Global Water primer: California dreamin' (of water)

Primer

Equity | 10 July 2015

A transforming world: global water crisis

As part of our work on A Transforming World, we update our Earth-focused theme with this Primer and a Primer Picks report – setting out the challenges and opportunities around global water with a deep-dive focus on the California water crisis.

California drought: a sign of things to come globally

We view the unprecedented drought in California as a harbinger of the coming global water crisis. California is in its 4th straight year of drought, with the last 3Y being the driest in recorded history. Groundwater levels have plunged up to 15-30m (50-100ft) and the Sierra Nevada snowpack is at 5% of historical levels. The drought is expected to cost California agriculture alone US$2.7bn in economic costs in 2015, with disruption extending to mandatory water restrictions, wildlife, land subsidence, seawater intrusion, wildfires, and human health. In a business as usual scenario, California water demand will outstrip supply by 50bn m^3 (1tn gallons) by 2060E, with an 80% chance of multi-decade "mega-drought" this century.

Globally: water is the #1 risk facing the planet

Water is recognised as the #1 global risk for 2015 in terms of impacts to economies, environments and people. Globally, 750mn people lack access to safe drinking water source and 2.4bn have no access to proper sanitation facilities. Close to 50 countries are officially classified as being water stressed, and up to 70% of the world's underground aquifers have reached peak water. Global water demand is set to overshoot supply by 40% by 2030E, and by 2050E, 3.9bn people will be living under "severe" water stress. Poor water supply and sanitation cost the global economy US$260bn per year or c1.5% of global GDP. By 2050E, 45% of projected GDP is at risk, with as many as 50 countries at risk of conflict over water.

Four major entry points, US$1tn market (2020E)

We have mapped efforts to tackle the global dynamics of water supply and demand to highlight four entry points for investors wishing to invest in the global or California water theme: 1) Water Treatment; 2) Water Management; 3) Water Infrastructure & Supply; and 4) Water-friendly Energy. We believe these entry points will represent a US$1tn+ market by 2020E

High growth: treatment, efficiency, tech, solar, EMs, desal

We see the fastest 3-5Y growth coming from the low hanging fruits of water treatment and recycling, more efficient water usage (smart meters, high efficiency irrigation, surface and groundwater storage), technology (precision Ag, IoT, drought resistant seeds and crops), EMs (China), water-friendly energy (solar and wind), and desalination.

BofAML Global & California stock lists & Primer Picks

We highlight 50+ global stocks covered by BofAML that have material exposure to California water solutions. We have also updated our Global Water stock list to include over 100+ covered stocks with exposure to the water theme. Our 40+ Global Water primer picks (Buy-rated stocks with material exposure) are detailed in an accompanying Primer Picks report.

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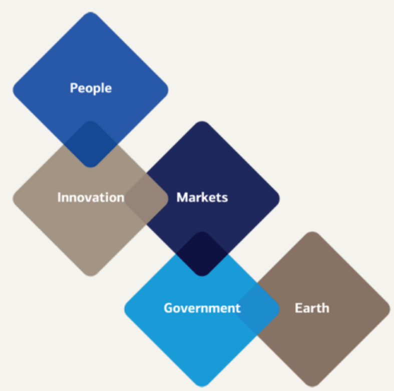
A Transforming World



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Refer to important disclosures on page150 to 152.

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California dreamin (of water)

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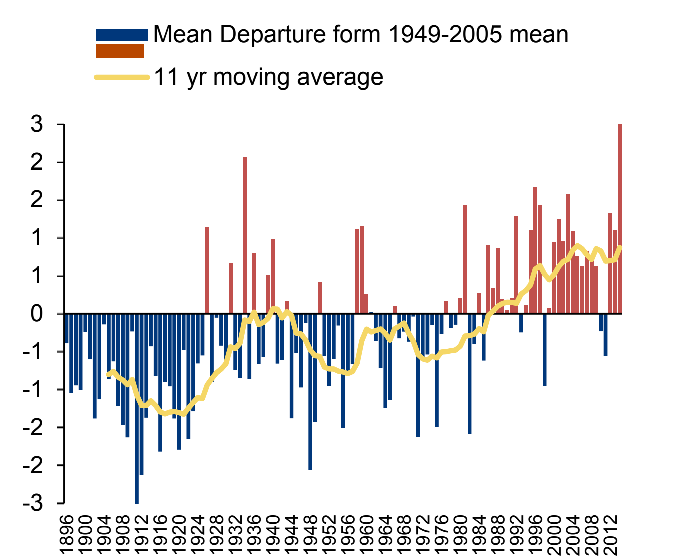
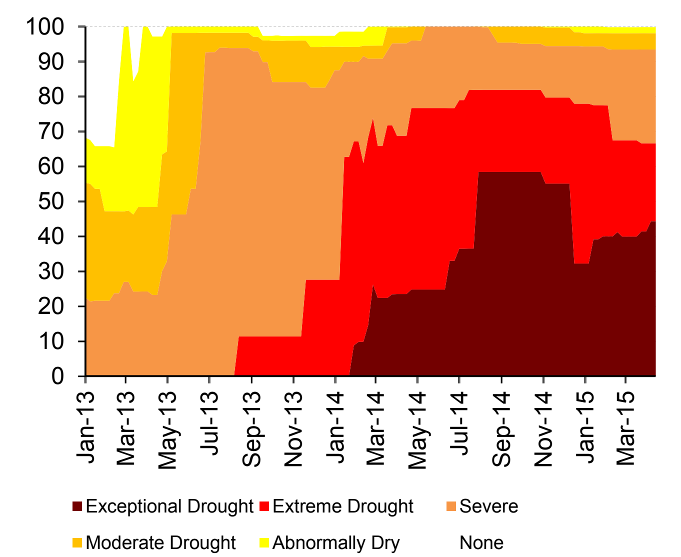
Chart 1: California statewide mean temperature departure



Source: WRCC

Chart 2: Percent of California in each drought category



Source: US Drought Monitor, BofA Merrill Lynch Global Research

Four major entry points for investors

We have mapped efforts to tackle the global dynamics of water supply and demand to highlight four entry points for investors wishing to invest in the global or California water theme: 1) Water Treatment; 2) Water Management; 3) Water Infrastructure & Supply; and 4) Water-friendly Energy. We believe these entry points will represent a US$1tn+ market by 2020E.

BofAML Global & California stock exposure lists & Primer Picks

We present a list of 50+ global stocks covered by BofAML that have exposure to California water solutions. We have also updated our global water stock list to include over 100+ covered stocks. Our 40+ global water primer picks (Buy-rated stocks with material exposure) are detailed in an accompanying Primer Picks report.

BofAML Global & California stock lists

We have mapped water opportunities and risks across a number of global sector value chains to highlight the diverse range of entry points for investors wishing to invest in the theme: 1) Water Treatment; 2) Water Management; 3) Water Infrastructure and Supply; and 4) Water-friendly Energy.

For each theme, together with our BofAML Global Research sector analysts, we have estimated the level and materiality of companies' exposure to water-related themes, and the role of water as a long-term growth driver. We have characterised each company's exposure as follows:

- **Low –** Water-related products, technologies, services, and solutions are not material to global revenues and/or growth but are one factor, among others, for the business model, strategy and R&D of the company.
- **Medium –** Water-related products, technologies, services, and solutions are an important factor for the business model, strategy and R&D of the company; material to sales and/or growth.
- **High –** Water-related products, technologies, services, and solutions are core to the business model, strategy and R&D of the company; material sales and/or growth driver; pure play (i.e., 100% of sales).

Within the list of companies with exposure to the BofAML Global Water theme, we also highlight companies with a particular exposure to the California drought. Although it is difficult to accurately gauge the link between such exposure and share price performance (as many factors outside the scope of this analysis are likely to play a role in short- and long-term price development), we still consider water-related exposure an important and positive point to track given that water is a thematic megatrend with a 25-50 year lifespan.

The aim of our Global Water exposure stock list, California drought exposure stock list, and its four underlying themes is to provide investors with information to identify company and sub-sector specific risks and opportunities that are inherent in the water theme.

Water treatment solutions

In our view, a number of stocks are well placed to benefit from the theme of water treatment through their involvement in areas such as wastewater, industrial treatment, chemicals, desalination, ballast water treatment, analysis, water quality, PV solar, bottled water, life science tools, and testing, inspection and certification, among other areas.

Increasing levels of water treatment will be an expanding area in the coming years given rising water scarcity and growing demand from the agriculture, residential and industrial sectors. Agriculture currently accounts for 80% of human water use in California, and 70% of use globally, and demand looks set to rise on the back of changing diets. Industry will be under pressure to treat water as global demand rises from 22% of total demand towards the current 59% in developed markets. Municipal and residential water use is also growing on the back of urbanisation and EM growth.

There are significant low hanging fruit opportunities around water treatment with less than 3% of water globally being recycled, with that figure at 13% for California. Water treatment covers the processes used to make water more acceptable for a desired end-use, such as drinking water, usage or re-usage by industry, in irrigation, or return to the natural environment. Moreover, this market is barely tapped with insufficient wastewater treatment around the world. For instance, wastewater reuse stands at only 2.41% of all water withdrawals globally (Source: FAO Aquastat). The goal needs to be to move to best-practice levels of water reuse of up to 75% (e.g. Israel).

The municipal and industrial water and wastewater treatment market was estimated to be c.US$178bn in 2013 (Source: GWI). On the municipal side, the increasing burden of environmental regulations and the need to extract more value from the water cycle is driving the market. Growth in spending is being driven by the Asia Pacific market, with China overtaking the US as the world's largest spender (Source: GWI)

We anticipate that some of the largest opportunities will emerge around the multi-billion dollar municipal and industrial water treatment market vis-à-vis sectors with heavy volumes and environmental constraints (utilities, oil & gas, mining), strict water constraints (FOB, cosmetics), variable effluents (petrochemicals, energy, breweries), as well as in emerging areas like ship ballast water treatment.

Desalination is also set to emerge as a US$41bn industry by 2025 (Source: Japanese Ministry of Economy), with PV solar a long-term opportunity.

Table 1: Water Treatment companies with exposure to our BofAML Global Water theme

Company	Exposure*	Company	Exposure*
BJ Water	High	Acciona	Low
China Everbright	High	Alfa Laval	Low
Kurita Water	High	ALS Ltd	Low
Stericycle	High	BASF	Low
SIIC Environment	High	BV	Low
Danaher	Medium	Doosan Heavy	Low
Danone	Medium	ICL	Low
Ecolab Inc	Medium	IDEXX	Low
Empresas ICA	Medium	Kuraray	Low
Nestle (Reg)	Medium	Lanxess	Low
NGL Energy Partners	Medium	Mitsubishi Heavy	Low
Rexnord	Medium	Nitto Denko	Low
		Outotec	Low
		Spirax-Sarco	Low
		Thermo Fisher Scientific	Low
		Toray	Low
		SGS SA	Low
		General Electric	Low

Source: BofA Merrill Lynch Global Research
Highlighted stocks also have exposure to the California drought
* Water exposure = BofAML estimates of current sales derived from water treatment-related products, services, technologies and solutions

Water management solutions

In our view, a number of companies are well placed to benefit from the theme of water management, vis-à-vis their involvement in areas such as “more crop per drop”, irrigation, drought resistant seeds and crops, precision agriculture, “big data”, smart metering and household water efficiency.

Water management has assumed greater importance in recent years as a strategy to improve efficiency and the sustainable use of resources. Water usage is growing faster than population growth – with US usage alone increasing 207% from 1950 to 2000 and per capita usage growing by 20% during the same period (Source: EPA). In a situation of growing water scarcity, fragmented water management (and conflicting interests of stakeholders) is no longer cost effective or sustainable in the long term. There is growing recognition that the current water crisis is as much a consequence of weak policies and poor management as natural scarcity. Effective water management enables users to cut their demand, mitigate the risks associated with its shortage and reduce the need for capex-intensive solutions.

Given that agriculture accounts for 70% of global water use (80% in California) – and up to 60% of this water is wasted, the “more crop per drop” theme will grow in importance in a climate change and extreme weather constrained world.

There is significant potential for the US$5.6bn irrigation market given that gravity flow/furrow irrigation accounts for 91% of irrigation globally, and low energy precision application still has extremely low global penetration. More efficient techniques such as mechanised irrigation offer hope and have captured close to 50% market share in some developed markets.

Precision agriculture and big data solutions are set to grow in importance in increasing agricultural production and profits with technology helping to optimise the use of farming practices and inputs including water, fertilisers, pesticides and seeds. The global market could be worth US$6.3bn by 2022, representing 12% CAGR growth (Source: MarketsandMarkets). Likewise, farmers and stakeholders are becoming increasingly open to drought tolerant/resistant seeds and crops, which are more resistant to adverse extreme weather and environmental conditions like drought and water stress.

Leakage and non-revenue water costs utilities upward of US$20bn pa in lost revenues, which should create substantial downstream basic and smart meter demand from water utilities. The smart water meter market is forecasted to grow at a CAGR of 14.7% till 2019.

Water efficiency will become as important as energy efficiency as 66% of the global population becomes urban by 2050. This will mean that household water management will become increasingly important. The potential is huge – if all US households installed water-saving features, the dollar-volume savings would be US$11.3mn per day or more than US$4bn pa (Source: American Water Works Association).

Table 2: Water Management companies with exposure to our BofAML Global Water theme

Company	Exposure*
Grupo Rotoplas	High
Itron	Medium
Melrose plc	Medium
Wolseley	Medium
BASF	Low
Deere & Co	Low
Duratex S.A.	Low
Hexagon AB	Low

Source: BofA Merrill Lynch Global Research

Highlighted stocks also have exposure to the California drought

* Water exposure = BofAML estimates of current sales derived from water management-related products, services, technologies and solutions

Water infrastructure & supply solutions

In our view, a number of companies are well placed to benefit from the theme of water infrastructure and supply solutions, vis-à-vis their involvement in areas such as engineering, procurement, construction and consulting, pipes, pumps and valves, and water, wastewater and sewage treatment utilities.

Water and sanitation infrastructure requires US$11.7tn in global investment to 2030 (Source: McKinsey, E&Y). Crumbling and incomplete infrastructure in developed markets are a primary cause of this – with the US alone estimated to need US$384.2bn in public water investments over the next 20 years simply to address shortcomings and another US$384.2bn to improve systems (Source: US EPA). For EMs, the challenge is building out basic water infrastructure with water infrastructure 3x more expensive to build and maintain than electricity infrastructure (Source: IBM). Overcoming the neglect and under-financing of earlier years could cost 0.35%-1.2% of GDP pa over the next 20 years (Source: OECD).

The private sector will play an increasingly important role in developing and running water infrastructure and is expected to account for 30% of water investments in the next 3-5Y (Source: Global Water Fund). Full cost pricing - and increasing tariffs, taxes and transfers - are being used as tools to address funding gaps and to strike a balance between infrastructure and financing needs, improving service provision levels for stakeholders, and profitable growth opportunities for corporates.

Global water equipment capex is expected to be a US$655bn market from 2013-2018 with pipes (US$132bn), pumps (US$71bn), automation and control (US$63bn), valves and fittings (US$56bn) and aeration (US$33bn) accounting for the largest segments. There will be a significant increase in spending as the late cycle business returns to previous trends, with industrial spend outpacing municipal spend (Source: GWI Global Water Market 2014).

The global water utilities industry is expected to grow by 3.6% CAGR to reach US$923.4bn by 2019 (vs. US$774.8bn in 2014) (Source: MarketLine). Growth rates are low but stable for the highly fragmented sector where around only 10% of customers are served by investor-owned companies – and performance depends on regulatory factors as well as fundamental drivers of revenue and cost. But we see significant opportunities in Brazil and China – where water is increasingly a long-term secular growth story - as well as the U.S.

Table 3: Water Infrastructure companies with exposure to our BofAML Global Water theme

Company	Exposure*	Company	Exposure*
Aguas Andinas	High	AECOM Technology	Low
Aguas Metropolit	High	Aveng	Low
American Water Works	High	Chiyoda Corp	Low
Beijing Enterprises	High	CIMIC	Low
BJ Water	High	Downer EDI	Low
COPASA	High	Empresas ICA	Low
Grupo Rotoplas	High	Flowserve	Low
Guangdong Invest	High	HK&China Gas	Low
Manila Water	High	Keppel Corp	Low
Pentair plc	High	Kinden	Low
SABESP	High	Rotork	Low
Sabesp-ADR	High	Samsung Engineering	Low
Severn Trent	High	Shanghai Indus	Low
United Utilities	High	UGL	Low
EBARA	Medium	Voltas	Low
Kubota	Medium	WorleyParsons	Low
Metro Pacific	Medium		
Pennon	Medium		
Rexnord	Medium		
Suez Environnement	Medium		
Veolia	Medium		

Source: BofA Merrill Lynch Global Research

Highlighted stocks also have exposure to the California drought

* Water exposure = BofAML estimates of current sales derived from water infrastructure-related products, services, technologies and solutions

Water-friendly energy solutions

In our view, a number of companies are well placed to benefit from the theme of water -friendly energy solutions, vis-à-vis their involvement in areas such as wind, solar and geothermal energy, co-production of energy and water, exploiting synergies (e.g. combined power and desalination plants, CHP plants using alternative water sources for thermal power plant cooling, and energy recovery from sewage water), energy efficiency in agriculture and across the agrifood chain, and smart irrigation and precision agriculture, among others.

Water and energy are interlinked and interdependent – with approximately 90% of global power generation water intensive. Moreover, today's power sector is largely designed for a water-rich world, which will become an increasingly unsustainable challenge in the coming years. Global water withdrawals for energy production – predominantly cooling water - amount to 583bn (c15% of the world's total withdrawals), of which 66bn m3 was consumed (Source: IEA). By 2035, water withdrawals could increase by 20% and consumption by 85% (manufacturing +400%, thermal electricity demand +140%), driven via a shift towards higher efficiency power plants with more advanced cooling systems (reduced water withdrawals but increased consumption) and increased production of biofuels (Source: IEA, UN).

From a water perspective, power generated from solar PV and wind is the most sustainable choice, having the lowest operational and lifecycle water consumption footprint (i.e. water use per unit of electricity generated). The economics of cleantech are increasingly compelling with recent technological advancements in solar and wind along with rising cost of emissions and pollution controls closing the gap between renewable power generation and fossil fuels. As of 2013, wind, coal, and gas generation were in line with one another at around US$0.07-0.08/kWh, with PV solar at US$0.14/kWh (Source: BNEF).

California and Hawaii have been flagged as the US states with the greatest potential for further solar adoption. Currently, less than 10% of California's electricity generation came from wind and solar in 2014, with more than 10,000 GwH from solar and 13,000 GwH of from wind (source: California Energy Commission). We believe the drought could be one of many catalysts for California's transition towards water-friendly sources of energy production.

Table 4: Water-Friendly Energy companies with exposure to our BofAML Global Water theme

Company	Exposure*	Company	Exposure*
Abengoa B	High	SQM	High
Abengoa Yield	High	SunPower Corp.	High
China Longyuan	High	Terraform	High
Datang Renewable	High	Tesla	High
EDP Renovaveis	High	Trina Solar	High
Enel Green Power	High	Vestas	High
Enphase Energy	High	Vivint Solar	High
First Solar	High	Xinyi Solar	High
Gamesa	High	Acciona	Medium
GCL-Poly	High	Advanced Energy	Medium
HuanengRenewable	High	AES Corporation	Medium
Iberdrola	High	CPFL Energia S.A	Medium
Inox Wind	High	Hitachi Chemical	Medium
Itron	High	Huadian Fuxin	Medium
Nordex	High	NextEra Energy	Medium
NRG Yield	High	NRG Energy	Medium
Pattern Energy	High	AGL Energy	Low
Saeta Yield	High	LGC	Low
SolarCity	High	Parker Hannifin	Low

Source: BofA Merrill Lynch Global Research

Highlighted stocks also have exposure to the California drought, * Water exposure = BofAML estimates of current sales derived from water treatment-related products, services, technologies and solutions

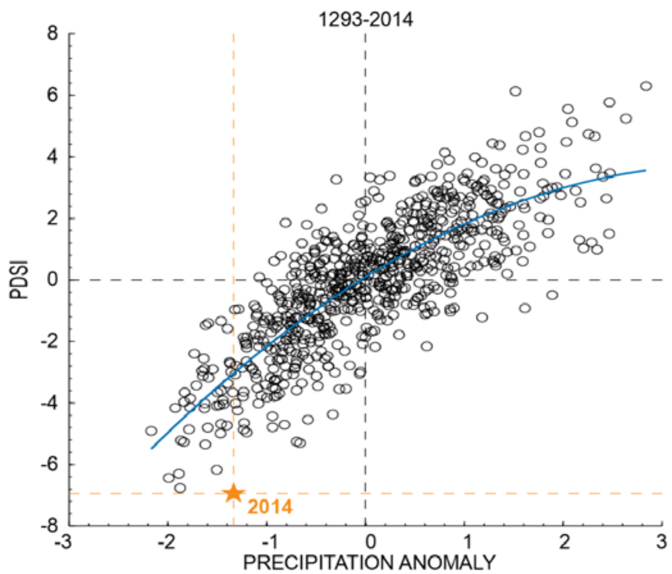
Challenges for the world's 7th largest economy

California is the most populous state in the United States, and the world's seventh largest economy, overtaking Brazil earlier this year with a GDP of US$2.2tn (source: California Environmental Protection Agency). It is also a diverse economy with a wealth of natural resources. California leads the country in agriculture, manufacturing, energy, tourism and is a major international exporter. From high-tech to Hollywood, California is a hub of innovation and is home to one in 10 Fortune 500 companies (source: Fortune).

Worst drought in 1200 years

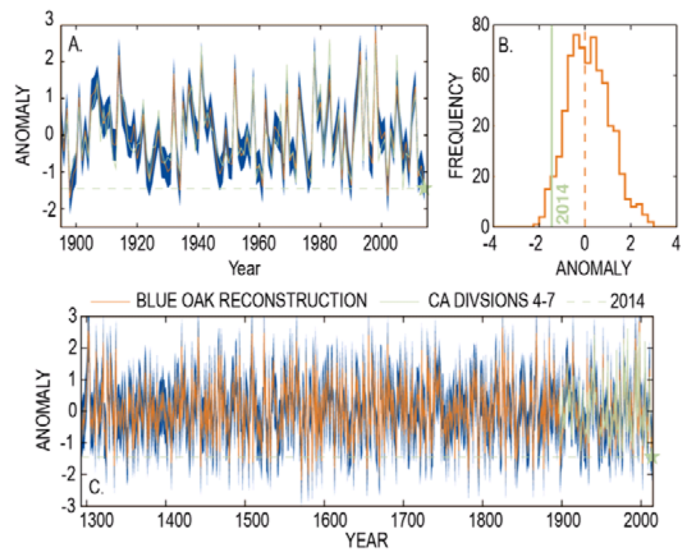
Studies have shown that the current period of drought in California are the most severe in the last 1200 years, with 2014 accumulating the highest moisture deficits than any previous span of dry years. Using paleoclimate data, researchers have found that exceptional aridity amplified by record high temperatures has brought about the worst drought conditions in the last millennium (source: Griffin et al, 2014)

Exhibit 1: Precipitation Anomaly 1293-2014



Source: Griffin et al. Bivariate distribution of the composite JJA NADA-NOAA PDSI and October–June reconstructed normalized mean precipitation anomalies. The 2014 value is indicated by the red star and dashed red lines and is labeled. The blue curve shows the least squares second-order polynomial fit to the data.

Exhibit 2: Mean precipitation anomaly 1300-2000

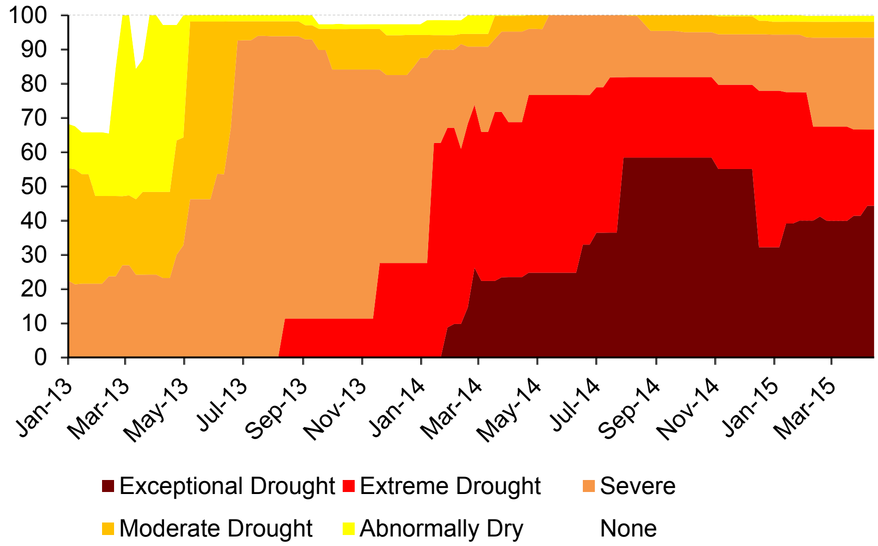


Source: Griffin et al. October through June normalized mean precipitation anomalies from California NOAA Climate Divisions 4–7.

100% of California in state of water stress

The U.S. Department of Agriculture (USDA) included all of California's counties in its drought disaster designations at various times over the course of 2012-14, either as primary counties or contiguous counties (source: CA Dept of Water Resources).

Chart 3: Percent of California in each drought category



Source: US Drought Monitor, BofA Merrill Lynch Global Research

Table 5: US Drought Monitor Drought Severity Classification

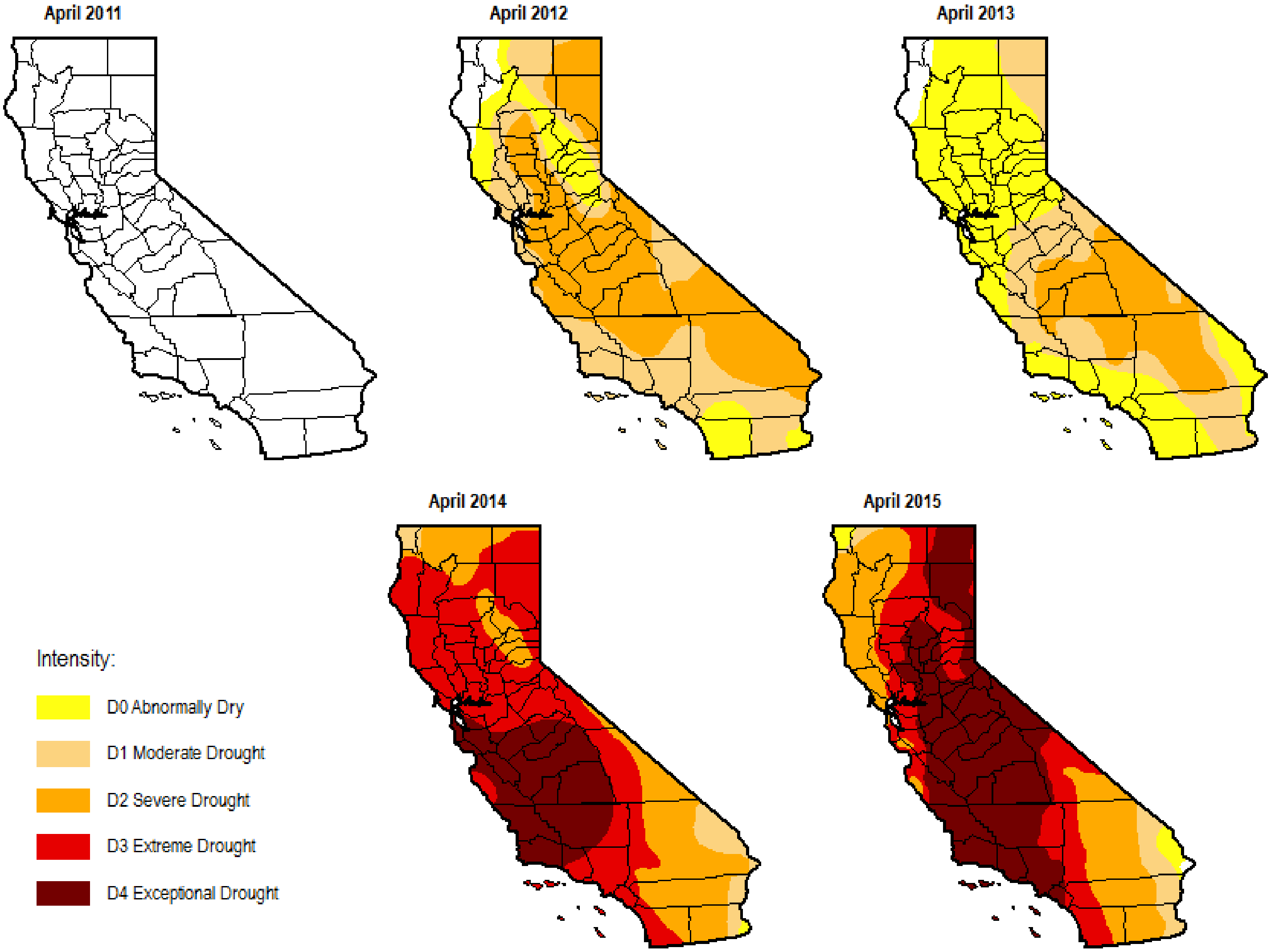
Category	Description	Possible Impacts	Palmer Drought Index	CPC Soil Moisture Model (Percentiles)	USGS Weekly Streamflow (Percentiles)	Standardized Precipitation Index (SPI)	Objective Short and Long-term Drought Indicator Blends (Percentiles)
D0	Abnormally Dry	Going into drought: short-term dryness slowing planting, growth of crops or pastures. Coming out of drought: some lingering water deficits; pastures or crops not fully recovered	-1.0 to -1.9	21-30	21-30	-0.5 to -0.7	21-30
D1	Moderate Drought	Some damage to crops, pastures; streams, reservoirs, or wells low, some water shortages developing or imminent; voluntary water-use restrictions requested	-2.0 to -2.9	11-20	11-20	-0.8 to -1.2	11-20
D2	Severe	Crop or pasture losses likely; water shortages common; water restrictions imposed	-3.0 to -3.9	6-10	6-10	-1.3 to -1.5	6-10
D3	Extreme Drought	Major crop/pasture losses; widespread water shortages or restrictions	-4.0 to -4.9	3-5	3-5	-1.6 to -1.9	3-5
D4	Exceptional Drought	Exceptional and widespread crop/pasture losses; shortages of water in reservoirs, streams, and wells creating water emergencies	-5.0 or less	0-2	0-2	-2.0 or less	0-2

Source: US Drought Monitor, BofA Merrill Lynch Global Research. Short-term drought indicator blends focus on 1-3 month precipitation. Long-term blends focus on 6-60 months. Additional indices used, mainly during the growing season, include the USDA/NASS Topsoil Moisture, Keetch-Byram Drought Index (KBDI), and NOAA/NESDIS satellite Vegetation Health Indices. Indices used primarily during the snow season and in the West include snow water content, river basin precipitation, and the Surface Water Supply Index (SWSI). Other indicators include groundwater levels, reservoir storage, and pasture/range conditions.

Drought continuing in its 4th year

The current drought, which had started in 2011, is now running into its 4th year, without any signs of relief. The 2014 water year ending on September 30, 2014 was the 3rd driest in 119 of recorded history (source: USGS), coinciding with the hottest year in California history (source: Western Regional Climate Center). The Sierra Nevada snowpack was at its 5% of average as of April 2015, the lowest of any year on record going back to 1950 (source: California Dept of Water Resources). Besides resulting in less snow water, the dramatic reduction in snow extent contributes to warming our climate by allowing the ground to absorb more sunlight. This reduces soil moisture, which makes it harder to get water from the snow into reservoirs once it does start snowing again. Groundwater levels across the US Southwest are in the lowest 1-10th percentile since 1949 (source: NASA JPL).

Exhibit 3: California Drought Monitor



Source: US Drought Monitor, BofA Merrill Lynch Global Research

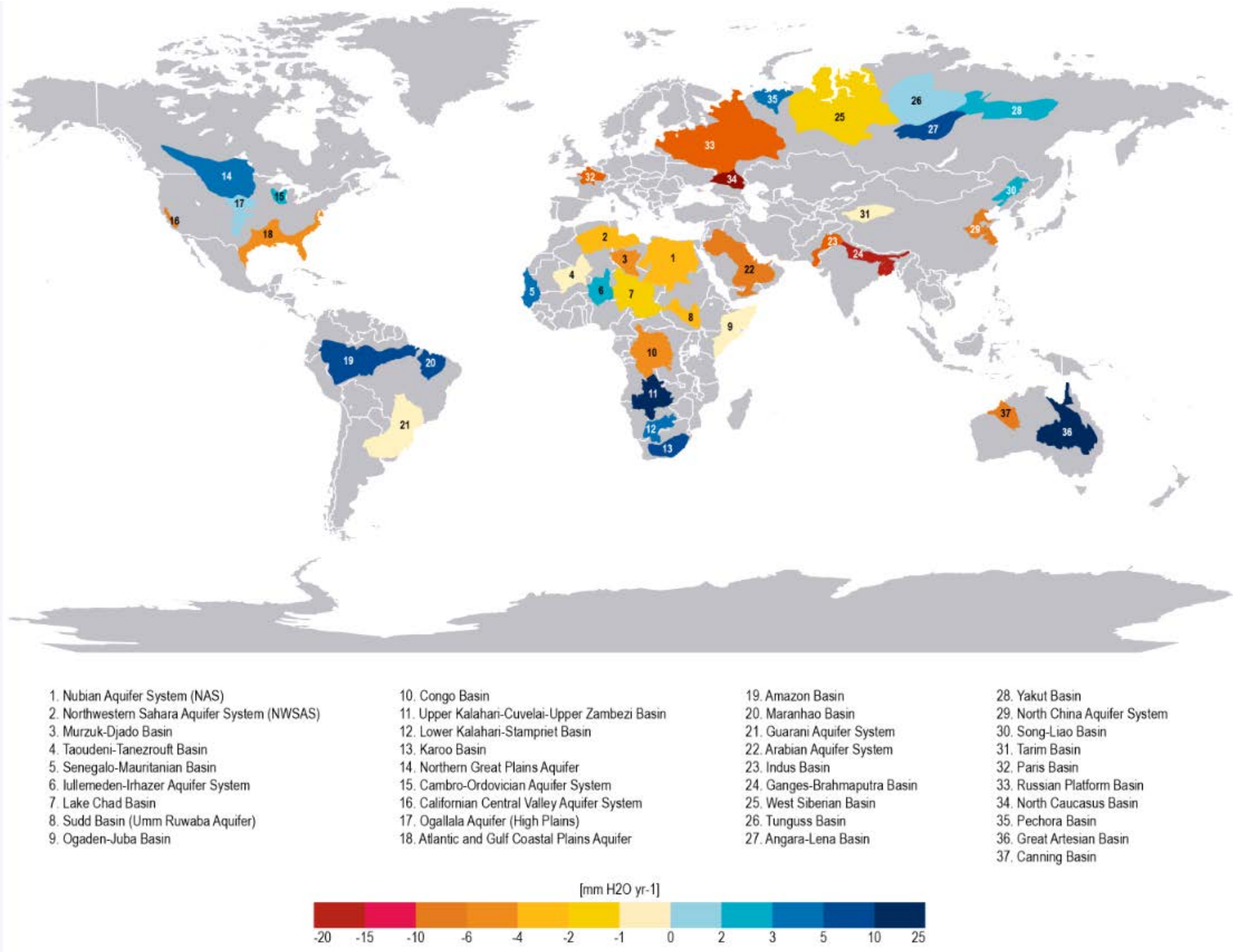
11 trillion gallons needed to end drought

We need 11tn gallons (40.5mn acre-feet, 50bn m^3) of water to replenish the water losses of the current drought, now running into its 4th year. This is 1.5 times the volume of Lake Mead, (source: Famiglietti et al, NASA JPL) or around the total amount of water the state uses in one year (Source: DWR). Since 2011, the Sacramento and San Joaquin river basins have suffered 4tn gallons of water losses per year. Two thirds of this has been due to groundwater depletion in California's Central Valley region.

70% of world's aquifers in distress

Developments in California's drought could serve as an important example for the rest of the world, given that 70% of the world's groundwater basins are in distress, with more water removed than replenished. University of California, Irvine released a study in June 2015 using NASA's Gravity Recovery and Climate Experiment (GRACE) satellites. Out of the world's 37 largest aquifers studied, 13 were being depleted between 2003 and 2013, while receiving little to no recharge. Eight were classified as "overstressed," with nearly no natural replenishment, and another five were found to be "extremely" or "highly" stressed. The severity of depletion is also occurring in some of the world's driest areas, as well as the most politically sensitive. Arabian Aquifer System, an important water source for more than 60mn people, is the most overstressed in the world. The Indus Basin aquifer of northwestern India and Pakistan is the second-most overstressed, and the Murzuk-Djado Basin in northern Africa is third. Central Valley in California is experiencing the highest level of distress in the US (source: Richey et al.).

Exhibit 4: Trends in groundwater storage from NASA GRACE mission (2003-2013)



Source: Richie, Thomas, Lo, Reager, Famiglietti, Voss, Swenson, Rodell 2015, NASA Jet Propulsion Laboratory

Drought hitting all parts of world

California is not the only region facing water shortages at present. Many other countries around the world fare facing unprecedented drought, hitting both developed and emerging economies:

- **Chile** – Capital city of Santiago, with population of 7mn is experiencing its driest year since 1966 (Source: DGAC), with little snow falling in the Andes mountains which supplies the city's water. Chile is facing an 8-year dryspell, with Santiago only receiving 1/3 of its normal rainfall since 2010. Choapa and Limari which have been agricultural regions are now losing livestock and idling land. Reservoirs like

Paloma, Cogoti, and Culimo dam now run dry. This has hurt industries ranging from copper mining to wine production.

- Thailand – Bangkok's tap water supply may run out in as soon as a month as the country suffers its worst drought in more than 10 years (Source: NIDIS). 20% of the country have been declared emergency disaster zones. Usable water in major dams across Thailand have now fallen below 10% according to the country's Irrigation Department (Source: TIWRM). The Metropolitan Waterworks Authority has started slowing down tap water production in May 2015. As one of the world's top rice producers, the country may face US$1.8bn in losses in the rice industry alone. Thailand also experiences flooding every year. The country's government plans on investing US$7.5bn in water management projects in the next two years (Source: World Bank).

- North Korea – Severe drought in spring and summer of 2014, as well as April through June 2015 in Hwanghae-do and Pyongan-do, the rice bowl of North Korea (Source: Korea Institute for National Unification). According to Korea Central New Agency, this is the worst drought in 100 years, with 136k hectares our of 441k hectares being parched. Drought-related decline in agricultural production persists in 2015 (Source: FAO, World Food Programme).

- South Africa – The country is facing its worst drought since 1992, cutting the dams levels in KwaZulu-Natal, North West and Free State provinces by 11-18% versus the year prior (Source: DWS). Average rainfall in South Africa is already less than half the world average (495mm vs. 1,033mm) (Source: UNEP; WMO):, with high rates of evaporation. White and yellow corn harvest will be at its lowest level since 2007 (Source: USDA; Grain SA).

- Canada – Western Canada, including Saskatchewan, British Columbia and Alberta are experiencing drought conditions. High prices for grass feed has led to meat plants running at 74% capacity and the smallest herd in 22 years. Some of this has been passed on to consumers with retail sirloin, prime rib, and stewing beef prices rising 50-60% since 2011(Source: Statistics Canada, CANSIM).

- Brazil – the country is still reeling from the worst drought in 80 years (Source: Environment Minister), despite holding 13-16% (Source: Aquastat) of the world's fresh water. Sao Paulo, Rio de Janeiro, and Minas Gerais were all heavily impact. 90% of the 936 municipalities in the north east region were declared disaster situations. The Cantateira water system that's feeds into Sao Paulo's population of 20mn was at 5% capacity by the end of the drought in February 2015, leading to water rationing.

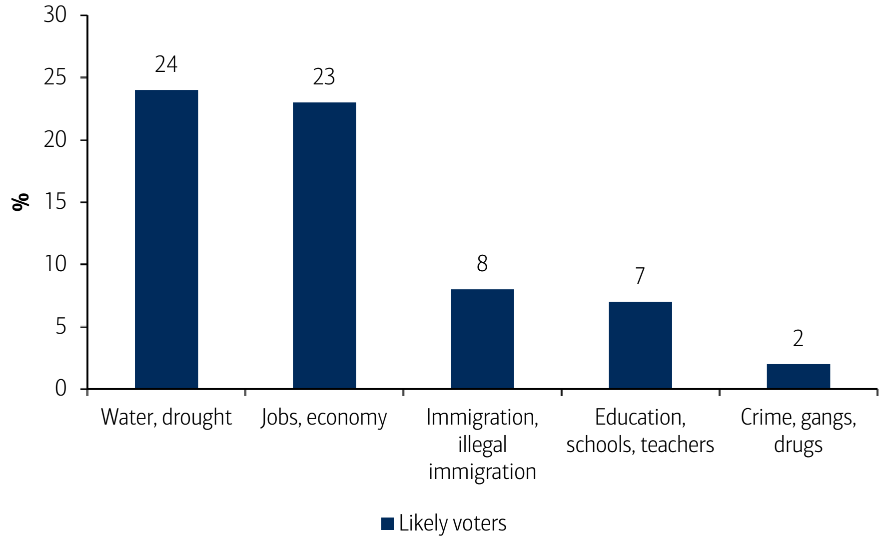
Globally: water is the #1 risk facing the planet

Water is recognised as the #1 global risk for 2015 in terms of impacts to economies, environments and people (Source: WEF). Globally, 750mn people lack access to safe drinking water source and 2.4bn have no access to proper sanitation facilities. Close to 50 countries are officially classified as being water stressed, and up to 70% of the world's underground aquifers have reached peak water. Global water demand is set to overshoot supply by 40% by 2030E, and by 2050E, 3.9bn people will be living under "severe" water stress. Poor water supply and sanitation cost the global economy US$260bn per year or c1.5% of global GDP. By 2050E, 45% of projected GDP is at risk, with as many as 50 countries at risk of conflict over water (Source: WHO).

Survey says: #1 problem facing California

The Public Institute of California showed in a March 2015 survey of likely voters that water and the drought is now that number one (24%) issue facing California. This precedes jobs and the economy, and immigration, education, and crime, drugs & gangs.

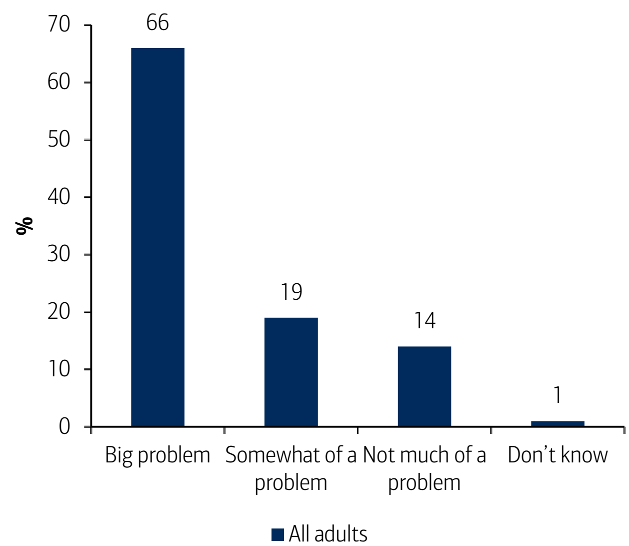
Chart 4: What do you think is the most important issue facing people in California today?



Source: PPIC, BofA Merrill Lynch Global Research

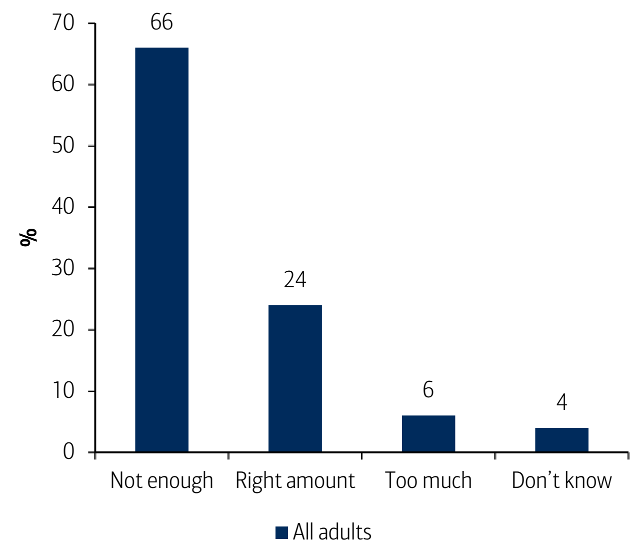
Two-thirds of Californians believe that the water supply is a big problem, and seven out of ten Californians expect the water supply in their area to be inadequate in the future. Out of that, 76% of Central Valley residents see the water supply as a big problem, followed by Orange/San Diego (71%). (Source: PPIC)

Chart 5: Is the water supply a problem in your part of California?



Source: PPIC, BofA Merrill Lynch Global Research

Chart 6: Do you think that the people in your part of California are doing enough to respond to the current drought?

