Responsive Report of Dr. Todd Kincaid Regarding the Safe Yield Values Proposed by the Indian Wells Valley Water District (IWVWD) and Meadowbrook Dairy

Opinion 1: The Thiessen polygon method is not appropriate for the determination of Safe Yield

The polygon method, as used by the IWVWD and Meadowbrook experts[1], is not appropriate for the determination of Safe Yield (SY) in the Indian Wells Valley because:

a) The results require an unreasonably high value for total recharge to the IWVGB;

b) The methodology inappropriately assumes that the entire basin is equally hydraulically connected to the area where the groundwater extractions are occurring;

c) The calculations rely on estimates of groundwater level changes that are inconsistent with the available data;

d) Results are highly sensitive to estimated coefficients for aquifer storage, which are highly uncertain; and

e) The calculation period is too short to be representative of a balanced hydrologic period in which higher than average groundwater recharge is balanced against lower than average groundwater recharge.

1a. Results require unreasonably large total recharge to the IWVGB

The most reliable estimate of total recharge to the IWVGB are those rendered by Kunkel and Chase (1969) and McGraw and others (2016) on the basis of detailed study and estimation of total evapotranspiration (ET) from the groundwater dependent ecosystems (GDEs) in the playas that likely occurred prior to the onset of groundwater pumping. At that point in the IWVGB's history, it is reasonable to assume:

- that total discharge from the basin equaled total recharge; and
- that total discharge from the basin occurred in the form of ET from the playa floors.

Any estimate of SY today must be evaluated in the context of two dependent conditions.

- Present-day total recharge which must be equal to the estimated SY plus a reasonable estimate of present-day ET; and
- The historical (pre-pumping) magnitude of total ET must have been equal to (or greater than) the estimated SY.

[1] The IWVWD and Meadowbrook experts relied on the same model and the same or similar methodologies. For simplicity I refer to the collectively in this report as IWVWD. When necessary, I have referred to the reports of Mr. Parker (IWVWD's designated expert) and Mr. Teasdale (Meadowbrook's expert) specifically.

The values of SY as estimated and proposed by the IWVWD necessitate values for total recharge to the IWVGB that are 157% to 217% of the maximum reasonable estimate of total recharge to the IWVGB, where the range reflects the range in present-day ET from the playas: approximately 2,000 AFY estimated by the IWVWD, and approximately 5,500 AFY estimated for the 2025 version of the groundwater flow model developed for the IWVGB Groundwater Sustainability Plan (GSP / GSP-GWM-2025; Table 1). The IWVWD's estimated SY values correspond to similarly elevated values for total historical (pre-pumping) ET; between 13% and 214% where the range reflects the range in pre-pumping ET from the playas: approximately 11,000 AFY estimated by Kunkel and Chase (1969) and 7,500 estimated by McGraw and others (2016).

Table 1. Range of SY values estimated by the IWVWD and the corresponding values of total recharge and total historical pre-pumping ET.

Teasdale Estimates (Report PDF-51)				Present-Day Total Recharge					
	Estiamted SY			IWVWD-ET		GSP-GWM-2025		% Historical ET	
Year	Ramboll	BC	Average	(AFY)	% PubMax	(AFY)	% PubMax	KC	DRI
2014	15,200	13,700	14,450	16,450	150%	21,950	200%	131%	193%
2015	19,900	19,200	19,550	21,550	196%	27,050	246%	178%	261%
2016	16,800	15,900	16,350	18,350	167%	23,850	217%	149%	218%
2017	11,900	10,600	11,250	13,250	120%	18,750	170%	102%	150%
2018	19,000	18,200	18,600	20,600	187%	26,100	237%	169%	248%
2019	15,900	15,400	15,650	17,650	160%	23,150	210%	142%	209%
2020	16,700	16,700	16,700	18,700	170%	24,200	220%	152%	223%
2021	19,400	19,700	19,550	21,550	196%	27,050	246%	178%	261%
2022	7,700	4,800	6,250	8,250	75%	13,750	125%	57%	83%
2023	14,700	15,000	14,850	16,850	153%	22,350	203%	135%	198%
Average	*15,700*	*14,900*	*15,300*	*17,300*	*157%*	*22,800*	*207%*	*139%*	*204%*

Parker Estimates (Report PDF-290)				Present-Day Total Recharge					
	Estiamted SY			IWVWD-ET		GSP-GWM-2025		% Historical ET	
Year	Ramboll	BC	Average	(AFY)	% PubMax	(AFY)	% PubMax	KC	DRI
2014	15,200	14,800	15,000	17,000	155%	22,500	205%	136%	200%
2015	22,100	21,800	21,950	23,950	218%	29,450	268%	200%	293%
2016	19,400	19,000	19,200	21,200	193%	26,700	243%	175%	256%
2017	13,600	13,400	13,500	15,500	141%	21,000	191%	123%	180%
2018	16,900	16,300	16,600	18,600	169%	24,100	219%	151%	221%
2019	17,600	17,300	17,450	19,450	177%	24,950	227%	159%	233%
2020	18,400	17,900	18,150	20,150	183%	25,650	233%	165%	242%
2021	19,900	19,600	19,750	21,750	198%	27,250	248%	180%	263%
2022	1,400	1,200	1,300	3,300	30%	8,800	80%	12%	17%
2023	17,500	17,200	17,350	19,350	176%	24,850	226%	158%	231%
Average	*16,200*	*15,800*	*16,025*	*18,025*	*164%*	*23,525*	*214%*	*146%*	*214%*

