CALIFORNIA GROUNDWATER ELEVATION MONITORING

BASIN PRIORITIZATION PROCESS

June, 2014

CALIFORNIA GROUNDWATER ELEVATION MONITORING BASIN PRIORITIZATION

INTRODUCTION

There are 515 alluvial groundwater basins and subbasins (basins) in California. These basins contribute 30 to 46 percent of the California's annual water supply. Statewide, approximately 30 million people, or 80 percent of Californians, live in areas overlying alluvial groundwater basins. At the local level, many municipal, agricultural, and disadvantaged communities rely on groundwater for nearly 100 percent of their water supply needs. Readily available quantities of high quality groundwater has provided long-term economic benefits to California and enabled the Central Valley to become a world leader in agricultural production. However, recent studies have identified the ongoing decline in California's groundwater quality and quantity—highlighting the vulnerability and bringing to question the long-term reliability and sustainability of California's groundwater resources (CWP, 2013; Harter, T., and J. Lund, 2012. ; Kuss, A., et al.; 2012; Scanlon, B. R., et al.; 2012; USGS, 2009; Walker, 2009).

Implementation of consistent data collection and assessment programs, along with application of effective local groundwater management practices, are important components to help minimize groundwater degradation and improve long-term reliability of groundwater resources. Financing groundwater data collection and management is a common challenge that requires alignment of State, regional, and local programs, and the strategic prioritization of resource management actions. Developing a common understanding of these priorities with respect to the California's 515 groundwater basins is an important first step toward the effective application of groundwater resource management practices. Historically, several programs have applied groundwater basin prioritization methods to help focus field investigations, to effectively utilize limited funding resources, and to align agency efforts (SWRCB, 1999; USGS, 2003). More recently, the CASGEM program has developed a process for statewide ranking and prioritizing California's 515 groundwater basins.

CALIFORNIA STATEWIDE GROUNDWATER ELEVATION MONITORING (CASGEM) PROGRAM

As part of the California's 2009 Comprehensive Water Package, a series of special session bills were passed in part to help ensure a reliable water supply for future generations of Californians. One of the enacted bills was SBx7-6, titled *Groundwater Monitoring*. The SBx7-6 Groundwater Monitoring legislation added Part 2.11 to Division 6 of the California Water Code (§ 10920 et seq.), which established provisions and requirements for local agencies to develop

and conduct groundwater level monitoring programs. In the fall of 2011, Assembly Bill 1152 provided subsequent clarification by amending portions of Sections 10927 and 10933 of the California Water Code (CWC)

The Department of Water Resources (DWR) is implementing the 2009 *Groundwater Monitoring* legislation under the California Statewide Groundwater Elevation Monitoring Program, or CASGEM Program. The overall purpose of CASGEM is to establish a permanent, locally managed program of regular and systematic groundwater level monitoring to track seasonal and long-term trends in groundwater elevations in all of California's 515 alluvial groundwater basins and to make this information readily available to the public. Groundwater basins and subbasins are defined as the 515 alluvial basins or subbasin (basins) outlined in DWR's *California's Groundwater,* Bulletin 118, Update 2003.

As part of the CASGEM Program legislation, and pursuant to the CWC §10933, DWR is required to prioritize California groundwater basins, so as to help identify, evaluate, and determine the need for additional groundwater level monitoring. The CWC directs DWR to consider, to the extent available, all of the data components listed below.

1. The population overlying the basin,
2. The rate of current and projected growth of the population overlying the basin,
3. The number of public supply wells that draw from the basin,
4. The total number of wells that draw from the basin,
5. The irrigated acreage overlying the basin,
6. The degree to which persons overlying the basin rely on groundwater as their primary source of water,
7. Any documented impacts on the groundwater within the basin, including overdraft, subsidence, saline intrusion, and other water quality degradation, and
8. Any other information determined to be relevant by the department.

This report provides an overview of the CASGEM groundwater basin prioritization results, an explanation of how the basin prioritization results may be used, and a summary of the rationale used in the development of the CASGEM basin prioritization, based on the eight data components listed above.

CASGEM Groundwater Basin Prioritization Results

The CASGEM groundwater basin prioritization was developed as a statewide ranking of groundwater basin importance, with a general focus towards implementation of the CASGEM Program. The priority ranking does not attempt to characterize how these basins are managed and monitored. In addition, evaluation of groundwater basins at a statewide scale does not necessarily capture the local importance of the smaller size or lower-use groundwater basins. For many of California's low-use basins, groundwater provides close to 100 percent of the local urban and agricultural water demands. Thus, when reviewing the CASGEM groundwater basin prioritization results, it is important to recognize the findings are not intended to characterize groundwater management practices or diminish the local importance of the smaller size or

lower-use groundwater basins; rather, they are presented as a statewide assessment of the overall importance of groundwater in meeting urban and agricultural demands, based on the evaluation of the eight required data components specified in the CWC.

The statewide summary of the CASGEM groundwater basin prioritization results are provided in Tables 1 and 2, and in Figure 1. A more detailed listing of the prioritization scoring for all 515 groundwater basins is provided in Appendix A. An explanation of the process for determining basin priority is provided in subsequent sections of this report.

As of May, 2014, the prioritization analysis ranks 43 of the 515 groundwater basins as High Priority, 84 as Medium Priority, 27 as Low Priority, and 361 as Very Low Priority. Groundwater basin prioritization results also indicate that 127 of the highest priority basins (High and Medium Priority) account for 96 percent of California's annual groundwater extraction and 88 percent of the population that overlies these basins.

Table 1. Statewide Summary of CASGEM Groundwater Basin Prioritization

Basin Priority Ranking	Basin Count	Percent of Total	
		GW Use	Overlying Population
High	43	69%	47%
Medium	84	27%	41%
Low	27	3%	1%
Very Low	361	1%	11%
Totals:	**515**	**100%**	**100%**

The results in Table 1 show that the High Priority groundwater basins account for 69 percent of California's average annual groundwater use and 47 percent of the 2010 population overlying these groundwater basins, while the Medium Priority groundwater basins account for 27 percent of the annual groundwater use and 41 percent of the overlying population. The remaining 388 groundwater basins ranked as Low or Very Low, account for a combined 4 percent of California's groundwater use and 12 percent of the overlying population.

Table 2 lists the number of groundwater basins and their priority by hydrologic region, along with the percentages of groundwater use and population associated with the High and Medium Priority basins. The South Coast Hydrologic Region has the largest number of High and Medium Priority basins (35), followed by the Central Coast (24), and Sacramento River (23) regions. The San Joaquin region has 9 basins groundwater basins (82 percent) ranked as High or Medium Priority. The nine High and Medium Priority Basins account for over 99 percent of the San

Joaquin region's average annual groundwater use and over 99 percent of the population overlying the basin area in the region.

Table 2. CASGEM Groundwater Basin Prioritization Summary, by Hydrologic Region

Hydrologic Region	CASGEM Groundwater Basin Ranking by Range and Hydrologic Region				HR Basin Count	Percent of Total Groundwater Use and Overlying Population for High & Medium Ranked Basins	
	High Ranking Range ≥ 21.08	Medium Ranking Range ≥ 13.42 to < 21.08	Low Ranking Range ≥ 5.75 to < 13.42	Very Low Ranking Range < 5.4		Groundwater Use *	Overlying Population *
North Coast	0	8	2	53	63	82%	62%
San Francisco Bay	0	7	0	26	33	90%	63%
Central Coast	9	15	0	36	60	97%	90%
South Coast	13	22	4	34	73	99%	94%
Sacramento River	5	18	4	61	88	96%	98%
San Joaquin River	7	2	0	2	11	100%	100%
Tulare Lake	7	1	1	10	19	99%	98%
North Lahontan	0	2	3	22	27	12%	55%
South Lahontan	2	4	4	67	77	84%	96%
Colorado River	0	5	9	50	64	82%	61%
Statewide	43	84	27	361	515	96%	88%