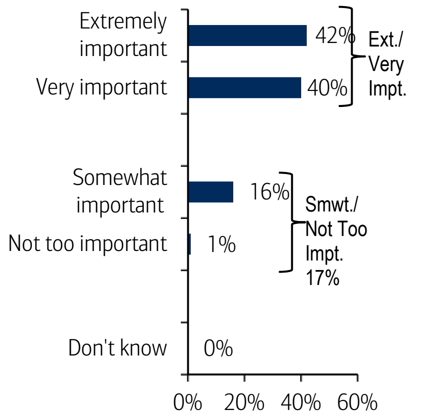


ource: PPIC, BofA Merrill Lynch Global Research

9 in 10 Californians willing to cut water use

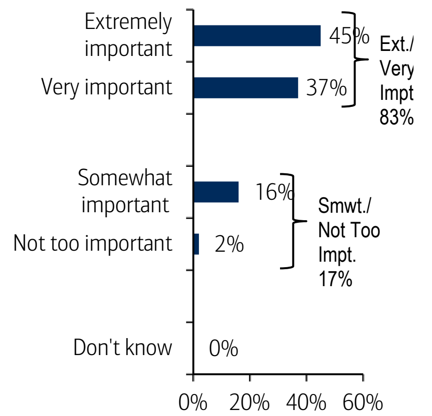
In a separate survey of 801 California voters in March 2015 by Fairbank, Maslin, Maullin, Metz & Associates (FM3). Four in five (82%) Californians now believe it is important to conserve water, regardless of whether we're in the middle of a drought or have been required to by local water agencies. Nine in ten (90%) indicated they would be willing to make "significant changes" to their own water usage to help the state meet its goal of reducing water usage. (Source: FM3).

Chart 7: With mandatory conservation mentioned



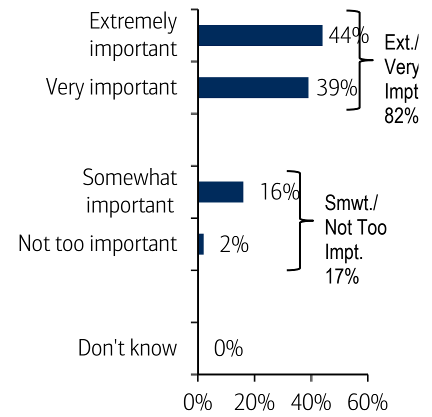
Source: FM3

Chart 8: Without mandatory conservation mentioned



Source: FM3

Chart 9: Total

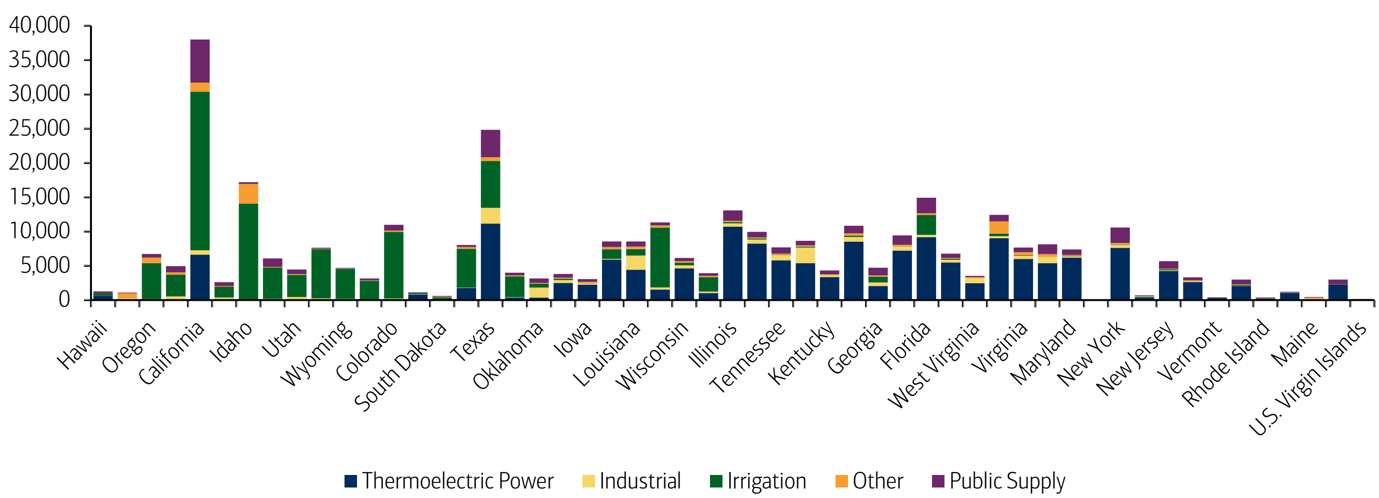


Source: FM3

California withdraws 38bn gallons a day

California is the top user, accounting for 11% of the total withdrawals nationwide and 10% of the total freshwater withdrawals. Considering the most recent data from 2010, California on average withdraws 38bn gallons (140k acre-feet) a day, with 181 gallons per person per day in terms of urban consumption. In the US, water withdrawals in four States — California, Texas, Idaho, and Florida—accounted for more than one-quarter of all fresh and saline water withdrawn in the United States in 2010. (Source: USGS 2010)

Chart 10: California leads water withdrawals nationwide



Source: USGS 2010

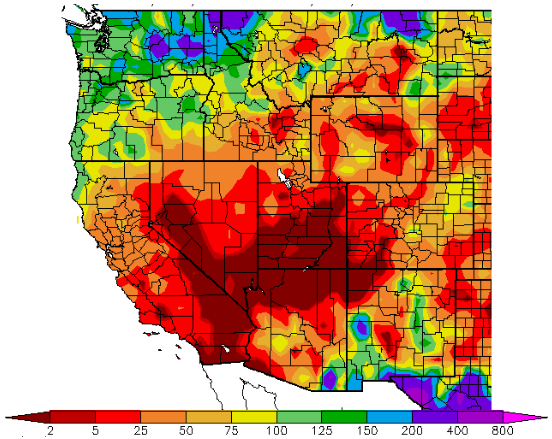
What causes drought

Drought is a period of drier-than-normal conditions caused by low rainfall, and resulting in reduction in flows of streams and rivers, falling water levels in lakes and reservoirs, and decreasing groundwater levels (source: USGS). Ultimately, drought in California stems from an absence of winter precipitation. At the weather timescale this occurs when an atmospheric high pressure ridge blocks winter storms from reaching the state, shunting them to other areas. In the longer-term climate timescale many other aspects come into play; the chaotic interaction of atmosphere- ocean dynamics and land processes combine at varied spatial and temporal scales to ultimately set the stage for the weather we experience. Many efforts have been made to identify particular climate patterns, or teleconnections, that could be used to predict or diagnose drought conditions (source: CA Dept of Water Resources).

Dry hydrology, no precipitation

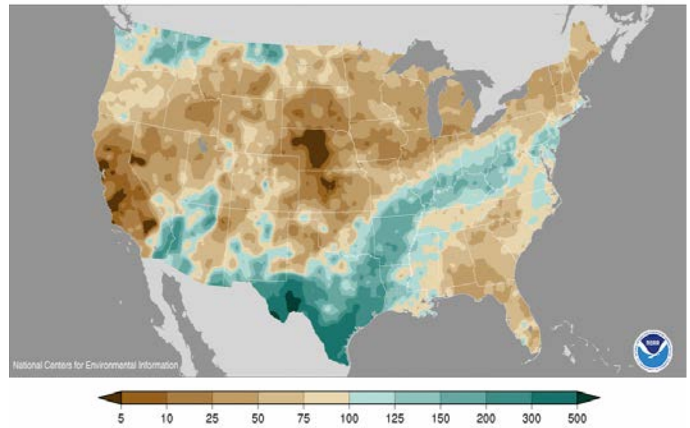
Water year 2014 ranked as the third driest on record in terms of statewide precipitation, with the three-year period of water years 2012-14 ranking as the driest consecutive three-year period on record in terms of statewide precipitation. Records for minimum annual precipitation were set in many communities in calendar year 2013 (source: CA Dept of Water Resources).

Exhibit 5: Western US 3-year precipitation as a percent of 20th century average (through April 2015)



Source: Western Regional Climate Center

Exhibit 6: US precipitation of a percent of 20th century average (through March 2015)



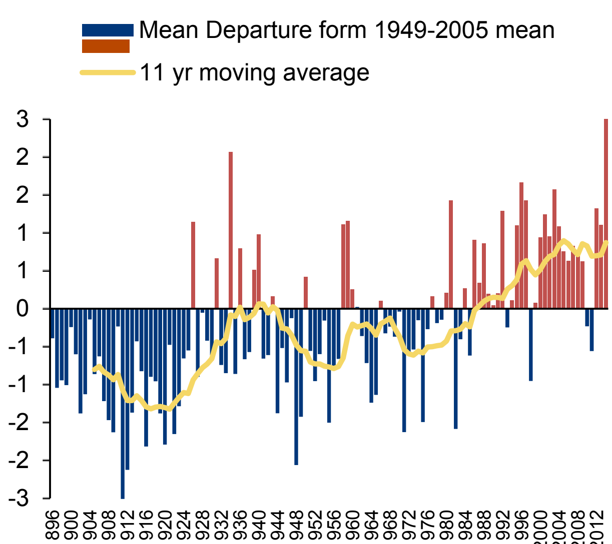
Source: NOAA

Note: Legend in %

California experiencing higher temperatures

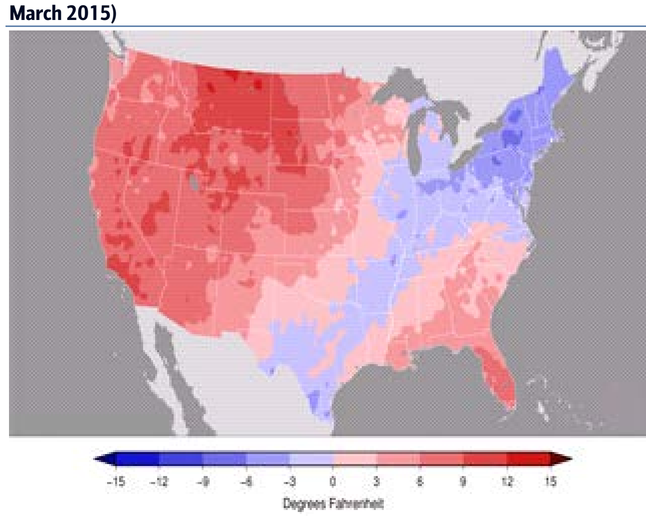
While 2012-14 marked California's driest period, it was also the hottest by a wide margin. The drought coincided with record warmth in California, with new climate records set in 2014 for average temperatures. It was 4.1 degrees Fahrenheit, or 2.3 degrees warmer than the 20th century average, passing the previous record set in 1934 by 1.8 degrees Fahrenheit. This is also in line with the rest of the world, where 2014 also was the 38th consecutive year (since 1977) that the yearly global temperature was above average (source: NOAA). Elevated warmth in turn affects the percentage of precipitation that falls as rain or snow and the mountain snowpack. It is also projected to increase evaporation from reservoirs by 15-37% (Medellin-Azuara et al. 2009; California Natural Resources Agency 2010)

Chart 11: California statewide mean temperature departure



Source: WRCC

Exhibit 7: Mean temperature departures from 20th century average (through March 2015)



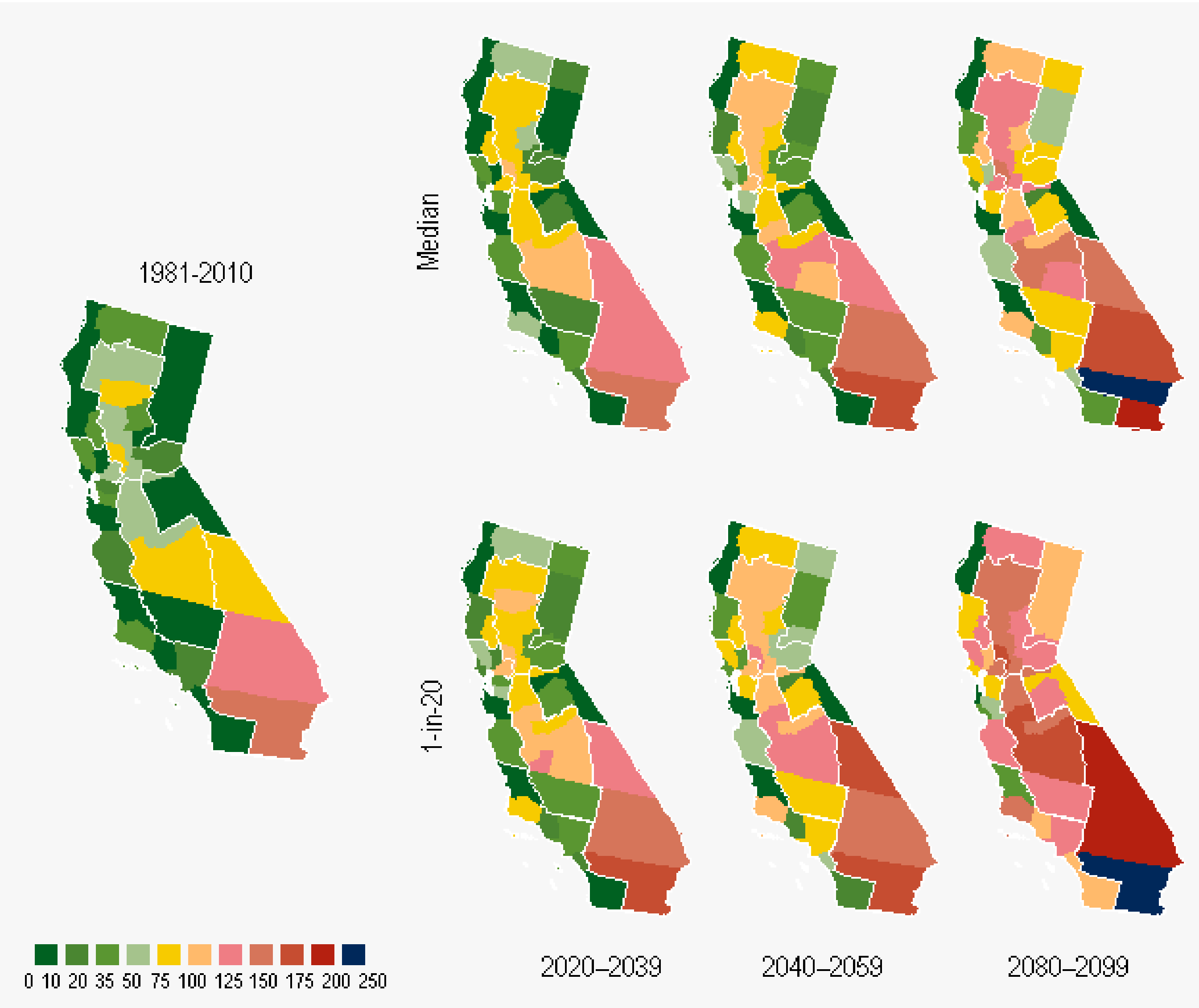
Source: NOAA

The extremes are getting worse

We are also likely to see a dramatic increase in extreme heat across California, especially in the San Joaquin Valley and Inland South regions

- The number of extremely hot days each year (temperatures 95°F+) will likely double or even triple by the end of this century. Summers in California will likely be hotter than that in Texas and Louisiana today.
- By mid-century, the San Joaquin Valley will likely experience 63-85 95°F+ days each year compared to average of 44 days over the past 30 years. By the end of the century, the number of extremely hot days will likely increase to 3-4 full months per year.
- 60%-90% decline in the annual average number of days below freezing. (source: Risky Business Project)

Exhibit 8: Average days over 95 degrees F

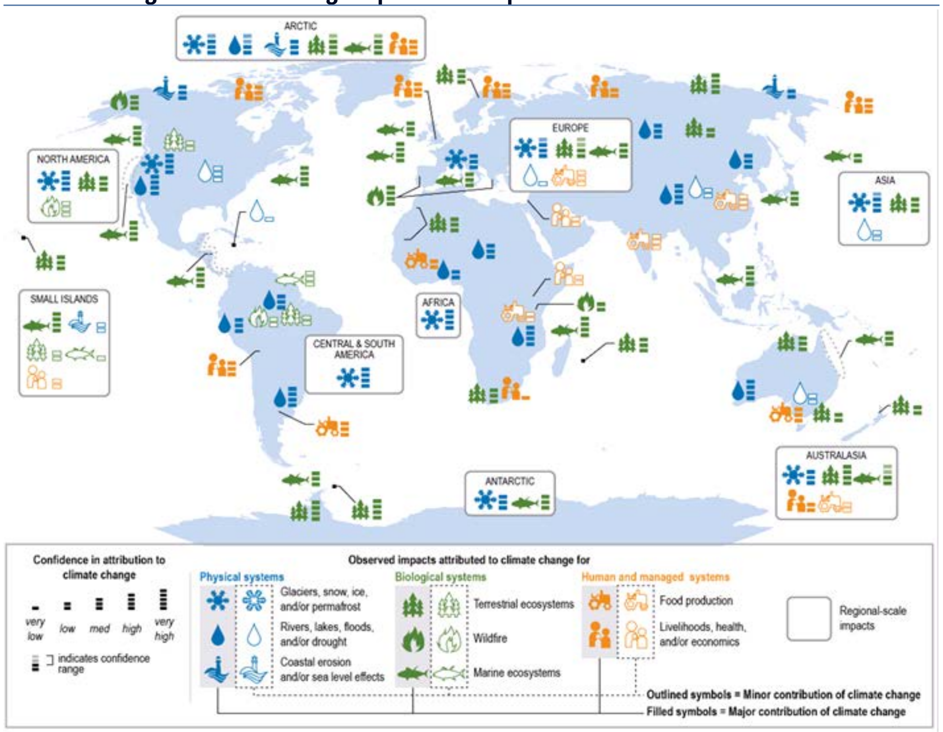


Source: American Climate Prospectus, Risky Business Project

We are on track for a 2-4°C warmer world

Analysis from the World Bank, Un Intergovernmental Panel on Climate Change (IPCC) as well as peer-reviewed literature finds that that globally, warming of close to 1.5°C above pre-industrial times – up from 0.8°C today – is already locked into Earth's atmospheric system by past and predicted greenhouse gas emissions. Without further action to reduce greenhouse gas emissions (GHGs), the report warned that the world is on pace for 2°C warming by mid-century and 4°C or more by the time today's teenagers are in their 80s.

Exhibit 9: How global climate change impacts various parts of the world

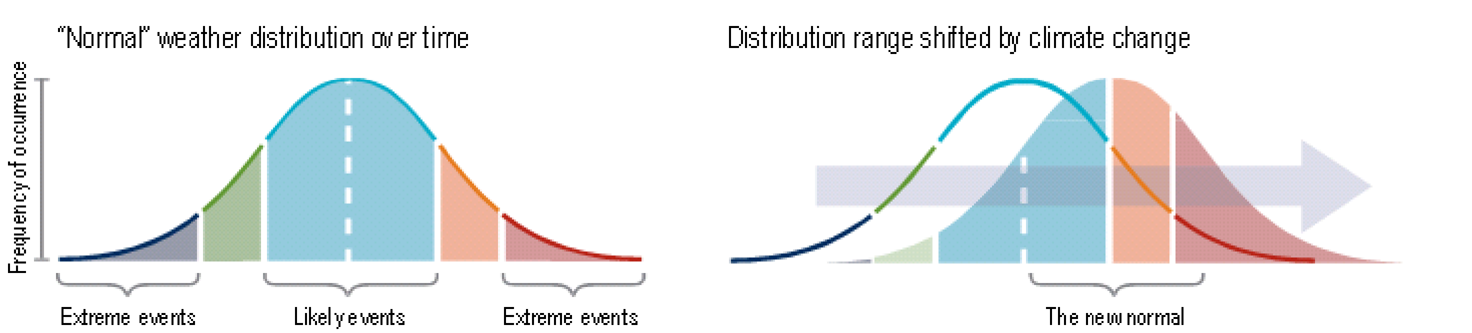


Source: IPCC, BofA Merrill Lynch Global Research

Extreme weather is on the rise

Climate change and extreme weather in general is on the rise, with extremes now cover 10% of the globe vs. 0.1% to 0.2% from 1951-1980 (Source: NASA). Extreme weather events were recognised as the number two global risk in terms of likelihood in the World Economic Forum's (WEF) Global Risks 2015 report.

Exhibit 10: How extreme weather events become the new normal



Source: Risky Business Project

40% of global land area at risk of extreme weather

While no single incident can be definitively attributed to climate change, there is overwhelming scientific evidence that we should expect more damaging extreme weather events, with up to 40% of global land area at risk from extreme heat by 2040E (Source: Coumou et. al., Environ. Res. Lett 8 2013). Examples of current adverse impacts include:

- **Extreme heat events are occurring more frequently**. The occurrence of record-breaking monthly mean temperatures has been attributed to climate change with 80% probability

- **Extreme precipitation has increased in frequency and intensity in many places**.

- **A robust drying trend has been observed for already drought prone regions** such as the Mediterranean.

- **A significant increase in tropical North Atlantic cyclone activity** has been observed and is affecting the Caribbean and Central America (source: World Bank).

Climate change leading to drought outcomes

In turn, climate change is expected to drive an increase in drought-related outcomes. The 2013 Southwest Climate Assessment (Garfin et al., 2013) and Risky Business Project discuss a few specific examples:

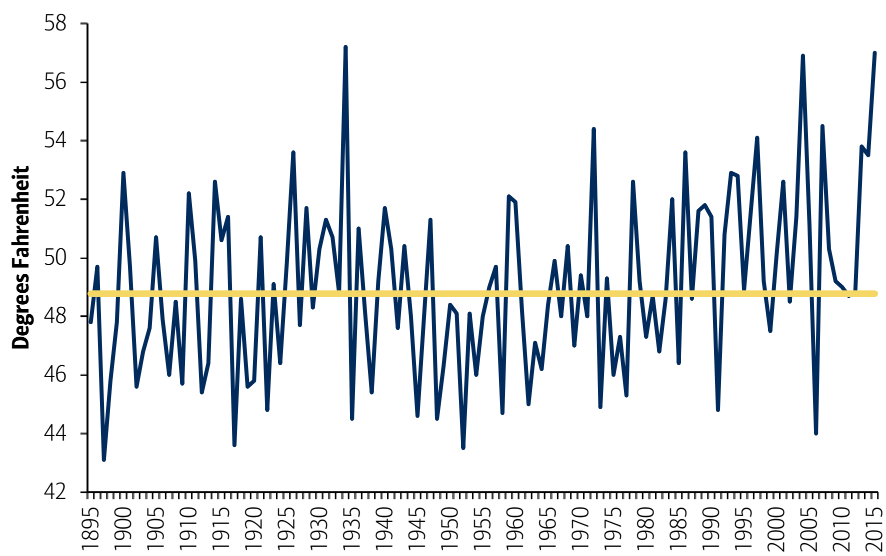
- Drought is projected to become more frequent, more intense, and longer-lasting, resulting in water deficits not seen during the instrumental period.

- Northern Sierra Nevada watersheds may become wetter, and in terms of flow, somewhat less drought-prone with climate change.

- In terms of soil moisture, drought is expected to generally intensify in the dry season due to warming.

- Changes in precipitation, combined with rising temperatures, could negatively impact California's water quality. (source: Risky Business Project)

Chart 12: Continuous Average March Temperatures in California



Source: NOAA, BofA Merrill Lynch Global Research

Snow is melting 5-30 days earlier in California today than in the past half-century. (Source: California Energy Commission)

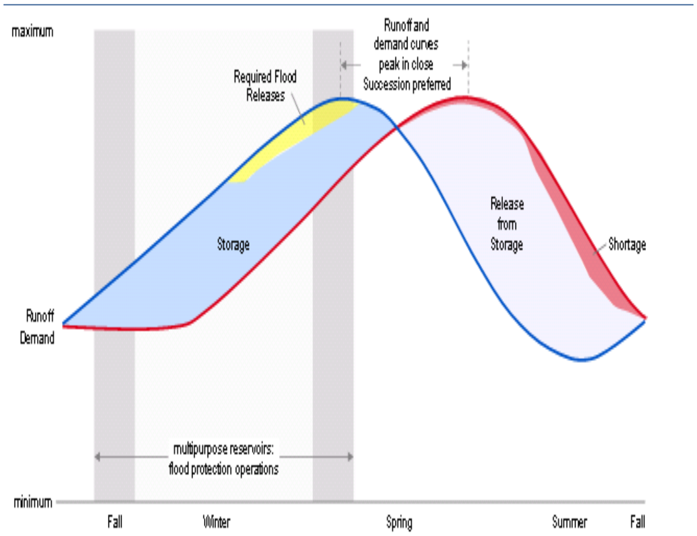
Both flood risk & water shortage are exacerbated

Warmer temperatures are likely to increase flood risk in the cooler months, while exacerbating water shortages in the summer dry months. Snowpack runoff peaks in the early spring, before high demand of the peak summer. While some of the runoff can be captured in existing reservoirs, the volume will likely increase beyond current capacity, creating flood risk. On the back of warmer weather, peak demand during the summer is likely to far exceed supply, making shortages more common (Source: California Water Plan 2013, Risky Business Project).

10% more water during cool weather, 30% less during warm

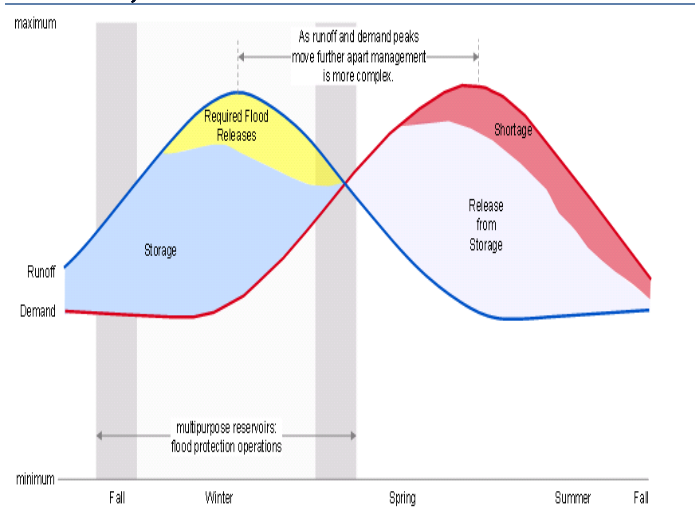
In areas like the Sacramento and San Joaquin Rivers basins at the Delta, water levels may increase by 10% during the cool season of December-March by 2070 versus 1990 levels. At the same time, runoff during the "warm" season of April-July will decrease by 30% by 2070. (Source: Risky Business Project)

Exhibit 11: How earlier runoff affects water conditions - Current Conditions



Source: California Water Plan 2013

Exhibit 12: Projected Conditions

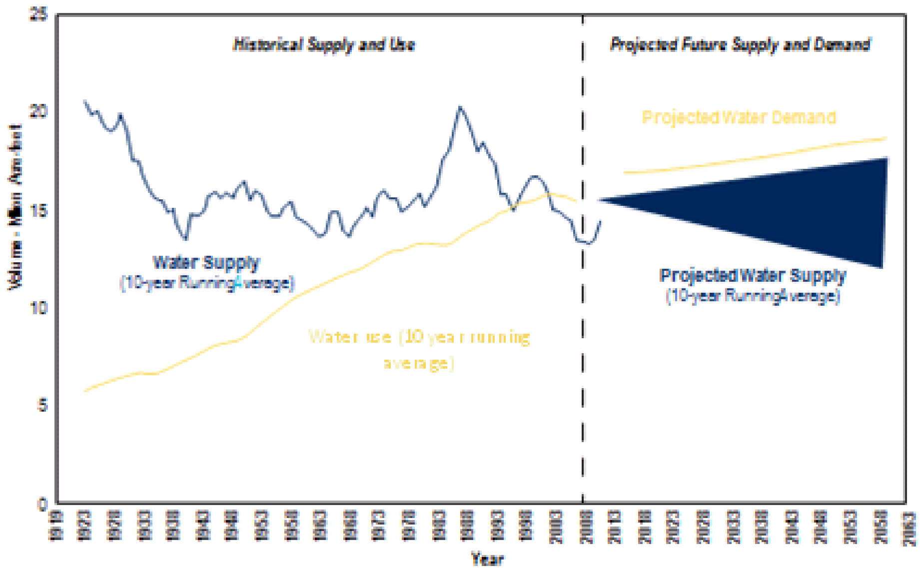


Source: California Water Plan 2013

Demand to outstrip supply by 1tn gallons by 2060E

The demand and supply gap could be as wide as 3.2mn acre-feet (1tn gallons) by 2060E. Part of this will be driven by the Colorado River basin, an important water source for the Inland South and South Coast regions, which is likely to decrease by almost 10% by 2070s (source: USBR). After a record eight-year drought in the Colorado River basin, reservoir storage throughout its river system is only 50% of storage capacity. It no longer runs to the ocean, and only one-tenth of its former flow now makes it to Mexico (source: California Water Project 2013).

Exhibit 13: Historical supply and use and projected future Colorado rive basin water supply and demand



Source: USBR 2013

Flood risk, US$8-10bn property underwater by 2050

Warmer temperatures and increases snowmelt will likely affect sea-levels along the California coast. More than 1mn Californians reside on coastal floodplains. Over 85% live in coastal communities, and more than 80% of the state's GSP is generated there. The human and economic impact of a rise in sea-level could be significant, including widespread losses of coastal property and infrastructure amongst others:

- By 2050, \$8-\$10bn of existing property in California will likely be underwater, with an additional \$6-\$10bn at risk during high tide.
- By 2100, \$19bn in coastal property will be underwater, with a 1 in 100 chance of more than \$26bn at risk.
- By 2100, mean sea-level rise of 4.6ft would result in the loss of 41 square miles of beach. Around 14,000 California residents live in areas at high risk of future erosion
- By 2100, San Francisco will likely see a mean sea-level rise of 0.7-1.1ft by 2050 and 1.8-3.3ft by 2100. San Diego is similar, with potential sea-levels rises of 0.8-1.2ft by 2050 and 1.9-3.4ft by 2100. (source: Risky Business Project)

> Half of the state's coast (including 1,100 miles of Pacific coastline and 500 miles of shoreline in the San Francisco Bay) has been identified as having high or extremely high vulnerability to sea-level rise (Source: NOAA)

Decrease in water quality

While climate change can drive water scarcity, there could also be a potential decrease in water quality. We can see additional water contaminants coming by washing nutrients and sediment into lakes and reservoirs during times of flood. This can be exacerbated with an increase of wildfires. This will have direct impact on human health, where one study already suggests the up to 1.5mn people contract gastroenteritis from swimming at contaminated beaches in Southern California each year (source: Given et al 2006)

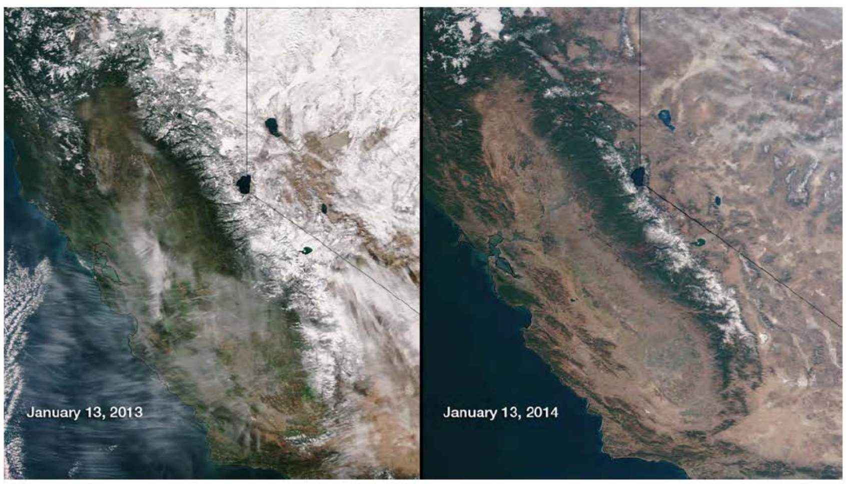
Water risk from multiple sides

Impact on various regions of California could be varied. Along the coast, rising sea-levels will threaten property and infrastructure. Further inland, dry and warm conditions will threaten agricultural productivity. Across the state, heat and climate change will fuel larger and more wildfires, endanger water resources and wildlife, while exacerbating air pollution.

Sierra Nevada snowpack non-existent, 30% of water needs

California's largest surface "reservoir" is the Sierra Nevada snowpack, supplying around 30% of state's water needs. As of April 2015, it stood at 5% of its historical average, the lowest of any year on record going back to 1950. The Phillips snow course portion of the testing site contained no snow, the first time in its 75 years of observation (source: California Dept of Water Resources). The Sierra Nevada snowpack contains 15 maf (4.9tn gallons) on average, which becomes snowmelt that ultimately feeds and replenishes the surface water reservoirs. (Source: California Water Plan 2013). NASA's Airborne Snow Observatory data from December 2014 showed that previous measurements of the Sierra Nevada snowpack had been overestimating the water content by a factor of two (source: Famiglietti et al, NASA JPL).

Exhibit 14: Comparing Sierra Nevada snowpack in two January 2013 vs. 2014



Source: NASA, CA Dept of Water Resources

Things will get worse, lose half of snowpack by 2100

Increased temperatures will continue to reduce amount of snowmelt as precipitation is shifted to rain, and with earlier melting of the snowpack. We may see loss of half or more of the Sierra Nevada snowpack by the end of the century, with impacts notably observable by the 2050 (source: CA Dept of Water Resources).

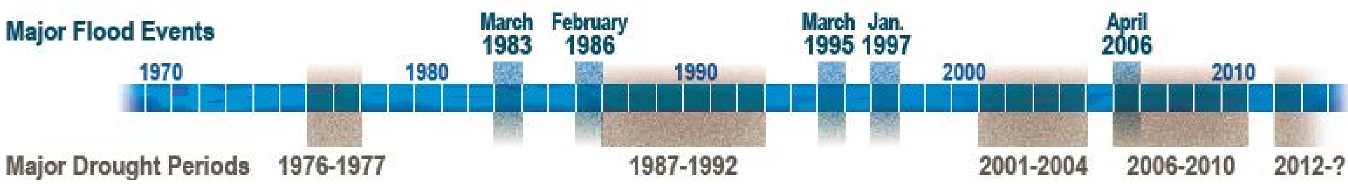
Sacramento-San Joaquin River Delta fresh water -25% by 2100E

Two major river systems, the Sacramento and San Joaquin, serve as natural barriers that prevent saltwater from the San Francisco Bay from intruding inland. The area is home to 25mn Californians and millions of acres of land. The rivers carve through California's Central Valley region, flowing into the Sacramento-San Joaquin Delta (Delta) where it halts saltwater from flowing into fresher water inland, and eventually running into the Pacific Ocean (source: CVP SWP drought contingency plan). We expect less upstream snowmelt to repel the seawater, which could reduce the amount of freshwater for drinking and irrigation by up to 25% by the end of the century (source: Risky Business Project).

Current drought 50% more expensive than 2009 drought

According to a UC Davis study, the combined socioeconomic effect of the current drought is US$2.2bn, which is up to 50% more expensive than the last one of 2009. Using preliminary data, this number could be as large as US$2.7bn in 2015. While the previous drought resulted in losses of 7,500 jobs and 270,000 acres of fallowed land, the current is up to 17,100 lost jobs and 428,000 acres of fallowed land through 2014. Around US$1.5bn of the losses will come from the agricultural sector.

Exhibit 15: Major flood events and major drought periods

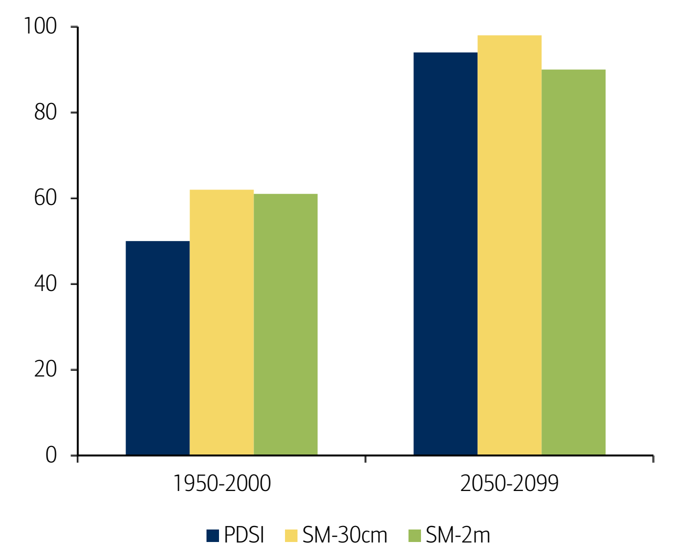


Source: California Water Plan 2013

80% chance of mega-drought this century

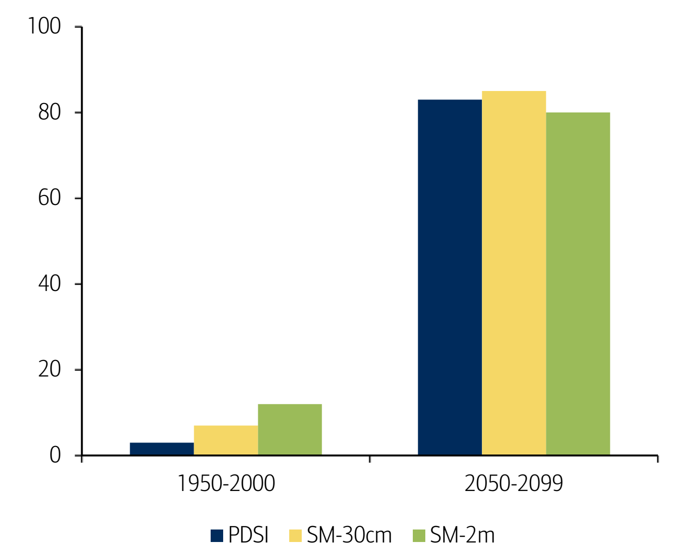
The risk of a multi-decadal drought (or 'mega-drought') in the Central Plains and the Southwest, which includes California, will likely increase from less than 12% historically (1950-2000) to 80% or more during the second half of this century (2050-2099). This will be driven by higher temperatures and changing precipitation combine to reduce soil moisture. Western US has experienced extended drought during the medieval era. Modelling shows that these future mega-droughts in the 21st century will also likely be drier than those over the past millennium. (source: Cook et al 2015)

Chart 13: Decadal drought risk - Southwest



Source: Cook et al 2015

Chart 14: Multidecadal drought risk - Southwest

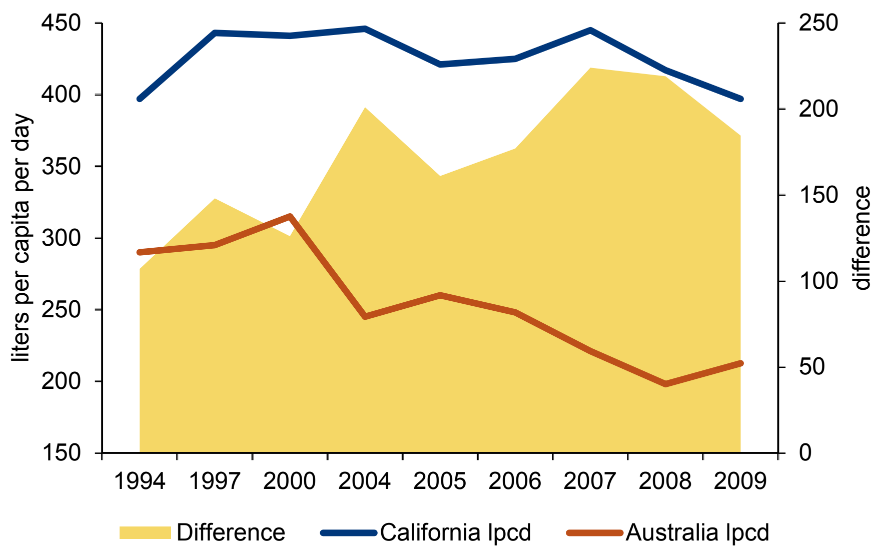


Source: Cook et al 2015

Learning from the Australian example

An example of the challenge and solutions ahead comes from Australia, which experienced persistent and severe drought between 2002 and 2012, with the Millennium Drought of 1996-2010 as one of its worst on record. The decade-long drought may have reduced Australia's GDP growth by up to 0.5% on the back of water curtailments, lowered productivity, unemployment and reduced exports. If this were to occur in California, cumulative state output would be reduced by US$0.5tn over the same 10-year timespan (source: CA Water Boards).

Chart 15: Historical Comparison of Average Residential Water Use in Australia and California, 1994–2009



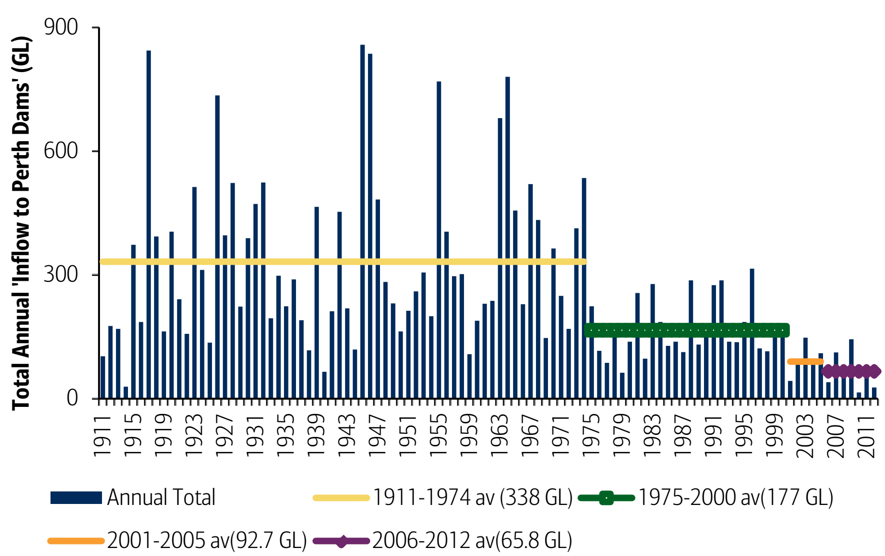
Source: Cahill and Lund 2013, ABS 1997, 2000, 2002, 2004a, b, c, 2006, 2008, 2010a, b;

WSAA 2011; and DWR 2011

Driest continent on earth, potential deficit of 30% by 2030E

Australia is the driest continent on earth with the most variable rainfall and streamflow. The country has suffered from severe episodes of drought throughout history including the Federation Drought (1895-1903), World War II Drought (1939-1945), and the Millennium Drought (1996-2010). Regions of southwest Australia including Perth could be facing water supply-demand deficits of 85bn litres annually by 2030. This is equivalent to 30% of the total water supply, enough to fill 34,000 Olympic sized swimming pools (source: Climate Council of Australia 2015)

Chart 16: Trend in total annual stream flow into Perth dams 1911-2012



Source: Climate Council of Australia 2013

Restrictions led to dramatic decline in water use

Similar to California, Australia imposed water restrictions. In 2009, Melbourne's water storage levels fell to a record of 25.6%, which led to Stage 3 restriction for the city during

2006-2009. This meant that residents could no longer water lawns, hose down hard surfaces, or fill swimming pools. The restrictions led to a significant drop in water use. In southeast Queensland, average water consumption plunged from 375 litres per person per day to 129 (source: Climate Council of Australia 2015).

Table 6: Water Use in Selected Australian and Western U.S. Cities, 2010

Location	Residential use, lpcd (gpcd)	Urban use, lpcd (gpcd)
Portland, OR	219 (58)	390 (103)
Albuquerque, NMc	282 (74)	587 (155)
Tucson, AZd	367 (97)	544 (144)
Denver, CO	393 (104)	604 (160)
California	394 (104)	568 (150)
San Francisco	172 (46)	295 (78a)
Oakland/East Bay	277–316 (73–83)	439–469 (116–124)
San Diego	277–350 (73–92)	490–524 (129–138)
San Jose	307–323 (81–85)	489–519 (129–137)
Los Angeles	345–376 (91–99)	450–547 (119–145)
Sacramento	428–455 (113–120)	642–667 (170–176)
Australia	204 (54)	318 (84)
Melbourne	150 (40)	238 (63)
Brisbane	172 (45)	289 (76)
Canberra	191 (50)	288 (76)
Sydney	207 (55)	312 (83)
Perth	284 (75)	399 (106)

Source: Calhill and Lund 2013

California can achieve higher reductions

Whereas California's per capita use dropped approximately 9% since restrictions were imposed in 2014 (source: SWRCB), Australia slashed consumption by 35% during its period of drought (DWR 2011; WSAA 2011). Several actions contributed to Australia's reduced water use:

- Outdoor water restrictions – Outdoor water use account for over half of the difference in residential usage between Australia and California. Many Australian cities limit outdoor water use. In Melbourne, for example, outdoor watering is prohibited 10am-8pm. Violators may be fined up to AUD$458.

