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A DRY CENTURY IN CALIFORNIA: CLIMATE CHANGE, GROUNDWATER, AND A SCIENCE-BASED APPROACH FOR PRESERVING THE UNSEEN COMMONS

BY
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In January 2015, California became the last Western state to adopt a comprehensive plan for managing its groundwater resources. With passage of the Sustainable Groundwater Management Act, the legislature overcame a century of resistance to impose substantial state-level regulatory control. The law vests authority in new local groundwater sustainability agencies, which must prepare sustainability plans for the over 100 aquifers presently experiencing critical declines in water levels. Under these plans, the statute contemplates that, among other criteria, withdrawals from aquifers must be managed to avoid both significant and unreasonable depletion of water storage levels and adverse effects on surface flows. This Article argues that the key standard imposed to meet these objectives, the sustainable yield, is fundamentally flawed because it specifies allowed withdrawals in terms of base periods representative of long-term conditions in each basin. However, such long-term conditions are no longer definable given twenty-first century climate models that predict sustained, increasing drought in the most populous parts of the state. To slow, and ultimately halt, the ongoing sharp declines in aquifer water levels, this Article suggests that the sustainable yield standard should be replaced

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with mandated, numerical criteria specifying defined levels of groundwater to be retained in each individual basin. This approach will require substantial, targeted efforts to gather missing data on the hydrological properties of aquifer basins across the state. It ultimately envisions a fully science-based approach to conjunctive management of ground and surface waters in California.

I. INTRODUCTION

There is yet another drought in California now, this one among the most severe in its history.[1] Around the many reports of dire facts and figures, and anecdotes of personal hardships, it is still possible to find the optimism that once consistently prevailed during such times—a notion that the weather reliably runs in cycles, and that better, wetter days are coming soon.[2] But as the dry months turn into years, with little respite apparently in sight, a more sober sensibility is also taking hold.[3] The warnings of the scientists are becoming difficult to ignore, and they have penetrated the public consciousness: *no matter where you are, the climate is moving away from*

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1 *California Drought*, http://ca.gov/drought/ (last visited July 18, 2015) (noting that in January, 2014 California governor Brown declared a drought state of emergency); Daniel Griffin & Kevin J. Anchukaitis, *How Unusual Is the 2012–2014 California Drought?*, 41 GEOPHYSICAL RESEARCH LETTERS 8673, 9017 (2014).

2 *See, e.g.*, Barbara Paulsen, *In Migrant Camp and Beyond, California Drought Brings a Familiar Desperation*, NAT'L GEOGRAPHIC, Jan. 1, 2015, http://news.nationalgeographic.com/news/2014/12/141231-dust-bowl-grapes-of-wrath-drought-migrants-family-trip-part-3/ (last visited July 18, 2015) ("More farmworkers than usual were unemployed because the drought had kept so many growers from planting crops."); Paul Rogers, *California Drought: Feds Forecast Good Chance of Wet Conditions for Next Three Months*, SAN JOSE MERCURY NEWS, Dec. 18, 2014, http://www.mercurynews.com/science/ci_27165355/california-drought-feds-forecast-good-chance-wet-conditions (last visited July 18, 2015) (reporting a 75% probability of average or above-average precipitation during the first three months of 2015).

3 Griffin & Anchukaitis, *supra* note 1, at 9017; *see also* Rogers, *supra* note 2 (stating that California has a "long, long way to go to recover" from the current drought).

what you are used to.[4] And in the most populous parts of California, almost every climate model, every data-based prediction about the next century says that it is going to be getting ever drier.[5] The scientists' message has finally become loud enough to penetrate even the deafest of communities: the Sacramento legislature. After decades of inaction while all of the other Western states adopted comprehensive plans for managing their groundwater, this body has at last responded by passing its own Sustainable Groundwater Management Act (SGMA),[6] which became law on January 1, 2015.[7]

The SGMA indeed opens new possibilities for conservation of the crucial groundwater resource, which is presently providing over fifty percent of the freshwater used in the state.[8] The Act creates new local agencies charged with protecting against groundwater depletion or other damage to the long-term viability of the resource, and confers substantial authority to enable execution of this goal.[9] It establishes a priority system to first manage those regions that are presently experiencing the severest shortfalls, effectively leveraging the emerging database of basin-specific groundwater levels created by the California Statewide Groundwater Elevation Monitoring (CASGEM) program in the Department of Water Resources (DWR).[10] And it strikes all the right chords in its comprehensive

4 *See generally* INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, MANAGING THE RISKS OF EXTREME EVENTS AND DISASTERS TO ADVANCE CLIMATE CHANGE ADAPTATION 29 (2012) (detailing wide ranging effects of climate change and suggesting response practices).

5 *See generally* Univ. of Cal., Santa Cruz, *Climate Change and Water Supply Security: Reconfiguring Management to Reduce Drought Vulnerability* (California Energy Commission White Paper CEC•500•2012•017, 2012), at 1 (reporting on studies that indicate drought conditions are expected to intensify and that many communities in California already face drought conditions).

6 Assemb. B. 1739, 2013–2014 Leg. (Cal. 2014); S.B. 1168, 2013–2014 Leg. (Cal. 2014); S.B. 1319, 2013–2014 Leg. (Cal. 2014) (codified in various sections of the Government Code and Water Code). *See, e.g.*, Gary C. Bryner & Elizabeth Purcell, GROUNDWATER LAW SOURCEBOOK OF THE WESTERN UNITED STATES 6 (2003), *available at* http://scholar.law.colorado.edu/cgi/viewcontent.cgi?article=1027&context=books_reports_studies (comparing groundwater law across the western states); A. Dan Tarlock, *Prior Appropriation: Rule, Principle, or Rhetoric?*, 76 N.D. L. REV. 881, 883 (2000) (referencing the comprehensive adjudications of water rights undertaken by Arizona, Idaho, and Montana).

7 *See* S.B. 1168, 2013–2014 Leg. (Cal. 2014) ("This bill, with certain exceptions, would prohibit, beginning January 1, 2015, a new groundwater management plan from being adopted or an existing groundwater management plan from being renewed.").

8 *See id.* (stating in findings that groundwater makes up more than one-half of the water used by California residents during drought years).

9 CAL. WATER CODE §§ 10723.6, 10725.2 (West 2009 & Supp. 2015).

10 *Id.* § 10933(b) (stating consideration factors for prioritization); *Id.* § 10920 (directing the DWR to maintain and improve its network of monitoring wells). *See also* Cal. Dep't of Water Res., *California Statewide Groundwater Elevation Monitoring (CASGEM)*, http://www.water.ca.gov/groundwater/casgem (last visited July 18, 2015) (explaining the CASGEM program). The California Department of Water Resources (DWR) is responsible for the management of water usage, including operation of the State Water Project, which delivers water from the northern part of the state to the more populous regions in Southern California. Cal. Dep't of Water Res., *About Us*, http://www.water.ca.gov/aboutus.cfm (last visited July 18, 2015). The DWR also

documentation of the many "undesirable results" to be avoided: chronic lowering of groundwater levels, impaired groundwater quality, seawater intrusion into aquifers, subsidence of surface land, and adverse impacts on hydrologically connected surface waters.[11]

The SGMA is surely a significant, long overdue step in California's ongoing saga to properly manage and conserve its freshwater resources. And yet, as presently formulated, it is very unlikely that the legislature has accomplished its stated goal to manage groundwater "sustainably for long-term reliability and multiple economic, social, and environmental benefits for current and future beneficial uses."[12] The problems arise because, rather than mandating the achievement and maintenance of well defined groundwater levels in its most stressed basins, lawmakers have instead taken refuge in the nebulous concept of "sustainable yield."[13] Further, by relying on a narrative standard that interprets compliance in terms of avoiding "significant and unreasonable" undesirable results,[14] the Legislature is providing little guidance to the agency that will actually administer the law, while also increasing the likelihood that difficult decisions will be made by the courts.