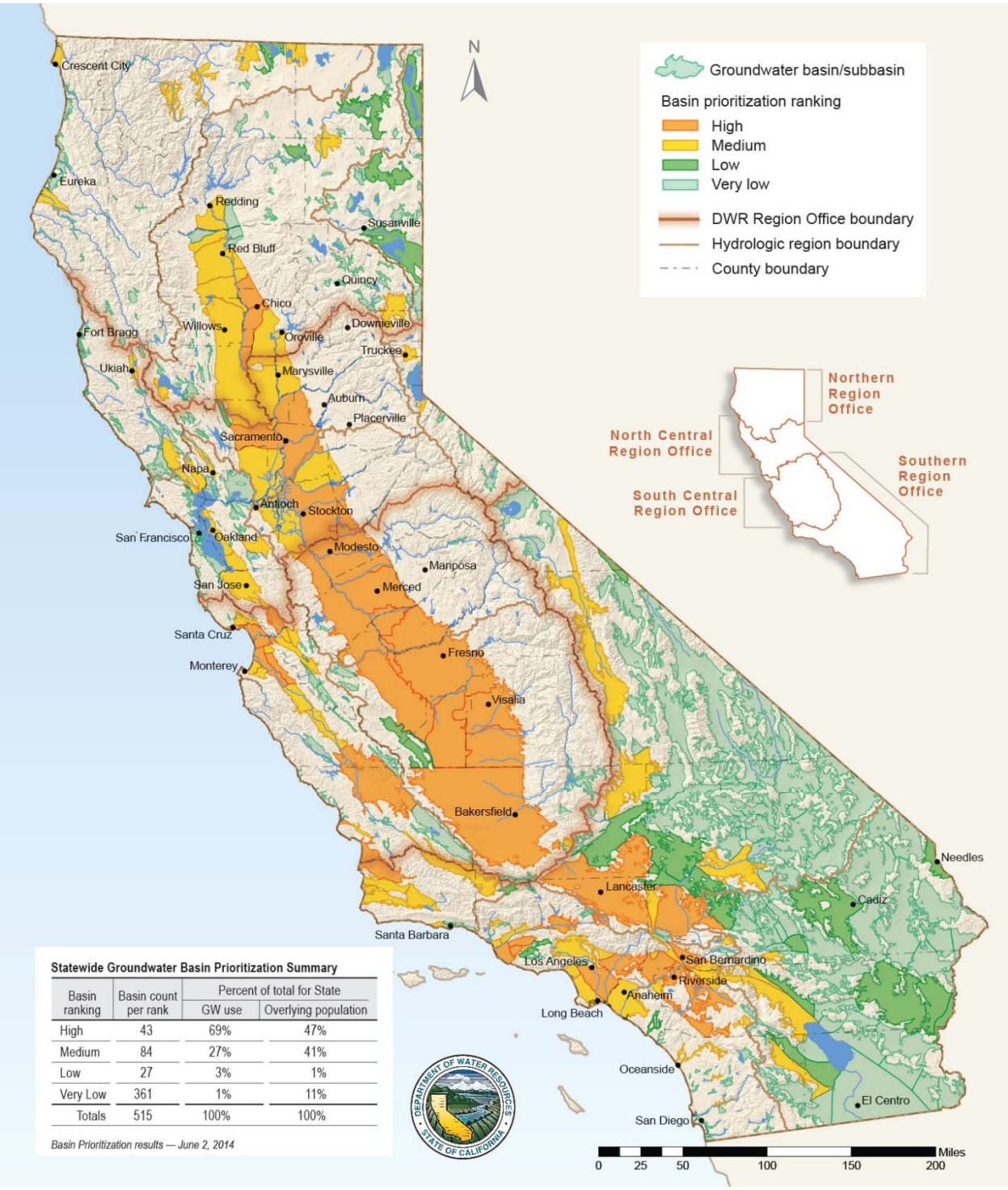
Note: * Estimated percentages are based on total groundwater use and population overlying all alluvial groundwater basins in the hydrologic region.

Figure 1 is a map of California's ten Hydrologic regions and 515 groundwater basins. The individual groundwater basins are color coded from High Priority (orange) to Very Low Priority (light green). Figure 1 shows that many of the groundwater basins within the Central and South Coast regions, and most of the basins within Central Valley, area are ranked as either High or Medium Priority. All of the groundwater basins within the Central Valley portion of the San Joaquin River and Tulare Lake regions are ranked as High Priority. All but five of the groundwater basins in the Central Valley portion of the Sacramento River region are listed as either High or Medium Priority. The North Lahontan, South Lahontan, and Colorado River regions have the lowest number of High and Medium Priority groundwater basins, primarily due to the low groundwater use and population.

As of June 13, 2014, about 60 percent of the High and Medium Priority groundwater basins are fully monitored under the CASGEM Program. An additional 11 percent of High and Medium Priority basins are partially monitored under CASGEM – leaving 29 percent of the High and

Medium Priority basins not monitored under CASGEM. Of the 37 High and Medium Priority basins that have not been fully or partially designated, 35 have a notification in-progress.

Figure 1. Statewide CASGEM Groundwater Basin Prioritization



Statewide Groundwater Basin Prioritization Summary

Basin ranking	Basin count per rank	Percent of total for State	
		GW use	Overlying population
High	43	69%	47%
Medium	84	27%	41%
Low	27	3%	1%
Very Low	361	1%	11%
Totals	515	100%	100%

Basin Prioritization results — June 2, 2014

Application of CASGEM Groundwater Basin Prioritization

The CASGEM basin prioritization is being used to focus and align limited resources towards the implementation of the CASGEM legislation that requires all groundwater basins to be monitored for seasonal and long-term groundwater elevation trends. Although participation in the CASGEM Program is voluntary, noncompliance with the CASGEM requirements could result in basin monitoring entities and overlying counties being ineligible for a water grant or loan awarded or administered by the State.

High and Medium Priority Basins: CASGEM basin prioritization findings indicate that 127 groundwater basins categorized as High and Medium Priority comprise 96 percent of California's annual groundwater pumping, and include 88 percent of the population overlying alluvial groundwater basin areas. Based on these findings and the limited resources for the CASGEM program, DWR will focus efforts on evaluating the status of groundwater level monitoring in High or Medium Priority groundwater basins where monitoring will have the greatest benefit.

If DWR determines that groundwater levels in all or part of a High or Medium Priority basin are not being monitored, or that a Monitoring Entity has not been designated for the basin or subbasin, then DWR will work cooperatively with local entities to establish a CASGEM monitoring program. If DWR is not able to designate a Monitoring Entity, then CASGEM program will compile a list of the High and Medium priority basins that are not being monitored. That list will be provided to the grants and loans programs at DWR, SWRCB, and DPH and the specific grant programs will determine eligibility for their respective grants with respect to the basin not being monitored under the CASGEM Program, as specified in the Water Code.

Low and Very Low Priority Basins: CASGEM basin prioritization results indicate that many of California's Low and Very Low Priority groundwater basins have few people, limited irrigation, and little to no groundwater use. Although the intent of the CASGEM legislation is to have adequate groundwater level monitoring for all 515 California groundwater basins, CASGEM legislation also prescribes the use of groundwater basin prioritization to help identify, evaluate, and determine the need for additional groundwater level monitoring.

Although the implementation of CASGEM-related groundwater level monitoring requirements will first focus on High and Medium Priority basins due to limited resources, this approach is not intended to diminish the importance of groundwater level monitoring and management in Low or Very Low Priority groundwater basins. Groundwater level monitoring and management in Low and Very Low Priority basins is still encouraged.

Additional Potential Applications of CASGEM Basin Prioritization: The primary application of CASGEM groundwater basin prioritization is to meet the requirements of the CASGEM legislation. However, based on the comprehensive set of data included in the CASGEM basin prioritization effort, the prioritization ranking could also help focus and align limited resources

and assistance to local agencies trying to implement best practices and procedures for groundwater basin management and planning. High and Medium Priority basins would also likely have a greater need and responsibility to implement effective and sustainable groundwater management practices. Similar to previous prioritization efforts related to groundwater quality monitoring and implementation of the groundwater ambient monitoring and assessment program (GAMA), the CASGEM groundwater basin prioritization results could also be used to promote:

- Informed decision making;
- A common vocabulary for communication between agencies
- Groundwater data collection and evaluation based on a common understanding of resource prioritization;
- A mechanism to align the goals, objectives, and priorities for groundwater resource management;
- Improved knowledge and understanding of local, regional, and statewide groundwater issues and concerns; and
- Collaboration and alignment of inter-basin agencies that have basin-wide or regional groundwater management objectives.

CASGEM Groundwater Basin Prioritization Process

The CASGEM basin prioritization process included an initial review and screening of groundwater basins for inclusion in the overall basin prioritization, followed by a more detailed analysis, review, and consideration of the eight data components stipulated in the CASGEM legislation listed below.

1. The population overlying the basin,
2. The rate of current and projected growth of the population overlying the basin,
3. The number of public supply wells that draw from the basin,
4. The total number of wells that draw from the basin,
5. The irrigated acreage overlying the basin,
6. The degree to which persons overlying the basin rely on groundwater as their primary source of water,
7. Any documented impacts on the groundwater within the basin, including overdraft, subsidence, saline intrusion, and other water quality degradation, and
8. Any other information determined to be relevant by the department.

Initial Groundwater Basin Screening: Review of previous efforts by the USGS to prioritize groundwater basins for groundwater quality sampling under the State Water Resource Control Board's GAMA program indicated that high use groundwater basins also commonly include basins having high public supply well density, high municipal groundwater use, and high agricultural groundwater use.

Using an approach similar to the GAMA Program, DWR selected *groundwater reliance* (data component number six listed above) as the primary component for the initial review and screening in the CASGEM groundwater basin prioritization process. Groundwater reliance data was developed in April 2010 using the most recent DWR statewide land and water use information, which estimated California's total annual groundwater use at about more than 13.6 million acre-feet (MAF). Analysis of groundwater reliance included consideration of the total annual volume of groundwater use, the annual volume of groundwater use per acre, and the percent to which groundwater contributes to the overall water supply for the basin.

Initial review of groundwater volume by basin indicated that the top 106 basins using groundwater represent about 97 percent of California's total annual groundwater use (see Figure 2). The 106 high-use basins all use 9,500 acre-feet or more groundwater per year. All of the 106 high-use groundwater basins were subsequently included into the overall groundwater basin prioritization process.

The second step in the initial basin prioritization process was to capture some of the lower-use groundwater basins having documented impacts or other issues that could potentially affect local groundwater supply reliability. In this step, 75 low-use groundwater basins with an estimated use of between 2,000 and 9,500 acre-feet of groundwater per year were further evaluated by DWR Regional Office groundwater staff with respect to documented impacts (data component 7, listed above) and "other" issues (data component 8, listed above). If further review of the 75 low-use groundwater basins identified impacts or other supply reliability issues, these low-use basins were subsequently included in the overall groundwater basin prioritization process. Ultimately, 48 out of the 75 low-use basins were included into the larger basin prioritization process.