Notes

Ramboll = Safe Yield estimates derived using Sy values from the Ramboll model
BC = Safe Yield estimates derived using Sy values from the Brown and Caldwell model
IWVWD-ET = IWVWD estimate of total present-day ET from IWVGB of approximately 2,000 AFY
GSP-GWM-2025-ET = Estimate of total present-day GSP-GWM-2025 of approximately 5,500 AFY
%PubMax = Maximum reasonable published value of historical recharge to the IWVGB of 11,000 AFY
KC = Pre-pumping total ET from the IWVGB estimated by Kunkel and Chase (1969) = 11,000 AFY
DRI = Pre-pumping total ET from the IWVGB estimated by McGraw and others (2016) = approximately 7,500 AFY

1b. Pumping is not drawing from the entire basin equally

The Indian Wells Valley Groundwater Basin (IWVGB) is subdivided by numerous faults that trend generally north-south and northwest-southeast. The impact of faulting on the groundwater flow system through within the IWVGB is expressed in varying degrees of offset in groundwater surface elevations across the faults and fault zones (Kunkel and Chase, 1969, Todd Engineers, 2014; Stetson Engineers, 2020). The significance of faulting to the characterization and management of the groundwater resource is further evidenced by efforts invested to address the probable impact of faulting including: adapting the groundwater model used to inform the GSP; and designing the set of Thiessen polygons on which the GSP-estimates of groundwater storage changes are calculated. Figure 1 and Figure 2 depict the two different sets of polygons developed and used by the IWVWD to estimate safe yield relative to the mapped faults in the IWVGB, the location of pumping wells, and the zonation defined in the GSP version of the polygons.

1a-1) All but one of the pumping wells are located in what is labeled as the main portion of the IWVGB. Only one domestic well is located within the El Paso portion of the basin (polygons 2-9). Polygons 78-85 cover the outlying portions of the IWVGB.

1a-2) The IWVWD's design unreasonably presumes that the pumping affects groundwater levels in all of the polygons and the corollary that recharge to the groundwater system within all of the polygons offsets the drawdown created by pumping.

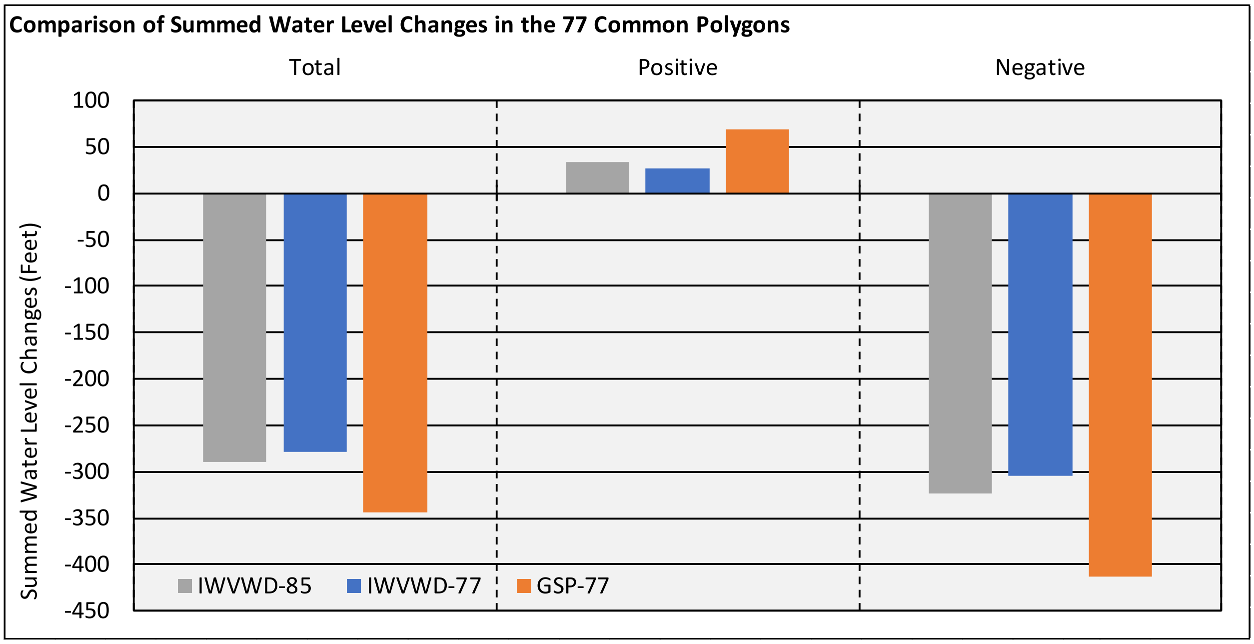
1a-3) The 85-polygon version follows the same boundaries as the GSP version for the 77 polygons that the two versions have in common. Those boundaries largely correspond to the location and orientation of the mapped faults except in the northern part of the basin.

1a-4) The boundaries of the polygons in the IWVWD's 81-polygon version deviate substantially from the location and orientation of the mapped faults and is thus less reliable than the 85-polygon version.

1c. Estimated groundwater elevation changes are inconsistent with available data

The values reported by both Parker and Teasdale in their 2025 expert reports for the change in groundwater level elevations in the 77 polygons that are common to both the IWVWD-85 and GSP-77 Thiessen polygon sets for the period 2014-2023 sum to a value that is 65.4 feet lower than what is indicated by the data included in the GSP groundwater database. No justification was provided for the lower values and the use of those values result in smaller estimates of the reduction in storage due to pumping by between 23% and 30% of what would be calculated using the GSP values. A map depicting the distribution of the differences between the IWVWD and GSP values for groundwater elevation change for the period 2014 to 2023 is provided on Figure 3. Maps depicting the change in groundwater elevations as depicted by the GSP and IWVWD datasets are provided as Figure 4 and Figure 5 respectively. A comparison of the magnitude of the different datasets for change in groundwater level elevation that occurred between 2014 and 2023 is provided as Exhibit 1. From Exhibit 1, it can be seen that, even after accounting for the eight polygons covering the outer reaches of the IWVGB in the IWVWD's 85 version of the Thiessen polygons, the total reduction in groundwater levels is significantly smaller as defined by the IWVWD's data.