In this Article, I suggest that the general framework of the statute is sound in its reliance on local authorities to sustainably manage groundwaters, but that the law must be amended—or regulations implemented by the State Water Resources Control Board (SWRCB)[15]—to replace the existing narrative standards with mandated, numerical criteria specifying defined levels of groundwater to be retained in each individual basin. Part II reviews the history of groundwater management in California, setting the stage for the SGMA. Part III then describes how the SGMA extends these prior efforts to conserve the resource. This section concludes with an analysis of why the statute's reliance on its particular notion of sustainable yield cannot provide a sufficiently clear and precise standard capable of sustaining groundwater levels in an era of continued population growth and climate change. In Part IV, I first explain why the local groundwater management scheme in the SGMA is consistent with the physical geography of the resource. Next, I describe how science-based management can be incorporated into the SGMA, with a goal of halting the present sharp declines in some groundwater basin water levels. Finally, I address the need for additional research to provide science-based guidance

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maintains an extensive database of publicly accessible information. Cal Dep't of Water Res., *Data*, http://www.water.ca.gov/data_home.cfm (last visited July 18, 2015).

11 CAL. WATER CODE § 10721(w) (West 2009 & Supp. 2015) (defining "undesirable results").

12 *Id.* § 113 (stating the general California state groundwater policy).

13 *See id.* § 10721(v) (defining "sustainable yield").

14 *See id.* § 10721(w) (setting the standard for "undesirable results" for specific groundwater conditions as "significant and unreasonable").

15 The California State Water Resources Control Board (SWRCB), also known as the Water Board, is the state administrative agency with authority to issue regulations to protect water quality and allocate surface water rights. *See* State Water Resources Control Board; *History of the Water Boards*, http://www.swrcb.ca.gov/about_us/water_boards_structure/history.shtml (last visited July 18, 2015) (describing the SWRCB).

for difficult issues associated with land subsidence and conjunctive management. This proposal also seeks to raise awareness of how law and science can practicably work together to preserve the groundwater commons in California.

II. Groundwater Management in California: An Historical Overview

Unlike other Western states, California lacks an integrated legal and administrative scheme for conjunctive management of its surface and groundwaters.[16] The roots of this division lie in the Water Commission Act of 1913,[17] which created an appropriation permit system for surface water rights but, with one exception, failed to mandate a similar process for allocation of the groundwater resource.[18] Owners of overlying land have thus retained rights to pump groundwater and are generally restrained only by the judicial correlative rights doctrine.[19] The exception in the 1913 law has been retained to this day as section 1200 of the California Water Code.[20] In its entirety, this section provides: "Whenever the terms stream, lake or other body of water, or water occurs in relation to applications to appropriate water or permits or licenses issued pursuant to such applications, such term refers only to surface water, and to subterranean streams flowing through known and definite channels."[21]

Because such "subterranean streams" are very rare in California,[22] this provision excludes almost all of the state's groundwater from the requirements of a permitting system.[23] Section 1200 remains in force after enactment of the SGMA, which explicitly states that the new local agencies it creates will lack permitting authority.[24] Remarkably, this entirely artificial division between surface and groundwaters still persists despite longstanding recognition, dating back at least to the seminal *Katz v.*

16 M. Rhead Enion, *Allocating Under Water: Reforming California's Groundwater Adjudications*, *in* Pritzker Envtl. L. and Pol'y Briefs (Emmett Ctron Climate Change and the Envtl., Policy Brief No. 4, Sept. 2013); Joseph L. Sax, *We Don't Do Groundwater: A Morsel of California Legal History*, 6 U. Denv. Water L. Rev. 269, 270 (2003).

17 Water Commission Act of 1913, ch. 586, 1913 Cal. Stat. 1012, 1033 (codified at Cal. Water Code § 1003 (West 2009)).

18 1913 Cal. Stat. §§ 1022, 1033.

19 Katz v. Walkinshaw, 74 P. 766, 772 (Cal. 1903) (establishing the correlative rights doctrine, stating: "In cases involving any class of rights in such waters preliminary injunctions must be granted, if at all, only upon the clearest showing that there is imminent danger of irreparable and substantial injury, and that the diversion complained of is the real cause.").

20 Cal. Water Code § 1200 (West 2009).

21 *Id.*

22 *See* Ca. Dep't of Water Res., California's Groundwater—Bulletin 118 Update 2003 82 (2003), *available at* http://www.water.ca.gov/pubs/groundwater/bulletin_118/california%27s_groundwater__bulletin_118_-_update_2003_/bulletin118-chapter6.pdf (explaining that the SWRCB has issued decisions finding the existence of subterranean streams under just twelve creeks and rivers in California) [hereinafter Bulletin 118].

23 *See* Sax, *supra* note 16, at 270, 300, 304–05 (providing an informative and entertaining discussion of the debate behind the 1913 law).

24 Cal. Water Code § 10726.4(b) (West 2009 & Supp. 2015).

Walkinshaw decision in 1903, that the two resources are hydrologically connected and fully contiguous.[25]

Despite the absence of state-level regulation or permitting, the need to settle disputes and to provide some degree of certainty for water planners gave impetus to a variety of other mechanisms for groundwater management.[26] One such approach to resolve conflicts has been through court adjudication. A key case that determined how settlements are reached was *City of Los Angeles v. City of San Fernando*,[27] which established that groundwater basins should be adjudicated based on the correlative rights doctrine among overlying users and the prior appropriations doctrine for off-tract users.[28] Twenty-six of the 515 enumerated groundwater basins and subbasins in California, including many in the Los Angeles area, are presently subject to adjudication.[29] Local entities in these twenty-six basins are not subject to SGMA-mandated requirements to form a new sustainability agency.[30] Instead, the SGMA directs that the watermaster or other court-appointed body administering the court-ordered allocation plan must report groundwater elevation data, groundwater extractions in the preceding year, surface water supplies available for groundwater recharge, total water use, and changes in groundwater storage.[31]

Although the concentration of adjudicated groundwater basins in populous regions makes this process significant, the primary authority for any groundwater management activity in California has always rested in local jurisdictions.[32] The state legislature has been active in this process to a point, by granting statutory authority to over twenty different types of local agencies.[33] The functions of these administrative bodies are diverse, and extend to the establishment of groundwater recharge programs and levying of pumping fees.[34] Local county ordinances have also proliferated.[35] Often these ordinances provide the authority to require permits for groundwater

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25 Katz v. Walkinshaw, 74 P. 766, at 767–70 (Cal. 1903) (discussing the connection between surface and groundwater and asserting that "[m]any water companies . . . have felt compelled to purchase, and have purchased, at great expense, the lands immediately surrounding the stream or source of supply, in order to be able to protect and secure the percolations from which the source was fed").

26 *See* Sax, *supra* note 16, at 271.

27 537 P.2d 1250 (Cal. 1975).

28 *Id.* at 1319.

29 Cal Dep't of Water Res., *Groundwater*, http://www.water.ca.gov/groundwater/ (last visited July 18, 2015) (stating that California has 515 groundwater basins); CAL. WATER CODE § 10720.8(a) (West 2009 & Supp. 2015) (listing the 26 adjudicated basins).