Figure 2 illustrates the distribution of annual groundwater use by groundwater basin, and illustrates that groundwater basins producing between 2,000 and 9,500 acre-feet of groundwater per year, represent 2.5 percent of California's annual groundwater use. Groundwater basins producing less than 2,000 acre-feet of groundwater per year represent less than 0.5 percent of California's annual groundwater use.

Data for the remaining 319 very low-use groundwater basins with groundwater use of less than 2,000 acre-feet per year were recorded and compiled for potential future analysis; however, if no impacts or issues were documented, these basins were automatically ranked as CASGEM Very Low Priority groundwater basins, meaning the Overall Basin Ranking Score is overridden with a zero. The individual component ranking values will remain for inclusion in other potential data analyses.

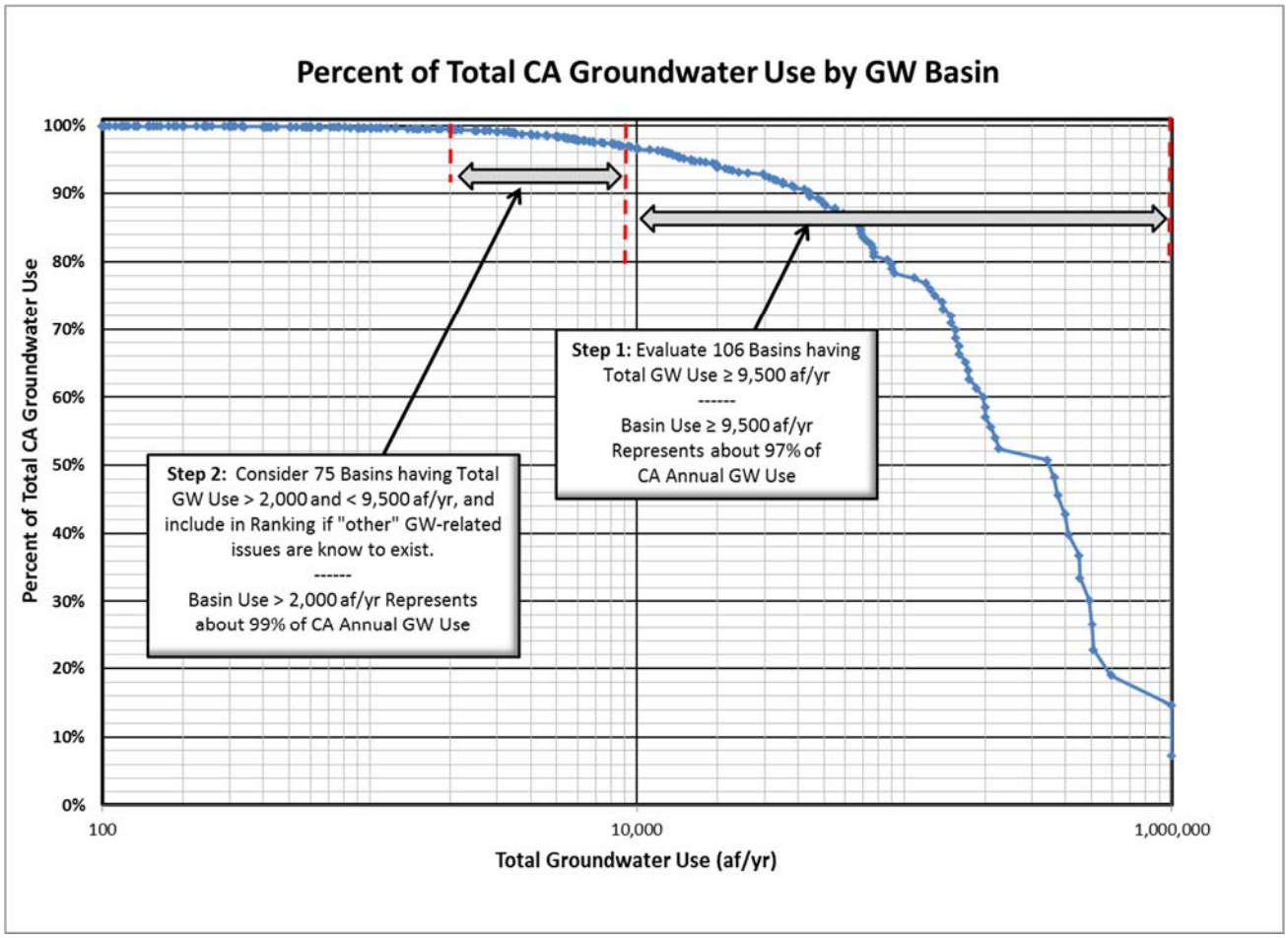
Inclusion of Data Components One through Six: Following the initial review and screening of groundwater basins based on groundwater reliance, the groundwater data were normalized for further review and ranking. Due to the large variability in the size of the groundwater basins,

the data associated with the first six data components were normalized by basin area to facilitate further basin-to-basin comparisons.

The normalized basin data for each groundwater data component were analyzed by their statistical distribution according to six ranking ranges (Very Low, Low, Moderately Low, Medium, Moderately High, and High). Each of the six data components were assigned a corresponding ranking value from 0 to 5, based on six ranking ranges. For most data components, the Very Low range included all zero values associated with the particular data component. The remaining data were ranked from Low to High, and assigned a value from 1 to 5.

The remaining ranking ranges were selected by endeavoring to evenly distribute the data ranges across the remaining data set, while also taking into account the number of basins and the overall percentage of data set included within each range, the skewed distribution of the data set, and the relative degree of significance associated with the range of data values. For example, a groundwater basin having a Very Low population density was assigned a 0, while basins having a High population density range were assigned a value of 5. Table 3 lists the data component ranges for the first six data components: population density, population growth, public supply well density, total well density, irrigated acreage, and groundwater reliance (volume and percent of total supply met by groundwater). Additional information regarding the data sources and processing methods are provided in the Data Component Sources and Processing section of this report.

Figure 2. Distribution of the Annual Volume of Groundwater Use by Groundwater Basin



Once the ranges for each of the first six data components were established, a basin prioritization database tool was developed to evaluate and prioritize groundwater basins based on the cumulative ranking of each data component. The basin prioritization tool allowed for rapid evaluation and prioritization of the basins in graphic and tabular form, and the ability to independently apply weighting factors to each of the eight datasets, if needed. The ability to apply weighting factors allowed for adjustments due to the variable quality of data within each of the data components. Additional information regarding processing for each data component is provided in the *Data Sources and Processing* section of this report.

Table 3. Data Component Ranking Ranges for CASGEM Groundwater Basin Ranking

Ranking	Ranking Value	Data Components and Ranking Ranges						
		Population		PSW Density	Total Well Density	Irrigated Acreage	Groundwater Reliance	
		Density	Projected Growth				GW Use	% of Total Supply [1]
		per sq.-mi	%	per sq.-mi	per sq. mi	ac/sq.-mi	ac-ft/acre	%
Very Low	0	x < 7	x < 0	x = 0	x = 0	x < 1	x < 0.03	x < 0.1
Low	1	7 ≥ x < 250	0 ≥ x < 6	0 > x < 0.1	0 > x < 2	1 ≥ x < 25	0.03 ≥ x < 0.1	0.1 ≥ x < 20
Moderately Low	2	250 ≥ x < 1000	6 ≥ x < 15	0.1 ≥ x < 0.25	2 ≥ x < 5	25 ≥ x < 100	0.1 ≥ x < 0.25	20 ≥ x < 40
Medium	3	1000 ≥ x < 2500	15 ≥ x < 25	0.25 ≥ x < 0.5	5 ≥ x < 10	100 ≥ x < 200	0.25 ≥ x < 0.5	40 ≥ x < 60
Moderately High	4	2500 ≥ x < 4000	25 ≥ x < 40	0.5 ≥ x < 1.0	10 ≥ x < 20	200 ≥ x < 350	0.5 ≥ x < 0.75	60 ≥ x < 80
High	5	x ≥ 4000	x ≥ 40%	x ≥ 1.0	x ≥ 20	x ≥ 350	x ≥ 0.75	x ≥ 80%

Note:
Population growth is percent growth from 2010 to 2030.
[1] Percent of total water supply (groundwater and surface water) that is provided by groundwater.
x = component data value

Inclusion of Data Components Seven and Eight: Data component seven includes groundwater basin impacts associated with overdraft, subsidence, saline intrusion, and other water quality degradation issues. Data Component eight includes any other information determined to be relevant by DWR, such as environmental impacts associated with surface water-groundwater interaction, adjudication, or other known groundwater issues that may justify an increase or decrease in the basin prioritization. Information associated with data components seven and eight were applied to the basin prioritization process by DWR Region office staff through review and consideration of information reported in DWR Bulletin 118, Update 2003, local groundwater management plans, public comments, or other readily available published information.

Based on the relative severity of groundwater basin impacts associated with component seven, an additional ranking value between 1 and 5 was applied to the total groundwater basin ranking value associated with data components one through six. A similar process was used to incorporate information associated with data component eight; however, a negative ranking value of up to -5 was also allowed, as appropriate, to help rectify known issues associated with basin-specific data relating to components one through six. All additional ranking value associated with data components seven and eight required a justification statement by the reviewer to support the change. Only one basin included a negative ranking value associated with data component eight.