Exhibit 1. Comparison of summed values for the change in groundwater level occurring between 2014 and 2023 as defined by the IWVWD and GSP datasets.

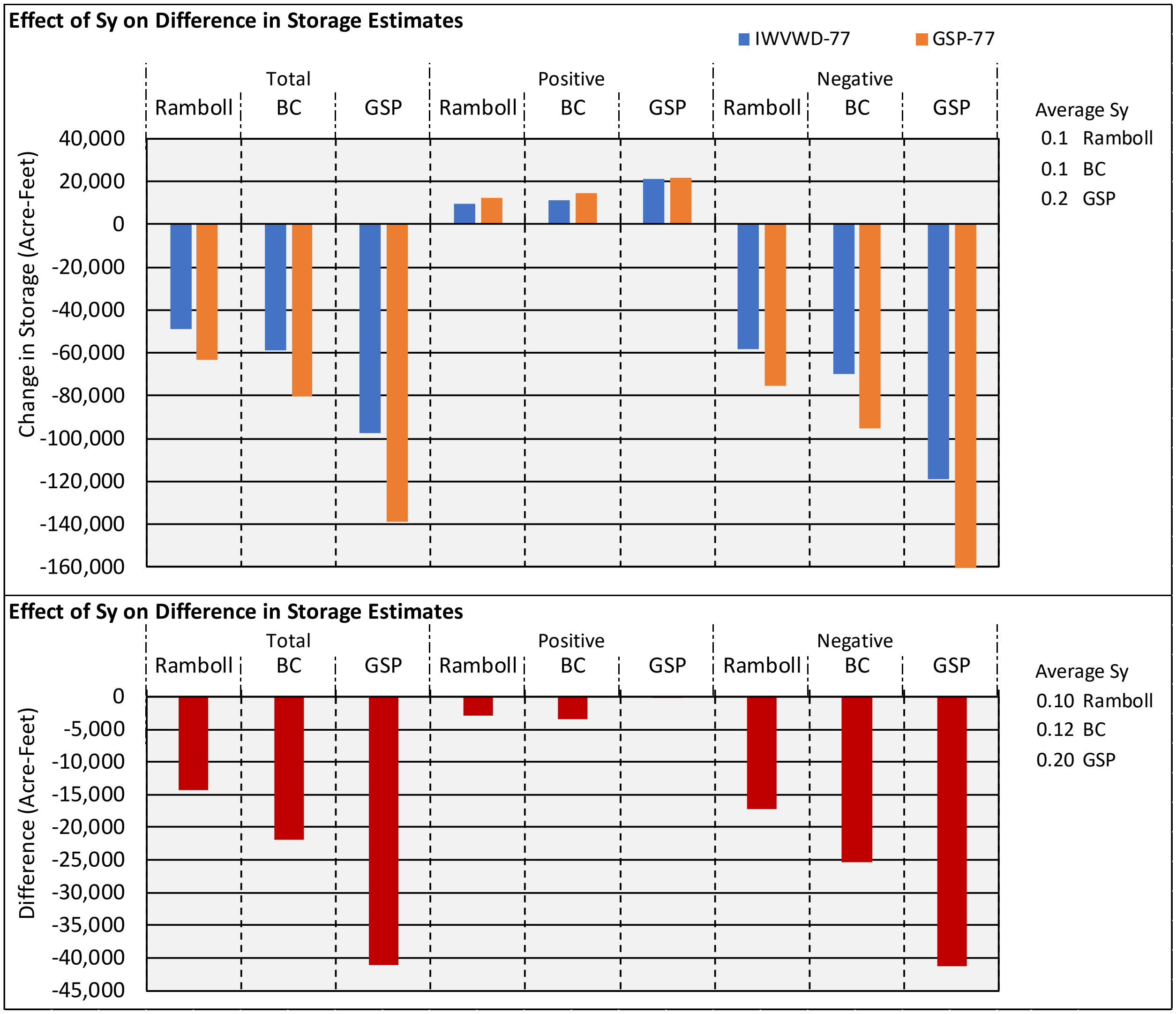


1d. Results are highly sensitive to estimated coefficients for aquifer storage

Three different datasets for the spatial distribution of aquifer storage capacity aka specific yield (Sy) have been proposed: two by the IWVWD and one by the GSP. The average values for the 77 polygons shared by IWVWD-85 and GSP-77 Thiessen polygon sets are 0.1 as indicated by the Ramboll groundwater flow model, 0.12 as indicated by the Brown and Caldwell 2009 groundwater flow model, and 0.2 as indicated by the GSP-GWM-2025. All were estimated through groundwater flow modeling. The total calculated reduction in groundwater storage as determined from the two different datasets proposed by the IWVWD and using their data for the change in groundwater levels increases by between 14% and 21% between the lower (Ramboll) and higher (BC) estimates for Sy. When considering the higher GSP-GWM-2025 estimates, the total calculated reduction in storage increases to between 195% and 200% of the calculated values based on the lowest estimates for Sy. Using the GSP version of the groundwater level changes, the range in calculated total reduction in storage rises to 220% when comparing the highest to the lowest estimates for Sy.

The IWVWD's estimates fail to depict the larger potential reductions in groundwater storage that would have occurred and will continue to occur if the actual aquifer storage capacity is closer to the higher values estimated for the GSP by the GSP-GWM-2025. Exhibit 2 provides bar charts that depict the different estimates of change in groundwater storage as calculated by the different estimates for Sy. The charts show the significance of Sy irrespective of the different groundwater level datasets and show how both the positive and negative changes are impacted as well as the totals.

