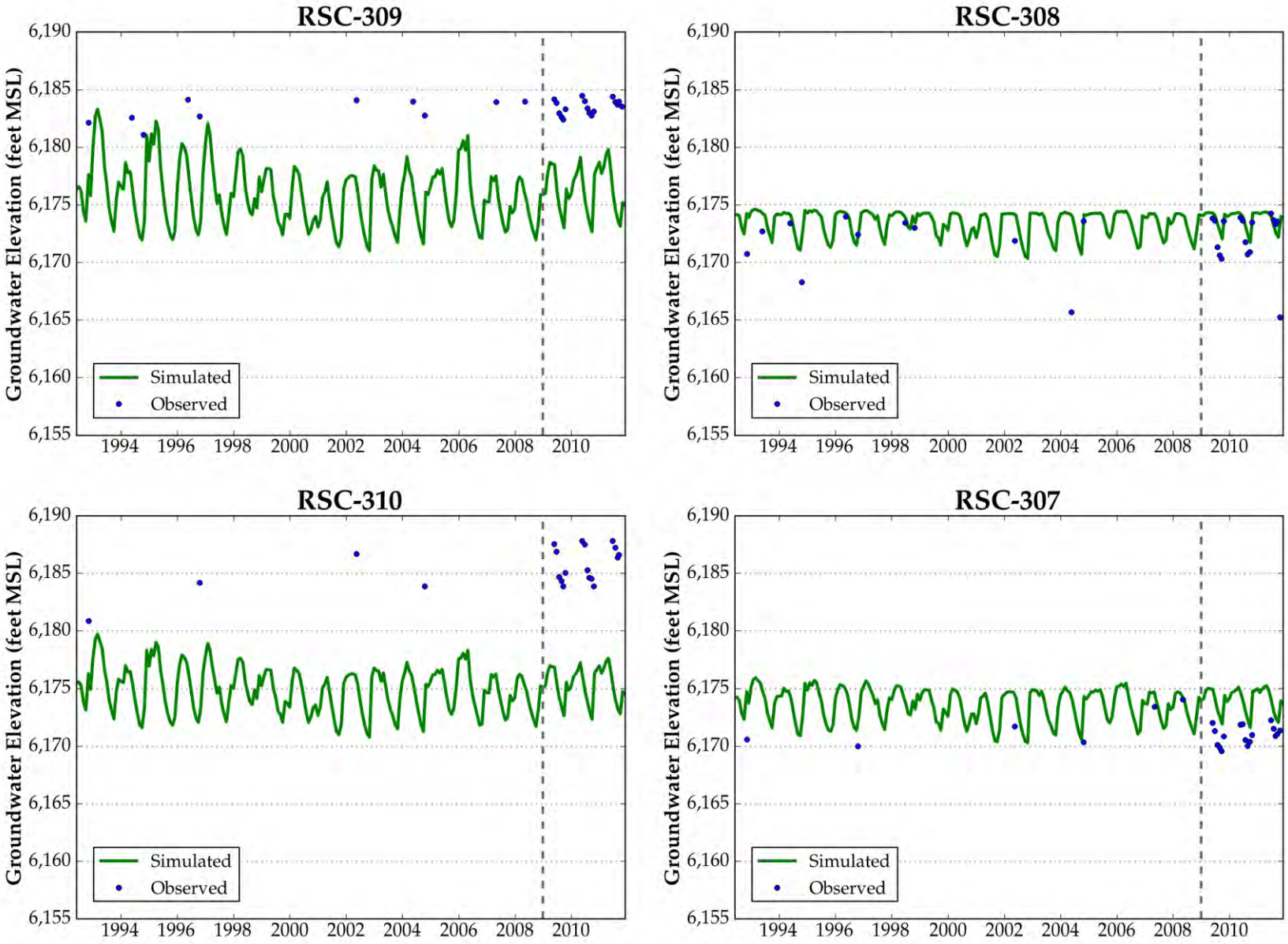

SVPSD-1R
SVPSD-5S
SVPSD-5R
SVPSD-5D
Groundwater Elevation (feet MSL)
6,200
6,195
6,190
6,185
6,180
6,175
6,170
6,165
6,160
1994
1996
1998
2000
2002
2004
2006
2008
2010
Simulated
Observed

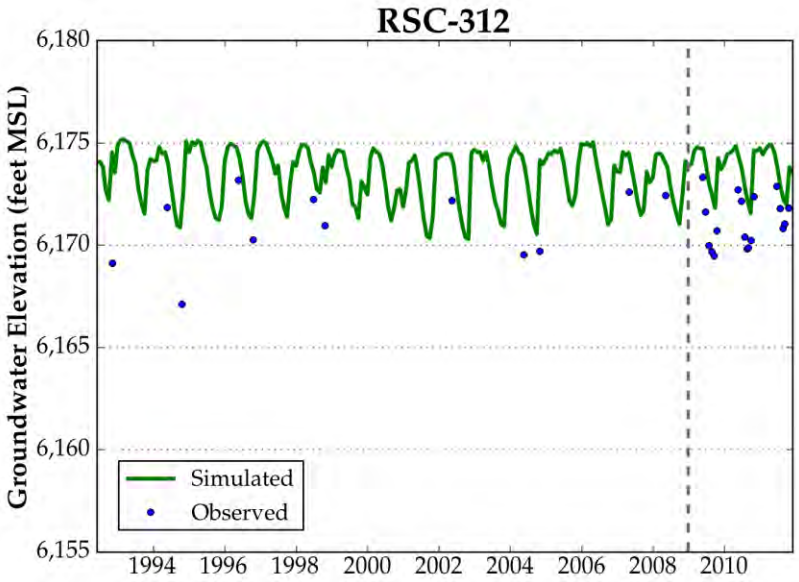

SVMWC-1
Poulsen Shallow
SVMWC-2
Poulsen Deep
Groundwater Elevation (feet MSL)
6,195
6,190
6,185
6,180
6,175
6,170
6,165
1994
1996
1998
2000
2002
2004
2006
2008
2010
Simulated
Observed