30 CAL. WATER CODE § 10720.8(a) (West 2009 & Supp. 2015).

31 *Id.* § 10720.8(f)(3).

32 Jan Stevens, *California's Groundwater: A Legally Neglected Resource*, 19 HASTINGS W.-N.W. J. ENVTL. L. & POL'Y 3, 24–25 (2013) (explaining the local planning process).

33 BULLETIN 118, *supra* note 22, at 33.

34 *See id.* at 33–35 (describing the power of local agencies to manage groundwater in underlying basins).

35 *Id.* at 36.

export outside the boundaries of the local jurisdiction.[36] Thus, some permitting of groundwater rights in California does exist at the local level. The principle of local control of groundwater use has been repeatedly reaffirmed by the legislature;[37] hence, the choice made in the SGMA to continue to vest authority for sustainable groundwater management in local agencies came as no surprise.

Several pieces of legislation in the past several decades began to provide the basis for a groundwater management regime containing additional elements of statewide jurisdiction. In 1992, the legislature passed Assembly Bill 3030,[38] which offered a systematic procedure to implement groundwater management plans, thus providing guidance to local authorities.[39] However, reflecting the continued local resistance to state control, the law did not include a requirement for any local administrative entity to actually adopt such a plan.[40] Thus, many districts remained entirely unregulated. However, other state legislative actions followed: most significantly, in 2002 the Legislature passed Senate Bill 1938,[41] which required that any local entity seeking state funds had to implement a groundwater management plan with certain specified components.[42] These included establishment of basin-wide objectives, monitoring of groundwater quality and quantity, and involvement of other local agencies in cooperative planning.[43] These provisions in SB 1938 clearly presaged the development of the SGMA, which also includes these elements in its mandates.[44]

Finally, in 2009 the legislature passed Senate Bill X7 6 (S.B.X.7 6),[45] which requires that either state or local agencies monitor all 515 basins and subbasins in California, to measure groundwater elevation levels.[46] The bill provides that local control is preeminent, because it contains a provision stating that any local program that is effective could not be taken over by state management.[47] Importantly, this legislation also incentivizes local action by making districts ineligible for state funds if they fail to implement

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36 *See id.* at 39 (presenting a table of local ordinances and the elements of each ordinance, including the authority to require an export permit).

37 *See* Stevens, *supra* note 32, at 17–21 (reviewing legislative acts that affirmed local control).

38 Act of Sep. 28, 1992, ch. 947, 1992 Cal. Stat. 4514 (codified at CAL. WATER CODE §§ 10750–10755.4).

39 CAL. WATER CODE §§ 10753–10753.11 (West 2009 & Supp. 2015).

40 *See, e.g.*, Josh Patashnik, Note, *All Groundwater is Local: California's New Groundwater Monitoring Law*, 22 STAN. L. & POL'Y REV. 317, 321 (2011) (explaining that A.B. 3030 gave local governments the authority to implement groundwater management plans, but many counties, including Los Angeles and Orange, chose not to do so).

41 Act of Sep. 16, 2002, ch. 603, 2002 Cal. Stat. 3365 (codified at CAL. WATER CODE §§ 10753, 10795.4).

42 CAL. WATER CODE § 10753.7 (West 2009 & Supp. 2015).

43 *Id.*

44 *Id.* § 10727.2.

45 Act of Nov. 6, 2009, ch. 1, 2009 Cal. Stat. 5367 (codified at CAL. WATER CODE §§ 10920–10936, 12924). For a brief review of S.B.X.7 6, *see* Josh Patashnik, *supra* note 40, at 321.

46 *See* CAL. WATER CODE § 10920(a) (West 2009 & Supp. 2015).

47 *Id.* § 10931(a).

such a monitoring program.[48] By mandating the collection of needed data regarding the extent to which basins are in overdraft, this legislation contributed to increased awareness of the groundwater shortfall problems and likely boosted the prospects for the broader regulatory scheme that is now embodied in the SGMA.[49]

S.B.X.7 6 also provided criteria for ranking the importance of groundwater basins, resulting in a prioritization scheme with four categories: High, Medium, Low, and Very Low.[50] The criteria used were the overlying population and its projected growth, the numbers of public supply and total wells available to measure groundwater levels, the amount of overlying irrigated acreage, the reliance of the local region on groundwater as its primary source, and the impacts of pumping—including overdraft, subsidence, saline intrusion, or other degradation of water quality.[51] The final basin prioritization findings are that 127 of the 515 basins and subbasins are ranked as High or Medium priority, and these particular aquifers are explicitly targeted for regulation in the SGMA.[52] The new statute encourages and authorizes, but does not require, sustainable management plans for Low and Very Low priority basins.[53] The 127 High and Medium priority basins account for 96% of all groundwater extraction in the state, and supply 88% of the population.[54] As of October, 2014, DWR reports that 34 of these 127 basins still remain either partially or fully unmonitored, while all other High and Medium priority aquifers are fully monitored.[55] Thus, the mandates in S.B.X.7 6 and prior statutes to acquire hydrogeological data for sustainable management are being met.

48 *Id.* § 10933.5–10933.7.

49 *See* Patashnik, *supra* note 40, at 327 (explaining that SB X7 6 generated monitoring data in areas that were previously unmonitored).

50 CAL. WATER CODE § 10722.4 (West 2009 & Supp. 2015).

51 *Id.* § 10933.

52 Cal. Dept. of Water Resources, *Groundwater Basin Prioritization: Final CASGEM Basin Prioritization Results—June 2014*, http://www.water.ca.gov/groundwater/casgem/basin_prioritization.cfm (last visited July 18, 2015) [hereinafter *Groundwater Basin Prioritization*]; CAL. WATER CODE § 10720.7(a)(1) (West 2009 & Supp. 2015).

53 CAL. WATER CODE § 10720.7(b) (West 2009 & Supp. 2015).

54 *Groundwater Basin Prioritization, supra* note 52. For information describing the outcome of the ranking system and the geographic distribution of the highly prioritized basins, *see id.* The present basin boundaries cover about 40% of the state; there are 431 basins, of which 24 are divided into a total of 108 subbasins, giving 515 distinct groundwater systems. Cal. Dept. of Water Resources, *Groundwater Basin Maps and Descriptions*, http://www.water.ca.gov/groundwater/bulletin118/gwbasins.cfm (last visited July 18, 2015). For a full list of basins and maps, see *id.*

55 Cal. Dept. of Water Resources, *Updated Report: Groundwater Resources Depleted by Drought*, Dec. 2, 2014, http://ca.gov/drought/news/story-65.html (last visited July 18, 2015). For a list of partially or fully unmonitored basins, *see* Cal. Dept. of Water Resources, UNMONITORED HIGH AND MEDIUM PRIORITY GROUNDWATER BASINS (2015), *available at* http://www.water.ca.gov/groundwater/casgem/pdfs/Web_High_priority_basin_status_10072014.pdf.