Exhibit 2. Bar charts showing the effect of both the different estimates of groundwater level change and different estimates of the coefficients of aquifer storage (Sy) on the calculation of total reduction in groundwater storage due to pumping. Top chart shows the variation in estimated values grouped in three sets, total changes (left), positive changes (middle), and negative changes (right). The bottom chart shows the magnitude of the difference between the estimates as derived from the different datasets for groundwater level change and Sy.



1e. The calculation period is too short to be representative of a balanced hydrologic period

The 10-year period used for the calculations of SY are too short and skewed by the larger recharge events that were incorporated into the Ramboll groundwater model to yield reliable estimates of long-term changes in storage due solely to groundwater pumping.

The assumption underlying the polygon method for the estimation of SY is that the changes in groundwater storage as measured and then interpolated from data are due only to groundwater pumping. At the yearly scale of investigation, the estimates will be skewed by recharge values that are substantially higher or lower than the average. As can be seen from the range of values calculated by Parker and Teasdale (Table 1), the estimation of SY varies between 1,300 and 21,950 AFY on a yearly basis. After some sufficiently long period of time in which periods of higher than normal recharge are balanced by periods of lower than normal recharge, the average estimate of SY plus ET will equal the total recharge to the basin. The average recharge assigned in the Ramboll model was however approximately 12,300 AFY meaning that the polygon method, when applied over a sufficiently long enough period of time, should result in an estimate of SY of approximately 10,300 AFY, that is total recharge of 12,300 minus the approximately 2,000 AFY of ET.

Opinion 2: The Thiessen polygon method is dependent on groundwater modeling and the reliability of the SY estimates are predicted on the reliability of the dependent groundwater model.

Estimates of SY derived from the polygon method used by the IWVWD are highly dependent on the SY values used in the calculation of groundwater storage change as was explained above in Section 1d. The IWVWD's assertion that the method is somehow primarily dependent on measured data and insulated from model uncertainties is wrong.

The capacity of the aquifer material to store and release water from storage can be estimated in two ways:

- Multi-well aquifer pumping tests in which the timing and patterns of changes in groundwater levels are recorded at some distance from the pumping well are recorded; and
- Calibration of transient groundwater flow models to variations in groundwater levels in response to changes in boundary conditions including the magnitude and spatial distribution of recharge and the changes in pumping.

Rarely are a sufficient number of multi-well aquifer pumping tests performed to adequately characterize aquifer storage at the basin scale. The IWVGB is not different in that regard. Storage capacity, aka Sy, has instead been estimated by different versions of transient groundwater models developed by and for different parties. The reliability of the Sy estimates is therefore predicated on the reliability of the groundwater model from which the Sy values were derived.

Model reliability is measured in judged in two ways.

- The degree to which the model reasonably simulates the conceptual understanding the of hydrogeologic system that the model is intended to represent including the
    - magnitude and distribution of inflows and outflows;
    - the hydrostratigraphy; and
    - the hydraulic characteristics of the aquifer materials.
- The degree to which the model accurately simulates the magnitude and temporal distribution of measure groundwater levels in the simulated aquifers.

When comparing the reliability of one estimation of Sy against another, I therefore expect to see some form of qualitative and quantitative analysis of the groundwater models from which the Sy datasets were derived. The IWVWD reports are lacking in this regard.

Opinion 3: The Ramboll model yields unreliable estimates of aquifer storage capacity, aka specific yield (Sy).

The Ramboll model is poorly constructed and calibrated in five ways, each of which I have described in greater detail in my report supporting my Direct Testimony (Kincaid, 2025).

- The recharge components are higher than what I believe is reasonable based on the previous studies that I reviewed.
- Spikes in annual recharge assigned in the transient model are not supported by groundwater levels in monitoring wells near the assigned sources of elevated recharge.
- Simulated ET is substantially lower than what has been measured and estimated from field data in the IWVGB and nearby similar dessert groundwater basins.
- The model inappropriately simulates perennial groundwater discharge to the surface across an area and at depths that are not supported by data or observations of surface hydrologic conditions.
- The model is poorly calibrated to the transient groundwater elevations at key monitoring wells within the model domain.

In each of these respects, the GSP-GWM-2025 is demonstrably better. Though I cannot say that the Sy values derived from the GSP-GWM-2025 are accurate, I do believe that the relative performance of the respective models indicates that the actual aquifer storage capacity is likely closer to the higher values estimated by the GSP-GWM-2025 than the lower values estimated by the Ramboll model.

I also note here that in their 2009 report, Brown and Caldwell stated that they chose to rely on the estimate of total recharge to the IWVGB published by Kunkel and Chase (1969) rather than values that they could have derived through modeling. This reflects an acknowledgement that the direct methodology used by Kunkel and Chase to estimate recharge from total pre-pumping ET is superior to what they could achieve through modeling.

Opinion 4: The IWVWD estimations of SY imply a significant deviation from the widely accepted conceptual understanding of the hydrogeology in the IWVGB.

As described in Table 1, the IWVWD's estimates of SY require a significantly higher value for total recharge to the basin as well as significantly higher values for historical (pre-pumping) ET than what has been published by other researchers over the past five decades. Moreover, the trend in the published research has been downward with respect to both of those quantities rather than upward. I discuss both of these conditions in detail in my report supporting my Direct Testimony (Kincaid, 2025).

Though the IWVWD's proposed SY values necessitate a substantially larger value for historical (pre-pumping ET) that what has been estimated by other researchers, they simultaneousely assert that present-day ET is substantially lower than what has been estimated. The IWVWD also asserts that present-day ET is supported to a larger degree by precipitation-recharge to the aquifer system occurring on the playa, an area assumed by other researchers as one in which precipitation-recharge is nill to nonexistent, and as a discharge area as defined by upward hydraulic gradients from the principal aquifer that is being pumping into the shallow aquifer that is the source of ET in the GDEs.