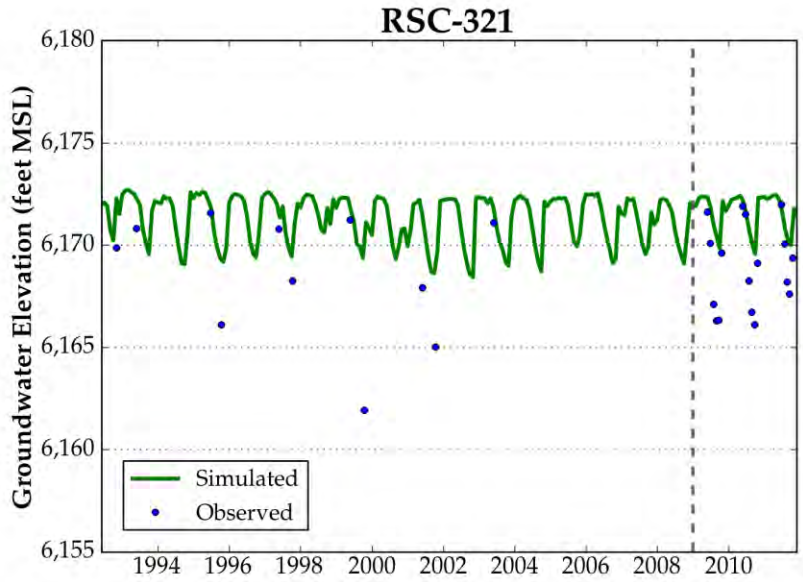

RSC-331
RSC-306
RSC-330
RSC-329
Groundwater Elevation (feet MSL)
6,190
6,185
6,180
6,175
6,170
1994
1996
1998
2000
2002
2004
2006
2008
2010
Simulated
Observed

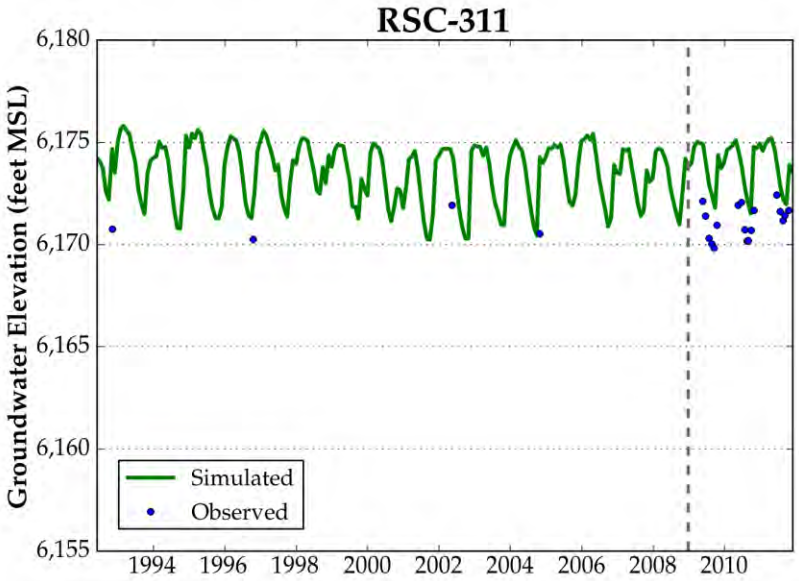

RSC-328
RSC-304
RSC-327
RSC-305
Groundwater Elevation (feet MSL)
6,184
6,182
6,180
6,178
6,176
6,174
6,172
6,170
1994
1996
1998
2000
2002
2004
2006
2008
2010
Simulated
Observed

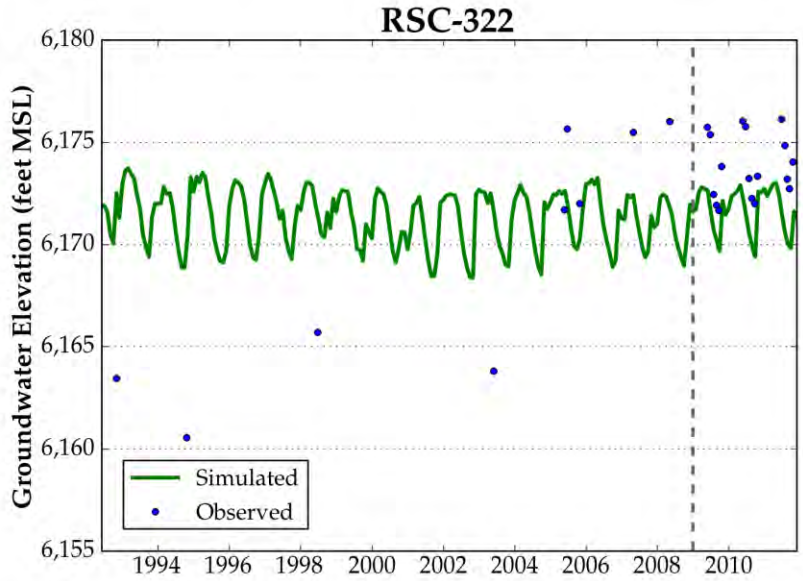

RSC-325
RSC-323
RSC-326
RSC-324
Groundwater Elevation (feet MSL)
6,185
6,180
6,175
6,170
6,165
6,160
1994
1996
1998
2000
2002
2004
2006
2008
2010
Simulated
Observed