- Lower-flush toilets – Toilets are the largest indoor end-use before the 2000s. By 2010, 86% of all Australian households had dual-flush toilets, using 1.6gal for a full and 0.8gal for a half flush. Californians have not adopted ultra low flow toilets (ULFTs) as quickly as Australians. California's lawmakers required ULFTs, which use 1.6gal/flush, in replacements and new construction after January 1992. By 2000, adoption was only 26%, with the same proportion still in 6gal/flush models.

- Water pricing – Australians pay the second highest water tariffs in the world at US$3.32/m3. People in nearly every major city in Australia pay more than Californians, despite lower consumption rates, which has likely contributed to reduced consumption. Per-unit consumption costs, rather than fixed costs, comprise a larger proportion of the total water bill in Australia (source: Cahill and Lund)

Table 7: Average 2014 tariffs (US$/m3) & water usage in selected major countries

Country	Combined tariff	Water tariff	Wastewater tariff	Change %	Domestic use 1/head/day	No. of cities
Denmark	$8.66	$3.94	$4.72	-1.4%	131	2
Australia	$6.50	$3.32	$3.18	3.8%	340	5
Germany	$6.02	$3.18	$2.84	-0.3%	127	10
United Kingdom	$4.91	$2.41	$2.51	2.7%	150	8
France	$4.59	$2.39	$2.20	0.9%	150	7
Canada	$3.54	$2.06	$1.49	6.6%	274	5
United States	$3.53	$1.46	$2.07	7.0%	380	51

Table 7: Average 2014 tariffs (US$/m3) & water usage in selected major countries

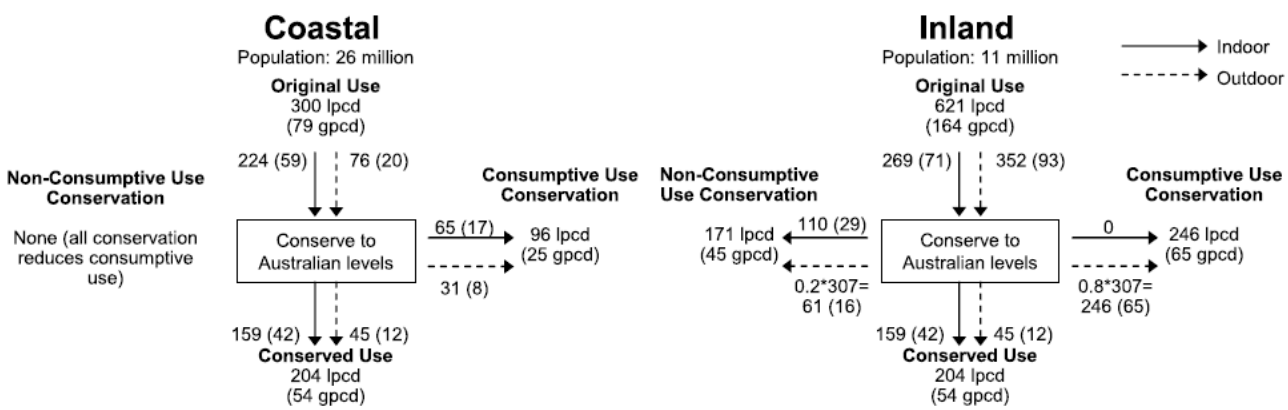
Country	Combined tariff	Water tariff	Wastewater tariff	Change %	Domestic use 1/head/day	No. of cities
Poland	$3.42	$1.55	$1.87	2.9%	125	6
Spain	$2.58	$1.81	$0.77	1.5%	265	6
Brazil	$2.43	$1.28	$1.16	6.7%	174	7
Portugal	$2.45	$1.77	$0.64	0.5%	161	3
Japan	$2.19	$1.21	$0.92	3.3%	373	13
Italy	$1.90	$0.90	$0.93	4.4%	190	6
Turkey	$1.73	$1.25	$0.48	8.2%	217	8
Russia	$1.01	$0.62	$0.30	6.9%	248	13
South Korea	$0.96	$0.66	$0.29	3.7%	183	7
Mexico	$0.96	$0.82	$0.13	13.7%	183	10
China	$0.52	$0.38	$0.14	2.7%	95	25
India	$0.14	$0.13	$0.02	3.9%	139	17

Source: Global Water Intelligence, BofA Merrill Lynch Global Research

Up to 2,600GL (2.1maf) reduction potential using best practice

Australian use nearly 200L per capita per day (50 GPCD) less than their Californian counterparts in 2009. If Californians adopt similar best practices, the can reduce 2,600GL per year, or 2.1maf, 570bn gallons. Nearly every major Australian city used less water per capita than metropolitan areas in western US. Given the similarities in climate, economy, and culture, California could use Australia as prime example of water conservation (source: Cahill and Lund).

Exhibit 16: California mass balance schematics for coastal and inland areas after conservation to Australia levels (using 2009 data)



Source: Cahill and Lund

The long-term impacts of drought

While the short-term effects of drought, such as declines in surface and groundwater levels, are pressing, the long-term knock-on impact of a sustained water shortage is just as alarming. Land subsidence, seawater intrusion and wildfires are just some of the potentially irreversible implications that California is facing.

Table 8: Typical Multi-year drought impacts

Unmanaged systems	**Health & Safety**	**Economics**	**Environment**
Risk of Catastrophic Wildfires	X	X	X
Non-Irrigates Agriculture	-	X	-
Fish & Wildlife	-	-	X
Managed Systems	**Health & Safety**	**Economics**	**Environment**
Small Water Systems/Private Wells	X	-	-
Irrigated Agriculture	-	X	-
Green Industry	-	X	-
Fish & Wildlife	-	-	X
Land Subsidence	X	X	X

Source: CA Dept of Water Resources

Subsidence – the land is sinking

Land subsidence, or the settling or sinking of the Earth's surface, is a global problem and continues to affect many parts of California (source: DWR). More than 80% of subsidence in the US is caused by the exploitation of groundwater. Water-related subsidence is caused by the compaction of aquifer systems, drainage, and the subsequent dissolution and collapse of susceptible rocks. Water helps to hold up the ground and, once it is withdrawn, rocks falls in on themselves (source: USGS).

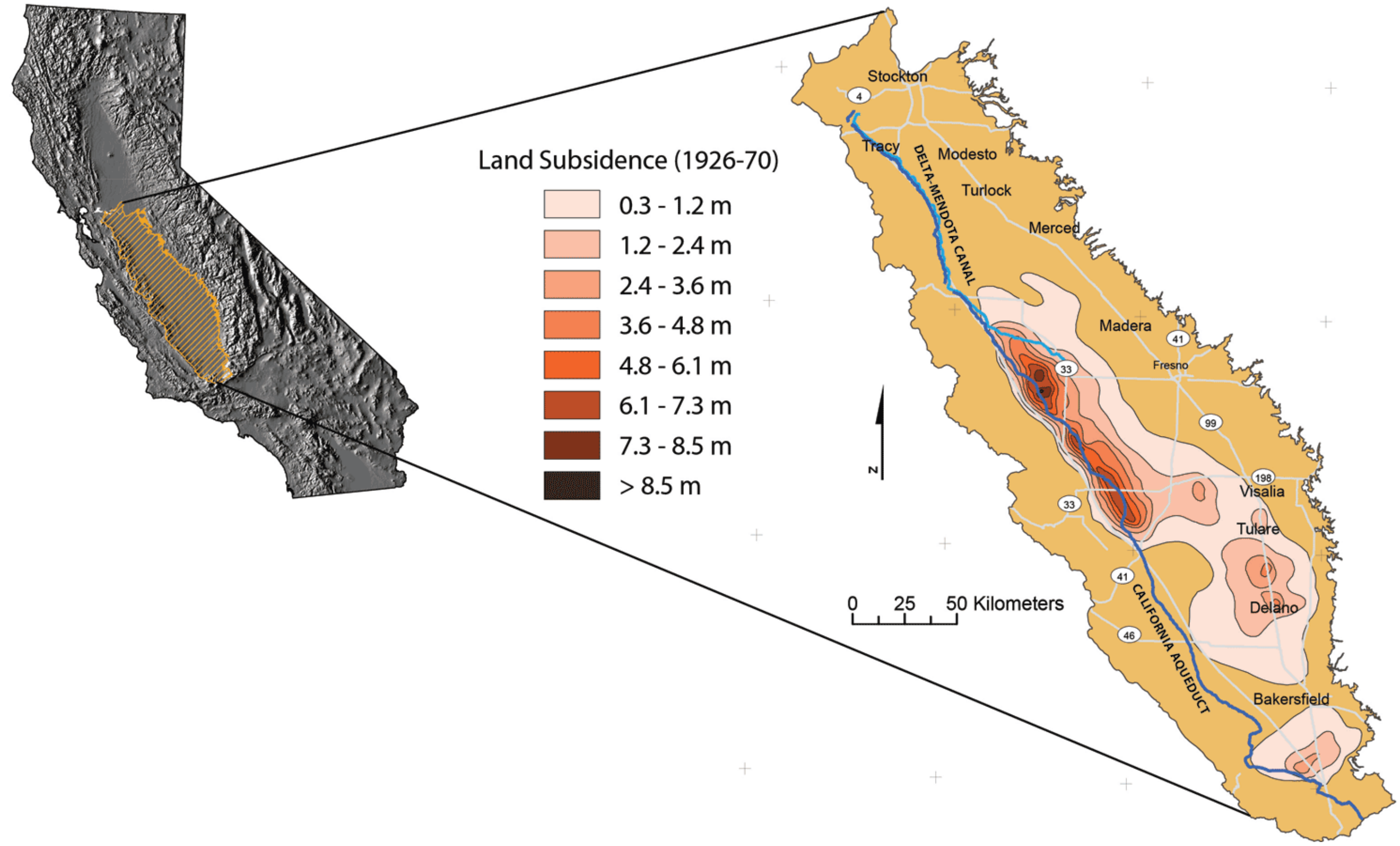
In the US, more than 17,000 square miles in 45 States, an area roughly the size of New Hampshire and Vermont combined, have been directly affected by subsidence (source: USGS)

San Joaquin Valley dropped 29ft in altitude

Subsidence has been occurring above aquifers all over California, but has been especially pronounced in the southern San Joaquin River and Tulare Lake hydrologic regions (source: DWR Public Update). Water-related subsidence started in the San Joaquin Valley in the mid-1920s. By 1970, significant subsidence of more than a foot had already occurred in half of the valley, covering 5,200 square miles. An area near Mendota in the Central Valley suffered a decline of 29ft between 1925 and 1977. Over-pumping in the San Joaquin aquifer system during 1976-77, 1986-92, and 2007-09, has led to renewed compaction and declines in surface altitude. This can cause serious operational and structural issues for water systems above it (source: USGS, US Bureau of Reclamation).

> 80% of the identified subsidence in the United States is a consequence of the human impact on subsurface water. (source: USGS)

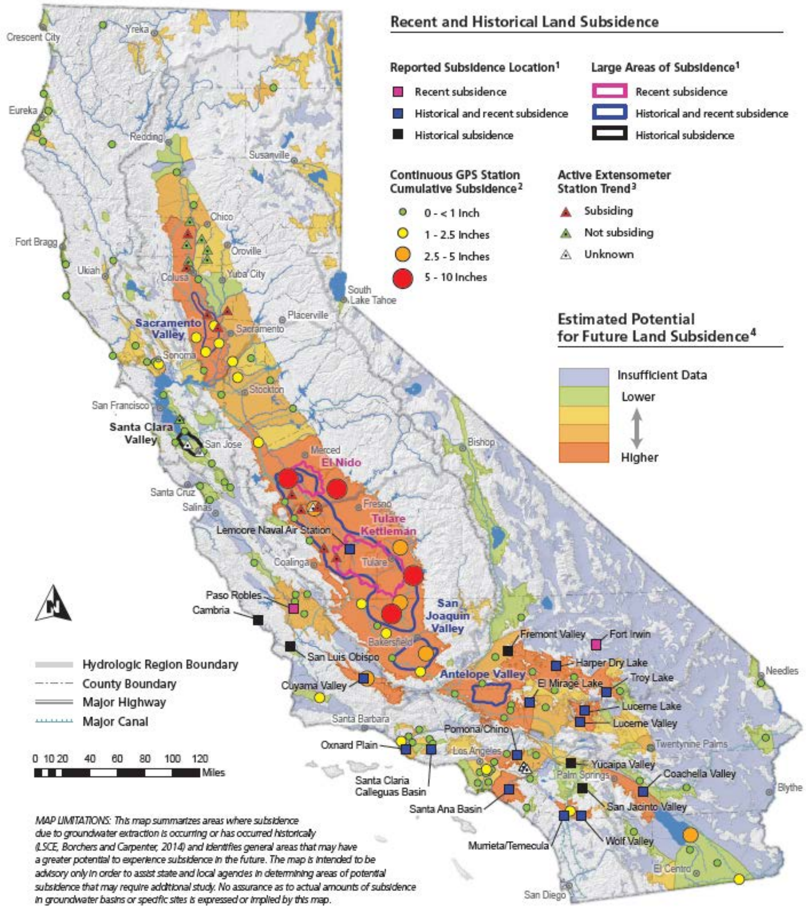
Exhibit 17: Land Subsidence



Source: USGS

With the ongoing decline of groundwater levels, the areas in the southern San Joaquin, Antelope, Coachella, and western Sacramento valleys have a higher potential for subsidence (Source: DWR Public Update).

Exhibit 18: Summary of Recent, Historical and Estimated potential for Land Subsidence



Source: DWR

Subsidence increases flood risk

While most of the subsidence occurs at a slow pace of around one inch per year, some areas in the San Joaquin Valley are sustaining drops of around a foot annually. At such a pace, infrastructure such as roads, water canals, and pipelines often cannot adopt to the ensuing rapid changes. Portions of flood control system are sinking along with it, reducing their ability to contain floodwater. Drought makes the situation worse as it leads to more groundwater pumping (Source: USGS).

Decreased groundwater storage

Another permanent impact on the region may be lost groundwater storage. As groundwater levels drop, clay deposits move closer together and space for groundwater is lost. "You can never get the deposits to go back," Sneed said. Groundwater provides about one-third of the area's total water supply, even more in drought years, officials said. In drought conditions, with lower surface-water flows, farmers are forced to pump even more water from the ground, which exacerbates subsidence (Source: USGS).

Salt-water intrusion risk

For coastal cities, salt-water intrusions are another challenge. Two major river systems, the Sacramento and San Joaquin, serve as natural barriers that prevent saltwater from the San Francisco Bay from intruding inland. The rivers carve through California's Central Valley region, flowing into the Sacramento-San Joaquin Delta (Delta) where it halts saltwater from flowing into fresher water inland, and eventually running into the Pacific Ocean. Both of the rivers are fed by upstream releases such as the Sierra Nevada snowmelt, which satisfies around one-third of the state's water needs in summer months. When there is not enough upstream water to repel saltwater, water quality is affected in downstream channels such as the State Water Project (SWP) and the Central Valley Project (CVP), but also Delta farm and water districts in Contra Costa, Alameda and Santa Clara counties (source: CVP SWP drought contingency plan).

Building and maintaining sufficient reservoir storage

The primary method of prevention is maintaining sufficient reservoir storage upstream in the spring to autumn months. This has to be balanced with critical water deliveries in the spring and summer seasons. Emergency drought barriers can be considered when there is not enough water upstream to meet downstream needs (source: CVP SWP drought contingency plan).

Emergency salinity barriers erected

By April 2015, the Sierra Nevada snowpack was as low as 5% of its average level, which convinced the federal and state wildlife and water agency managers to implement an emergency salinity barrier. Installation of the barrier began in May 2015 on West False River in the Sacramento-San Joaquin Delta, to lessen the saltwater impact on the water supply used by up to 25mn Californians. The temporary barrier will be removed by November to miss the flood season and avoid harm to migratory fish (source: DWR).

Wildlife negatively impacted

While water allocations for environmental purposes remain robust, wildlife in the region has been harmed as the drought continues in its fourth year. The viability of many ecosystems has come under threat as vulnerable species cause harmful chain reactions to others.

The Delta is California's estuary

The Sacramento-San Joaquin Delta is California's most crucial water and ecological resource. A total of five rivers feed into the Delta, which combine with saltwater from the ocean to create the largest estuary on the West Coast. It covers more than 40% of California, spanning 738k acres in five counties, and is home to 750 species. Eighty percent of commercial fishery species live or migrate through the region, while millions of migratory waterfowl rely on the Delta's wetlands (source: USBR).

Water diversions are a contributor

In California, 70% of the water supply originates in the north while the south account for 70% of consumption. For instance, the State Water Project pumps water from the Sacramento-San Joaquin Valley 700 miles down to southern California, where a large proportion of the state's population lives (source: DWR). In 2014, the combination of diversions, water storage, and drought decreased freshwater flows to the San Francisco Bay by 50%.

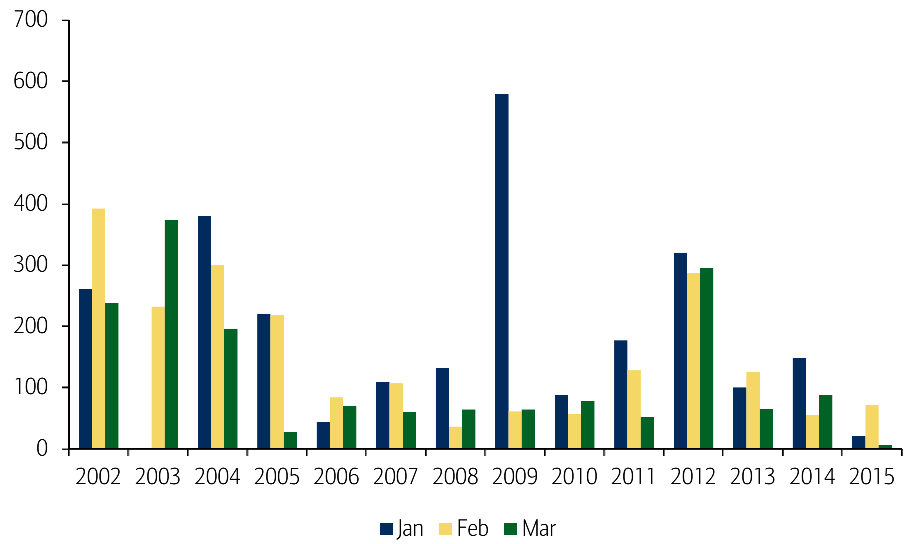
Natural wildlife has changed dramatically

In recent years, the population of native fish species in the Delta has dropped precipitously (source: Water Education Foundation). Natural habitats for many species have been challenged by the unprecedented drought. These include fish such as delta smelt, green sturgeon, Chinook and coho salmon, and steelhead rainbow trout. Habitats include the vast network of mudflats and wetlands, home to native species, such as Dungeness crab, valley elderberry longhorn beetle, giant gartersnake, and several migratory bird species. Many native species have come under increasing pressure in recent years, often displaced by exotic species that have adapted better (source: California Water Plan 2013).

Smelt close to extinction

The four-year drought is driving the delta smelt close to extinction, a species endemic to California. The most recent Delta Smelt Survey by the state's biologists found only six smelts, the lowest in 13 years of recordkeeping. The delta smelt is a small silvery fish that spawns in the Sacramento-San Joaquin Delta and feeds in the San Francisco Bay. Though it was once abundant, the species has declined rapidly in the past several years as the drought has exacerbated (source: CA Dept of Fish and Wildlife). Because they have a one-year lifecycle and are highly susceptible to environmental changes, they are often used as an indicator of the overall health of the Delta. The US Fish and Wildlife Service has begun drought-focused smelt surveys as part of a federal response (source: ACWA). Many fear that the species will be driven to extinction in the coming years.

Chart 17: Six smelts in March 2015 – a new low in 13 years of recordkeeping



SOURCES: California Department of Fish and Wildlife; San Francisco Estuary Institute; J. E. Merz, et al. California Fish and Game; California Department Of Water Resources; Bureau Of Reclamation

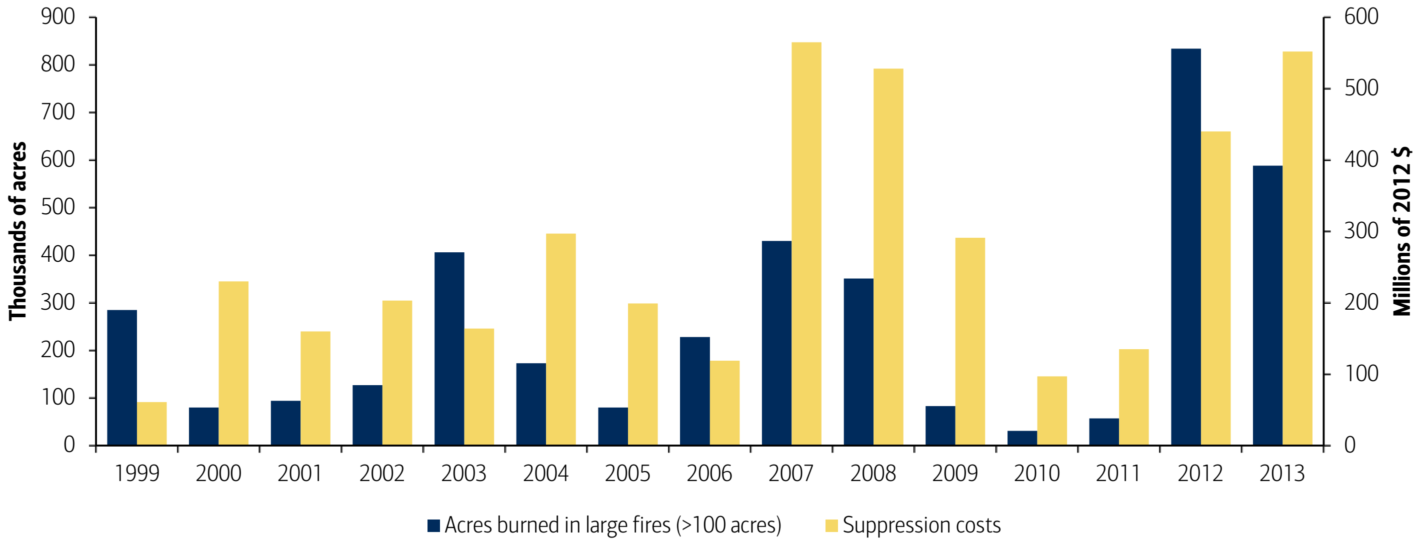
Salmon and steelhead threatened

Smelt is not the only species affected. During the 2013-14 migration season, smolt production from upper Redwood Creek was only 1% of the total from the previous season, leading to fewer adult Chinook salmon (source: CDFW). On the back of these developments, the Central Valley Project and State Water Project plan to preserve upstream reservoirs to help maintain cool temperatures for the salmon and federally threatened steelhead trout populations. This should also help with general water deliveries and Delta salinity management (source: CVP SWP Drought Contingency Plan).

Up to 169% increase in wildfires by 2085

There is vast and growing body of evidence suggesting that lower precipitation and rising temperatures, in combination with dry vegetation, will increase the intensity and frequency of wildfires in California (source: USGS). Climate outweighed all other factors in determining the burned area in western US during 1916-2003. The Risky Business Project predicts that California will experience up to a 74% increase in burned areas by the end of this century due to its climate (source: Risky Business Project). Similar analysis shows that the number of fires may increase by 58-128% versus historical levels by 2085, leading to a 57-169% rise in area burned (source: UCS, Risky Business Project).

Chart 18: Recent large wildfires in California, 1999-2013



Source: UCS

78,000 wildfires during 1999-2013, US$4bn in cost

There were more than 78k wildfires in California during 1999-2013, burning 3.8mn acres and incurring US$4bn in suppression costs. California ranks #1 in average annual cost for fighting wildfires on federal land, exceeding the 10 other western states combined (Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington and Wyoming). The Cedar, Rush, Rim, Zaca, and Matilja fires each burned more than 200k acres (source: UCS).

California has an annual fire suppression budget of more than US$1bn (source: Union of Concerned Scientists)

Table 9: 20 Largest Fires in California (More than 200,000 acres)

2013	Rim	2008	Klamath Theater Complex	2003	Simi	1987	Stanislaus Complex
2012	Rush	2007	Witch	2002	McNally	1985	Wheeler
2009	Station	2007	Zaca	1999	Big Bar Complex	1977	Marble Cone
2008	Basin Complex	2006	Day	1996	Highway 58	1970	Laguna
2008	Iron Alps Complex	2003	Cedar	1990	Campbell Complex	1932	Matilija

Source: UCS

Wildfire impact on water quality and supply

Furthermore, intense wildfire can inhibit long-term water storage. Wildfire leads to the development of impermeable hydrophobic soil layers that dramatically reduce surface-water infiltration rates. This prevents water from replenishing groundwater aquifers. This can also lead to increased soil erosion, causing greater transport of sediment downstream, which hampers water treatment and transfer (Neary et al. 2005, Onda et al. 2007, Moody et al. 2008).

Negative health impacts - 7,700 more heat-related deaths pa by 2100

Higher temperatures and more frequent wildfires exacerbated by drought conditions can increase air pollution in areas that already suffer from poor air quality. We may see worsening respiratory problems, more hospitalisations, productivity impairments, and higher heat-related mortality. According to analysis by the Risky Business Project, California may experience:

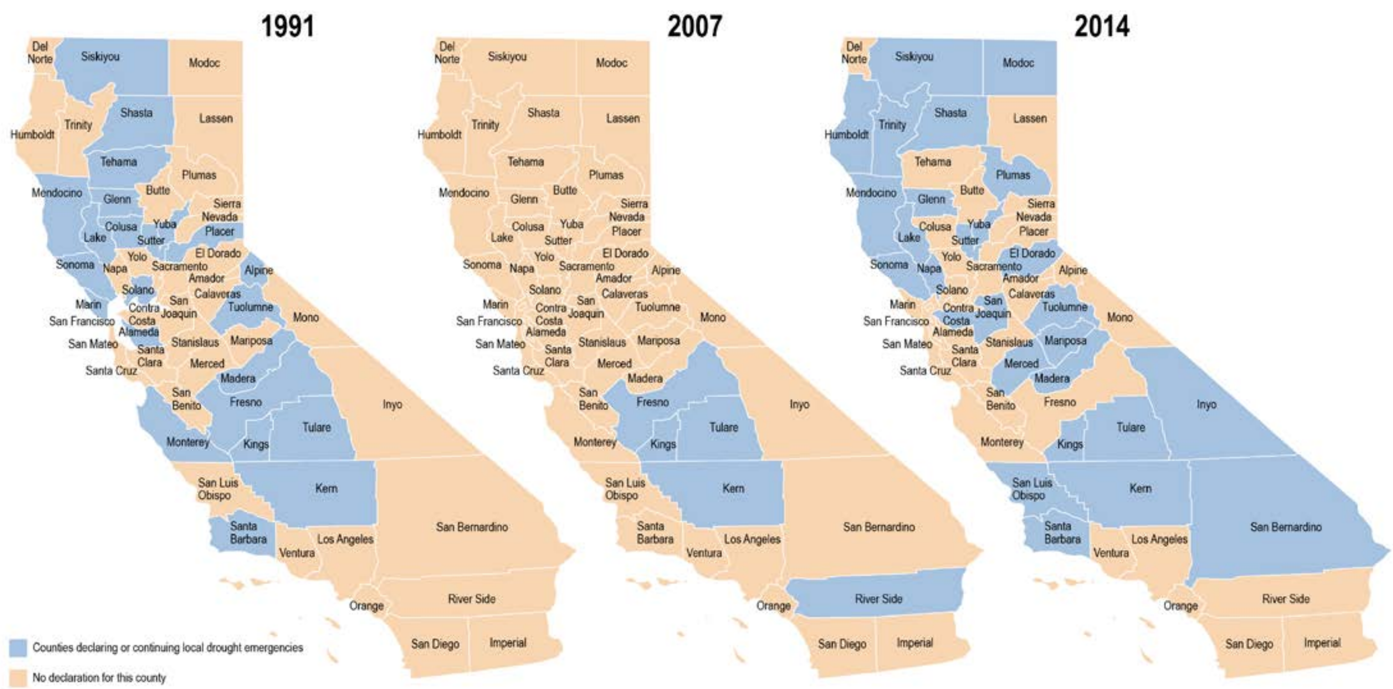
- Up to 7,700 additional heat-related deaths per year by late century, 2x the average number of traffic deaths.
- 30% of California workers in 'high risk' industries that are vulnerable to high temperatures.
- Declining labour productivity across the state, most pronounced in the Sacramento and San Joaquin Valley regions.

State of emergency

On 17 January 2014, Governor Jerry Brown proclaimed a state of emergency that mandated state agencies to take specified actions and called on Californians to reduce their water usage by 20% voluntarily. Among other things, the order mandated:

- Local urban water suppliers must immediately implement their water shortage contingency plans, as well as update water management plans.
- California's drinking water programme must identify communities in danger of running out of water and to help them address shortages.
- The State Water Resources Control board (SWRCB) and Department of Water Resources (DWR) must expedite water transfers and take various water rights administrative actions.
- The DWR and Water Board will accelerate funding for water supply enhancement projects.
- California's drinking water programme will provide technical and financial assistance to help vulnerable communities access drinking water (source: State of California).

Exhibit 19: Comparison of Counties with Emergency Proclamations



Source: California Department of Water Resources, California Office of Emergency Services

Efforts redoubled

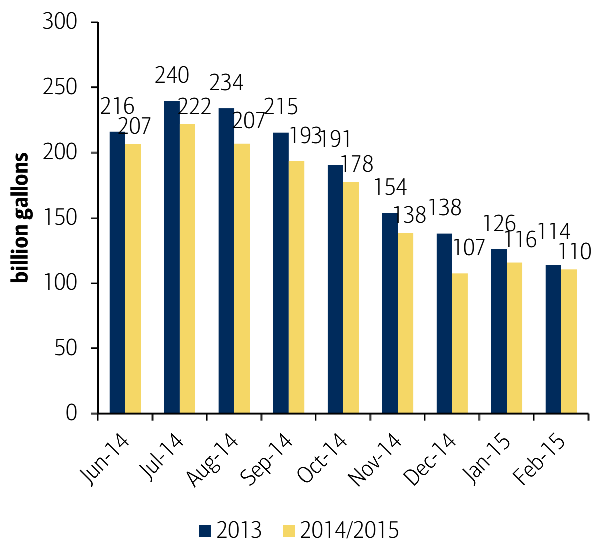
By March 2014, the Governor had signed measures to provide US$687.4mn for drought relief. The majority of that funding (US$549mn) was dedicated to accelerated expenditure of Proposition 84 and Proposition 1E bond funds for grants to local agencies for integrated regional water management projects. The money was also used to fund emergency drinking supplies, as well as US$46mn in housing and food assistance for workers directly impact by the drought. In April, the Governor issued an executive order to redouble state drought actions:

- SWRCB to adopt emergency regulations to direct urban water suppliers to limit wasteful outdoor water use practices.
- The DWR must conduct intensive outreach to local agencies to increase their groundwater monitoring in areas of significant impacts.
- Residents must refrain from wasting water – avoid using it to clean sidewalks and driveways, turn off decorative water features, limit washing vehicles and watering lawns.
- Many local agencies also issued proclamations of emergency (source: State of California, CA Dept of Water Resources).

Voluntary measures falling short - only 9% reduction

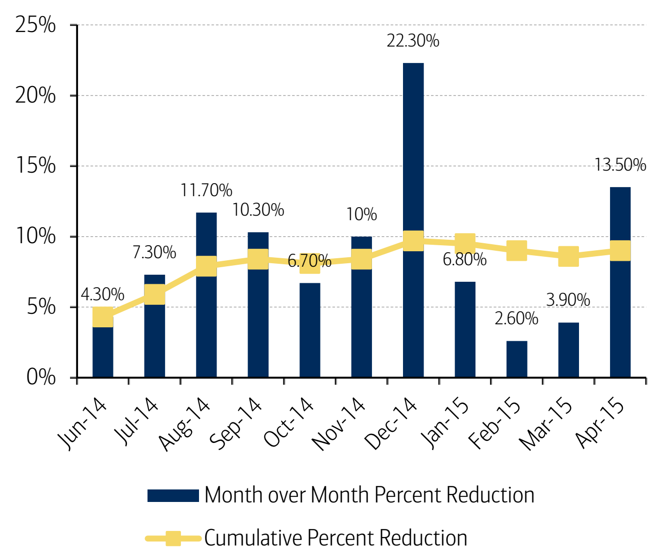
Between June 2014 and April 2015, Californians conserved 175.6bn gallons of water versus the same period in 2013, amounting to a cumulative reduction of 9%. This is enough to supply 2.35mn Californians for a year. While conservation jumped from 3.9% in March to 13.5% in April (2015), this was a far cry from the 20% guideline set the year prior in 2014 (source: CA State Water Resources Control Board).

Chart 19: Water production June 2014 - February 2015



Source: California Water Boards

Chart 20: Statewide Water Conservation Results - Water Production Percentage Reduction (compared to 2013)



Source: California Water Boards

Executive order - mandatory 25% reduction

On 1 April 2015, Governor Jerry Brown issued an executive order requiring mandatory water reductions in cities and towns across California to reduce water usage by 25%. To implement this, the State Water Board drafted a detailed framework for adoption beginning in June (source: CA State Water Resources Control Board).

- 25% state-wide reduction in potable urban water use
- Use of rates and pricing
- Additional conservation incentive programmes
- Additional specific use prohibitions.

Table 10: Emergency Conservation Regulation

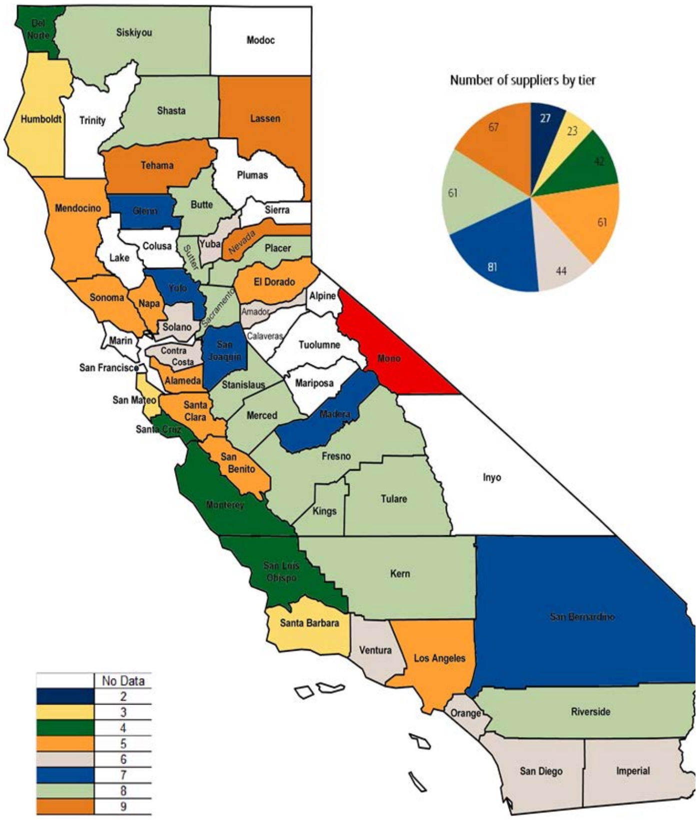
What's Prohibited for Everyone	What Water Suppliers Must Do	What's Required for Business
• Using potable water to wash sidewalks and driveways • • Using potable water to irrigate landscapes of new homes and buildings inconsistent with CBSC and DHCD requirements • Using outdoor irrigation during and 48 hours following measurable precipitation • Using potable water in decorative water features that do not recirculate the water • Using hoses with no shutoff nozzles to wash cars • Runoff when irrigating with potable water • Using potable water to wash sidewalks and driveways	• Achieve designated conservation standard (4-36%) • Notify customers about leaks that are within their control • Report on water use, compliance and enforcement • Achieve designated conservation standard (4-36%)	• Hotels and motels must provide guests with the option of not having towels and linens laundered daily • Restaurants and other food service establishments can only serve water to customers on request • Hotels and motels must provide guests with the option of not having towels and linens laundered daily

Source: California Environmental Protection Agency

1.3maf potential water savings – the size of Lake Oroville

Suppliers have been divided into nine tiers and assigned conservation standards ranging from 4-36% based on their residential gallons per capita per day (R-GPCD). If every water district achieves the mandated goals, the total water savings will amount to 1.3maf (0.42tn gallons) for the next nine months, or as much water as is currently in Lake Oroville. The Water Board will also continue to mandate monthly water production figures by supplier, for as long as emergency regulations are in effect (source: California Water Board).

Exhibit 20: Proposed water cuts by Californian county



Source: California Water Boards, BofA Merrill Lynch Global Research

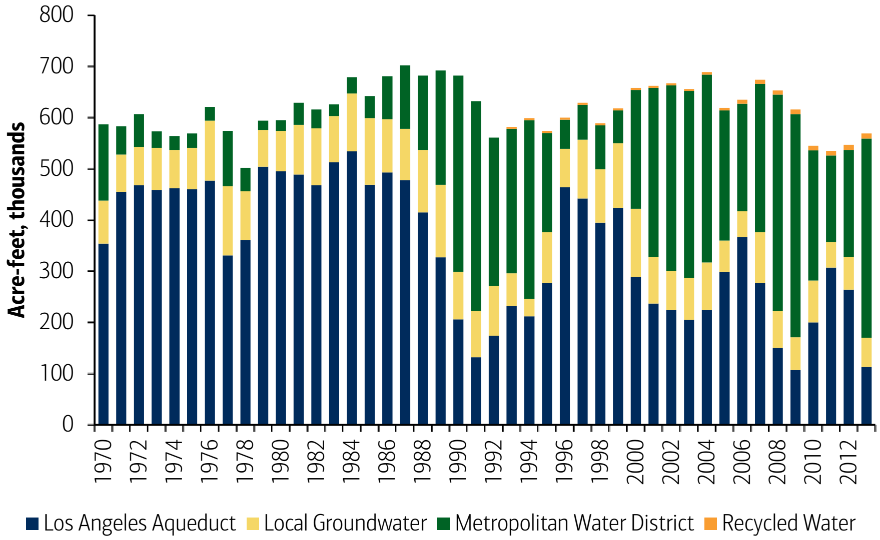
Residential End-User Prohibitions

- Irrigation with potable water of ornamental turf on public street medians is prohibited
- Irrigation with potable water outside of newly constructed homes and buildings not in accordance with emergency regulations or other requirements established in the California Building Standards Code is prohibited.
- Using potable water to wash sidewalks and driveways
- Allowing runoff when irrigating with potable water
- Using hoses with no shutoff nozzles to wash cars
- Using potable water in decorative water features that do not recirculate the water
- Irrigating outdoors during and within 48 hours following measureable rainfall
- Restaurants from serving water to their customers unless the customer requests it. (source: CA Water Boards)

Interconnected systems allow flexible response

The interconnected nature of water infrastructure in most large urban areas in California has allowed the regions to be flexible and respond more quickly to water demand and supply changes. Water infrastructure is also becoming increasingly connected. The Delta-Mendota Canal's intertie with the California Aqueduct in 2012, and the East Bay Municipal Utility District's connection to the Contra Costa Water District are good examples of this (source: CA Dept of Water Resources). During the drought, the city of Los Angeles has been able to source a higher proportion of its water supply from the Metropolitan Water District as flow from the Los Angeles Aqueduct slowed (source: Los Angeles Dept. of Water & Power).

Chart 21: Sources of City of Los Angeles water supply



Source: Los Angeles Dept. of Water & Power

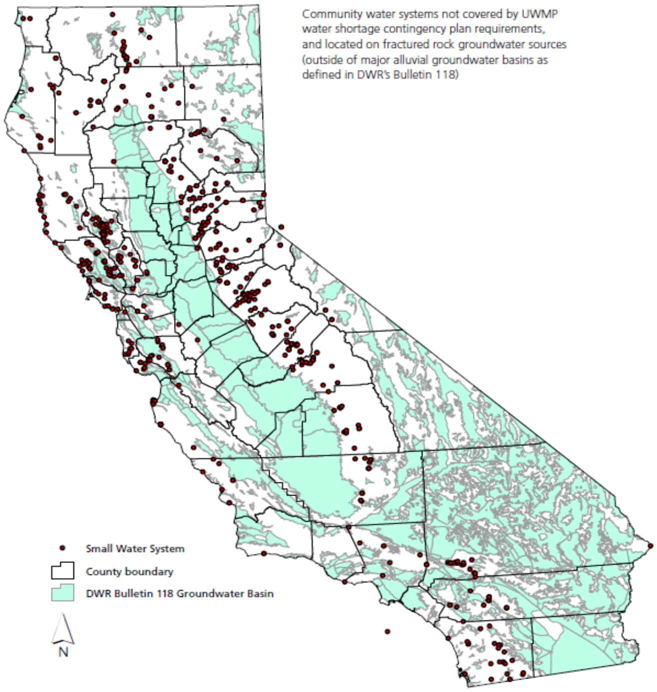
Private residential water - a vast system

California has 7,500 water systems providing drinking water for 98% of the state's population. The State Water Resources Control Board (SWRCB) Division of Drinking Water has the responsibility of regulating the public water systems with at least 15 service connections, or serve at least 25 people for at least 60 days per year (source: DWR Public Update 2014).

Smaller water systems at higher risk, need US$5.2bn over 20Y

California's small water systems tend to suffer the bulk of water shortage emergencies, as well as issues in water quality, regardless of year. The EPA estimates that the investment need for such systems in California is about $5.2bn over the next 20 years (source: PPIC 2014). Drought makes the situation worse. The main problem is that most small water systems are reliant on groundwater in fractured rock systems or other unreliable sources. They tend to be outside metropolitan areas, in lightly populated rural places where interconnections with other systems are more limited. This is exacerbated by having less financial resources, which constrains their ability to undertake major capital improvements. The most at-risk regions have been the foothills of Sierra Nevada and the Coast Range, inland Southern California, and the North and Central Coast regions (source: CA Dept of Water Resources).

Exhibit 21: Example of potentially at-risk small water systems



Source: CA Dept of Water Resources

US Environmental Protection Agency (USEPA) classifies public water systems according to size:

-Very small water systems serve 25-500 people

-Small water systems serve 501-3,300 people

-Medium water systems serve 3,301-10,000 people

-Large water systems serve 10,001-100,000 people

-Very large water systems serve 100,001+ people

Contaminated wells – one in six failing to meet standards

Recent studies show that 17% of small water systems failed to meet quality standards. Around 2,300 small water systems, with 15-999 connections, are regulated under the Safe Drinking Water Act. Collectively they serve 380k Californians. 185 systems exceeded one or more health-related maximum contaminant levels (MCLs) in their water supply. Another 215 rely on at least one contaminated groundwater well, and failed to meet standards for at least one MCL during 2002-10. While the sources of contamination are diverse, the issues tend to hit small, disadvantaged communities (source: Hanak et al PPIC).

1,483 incidents in 36 counties

As of 20 November 2014, there have been 1,483 incidents of domestic water issues reported from 36 counties in California. More than half have been from Tulare County, with Madera, Butte, Fresno, Inyo and Tehama also facing significant ongoing issues (source: DWR Public Update 2014).

Exhibit 22: Small water systems with contaminated groundwater are located across the state

Source: Hanak et al PPIC

California Emergency Drought Relief Act of 2014

The US Senate unanimously passed the California Emergency Drought Relief Act in May 2014 to give greater flexibility to federal and state agencies in delivering water during the drought. It granted the Secretaries of Commerce and the Interior emergency powers to direct the operations of the Central Valley Project and State Water Project to the provide maximum water supplies. Provisions include voluntary water transfers, temporary emergency barriers, and increasing water supplies without damaging the environment (source: Congressional Research Service, ACWA).

US$1bn emergency drought relief

In March 2015, Governor Jerry Brown approved a US$1.059bn drought relief package. The package accelerates US$128mn in expenditures from the Governor's budget to provide direct assistance to workers and communities impacted by drought and to implement the Water Action Plan. It also includes US$272mn in Proposition 1 Water Bond, a US$7.5bn California water bond approved in November 2014, funding for safe drinking water and water recycling, and accelerates US$660mn from the Proposition 1E for flood protection in urban and rural areas (source: State of California). It also allocates an additional US$17mn for emergency food aid, US$4.4mn for disaster recovery support and US$24mn for emergency drinking water in communities impacted by the drought (source: Community Water Center).