The IWVWD, through the proposal of their SY values, asserts that the previous work and the conceptual understanding based on that body of work should be rejected yet provides no new data or justification for such a large change in understanding.

Opinion 5: Both the Parker and Teasdale computation methods contain errors that affect their calculation of SY.

- Teasdale describes increases in groundwater levels for the polygons encompassing the Meadowbrook Dairy (polygons 58, 59, 61, and 64) predicated on an inappropriate depth to water measurements in lieu of groundwater elevation measurements. When correctly interpreted, the slopes for the hydrographs he presents in his report show downward rather than upward trends.
- Teasdale describes groundwater recharge within the playa areas that are in fact discharge areas.
- Parker defines areas for polygons 78 and 83 that are not supported by calculations performed for the polygons as defined in the IWVWD's reporting for the 85 Thiessen polygon set.

References

Kincaid, T.R., 2025. Expert Opinion of Dr. Todd Kincaid, P.G. Regarding the Safe Yield of the Principal Aquifer in the Indian Wells Valley Groundwater Basin. Prepared for Richards Watson Gershon, Los Angeles, CA, 42 p.

Kunkel, F., and G.H. Chase, 1969. "Geology and Groundwater in the Indian Wells Valley, California." USGS Open-File Report 69-329.

McGraw, D., Carroll, R., Pohll, G., Chapman, J., Bacon, S., and Jasoni, R., 2016. Groundwater Resource Sustainability: Modeling Evaluation for the Naval Air Weapons Station, China Lake. California. prepared by Desert Research Institute for the Naval Air Warfare Center Weapons Division, Final Evaluation Report NAWCWD TP 8811.

Stetson Engineers (Stetson), 2020. Groundwater Sustainability Plan for the Indian Wells Valley Groundwater Basin, Bulletin 118 Basin No. 6-054, Indian Wells Valley Groundwater Authority.

Todd Engineers, 2014. Indian Wells Valley Resource Opportunity Plan – Water Availability and Conservation Report, Submitted to Kern County Planning and Community Development Department, 89p.SRI, 2016

Figures

Thiessen Polygons (85): GSP Zones, Faults, & Wells

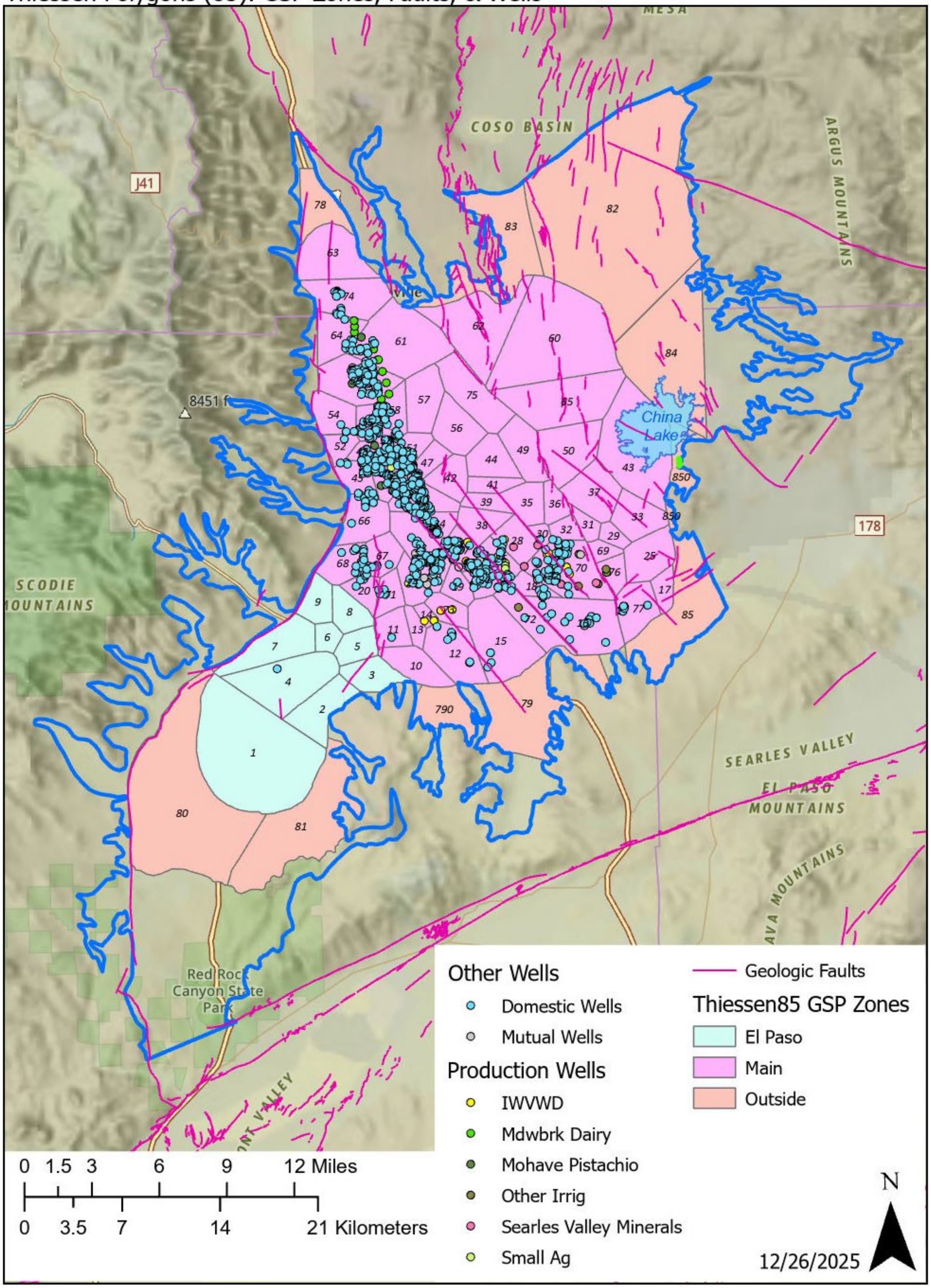


Figure 1. Map showing the relationship between the 85 Thiessen polygons designed and used by the IWVWD to estimate Safe Yield and the zonation within the 77 Thiessen polygons designed and used in the GSP for the estimation of changes in groundwater storge, and the location of mapped faults and pumping wells across the IWVGB.