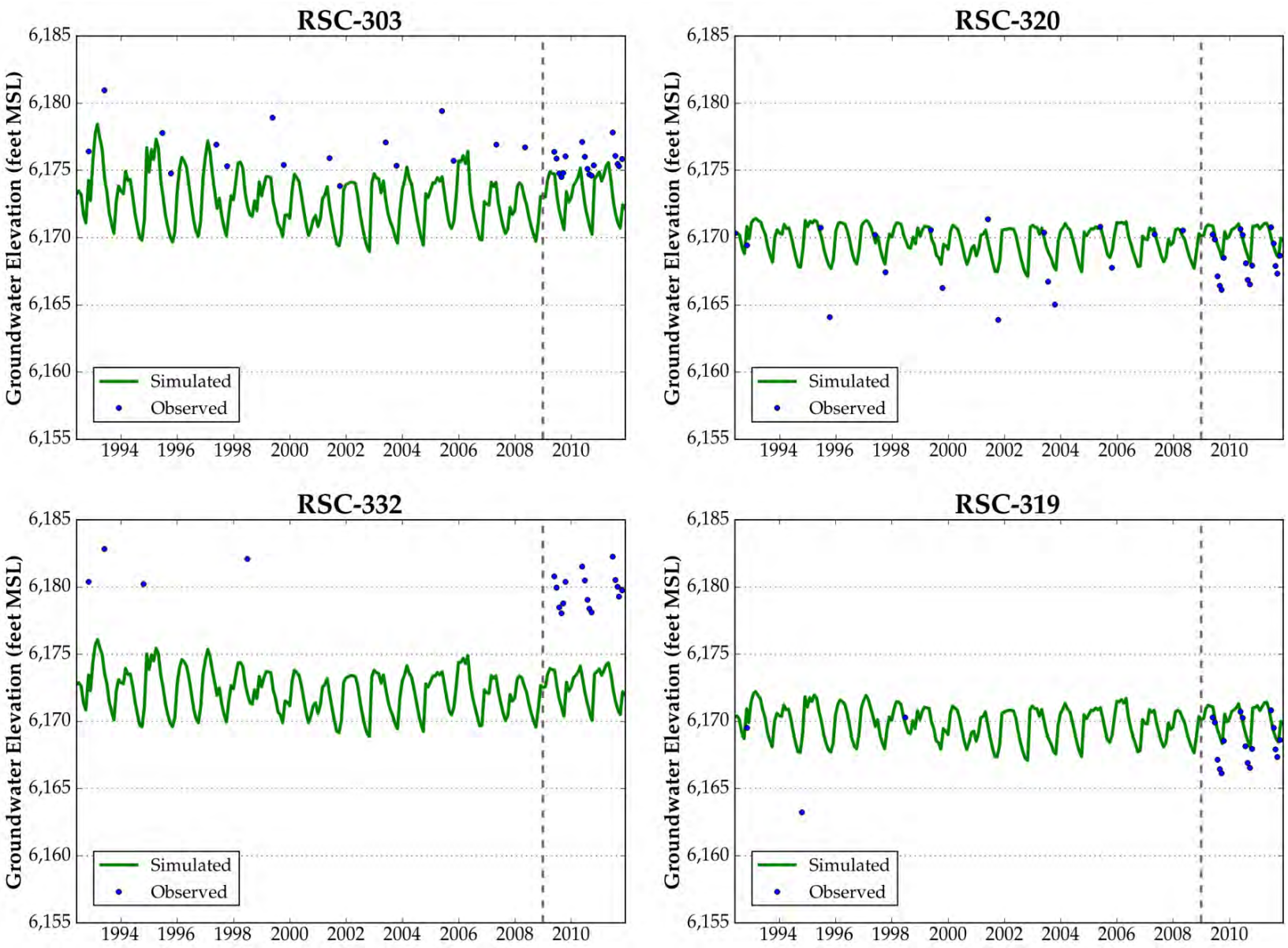

RSC-309
RSC-308
RSC-310
RSC-307
Groundwater Elevation (feet MSL)
6,190
6,185
6,180
6,175
6,170
6,165
6,160
6,155
1994
1996
1998
2000
2002
2004
2006
2008
2010
Simulated
Observed