III. THE CALIFORNIA SUSTAINABLE GROUNDWATER MANAGEMENT ACT

The aforementioned events offer important context for appreciating the provisions of the SGMA, which now provides a comprehensive groundwater regulatory scheme for the first time in the history of California.[56] As mentioned above, the statute creates new local groundwater sustainability agencies (GSAs), and these entities are charged with implementing groundwater sustainability plans (GSPs) by June 30, 2017.[57] A GSA may be any local agency or combination of agencies overlying a particular basin.[58] The SGMA apparently envisions distinct GSAs for each basin, although DWR will also entertain requests to redraw basin or subbasin boundaries, as may be warranted by ongoing investigations into hydrological properties or to improve management efficiency.[59] To administer the GSPs, the statute provides GSAs with substantial authority, which includes requiring the registration of groundwater wells, imposing well spacing parameters and pumping limits, and demanding data on amounts of groundwater extracted.[60] Basins for which GSAs are not formed or that implement GSPs that fail to sustainably manage the resource will be placed on probationary status, with the possibility that interim plans could be formulated and imposed by the SWRCB.[61] These mandates in the law impose much more state-level groundwater management than has previously been the case.[62] Clearly there has been a breakthrough in the willingness of the legislature to assume regulatory control, and this must be accorded great significance following over a century of strong resistance.

What must the GSPs actually consist of, and what standards does the SGMA impose for meeting them? At first blush, the law appears to give many good answers to these key questions. Every GSA must establish a

56 *See* Ass'n of Cal. Water Agencies, *Sustainable Groundwater Management Act of 2014*, http://www.acwa.com/content/groundwater/groundwater-sustainability (last visited July 18, 2015) (providing useful information summarizing the law). The SGMA is the amalgam of three companion bills: Assemb. B. 1739, 2013–2014 Leg. (Cal. 2014), S.B. 1168, 2013–2014 Leg. (Cal. 2014); and S.B. 1319, 2013–2014 Leg. (Cal. 2014). *See* Cal. Dept. of Water Resources, *Key Legislation*, http://www.water.ca.gov/groundwater/groundwater_management/legislation.cfm (last visited July 18, 2015). Assemb. B. 1739 amends §§ 348, 1120, 1552, 1831, 10721, 10726.4, and 10726.8, and adds §§ 5200 and 10729–10735 to the California Water Code. *See* Assemb. B. 1739. S.B. 1168 amends §§ 10927, 10933, and 12924, and adds §§ 113, 10750.1, and 10720 to the California Water Code. *See* S.B. 1168. S.B. 1319 amends 10735.2 and 10735.8 of the California Water Code. *See* S.B. 1319.

57 CAL. WATER CODE § 10735.2(1) (West 2009 & Supp. 2015).

58 *Id.* § 10723(a).

59 *Id.* § 10722.2(a). Many subbasins were determined in the absence of adequate data, and thus require further studies for better delineation. *See* BULLETIN 118*, supra* note 22, at 11 (recommending that basin boundaries identified in Bulletin 118 should be updated as better data becomes available).

60 CAL. WATER CODE §§ 10725.6, 10726.4(a), 10725.8(c), 10725.8(d) (West 2009 & Supp. 2015).

61 *Id.* §§ 10735.2, 10735.4.

62 *See supra* notes 32–42 and accompanying text (discussing how the history of groundwater management activity has always rested in local jurisdictions and how locals have continued to resist state control).

sustainability goal, defined as the existence and implementation of one or more GSPs that achieve sustainable groundwater management by identifying and implementing measures to have the basin operate within its sustainable yield.[63] The GSP must include 1) a description of the present state of the basin, including its recharge areas; 2) measurable objectives with interim milestones and how the plan facilitates meeting them; 3) a planning and implementation horizon; 4) components relating to measurement and management, as well as replenishment and avoidance of "undesirable results"; 5) a summary of monitoring information; and 6) monitoring protocols.[64]

As described in Part I, the "undesirable results" are defined as chronic lowering of groundwater levels indicating a *significant and unreasonable* depletion of supply over a fifty year planning window, *significant and unreasonable* reduction of storage, seawater intrusion, land subsidence, or degraded water quality, or *significant and unreasonable* adverse impact on beneficial use of surface water.[65] This is certainly a comprehensive list and indicates that the legislature is well aware of what the management objectives should be. However, the all-important key to the success of the law is the standard applied to meet these objectives—namely, the "sustainable yield." This is defined as "the maximum quantity of water, *calculated over a base period representative of long-term conditions in the basin and including any temporary surplus*, that can be withdrawn annually from a groundwater supply without causing an *undesirable result*."[66] There are two major difficulties associated with the use of this sustainable yield standard, each of which may severely limit the effectiveness of the law.

First, in light of accelerating climate change, there is no definable base period that is representative of long-term conditions in any California groundwater basin.[67] The recently published National Climate Assessment, an exhaustive study carried out by a panel of 300 experts and reviewed by the National Academy of Sciences, documents the severe water resource challenges for the American Southwest that are all but certain to develop in the next few decades and beyond.[68] Snowpack and streamflow amounts are projected to continuously decline, amplifying decreases already recorded in the past few decades and further reducing recharge flow into aquifers.[69] Importantly, paleoclimatological investigations further indicate that, over a timespan encompassing at least several millennia, the past 150 years

63 CAL. WATER CODE §§ 10727, 10727.2 (West 2009 & Supp. 2015).

64 *Id.* § 10727.2.

65 *Id.* §§ 10721(q), 10721(w); *see supra* Part I.

66 CAL. WATER CODE §10721(v) (West 2009 & Supp. 2015) (emphasis added).

67 B. LYNN INGRAM & FRANCES MALAMUD-ROAM, THE WEST WITHOUT WATER: WHAT PAST FLOODS, DROUGHTS, AND OTHER CLIMATIC CLUES TELL US ABOUT TOMORROW 9–10, 20 (2013) (pointing out that extreme fluctuations of precipitation over long periods of time make it hard to predict what to expect in the future).

68 Gregg Garfin et al., *Ch. 20: Southwest in* CLIMATE CHANGE IMPACTS IN THE UNITED STATES: THE THIRD NATIONAL CLIMATE ASSESSMENT 462–71 (2014), *available at* http://nca2014.globalchange.gov/report/regions/southwest.

69 INGRAM & MALAMUD-ROAM, *supra* note 67, at 193–96.

represents a particularly wet period.[70] These findings demonstrate that there simply is no recent time period for which groundwater data are available and capable of reliable extrapolation to estimate "sustainable yield" as defined in the statute. It is troubling that the legislature defines climate change as a motivating factor in the preamble to the SGMA,[71] yet ignores its effects entirely in drafting one of the key provisions. Since surface water supplies are projected to continually decrease in the upcoming decades, any definition of the base period as encompassing the present or past decades will almost certainly result in significant groundwater depletions over the long term.[72]

Second, undesirable results are enumerated as narrative standards. For a GSA to be out of compliance with the statute, thereby triggering the designation of the local basin as probationary by the SWRCB, there must be a finding that the GSP is not being implemented in a manner that will likely achieve the *sustainability goal*.[73] This implies that one or more of the deficiencies are present in the basin to a degree that is *significant and unreasonable*, and may also be manifested in findings of significant depletions of interconnected surface waters or a condition of long-term overdraft.[74] However, the SGMA does not address either the procedures by which these findings would be adjudicated, or how to resolve conflicts between water rights holders.[75] Even presuming that these matters become the subject of subsequent legislation or administrative rulemaking, it is questionable whether narrative standards can provide sufficient force and definition to be effective in the face of the severe and inevitable pressures that increasing water scarcity will create to avoid the statutory mandate. In fact, the SGMA does not ban groundwater mining, land subsidence, water quality degradation, saline intrusion or harmful diminution of surface flows—but only *significant and unreasonable* manifestations of these.[76]

In addition to these difficulties, another concern is that the required timeframes for implementation are quite long.[77] GSAs for the highest priority basins in "critical conditions of overdraft" must produce GSPs by January 31, 2020,[78] while those for other high and medium priority basins are due two

70 *Id.* at 206.