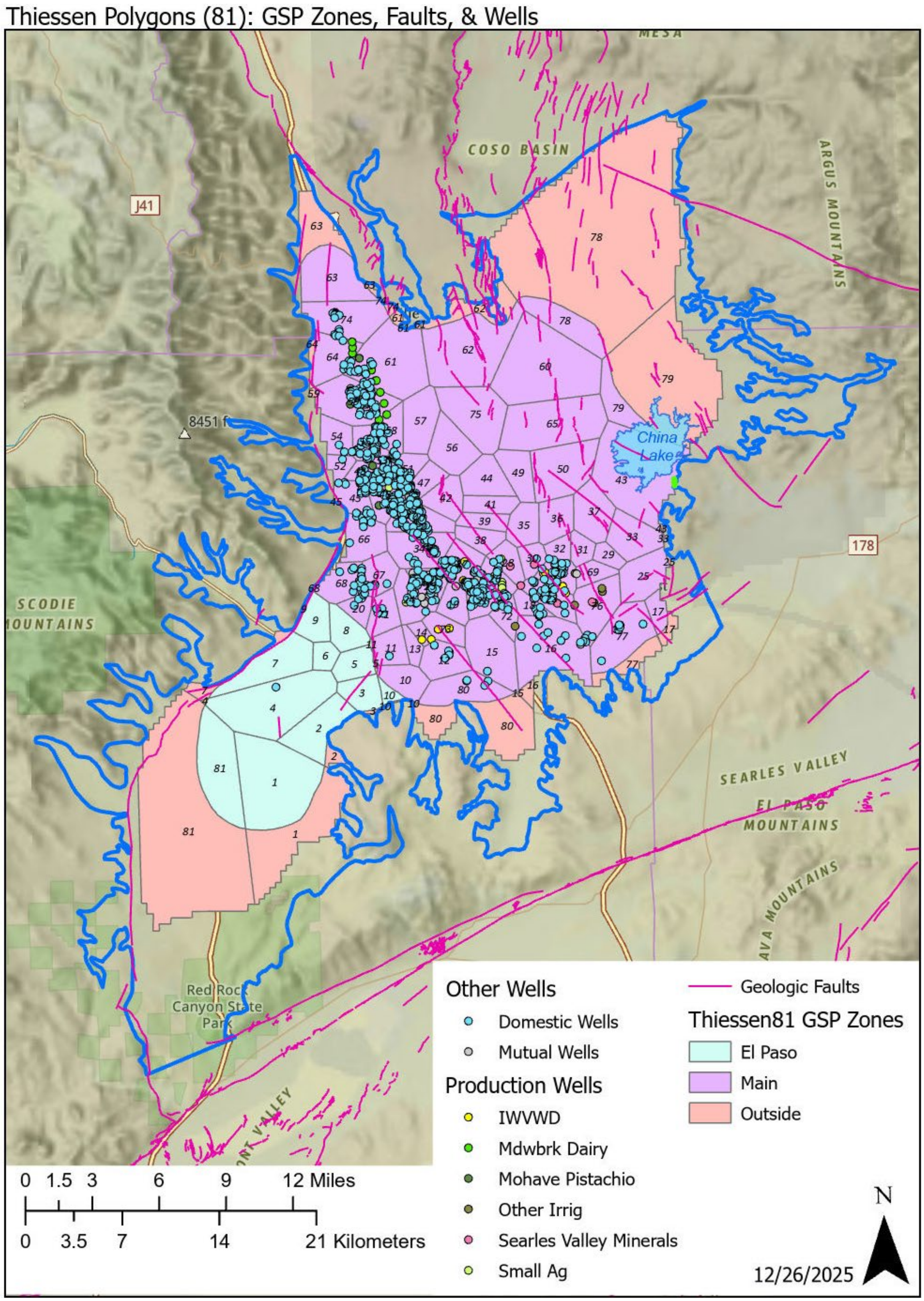


Figure 2. Map showing the relationship between the 81 Thiessen polygons designed and used by the IWVWD to estimate Safe Yield and the zonation within the 77 Thiessen polygons designed and used in the GSP for the estimation of changes in groundwater storge, and the location of mapped faults and pumping wells across the IWVGB.