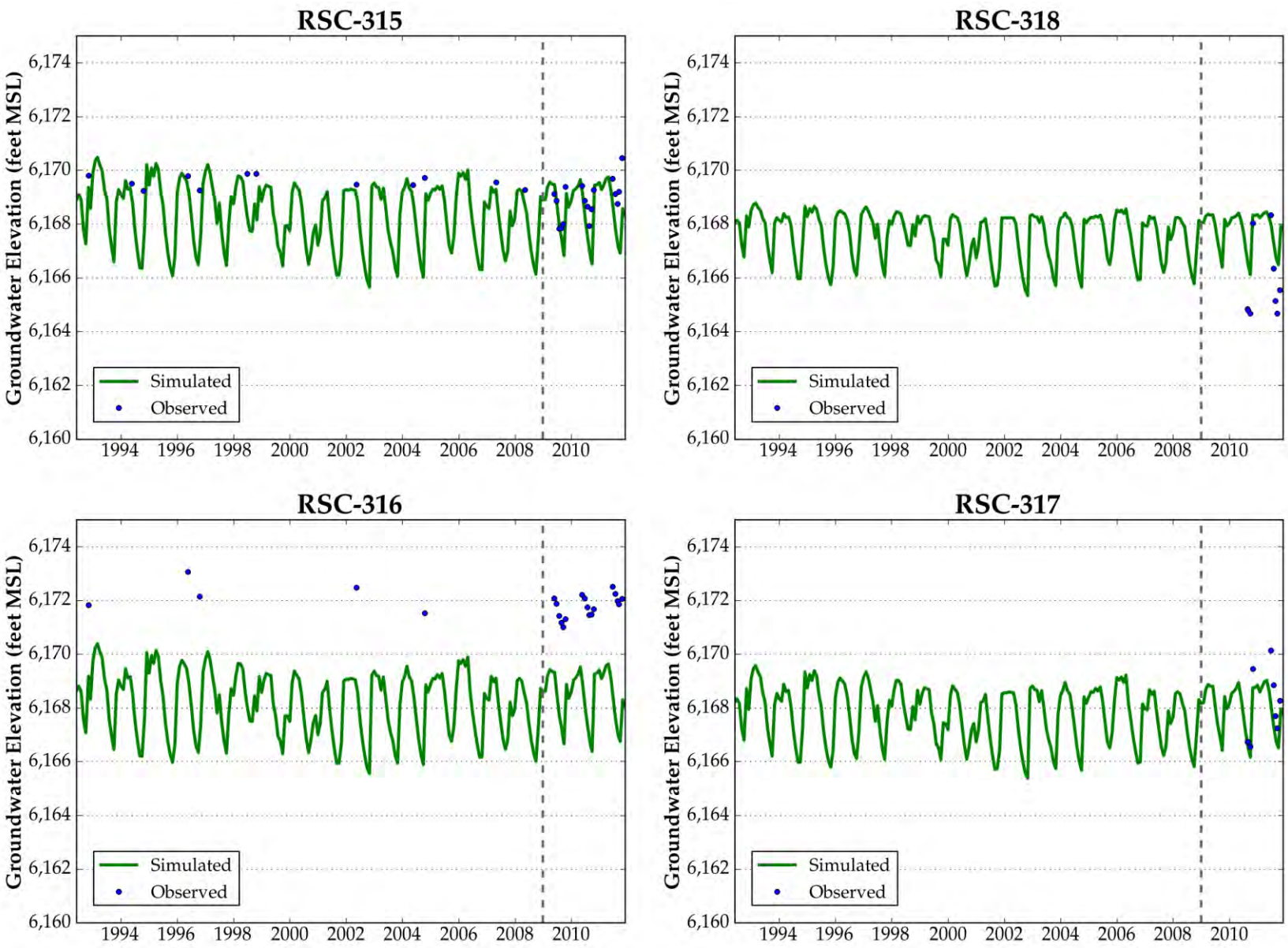

RSC-312
Groundwater Elevation (feet MSL)
6,180
6,175
6,170
6,165
6,160
6,155
1994
1996
1998
2000
2002
2004
2006
2008
2010
Simulated
Observed

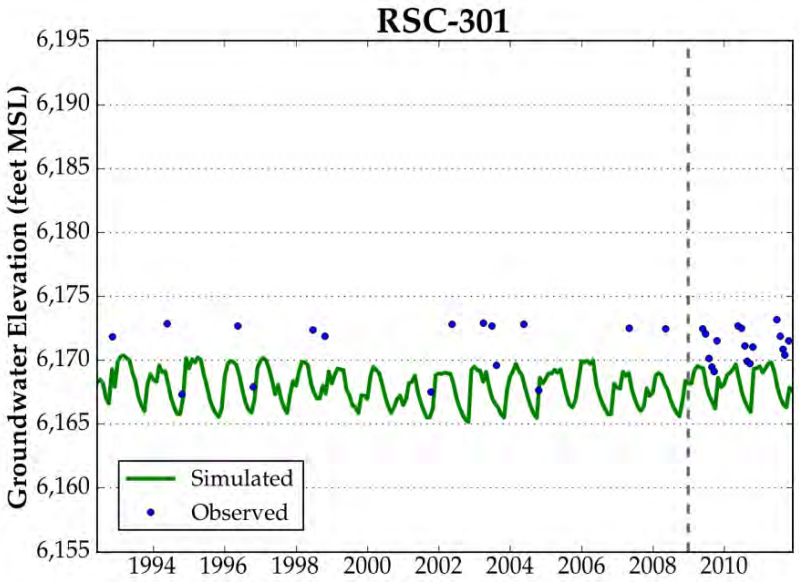

RSC-321
Groundwater Elevation (feet MSL)
6,180
6,175
6,170
6,165
6,160
6,155
1994
1996
1998
2000
2002
2004
2006
2008
2010
Simulated
Observed