Data Component Sources and Processing

Compilation and evaluation of data from multiple sources was required to achieve statewide prioritization of groundwater basins through consideration of data components one through six. Most of these datasets are not collected or stored at the groundwater basin scale, which is needed to facilitate prioritization under the CASGEM legislation. Compiling and evaluating multiple datasets from multiple sources posed a number of challenges; however, the spatial scale and distribution of the data provided a level of accuracy that is considered adequate for a statewide evaluation and prioritization of California groundwater basins. When appropriate, the spatial distribution of the data were normalized or reparsed to achieve better representation at the basin and subbasin scale. Inaccuracies associated with the spatial translation or rescaling of the data were minimized through multiple inspections of the data by DWR staff and comments received from five public workshops held throughout the state in January, 2014. A description of the data sources and evaluation process associated with data components one through six is provided below. A complete listing of the individual ranking values for each data component, along with the overall basin prioritization results, are provided in Appendix A.

Data Component 1: Population Overlying the Basin: Population overlying the groundwater basins was derived using 2010 California census data processed by DWR's demographic staff in the Division of Statewide Integrated Water Management. Using GIS methods, the 2010 census data from the various population reporting centers were attributed to the overlying groundwater basins. If groundwater basin boundaries split population reporting centers, the population data was proportionally distributed to the overlying groundwater basins. Due to the variable size of the groundwater basins, the population data was normalized by dividing the total population of a groundwater basin by the basin area to produce a population density (persons per square mile) for each basin. Confidence with this set of the population data is considered high and no weighting factors were applied.

The 2010 census data estimates California population at about 37 million people, with the average population density of about 242 people per square mile. Although alluvial groundwater basins cover only 38 percent of California's total landmass, approximately 81 percent (30 million) of California's 37 million residents live in areas overlying alluvial groundwater basins. The average population density overlying alluvial groundwater basin areas is about 480 persons per square mile, approximately double the population density for the entire state. Even though roughly 80 percent of California's land area is designated as rural, about 87 percent of the population lives in urban areas.

There are numerous definitions for rural versus urban areas based on population density. Most of these definitions are associated with government assistance or reimbursement programs and come with their own classification system based on population densities. The US Census

Bureau defines an urban area as having a nucleus of 50,000 or more people, and a population density of 1,000 persons per square mile. Analysis of 2000 census data indicates that California's urban population density ranges from 328 to 4,548 persons per square mile and the population density for rural areas ranges from 14 to 35 persons per square mile.

Although the rural versus urban population densities will not always have a direct relationship to the level of groundwater demand, the density ranges were used as a point of reference to help identify a reasonable range of population densities for the groundwater prioritization effort.

The distribution of population density by basin, along with the ranking ranges and values for this data set, are provided in Figure 3 and Table 4. The 2010 census data in Figure 3 shows that all basins with population density of less than seven persons per square mile were assigned a Very Low data ranking range, and a data ranking value of 0 towards the overall basin prioritization. The Very Low data ranking comprises a total of 196 basins, including 85 basins that are estimated to have zero population.

One hundred sixty four basins with a population density of 7 to 250 persons per square mile were assigned a Low data ranking value of 1. Based on an average per capita use of 250 gallons per day per year, 250 persons per square mile equates to about one tenth of an acre-foot per acre of groundwater use per year.

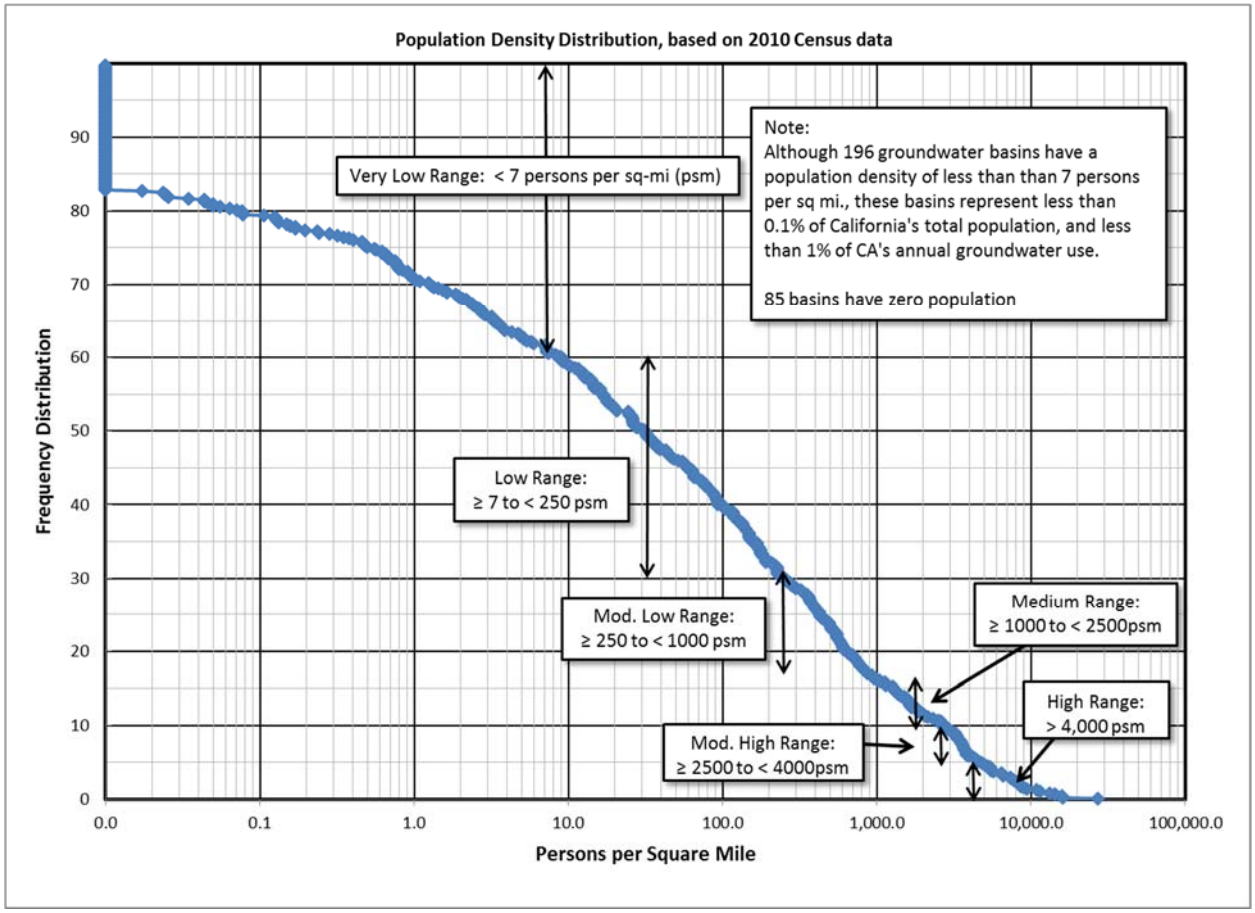
Together, the Very Low and Low ranges represent only nine percent of California's overall population. The remaining dataset ranges (Moderately Low – High), include a total of 155 basins, representing approximately 91 percent of 2010 population overlying alluvial groundwater basins.

Table 4. Data Component Ranking Ranges for Population Density

Data Component Ranking	Ranking Value	Population Density (persons/sq.-mile)	Total Number of Basins in Rank	Cumulative Percent of Total 2010 Population incorporated by the Ranking Interval [1]
Very Low	0	$x < 7$	196	100%
Low	1	$7 \geq x < 250$	164	100%
Moderately Low	2	$250 \geq x < 1000$	71	91%
Medium	3	$1000 \geq x < 2500$	28	73%
Moderately High	4	$2500 \geq x < 4000$	26	61%
High	5	$x \geq 4000$	30	50%

Notes:
x The basins person per square mile value
[1] Cumulative percentage of the Total 2010 population residing in the basins for each ranking group

Figure 3. Distribution Curve and Ranking Ranges for Population Density



<u>Data Component #2: Projected Population Growth of the Overlying Basin:</u> Population growth is based on 2010 census data and 2030 population growth projections generated by the Department of Finance and compiled by DWR's demographic staff in the Division of Statewide Integrated Water Management. Confidence in the rate of population growth for overlying groundwater basins is considered high and no weighting factors were applied to the data.

As of the 2010 census, 85 groundwater basins were identified as unpopulated and an additional 185 groundwater basins were recorded to have a population of less than 1,000 people. Evaluation of the population growth rates revealed that many of the groundwater basins having the lowest population also had the highest projected growth, due to the situation where a relatively small increase in population for a low populated basin results in an extremely high rate of growth. For example, Yosemite Valley has an estimated 2010 population of 1,016 people, but due to a 2030 projected population of 3,247 people, the projected rate of growth exceeds 300 percent. In order to reduce the effects of very low populated basins skewing the overall dataset, and in recognition that the slightly higher populated basins tend to have higher statewide significance with respect to groundwater prioritization, all basins with a population of

less than 1,000 were assigned Very Low data ranking, or zero for this particular data component.

For similar reasons, basins with zero population or population densities less than 50 people per square mile were also assigned a Very Low data ranking, or zero for this particular data component. An exception was made for two basins with a population density of less than 50 people per square-mile, but an overall 2010 population of greater than 25,000 people (5-21.52 and 5-22.09). For these two basins, ranking ranges and values were applied according to the breakdown shown in Figure 4 and Table 5. The data ranking values associated with the population growth data were subsequently combined with the data rankings from the other seven data components to create the overall groundwater basin prioritization results.

Figure 4 and Table 5 provide the projected population growth data by basin, along with the breakdown of the various priority ranking ranges and values for this particular dataset, using a scale from 0 to 5. Table 5 shows that 336 groundwater basins were given a population growth ranking of Very Low, and a data ranking value of zero for this particular data component. The criteria for assigning the 336 groundwater basins a zero, or Very Low, ranking with respect to the 2030 projected population growth rate is summarized below.