71 S.B. 1168, ch. 346, §§ 1(a)(11), 1(b)(3), 2013–2014 Leg. (Cal. 2014).

72 Garfin, *supra* note 68, at 465–66.

73 CAL. WATER CODE § 10735.2(a)(3), 10735.2(a)(5)(A)–(5)(B) (West 2009 & Supp. 2015).

74 *Id.* §§ 10735(a), 10735(d), (West 2009 & Supp. 2015).

75 *See id.* § 10732 (the violations and penalties provisions of the SGMA, lacking mechanisms for adjudication or resolution of conflicts for water rights holders).

76 *Id.* § 10721(w).

77 *See e.g.*, Mark J. Hattam, *California Acts to Manage Statewide Groundwater Issues*, THE NAT'L L. REV., Sept. 19, 2014, http://www.natlawreview.com/article/california-acts-to-manage-statewide-groundwater-issues (last visited July 18, 2015) (stating that the timeframes will be considered slow by many).

78 CAL. NATURAL RES. AGENCY, CALIFORNIA DEP'T OF WATER RES., *California Statewide Groundwater Elevation Monitoring* (CASGEM) STATUS REPORT 7, *available at* http://www.water.ca.gov/groundwater/casgem/pdfs/2012%20CASGEM%20Report%20to%20the%20Legislature.pdf (explaining that basins in "critical conditions of overdraft" are distinguished as a separate and very highest priority category). These basins, a subgroup within those designated

years later.[79] However, for all plans, the sustainability goal within the basin need only be met within twenty years of implementation of the GSP, and there is provision for up to two additional five-year extensions.[80] Therefore, some basins that are critically overdrafted now may be lawfully managed within the statute even if they do not meet sustainability goals until 2050. This is a sobering reality check for any Californians hoping that the SGMA would offer a path better grounded in the urgency of the present circumstances.

IV. BEYOND THE STATUTE: A VISION FOR SCIENCE-BASED GROUNDWATER MANAGEMENT IN CALIFORNIA

How can the SGMA be amended in ways that are acceptable given the political realities of water management in California? The essential shortcoming of the law is that it fails to create a legal and administrative framework that is properly informed by and consistent with state-of-the-art climate change science and hydrogeology. Fortunately, as described below, the deficiencies can be remedied in ways that can be introduced incrementally and that can be presented such as to retain the public support of Californians. Historically, the state's populace has embraced its image as a national trendsetter in both environmental policy and technology development generally.[81] Most recently, in the 2014 elections, the electorate endorsed passage of the Proposition 1 ballot measure, which allocates $7.5 billion to building water infrastructure and quality control.[82] It seems clear, then, that Californians are well aware of the critical importance of their water resources. Therefore, positively communicating the deficiencies of the SGMA while suggesting scientifically-based solutions is a project that may plausibly succeed.

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as high priority, are in the process of being updated. In the 2003 updates to Bulletin 118, eleven such basins were specified. BULLETIN 118, *supra* note 22, at 98; CAL. WATER CODE § 10720.7(a)(1) (West 2009 & Supp. 2015).

79 CAL. WATER CODE § 10720.7(a)(2) (West 2009 & Supp. 2015).

80 *Id.* § 10727.2(b)(1), (3).

81 *See, e.g.*, Alex Jackson, *Results Are In: California Carbon Market Takes Flight; Backed by 2-to-1 Support*, NATURAL RESOURCES DEFENSE COUNCIL SWITCHBOARD, Nov. 19, 2012, http://switchboard.nrdc.org/blogs/ajackson/results_are_in_california_carb.html (last visited July 18, 2015) (recognizing that in the two polls to emerge after California held its first cap–and–trade auction "Californians overwhelmingly support the cap–and–trade program as a way to hold polluters accountable and drive investment in clean energy technologies and infrastructure").

82 Katherine Hafner & Jonathan Lloyd, *"Save Money, Save Water": CA Voters Pass Fiscal Propositions 1 and 2*, http://www.nbclosangeles.com/news/local/Calif-Voters-Pass-Fiscal-Propositions-1-and-2-281557631.html (last visited July 18, 2015); *see also* CAL. ATTORNEY GEN., WATER BOND. FUNDING FOR WATER QUALITY, SUPPLY, TREATMENT, AND STORAGE PROJECTS 6–9 (2014), *available at* http://vig.cdn.sos.ca.gov/2014/general/en/pdf/proposition-1-title-summary-analysis.pdf (providing a detailed summary of Proposition 1).

A. Local Groundwater Management is Suited to the Physical Geography of the Resource

To first give the statute its due, I should note that its choice—however politically necessitated—to embed fundamental management functions in local sustainability agencies is a sound one. To see this requires a brief primer on the physical nature of groundwater in California. Most of the state's groundwater is concentrated in alluvial basins, which consist of loose and unconsolidated soils and sediments—the water-accessible *aquifer* portions—together with much more finely grained clay and silt sediment beds that retard the passage of water—*aquitards*.[83] Almost all of California's groundwater basins are *semiconfined*, with multiple intermingled aquifer and aquitard layers leading to increased water entrapment and decreased extractability with greater depth.[84] The bottom and sides of the basins are composed of relatively impermeable bedrock, fine-grained sediments, or other materials that inhibit water transport, so that the basin dimensions can be well defined.[85] Subbasins are defined either by clear hydrologic features, such as a stream that creates a groundwater divide, or are based on political boundaries.[86] In addition to these alluvial basins, volcanic, sedimentary, metamorphic, and other types of rocks also can contain significant amounts of groundwater.[87] These regions are confusingly termed "groundwater source areas," and their hydrologic features are much less well understood.[88] Because there is also much less groundwater in these areas, and the overlying populations are relatively small, they have not been subjected to regulation under the SGMA.[89]

The 515 alluvial basins and subbasins are fairly well distributed across the state of California.[90] Although their general features are common, the detailed geologic ultrastructure that controls each basin's particular hydrologic response is unique, and each must become independently well understood to optimize water management.[91] Subsurface connections between basins do exist in some regions, which will require collaboration between some GSAs.[92] However, in general the physical nature of the resource clearly lends itself to localized administration. This is extremely

83 BULLETIN 118, *supra* note 22, at 80.

84 *Id.* at 80, 87.

85 *See id.* at 88 (discussing the characteristics of groundwater basins and their boundaries).

86 *Id.* at 90.

87 *Id.*

88 *Id.* These regions are primarily located in the more mountainous northern and eastern portions of the state. *Id.* at 90, 92.

89 *See* CAL. WATER CODE § 10727(a) (West 2009 & Supp. 2015) (requiring a groundwater sustainability plan for medium- or high-priority basins); Cal. Dep't of Water Res., *supra* note 55 (showing very low- and low-priority basins in the northern and eastern mountainous areas of the state).

90 *See* Cal. Dep't of Water Res., *supra* note 55.

91 *See infra* Part IV.C.

92 *See* BULLETIN 118, *supra* note 22, at 88 tbl. 8, 92 (discussing how basins and subbasins can have political boundaries, such as a county line, that are not related to the hydrological boundaries, indicating that subsurface connections can exist between basins).

fortunate given the resistance to centralized groundwater management in California.[93] It is indeed a happy coincidence that political necessities are consistent with the physical geography of the commons to be managed.