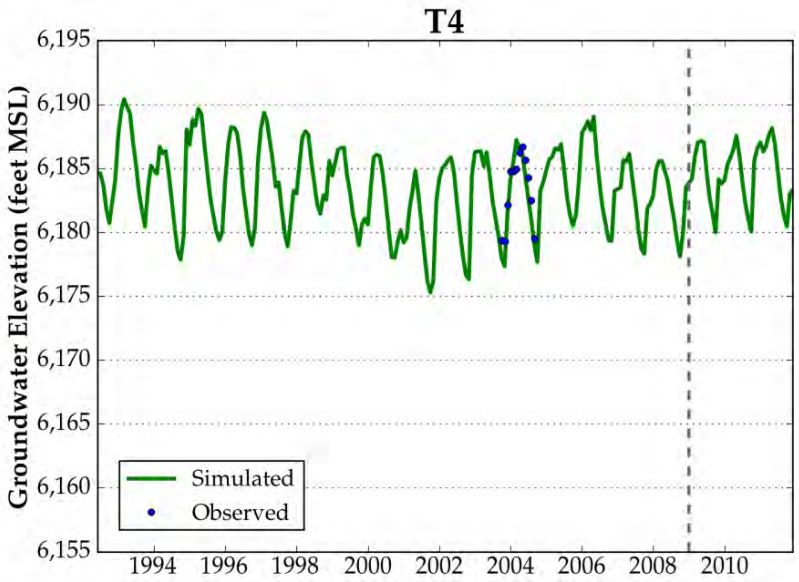

RSC-311
Groundwater Elevation (feet MSL)
6,180
6,175
6,170
6,165
6,160
6,155
1994
1996
1998
2000
2002
2004
2006
2008
2010
Simulated
Observed

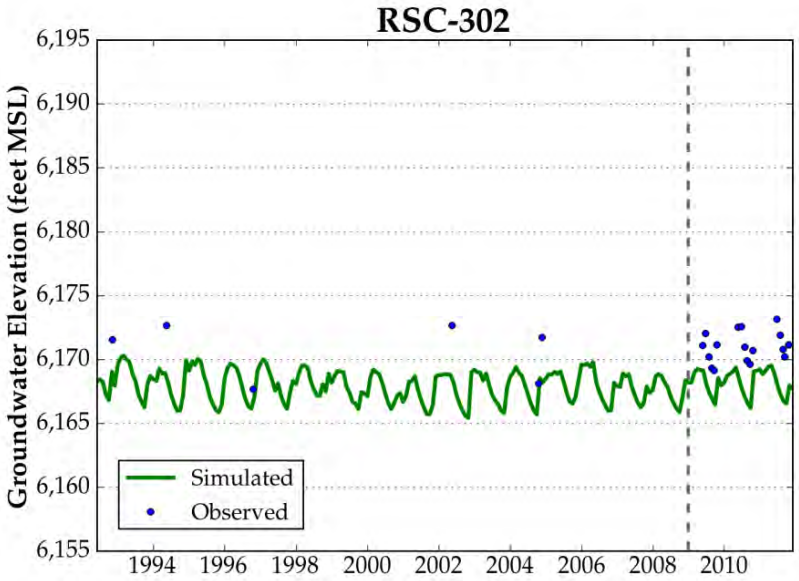

RSC-322
Groundwater Elevation (feet MSL)
6,180
6,175
6,170
6,165
6,160
6,155
1994
1996
1998
2000
2002
2004
2006
2008
2010
Simulated
Observed


RSC-303
RSC-320
RSC-332
RSC-319
Groundwater Elevation (feet MSL)
6,185
6,180
6,175
6,170
6,165
6,160
6,155
1994
1996
1998
2000
2002
2004
2006
2008
2010
Simulated
Observed


RSC-315
RSC-318
RSC-316
RSC-317
Groundwater Elevation (feet MSL)
6,174
6,172
6,170
6,168
6,166
6,164
6,162
6,160
1994
1996
1998
2000
2002
2004
2006
2008
2010
Simulated
Observed


RSC-301
Groundwater Elevation (feet MSL)
6,195
6,190
6,185
6,180
6,175
6,170
6,165
6,160
6,155
1994
1996
1998
2000
2002
2004
2006
2008
2010
Simulated
Observed


T4
Groundwater Elevation (feet MSL)
6,195
6,190
6,185
6,180
6,175
6,170
6,165
6,160
6,155
1994
1996
1998
2000
2002
2004
2006
2008
2010
Simulated
Observed


RSC-302
Groundwater Elevation (feet MSL)
6,195
6,190
6,185
6,180
6,175
6,170
6,165
6,160
6,155
1994
1996
1998
2000
2002
2004
2006
2008
2010
Simulated
Observed

APPENDIX C

Squaw Valley Groundwater Update 2015

HydroMetrics, WRI, July 6, 2015

HydroMetrics WRI
1814 Franklin St, Suite 501
Oakland, CA 94612

TECHNICAL MEMORANDUM

To: Mike Geary/SVPSD

From: Derrik Williams/Sean Culkin

Date: July 6, 2015

Subject: Squaw Valley Groundwater Model 2015 Update

SECTION 1
Background and Purpose

This technical memorandum documents a recent update to the Squaw Valley groundwater model. This model update reassesses and modifies the existing groundwater flow model. The modified model simulates flow conditions up through January 2015, and is appropriate for use in future predictive scenarios and water supply assessments.

The updated model follows, and is based upon, a previous update and recalibration effort documented in a Technical Memorandum dated June 17, 2014 (Hydrometrics WRI, 2014), as well as earlier versions of the model (HydroMetrics WRI, 2013). The updated groundwater model accurately simulates groundwater levels and flow within Squaw Valley to a similar degree as in the 2014 update, and will continue to serve as an effective tool for managing groundwater pumping in Squaw Valley. The updated groundwater model can be confidently used to develop future groundwater pumping plans that minimize impacts on Squaw Creek.

SECTION 2
Model Modifications

Major structural changes to the groundwater model made in the previous version (Hydrometrics WRI, 2014) were retained in this update. No changes to the hydrostratigraphy or material properties were made during this 2015 update. The following sub-sections document the changes made to the model since 2014.