- Groundwater Basins with zero 2010 population (85 basins)
- Groundwater Basins with a negative 2030 projected population growth (110 basins)
- Groundwater Basins with a positive 2030 growth rate, but with a population of less than 1,000 people (115 basins)
- Groundwater Basins with a positive 2030 growth rate, but a population density less than 50 people per square mile, and a current (2010) population of greater than 25,000 people (2 basins)

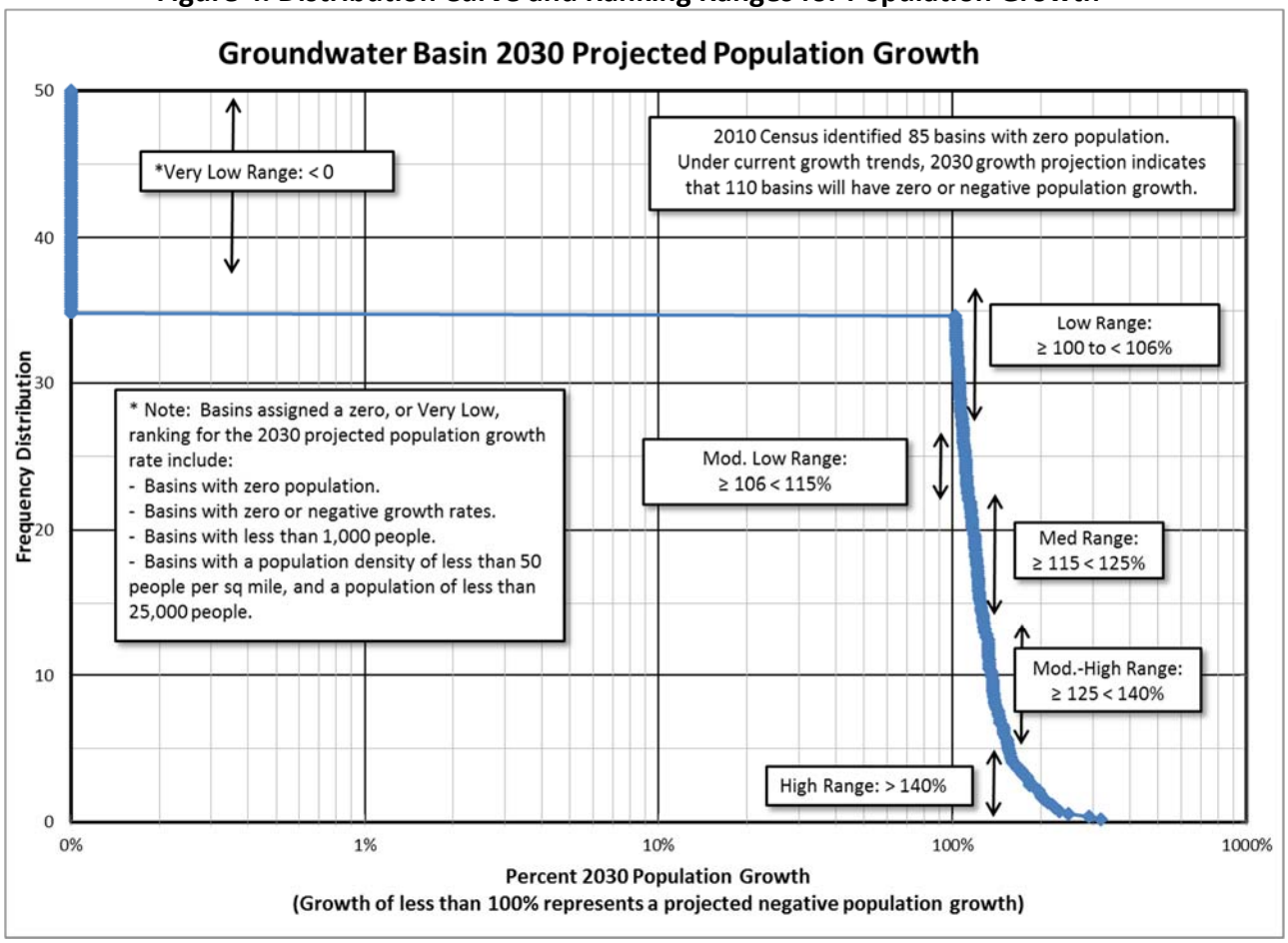
Table 5. Data Component Ranking Ranges for Population Growth

Data Component Ranking	Ranking Value	Population Growth (% population growth)	Total Number of Basins in Rank	Cumulative Percent of Total Population Growth incorporated by the Ranking Interval [1]
Very Low	0	$x < 0$	336	100%
Low	1	$0 \geq x < 6$	55	97%
Moderately Low	2	$6 \geq x < 15$	36	75%
Medium	3	$15 \geq x < 25$	28	42%
Moderately High	4	$25 \geq x < 40$	29	22%
High	5	$x \geq 40\%$	31	9%

Notes:
Population growth is estimated growth between 2010 and 2030, based on current growth trends
Population growth of less than 100% equals negative growth projection
x Population growth percentage less 100 (Example: Population growth of 105%, x=5%)
[1] Cumulative percentage of the projected population residing in the basins for each ranking group

Although, the Very Low data ranking for population growth incorporates a large number of groundwater basins, it represents less than 7 percent of the population overlying groundwater basin areas, while the remaining 179 basins with a ranking of Low to High include over 93 percent of 2010 population overlying groundwater basin areas.

Figure 4. Distribution Curve and Ranking Ranges for Population Growth



<u>Data Component #3: The Number of Public Supply Wells that Draw from the Basin:</u> The number of public supply wells (PSWs) within a groundwater basin is directly related to the number of municipal water users who rely on groundwater, and serves as a key CASGEM data component in evaluating the relative priority of groundwater resources within a basin. Public supply well information was derived from the California Department of Public Health (DPH) Drinking Water Supply Database. The DPH PSW database was filtered to include only active wells within alluvial groundwater basins. The filtered PSW database resulted in about 12,000 active public supply wells over 316 groundwater basins. Due to the variable size of the

groundwater basins, the PSW data was normalized by dividing the total number of PSWs by the basin area to produce a PSW Density (wells per square mile) for each basin. Data confidence is considered high, with a dataset weighting remaining at 100 percent. The data ranking values associated with the PSW data were subsequently combined with the data ranking values from the other seven data components to create the overall groundwater basin prioritization results.

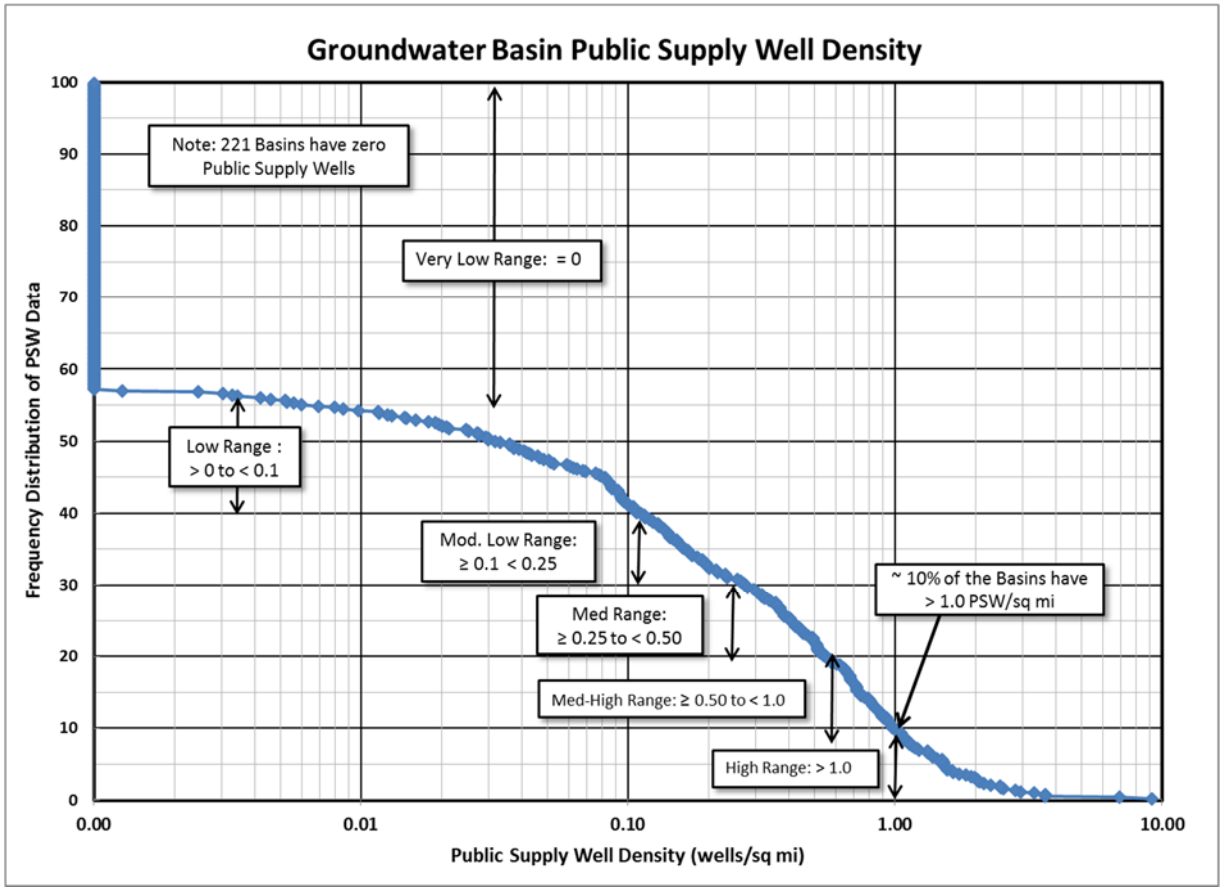
Table 6 and Figure 5 show the distribution of PSW density data by basin, along with the breakdown of the various ranking ranges and data ranking values for this particular dataset, based on a scale of 0 to 5. The data in Figure 5 and Table 6 indicates that 221 basins have zero PSWs and are assigned a Very Low, or zero priority ranking, for this dataset. The dataset with a Low ranking includes 82 basins, while the remaining dataset rankings (Moderately Low to High) include 212 basins representing 92 percent of the 12,000 public supply wells. The breakout for cumulative percent each of the rankings represents of the total PSWs installed in the 515 basins can be viewed in Table 6.