Thiessen Polygons (85): Difference in Estimated WLElev Change (IWVWD-GSP)

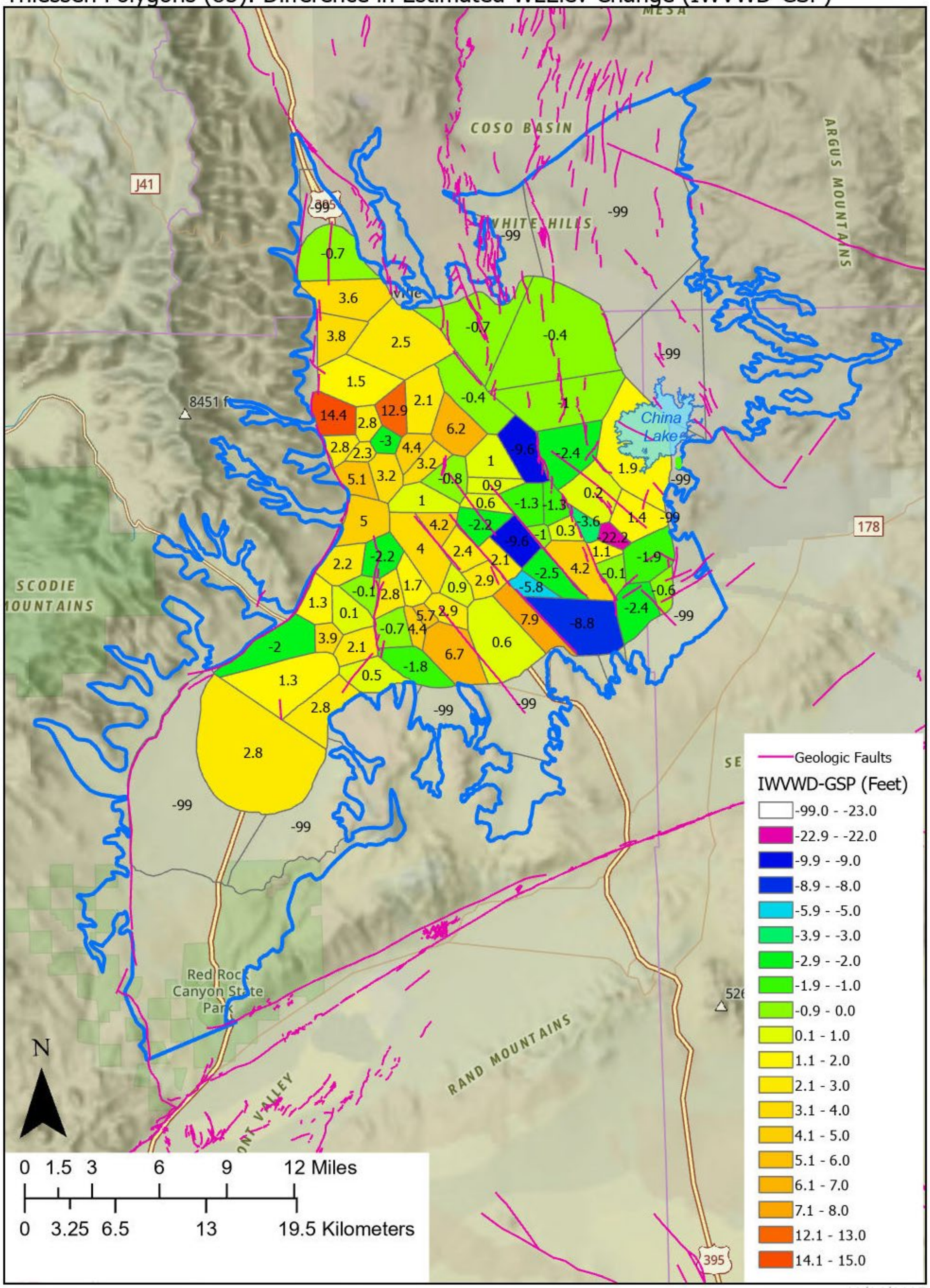


Figure 3. Map showing the magnitude of the difference between the change in groundwater elevation occurring between 2014 and 2023 as reported by the IWVWD in the Parker and Teasdale expert reports and the GSP groundwater elevation database. Yellow to red values mark polygons where the IWVWD values show smaller declines or larger increases than the GSP values.