2.1 STRESS PERIODS

The transient groundwater model consists of monthly stress periods beginning in May 1992. The previous version of the model simulated from May 1992 to December 2011. The number of stress periods was extended through (and inclusive of) January 2015 for the update presented here.

2.2 RECHARGE

The aerial recharge zonation of the model was retained through the current model update. Recharge to the model domain continues to consist of nine zones (Figure 1) that receive recharge from a variable combination of precipitation, irrigation return flows, pipe losses, and sewer inflow/outflow. The relative percentages of recharge from precipitation were also retained, with recharge zones assigned a recharge percentage of either 6% or 10% of precipitation to reflect the general distribution of permeable and impermeable surfaces within each zone. In addition, The precipitation delay applied to the 2014 model (Hydrometrics WRI, 2014) was retained in the current version of the model.

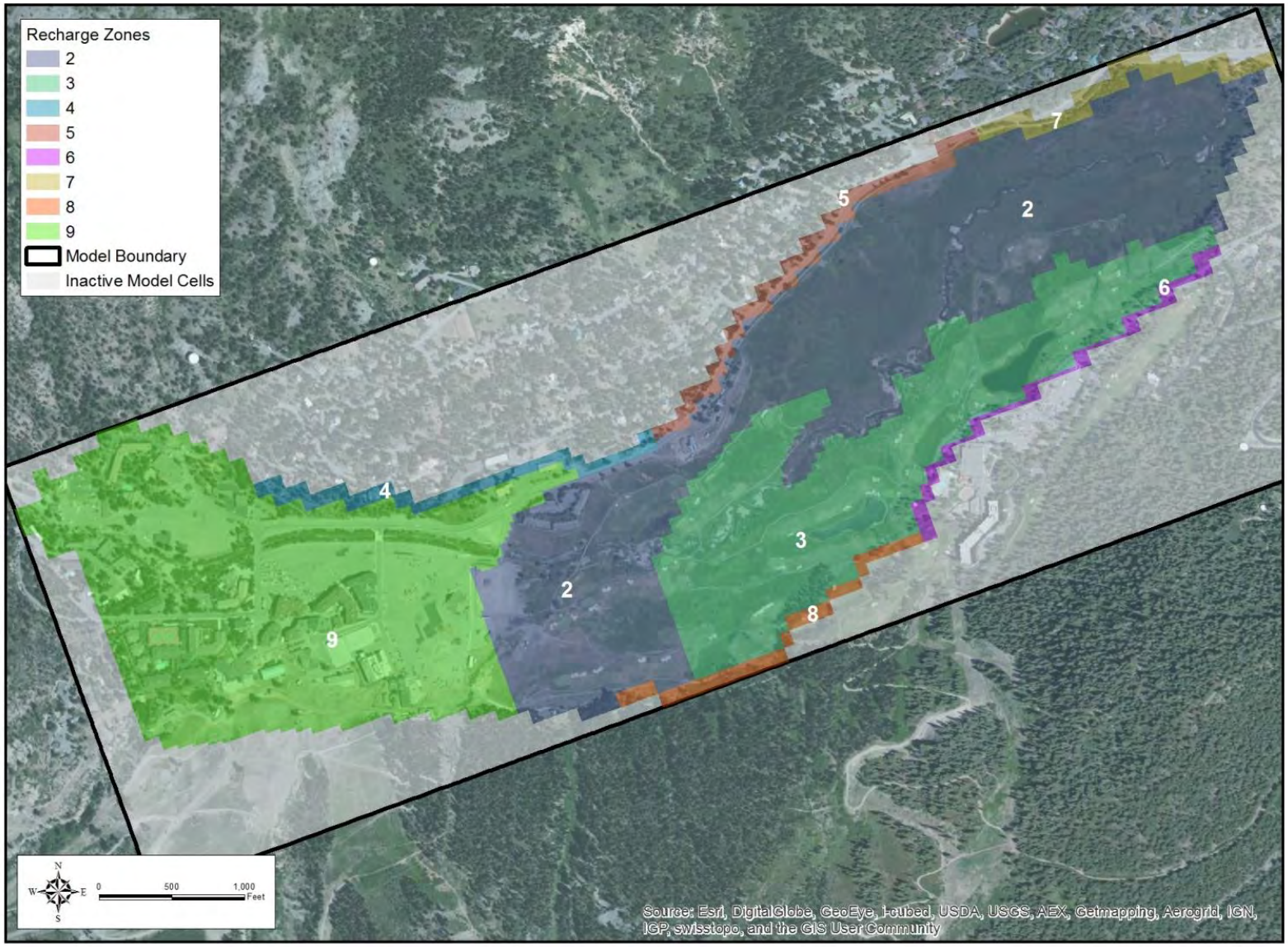


Figure 1: Recharge Zones

2.2.1 RECHARGE INFILTRATION THRESHOLD

One modification to the recharge dynamics of the model is a threshold value placed on the amount of precipitation needed before infiltration begins. For all stress periods, a maximum threshold of 1 inch of monthly precipitation was imposed before any precipitation entered the model as recharge. Conceptually, this change was applied to the model to account for the uptake of water by plants and soil resaturation prior to infiltration. The value of one inch was a calibrated parameter used to improve simulated hydrographs in summer months. This change particularly improved calibration, during recent-time monthly stress periods.

2.2.2 SEWER INFILTRATION AND EXFILTRATION

Sewer infiltration and exfiltration are calculated similarly to the previous model. Figure 2 shows that groundwater gains and losses from sewer infiltration and exfiltration remain a minor component of the Valley's water budget through 2014. This plot also demonstrates the relatively low monthly recharge from rainfall over the past several years. The rainfall recharge data plotted in Figure 2 reflect the threshold modification described in Section 2.2.1.