Table 6. Data Component Ranking Ranges for Public Supply Well Density

Data Component Ranking	Ranking Value	Well Density (wells per sq. mile)	Total Number of Basins in Rank	Cumulative Percent of Total PSWs incorporated by the Ranking Interval [1]
Very Low	0	x = 0	221	100%
Low	1	0 > x < 0.1	82	99%
Moderately Low	2	0.1 ≥ x < 0.25	53	92%
Medium	3	0.25 ≥ x < 0.5	46	73%
Moderately High	4	0.5 ≥ x < 1.0	63	51%
High	5	x ≥ 1.0	50	19%

Notes:
x PSW **per square mile value**
[1] **Shows the cumulative percentage of the PSW within the basins in each ranking group**

Figure 5. Distribution Curve and Ranking Ranges for Public Supply Well Density



<u>Data Component # 4: The Total Number of Wells that Draw from the Basin:</u> The number and type of wells that draw groundwater from a basin is indicative of the overall demand and importance of the groundwater resources for the basin. Information associated with the total number of wells was derived from the DWR Well Master database (WellMa). The WellMa database contains approximately 390,000 well locations by township, range, and section as recorded by the well drillers in the submitted Well Completion Reports. Due to the variable size of the groundwater basins, the well data was normalized by dividing the total number of wells by the basin area to produce a total well density (wells per square mile) for each basin.

The level of well log information within the WellMa database is not consistent throughout the state. Data pertaining to well use, well construction, or detailed well location is not available for many groundwater basin areas. Thus, evaluation of the well log data by well type (production versus monitoring wells) and by groundwater basin, was not possible at a statewide scale and the total number of well logs used for the basin prioritization analysis includes all well types (domestic, irrigation, observation, etc.). In highly urbanized groundwater basin areas, the number of total wells will be skewed by high numbers of shallow non-producing observation wells, typically associated with urban-related groundwater clean-up sites.

Because of the inherent deficiencies with the well log database, the confidence and weighting of this dataset was reduced. A data weighting of 75 percent was subsequently applied to the ranking values associated with total well data, prior to combining with the other seven data components to create the overall groundwater basin prioritization results. Figure 6 and Table 7 show the distribution of total well density data by basin, along with the breakdown of the various priority ranking ranges and data ranking values for this particular dataset, based on a scale of 0 to 5.

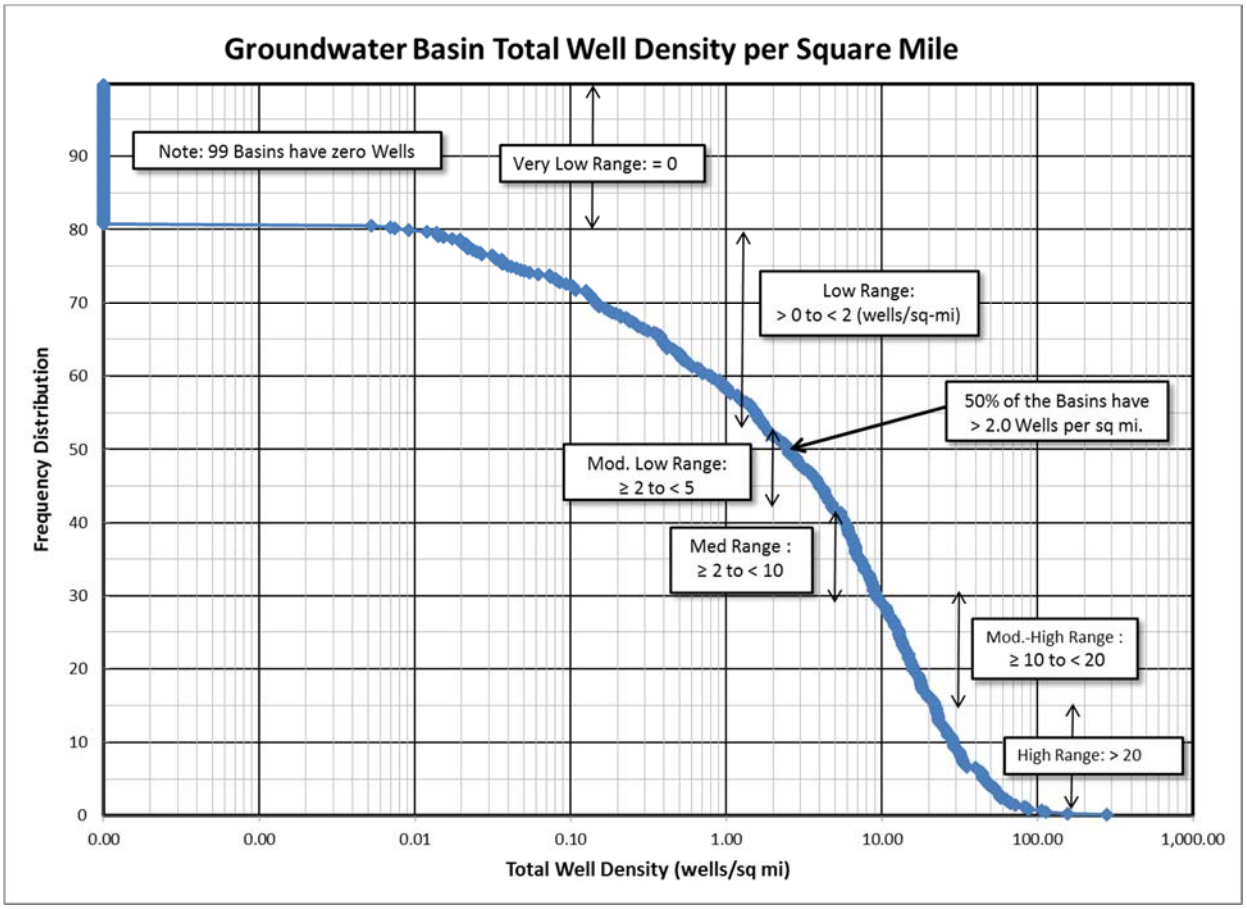
Table 7. Data Component Ranking Ranges for Total Well Density

Data Component Ranking	Ranking Value [2]	Well Density (wells per sq. mile)	Total Number of Basins in Rank	Cumulative Percent of Total Wells incorporated by the Ranking Interval [1]
Very Low	0	x = 0	99	100%
Low	1	0 ≥ x < 2	149	99%
Moderately Low	2	2 ≥ x < 5	52	98%
Medium	3	5 ≥ x < 10	66	92%
Moderately High	4	10 ≥ x < 20	66	79%
High	5	x ≥ 20	83	49%

Notes:
x Wells per square mile value
[1] Cumulative percentage of the wells within the basins in each ranking group
[2] A data weighting of 75 percent was subsequently applied to the ranking values a**bove prior to combining with the other seven data components to create the overall groundwater basin prioritization results**

The data in Figure 6 and Table 7 indicates that 99 groundwater basins are estimated to have zero wells and are assigned a Very Low, or zero priority ranking for this dataset, and approximately 149 basins have a total well density between 0 and 2.0 wells per square-mile. Although the Low and Very Low data ranking ranges for total well density includes 248 groundwater basins, the data ranking ranges represent only two percent of the California's total number of well logs. The top two data ranking ranges (High and Moderately High) include 149 basins and 49 percent of the 390,000 well log records submitted to DWR.

Figure 6. Distribution Curve and Ranking Ranges for Total Well Density



<u>Data Component #5: The Irrigated Acreage Overlying the Basin:</u> Worldwide, almost 60 percent of our planet's freshwater goes towards irrigation uses (USGS, 2000). In California, over nine million acres, or approximately 24 percent of the overlying groundwater basin areas are under irrigated lands. Statewide, agricultural use of groundwater represents about 76 percent of California's average annual groundwater extraction. <u>Evaluation of irrigated acreage overlying the basin includes acreage irrigated by either groundwater or surface water.</u>

Irrigated acreage data was compiled by DWR land and water use staff using the latest land use data and digitally parsed according to Bulletin 118 groundwater basin boundaries using GIS techniques. In areas where DWR land use data was not available, irrigated acreage data was derived from the Department of Conservation Farmland Mapping Program.

Irrigated acreage outside the basin boundaries was not included in the basins calculations and analysis. Due to the variable size of the groundwater basins, irrigated acreage data was normalized by dividing the total irrigated acres by the basin area in square miles.