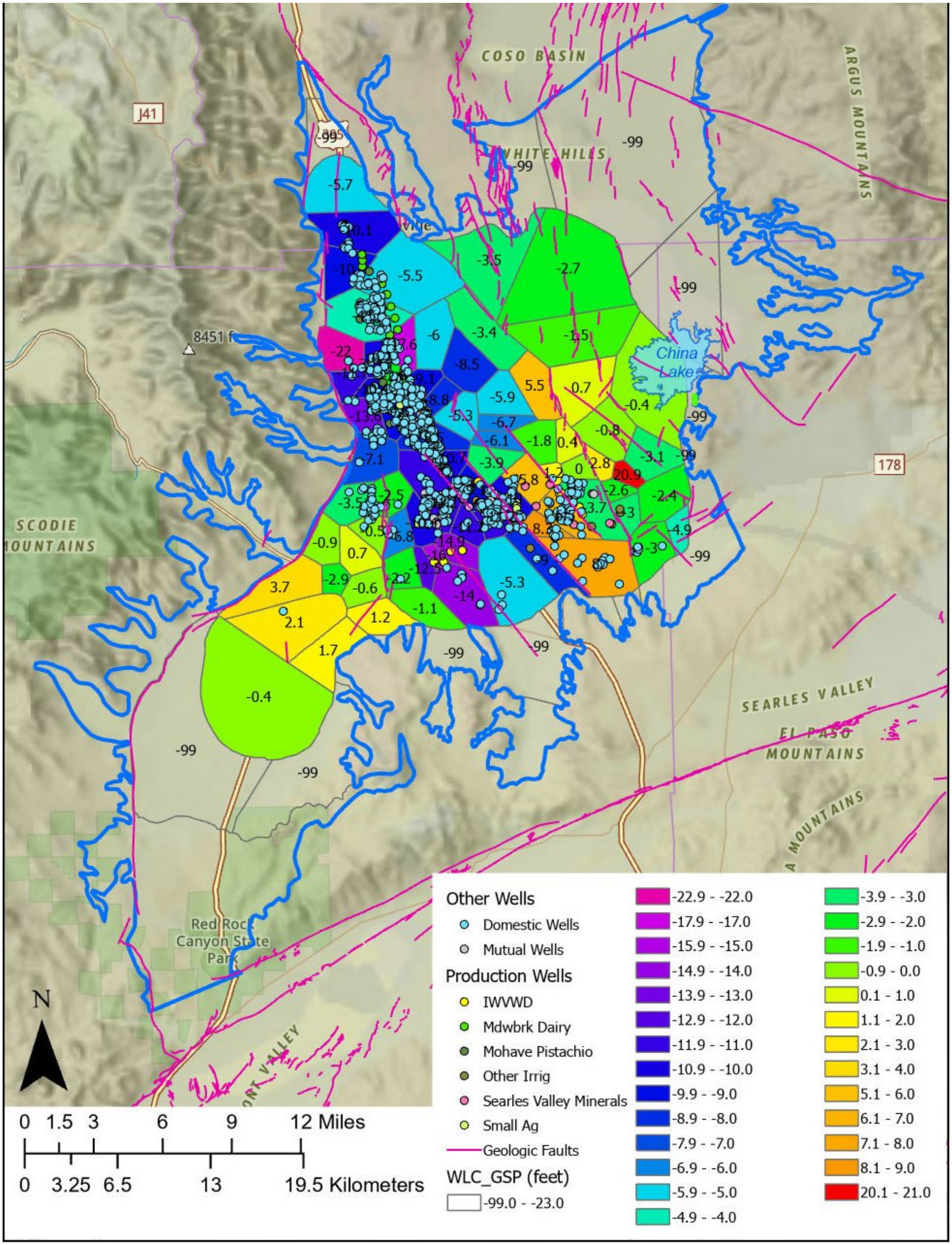


Figure 4. Change in groundwater level elevation between 2014 and 2023 as depicted by the GSP data.

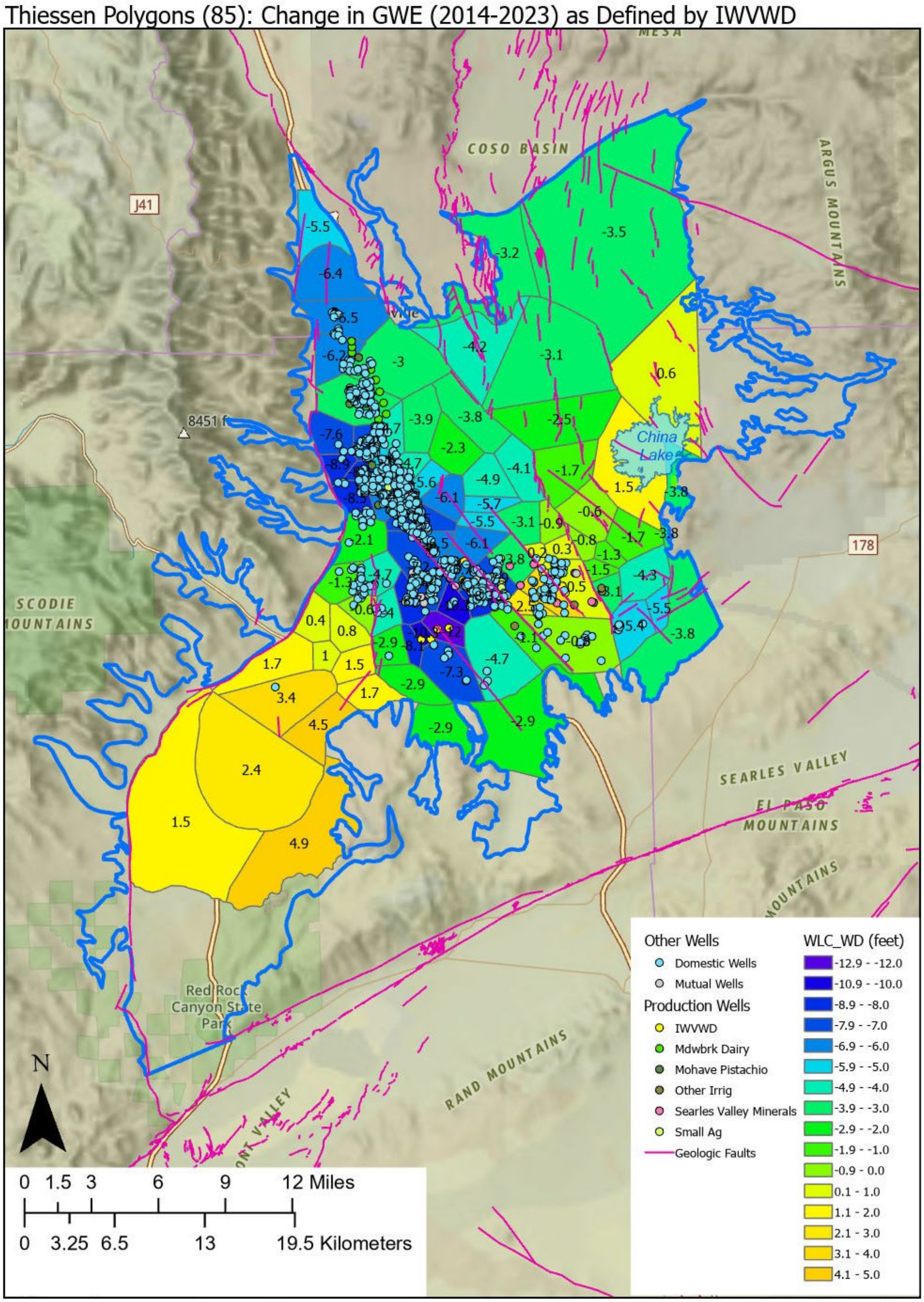


Figure 5. Change in groundwater level elevation between 2014 and 2023 as depicted by the IWVWD data.