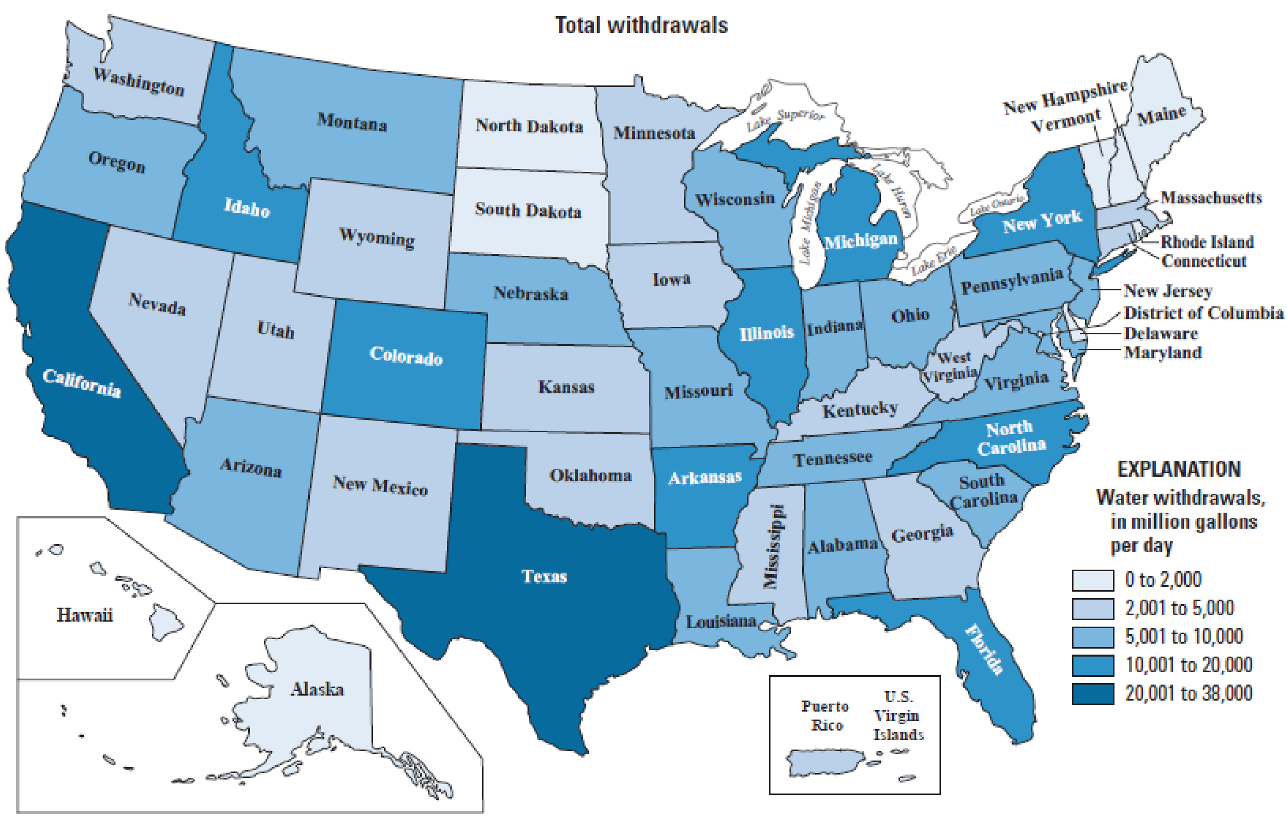
Federal aid: US$50mn for West, including US$20mn for Central Valley

The Obama administration has provided aid at the federal level. In February 2015, the Bureau of Reclamation made US$50mn available immediately for drought relief projects throughout the West – including nearly US$20mn for California's Central Valley Project. This was upped in June when federal agencies pledged another US$110mn for the West, providing assistance to drought-stricken farmers, battling wildfires, jobs programmes and water management improvement projects, among others (source: US Department of the Interior).

California – a potential bellwether for the rest of the US

While the Golden State experiences a confluence of environmental and consumption factors that contribute to drought, it is not the only region at risk. Forty out of 50 states have at least one region that is expected to face some kind of water shortage in the next 10 years, according to the US Government Accountability Office (source: US GAO 2014). On a global scale, 70% of the world's groundwater basins are in distress, with more water removed than replenished (source: UC Irvine, NASA JPL). The extraordinary circumstances in California serve as a potential bellwether for the rest of the US, and even the world.

Exhibit 23: Total withdrawals in million gallon per day



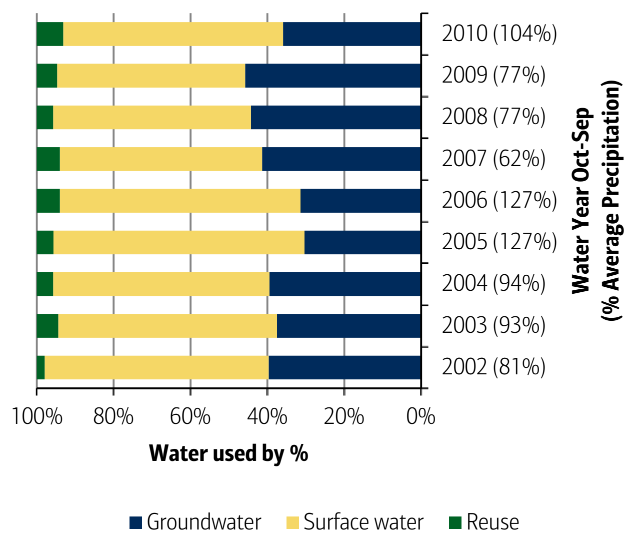
Source: USGS 2010

Supply-side challenges for Golden State

California's water supply faces a multitude of challenges including low rainfall, high variability in precipitation, a shortage of water storage and unregulated groundwater, which have been exacerbated by insufficient water efficiency and conservation, as well as funding challenges.

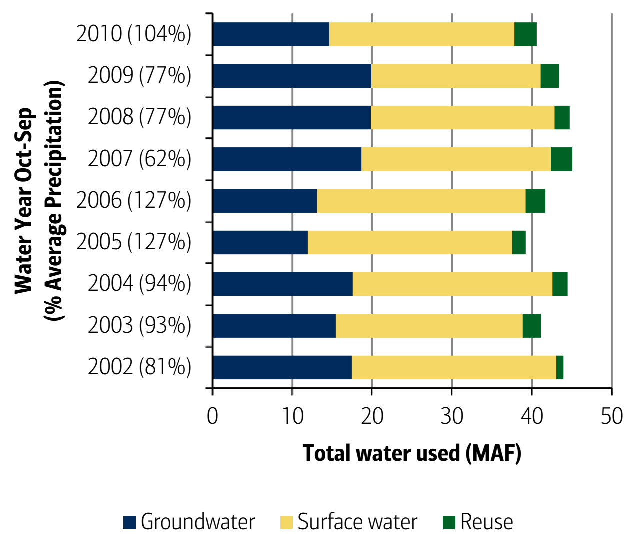
Most of California's precipitation comes from the Pacific due to its proximity to the ocean and its mountain ranges. Moist air moves over the Sierra Nevada or Transverse Ranges, where it is cooled, resulting in rain or snow. The snowpack from the Sierra Nevada and Cascade Range contributes to the runoff that supports much of the state's water use (source: California Water Plan 2013). In fact, northern California provides for around 70% of the state's total needs (source: DWR).

Chart 22: Water Used by %



Source: California Water Plan 2013

Chart 23: Total water Used (MAF)

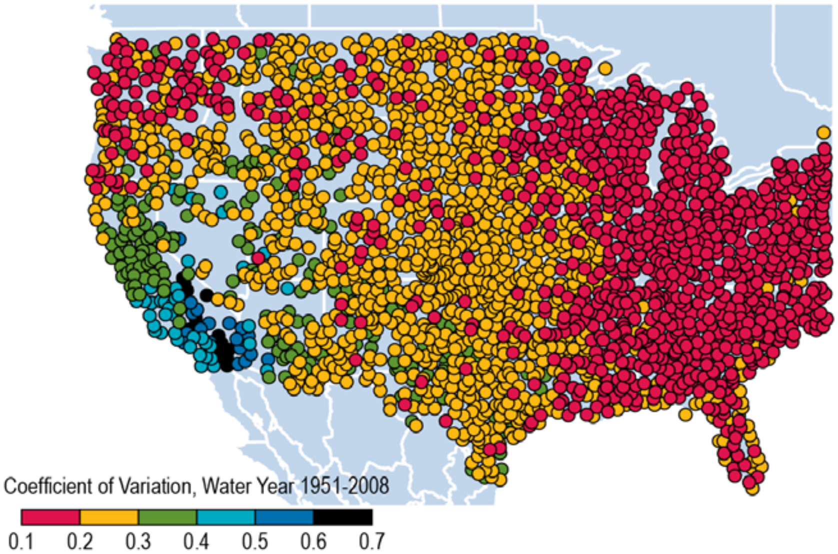


Source: California Water Plan 2013

High variability in precipitation

California experiences high annual variability in precipitation because a small number of storms make up the majority of the state's water budget. Around 75% of California's average annual precipitation of 23 inches falls between November and March, with 50% falling between December and February. A few wet storms or a shortfall could determine a particularly wet or dry year. Atmospheric river storms – storms fuelled by concentrated streams of water vapour across the Pacific to the West Cost – make up around 40% of California's annual precipitation (Dettinger, 2013).

Exhibit 24: **Comparative variability of California precipitation**



Source: USGS, BofA Merrill Lynch Global Research

10 major drainage basins, 1500 lakes and reservoirs

The California water system comprises 10 drainage basins, also known as hydrologic regions, more than 1,500 lakes and reservoirs, and hundreds of rivers and streams. Groundwater basins can store around 850maf (277tn gallons) of water, or 10 times the capacity of surface waterways. However, most of that is inaccessible, with only around 15maf (4.9tn gallons) of groundwater pumped each year (source: ACWA)

Most of California's precipitation falls as snow in the northern part of the state during winter, where the snowpack acts as a natural reservoir. The Sierra Nevada snowpack, for instance, is California's largest water reservoir. In the spring, the snowpack melts and flows into streams and rivers, making its way into the water supply or back into the ocean (source: NDRC).

Table 11: 10 major basins/hydrologic regions in California

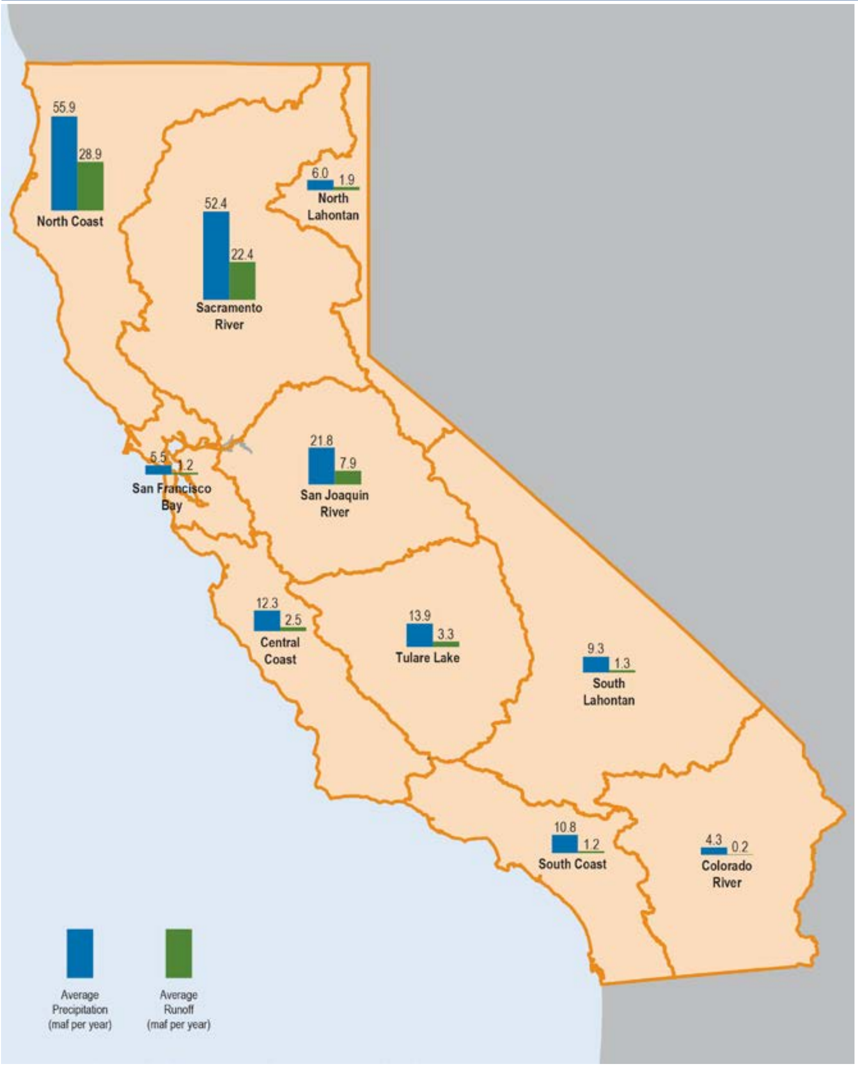
From North to South
North Coast
Sacramento River
North Lahontan
San Francisco Bay
San Joaquin River
Central Coast
Tulare Lake
South Lahontan
South Coast
Colorado River

Source: California Department of Water Resources

Surface water, 25bn gallons a day

Surface water is the most important source of supply for California, providing 25bn gallons per day (67%) in the most recent study in 2010. This is nonetheless down from 35bn gallons per day (76%) in 2005 (source: USGS 2010), much of which has been driven by declines in precipitation and reservoir levels during the drought.

Exhibit 25: Average precipitation and average runoff by hydrological region

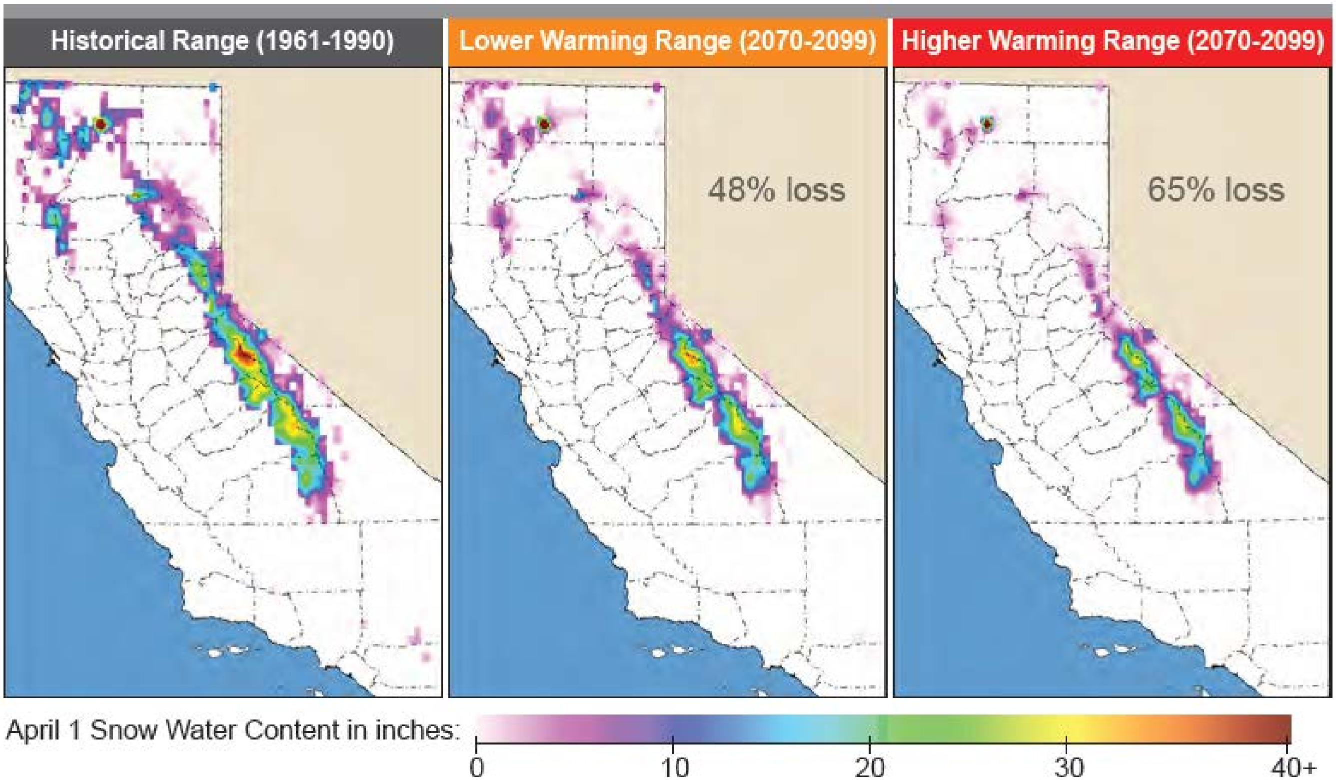


Source: CA Dept of Water Resources, BofA Merrill Lynch Global Research

Decreased snowpack, 25-40% decline by 2050

Since the 1970s, California has experienced a 15% drop in precipitation that fell as snow. Peak snowpack could decrease by 25-40% from historical levels by mid-century (Source: Risky Business Project). California's largest surface "reservoir" is the Sierra Nevada snowpack, which provides an annual average of 15maf (4.9tn gallons) of gallon every year, slowly melting from April to July. This supplies around 30% of the state's water needs. As of April 2015, the snowpack is now at 5% of its historical average, the lowest of any year on record going back to 1950 (source: DWR). It may lose 48-65% from its 1961-1990 average by the end of this century (Pierce and Cayan 2013).

Exhibit 26: Snowpack projections



Source: Pierce & Cayan

Decreased snowpack inhibits future groundwater recharge

Besides resulting in less snow water, the dramatic reduction in snow contributes to warming our climate by allowing the ground to absorb more sunlight. This reduces soil moisture, making it harder to get water from the snow into reservoirs once it does start snowing again. Groundwater levels across the US Southwest are in the lowest 1-10th percentile since 1949 (source: NASA JPL).

Central Valley surface water drops by 6m acre feet pa

The Central Valley is experiencing some of the highest levels of depletion in both its surface water and groundwater supplies. Surface water in the region is dropping at the rate of 6maf (2tn gallons) per year between 2014 and 2016, with nearly half coming from the San Joaquin Valley (source: UC Davis). The situation beneath the ground is similar. UC Irvine released a study in June 2015 using NASA data, revealing that Central Valley's underground aquifer is experiencing the highest level of distress in the US. It has the highest water withdrawal rate without adequate recharge (source: Richey et al).

Table 12: Change in Surface Water by Region Relative to an Average Year (in millions of acre-feet per year)

Region	**Surface Water Use Change**		
	2014	2015	2016
Sacramento Valley, Delta and East of Delta	-1.8	-2.3	-2.3
San Joaquin Valley	-1.8	-1.4	-1.4
Tulare Lake Basin	-3	-2.3	-2.3
Central Valley subtotal	-6.5	-6	-6
Central Coast	0		
South Coast	0.1		
South Inland	0		
State-wide	-6.6		

Source: UC Davis

Colorado River no longer runs to the ocean

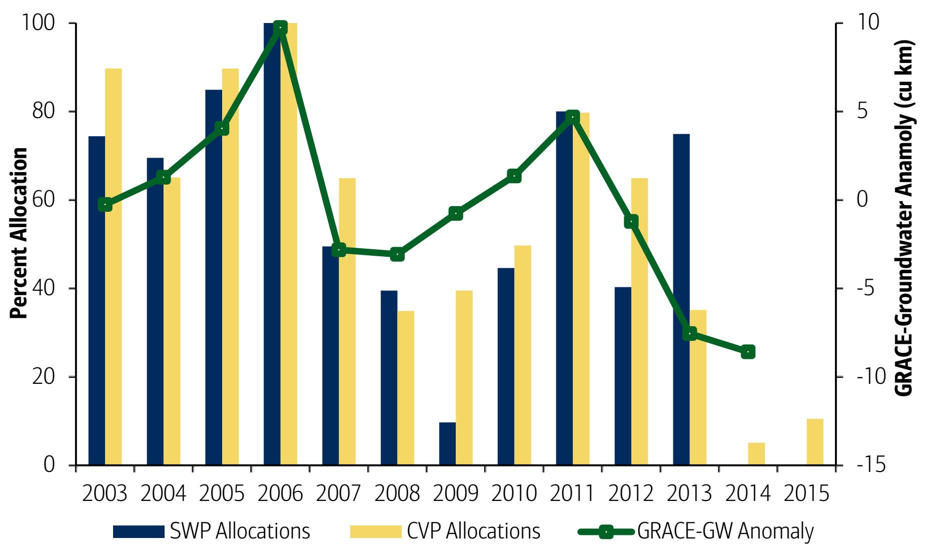
The Colorado River is one of the principal bodies of water in North America, running through seven US states and two Mexican states. Prior to 2003, California extracted 4.5-5.2maf (1.4-1.7tn gallons) from it annually. However, after a record eight-year drought in the Colorado River basin, reservoir storage throughout its river system is only 50% of storage capacity. It no longer runs to the ocean, and only one-tenth of its former flow now makes it to Mexico (source: California Water Project 2013). Furthermore, both Arizona and Nevada have begun exercising their full basic entitlement, putting further pressure on water levels.

Surface and groundwater are connected

Surface water and groundwater are typically managed as separate sources, while they are a highly interdependent system of watersheds and groundwater basins. Winter precipitation and spring snowmelt that are captured go towards replenishing surface water reservoirs, providing for year-round water supply as well as flood protection and environmental uses. Surface water also infiltrates soil and replenishes underground aquifers.

Conversely, groundwater also affects surface water supplies. Groundwater overdraft can result in depletion of aquifer storage and lowering of the groundwater table. Aquifer storage is replaced through increases in stream infiltration or through the capture of groundwater underflow that would otherwise have discharged into the stream and contributed toward base flow. Streamflow depletion can last months and in some cases even years (source: California Water Plan 2013).

Chart 24: Central Valley groundwater depletion from GRACE



Source: NASA, Famiglietti, et al

Disconnection can have devastating impact

In fact, disconnect between surface water and groundwater can have devastating consequences. In healthy circumstances, underground aquifers can be permanent or seasonally connected to surface water which contributes to increased base-flow during summer and fall months. This acts as a stabiliser of surface flow. Groundwater overexploitation can cause elevation levels to drop below stream flow. In this case, streams can have extended dry periods or overflow, with negative impact on fish, riparian habitat communities, and ecosystems (source: California Water Plan 2013).

California water infrastructure

California is home to several major water infrastructure projects. Its major urban centres – Southern California and the Bay Area – lack sufficient groundwater and other local resources to support their large populations so water must be imported from other parts of the state.

In addition to the most important Central Valley Project and California State Water Project, there are several other key water infrastructure endeavours in the state

- Central Valley Project (CVP): As California's largest water supplier, the CVP delivers on average more than 7maf (2.3tn gallons) of water per year. CVP water is used to irrigate 3m acres of farmland in the San Joaquin Valley, as well as provide water for urban use in Contra Costa, Santa Clara, and Sacramento counties (source: USBR).

- State Water Project (SWP): As the largest state-built water and power project in the United States, the SWP spans 700 miles from Northern California to Southern California, providing drinking water for 25m people and irrigation water for 750k acres of farmland (source: DWR).

- Los Angeles Aqueduct: Owned and operated by the Los Angeles Department of Water and Power, the Los Angeles Aqueduct supplies a portion of the water needed to supply the residents and businesses in its 465 square mile service area. The Los Angeles Aqueduct system brings water 338 miles from the Mono Basin and 233 miles from the Owens Valley by gravity to Los Angeles.

- Hetch Hetchy Aqueduct: The Hetch Hetchy water system delivers about 265,000 acre-feet of pristine Sierra Nevada water per year to 2.4m people in San Francisco, Santa Clara, Alameda and San Mateo counties. The San Francisco Bay Area imports more than 65% of its water through here. Some 85% of the water comes from Sierra Nevada snowmelt stored in the Hetch Hetchy reservoir situated on the Tuolumne River in Yosemite National Park. Hetch Hetchy water travels 160 miles via gravity from Yosemite to the San Francisco Bay Area.

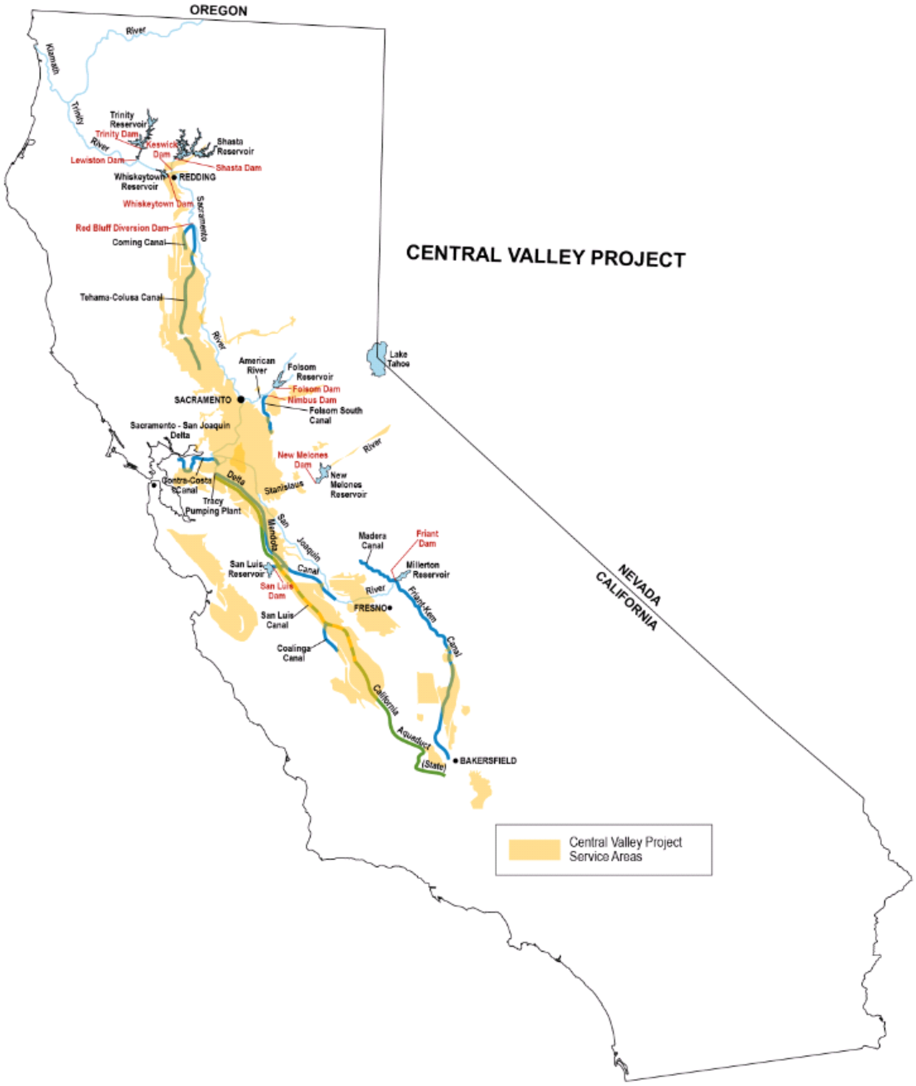
- Mokelumne Aqueduct: The East Bay Municipal Utilities District draws water from the Mokelumne River and transports it 91 miles from the Sierra Nevada through three steel pipeline aqueducts to serve its customers in the East Bay Area. The Mokelumne Aqueduct provides 90% of the water served by East Bay Municipal Utilities District.

- Colorado River: Colorado River is the principal water resource for California and six other states, Indian tribes and parts of Mexico. It spans 1,440 miles from Wyoming to the Gulf of California and Mexico. It supplies urban areas through the Metropolitan Water District of Southern California, as well as farmers in the Imperial, Palo Verde and Coachella valleys (source: Water Education Foundation).

Central Valley Project, CA's largest provider of water

The federally controlled Central Valley Project (CVP) is the largest provider of water for California. It consists of 20 dams and reservoirs and 11 power plants, spanning nearly 500 miles from the northwest to the southeast. This includes major watersheds such as the Sacramento River, San Joaquin River and the Tulare Lake Basin. CVP manages 9maf (2.9 gallons) of water, and delivers 7maf (2.3tn gallons) annually for agricultural, urban and wildlife use. 5maf (1.6tn gallons) of this goes to farms irrigating 3m acres of land, or one-third of California's total. A further 1.2maf (0.4tn gallons) goes to wildlife and wetlands as part of the Central Valley Project Improvement Act (source: U.S. Bureau of Reclamation).

Exhibit 27: Map of California's Central valley Project Service Areas



Source: U.S. Bureau of Reclamation

State Water Project, up to 3.7maf per year

The California State Water Project (SWP) is the largest state-built and operated water system in the US. It comprises 701 miles of canals and pipelines, 34 storage facilities, 21 lakes and reservoirs, supplying water for 25m Californians and irrigation for 750k acres of land. SWP starts in the north with Lake Oroville, down to the Bay-Delta, down the Central Valley, and into regions of southern California including Silverwood Lake. On average it delivers 2.4maf (0.78tn gallons) pa and up to 3.7maf (1.2tn gallons) in the highest years. SWP includes the Oroville Dam as part of its infrastructure, which is the tallest dam in US and also provides hydropower for the SWP (source: DWR).

Bank of America Merrill Lynch

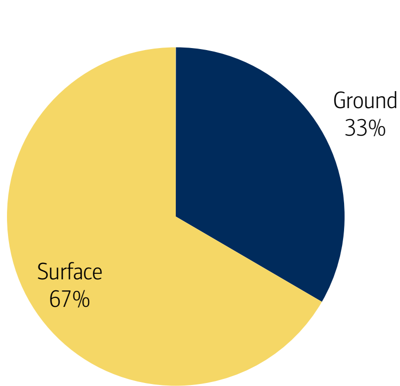
Exhibit 28: Map of California's State Water Project Facilities

Source: DWR

Groundwater provides 13bn gallons a day

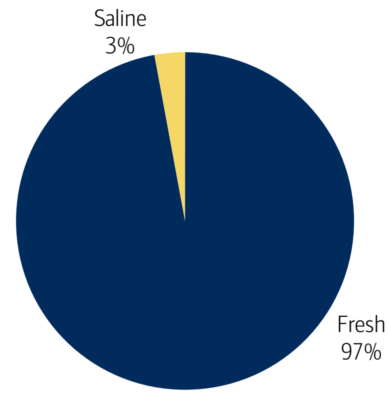
Groundwater provides for one-third of California's water supply annually, averaging 30-46% during 2002-10, which includes both dry and wet years. Half of Californians, or 16m people, derive at least part of their drinking water from groundwater supplies. However, this figure rises during drought. According to the last figures in 2010, groundwater provided for 38% of all water used in the state, totalling more than 16maf (5.2tn gallons). This is equivalent to 13bn gallons per day versus only 11bn gallons in 2005, or 24% of total consumption (source: USGS).

Chart 25: Groundwater vs surface water



Source: USGS 2010

Chart 26: Groundwater

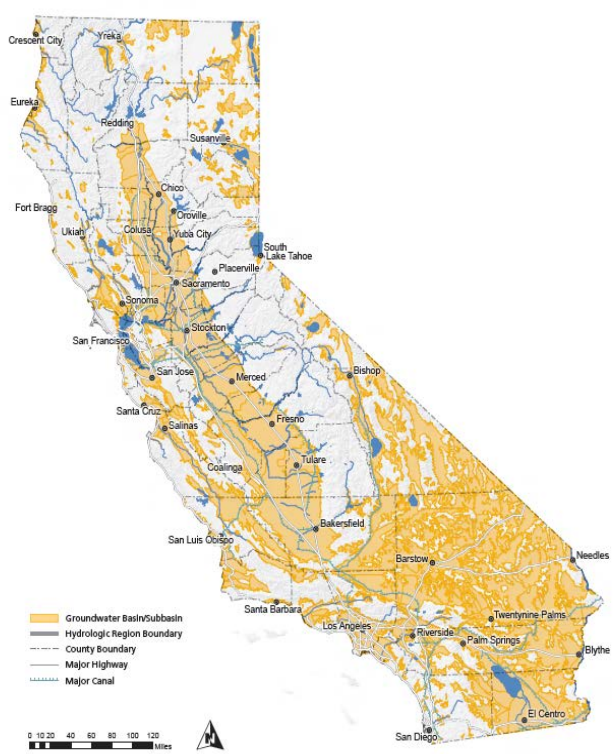


Source: USGS 2010

Tapping into groundwater during times of drought

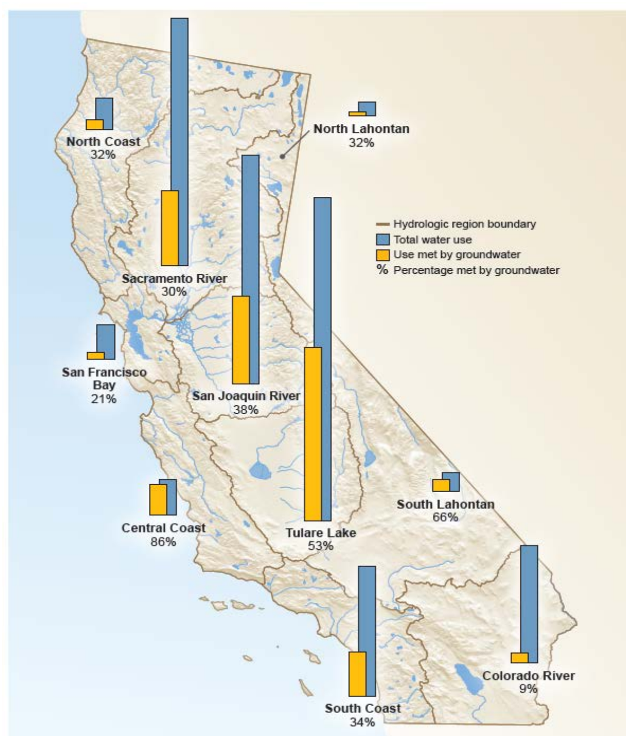
The primary response to reduced surface water availability is groundwater substitution. California already uses more groundwater than any other state. Three hydrological regions, Tulare Lake, San Joaquin River, and Sacramento River, make up 75% of California's groundwater use. Tulare Lake withdraws around 6.2maf (2tn gallons) a year – nearly double that of the next largest user. It is also the third most groundwater-reliant region, with groundwater comprising 53% of its supply (source: California Water Plan 2013).

Exhibit 29: California Groundwater Basins



Source: California Department of Water Resources

Exhibit 30: Groundwater contribution to total water use by hydrological region



Source: California Department of Water Resources

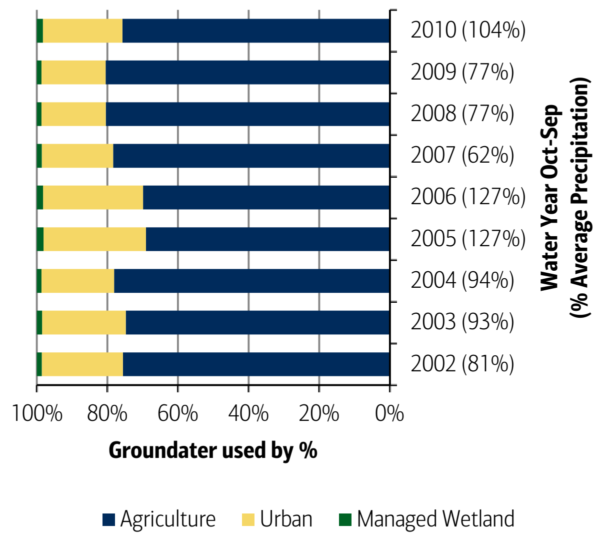
Groundwater levels dropping 50-100ft in some regions

As we witness record low levels of surface water, groundwater pumping has increased significantly. Groundwater levels in many parts of the state have dropped 50-100ft versus even their previous historical lows (source: CA Dept of Water Resources). California pumps out up to 2maf (0.65tn gallons) more water per year than is recharged, enough to supply 10m people (source: Water Education Foundation).

Agriculture accounts for 76% of groundwater extraction

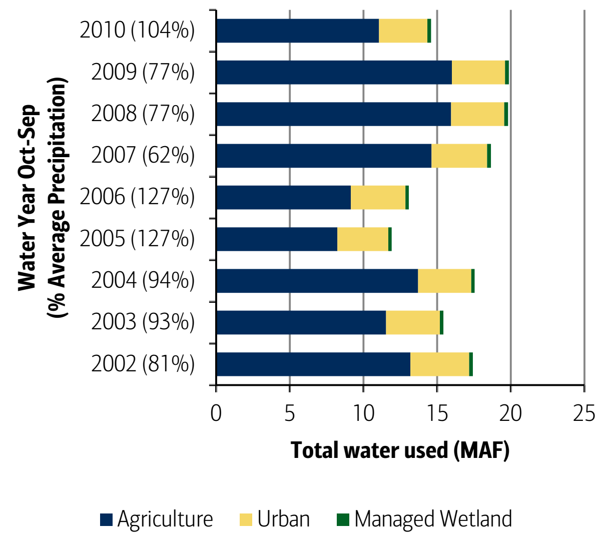
Agriculture is the most reliant on groundwater availability: 76% of extraction goes towards agricultural uses, with only 22% and 2% going to urban and managed wetland uses respectively (source: California Water Plan). On the back of this year's ongoing drought, groundwater may replace up to 5.1maf (1.7tn gallons) of the 6.6maf (2.2tn gallons) of loss in surface water. This would raise groundwater's share of agricultural water supply from 31% to 53% (source: UC Davis).

Chart 27: Groundwater Used by %



Source: California Water Plan 2013

Chart 28: Total Groundwater Used (MAF)



Source: California Water Plan 2013

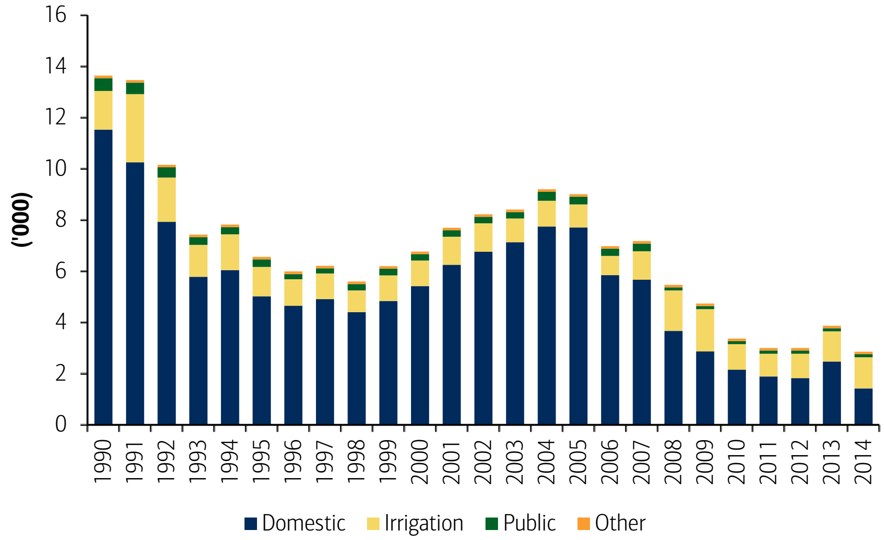
New wells being drilled

As surface reservoirs run low, there has been a flurry of well drilling, reaching for more groundwater. In 2014, more than 350 new water wells were reportedly drilled in Fresno and Tulare counties. More than 200 were drilled in Merced. Also, Butte, Kern, Kings, Shasta and Stanislaus counties each drilled more than 100 new water wells. Together they make up 57% of all new wells reported in 2014 (source: DWR Public Update 2014).

Domestic wells make up a large proportion of new wells

While the total number of new wells has been declining, from 14,000 in 1990 to 3,000 in 2011, domestic purposes have been rising to make up a larger proportion of new wells drilled. By 2015, half of new water supply wells were for domestic uses, with 47% for irrigation (source: DWR Public Update 2014). This is especially worrisome as it highlights the challenges to the residential drinking water supply.

Chart 29: Reported new water supply wells 1990 to 2014

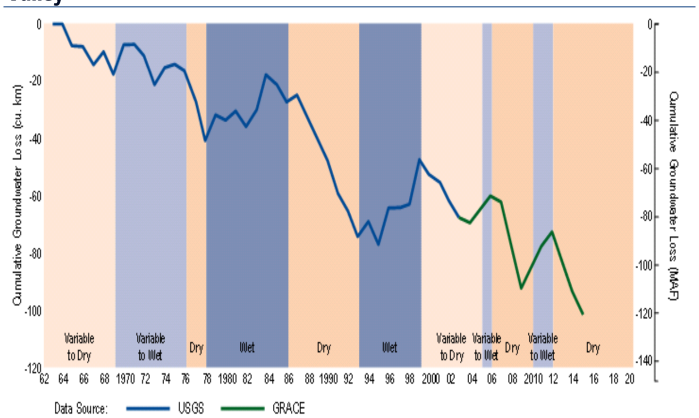


Source: DWR Public Update 2014

Depletion of groundwater, lowest 1-10% since 1949

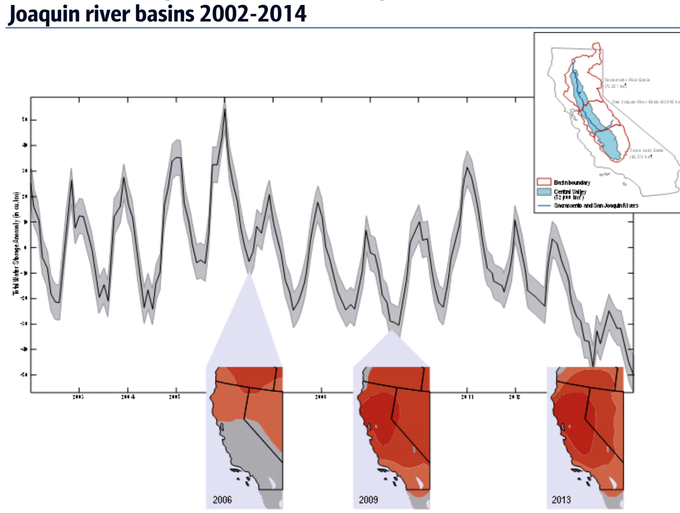
Since 2008, groundwater levels have been at all-time lows. Groundwater levels across southwest US now rank in the lowest 1-10% since 1949 on the back of increased pumping (source: Famiglietti et al, NASA JPL). Basins with the most dramatic drops in groundwater levels are in the Sacramento River, San Joaquin River, Tulare Lake, San Francisco Bay, Central Coast, and South Coast hydrologic regions. Groundwater levels in 35% of the monitored areas in Sacramento Valley, and 55% of monitored areas in San Joaquin, are now at historically low levels. Water levels have plunged 50-100ft in many regions (source: DWR Public Update). As surface water levels continue to decline, groundwater resources will come under increasing threat, barring changes in conservation and water management methods.