B. Mandating Numeric Standards for Groundwater Levels

How should the SGMA be amended to better fulfill its purpose to conserve the groundwater resource? As mentioned above, the most glaring deficiency in the law is that the sustainable yield standard is linked to a base period "representative of long term conditions" that, because of past, present, and future projected climate change, simply cannot be defined.[94] Put differently, the statute fails to recognize that we are now entering uncharted climate territory without historical precedent. Perhaps in tacit acknowledgment of this, the law nowhere describes how a base period should be determined, nor does it articulate whether a single base period is envisioned for all managed basins or whether individual basins might be distinguished in this regard.[95] The SGMA also does not describe what physical parameters should be captured within the meaning of "long-term conditions," or, again, whether such conditions could be distinctive to individual basins.[96] The legislature's use of such a clearly flawed basis for defining the key standard in the law demonstrates that it has chosen to ignore the scientifically well-accepted forecasts of increasing drought in the twenty-first century. This matters because using a relatively wet base period to define maximum withdrawals will produce groundwater depletions if subsequent years are drier, as predicted.[97]

One way to bring the SGMA's definition of sustainable yield at least partly within the bounds of climate science would be to precisely define a base period that encompasses times of historical drought. This would result in lower amounts of maximally withdrawable water per year. However, even if such a definition were to be added to the statute, the absence of detailed climate records would make it very difficult to calculate what the maximum quantity of water to withdraw should actually be.[98] Such a precise definition would also not solve the problem of how to identify a single base period in the context of continually decreasing rainfall over the twenty-first century, nor would it account for the possibility that twenty-first century droughts

93 *See supra* notes 32–42 and accompanying text (discussing how the history of groundwater management activity has always rested in local jurisdictions and how locals have continued to resist state control).

94 *See supra* Part III; CAL. WATER CODE §10721(v) (West 2009 & Supp. 2015).

95 *See* CAL. WATER CODE § 10721(v) (West 2009 & Supp. 2015) (defining sustainable yield as being calculated over a base period without defining the length of the base period).

96 *See id.* (failing to describe the physical parameters or individual nature of basins in conjunction with long-term conditions).

97 *See supra* Part III (predicting that decreasing surface water supplies in the future will likely result in groundwater depletion if current or past decades are included in the definition of the base period).

98 *See supra* Part III (explaining that the sustainable yield standard depends on a base period that cannot reliably represent long term conditions because of climate change).

might well be worse than historical droughts of the past millennium. Of course, in practice, water managers in SGAs and at the SWRCB will not be performing *calculations*; instead, they will manage operationally to avoid *significant and unreasonable* undesirable results—and they will inevitably impose their own personal notions of what this entails.[99] Under the SGMA, as now, Californians will have little recourse beyond hoping that the water managers of their local basins make good choices.

The SGMA does not hold water managers sufficiently accountable to preserve the commons. Managers will be under increasing pressure to allow more pumping as surface flows continue to decline, and the SGMA does not prevent them from defining *significant and unreasonable* in increasingly less stringent terms.[100] This severely risks irrevocable losses to the resource, since surface flows for artificial replenishment of basins will also be declining.[101] To remedy this, Californians must be willing to break with the past in a significant way: *they must demand that the SGMA mandate numeric criteria for minimum required water levels in every High and Medium priority groundwater basin managed by an SGA*. The purpose of imposing these numeric criteria, at least initially, is to provide a mechanism to stem the present tide of ongoing groundwater losses.

The need for the numeric mandate will become ever clearer with time if basin water levels continue to drop as predicted.[102] That stark physical reality is best confronted now, before water shortages become even more severe, and energy costs to lift water from increasingly deep wells become prohibitively high.[103] The discretion of GSAs must be limited in favor of a science-based management approach, so that: 1) the inexorable impact of climate change on water resources is fully embodied in the provisions of the law, not relegated to a general statement in the preamble; and 2) precise measurement techniques are employed to define and regularly monitor groundwater levels. California law already embodies the second of these precepts,[104] and data on declining groundwater levels is available.[105] However,

99 CAL WATER CODE § 10721(w) (West 2009 & Supp. 2015) (defining "undesirable results" as "significant and unreasonable" effects caused by groundwater conditions occurring throughout the basin, but not providing a definition for "significant and unreasonable," leaving water managers to determine its meaning).

100 The statute contains a provision indicating that GSPs should be periodically reviewed and updated to accommodate changing basin conditions. *Id.* § 10728.2. Nothing in the SGMA, however, specifically requires that increasing depletions be met with decreased withdrawals. *See id.* § 10721(w) (failing to mention any discussion about withdrawals following increased depletions).

101 Garfin, *supra* note 68, at 464–66 (highlighting projections of reduced precipitation and runoff from winter snowpack throughout the Southwest).

102 *Id.*; *see infra* notes 128 and 135 (discussing how competing groundwater uses will not be met in the future and suggesting that new management approaches, such as numeric standards, will be required).

103 Garfin, *supra* note 68, at 463; Tara Moran et al., *The Hidden Costs of Groundwater Overdraft*, http://waterinthewest.stanford.edu/groundwater/overdraft/ (last visited July 18, 2015).

104 *See supra* Part III; CAL. WATER CODE § 10727.2 (West 2009 & Supp. 2015) (requring GSPs to include specific data and measurable objectives).

the ongoing reductions in groundwater reserves suggest that this information alone is insufficient to motivate actions needed to conserve the resource. To make use of this knowledge, numeric criteria to maintain groundwater levels above defined lower limits provides a precisely targeted approach.

Although this proposal for comprehensive management of California's groundwater is novel,[106] the use of numeric criteria is well established in the context of water quality standards and other pollution control laws. In California, the Porter-Cologne Water Quality Control Act[107] sets use-based water quality criteria.[108] This state law defines water more broadly than the federal Clean Water Act,[109] and includes groundwater within its ambit.[110] Also, regulations established under the California Health and Safety Code specify numeric maximum contaminant levels for drinking water,[111] and numeric standards for salinity.[112] Hence, use of numeric standards to mandate minimum aquifer groundwater levels under the SGMA follows that precedent. Given the extensive water quality provisions already established in California law and applicable to groundwater, provisions in the SGMA that mandate the avoidance of significant and unreasonable adverse effects on *groundwater quality*, or significant and unreasonable *saline water intrusion* into coastal aquifers, might be amended to refer to the relevant sections of the Porter-Cologne Act.

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105 *See* Cal. Dep't of Water Res., *Maps and Reports*, http://www.water.ca.gov/groundwater/data_and_monitoring/groundwater_reports.cfm (last visited July 18, 2015) (providing groundwater level change maps).

106 *See, e.g.*, Sharon Megdal, *Arizona Groundwater Management*, THE WATER REPORT, Oct. 15, 2012, at 9, *available at* http://www.thewaterreport.com/Issues%20101%20to%20104.html. Although Megdal describes the 1980 Arizona Groundwater Management Act as the most far-reaching groundwater management statute in the United States, *id.*, the statute still does not mandate the numeric criteria suggested in this Article. *See* ARIZ. REV. STAT. ANN. §§ 45-401–704 (West 2012). The Arizona statute uses a "safe-yield" criterion that might be characterized as "narrative-numeric." *Id.* § 45-561(12). "'Safe-yield' means a groundwater management goal which attempts to achieve and thereafter maintain a long-term balance between the annual amount of groundwater withdrawn . . . and the annual amount of natural and artificial recharge . . . ." *Id.* While speaking in terms of *amounts*, the law nonetheless does not require maintenance of defined water levels. *See id.* § 45-562 (noting that the management goals for areas in Arizona require meeting safe-yield but do not require meeting a specific amount).

107 CAL. WATER CODE §§ 13000–16104 (West 2009 & Supp. 2015).

108 *See id.* § 13241.