The annual net sewer gains and losses can be derived by summing annual sewer exfiltration with total annual sewer infiltration. Figure 3 shows the annual net sewer gains and losses as a percent contribution to total recharge in the updated version of the model. The net sewer gains and losses average 0.99% of all recharge for the period of 1993 through 2014. The apparent increase in proportional sewer contribution to recharge is likely due to the relatively low annual precipitation totals over the last several years.

2.2.4 STREAM FLOW

Streamflow inputs to the model were updated for the simulated time period up to and including January 2015, and applied to the model as in previous versions. Streamflow data was obtained from gauges in the North Fork (Shirley Canyon) and South Fork reaches of Squaw Creek. These data were obtained from the Friends of Squaw Creek website.

2.2.5 PUMPING AND MONITORING WELLS

Groundwater extraction was simulated from 14 pumping wells within the model domain, listed below:

Squaw Valley Resort Production Wells	Squaw Valley Resort – Children's W
	Squaw Valley Resort – Children's N
	Squaw Valley Resort – Children's S
	Squaw Valley Resort – Cushing
RSC Irrigation Wells	RSC-18-1
	RSC-18-2
	RSC-18-3R
SVMWC Production Wells	SVMWC-1
	SVMWC-2
SVPSD Production Wells	SVPSD-1
	SVPSD-1R
	SVPSD-2/SVPSD-2R
	SVPSD-3
	SVPSD-5/5R

For all pumping wells, monthly total flow rates were applied to each monthly stress period through January 2015. Pumping was distributed among the three RSC wells slightly differently than in previous models. The Resort at Squaw Creek does not measure pumping at individual wells; instead it measures total delivered water and divides that amount among its three operating wells. RSC has changed the methodology for dividing delivered water among its three wells over the years. For the current model, pumping was redistributed between the three wells for all years based on the most recent RSC methodology. This redistribution had little noticeable effect on the calibration or water budget of the groundwater flow model, as the cumulative outflow from the three RSC wells did not change from previous versions of the model.