Exhibit 31: Cumulative groundwater depletion in California's Central Valley



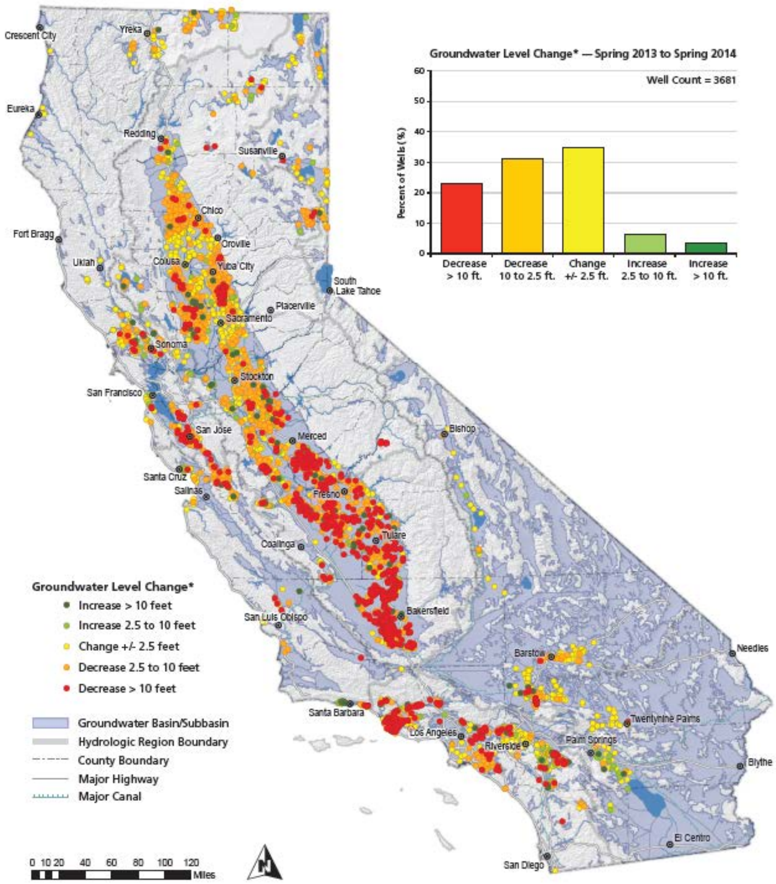
Source: NASA, Famiglietti, et al

Exhibit 32: Change in total water storage in the Sacramento-San Joaquin river basins 2002-2014



Source: NASA, Famiglietti, et al

Exhibit 33: Change in groundwater levels in wells – Spring 2013-2014



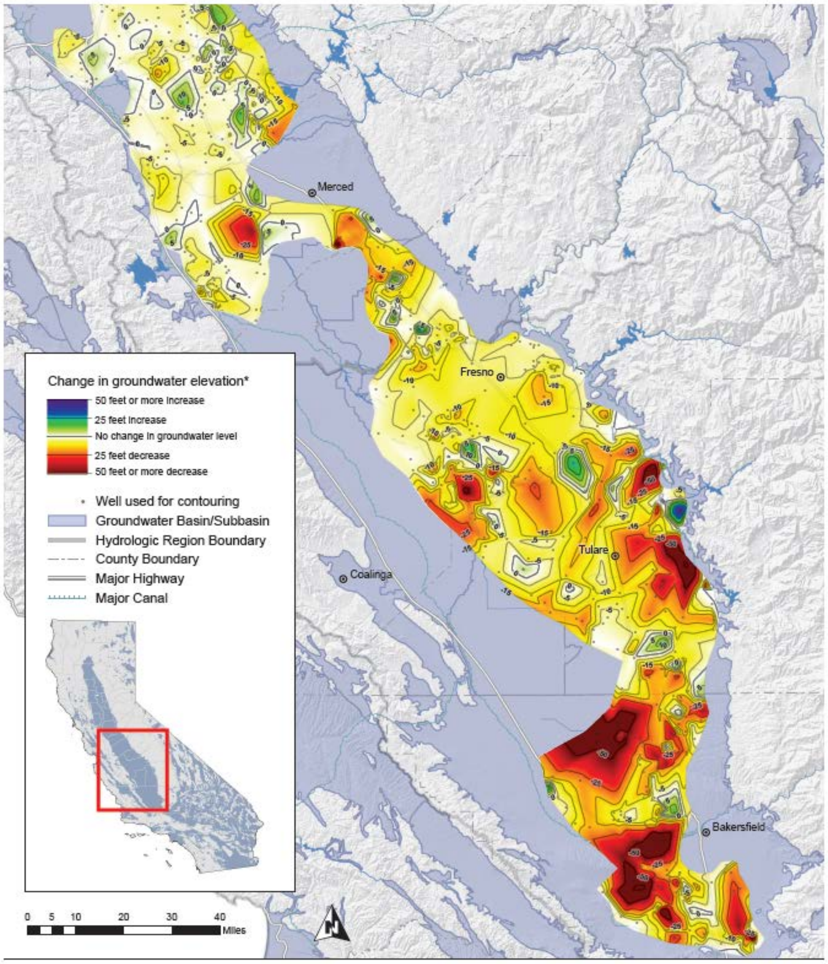
Source: DWR Public Update 2014

Slow recharge

Recharge of groundwater supply could also be extremely slow. California groundwater is recharged in three ways:

- Nature – rain and snow (7maf or 2.3tn gallons per year)
- After usage – agriculture and industry (6.65maf or 2.17tn gallons per year)
- Recharge programs by districts and regions where water is purposely managed to percolate down into the groundwater basin. (source: DWR)

Exhibit 34: Change in groundwater elevation, Southern Central Valley – Spring 2013-2014



Source: DWR

Diminished cushion for future droughts

Groundwater overdraft during dry years without adequate recharge will likely cripple California's ability to cope against future drought. As the groundwater level drops, the cost to drill new and deeper wells will increase. In some areas, water levels could drop below the installed capacity of wells, causing wells to go dry and reducing the ability to extract for future droughts. This also has other knock-on impacts, such as reducing groundwater quality and increasing land subsidence (Source: UC Davis)

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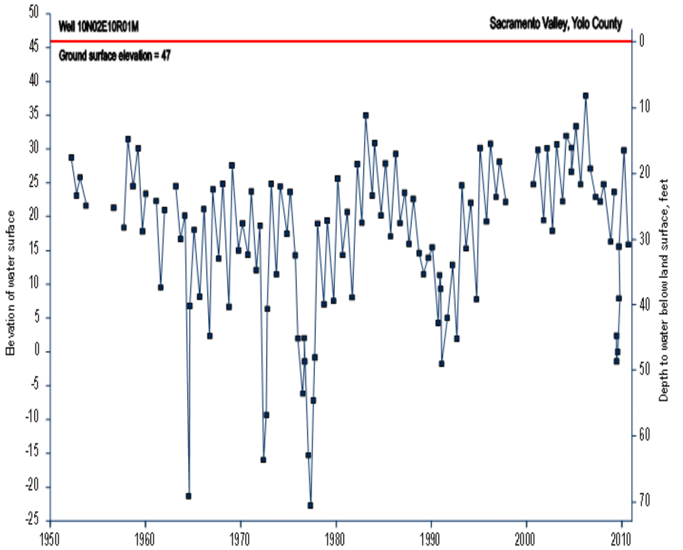
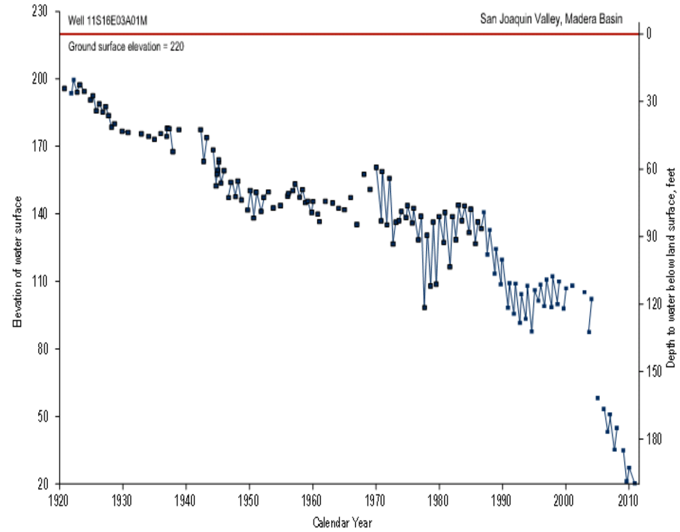
Exhibit 35: Sample hydrographs of wells in the Sacramento Valley



Source: California Dept. of Water Resources

Exhibit 36: Sample hydrographs of wells in the San Joaquin Valley



Source: California Dept. of Water Resources

Risk of contamination

Drilling deeper wells may also increase the risk of water contamination. The State Water Resources Control Board (SWRCB) estimates that 682 communities serving 21m people use at least one contaminated groundwater well for their supply source. This increases the supply cost as contaminants will need to be removed before delivery to customers. When treatment and alternative supplies are not available, some smaller water systems may be delivering contaminated groundwater until a solution can be implemented (source: California Water Plan 2013).

Long-term impacts

The overexploitation of groundwater has a long-term impact on both water sustainability as well as the overall environment. Groundwater overdraft makes wells run dry, forcing people to drill deeper, affecting aquifer integrating and cause the land to sink. Furthermore, this could also cause saltwater intrusion, giving water a higher salinity than acceptable for normal use (source: Risky Business Project).

Convoluted dual water rights system

Water in California is governed by a water rights system dating back to the Gold Rush era of the 1800s. The water rights govern the system of surface water, while groundwater remains unregulated. In theory, the State of California owns all the water in the state and has the ability to divide its usage (source: SWRCB, Waterscape). The first-ever state-wide water commission was establish in 1914, which then enshrined water rights into law. Today, the State Water Resources Control Board (SWRCB) is the state agency in charge of administering and allocating water rights. More than 2,049 corporations, local water districts, and other entities hold water rights that predate 1914 (source: SWRCB).

Tiered system of seniority

California has a dual system of water rights, recognising both the riparian and prior appropriation doctrines. Riparian rights are an entitlement for people who own land that borders water, who then have the right to make reasonable use of that water. Appropriative rights entitle people to divert water from a watercourse regardless of their location, and make reasonable use. Before diverting water, appropriative users have to obtain permission from SWRCB. Generally, riparian rights have superior claims to appropriative rights holders. Other less common water rights such as prescriptive and overlying also exist (source: SWRCB, CRS 2009).

Table 13: California water rights

Type	Attributes
Riparian	Entitlement stems from the ownership of property abutting a natural watercourse. Riparian rights are a facet of English Common Law which the US adopted following the revolution. Entitlement established under the riparian doctrine must only be for use on the riparian parcel. Rights are subject to "reasonable and beneficial use" clause. Rights are senior to appropriators and correlative with respect to other riparians. Title cannot be lost through non-use.
Appropriative	Entitlement is based on actual use of the water and developed from the miners in the 1850's using water on the public domain. Appropriative rights may be sold or transferred. Rights of appropriators who divert first are senior to subsequent (junior appropriators. Must apply to the State Water Resources Control Board for a permit. Approval is based on availability of water, "reasonable and beneficial use" clause, possession of the water, and priority in appropriation. Title can be lost through non-use.
Prescriptive	Generally means that if you are a junior user and have been openly and notoriously using water adverse to a senior rights holder for a few years, then you have priority equal to him. Allows for junior rights holders to immunize themselves from senior rights holders. This is important because in times of water shortage, junior rights holders typically have to give up a larger share of the water. Applies the real property common law theory of adverse possession to water. Difficult to obtain and can only be granted by a court. Most people in CA do not have it and cannot acquire it.
Overlying/ Groundwater	Landowners have overlying rights to use groundwater beneath their parcel. These rights are correlative with respect to other overlying users for use on overlying land. Use on overlying land is paramount to use on non-overlying lands. Subject to "reasonable and beneficial use" clause. No permit is required and the state has no program for managing groundwater, with exception of adjudicated basins. These adjudicated basins use the courts to resolve disputes and appoint a water master to apportion water.

Source: SWRCB, Waterscape International Group, BofA Merrill Lynch Global Research

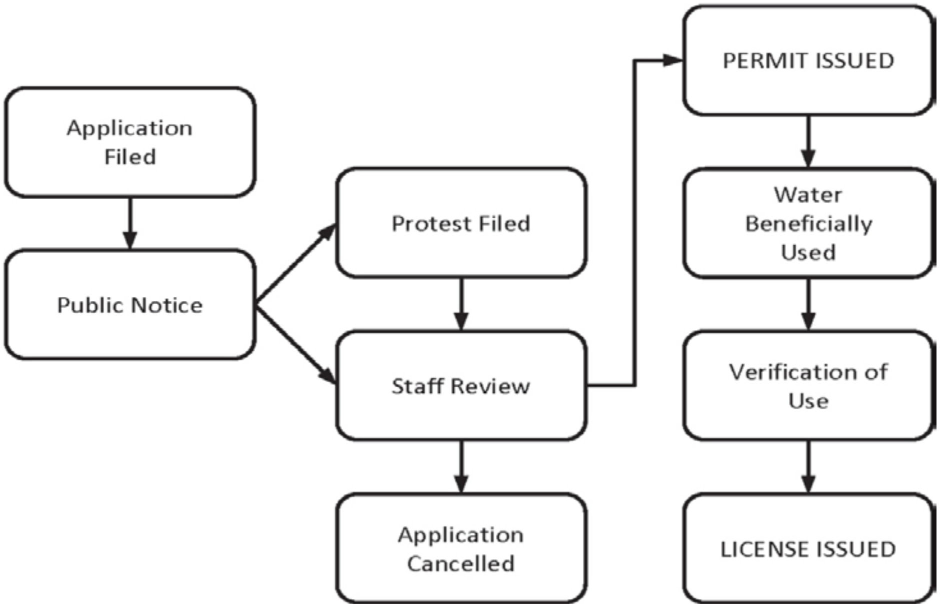
Senior vs junior rights

In 1849, many Americans flocked to California during the Gold Rush. Between then and 1914, water rights were awarded on a first-come-first-serve basis, whereby miners simply posted notice to stake their claim. The Water Commission Act of 1914 established the current permit process which granted the SWRCB the ownership and also the authority to grant use of surface water. In times of shortage, more recent “junior” rights holders have had to cede water use to more “senior” holders that had an earlier claim to the same water supply (source: SWRCB).

The process

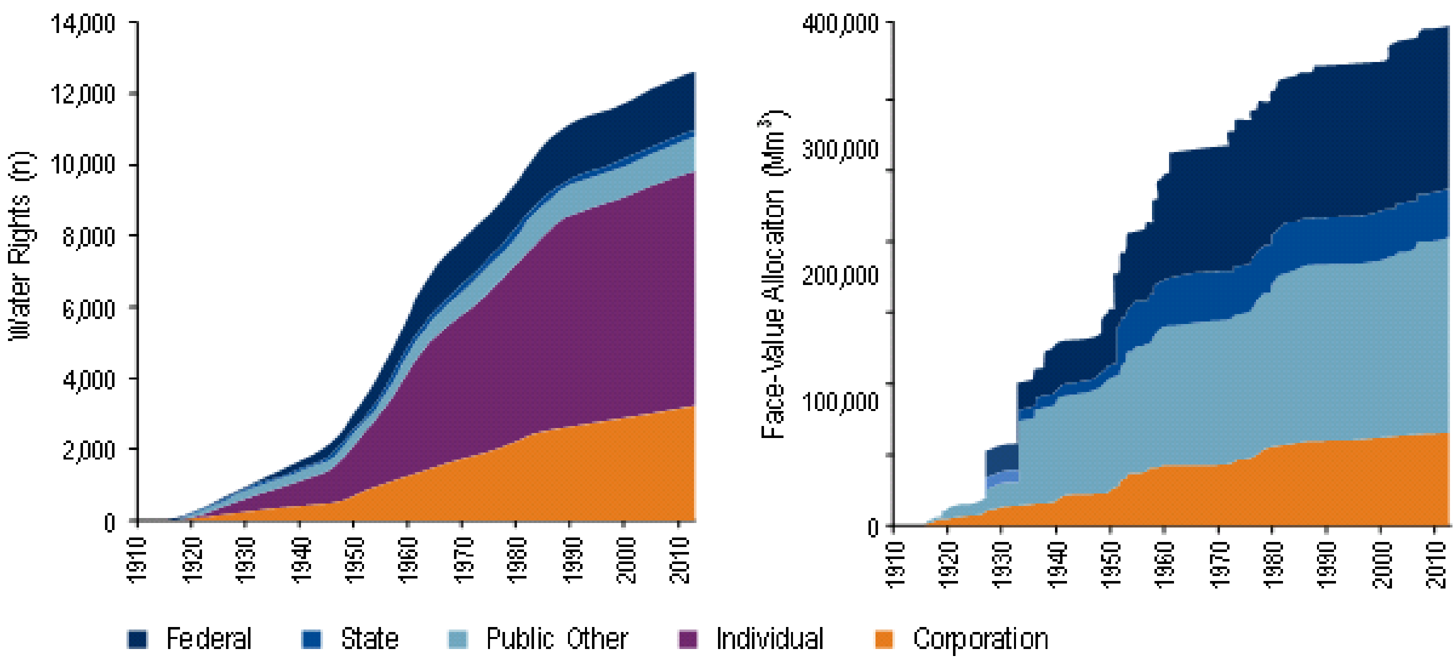
In theory, anyone can apply for a water right with the SWRCB. Decision of issuance is predicated on availability of water, satisfaction of reasonable requirements, and preservation of environment. Once an application is approved, the right can be exercised according to the permit terms, with amounts that may vary by year. Following a monitoring period of typically 10 or more years, the SWRCB will confirm the terms and conditions of use and issue the final permit (source: Grantham et al, UC Davis).

Exhibit 37: Process to obtain a water right



Source: California Water Board

Exhibit 38: **Historic number of water rights and face value amount (mm³)**

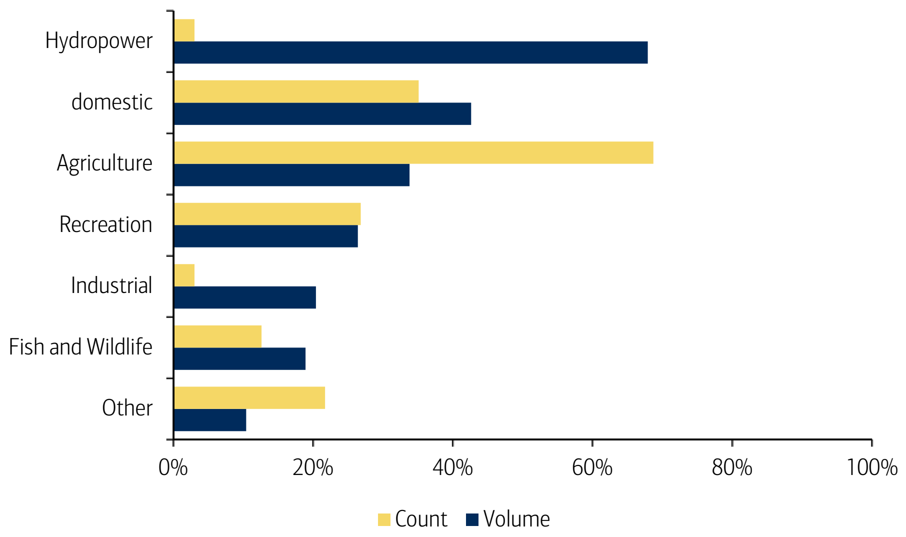


Source: Grantham et al, UC Davis

Allocations are 5x the annual runoff

A 2014 study by UC Davies shows that water right allocations total 400bn m3, or approximately five times the state's average annual runoff. In the state's major river basins, water rights account for up to 1,000% of natural surface water supplies, with the greatest degree of appropriation observed in tributaries to the Sacramento and San Joaquin Rivers and in coastal streams in southern California (source: Grantham et al, UC Davies).

Chart 30: Water rights use breakup



Source: Grantham et al, UC Davis

No ground water rights exist

California's water rights system only distinguished surface water, while groundwater can be extracted at will (source: SWRCB). The lack of regulation is one of the many reasons that groundwater has been overexploited without allowing sufficient recharge. In fact, California is the only state in western US without groundwater rights or regulations. Prior to 2014, local groundwater management by local agencies were some of the first measures in exercising proper use (source: UC Davis, PPIC).

Landmark Sustainable Groundwater Management legislation

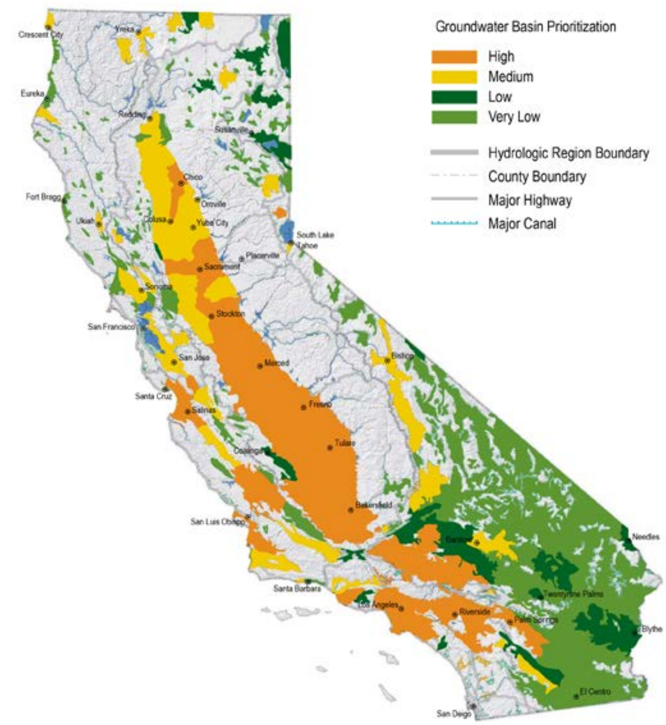
On 16 September 2014, the Governor of California signed into law a three-bill legislative package: AB 1739, SB 1168, and SB 1319. These laws are collectively known as the Sustainable Groundwater Management Act, and are meant to be the first laws regulating and monitoring groundwater, which supplies up to 60% of the state's water supply in dry years (source: State of California).

Adoption by 2020E

The DWR divided the state's 515 groundwater basins into four priority categories: Very Low, Low, Medium, and High Priority. The Groundwater Management Act essentially requires High and Medium Priority basins to be managed according to plan by 31 January 2020. This new legislation defines sustainable groundwater management as the "management and use of groundwater in a manner that can be maintained during the planning and implementation horizon without causing undesirable results." "Undesirable results" are defined as:

- Chronic lowering of groundwater levels indicating a significant and unreasonable depletion of supply
- Significant and unreasonable reduction of groundwater storage
- Significant and unreasonable seawater intrusion
- Significant and unreasonable degraded water quality
- Significant and unreasonable land subsidence
- Surface water depletions that have significant and unreasonable adverse impacts on beneficial uses of the surface water (source: DWR)

Exhibit 39: Groundwater Sustainability Program draft strategic plan



Source: DWR, BofA Merrill Lynch Global Research

Table 14: Groundwater Sustainability prioritization

Basin Ranking	Basin count per Bank	Percent of total for sale GW Use	Overlying population
High	43	69%	47%
Medium	84	27%	41%
Low	27	3%	1%
Very Low	361	1%	11%
Total	515	100%	100%

Source: DWR, BofA Merrill Lynch Global Research

Regulation spans 96% of groundwater and 88% of population

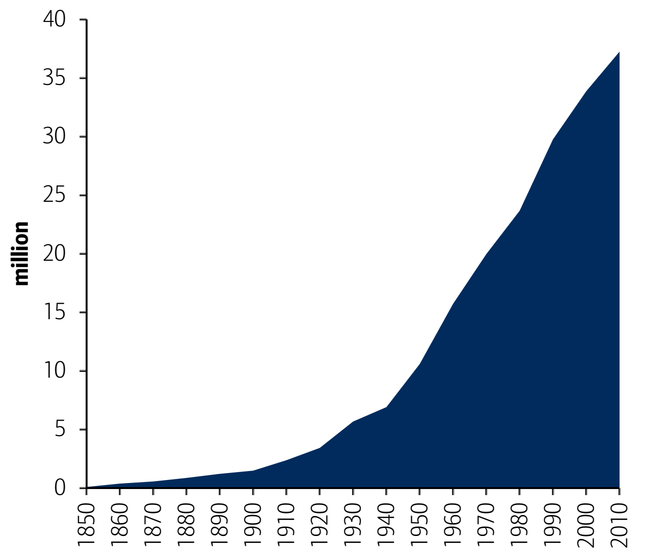
Some 43 groundwater basins were designated as High and 84 as Medium priority, which together comprise 96% of annual groundwater use and 88% of the population (2010 numbers) overlying the groundwater basic area. While adoption is set for January 2020, full achievement of sustainability objectives not set for 20 years from adoption (source: DWR). While most people agree the legislation is the first to regulate groundwater, some critics argue that 2020 adoption deadline will not have significant impact on the current drought.

Demand-side pressures of drought

Tremendous population growth – 51mn by 2050

California is the most populous state in the US, almost 1.5x the size of runner-up Texas. The population grew exponentially during the 20th century: from fewer than 2mn in 1900, to 30mn by 1990 and topping 38mn by 2014E (source: US Census). The California Department of Finance projects that the population will balloon to around 51mn by 2050E.

Chart 31: Historical California Estimated Population



Source: CA Department of Water Resources; California State Dept. of Finance

Table 15: California Population Change 2005 to 2010 Statewide and by Hydrologic Region

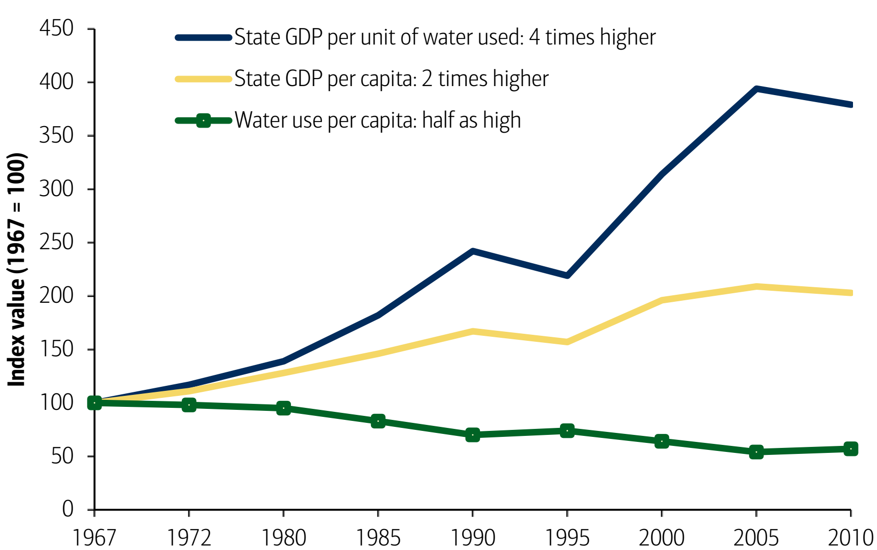
Hydrologic Region	2005 Population	2010 Population	Growth
North Coast	656,064	671,344	2.30%
San Francisco Bay	6,132,111	6,345,194	3.50%
Central Coast	1,486,250	1,528,708	2.90%
South Coast	19,176,154	19,579,208	2.10%
Sacramento River	2,846,723	2,983,156	4.80%
San Joaquin River	1,999,295	2,104,206	5.20%
Tulare Lake	2,093,865	2,267,335	8.30%
North Lahontan	97,644	96,910	-0.80%
South Lahontan	806,672	930,786	15.40%
Colorado River	690,804	747,109	8.20%
Total	35,985,582	37,253,956	3.50%

Source: California Water Plan

Per capita water consumption has been decreasing

Water use efficiency continues to rise in all sectors. Between 1967 and 2005, per capita water consumption halved, while California's GDP doubled, and the economic value of each unit of water increased fourfold. Per capita water use has decreased despite little expansion of the state's water infrastructure since the 1970s (source: PPIC).

Chart 32: The economic efficiency of water use continues to rise

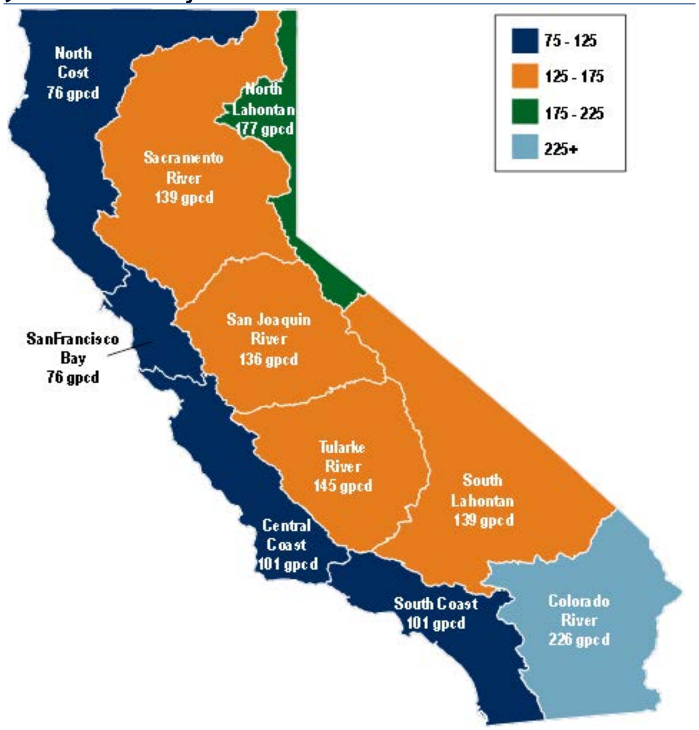


Source: E Hanak et al.

38bn gallons per day, 1,000+ gallons per person

As of the most recent numbers in 2010, California withdrew 38bn gallons every day, which is equivalent to more than 1,000 gallons per person (source: USGS). However, on the residential level, domestic per capita use averaged only 98 gallons between June 2014 and April 2015 (source: California Water Boards). This is down substantially from 232 gallons in 1990 and 178 gallons in 2010.

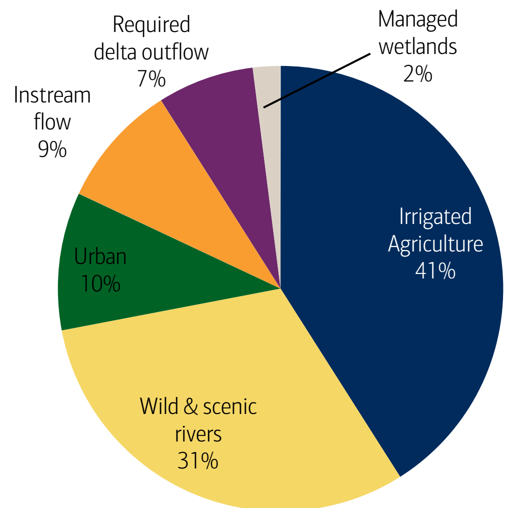
Exhibit 40: California residential gallons-per-capita-Day average over June 2014-February 2015



Source: CA State Water Resources Control Board

Residential Gallons per capita Day average over June 2014- February 2015

Chart 33: California water use 2013

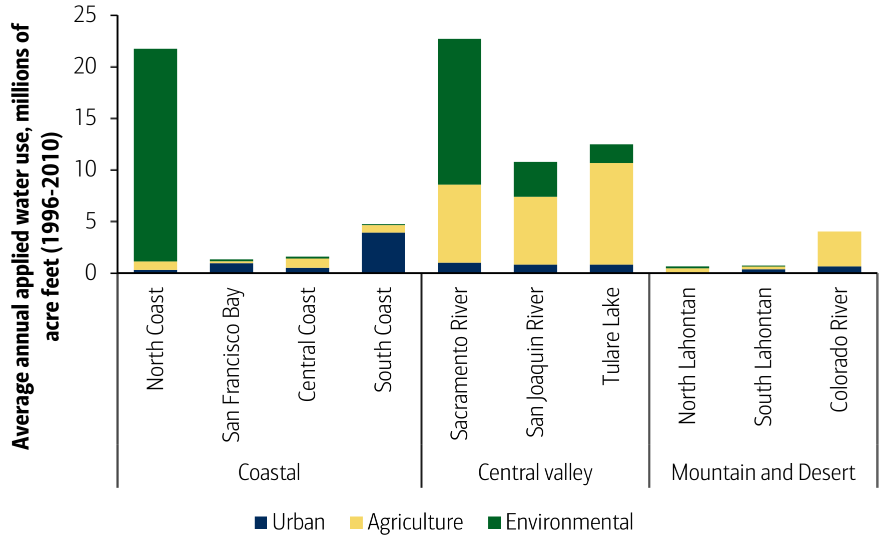


Source: California Water Plan, Northern California Water Association

Water use varies by region

Three main sources account for all water withdrawals in California: environmental (50%), agriculture (40%) and urban (10%). However, water use by sector varies dramatically across different parts of the state, and between wet and dry years. Depending on location, land use may also serve multiple purposes. Some of the water can also be returned to rivers and groundwater basins and be reused (source: PPIC).

Chart 34: Water use varies dramatically by region



Source: Dept. of Water Resources

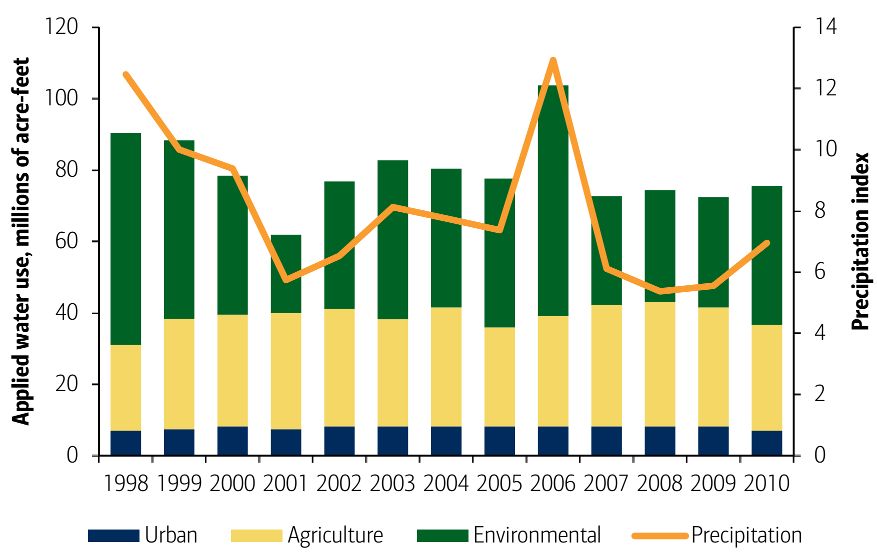
Environment makes largest withdrawals, provides for wildlife and habitat uses

Environmental water accounts for the largest share, and includes uses such as water for protected rivers, maintaining habitat within streams, and supporting wetlands within wildlife preserves. More than half of the state's environmental water is used in rivers along the north coast. This is largely isolated from major agricultural and urban areas and does not affect other water uses. Where water is shared by the three sectors, environmental use is not dominant (source: PPIC).

Environmental use fluctuates the most

Of the three uses, environmental fluctuates the most given the sensitivity of wildlife and ecosystems. Both urban and agricultural use tends to remain relatively steady despite water efficiency increases and shifts to higher-value crops (source: PPIC).

Chart 35: Environmental water use fluctuates most



Source: Dept. of Water Resources, PPIC

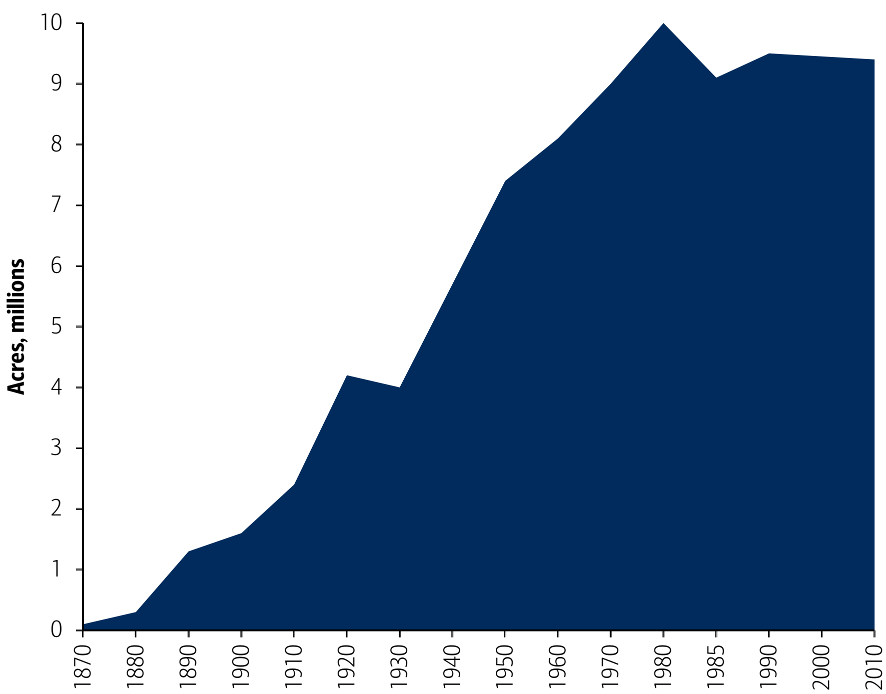
Agriculture: 80% of human use, ~40% of all use

Around 9mn acres of farmland in California are irrigated. This is 80% of all human use (source: PPIC) and 40% of total use (source: USGS). According to the 2013 Farm and Ranch Irrigation Survey, Californian farmers applied 9.8maf (3.2tn gallons) of groundwater, 1.9maf (0.61tn gallons) of on-farm surface water, and 11.9maf (3.9tn gallons) of off-farm surface water (source: USDA ERS).

Irrigated farmland has sky-rocketed

Agricultural water use in California is higher than the national and global average. Specifically, irrigation accounted for 60.7% of all water withdrawals in the state or 23bn gallons per day in 2010. This is versus 33% for the rest of the US. This includes irrigation systems to assist crop and pasture growth, or to maintain vegetation in golf courses, parks, cemeteries, etc. Higher-efficiency sprinkler and micro-irrigation comprised around 58% of irrigated acreage across the US in 2010. Surface water supplied around half (57%) of the withdrawals in the US (source: USGS).

Chart 36: Historical California Estimated Irrigated Acreage



Source: DWR

World's #5 food supplier running out of water

California is the world's fifth-largest producer of food, and is now faced with the warmest temperature in history (source: DWR) and worst drought in 1,200 years (source: Griffin et al), with agriculture accounting for 80% of human withdrawals. California has led the US in agricultural output for 50 consecutive years, and produces nearly two-thirds of the country's fruit and nuts and more than one-third of its vegetables. It produces virtually all the country's almonds, artichokes, lemons, pistachios and processed tomatoes. Although agriculture currently makes up only 2% of the state's GDP, it employs around 0.5mn people on 77,900 farms, generating US$46bn in output and supporting US$100bn in economic activity (source: CDFA, USDA, NASS).

> California represents 70% of total US fruit and tree nut farm value; 55% of vegetable farm value (source: USDA ERS)

Table 16: More than half of US fruit, vegetables & nuts are grown in California

Percentage of US production coming from California

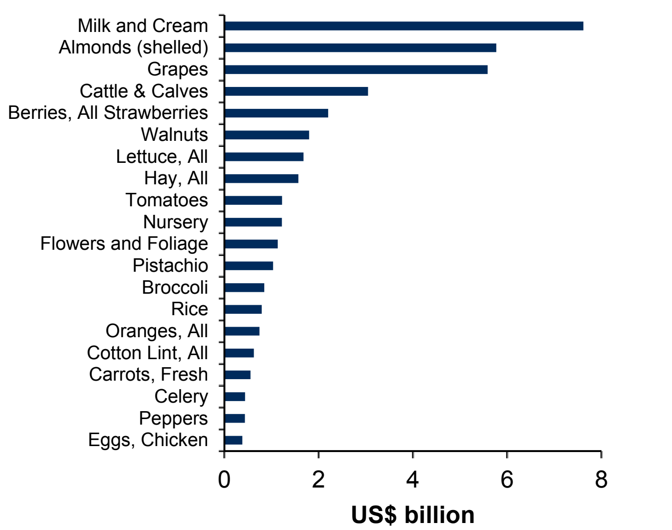
California Crops			
Almonds	99%	Celery	95%
Artichokes	99%	Apricots	94%
Dates	99%	Wine Grapes	92%
Figs	99%	Strawberries	90%
Kiwifruit	99%	Cauliflower	90%
Olives	99%	Avocados	87%
Clingstone Peach	99%	Lemons	89%
Pistachios	99%	Carrots	88%
Pomegranates	99%	Lettuce	78%
Walnuts	99%	Spinach	62%
Garlic	97%	Chilli Peppers	57%
Plums	97%	Bell Peppers	49%
Broccoli	96%	Rice	26%
Nectarines	96%	Sweet Potatoes	23%
Tomatoes, Canned	96%	Milk & Cream	21%

Source: California Department of Food and Agriculture

US$46bn industry driven by fruits, nuts, and dairy

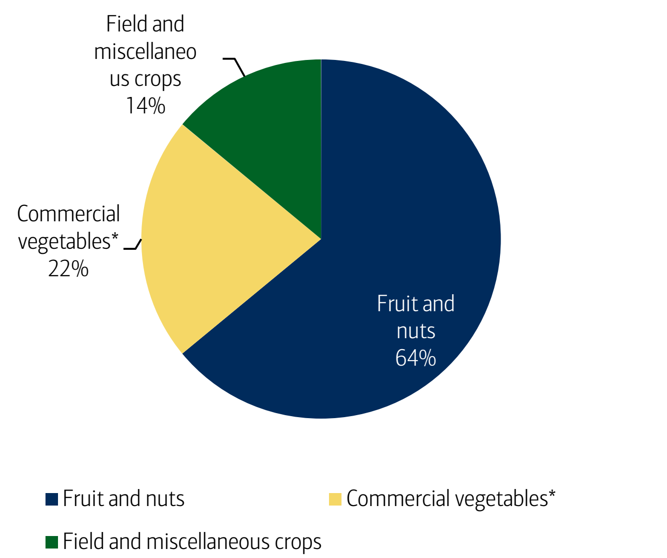
Of the US$46bn of output in 2013, fruit and nuts represented more than 40% or nearly US$20bn. Of that, grapes, almonds and berries had a combined production value of US$13.6bn. However, dairy is the highest-grossing agricultural commodity at US$7.6bn in 2013. California produces around 20% of the nation's milk, and is a leading producer of butter, non-fat dry milk, and is only second to Wisconsin in cheese production (source: USDA ERS).

Chart 37: California's top agricultural products in 2013



Source: USDA, NASS, BofA Merrill Lynch Global Research

Chart 38: The value of California's output split by crop, 2012-14 average

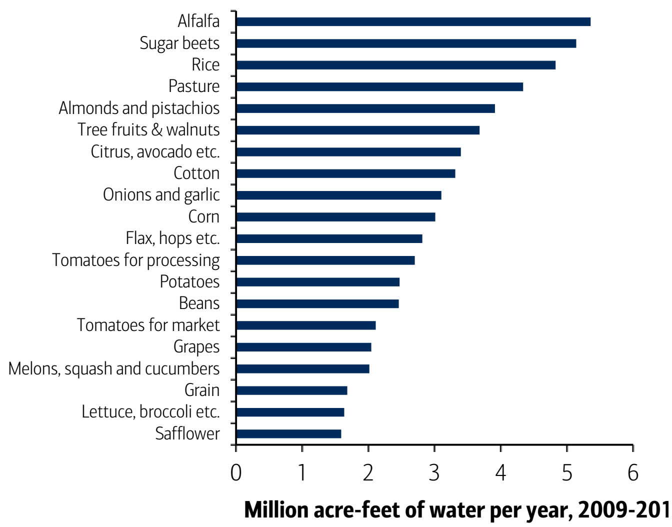


Source: USDA, National Agricultural Statistics Service, Crop Values 2015 Summary, BofA Merrill Lynch Global Research

Thirstiest crops – alfalfa then almonds

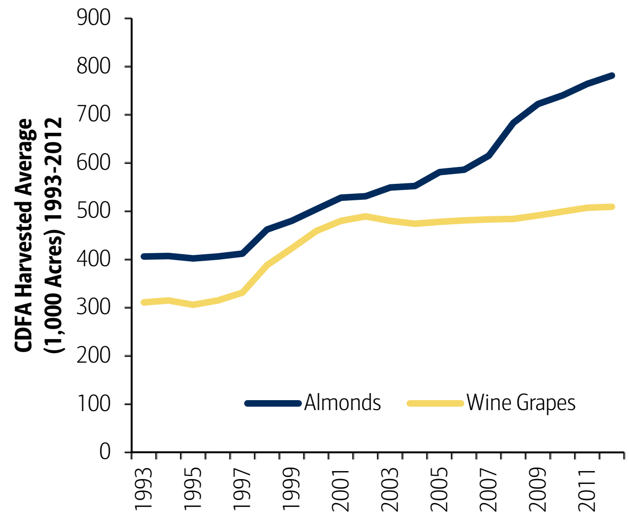
While almonds have come under tremendous scrutiny for their water use (it takes 1.1 gallons of water to grow one almond), alfalfa consumes the greatest proportion of water (source: State of California, DWR). Almonds (1.15 litre/calorie) are actually more water-efficient per calorie than milk (2.04 litre/calorie) or beef (8.3 litre/calorie). Alfalfa is mixed with hay and is the primary feed for California's 5.2mn cows, a large proportion of which are dairy cows. However, alfalfa has been on the decline as farmers have moved into higher-value crops such as almonds and wine grapes (source: USDA, NASS).

Chart 39: California's thirstiest crops



Source: State of California, Department of Water Resources

Chart 40: Example of increased acreage in permanent plantings



Source: CA Dept of Water Resources

> More water is used in almond production in California than the combined usage of residents and companies in San Francisco and LA

Table 17: Water footprint of agriculture

Amount of water requires to produce each unit of food

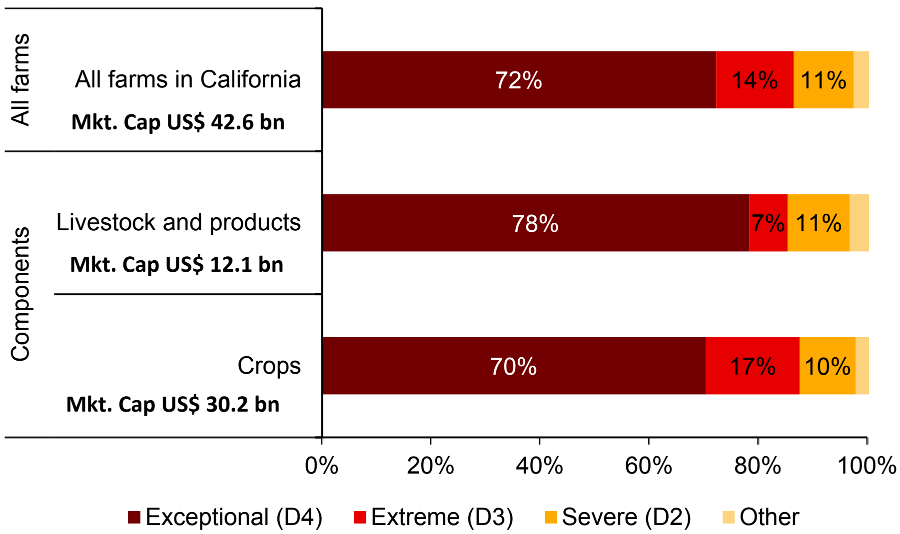
Product	Global average water footprint	Product	Global average water footprint
Almonds (with shell)	8047 litre/kg	Grape wines, sparkling	869 litre/kg
Almonds (shelled/peeled)	16095 litre/kg	Groundnuts in shell	2782 litre/kg
Apples, fresh	822 litre/kg	Leather	17093 litre/kg
Bananas	790 litre/kg	Lettuce	237 litre/kg
Beef	15415 litre/kg	Maize (corn)	1222 litre/kg
Beer made from malt	74 litre for a glass of 250 ml	Mangoes, mangosteens, guavas	1800 litre/kg
Bio-diesel (from soybean)	11397 litre water per litre biodiesel	Milk	255 litre for a glass of 250 ml
Bread (from wheat)	1608 litre/kg	Olives	3015 litre/kg
Butter	5553 litre/kg	Oranges	560 litre/kg
Cabbages and other brassicas	280 litre/kg	Pasta	1849 litre/kg
Cheese	3178 litre/kg	Peaches and nectarines	910 litre/kg
Chicken	4325 litre/kg	Pizza Margherita	1259 litre per pizza
Chocolate	17196 litre/kg	Pork	5988 litre/kg
Coffee	132 litre per cup of 125 ml	Potatoes	287 litre/kg
Cotton fabric, finished textile	2495 litre for a shirt of 250 gram	Rice	2497 litre/kg
Cucumbers and gherkins	353 litre/kg	Sheep Meat	10412 litre/kg
Eggs	196 litre for a 60-gram egg	Tomatoes	214 litre/kg

Source: Mekonnen, M.M. and Hoekstra; FAO

97% of agricultural land in severe, extreme, exceptional drought

According to the latest USDA analysis, more than 97% of California's agricultural sector is experiencing severe, extreme or exceptional drought. The livestock sector is more directly exposed to exceptional drought than the crop sector (source: USDA ERS).