109 Federal Water Pollution Control Act, 33 U.S.C. §§ 1251–1387 (2012).

110 CAL. WATER CODE § 13169 (West 2009 & Supp. 2015) (authorizing the SWRCB to develop and implement a groundwater protection program that conforms to the Safe Drinking Water Act, 42 U.S.C. §§ 300f–300j-9 (2012)); 40 C.F.R. § 122.2 (2013) (excluding groundwater from the definition of "waters of the U.S.").

111 CAL. HEALTH AND SAFETY CODE § 116365 (West 2014) (allows for the establishment of drinking water quality standards). For precise numerical maximum contaminant levels, see, e.g., Cal. Code of Regulations, § 64431 (listing maximum contaminant levels for inorganic chemicals).

112 The California Department of Public Health has established numerical drinking water standards for salinity. *See* STATE WATER RESOURCES CONTROL BOARD, GROUNDWATER INFORMATION SHEET—SALINITY (2d), *available at* http://www.waterboards.ca.gov/gama/docs/coc_salinity.pdf.

Numeric criteria may be resisted on the grounds that their imposition interferes with established groundwater pumping rights. One way to address this would be to allocate the work of determining what the minimum groundwater levels should be to the local GSAs, with mandated review by the SWRCB. This envisions a collaborative process allowing local interests a stronger voice, rather than a command and control approach. The revised statute—or the implementation of administrative rules—should specify a timeframe for identifying groundwater levels. A reasonable timeframe could be when the GSP is implemented, although postponements may be appropriate for some basins to allow necessary data acquisition before levels can be specified.[113] Bringing adjudicated basins into the larger framework of the amended law will require that the courts relinquish or at least substantially modify their supervisory functions to include numeric standards.

Numeric standards offer the possibility of a more objective and transparent process whereby GSAs justify allocation decisions with respect to the more precise standard. Such decisions should be less likely to be perceived as arbitrary or to favor particular political constituencies. The agency may also be more likely to reveal its assumptions and to disclose uncertainties in its analysis. Numeric criteria will also provide a better framework to enable more rational allocation of local permits for off-basin uses of groundwater. The numeric standards imply a more active role for the GSA in monitoring the groundwater levels, beginning with the identification of gaps in the existence of groundwater wells, and requests for state funding to drill additional monitoring wells, as may be necessary.[114] More comprehensive and detailed information about how groundwater levels may vary in different subregions of an aquifer might also facilitate the development of regulated water markets aimed at enabling more efficient allocations.[115]

A difficult question with respect to the implementation of numeric criteria is how the SWRCB should respond when basins are in non-compliance. There are at least two ways in which the SWRCB might facilitate a GSA's efforts to meet the numeric standards. First, the SWRCB may take a more active role in investigating wasteful water practices in the basin, and, having identified these, may provide guidelines and incremental standards for helping both GSAs and surface water districts to implement better water conservation and efficiency practices. Enforcing better measurement and monitoring of water diversions and uses is an essential

113 *See infra* Part IV.C (arguing that it is necessary to gather data to calculate groundwater budgets and establishing that California has the capacity to begin this task). GSPs must be completed by January 31, 2020 for basins in critical conditions of overdraft, and by January 31, 2022 for all other High and Medium priority basins. CAL. WATER CODE § 10720.7(a) (West 2009 & Supp. 2015).

114 *See infra* Part IV.C (explaining that the effective implementation of numeric standards will require an extensive system of monitoring wells and further allocation of funds).

115 Kevin M. O'Brien, *Water Marketing in California*, 19 PAC. L. J. 1165, 1171–72 (1988) (explaining that ambiguity concerning water rights creates barriers to water markets).

aspect of this work.[116] Second, the SWRCB may help enhance local groundwater reserves by supporting a GSA's efforts towards maximizing aquifer recharge.[117] This will be facilitated by the recent passage of Proposition 1, which obligates $2.7 billion dollars towards construction of water storage projects, dams, and reservoirs.[118] Diversion of excess surface flows into aquifers without damaging instream uses is essential to groundwater conservation, because it compensates for variations in seasonal flows and, in contrast to surface storage, incurs little to no evaporative losses.[119] The SGMA requires mapping of aquifer replenishment areas, and suggests—but does not mandate—replenishment as an option for GSAs to consider in meeting their sustainability goals.[120] However, mandated recharge programs should be considered for basins that are out of compliance with the numeric standards.

C. Acquiring Additional Hydrological Data for California's Aquifers

Finally, it is necessary to address in more detail how the specific numeric criteria are to be determined. This question implicates larger issues of whether enough is known of aquifer hydrology to enable proper specifications of lower limits to water levels, an objection that will certainly be raised by those who would oppose the proposal.[121] Further, the SGMA also seeks to manage groundwater to avoid significant and unreasonable land subsidence and adverse impacts to surface flows.[122] These complex issues require in-depth understanding of the particular characteristics of individual aquifers. In particular, managing aquifers by monitoring water levels alone is insufficient to safeguard the integrity of surface waters, since maintenance of the water table may only reflect draining of interconnected lakes or rivers.[123]

Information regarding aquifer characteristics and groundwater responses to climate stress derives from three types of measurements: 1) ground-based monitoring by traditional techniques such as the use of

116 Janet C. Neuman, *Beneficial Use, Waste and Forfeiture: The Inefficient Search for Efficiency in Western Water Use*, 28 ENVTL. L. 919, 986 (1998).

117 *See* Ruth Langridge, *Drought and Groundwater: Legal Hurdles to Establishing Groundwater Drought Reserves in California*, 36 ENVIRONS ENVTL. L. & POL'Y J. 91, 93–94, 102, 106, 113 (2012) (explaining that the SWRCB could expand its jurisdiction to decrease overdraft of aquifers and increase local groundwater reserves).

118 *See supra* note 82 and accompanying text (providing details on how the Proposition 1 budget for building water infrastructure is allocated).

119 *See* Sharon B. Megdal & Peter Dillon, *Policy and Economics of Managed Aquifer Recharge and Water Banking*, 7 WATER 592 (2015) (explaining that managing the recharge of aquifers can play an important role in buffering against drought and climate change).

120 CAL. WATER CODE §§ 10727.2(a)(5), 10727.2(d)(4), 10727.4 (West 2009 & Supp. 2015).

121 *See* Joseph W. Dellapenna, *A Primer on Groundwater Law*, 49 IDAHO L. REV. 265, 267–268 (2013) (explaining that hydrogeology emerged as a full-fledged science only relatively recently, and indicating the existence of "disconnects" between water science and water law).