The ranking values associated with the irrigated acreage data were subsequently combined with the data ranking values from the other seven data components to create the overall groundwater basin prioritization results. Confidence associated with this data set is considered high with a dataset weighting of 100 percent. Figure 7 and Table 8 show the data distribution for density of irrigated acres by basin, along with the breakdown of the various ranking ranges and ranking values for this particular dataset, based on a scale of 0 to 5.

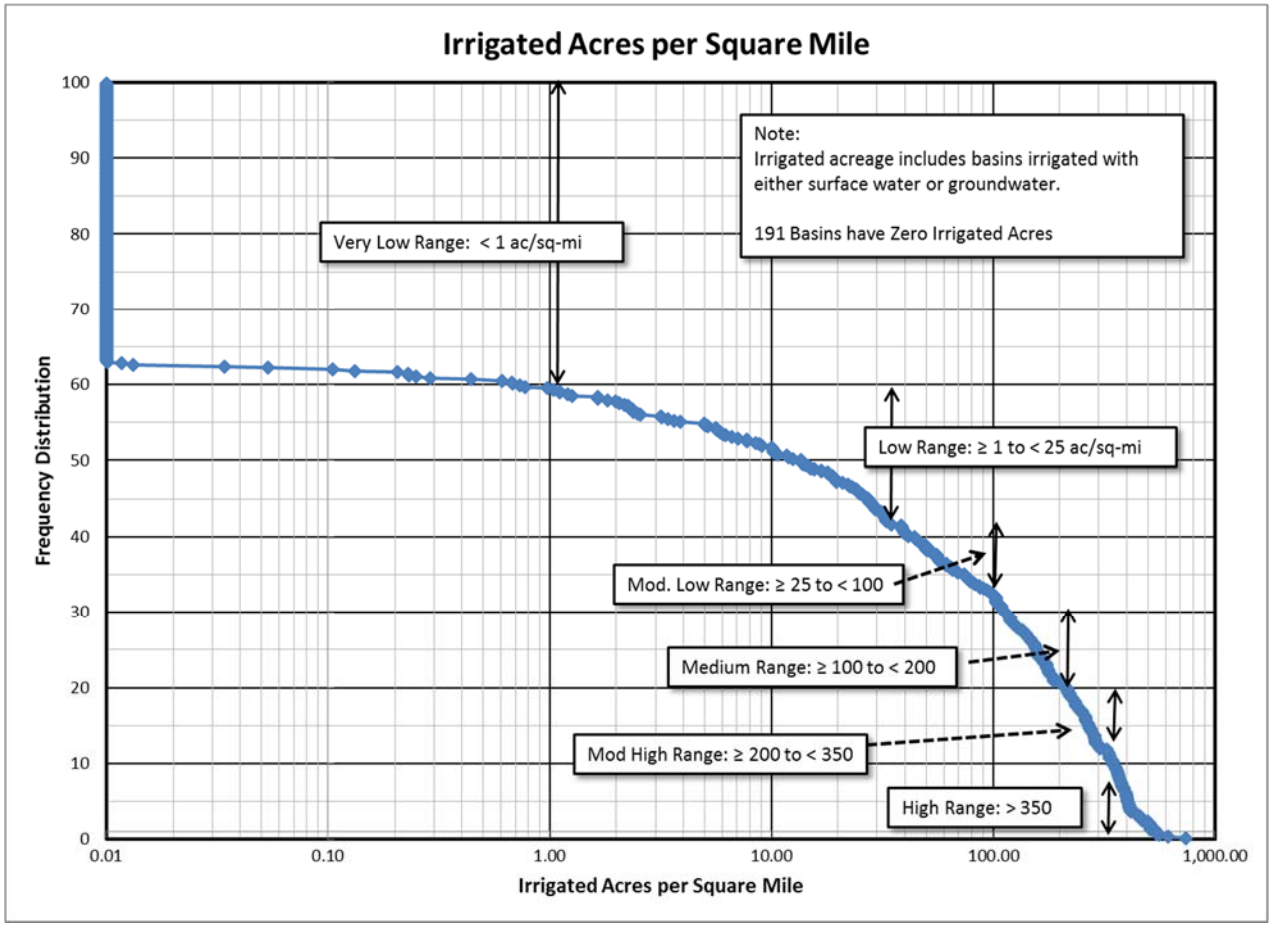
Table 8. Data Component Ranking Ranges for Density of Irrigated Acres

Data Component Ranking	Ranking Value	Density of Irrigated Acres (acres per sq. mile)	Total Number of Basins in Rank	Cumulative Percent of Irrigated Acreage incorporated by the Ranking Interval [1]
Very Low	0	x < 1	209	100%
Low	1	1 ≥ x < 25	71	100%
Moderately Low	2	25 ≥ x < 100	68	99%
Medium	3	100 ≥ x < 200	60	97%
Moderately High	4	200 ≥ x < 350	57	90%
High	5	x ≥ 350	50	69%

Notes:
Irrigated acres includes groundwater basin areas irrigated with surface water or groundwater or both
x Irrigates Acres per square mile value
[1] Cumulative percentage of the irrigated acreage within the basins in each ranking group

The data in Figure 7 and Table 8 indicates that the Very Low ranking comprises 191 basins (nearly 37 percent) having zero irrigated acreage and another 18 basins (3.5 percent) having less than 1 acre per square mile. Overall, 209 basins were assigned a data ranking value of zero. A Low data ranking was assigned to 139 groundwater basins having between 1.0 to 100 acres of irrigated land per square mile. Although the Low and Very Low ranked basins constitute nearly 68 percent (348) of the groundwater basins, they only comprise approximately three percent of the irrigated acreage overlying California's groundwater basin areas. The 167 groundwater basins within the Medium to High rankings comprise about 97 percent of the irrigated groundwater basin areas.

Figure 7. Distribution Curve and Ranking Ranges for Density of Irrigated Acres



<u>Data Component #6: The Degree to Which Persons Overlying the Basin Rely on Groundwater as their Primary Source of Water:</u>

DWR selected groundwater reliance as the primary component for the initial review and screening in the CASGEM groundwater basin prioritization process (see previous section titled: *Initial Groundwater Basin Screening under CASGEM*). Analysis of groundwater reliance included consideration and review of the estimated annual volume of groundwater use and the percent to which groundwater pumping contributes to the overall water supply for the basin. The two data ranking values associated with groundwater reliance (volume and percent of overall supply) were averaged, prior to combining with the seven other data components to create the overall groundwater basin prioritization results.

Groundwater Reliance by Evaluation of Volume of Use: Statewide groundwater volume information was estimated using the most recent DWR Land and Water Use (LWU) survey data. Agricultural groundwater use was estimated by compiling statewide irrigated land and water

use data, digitally parsing the data by groundwater basin, and then processing the data using DWR's Agricultural model which incorporates local soils, irrigation methods, irrigated water source, and evapotranspiration data. Urban groundwater use was estimated by applying local per capita groundwater use data reported by public water supply purveyors to the 2010 population estimates for each groundwater basin. Considerable efforts were made by DWR Region staff to verify groundwater use by groundwater basin through the review of aerial photography, local groundwater management plans, Bulletin 118-03 data, public comments, and other readily available sources of information. Because of the additional steps taken to help verify the estimated volume of groundwater use by groundwater basin area, confidence in this dataset is considered acceptable for the intended use, and no weighting factors were applied.

Table 9. Data Component Ranking Ranges for Groundwater Reliance, as it relates to Groundwater Use in acre-feet per acre

Data Component Ranking	Ranking Value	Groundwater Use Volume (ac-ft per acre)	Total Number of Basins in Rank	Cumulative Percent of Groundwater Use incorporated by the Ranking Interval [1]
Very Low	0	x < 0.03	269	100%
Low	1	0.03 ≥ x < 0.1	51	100%
Moderately Low	2	0.1 ≥ x < 0.25	71	98%
Medium	3	0.25 ≥ x < 0.5	44	91%
Moderately High	4	0.5 ≥ x < 0.75	30	84%
High	5	x ≥ 0.75	50	55%

Notes:
x Groundwater Use Acre Feet per acre value
[1] Cumulative percentage of the groundwater use volume within the basins in each ranking group

Table 9 and Figure 8 show the data distribution for the volume of groundwater use by basin, along with the breakdown of the various ranking ranges and values for this particular dataset, based on a scale of 0 to 5. Evaluation of annual groundwater use data indicates 320 groundwater basins fall within the Low and Very Low data ranges have a groundwater use of less than 0.1 acre-feet per acre, and represent approximately two percent of the estimated total groundwater use. Within the moderately high to high ranges, approximately 30 basins have an annual groundwater use between 0.50 and 0.75 acre-feet per acre, and 50 basins have a groundwater use of greater than 0.75 acre-feet per acre. The combined medium and high ranges account for nearly 85 percent of the groundwater use in the 515 basins.

Groundwater Reliance by Evaluation the Overall Supply Met by Groundwater: Evaluation of groundwater reliance included an assessment of the percent to which groundwater contributes to the overall water supply for the basin. Similar to the groundwater use data, groundwater

use as a percent of the overall supply was evaluated using the DWR land and water use data compiled by groundwater basin, and assessed by DWR Region land and water use staff. Because of the additional steps taken to help verify the estimated volume of groundwater use by groundwater basin area, confidence in this dataset is considered acceptable for the intended use, and no weighting factors were applied.