Chart 41: Exposure to drought in California



Source: ERS calculations of exposure are made using county-level value of production data from the 2012 Census of Agriculture and the March 31, 2015 county-level Drought Monitor data. Market value numbers are from the USDA 2012 Census of Agriculture. BofA Merrill Lynch Global Research

57 counties are disaster areas

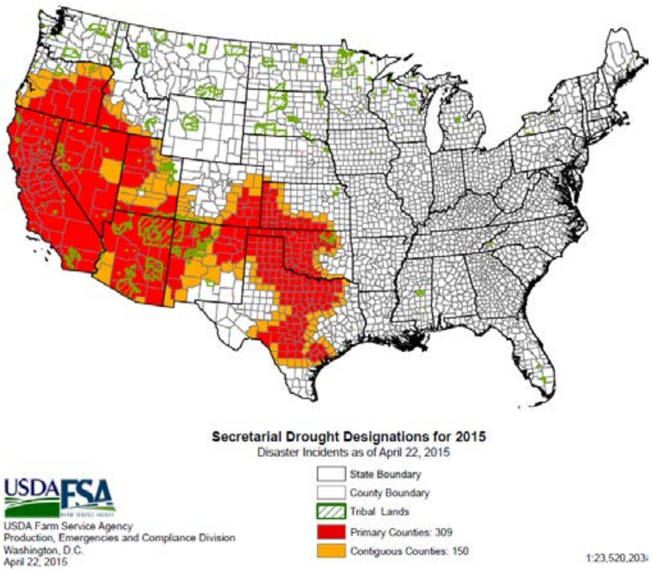
The USDA has designated 57 counties as disaster areas. Farmers and ranchers in those regions may qualify for low-interest emergency loans through the USDA's Farm Service Agency. At the same time, the 2014 Farm Bill has paved the way for qualified farmers in affected counties to apply for a variety of safety-net programmes and loans (source: USDA).

Table 18: California counties designated as disaster areas

California Counties			
Alameda	Kings	Placer	Siskiyou
Alpine	Lake	Plumas	Solano
Amador	Lassen	Riverside	Sonoma
Butte	Los Angeles	Sacramento	Stanislaus
Calaveras	Madera	San Benito	Sutter
Colusa	Marin	San Bernardino	Tehama
Contra Costa	Mariposa	San Diego	Trinity
Del Norte	Mendocino	San Joaquin	Tulare
El Dorado	Merced	San Luis	Tuolumne
Fresno	Modoc	San Mateo	Ventura
Glenn	Mono	Santa Barbara	Yolo
Humboldt	Monterey	Santa Clara	Yuba
Imperial	Napa	Santa Cruz	
Inyo	Nevada	Shasta	
Kern	Orange	Sierra	

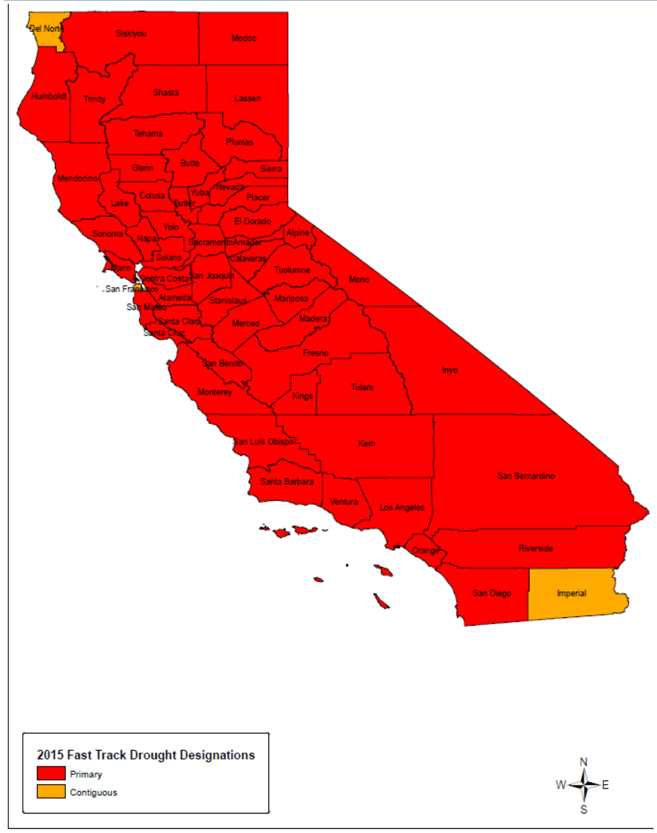
Source: USDA FSA, BofA Merrill Lynch Global Research

Exhibit 41: USDA designated agricultural drought disaster areas



Source: USDA FSA

Exhibit 42: Agricultural drought disaster areas in California



Source: USDA FSA

Extreme weather and climate change – up to 25% global wheat yields at risk

Extreme weather and climate change can have a negative impact on agriculture by changing water availability, quality and timing. They also have a direct impact on yield and output. Changing climate conditions are expected to increase the spread of invasive pests and weeds, as well as threaten livestock productivity. We may also see yield losses for heath-sensitive crops like cotton and corn. The Inland South region may take an economic hit of up to US$38mn per year due to cotton yield declines by 2100. This all has major repercussions for both local and global markets (source: Risky Business Project). Globally, climate trends already account for c.10% of stagnation in wheat and barley yields in Europe (source: Moore et. al, PNAS 2015 112). Up to 25% of global wheat yields could be at risk (source: Asseng et al, Nature Climate Change 5, 2015).

Dairy and livestock disproportionately impacted

California ranks first in number of dairy cows and fourth in total US cattle inventory. The state has 5.3mn heads of cattle, or 6% of all US cattle and 8% of all US calves. As of April 2015, 78% of cattle were located in areas of exceptional drought, ie, with the highest degree of urgency. Dairy production is concentrated in a few regions, such as the San Joaquin Valley, which has been hit particularly hard by the drought. In fact, San Joaquin Valley accounts for 89% of Californian dairy cow inventory and 76% of its dairies (source: USDA ERS).

The alfalfa read-through

California is the largest producer of alfalfa – 10% of the total or 5.7mn tons in 2014, almost all of which is consumed by the state's dairy cows. The majority of dairy cows in California do not graze in pasture, but are raised in dry lots and fed grain, including alfalfa hay. Alfalfa is also the single largest consumer of water in California. Total production has declined 20% since 2012, when the current drought began. Decline in alfalfa supply has direct implications for dairy farming (source: USDA NASS).

In California, 98% of orchard land is irrigated, as is 100% of the land used to cultivate both berries and vegetables (source: USDA ERS)

SWP and Federal Central Valley Project provide surface water for farmers

The two primary providers of surface water to farmers are the California State Water Project (SWP) and federal Central Valley Project (CVP). Water supply at the farm level varies depending on the location of the farm and its established water-rights priority.

- State Water Project – manages reservoirs, aqueducts and pumping plants, and delivers water to 29 local water agencies according to the terms of long-term supply contracts. 30% of water supplies go to agricultural users and 70% to urban users.

- Central Valley Project – delivers water to hundreds of different contracted end-users, including some that also receive water from the State Water Project; 70% of deliveries go to agriculture (5mn of 7mn acre-feet). The CVP is managed by the U.S. Bureau of Reclamation (source: USDA ERS).

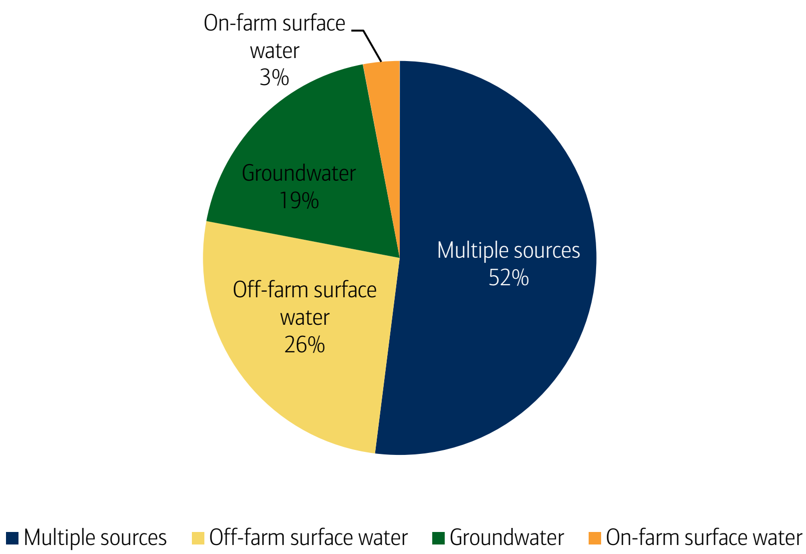
Two years of zero allocation for farmers

We are in the second year of no water allocation to farmers by the State Water Project and the Central Valley Project. In January 2014, the SWP, which provides surface water for 750k acres of farmland, announced, for the first time in history, a zero allocation to agricultural users for the year. Similarly, the CVP has delivered no water to agricultural users for the year. As of 2015, both entities are projecting to make no deliveries for a second year (source: USDA ERS).

Farmers have increased groundwater pumping

On the back of a decline in surface water, farmers are deriving a much larger proportion from groundwater. According to a UC Davis study, agriculture withdraws 26maf (8.5tn gallons) per year on average: 18maf (5.7tn gallons) from surface water and 8maf (2.6tn gallons) from groundwater. Due to the ongoing drought and shortage of surface water, this figure was estimated to have been 1.5maf (0.49tn gallons) and 6.6maf (2.1tn gallons) in 2014 respectively. This suggests the proportion of irrigation water from wells will jump from 31% historically to 53% this year, or a 62% increase in groundwater pumping (source: UC Davis).

Chart 42: Irrigated acreage in 2013 in California by source



Source: 2013 USDA Farm and Ranch Irrigation Survey, BofA Merrill Lynch Global Research

Drought leads to idled land and crop losses

The impact of reduced water supplies is reflected in farmers abandoning permanent plantings such as orchards, or allowing their fields to fallow. As a general method of conservation, farmers have adjusted crop rotations or switched to higher-value crops. In areas where there is no alternative water supply and groundwater levels drops below installed capacity, farmers are forced to fallow fields. In other areas, there may be deeper wells but farmers may face higher energy costs to extract water (source: UC Davis).

700,000 additional acres fallowed vs 2011

A NASA-led study has shown that up to 700,000 additional acres of land may have been fallowed on the back of the current drought. NASA, along with the US Geological Survey, US Department of Agriculture, and the National Agricultural Statistics Service, developed a model to estimate idled land using NASA's satellite sensors. They estimated peak summer idling showing 1.7mn acres to be fallowed in the Central Valley. This was 700,000 acres more than the summer of 2011, which was the last wet year (source: NASA, DWR Publish Update 2014).

Table 19: Central valley total idled acreage, 27 July 2014

Year	Summer Idled (acres)
2014	1,706,038
2011	1,013,233
2012-2011	692,805

Source: NASA

Cost of 2015 drought: US$2.7bn

A separate study based on economic modelling conducted by the University of California, Davis, showed that the economic cost of drought was US$2.2bn in 2014. It drew the following conclusions on the total socioeconomic impact of the drought:

- The total state-wide economic cost is US$2.7bn.
- Direct costs to agriculture total US$1.8bn (revenue losses of US$1.2bn and US$0.6bn in additional pumping costs). This net revenue loss is about 3% of the state's total agricultural value.
- The loss of 18,600 seasonal and part-time jobs related to agriculture, representing 3.8% of farm unemployment.
- 565,000 acres, or 5%, of irrigated cropland is going out of production in the Central Valley, Central Coast, and Southern California.
- The Central Valley is hardest hit, particularly the Tulare Basin, with projected losses of US$856mn (UC Davis).

Table 20: Statewide 2015 Drought Impacts Summary

Drought Impact	Loss Quantity
Water Supply	
Surface water reduction	8.7 million acre-feet
Groundwater pumping increase	6.2 million acre-feet
Net water shortage	2.5 million acre-feet
Statewide Costs	
Crop revenue loss	$856 million
Addition groundwater pumping cost	$595 million
Livestock revenue loss	$100 million
Dairy revenue loss	$250 million
Total direct agricultural costs	$1.8 billion
Total statewide economic cost	$2.7 billion
Total job losses	18,600

Source: California Department of Food and Agriculture

Table 21: Estimated Change in Water Use in 2015 Drought Relative to Average Conditions (maf)

Region	Surface Water (maf)	Ground water (maf)	Net Delivery Shortage (maf)
Sacramento	-2.17	1.28	0.89
San Joaquin	-1.86	1.4	0.46
Tulare	-4.75	3.45	1.3
Central Coast and Southern CA	-0.01	0.02	-0.01
Total	**-8.7**	**6.2**	**2.5**

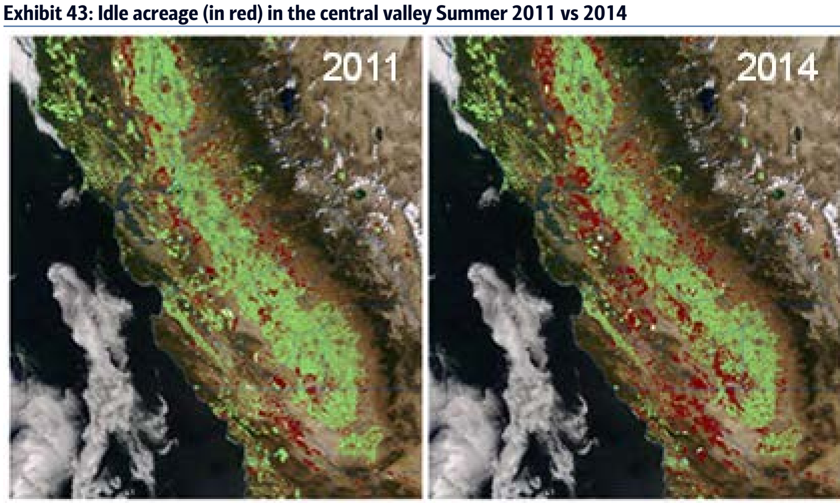
Source: California Department of Food and Agriculture

Central Valley feels the most pain

Both the NASA and UC Davis studies indicated that the Central Valley has been the worst hit during this drought. For instance, San Joaquin Valley is the largest fruit- and nut-producing region in the state, accounting for 65% of total crop value in 2013. It also produces a third of the state's vegetables. The region is one of the most agriculturally intensive areas in the state, has sustained some of the worst drops in both surface water and groundwater levels, and has fallowed up to 700k acres of land (source: DWR Publish Update).

By 2100, San Joaquin Valley will experience corn yield declines of 10-43% unless farmers adopt new practices (source: American Climate Prospectus)

Exhibit 43: Idle acreage (in red) in the central valley Summer 2011 vs 2014



Source: NASA, CA Department of Water Resources

Table 22: Estimated Change in Irrigated Crop Revenues Due to Drought, 2015 (US$mn)

Region	Feed Crops	Vegetables	Orchard & Vines	Grain	Other Field	Total
Sacramento	-52.4	-4.1	-2	-170.6	-2.7	-231.6
San Joaquin	-21.4	3	15.7	-35.7	-13.5	-51.9
Tulare	-87.6	-102.3	-115.5	-141.4	-173.6	-620.3
Central Coast and Southern CA	29.4	-4.4	18.9	-2.2	5.8	47.5
Total	-131.9	-107.7	-82.8	-349.9	-184	-856.3

Source: California Department of Food and Agriculture

Junior water-rights holders lose out first

Any reduction in water allocation hits farmers with junior water rights disproportionately harder than those with senior water rights. Local newspaper Fresno Bee reported that water deals for senior holders were pricing at US$250 per acre-foot in 2014 versus US$1,000-2,000 for others (source: Climate Central). Furthermore, in April 2015, the State Water Resources Control Board (SWRCB) ordered 9,000 junior water-rights holders in the Sacramento and San Joaquin river basins to stop withdrawing surface water. By June 2015, the SWRCB had sent curtailment notices to senior water-rights holders with seniority after 1903, while allowing them to maintain riparian claims. This gave them time to react to the new cutbacks (source: SWRCB). All this puts further pressure on underground aquifers, which are still unregulated.

US$4.2bn in potential insurance liabilities

A recent study by the USDA Economic Research Service (ERS) suggests that California could be facing up to US$4.2bn in insurance liabilities because of the drought. The study was based on a combination of irrigation data, crop insurance participation, rates and liabilities across commodity crops. The commodities considered were orchards, forage, vegetables, rice, corn and cotton, which together consume 80% of irrigation water in California. Total insurance liability across all crops considered was US$4.2bn, with almonds ranking as the #1 source (source: USDA ERS).

Table 23: Factors influencing drought vulnerability for selected crops in California

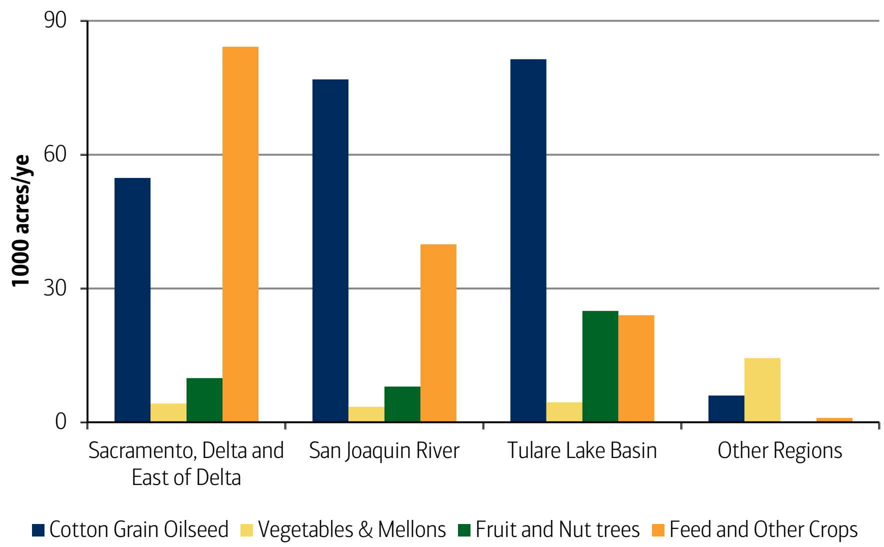
	Est. 2012 Water use (million acre-feet)	2012 Total acreage (1,000)	2012 Percent irrigated	2014 Insured acreage (1,000)	2014 Liability (US$mn)
Land in orchards	8.3	3,139	98		
Almonds		936		720	1,517
Grapes		940		577	1,350
Walnuts		329		147	257
Forage	5.1	1,670	81	135	69
Alfalfa		990			
Other hay		600			
Land in vegetables	3.2	1,126	≈100		
Tomatoes		295		250	451
Rice	2.5	562	100	422	297
Corn	2	668	95	165	86
Cotton	1.1	368	100	264	166

Source: Water use totals are ERS calculations based on 2012 acreage (from USDA Census of Agriculture) and 2013 water application rates (from the Farm and Ranch Irrigation Survey). Acreage totals are from the 2012 USDA Census of Agriculture. The insured acreage and liability numbers are from the RMA Summary of Business data.

Rotating into higher-value crops

As California grapples with the implications of long-term water scarcity, we may see farmers migrate permanently to higher-value produce versus traditional commodity crops. For instance, corn (-34%), wheat (-53%) and cotton (-60%) acreage all plummeted in 2014 as farmers fallowed land. Conversely, almond acreage rose to 870k in 2014, which is 51% higher than a decade ago (source: USDA NASS). Higher-value perennial crops such as nuts, grapes, and other fruit have grown from 27% of irrigated acreage to 32% in 2010, and from 33% to 40% in the southern Central Valley, where the drought has been especially severe (source: PPIC). As farmers in the world's fifth-largest food supplier rebalance their agricultural portfolio, we will inevitably see changes in global food and consumption patterns. Despite increasing efficiencies and the production of higher-value crops, the combination of drought and demographic changes has led to agriculture falling from 5% of California GDP in the 1960s to only 2% today.

Chart 43: Crop acreage reductions in 2014 drought, Central Valley regions

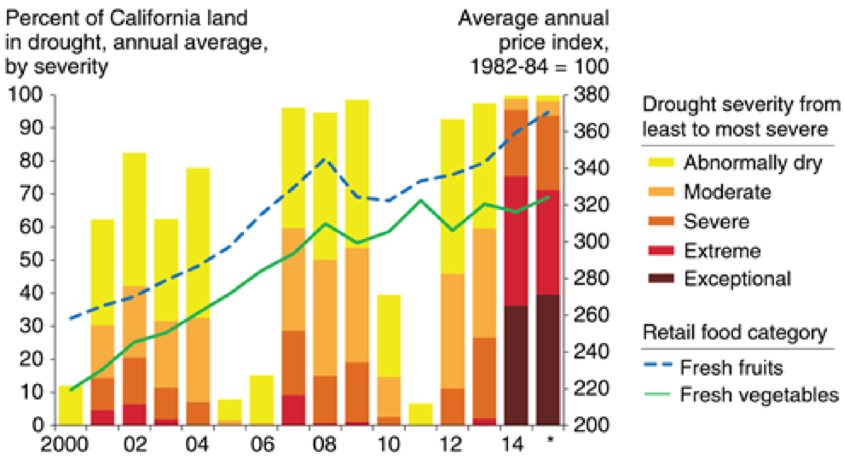


Source: UC Davis

Pricing read-through is less certain

Despite the mandatory water restrictions in California, the read-through to commodity prices has been limited. The retail price of fruit and vegetables has a stronger relationship with farm commodity prices than many other foods. Fresh produce undergoes relatively little processing, packaging and advertising. It is also highly perishable, meaning that storage has little-to-no impact on the transmission of prices from the farm to retail level. Changes in fruit and vegetable farm prices are translated to supermarket shelves, and CPI, within a month. Increases in the retail price for fresh fruit and vegetables in 2014 were primarily driven by a rise in the price for citrus fruit. However, citrus prices were driven up by the greening disease of Florida citrus and the December 2013 freeze in southern California that reduced the fresh orange crop (source: USDA ERS).

Exhibit 44: California drought and severity change in CPI for fresh fruits and vegetables



Source: USDA

Driving up price of dairy to historical highs

Californian dairy and livestock has a commodity value of US$12bn+, with dairy a US$6.9bn market and calves accounting for another US$3.3bn (CDFA 2014). Feed represents more than 65% of the production cost for dairy, with alfalfa and silage making up a combined 30% of feed costs. Alfalfa hay prices have jumped 40% since January 2014, and higher feed costs have increased the total production cost of dairy by around 12%. At the same time, the price of milk and cattle has increased dramatically since 2012 to historical highs. UC Davis estimates dairy output to be 1.5% lower than in a normal year, leading to a US$104mn direct impact state-wide.

Illegal marijuana cultivation is diverting water

In the past five years, an increased impact from commercial-scale illegal cannabis operations has been documented in forested counties throughout California, particularly in the coastal ranges. Illegal growing activities adversely impact the watershed:

- Illegal diversions of water from tributary streams use low summer flows required for sustaining state and federally listed anadromous salmonids and other species.
- Illegal grading and road-building operations cause surface erosion and slope instability, which accelerates sedimentation.
- Large-scale use of pesticides, fertilizers and rodenticides adversely impacts water quality (source: California Water Plan 2013).

Up to 380-500mn gallons used per year

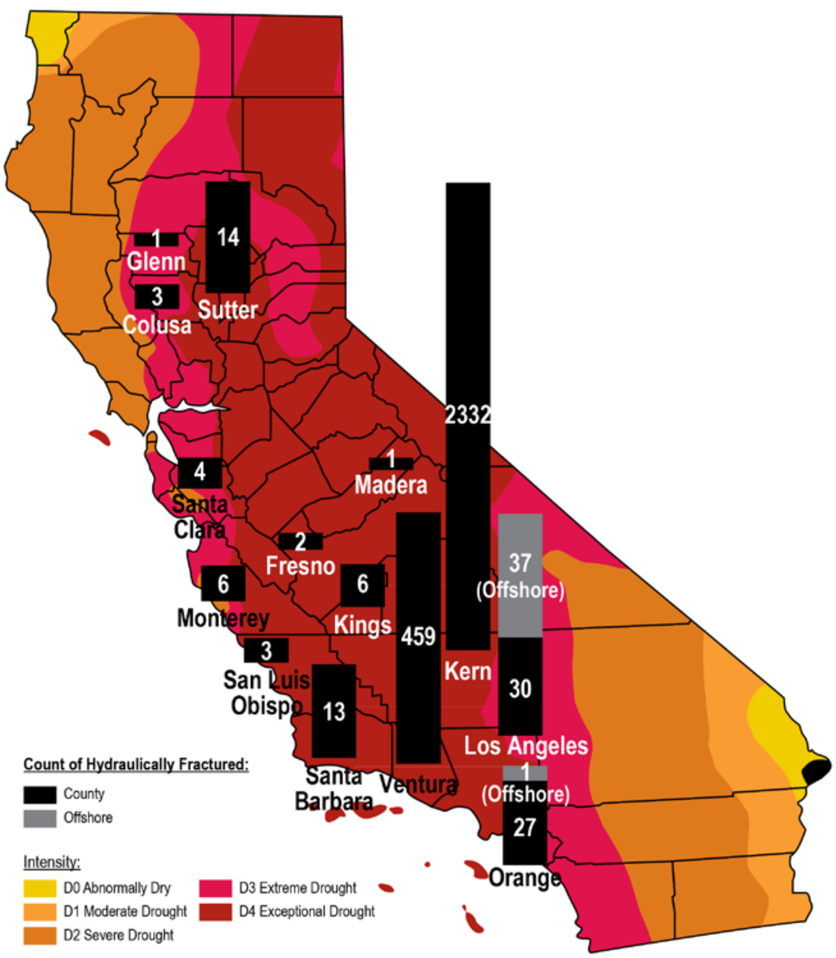
Illegal marijuana cultivation could be using 380-500mn gallons of water every year – enough to sustain 50k Californian residents. Typical commercial-scale illegal marijuana gardens have

7,000 plants, with each using one gallon of water per day (Mallery 2011). This equates to approximately 7,000 gallons of water per day over a period of three to four months or about 2-2.5 acre-feet per year per commercial-scale operation. The 2010 Mendocino County Grand Jury Report estimates that only 10% of illegally grown marijuana is confiscated annually. More than 500,000 plants are impounded in many years. Assuming those years are representative, suggests an estimated 5,000,000 plants are produced annually, using 380-500mn gallons of water every year. This is enough to sustain 50k Californians (source: California Water Plan 2013).

Fracking – consumer of vast amounts of water

Hydraulic fracturing, or fracking, as a method of oil and gas exploration, has come under extreme scrutiny in California. Fracking is the process of drilling and injecting fluid into the ground at high pressure to fracture shale rocks and release the natural gas inside. Fracking both requires significant amounts of water and produces water that must then be treated.

Exhibit 45: Drought intensity and number of hydraulically fractured wells



Source: BofA Merrill Lynch Global Research

300 acre feet used in 2013

Even amid the historic drought, around 300 acre-feet (81mn gallons) of water was used for fracking in 2013. Around 86k to 1.2mn gallons are required in total for a typical Californian fracking job, expending 86-240k gallons at each of the five stages of fracking (source: CA Department of Conservation).

Table 24: Range of Water Use for Steps in the Hydraulic Fracturing Process*

Step/Treatment	Estimated Water Use (gallons)	Estimated Water Use (AF)	Purpose
1. Acid Treatment*	2,125	0.007	Cleans out wellbore and perforations
2. Pad (fluid without proppant)	1,260 to 25,000	0.004 to 0.077	Opens fissures in the formation
3. Proppant	80,000 to >200,000	0.25 to >0.61	Holds open the new fissures
4. Flushing	2,730 to 12,600	0.008 to 0.039	Flushes excess proppant back to the well
5. Flowback			Allows fluid to flow back into the well
Total – One Stage	86,115 to >239,725	0.26 to >0.74	
Total – Three Stages	258,345 to >719,175	0.79 to >2.21	
Total – Five Stages	430,575 to >1,198,625	1.32 to >3.68	

Source: CA Dept. of Conservation

* Although the acid treatment step has been reported as generally not used in California, the relatively small amount of water is included in the totals on the table to represent a conservative range of water use.

Surface water is primary source

According to the California Department of Conservation, between January and September 2014, 81 acre-feet of surface water was used for fracking. This represents around two-thirds of total water use for the activity in the State, while groundwater accounted for 31.31 acre-feet. Only 8.8% came from produced water, or water recycled from fracking (source: CA Dept. of Conservation).

Table 25: Water Sources Used for Hydraulic Fracturing, January–September 2014[1]

	Gallons	Acre-Feet	Percent
Total Water Use	40,226,004	123.45	100%
Surface Water[2]	26,484,318	81.28	65.84%
Groundwater	10,203,808	31.31	25.36%
Produced Water	3,537,878	10.86	8.80%

Source: CA Dept. of Conservation

1 - Source: 2014 Interim Well Stimulation Treatment Disclosures, DOGGR online database, updates through December 2, 2014. Includes IWST disclosures from January 2014 through September 2014

2 - Includes imported water.

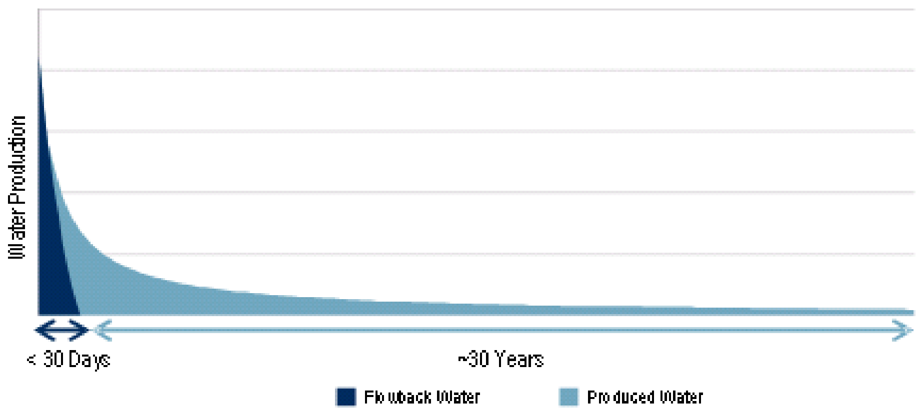
San Joaquin Valley – not just the breadbasket, also the energy producer

In addition to agriculture, the San Joaquin Valley is a major producer of energy. It is the source of 75% of the state's oil production and 65% of its gas production. San Joaquin Valley's Kern County is the third-biggest oil-producing county in the US, accounting for a 10th of the country's oil production and three of its five largest oil fields. In 2014, there were 2,332 fracking wells in the county. Kern is also home to the world's second-largest onshore wind farm, the Alta Wind Energy Center, and construction is underway on what will be the world's largest solar PV installation, at Antelope Valley (source: Risky Business Project).

Shale gas under growing water pressure

Shale gas is controversial in many circles because the industry's process of fracking uses large volumes of ground and surface water, which some believe could impair drinking water resources, and pose a contamination risk because of the chemicals used. An average of 6.3mn gallons of water are used per well in the US (source Heckmann), and with companies drilling up to 16 wells per well pad, this means sizeable water treatment needs. Chemical and toxin-laced flowback water, which returns to the surface after the well is completed (over c.30 days), accounts for 20% of water used. Produced water or water that flows over the lifecycle of a well after it has been drilled (over c.30 years), accounts for 80%.

Exhibit 46: Water use in shale wells



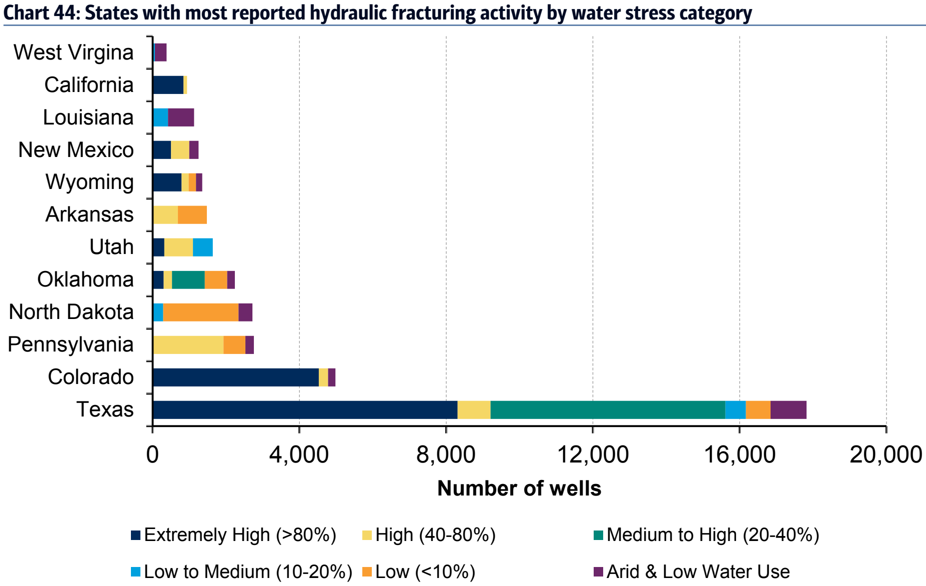
Source: Heckmann, BofA Merrill Lynch Global Research

50% of recent wells in water-stressed areas

A 2014 report by CERES – a US-based not-for-profit organisation – notes that close to half the oil and gas wells recently fracked in the US "are in regions with high or extremely high water stress" and more than 55% are in areas experiencing drought. In Colorado and California, 97% and 96% of wells, respectively, are in regions with high or extremely high water stress. Between January 2011 and May 2013, 97bn gallons of water was used for fracking, with an average of 2.5mn gallons per well.

Texas is high on the list for water-sourcing risk due to its intense shale energy production in Eagle Ford, Permian, Barnett and Haynesville, and a projected doubling of hydraulic fracturing water use over the next decade. Total hydraulic fracturing water usage in 2012 was 25bn gallons – half the total in the US for that year. This number is expected to rise to approximately 40bn gallons by 2020s. This coincides with drought conditions in two-thirds of Texas, stressed fresh water aquifers, and anticipated population growth.

Chart 44: States with most reported hydraulic fracturing activity by water stress category



Source: Ceres, BofA Merrill Lynch Global Research

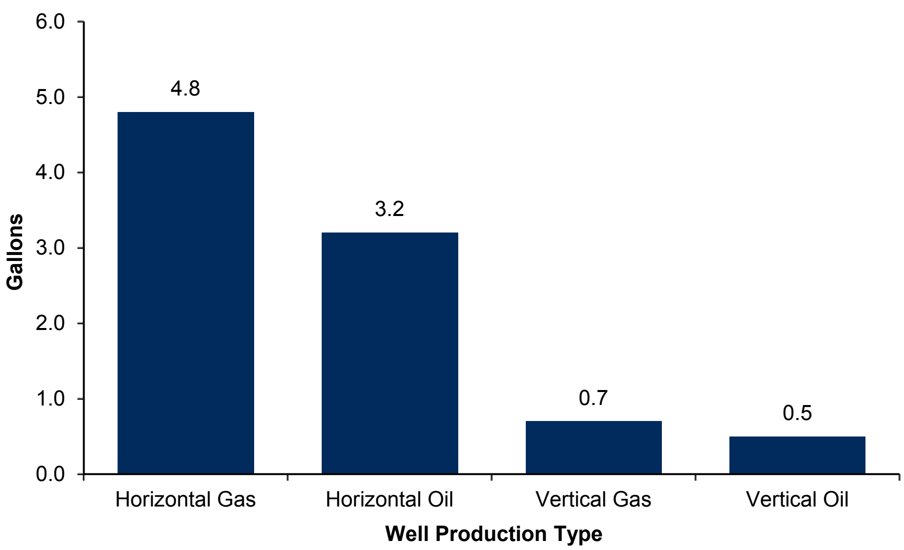
Groundwater depletion is a particular concern given that it is less regulated compared to other water depletion categories, and there is little visibility on how much is withdrawn. In addition, groundwater flows are connected with one another and with surface-water resources. Overuse creates not only local stress to groundwater but also reductions in surface-water flows. While groundwater supplies are naturally replenished by rainfall, this process can take decades or even centuries.

Fracking dominated by a few oil & gas companies

Oil and gas exploration and production (E&P) companies that are involved in hydraulic fracturing are ultimately liable for its environmental impact and are most exposed to related water issues. In the US, the top 10 E&P companies account for 56% of fracking water. Oil servicers that conduct field operations for E&P companies, are even more concentrated. The top three servicers handle 55% of all hydraulic fracturing nationally (source: Ceres).

Studies have shown that power production from hydraulically fractured natural gas consumes less water in aggregate than burning coal, but much can be done to use more recycled water or alternative inputs such was brackish and waste water. Many oil servicers are developing technologies to recycle frack water themselves. Currently about one-fifth of total frack water supply comes from recycled or brackish water (source: University of Texas). With more stringent regulation and increasing water scarcity, we expect energy companies would be compelled to be more efficient in their water management for long-term sustainability.

Chart 45: Average water use per well by type of production (in mm)

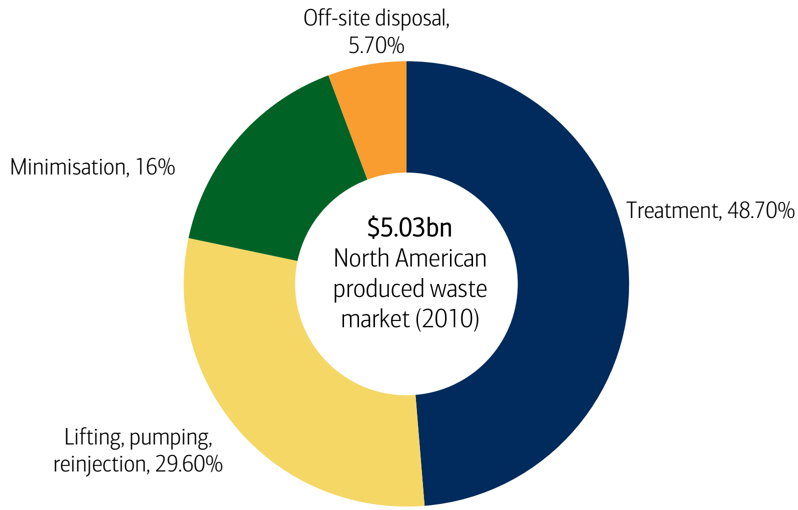


Source: Ceres (based on PacWest FracDB from FracFocus data from wells drilled January 2011-May 2013)

Oil & gas – growing focus on produced-water market

Oil is an indirect water industry, producing it as a by-product ('produced water'). The water to oil ratio (WOR) for the industry as a whole is around 2.5x, with some segments, such as North American onshore oil, producing 8x more water than oil. By 2025, the sector could be producing 5x more water than oil, with onshore crude oil having a ratio of up to 12x, largely on the back of ageing wells and increased unconventional O&G, such as EOR, shale gas and oil sands – all of which have high water needs. This produced water is often highly saline and contaminated by hydrocarbons: it is a hazardous waste that requires treatment, disposal and – with advances in desalination – potentially on- or off-site recycling (source: GWI).

Chart 46: North America produced water market 2010

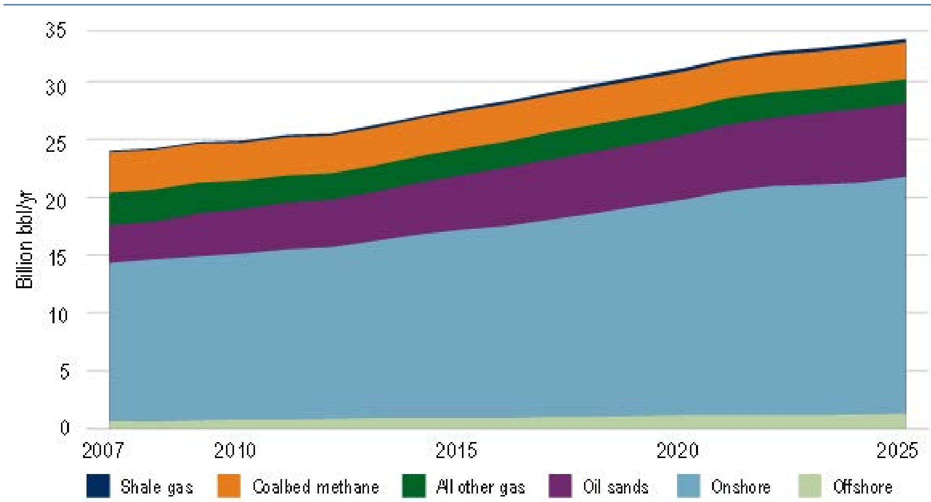


Source: GWI, BofA Merrill Lynch Global Research

Produced-water market to post a 20-year 5% CAGR

We estimate the market for water-treatment technologies, such as membrane and thermal desalination, filtration systems and biological treatment systems, will grow at close to 5% pa over the next 20 years driven by an increased WOR, growing environmental concerns and stricter regulation. Enhanced oil recovery (which needs water with a precise salinity) and highly water-intensive oil sands and shale gas will offer the largest opportunities, in our view.

Exhibit 47: Produced water forecast to 2025

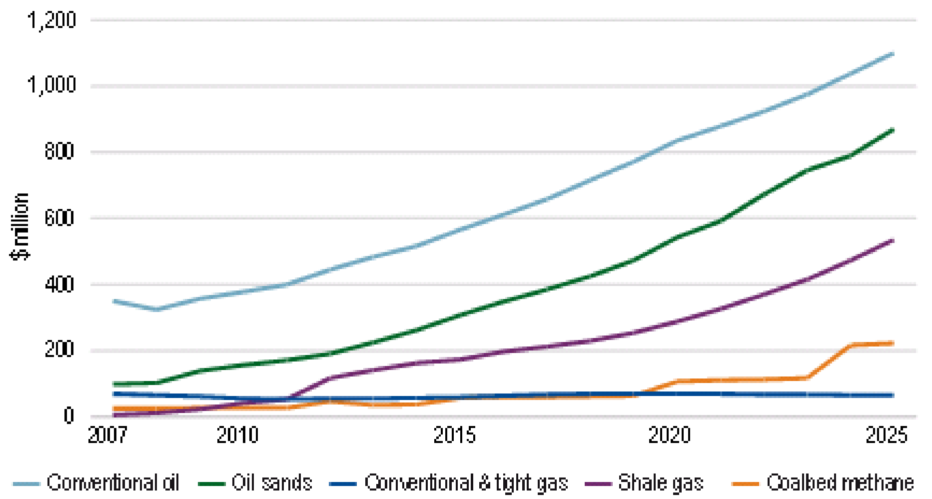


Source: GWI

> Disposing of produced water off-site can cost as much as US$10 per barrel ($63/m3) (GWI)

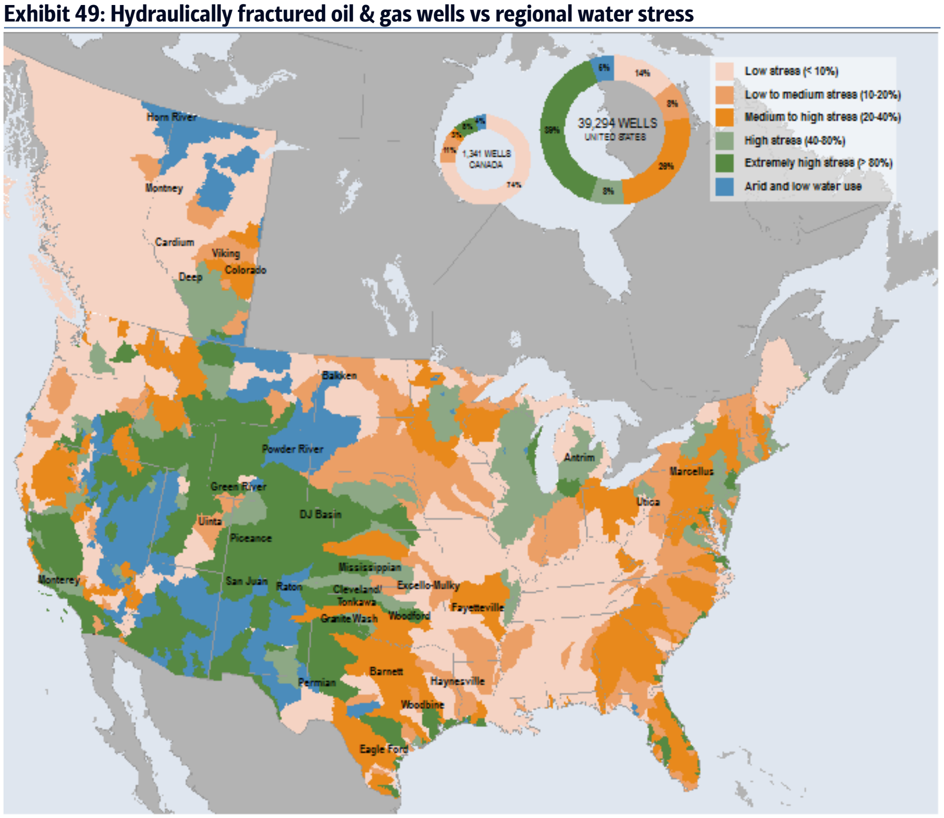
Treatment of produced water in the North American oil sector alone could grow from an estimated US$5bn in 2010 to US$10bn by 2025, a CAGR of 4.7%. Within the sector, the US produced-water treatment equipment market is set to grow from US$693mn in 2010 to US$2.9bn during that time, an annual growth rate of 10.1%. The desalination technologies market, currently worth US$59mn, should enjoy the fastest growth rate, averaging 20.4% per year (source: GWI).