122 CAL. WATER CODE § 10721(w)(5)–(6) (West 2009 & Supp. 2015).

123 *See* BULLETIN 118, *supra* note 22, at 81–83 (describing the physical interconnection of groundwater and surface water).

fluorescent tracers, aquifer pumping tests and fine textural analysis of sediments; 2) numerical modeling to simulate the three-dimensional spatial characteristics of groundwater basin sediments and water movements; and 3) satellite monitoring of groundwater depletion by the Gravity Recovery and Climate Experiment (GRACE) of the National Aeronautics and Space Administration (NASA).[124] State-of-the-art work has been conducted to generate a hydrological model of California's Central Valley, computed over fine spatial resolutions: the textural model of the basin, for example, which contains a fine-scale description of sediment characteristics, is attributed on surface grid points separated by one mile, and then at fifty-foot intervals from the surface to a depth of 2,800 feet.[125] The modeling accounts for all major surface flows, including irrigation and diversions from north to south in the valley.[126] The amount of water and its distribution in the Central Valley Basin is thus very well-known from both conventional modeling and measurements, and from the more recent GRACE data.[127] Estimates from GRACE describe a 14% water loss since the advent of large scale irrigation, which is concentrated almost entirely in the southern Tulare basin.[128] GRACE measurements of depletion during a drought in the late 2000s are similar to depletions estimated from groundwater modeling for previous droughts, suggesting that these approaches are complementary.[129]

The Central Valley model allows for the calculation of groundwater budgets that account for all input and output flows, and the fine textural model of the sediments also allows for both assessment of the potential for land subsidence.[130] and evaluation of preferred areas at which to target aquifer recharge.[131] However, while clearly an essential tool, the model remains limited by the amount of experimental ground-based monitoring data.[132] Further, other basins in California have not been so thoroughly analyzed, and the required extensive system of monitoring wells does not yet

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124 B.R. Scanlon et al., *Groundwater Depletion and Sustainability of Irrigation in the U.S. High Plains and Central Valley*, 109 PROC. NAT'L ACAD. SCI. OF THE U.S. 9320, 9320 (2012); CLAUDIA C. FAUNT ET AL., U.S. GEOLOGICAL SURVEY, GROUNDWATER AVAILABILITY OF THE CENTRAL VALLEY AQUIFER, CALIFORNIA 1–2 (2009), *available at* http://pubs.usgs.gov/pp/1766/PP_1766.pdf; James S. Famiglietti & Matthew Rodell, *Water in the Balance*, SCIENCE 340, 1300–01 (2013).

125 *See* FAUNT, *supra* note 124, at 2.

126 *See id.* at 2–3 (describing the process used for simulating the hydrologic system of the Central Valley).

127 *Id.* at 1. The total amount in the upper 1,000 feet of sediments is 800 million acre-feet. *See id.* at 103.

128 *See* Scanlon, *supra* note 124, at 9321. Based on measured ongoing losses, expert opinion is that competing groundwater uses will ultimately not be met in the Central Valley even when climate change is not accounted for. *See* FAUNT, *supra* note 124, at 104. New management approaches are thus clearly required.

129 *See* Scanlon, *supra* note 124, at 9324. Estimated groundwater storage measurements from GRACE experiments are also highly correlated with those from detailed groundwater monitoring data in the central plains aquifer of the United States. This further supports the notion that these measurements are complementary.

130 *See* FAUNT, *supra* note 124, at 98.

131 *Id.* at 108.

132 *See id.* at 109–10 (discussing the lack of an integrated monitoring network in California and the data gaps in the model).

exist in many areas.[133] Addressing these deficiencies will require the state to allocate substantial funds for well construction and monitoring, and such spending will be needed initially for effective implementation of numeric standards for groundwater levels in each highly stressed aquifer.[134] Knowledge of aquifer characteristics must advance rapidly and sufficiently so that informed choices can be made regarding which wells are best suited to provide the groundwater levels on which the numeric standards can be based.[135] Later, after groundwater levels stop declining, the data derived from additional wells will facilitate modeling of groundwater budgets for all California aquifers.

To be most useful, science-based groundwater management should ultimately be able to reliably estimate, for different climate change scenarios, how much groundwater can be withdrawn from each basin to maintain levels sufficient to avoid subsidence, diminished water quality, and adverse effects on surface flows.[136] Modeled groundwater budgets based on new experimental information are essential for this.[137] While we are still a long way from this goal, it is important to begin to concretely imagine such a comprehensive conjunctive management scheme and, most importantly, to recognize that present limitations do not arise from a fundamental lack of physical understanding or from inadequate measurement technology, but

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133 *See id.*; Famiglietti, *supra* note 124, at 1301 ("few hydrologic observing networks yield sufficient data for comprehensive monitoring of changes in the total amount of water stored in a region").

134 *See* James D. Fine & Dave Owen, *Technology and Democracy: Conflicts Between Models and Participation in Environmental Law and Planning*, 56 HASTINGS L.J. 901, 913 (2005) (noting the costs associated with building and improving models used in policy decisions). Obtaining land rights for well sitings has often been difficult. *See* Nathan Bracken, *Exempt Well Issues in the West*, 40 ENVTL. L. 141, 227 (2010) (discussing a program in Washington State that made it "difficult for developers to obtain water permits"). If necessary, California must exercise eminent domain to take land for this public use, while paying just compensation. *See* D. Zachary Hudson, *Eminent Domain and Due Process*, 119 YALE L.J. 1280, 1292 (2010) (discussing the due process requirements imposed on the exercise of eminent domain authority in California). Of course, this increases costs.

135 *See* MINN. DEP'T OF NATURAL RES., GROUNDWATER TECHNICAL WORKGROUP, EVALUATION OF MODELS AND TOOLS FOR ASSESSING GROUNDWATER AVAILABILITY AND SUSTAINABILITY: PRIORITIES FOR INVESTMENT 12, n.10 (2010) *available at* http://files.dnr.state.mn.us/publications/waters/modelsandtools.pdf (suggesting that "[o]nce the important relationships and the available data are known, . . . the conceptual model [could be] used to guide efforts to create an analytical or numerical model"). It is likely that many if not all basins would define the numeric standard based on aggregating data from a number of representative wells. *See* Scanlon et al., *supra* note 124, at 9320 (describing groundwater depletion study methodology "based on water level monitoring in ~9,000 wells in the [High Plains] and ~2,300 wells in the [California Central Valley]"). To provide a common standard, levels in each well might be defined as heights above or below sea level.

136 *See* FAUNT, *supra* note 124, at 102 (describing how future hydrologic conditions can be predicted through analysis of "historical climate variability" and describing some likely future changes based on projections).

137 *See id.* ("The response of the hydrologic system during dry years in the historical record can be used as an indicator of possible changes in the landscape and groundwater budgets in future droughts.").

primarily from the fact that sufficient data have not been gathered yet.[138] Uncertainties will remain no matter how much ground-based monitoring is done, but they will also be further reduced by predictable continued advances in computational power and numerical modeling techniques. The main task now is to acquire the necessary experimental information, and this is well within the capability of California to achieve.

V. CONCLUSION

Projected changes in the climate system for many twenty-first century scenarios predict significant decreases in precipitation for the American Southwest, and concomitant diminution in surface freshwater flows.[139] Placing California's water resources on a secure footing thus necessarily requires aggressive policies to preserve the groundwater resource on which the population is expected to increasingly rely. Declining aquifer levels justify serious concern and hence a substantive shift in water management approaches to enforce quantitative, numeric standards for maintaining water tables within safe parameters. As presently written, the SGMA allows too long for GSAs to implement sustainability regimens, and it relies on narrative standards that can be easily interpreted to permit continued groundwater mining beyond reasonable capacities for replenishment. Put differently, despite the new focus on state-level governance, the SGMA remains a statute that relies on an optimistic view of California water resources incongruent with the known physical realities of climate change. To preserve the hidden groundwater commons for sustained public use and future generations, the California legislature still has work to do to fulfill its clear duty to embody the findings of climate science within the action-forcing provisions of the law.

138 *See* Jessica A. Reeves et al., *Estimating Temporal Changes in Hydraulic Head Using InSAR Data in the San Luis Valley, Colorado*, WATER RESOURCES RESEARCH 4459 (2014) (describing how a remote sensing method for groundwater measurement can address current gaps in conventional hydraulic head measurements).

139 Garfin, *supra* note 68, at 465; FAUNT, *supra* note 124, at 104.