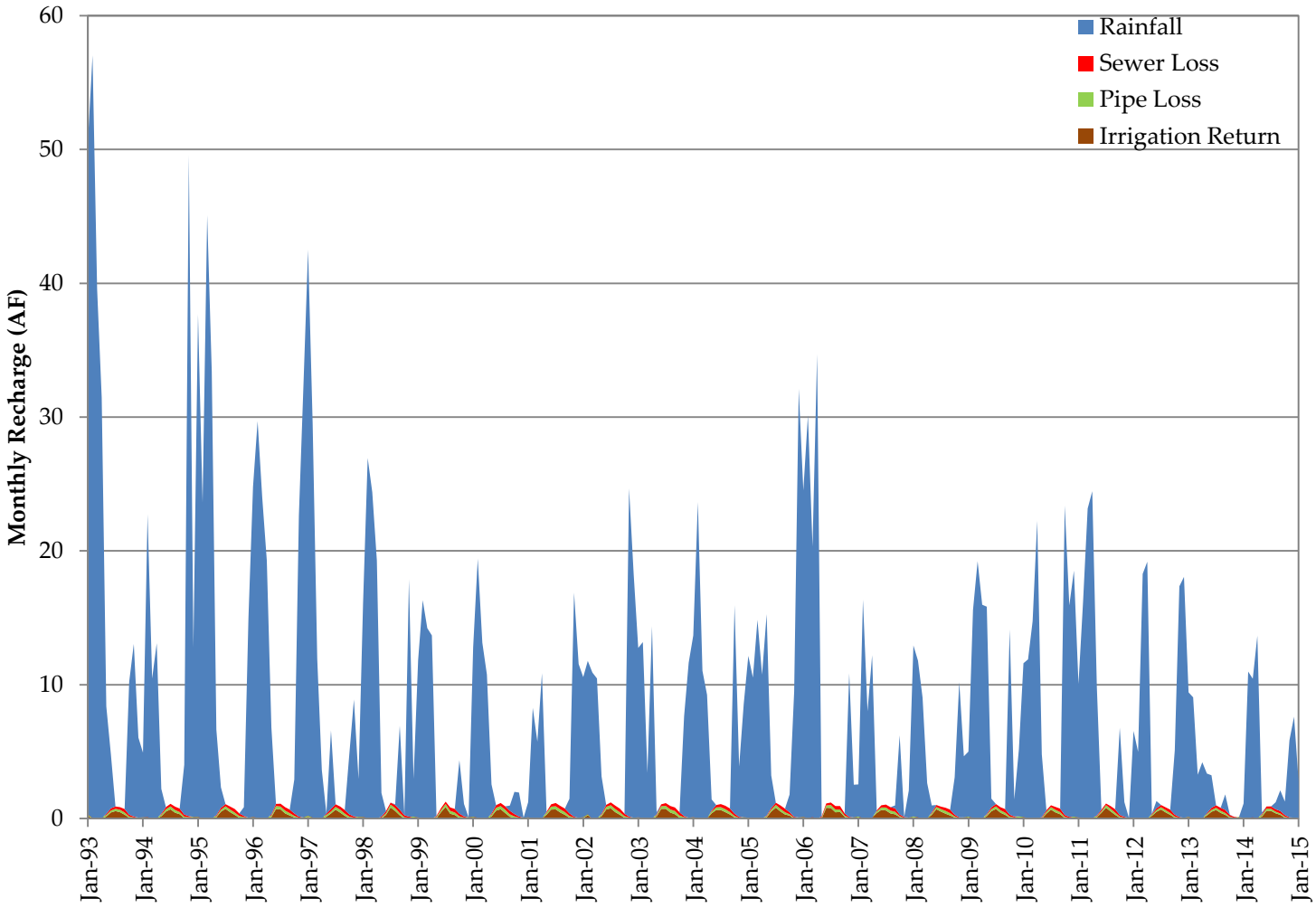


Figure 2: Monthly Recharge by Source for WSA Scenario

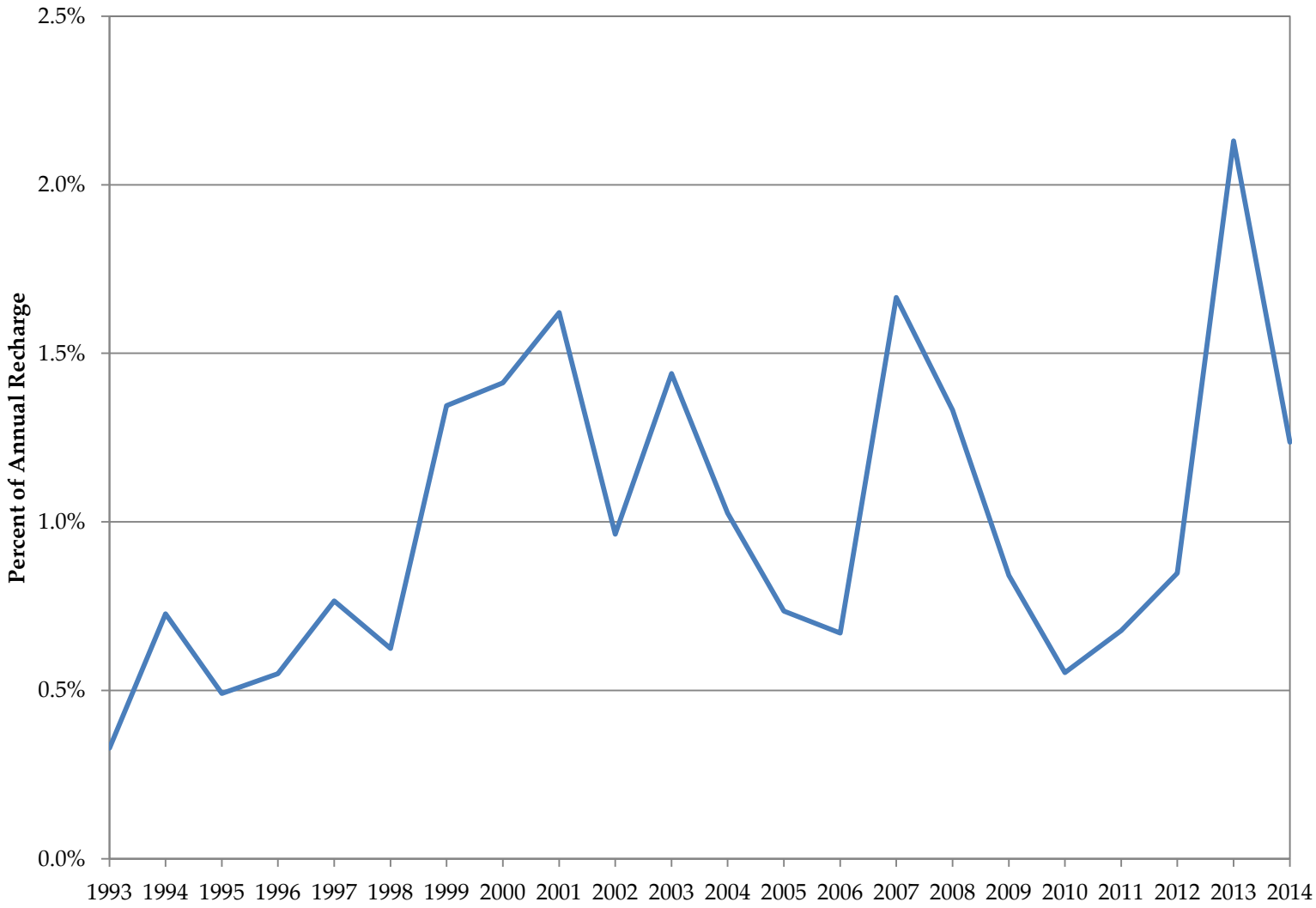


Figure 3: Sewer Leakage Percent of Annual Recharge for WSA Scenario

SECTION 3
Model Calibration

3.1 APPROACH

Previous calibration efforts on the regional groundwater flow model involved successive attempts to match model output to measured data from the calibration period. The 2015 model update built upon calibration efforts performed in 2014 and documented in the Technical Memorandum dated June 17, 2014 (HydroMetrics WRI, 2014). Unlike the calibration procedures described in that document, no changes to the material properties or boundary conditions were made to the current version of the model. Only changes to the amount of precipitation entering the model, as described in Section 2.2.1, were made in the interest of improving model fit.

3.2 CALIBRATION RESULTS

3.2.1 GROUNDWATER ELEVATION CALIBRATION

The degree of calibration achieved by the groundwater flow model was evaluated by comparing simulated groundwater elevations with observed groundwater elevations measured at monitoring and production wells, and the differences between simulated and observed values were analyzed per generally-accepted statistical methods. The well locations used for calibrating the groundwater flow model are shown on Figure 4.