Exhibit 48: North American produced-water equipment market 2007-25 (US$m)



Source: GWI, BofA Merrill Lynch Global Research

Exhibit 49: Hydraulically fractured oil & gas wells vs regional water stress



Source: Ceres, BofA Merrill Lynch Global research

US$9bn market by 2020E

The large amount of water needing to be treated is creating a frack water treatment industry, which is expected to exhibit a 28% CAGR to become a US$9bn market by 2020 (source: Lux Research). In the US, the Clean Water Act gave the EPA the authority to secure and maintain the chemical, physical, and biological integrity of US water. In turn, the US EPA has clarified that hydraulic fracturing liquid and oil-based fluids are not authorised and must be treated as hazardous waste (source: CA Department of Conservation, EPA). This is positive for technologies including bag filters, chemical precipitation, electric coagulation, distillation, membrane filtration or a combination (eg, adding ozone, ultrasound, electricity and pressure).

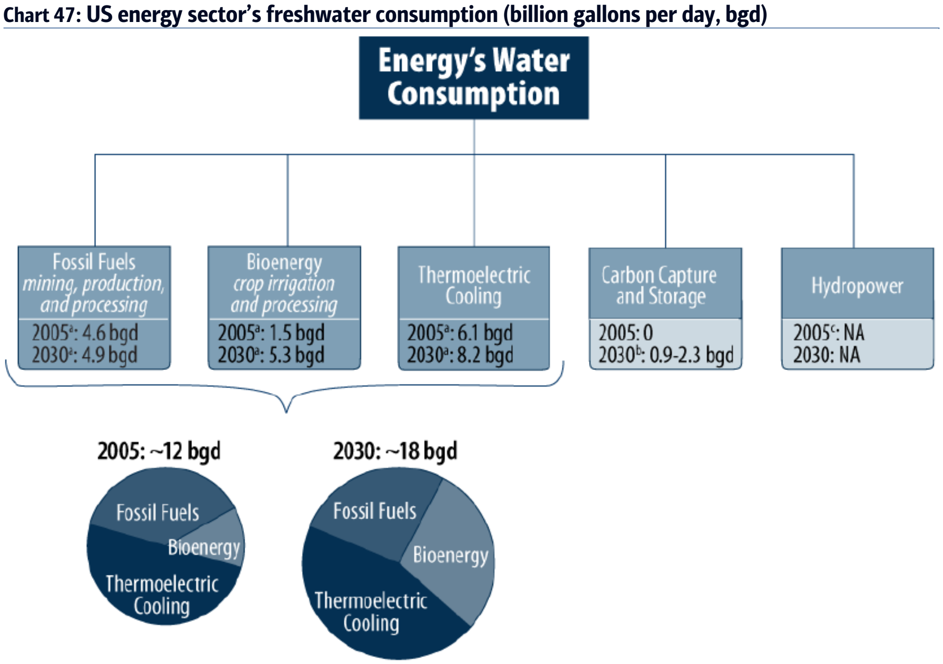
Water-energy nexus

Water and energy are interlinked and interdependent – with approximately 90% of global power generation being water-intensive. In many regions, and California in particular, water is also very energy-intensive, where large quantities of water are conveyed over long distances, including over hills and mountains. Additional energy is needed to treat and pump water, and distribute it to various residential, industrial, and agricultural users. According to the California Energy Commission, water for residential, commercial and industrial use needs the most energy (11%), followed by agriculture (3%).

Power generation – #2 user of all water

Thermoelectric power generation accounted for the second-largest proportion of water withdrawals in California, at 17.4% or 6.6bn gallons per day, versus the 44% national average (source: USGS 2010, CRS). Water for thermoelectric power is used in the process of generating electricity using steam-driven generators. Large volumes of water are needed for cooling in thermoelectric power plants.

Chart 47: US energy sector's freshwater consumption (billion gallons per day, bgd)



Source: Congressional Research Service (CRS)

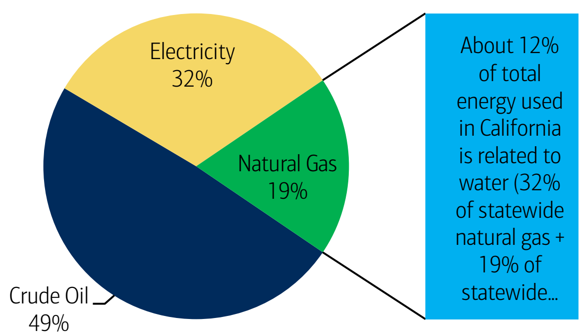
Urban use: population growth

Some of the most populous regions in California of San Francisco and the South Coast account for the highest urban water use, much of which is imported from within the state. Around half of the water use is for residential and commercial landscaping (source: PPIC). Despite the population growing from 30mn in 1990 to 38mn today, total urban use has remained relatively constant. Residential per capita water use has declined from 232 gallons per person per day in 1990 to 178 gallons in 2010 (source: PPIC), and averages below 100 gallons in the current period of conservation (source: California Water Boards).

Water accounts for 19% of electricity and 32% of natural gas consumption

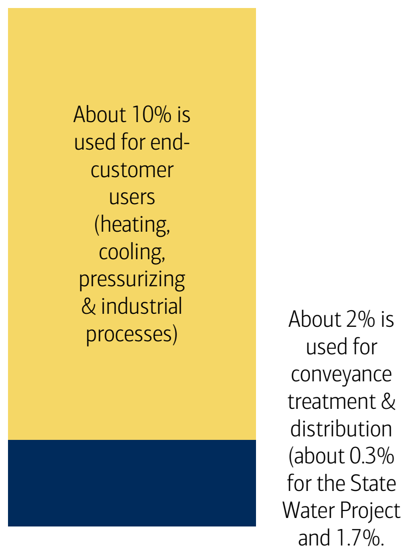
The California Energy Commission estimates that water systems and users in the state consume 19% of electricity, 32% of natural gas, and 12% of all energy (source: California Water Plan 2013). Around 75% of all demand is from end-users – water heating and cooling in residences, advanced treatment for industrials, and onsite pumping for agricultural users. The remaining 25% is used in water and waste collection and treatment (California Public Utilities Commission 2010).

Chart 48: California energy use breakdown related to water



Source: California Water Plan 2013

Chart 49: 12% of total energy used in California is related to water



Source: California Water Plan 2013

4.5 days of water electricity = five months of household electricity

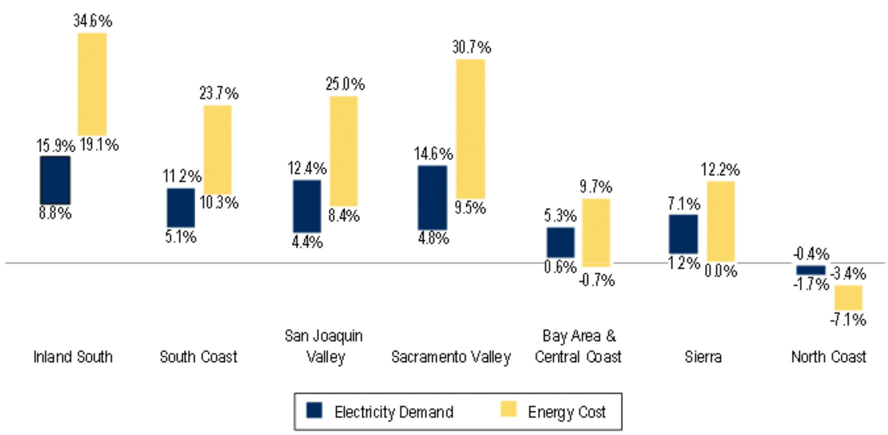
Much of the water used in California is imported from regions within the state. The State Water Project pumps water 700 miles and 2,000ft over the Tehachapi Mountains from the Sacramento-San Joaquin Delta to southern California, where two-thirds of the state's population live. To provide a southern Californian household with the SWP water it needs for 4.5 days requires the same amount of electricity it will use over five months (source: IEA, Water Education Foundation).

Oil & gas extraction also water-intensive

In addition to fracking and electricity, the other side of the water-energy nexus relates to the amount of water used in producing energy, including that used as the working fluid for hydropower or the working fluid and cooling agent in thermal-generation systems, and for irrigating biofuels. Water requirements for energy systems are highly variable and are affected by extreme weather and climate change:

- Rising temperatures are likely to increase electricity use for residential and commercial cooling, driving up demand across the state.
- Increasing heat, drought and wildfires will stress California's electricity infrastructure, decreasing the efficiency of the state's centralised natural gas and nuclear power plants, jeopardising hydropower generation, and disrupting transmission.
- Building new electricity capacity to meet demand will result in significant increases in energy costs in some parts of the state. The Inland South region is likely to be the hardest hit, with total energy costs growing as much as 35% by the end of century. (source: Risky Business Project).

Exhibit 50: Projected change in electricity demand and energy costs by region



Source: American Climate Prospectus

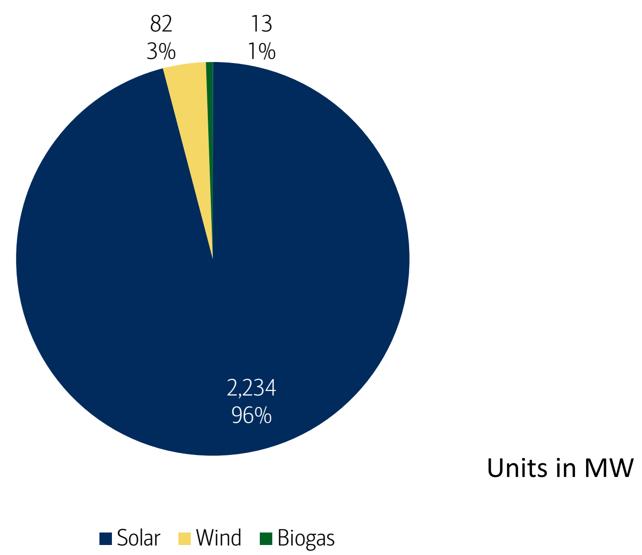
Up to 37% reduction in hydro power

Drought conditions have hampered hydro-electricity generation capacity. According to the California Independent System Operator (CAISO), capacity for peak demand in August is 7,428MW. However, under this year's severe drought conditions, the hydro capacity may reduce by 1,511MW or 2,733MW in base case and extreme scenarios, respectively. The latter is nearly a 40% cut in hydro power production versus the 10-year average of 8,180MW (source: California ISO 2015).

To be replaced by solar

While hydro generation in down, solar has more than made up for the gap. In California, a total of 2,328MW of additional electricity generation is expected to become operational between June 2014 and June 2015. Of this, 96% is solar, 3.4% wind, and 0.6% biogas (source: California ISO 2015).

Chart 50: Generation addition between June 2014 and June 2015 (MW)



Source: California ISO 2015

Potential shutdowns in thermal power production

CAISO is tracking the drought impact on thermal generation for summer 2015. Some capacity may be out-of-service due to water supply curtailments. Among the units with greater than 20MW capacity, four natural gas-fired power plants that were identified to have water supply concerns during 2014 have addressed the issue by establishing alternatives or by managing groundwater supply (source: California ISO 2015).

Travel industry – US$30bn value, 873k jobs

Water-dependent recreation has a major influence on California's economy. During 2010, travel spending in California directly supported 873k jobs with earnings of US$30bn. This includes jobs in the arts, entertainment, and recreation totalling 226k, and 520k in accommodation and food services (source: California Department of Parks and Recreation, Planning Division 2011, California Water Plan 2013).

-52% of Californians participate in beach activities
-35.4% swim in freshwater lakes, rivers, or streams
-25.6% fish in fresh waters (source: California Dept of Parks and Recreation 2012, California Water Plan 2013)

Impacting the US$1.4bn winter tourism industry

Winter recreation is a US$1.4bn industry in California, attracting more than 7.5mn visitors to its ski resorts in the 2009-10 season. On our current trajectory, northern California is likely to see a drop in days below freezing of 41% by 2050E, and up to 72% by 2100E. Warmer temperatures will also meaningfully shift the proportion of precipitation falling as rain versus snow. Since the 1970s, California has seen a 15% decline in snowfall, with the Sierra Nevada snowpack now at 5% of its average. For instance, the ski resort Squaw Valley spends about US$90,000 on one weekend of snow-making. This pumps 7,000 gallons of water per minute at a cost of US$3,000 per hour (source: Risky Business Project).

Summer tourism affected as well

The Sacramento-San Joaquin Delta is a regional summer tourism hub that draws 7mn visitors a year. It has 290 shoreline recreation areas, 200 marinas, 12,000 in-water boat slips, 635 miles of boating waterways, and 61k acres of open water. Activities such as fishing, boating, water-skiing, wind surfing, sightseeing, bird watching, biking and camping generate about US$1bn annually in economic activity and support about 8,000 jobs (source: Water Education Foundation). Degradation of the Delta would be detrimental to tourism in the region.

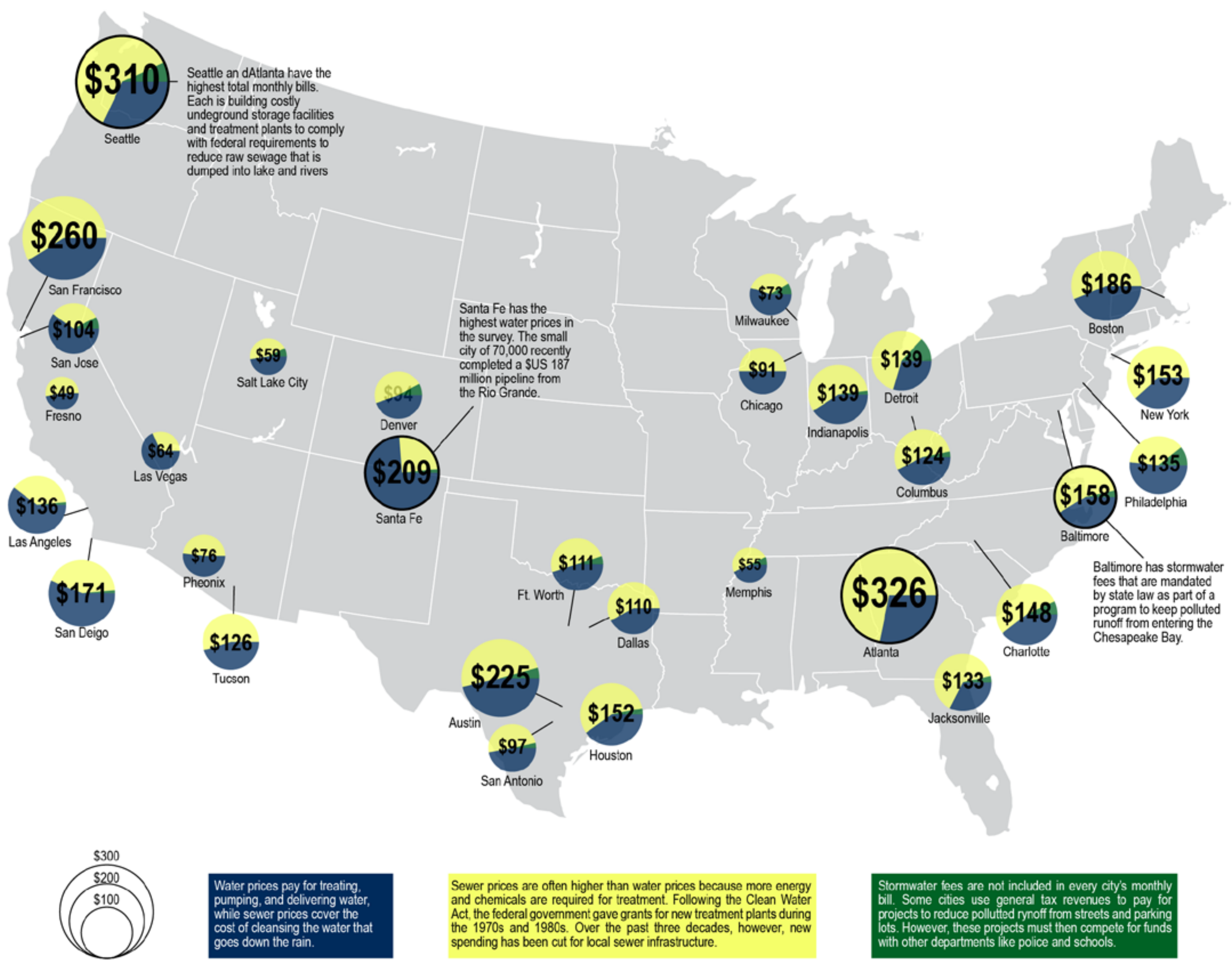
Price of water - better pricing mechanisms needed

Water rates, not being priced

As California and other regions in the US face droughts, there is increasing interest in pricing and other market mechanisms to rein in water consumption. In 2015, the average monthly cost of water for a US family of four using 100 gallons per person per day increased 6% YoY, resulting in a 41% rise since 2010. This is more than three times the 1.8% CPI increase over the same 12-month period (source: Circle of Blue). While this should encourage conservation, much will also go towards funding the US$1tn required to repair and replace old water infrastructure over the next 25Y (source: American Water Works Association).

> "We expect water rates to continue to grow above inflation for some time. We don't see an end in sight." – Andrew Ward, director of US public finance

Exhibit 51: The price of water in 2015 - combined water, sewer, stormwater prices for households in 30 major US cities



Source: Circle of Blue, BofA Merrill Lynch Global Research

High costs of free water - higher prices are a must

Water is often viewed as a free or cheap resource, or is not subject to market forces – meaning that it suffers from the tragedy of the commons where overuse and/or highly inefficient use is the norm. This needs to change especially given that water costs are significant. Water infrastructure is three times more expensive to build and maintain than electricity infrastructure (Source: IBM). Also, there are costs associated with demand, transport, treatment and price subsidies. Yet many municipal suppliers do not charge enough for water to meet even their basic operational and maintenance costs. As an example of inefficient pricing, water revenues in New Delhi are less than 20% of what the municipality spends each year to provide water.

> "When the well's dry, we know the worth of water" – Benjamin Franklin, Poor Richard's Almanac (1746)

While water will never be a wholly commercial product, higher water prices or full cost recovery pricing are clear incentives for efficient water use. They are also crucial to increasing cost recovery in the water sector and enhancing the financial sustainability of urban water supply systems. This would be beneficial for the entire water sector from an investment perspective, as well as for many of the world's poor, although striking a balance between affordability and social equity will be vital to maintaining licence to operate. Brazil is a good example of a country striking this balance (cf. *Water Infrastructure & Supply* section). We also need to explore new market-based mechanisms, such as water trading, water marketing, wand water banking, which would explicitly or implicitly incorporate infrastructure, maintenance, provision and administration costs into the water price.

Global water tariffs on the rise

Global water tariffs rose by an average of 4.3% between July 2013 and July 2014, compared with 3.7% in 2012-13, 3.6% for 2011-12, 6.8% for 2010-11 and 8.5% for 2009-10 (Source: GWI). The average water and wastewater tariff for the 355 cities in the 2014 GWI Water Tariff Survey is US$2.18 per m^3 (vs.US$2.11 per m^3 in 2013). Water and waste tariff rates are growing quickly in the US, rising 7%., driven by a combination of ageing infrastructure and the drought in California (source: GWI).

Table 26: Average 2014 tariffs (US$/m3) & water usage in selected major countries

Country	Combined tariff	Water tariff	Wastewater tariff	% Change	Domestic use 1/head/day	No. of cities
Denmark	$8.66	$3.94	$4.72	-1.4%	131	2
Australia	$6.50	$3.32	$3.18	3.8%	340	5
Germany	$6.02	$3.18	$2.84	-0.3%	127	10
United Kingdom	$4.91	$2.41	$2.51	2.7%	150	8
France	$4.59	$2.39	$2.20	0.9%	150	7
Canada	$3.54	$2.06	$1.49	6.6%	274	5
United States	$3.53	$1.46	$2.07	7.0%	380	51
Poland	$3.42	$1.55	$1.87	2.9%	125	6
Spain	$2.58	$1.81	$0.77	1.5%	265	6
Brazil	$2.43	$1.28	$1.16	6.7%	174	7
Portugal	$2.45	$1.77	$0.64	0.5%	161	3
Japan	$2.19	$1.21	$0.92	3.3%	373	13
Italy	$1.90	$0.90	$0.93	4.4%	190	6
Turkey	$1.73	$1.25	$0.48	8.2%	217	8
Russia	$1.01	$0.62	$0.30	6.9%	248	13
South Korea	$0.96	$0.66	$0.29	3.7%	183	7
Mexico	$0.96	$0.82	$0.13	13.7%	183	10
China	$0.52	$0.38	$0.14	2.7%	95	25
India	$0.14	$0.13	$0.02	3.9%	139	17

Source: Global Water Intelligence, BofA Merrill Lynch Global Research

California has highest water rates in US, and they are rising

Cities in California are paying some of the highest water tariffs in the US. A 2013 survey by Black & Veatch shows that San Diego and San Francisco pay the second- and third-highest water bills in the 50 largest cities in the US (source: Black & Veatch). San Francisco also experienced the third-largest increase in water prices, at +15% in 2015 versus the previous year. The highest increases were in Austin (+31%) and Chicago (+15%), both of which were using additional revenue to revamp water infrastructure (source: Circle of Blue).

Table 27: Water rates for 50 largest US cities, 2012-2013

Residential Customers – 7,500 gallons billable water usage. Most to least expensive.

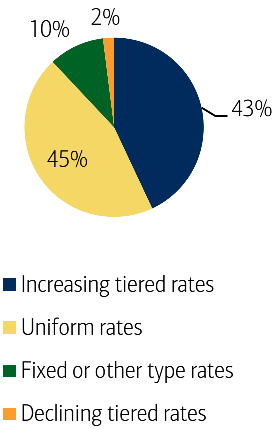
Community	Water $	Rank	Community	Water $	Rank
Seattle	61.43	50	Oklahoma City	29.68	25
San Diego	56.37	49	Fort Worth	28.86	24
San Francisco	56.00	48	Louisville	28.55	23
Atlanta	54.96	47	Sacramento	28.39	22
Kansas City	49.19	46	Las Vegas	28.39	21
New York	47.70	45	Albuquerque	27.35	20
Boston	45.39	44	Tulsa	26.78	19
Colorado Springs	45.26	43	San Antonio	26.54	18
Portland	43.25	42	Denver	25.76	17
Philadelphia	41.75	41	Omaha	25.74	16
Oakland	39.31	40	Tucson	25.17	15
Washington, D.C.	38.06	39	Detroit	25.12	14
Raleigh	37.73	38	Jacksonville	24.86	13
Virginia Beach	37.49	37	Dallas	23.91	12
Houston	37.27	36	Wichita	23.85	11
Los Angeles	37.16	35	Milwaukee	23.56	10
Indianapolis	36.82	34	Charlotte	23.11	9
Long Beach	35.72	33	Arlington	22.52	8
San Jose	35.28	32	Nashville	21.77	7
Minneapolis	34.90	31	Chicago	21.56	6
Columbus	34.68	30	El Paso	20.93	5
Cleveland	33.69	29	Fresno	20.63	4
Mesa	32.43	28	Miami	17.03	3
Baltimore	31.97	27	Phoenix	16.47	2
Austin	30.10	26	Memphis	14.74	1
Average	**32.70**				
Median	**29.89**				

Source: Black & Veatch, BofA Merrill Lynch Global Research

A third of Californians do not have increasing tiered pricing

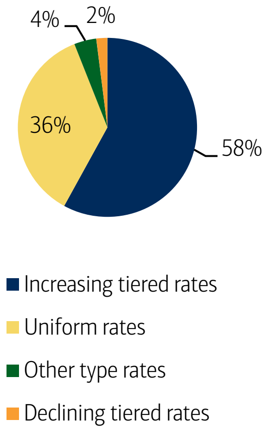
While tiered pricing for water has been on the rise, around one in three Californians still pays a flat, declining tariff, or another fee structure. In 1999, a survey of the California urban water purveyors found that about 43% had increasing tiered rates, 45% with uniform rates, 10% fixed or other type rates, and 2% with declining tiered rates. By 2011, the number with increasing tiered pricing had risen to cover two-thirds (67%) of the population (source: California Water Plan 2013). Tiered pricing allows people to access water for basic needs, such as drinking and showering, but an appropriate price for people that want to maintain a swimming pool or a green lawn. Despite the drought, certain cities in California charge the lowest differential between heavy and light water users. The 2014 Circle of Blue survey showed that Fresno charged the smallest difference out of 30 major US cities surveyed (source: Circle of Blue).

Chart 51: 1999 survey of rates



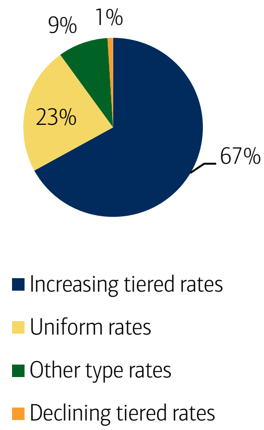
Source: California water plan 2013

Chart 52: 2007 survey of rates



Source: California water plan 2013

Chart 53: 2011 survey of rates



Source: California water plan 2013

High water price – economic development link

There is a correlation between economic development and high(er) water prices: 16 of the 20 countries with an average combined tariff of >US$3.00 per m^3 have a per-capita GDP of >US$35,000. Higher tariffs are needed to support well-developed water supply networks and to treat the wastewater that is produced (source: GWI).

Table 28: Top 15 average 2014 tariffs (US$/m3) & water usage in selected major cities

City	Tariff (US$/m3)	Tariff (US$/kgal)	% Change
Melbourne, Australia	$7.02	$26.57	8%
Perth, Australia	$6.81	$25.78	5%
Brisbane, Australia	$6.66	$25.21	7%
Sydney, Australia	$6.24	$23.62	4%
Adelaide, Australia	$5.76	$21.80	3%
San Francsico, California	$5.65	$21.39	12%
San Diego, California	$4.88	$18.47	40%
London, England	$4.30	$16.28	4%
Nassau, Bahamas	$4.26	$16.12	0%
Las Palmas, Spain	$3.27	$12.38	0%
LA, California	$3.26	$12.34	16%
Houston, Texas	3..13	$11.85	1%
San Antonio, Texas	$2.70	$10.22	4%
Tel Aviv, Israel	$2.66	$10.07	-4%
Dubai, UAE	$2.45	$9.27	0%
Worldwide Average	**$2.18**	**$8.25**	**4%**

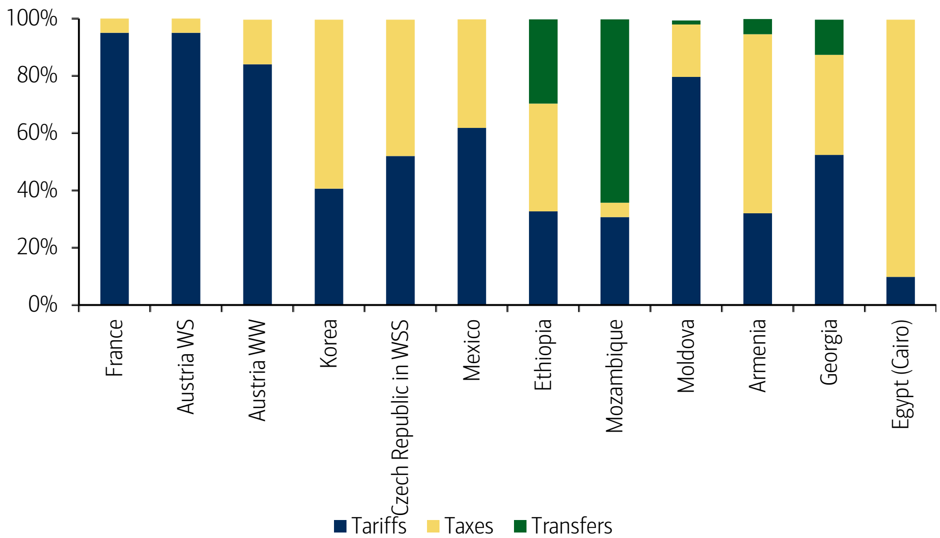
Source: Global Water Intelligence, BofA Merrill Lynch Global Research

Fuller cost but stakeholder-friendly recovery is key

Higher water prices could raise incentives for efficient water use, increase cost recovery in the water sector, and enhance the financial sustainability of urban water supply systems. We would see this as largely beneficial for the entire water sector from an investment perspective. It could also benefit many of the world's poor, who are not connected to municipal water supplies and who have no choice but to pay for informal purchases, which are up to 50x the price paid by middle- and high-income households.

> "Water is not a commercial product like any other, but, rather a heritage which must be protected, defended and treated as such" – EU Water Framework Directive's 1st paragraph

Chart 54: Global approaches to water finance



Source: OECD, BofA Merrill Lynch Global Research

In Europe, the Water Framework Directive, adopted in 2000, requires member states to impose pricing policies to encourage users to consume water more efficiently. However, many markets have no such policy. Moreover, there is no generally accepted pricing mechanism and countries tend to use a mix of three different mechanisms to finance and operate water infrastructure:

- Users can be charged a tariff for the water provided to them;
- Tax revenue can be used to subsidise opex and capex costs; and
- Transfer payment such as grants can be sourced from other countries.

Factors that need to be taken into account include public vs. private usage, abundant vs. scarce supply, supply to households vs. industry vs. agriculture and institutional capacity.

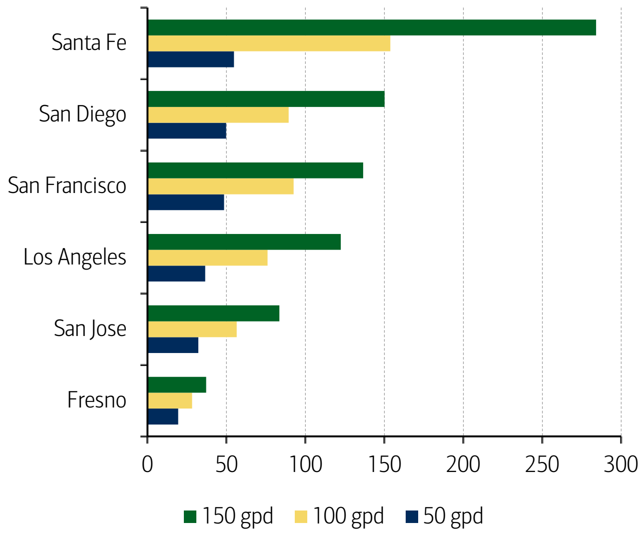
Affordability and social equity are key but difficult to achieve

Prices need to be balanced with affordability and social equity to ensure that lower-income and vulnerable consumers are not priced out of the market. This will be key to avoiding social unrest and political opposition (even in developed markets), and for utilities to maintain their licence to operate. This is no easy challenge given the pressing water infrastructure and O&M needs.

Follow the Santa Fe example

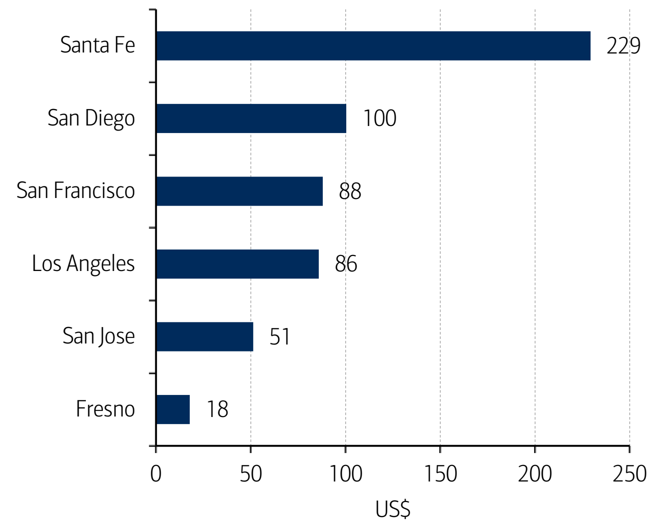
On the other side of the spectrum, the city of Santa Fe, New Mexico, has the most expensive water of the 30 US major cities surveyed, and also charges the highest prices for heavy users versus light (source: Circle of Blue). After implementation of the pricing system, total water consumption for the city plunged from 140 gallons per person per day in 2001 to 100 today. The city has been able to take the additional funds from higher water tariffs and a bond offering to renovate its water system as well (source: City of Sante Fe).

Chart 55: Average monthly water bill (US$) for a family of four, by gallons/person/day (gpd) in 2014



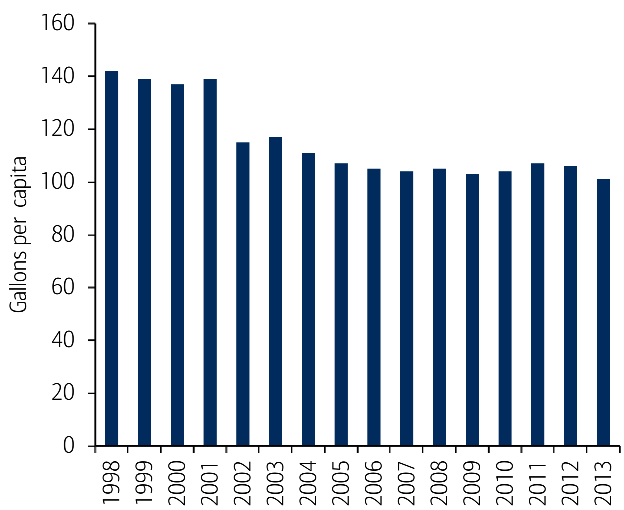
Source: Circle of Blue

Chart 56: Difference between 50 gpd vs 150 gpd (US$)



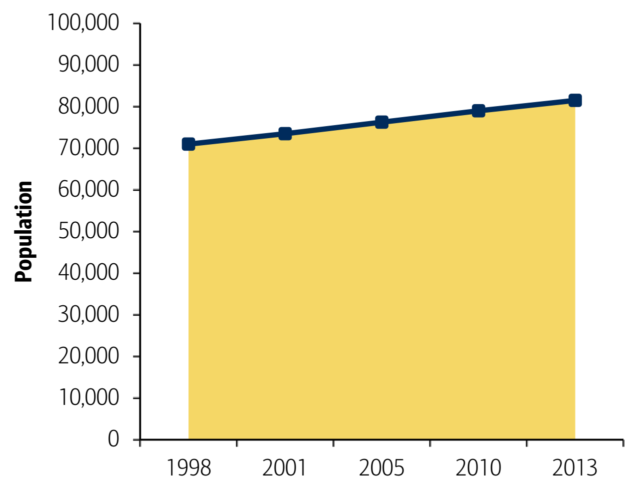
Source: Circle of Blue

Chart 57: Santa Fe water consumption (gallons per person per day)



Source: City of Santa Fe Water Division, BofA Merrill Lynch Global Research

Chart 58: Santa Fe population



Source: City of Santa Fe Water Division, BofA Merrill Lynch Global Research

Market-based mechanisms needed

Beyond pricing, there is an increasing call from many stakeholders for market-based mechanisms for water – policy instruments that use markets, price and economic variables to provide incentives for efficient water use. Water trading, water banking, and water transfers are three examples.

Table 29: Possible market-based mechanism for water security management

Water security issue	Recommended market-based instruments	Advantages of use
Water supply	Marginal social cost pricing, incorporating the scarcity value of water	Signals the optimal time to invest in water infrastructure so that supply is augmented efficiently
	International and regional water markets	Allows trade of water from areas of surplus to increase the water supply in areas of scarcity

Table 29: Possible market-based mechanism for water security management

Water security issue	Recommended market-based instruments	Advantages of use
Water demand	Regional water markets	Allows trade of water from low to high value uses creating incentives to use water efficiently and reduce demand
	Marginal social cost pricing, incorporating the scarcity value of water	Reduces demand for water during periods of scarcity
Water quantity	Buy-backs of water user's rights	Secures water for environmental flows and offsets economic losses
Water quality	Emission permit trading for point and non point pollution	Allows pollution to be reduced from the lowest cost sources
	Emission taxes	Creates ongoing incentive for all sources to reduce pollution

Source: OECD

Water trading

An alternative to traditional pricing would be water trading, whereby the price would be determined by market forces. Many believe water trading has the potential to limit the impacts of water scarcity as it would encourage users to understand the economic value of water and to use it more efficiently. This could work as follows

Water is not the new carbon in the sense that water trading would probably be local or regional because of its physical characteristics and the difficulty of transporting it over long distances

- A facility that reduces initial demand or improves the quality of discharge against an established baseline might trade excess demand or allocate it to another facility
- A facility that reclaims water and provides it to an external reuse application might use the corresponding reduction in demand to offset its own water intake.

Some of the western states of the US, Chile, South Africa, and Spain's Canary Islands already have water trading schemes, while Australia's is considered to be the most developed (see below). Informal water trading schemes also exist in parts of South Asia and China is looking at expanding its pilot water rights trading system programme in Ningxia-Hui and Inner Mongolia Autonomous regions.

Water is not the new carbon in the sense that water trading would probably be local or regional because of its physical characteristics and the difficulty of transporting it over long distances

A hypothetical model for trading

A hypothetical trading structure would be the development of a regional cap-and-trade system in water abstraction licences: a pre-assigned abstraction limit would define the volume of water that licence holders would be allowed to abstract in a particular region.

Other forms of water trading include treated wastewater trading, which would create a financial incentive for suppliers to install treatment technologies

Table 30: Hypothetical water trading model

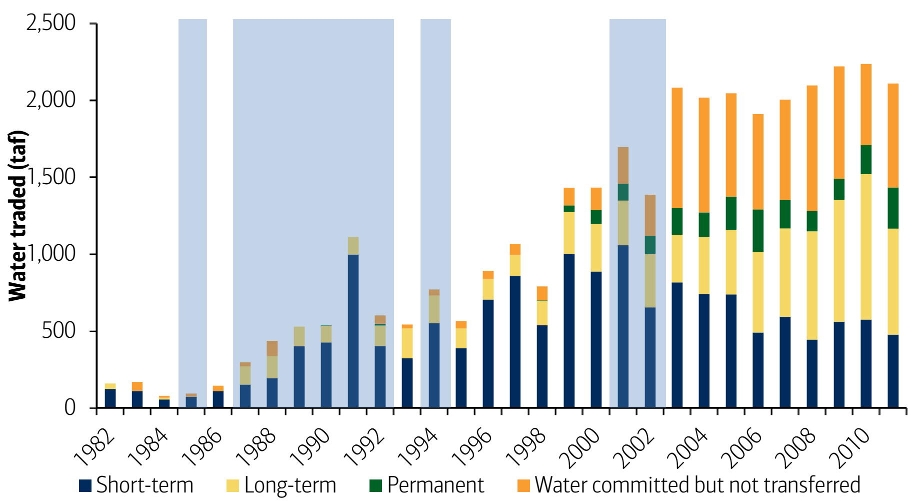
Factor	Overview
Area under coverage	Defined by the watershed in which the body of water drains
Allowances	Distributed via competitive auctions held at the beginning of each year. The highest bidding firms to receive allowances up to a limit set during an initial consultation period. The total no of licences will be reduced in a systematic fashion once the market has been established
Auction proceeds	Will go towards the funding of R&D
Fully developed market	futures, forwards and options may be purchased to secure supplies in advance of predicted water shortages

Source: BofA Merrill Lynch Global Research

2maf water trades pa in California, but still early days

Hundreds of water transfers are already occurring in California every year. Jump-started by a prolonged drought in the late 1980s and early 1990s, the water market now accounts for around 5% of all water used by California's businesses and residents. Every year, around 2maf (0.65tn gallons) of water trades are committed, with around 1.4maf (0.46tn gallons) actually exchanging hands. The market has shifted from primarily short-term, single-year contracts to one dominated by longer-term and permanent trades (source: PPIC 2012).

Chart 59: California's water market has grown substantially since the early 1980s



Source: PPIC 2012

Shaded area = Dry and Critically dry years

Farmers are the dominant traders

Farmers have been the primary source of water, and the destinations include other farmers, cities, and the environment (source: PPIC 2012). While data is scarce, there is anecdotal evidence that the amount of agricultural water transfers between agricultural users is increasing. The majority are within the basin, which does not require review by government agencies. They are simply governed by water rights held by the water district, and are a matter of internal allocation. During the current drought, there has been a shift towards planting higher-value crops like almonds, which appears to be permanent. Many water districts have been participating in the water markets to meet these water requirements (source: California Water Plan 2013).

SWRCB gives oversight

Transfers outside of the basin require involvement of the State Water Resources Control Board (SWRCB). Transfers through greater distances will often require the use of state, regional, or local public agency's conveyance facilities, which necessitates oversight to make sure fish and wildlife are not unreasonably affected (source: California Water Plan 2013).

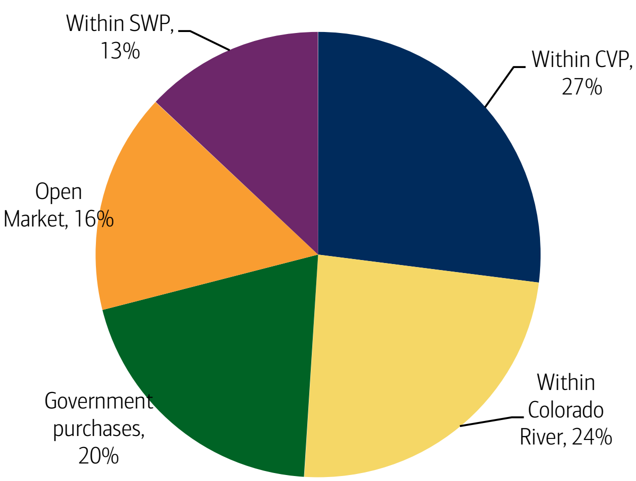
Benefits both sides

Market-based mechanisms allowing water transfers have the potential to improve economic stability and environmental conditions that would otherwise deteriorate with water scarcity. In the case of California, compensation received will either go directly to the landowner, often a farmer, or to the water district (source: California Water Plan 2013). This allows the money to be reinvested back into the land or to go towards improving water facilities or environmental conditions. For the buyer, this may prevent land from going idle and towards saving permanent plantings during this drought.

Water transfers becoming more localized

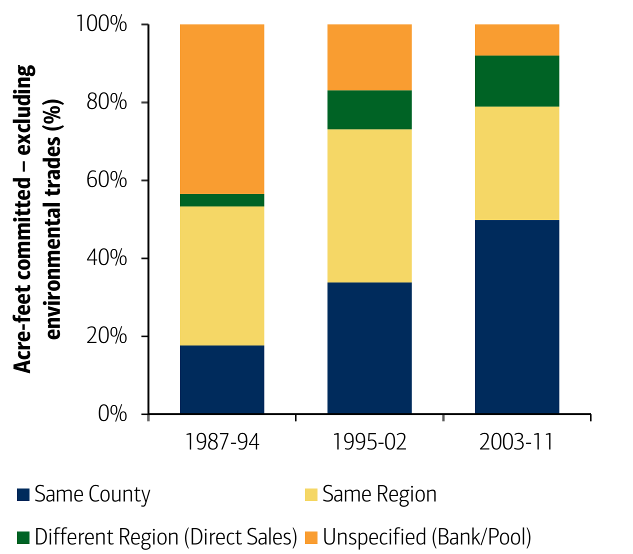
Over time, water transfers in California have become more localized, with trades within a county climbing from 18% in 1984-94 to 50% in 2003-11. This is reflective of long-term transfers of water from nearby agricultural areas to urban areas within the San Joaquin Valley, as well as localised trading between farms in the San Joaquin and Sacramento Valleys (source: PPIC 2012).