Figure 8. Distribution Curve and Ranking Ranges for Groundwater Reliance, as it relates to Groundwater Use in acre-feet per acre

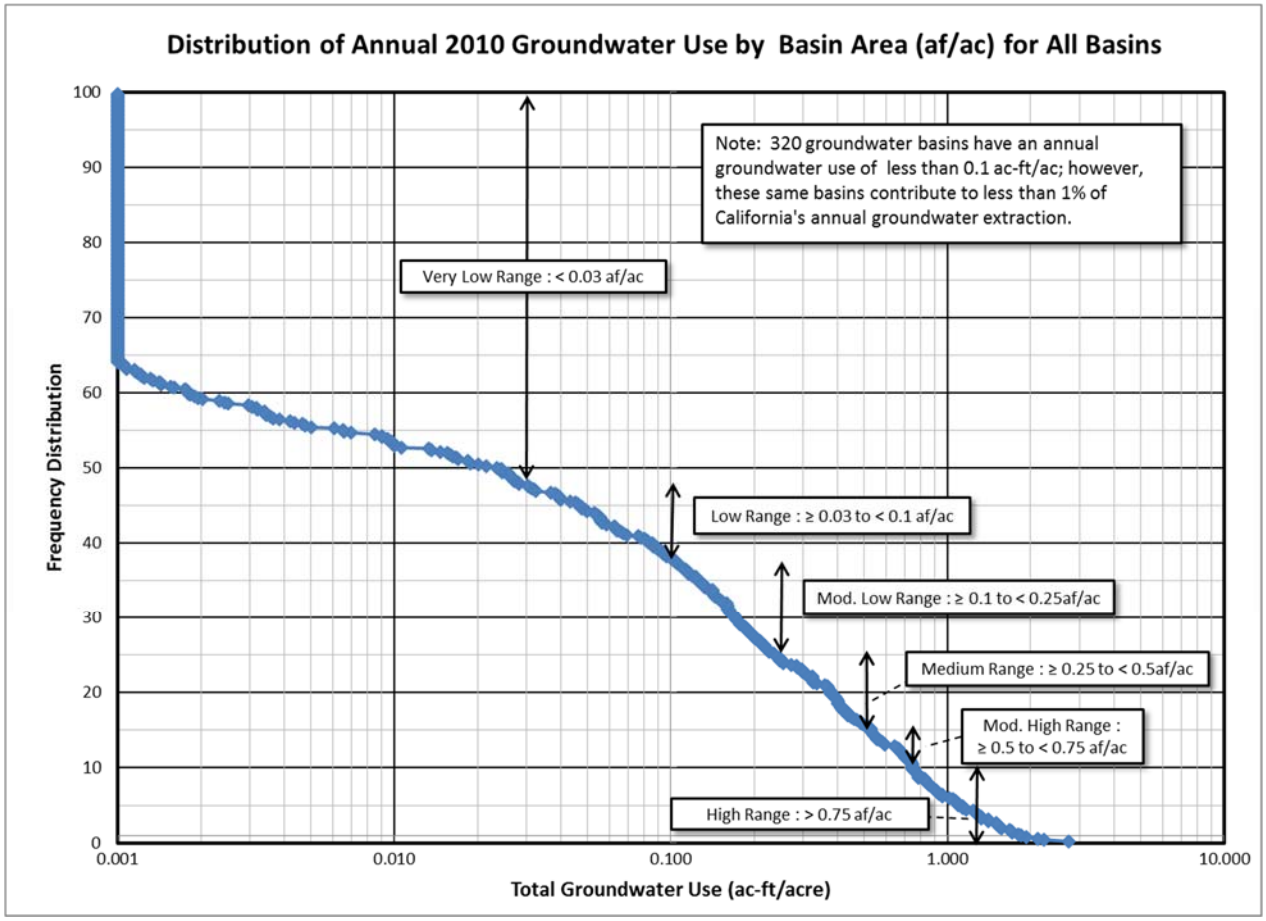


Figure 9 and Table 10 show the distribution of the groundwater reliance, with respect to the percent that groundwater contributes to the total water supply for the basin, and breakdown the data ranking ranges and values for this dataset, using a scale of 0 to 5. Information in Figure 9 and Table 10 indicates that groundwater contributes to less than 20 percent of the basin's overall water supply in 244 groundwater basins within the Low and Very Low data ranges. In approximately 99 basins, groundwater contributes to between 21 and 60 percent of the basin's overall water supply (Moderately Low to Medium data range), and for 172 basins, groundwater contributes to greater than 61 percent of the basin's overall water supply

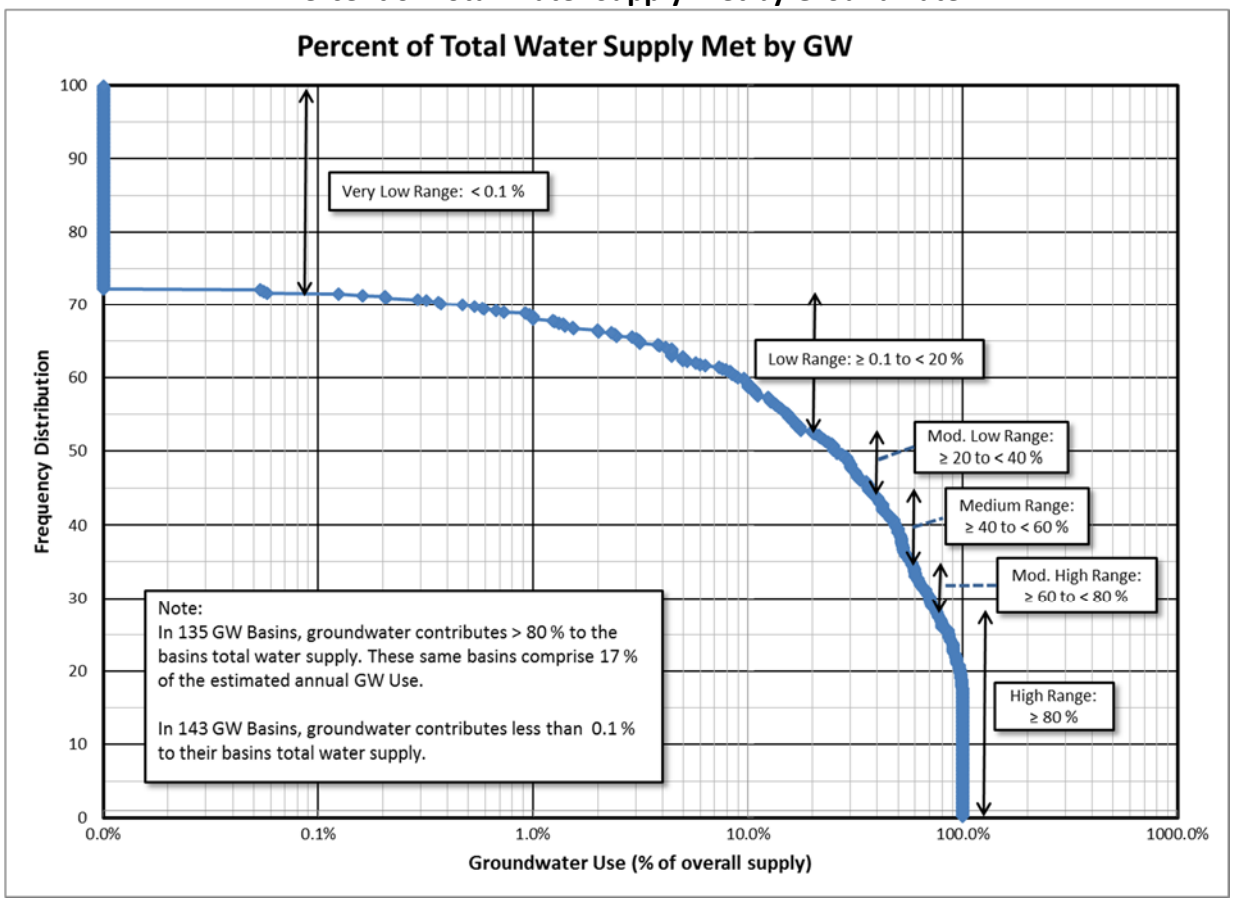
(Moderately High to High data range). Basins within the Medium to High ranking ranges also comprise about 61 percent of the statewide annual groundwater extraction.

Table 10. Data Component Ranking Ranges for Groundwater Reliance, as it relates to Percent of Total Water Supply Met by Groundwater

Data Component Ranking	Ranking Value	Total Supply Met by Groundwater [2] (%)	Total Number of Basins in Rank	Cumulative Percent of Groundwater Use [1] incorporated by the Ranking Interval
Very Low	0	x < 0.1	143	100%
Low	1	0.1 ≥ x < 20	101	100%
Moderately Low	2	20 ≥ x < 40	45	93%
Medium	3	40 ≥ x < 60	54	61%
Moderately High	4	60 ≥ x < 80	37	25%
High	5	x ≥ 80	135	17%

Notes:
x Basin groundwater use as a percent of Total Water Supply used within the basin
[1] Cumulative percentage of the groundwater use by the basins in each of the ranking groups (ranking group total groundwater use / total groundwater use of the 515 basins * 100)
[2] Total Supply = Groundwater + Surface Water used in Agriculture and Urban within the basin, Percent = Groundwater / Total Supply used in the basin * 100

Figure 9. Distribution Curve and Ranking Ranges for Groundwater Reliance, as it relates to Percent of Total Water Supply Met by Groundwater



A listing of the individual ranking values for each data component, along with the overall basin prioritization results, are provided in Appendix A.

The individual ranking values for each data component were combined to establish the total basin ranking score and a final basin ranking of Very Low to High. The final basin ranking score was translated to a final basin ranking by taking the difference between the highest and lowest basin ranking scores and dividing by the four ranking categories (see Table 2).

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