Chart 60: Sales within the major projects dominate the market



Source: PPIC 2012

Chart 61: Local water transfers are increasing



Source: PPIC 2012

Growth has slowed, policy changes necessary

Market growth of the water trade market has slowed since the early 2000s, reflecting a variety of infrastructure and institutional constraints. This includes new pumping restrictions in the Sacramento-San Joaquin Delta and more complicated approval procedures (source: PPIC 2012). Policy changes are necessary to spur growth once again.

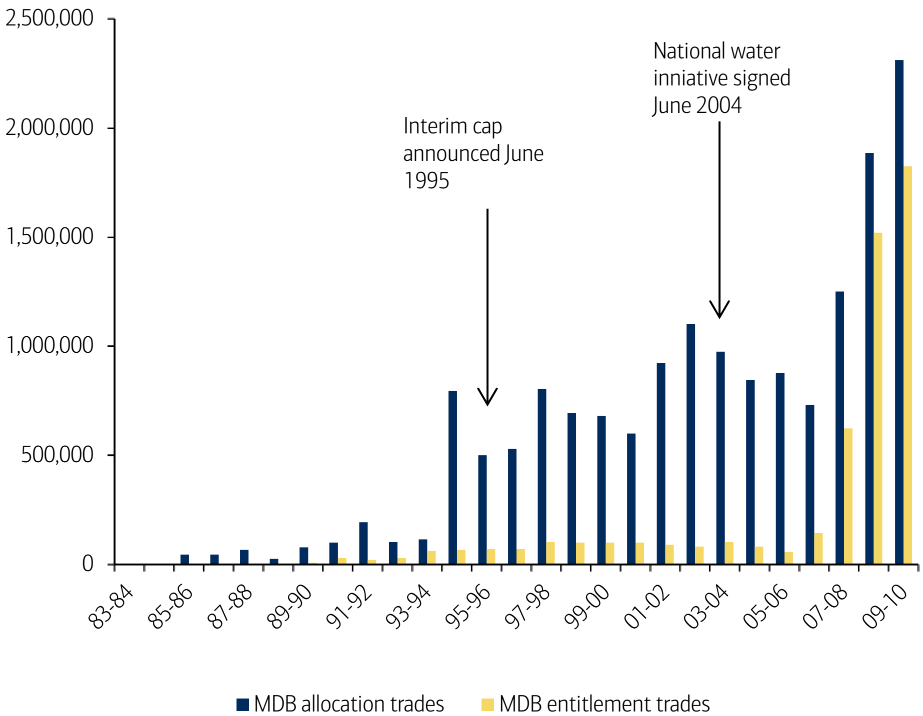
Australia – the most mature market

Australia has been constructing a market for water trading since 1983. Under the country's National Water Initiative, land and water rights were separated, allowing water entitlements (permanent) and seasonal allocations (temporary) to be transferred between different entities within the Murray-Darling Basin, which covers one-seventh of Australia and includes four states. Currently, water is traded mostly over-the-counter through water brokers, water exchanges and message boards.

In 2012, the National Water Commission said that "Australia's water markets have allowed water to be reallocated to where the need is greatest and reduced the impact of the drought on regional production… [and] of maximising the economic, social and environmental values of scarce water resources."

> By 2010, the water rights market was valued at up to A$2.8bn

Chart 62: Increases in Australian water trading (1984-2010)



Source: Australian Government – National Water Commission, BofA Merrill Lynch Global Research

Many challenges remain

While there is scope for water trading, it is currently constrained in many markets by the nature of the underlying commodity, a lack of incentives to buy or sell water, complexity in the process of agreeing a bulk supply, and the lack of a clear pricing model around marginal costs (source: E&Y and Severn Trent).

If we take the UK as an example, regulators are keen to promote water trading to relieve local pressure on water resources. Yet, under current pricing policies, the buyer of water is subject to operating cost efficiency adjustments despite not having ultimate control of the costs. A solution would be to remove the capital expenditure and operational expenditure costs associated with bulk supplies from the price review process; we do not expect this to be considered until the next pricing review at the earliest.

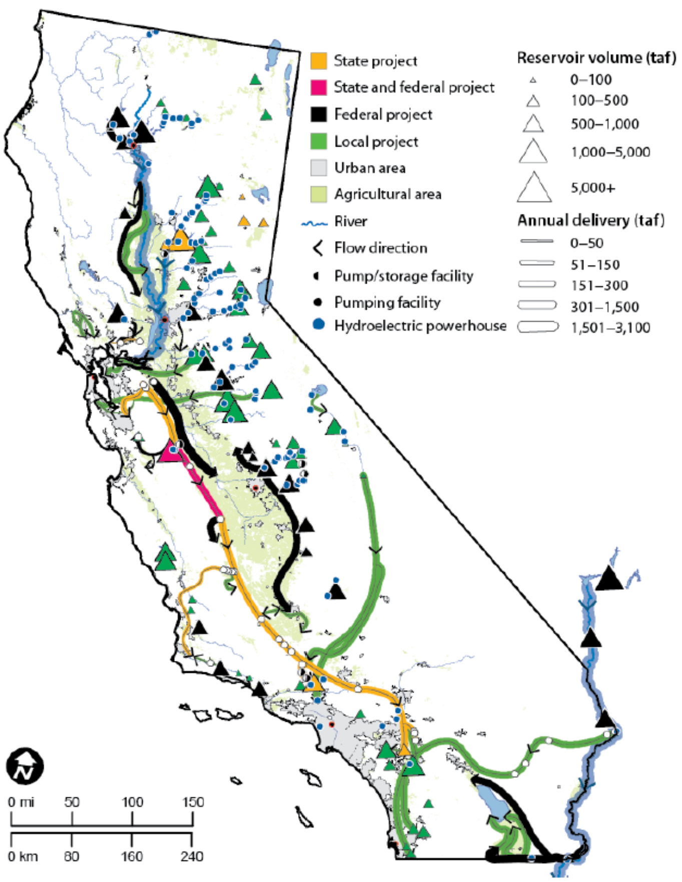
Water banking

Water banking is the practice of forgoing water deliveries during certain periods, and "banking" the right to use the forgone water in the future, or saving it for other users in exchange for a fee or delivery in kind. It makes sense where there is significant storage capacity to facilitate such transfers of water. Spain has planned to create a public water bank in each hydrographical basin, which would allow historical water resources to be re-allocated according to criteria of equity, efficiency, and sustainability. A 2012 study by the Public Policy Institute of California found that water banking could promote conservation, local infrastructure development and cooperation among water agencies.

California's infrastructure facilitates banking and trade

California's extensive water infrastructure network gives it the extensive ability to run a water market, in both water banking and transfers. Large water projects developed in the early to mid-20th century, including the Central Valley Project, the State Water Project, and investments to harvest water from the Colorado River and various local rivers, have forged hydrologic connections among most population and farming centres (source: PPIC 2012). This provides a perfect platform for trade.

Exhibit 52: California's extensive infrastructure network facilitates water marketing

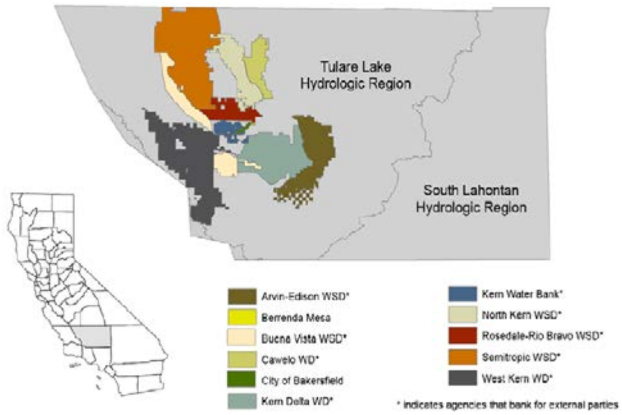


Source: PPIC 2012

Kern and Southern California made 1.9maf available in last drought

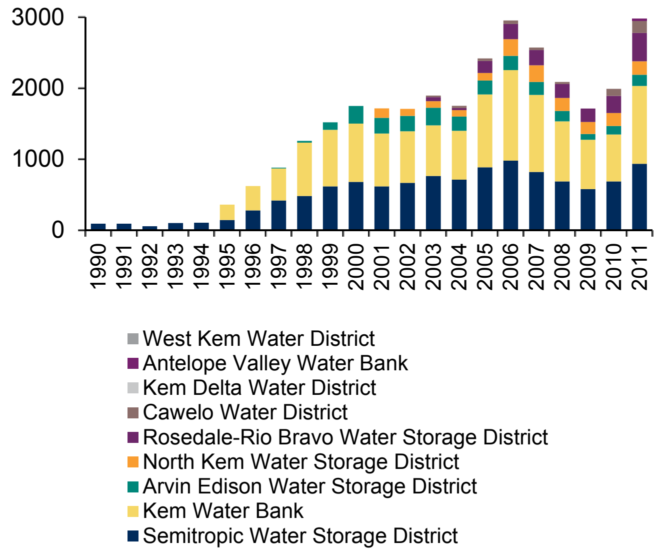
Water banks in Kern county and Southern California had built up reserves of nearly 3.4maf (1.1tn gallons) by 2006. While water banking has existed for a few decades, the practice accelerated in the mid-1990s. Today, around half of the water balances are held for Kern County, with the remainder split between Southern California (28%), the Bay Area (18%), and elsewhere within the San Joaquin Valley (8%). During the drought of 2007-10, water banks made 1.9maf (0.62tn gallons) available to their depositors (source: PPIC 2012).

Exhibit 53: Groundwater banks in Kern county are concentrated in the Tulare Lake hydrologic region



Source: PPIC 2012

Chart 63: Groundwater bank balances in Kern County have recovered since the recent drought



Source: PPIC 2012

Financing - US$30bn in water investments needed pa

Water management agencies in California spent more than US$30bn pa, or about US$2,350 per household during 2008-11. This went towards delivering supplies, preventing water pollution, providing flood protection, and managing aquatic ecosystems. Even at this rate, the state faces funding gaps of US$2-3bn per year (source: Hanak et al, PPIC). We believe new financing mechanisms and regulatory changes are necessary to close this gap. Recent financial innovation such as Green Bonds could be a potential solution.

Table 31: Yearly water-related spending in California by source, 2008–2011 (2012 $, millions)

	Local	State	Federal	Total
Water supply	14,777	1,603	477	16,857
Water pollution control	9,458	434	222	10,114
Flood management	1,324	574	254	2,152
Aquatic ecosystem management	25	405	241	671
Debt service on GO water bonds	—	689	—	689
Total Spending	**25,584**	**3,703**	**1,193**	**30,480**
Total Spending (%)	84%	12%	4%	100%

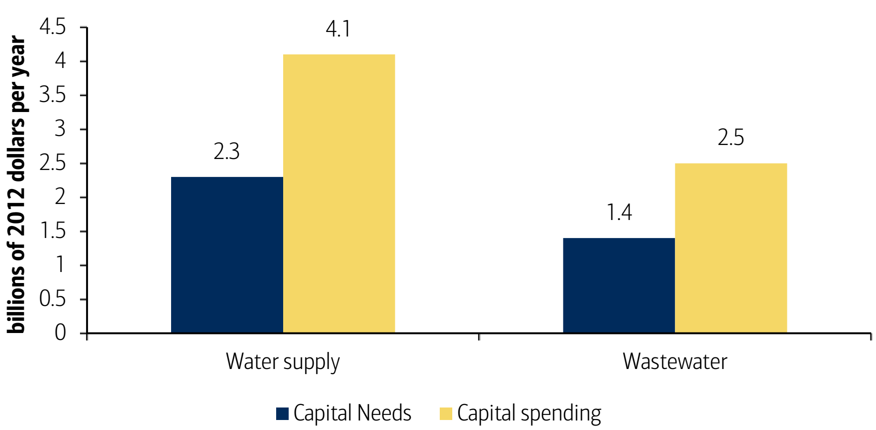
Source: Hanak et al PPIC

US$2-3bn funding gap per year in California

California faces critical funding gaps of US$2-3bn per year, or 7-10% above current spending, US$120-230 per household every year. There are several key areas that the state has already fallen short in:

- Integrated water management – US$200-300mn
- Stormwater management – US$500-800mn
- Floods – US$800mn-US$1bn
- Provide safe drinking water in small, disadvantaged rural communities – US$30-160mn
- Ecosystem support for endangered species – US$400-700mn (source: Hanak et al. PPIC)

Chart 64: California's drinking water and wastewater utilities seem to meet investment needs



Source: Hanak et al PPIC

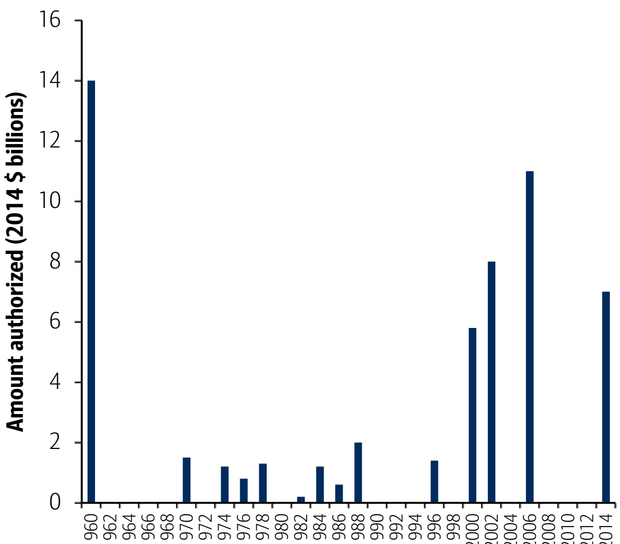
US water infrastructure requires US$1tn over next 25Y

For the US as a whole, US$1tn in water infrastructure investments are needed over the next 25 years to maintain even the current levels of water service. The country's drinking-water infrastructure was built more than 50 years ago, with a large proportion approaching or having exceeded its useful life (source: AWWA 2012). The US EPA, for instance, estimates that US$384bn would be required to 2030 simply to address infrastructure shortcomings – and an additional US$335bn to improve the systems. The American Society of Civil Engineers currently ranks both the nation's drinking water and wastewater infrastructure as D-.

State GO bonds provide some support

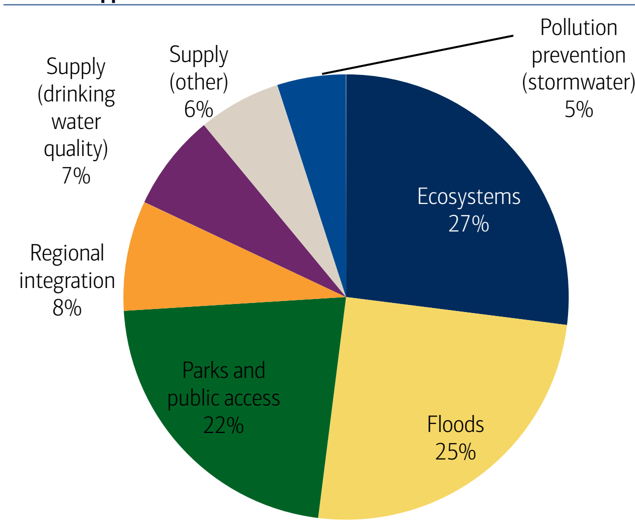
While Californians pay for the majority of the water system expenditures through their water and wastewater bills, the sector has been increasingly reliant on state and municipal general obligation (GO) bonds since 2000. There were six water-oriented GO bonds issued between 2000 and 2013, totalling US$24.8bn (source: PPIC 2014). These have gone towards innovative projects such as water recycling and groundwater banking, as well as essentials such as flood protections, stormwater and ecosystem management projects. Even with the passage of the new US$7.5bn bond (Proposition 1) in November 2014, additional funding will be needed. Bonds provide US$1bn per year at most, falling short of the additional US$1-2bn needed annually (source: Hanak et al, PPIC).

Chart 65: Past water related general obligation bonds



Source: PPIC, LAO 2009

Chart 66: Approved bonds in California 2000-2006

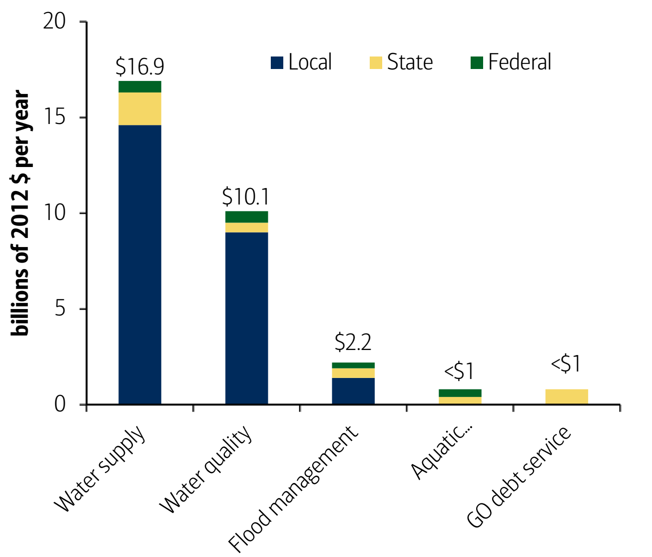


Source: Hanak et al PPIC

Local agencies raise majority of funds for water

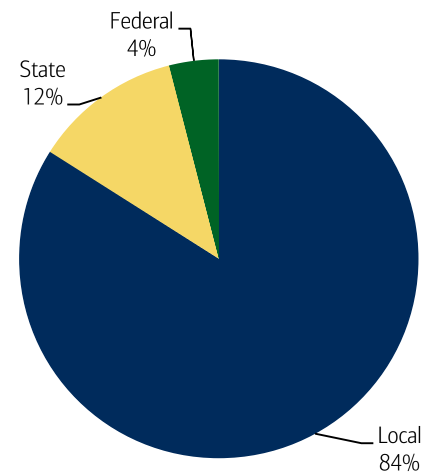
Local entities including private water utilities, private sector spending on flood insurance, have been the primary source of funding, accounting for 84% of total during 2008-11. The state of California only comes in at 12%, which accounts for only 4% of the total, according to the federal government (source: Hanak et al, PPIC).

Chart 67: Local agencies raise most of the money spent on the water sector
California annual water system spending (2008 - 2011)



Source: E. Hanak et al, PPIC 2014

Chart 68: Local agencies raise most of the money spent on the water sector
California annual water system spending breakdown (2008 - 2011)

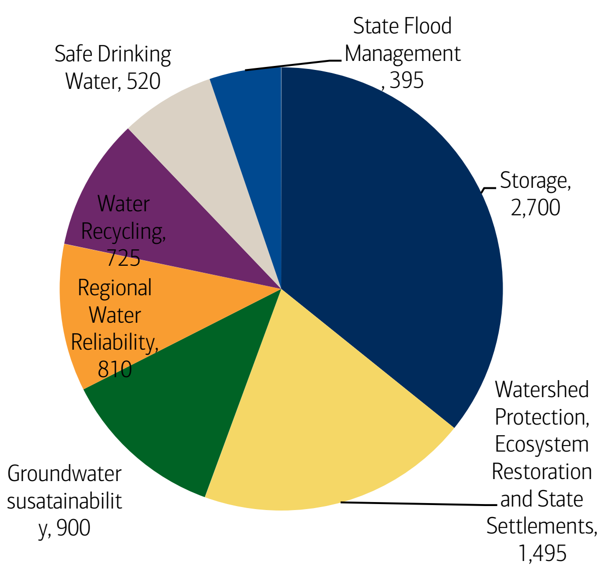


Source: E. Hanak et al, PPIC 2014

Ground-breaking US$7.5bn water bond

On 4 November 2014, with bipartisan support, California legislation passed Proposition 1, the fourth-largest water bond in California's history. The bill authorised the sale of US$7.12bn in new GO bonds and the reallocation of an additional US$425mn of previously authorised, but unissued bonds. This was called the Water Quality, Supply, and Infrastructure Improvement Act of 2014. The total cost of Proposition 1, including interest, will exceed US$14bn over 30 years (source: PPIC 2014).

Chart 69: Prop I Key Funding Areas (in US$mn)



Source: ACWA, California Natural Resources Agency

Table 32: Uses of Proposition 1 bond funds

Bond Sections	**Amount ($ millions)**
Water Supply and Reliability	$4,235
Surface and groundwater storage	2,700
Regional projects in the state's hydrologic regions1	510
Stormwater management	200
Urban and agricultural water conservation	100
Water recycling, including desalination	725
Watershed Protection and Restoration	$1,495
Watershed restoration and habitat protection in designated areas	515
State commitments for environmental restoration	475
Restoration programs available to applicants statewide	305
Projects to increase water flowing in rivers and streams	200
Improvements to Groundwater and Surface Water Quality	$1,420
Prevention and cleanup of groundwater pollution	800
Drinking water projects for disadvantaged communities	260
Wastewater treatment in small communities	260
Local plans and projects to manage groundwater	100
Flood Protection	$395
Repairs and improvements to levees in the Delta	295
Flood protection around the state	100
Total	$7,545

Source: PPIC, LAO 2014

Cost varies by type of allocation

The uses provided for by Proposition 1 vary widely in their cost of supplying water. The majority of bond funds have been allocated to new water storage, which is expected to boost water supplies by 0.6-3.1 million acre-feet at a cost of US$90-1,100 per acre-feet, with the median cost likely to be US$395. Additional build-out of groundwater storage will generally generate greater water supply at a lower cost. Some other cost-efficient methods that were not allocated as much funding include recycled water, stormwater capture, and efficiency (source: PPIC 2014).

Table 33: Bond Allocation, technical potential, and cost of various water supply options

	Bond Allocation ($ Millions)	Technical Potential (MAF per Year)	Cost ($/AF)
Surface water storage	$2,700	0.1–1.1	$300 to $1,100
Groundwater storage		0.5–2.0	$90 to $1,100
Recycled water	$725	1.2–1.5	$300 to $1,300
Brackish water desalination		0.3–0.4	$500 to $900
Seawater desalination			$1,900 to $3,000
Stormwater management	$200	0.4–0.6	Not known
Urban efficiency	$100	1.3–3.9	$223 to $522
Agricultural efficiency		0.4–2.0	$85 to $675
Various projects in several hydrologic regions	$510	Not known	Not known
Total	$4,235		

Source: PPIC 2014

US$700mn for disadvantaged communities

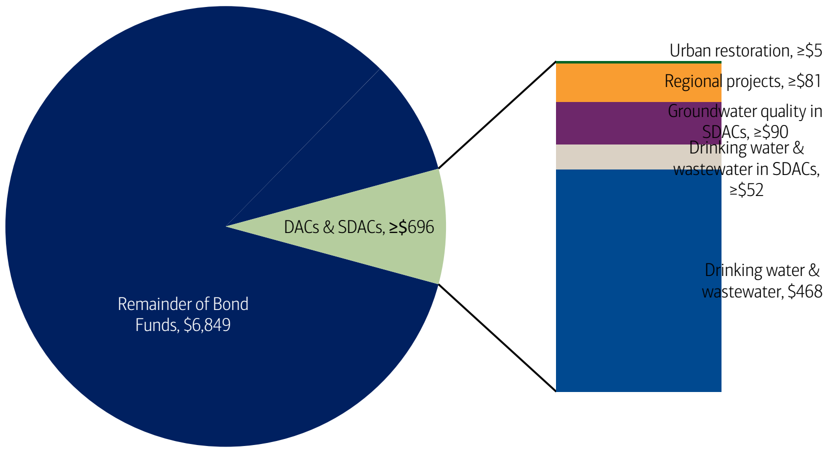
Small and poor communities tend to be in greatest need of financial assistance to access clean and safe water. Proposition 1 has allocated 9% of the water bond, or at least US$696mn to disadvantaged communities. US$520mn of this will provide funding for drinking water and wastewater projects. This goes towards fulfilling needs for small-community water systems, which the EPA estimates to be US$5.2bn over the next 20 years (source: PPIC 2014).

Table 34: Definitions used in the 2014 bond to target vulnerable communities

Disadvantaged community (DAC)	A community with an annual median household income that is less than 80% of the statewide annual median household income
Severely disadvantaged community (SDAC)	A community with a median household income of less than 60% of the statewide average.
Economically distressed area	A municipality with a population of 20,000 persons or less, a rural county, or a reasonably isolated and divisible segment of a larger municipality where the segment of the population is 20,000 persons or less, with an annual median household income that is less than 85% of the statewide median household income, and with one or more of the following conditions as determined by the department: (1) Financial hardship. (2) Unemployment rate at least 2% higher than the statewide average. (3) Low population density.

Source: PPIC 2014

Chart 70: Funding available for disadvantaged and severely disadvantaged communities (US$ mn) in the proposed 2014 bond



Source: PPIC 2014

Table 35: 2014 Water bond timeline

Category	Agency	Guideline Process	
		Expected Start	Expected Completion
Small community wastewater treatment	State Water Resources Control Board	Mar-15	Jun-15
Safe and affordable drinking water	State Water Resources Control Board	May-15	July-Aug. 2015
Multibenefit watershed projects	State Conservancies (various)	Jan.-Feb. 2015	Various dates
Enhanced stream flows	Wildlife Conservation Board	Feb. 2015	May-15
Urban creek restoration	State Conservancies (various)	In process	TBD
State obligations in water-related settlements	Natural Resources Agency	In process	TBD
Watershed and Urban River Enhancements	Natural Resources Agency	In process	TBD
Watershed restoration and Delta water quality and ecosystem restoration	Department of Fish and Wildlife	Jan. 2015	May-15
Integrated regional water management	Department of Water Resources	Mar-15	2016 (Final Round of Prop 84 in progress and to be awarded by Aug. 2015)
Water Use Efficiency Grants, Round 1 – Urban and Agricultural	Department of Water Resources	Jul-15	Dec. 2015
Stormwater management	State Water Resources Control Board	In process	TBD
Water Storage Investment Program	California Commission	Jan. 2015	Submission of draft regulations to Office of Administrative Law by Oct. 2015 (OAL process may take up to 12 months)
Water recycling	State Water Resources Control Board	Apr-15	Jun-15
Groundwater Plans and Project Grant Program – Phase 1	Department of Water Resources	Mar-15	TBD
Groundwater Sustainability (clean-up)	State Water Resources Control Board	In process	TBD
Multibenefit projects to achieve public safety and enhance fish/wildlife, including Delta levee maintenance and improvements	DWR/Central Valley Flood Protection Board	In process	TBD

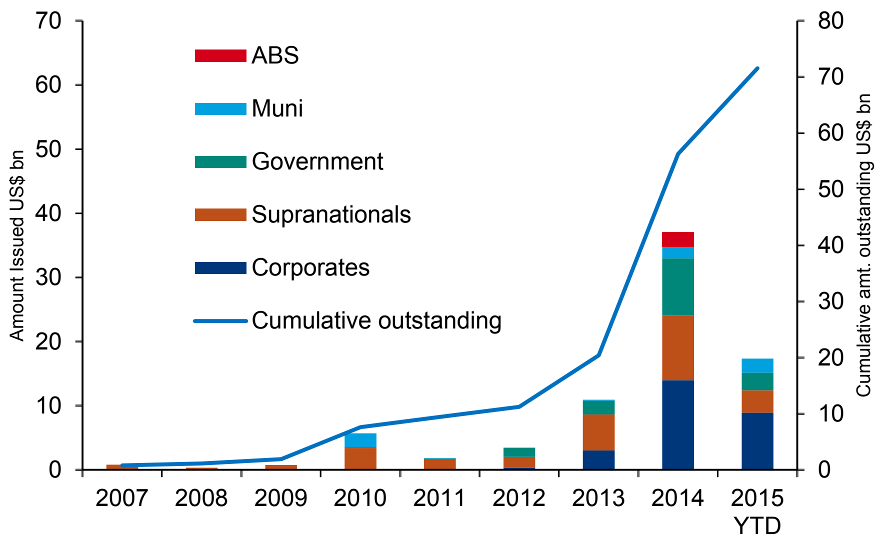
Source: ACWA

Green Bonds are a potential tool

Green Bonds could be a potential tool in connecting private capital with financing needs in water infrastructure. Green Bonds are debt instruments in which the proceeds are used for environmental solutions, including water and wastewater needs. The market really came to fruition in 2014 when the first set of guidelines and definitions were created with the introduction of the Green Bond Principles. The Green Bond market now stands at US$71bn.

Governments and municipalities are using it increasingly as a way to access private capital. Corporates and international agencies are active in the space as well.

Chart 71: Corporates leading growth in "Use of Proceeds" green bonds YTD, through June 12 2015



Source: BofAML Global Research. Compiled from Bloomberg, CBI, company filings.

Thematic Investing: Fixing the Future: Green Bonds Primer 08 September 2014

California already issuing "blue" Green Bonds

The earliest green muni bonds to come out of California date back to 2010, and most had been earmarked for renewable energy uses. Both the State of California and the City of San Francisco have now issued Green Bonds where use of proceeds will go towards water infrastructure. This could be another means to fill the US$2-3bn annual funding gap in California water.

Table 36: Muni Green Bonds in California

Issue Year	Issue	US$ mn	Description
2015	City of San Francisco CA Public Utilities Commission Water Revenue	32	Green Bond Muni issue to fund the renovation of the Hetch Hetchy project. This A+ rated bond is a series of 13 tranches with maturities ranging from 11yrs to 30yrs and either a 4% or 5% coupon. Proceeds for this bond will be used for hydropower generation and other renewable energy projects in California.
2014	State of California	300	Green Bond Muni issue to fund various environmentally beneficial projects. The proceeds from the bond are intended to finance public transportation and water infrastructure. With an investment rating of A+ by S&P the green bond offering included 14-year notes, which promised returns at 2.9% and 23-year notes with 3.37% returns.
2013	Los Angeles Department of Water & Power	28	Green Bond Muni issue to fund energy conservation projects
2012	Lincoln Unified School District	7	Green Bond Muni issue to fund clean energy projects
2011	Southern California Public Power Authority	159	Joint powers agency of 12 public power utilities who have issued a tax-exempt $159.4m project revenue bond to prepay for electricity from a wind farm.
2011	California Community College Financing Authority	5	Green Bond Muni issue to fund clean energy projects
2011	Calistoga Joint Unified School District	2	Green Bond Muni issue to fund clean energy projects
2011	Glendale Unified School District/CA	4	Green Bond Muni issue to fund clean energy projects
2011	Rancho Water District Financing Authority	10	Green Bond Muni issue to fund energy conservation
2011	Twin Hills Union School District	1	Green Bond Muni issue to fund clean energy projects
2011	West Sonoma County Union High School District	2	Green Bond Muni issue to fund clean energy projects
2011	Yuba Community College District	13	Green Bond Muni issue to fund a solar photovoltaic project
2010	Anderson Valley Unified School District	2	Green Bond Muni issue to fund clean energy projects
2010	Big Pine Unified School District	1	Green Bond Muni issue to fund clean energy projects
2010	Mount Diablo Unified School District/CA	58	Green Bond Muni issue to fund clean energy projects
2010	Santee School District	2	Green Bond Muni issue to fund clean energy projects
2010	Sonoma Valley Unified School District	11	Green Bond Muni issue to fund clean energy projects

Source: BofAML Global Research. Compiled from Bloomberg, CBI, company filings

Solutions

There are numerous potential solutions to increase California's water supply, as well as manage it in an efficient manner. They are assessed according to cost, water quality, energy benefits, environmental benefits, amongst others. We believe that the dynamics of water supply and demand mean that the water sector offers numerous growth opportunities for those with exposure to the value chain.

Table 37: Resource Management Strategy Summary

	Water Supply Benefits by 2030 (million acre-feet/year)		Reduce Drought Impacts	Improve Water Quality	Higher Operational Flexibility & Efficiency	Reduce Flood Impacts	Environmental Benefits	Energy Benefits	More Recreational Opportunities	Reduce Groundwater Overdraft	Improve Food Security	Public Safety & Emergency Response	Accumulated Cost by 2030 ($ Billion)
Reduce Water Demand													
Agricultural Water Use Efficiency	x	0.1 – 1.03		x	x		x				x		0.3 – 0.5
Urban Water Use Efficiency	x	1.2 – 3.1	x	x	x		x	x					2.5 – 6.0
Improve Operational Efficiency & Transfers													
Conveyance — Delta	x	N/A	x	x	x	x	x		x	x	x	x	1.2 – 17.2
Conveyance — Regional / Local	x	N/A	x	x	x	x	x			x	x		N/A
System Reoperation	x	N/A	x	x	x	x	x	x		x		x	N/A
Water Transfers	x	N/A	x		x		x				x		N/A
Increase Water Supply													
Conjunctive Management & Groundwater	x	0.5 – 2.0	x	x	x	x	x			x	x		N/A
Desalination — Brackish Water & Seawater	x	0.3 – 0.4	x	x		x				x			2.0 – 3.0
Precipitation Enhancement	x	0.3 – 0.4						x					0.1 – 0.2
Recycled Municipal Water	x	1.8 – 2.3	x		x			x					6.0 – 9.0
Surface Storage – CALFED	x	0.1 – 1.1	x		x	x			x	x	x		0.7 – 9.2
Surface Storage – Regional / Local	x	N/A	x	x	x	x		x	x	x	x		N/A
Improve Flood Management													
Flood Management	x	N/A	x	x		x	x			x		x	32 – 100

Source: California Water Plan 2013

Marginal cost of water highly variable

The marginal cost of varies depending on the location and the time, driven by local availability of resources as well as supply and demand. The City of San Diego performed a cost and benefit analysis when considering building desalination plants. They found that attaining additional surface and groundwater supplies were generally lower than cost of desalination and recycled water were highest (Source: PPIC 2012). However, these would not solve the problem of long-term water sustainability.

Table 38: Example of the Marginal Cost of Water in San Diego County

Water Alternative	Cost Per Acre-Foot	Cost Per Cubic Meter
Imported Water	$875 - $975	$0.71 - $0.79
Surface Water	$400 - $800	$0.32 - $0.65
Groundwater	$375 - $1,100	$0.30 - $0.89
Seawater Desalination	$1,800 - $2,800	$1.46 - $2.27
Recycled Water (Non-Potable)	$1,600 - $2,600	$1.30 - $2.11
Recycled Water (Potable Water)	$1,200 - $1,800	$0.97 - $1.46
Water Conservation and Efficiency	$150 - $1,000	$0.12 - $0.81

Source: PPIC 2012, Equinox Center 2010

Conservation still the cheapest

While desalination and water recycling are good ways generate new or alternative water supply, the cheapest method remains simple conservation. For instance, it can be up to 30 times more cost effective to attain a marginal acre-foot of water through agricultural water efficiency versus seawater desalination.

Table 39: Sample Costs of Water Use Efficiency to Water Suppliers per Acre-Foot of Water Saved

Program Types	Sample Costs per Acre-foot
Residential programs	Toilet rebates: $158-$475/af Residential audits: $236-$1,474/af Clothes washer rebates: $154-$480/af
Landscape programs	Landscape audits: $58-$896/af Equipment rebates: $15-$181/af Turf removal: $274-$717/af Water budgets: $10-$59/af
Commercial, industrial, and institutional (CII) programs	Toilet rebates: $242-$1,018/af Urinal replacement: $320-$583/af Pre-rinse spray valves: $78/af
Utility operations programs	System audits/leak detection: $203-$658/af

Source: California Water Plan 2013

Table 40: Unit Cost Information for Selected Resource Management Strategies

Resource Management Strategy	Range of Costs (Dollars/Acre-Feet)
Agricultural Water Use Efficiency	$85-$675
Brackish Groundwater Desalination	$500-$900
Meadow Restoration	$100-$250
Ocean Desalination	$1,000-$2,500
Municipal Recycled Water	$300-$1,300
Surface Storage	$300-$1,100
Urban Water Use Efficiency	$223-$522
Wastewater Desalination	$500-$2,000

Source: California Water Plan 2013

Water treatment solutions

We believe that companies involved in water treatment including: desalination, wastewater, industrial treatment, chemicals, analysis, water quality among others offer long-term solutions to water stress. Desalination has been a particularly important focus for California given the state's geographical setting. At the same time, global desalination will be a US$42bn market by 2025E (source: Japan's Ministry of Economy, Trade and Industry), with the US making up US$11bn (source: GWI).

Global US$178bn water & wastewater treatment market in 2013

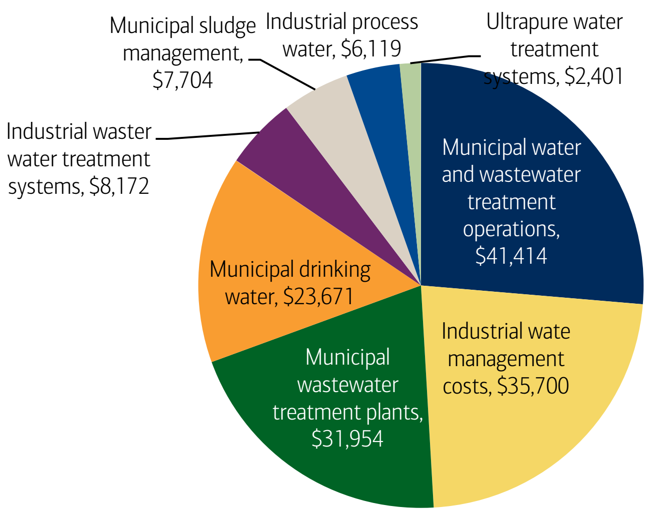
Globally, the municipal and industrial water and wastewater treatment market was estimated to be c.US$178bn in 2013 (source: GWI). On the municipal side, the increasing burden of environmental regulations and the need to extract more value from the water cycle is propelling the market. Growth in spending is being driven by the Asia Pacific market, with China overtaking the US as the world's biggest spender (source: GWI).

California still has room for improvement

There are significant low hanging fruit opportunities around water treatment with around 13% of California's municipal wastewater being recycled, or 670k acre-feet of the 5m acre-feet produced (source: Natural Resources Defense Council). Globally, this figure is less than 3%, whereas the goal needs to be to move to best-practice levels of water reuse of up to 75% (e.g., Israel). Water treatment covers the processes used to make water more acceptable for a desired end-use, such as for drinking, usage or re-usage by industry, for irrigation, or a return to the natural environment.

Chart 72: Water & wastewater treatment: industrial & municipal market (2013)

$177,739 mn Treatment market (2013)



Source: GWI

Desalination: 3,427 miles of Californian shoreline

While conservation and water treatment and recycling are recommended as the first course of action, alternatives such as desalination are being increasingly incorporated into the state's water portfolio. California has 3,427 miles of tidal shoreline, with 74% of the population living in coastal cities. This makes seawater desalination a likely candidate (source: NDRC)

Proposed plants can provide up to 7% of water demand, 390-570m gallons/day

As of July 2012, there were 17 desalination plants proposed or in the process of developments along the California coast. The total combined capacity of the proposed plants ranges from 390- 570mn gallons per day. If all were utilised, this would have supplied 5-7% of urban water demand in California (source: PPIC 2012). All utilise reverse osmosis (SWRO) technology (source: PPIC). The associated cost of water production and environmental implications vary depending on source of water intake, as well as size and location of the plants (source: NDRC).

Table 41: Desalination projects in California

Project Partners	Location	Capacity (MGD)	Est. Completion	Intake	Brine Discharge
East Bay Municipal Utilities District/San Francisco Public Utilities Commission/Contra Costa Water District/Santa Clara ValleyWater District/Zone 7 Water Agency	Pittsburgh	19.2 to 19.8	2020	Surface	Undetermined but may be mixed with wastewater
California Water Service Company	Not known	5	2025	Undetermined	Undetermined
City of Santa Cruz/Soquel Creek Water District	Santa Cruz	2.5, possible expansion to 4.5	2016	Evaluating both surface and subsurface	Mixed with wastewater
DeepWater, LLC	Moss Landing	25	2015	Surface	Mixed with cooling water
The People's Moss Landing Water Desal Project	Moss Landing	10	2015	Surface	Surface
California American Water	North Marina	5.4 to 9.0	2016	Subsurface	Surface
Ocean View Plaza	Monterey	0.25	2015	Subsurface	Surface
Monterey Peninsula Water Management District	Del Monte Beach, Monterey	2	Unknown	Undetermined	Undetermined
Seawater Desalination Vessel	Monterey Bay	10 to 20	Unknown	Surface	Surface
Cambria Community Services District/U.S. Army Corps of Engineers	Cambria	0.6	Unknown	Subsurface	Subsurface
Arroyo Grande/Grover Beach/Oceano Community Services District	Oceano	2	2016	Subsurface	Mixed with wastewater
West Basin Municipal Water District	El Segundo	18	2017	Evaluating both surface and subsurface	Surface
Poseidon Resources	Huntington Beach	50	2018	Surface	Surface
Municipal Water District of Orange County, Laguna Beach County Water District, Moulton Niguel Water District, City of San Clemente, City of San Juan Capistrano, South Coast Water District	Dana Point	15	2020	Subsurface	Mixed with wastewater
City of Oceanside	City of Oceanside	5 to 10	2020	Subsurface	Undetermined
Poseidon Resources/San Diego County Water Authority	Carlsbad	50	2015	Surface	Surface
San Diego County Water Authority	Camp Pendleton	50, expanding to 150	2020	Evaluating both surface and subsurface	Surface
NSC Agua	Rosarito, Mexico	100	Unknown	Undetermined	Undetermined
San Diego County Water Authority	Rosarito, Mexico	25, possible expansion to 75	2020	Undetermined	Undetermined

Source: Pacific Institute 2012, Poseidon Water, Carlsbad Deslination Project, BofA Merrill Lynch Global Research

Cost varies but generally expensive

The cost of desalination is highly variable, with that of plants proposed in California ranging from US$1,900-3,000/acre-foot (source: PPIC 2012). While the cost of desalination has declined considerably over the past few decades, cost is often a key barrier to adoption.

Table 42: Desalination Costs for Proposed and Recently Constructed Plants

Project	Capacity (MGD)	Capital Cost ($ millions)	O&M Cost ($ millions)	Unit Cost ($/AF)	Dollars are in...	Status
Santa Cruz/ Soquel Creek Water District	2.5	$114	$3 - $4	N/A	2012 dollars	Proposed
California American Water	4.9 – 8	175 - $207	$7.77 - $11.0	$2,555 - $3,250	2012 dollars	Proposed
Deep Water Desal	4.9 - 8	134 - $ 160	$9.38 - $12.3	$2,395 - $3,120	2012 dollars	Proposed
The People's Moss Landing Water Desal Project	4.9 - 8	161 - $190	$7.06 - $10.1	$2,345 - $2,980	2012 dollars	Proposed
Tampa Bay, Florida	25	$158	N/A	$1,100	2007 dollars	Complete
Gold Coast Desalination Plant	33	$888	$30	$1,982	2009 dollars	Complete
Kwinana Desalination Plant – Perth	38	$330	$17	$1,221	2008 dollars	Complete
Carlsbad Desalination Plant	50	$771	$50 - $54	$2,042 - $2,290	2012 dollars	Proposed
Camp Pendleton	50 - 100	$1,300 - $1,900	$45 - $105	$1,900 - $2,340	2009 dollars	Proposed
Kurnell Desalination Plant- Sydney	55	$1,565	$47	$2,407	2008 dollars	Complete
Southern Seawater Desalination Plant	72	$1,466	N/A	$2,827	2012 dollars	Complete
Port Stanvac – Adelaide	72	$1,878	$136	$2,389	2012 dollars	In progress
Wonthaggi Desalination Plant – Melbourne	109	$3,651	$63	$6,552	2012 dollars	In progress

Source: PPIC 2012

New source of water

One of the reasons that there has been keen interest in desalination is that is comprises a new source of fresh water. Most Californian utilities already have 5-15% of their water portfolios coming from reuse, with the state average at around 13% (source: NDRC). Much of this is low-cost and has been in place since the early 1990s. To attain the next 10-15% of water savings may require more sophisticated equipment or higher levels of technology that are often costlier. In some cases this may approach even the current cost of desalination (source: Water Reuse Association).

Mixed sources of funding, room for private sector

Nine, or around half of the proposed desalination plants in California are fully or partially financed and owned by private companies, with public water utilities making up the rest. Publicly developed plants generally use municipal revenue bonds, with government grants and loans contributing too. Financing mechanisms for private ventures tend to be backed by a combination of debt and private equity (source: PPIC 2012). As public funding becomes stretched, private and public-private partnerships can become attractive mechanisms to attain financing, as well as a way to disperse project risk.

Table 43: Degrees of salinity

General Water Term	Relative Salinity, mg/L (ppm) TDS
Fresh (natural)	Less than 1,000a
Brackish	1,000 to 30,000
Sea	30,000 to 50,000
Hypersaline	Greater than 50,000 or that is found in the sea
Natural brine	Greater than 50,000 to slurriesb
Discharge brine	1,000 to slurriesc

Source: California Water Plan 2013

Brackish water is primary input in California

The most common source of water for desalination in California is brackish groundwater located inland from the ocean. The salinity may be natural or caused by human activity, such as agricultural irrigation. Salts in irrigation water left by plants tend to concentrate and migrate to groundwater. Animal waste from dairies and feed lots can be significant contributors to salt as well (source: California Water Plan 2013).

Table 44: Summary of California desalting, 2013

General Source Water Designation	In Operation			In Design and Construction		Proposed	
	NO. OF PLANTS	2010 PRODUCTION	ANNUAL CAPACITY	NO. OF PLANTS	ANNUAL CAPACITY	NO. OF PLANTS	ANNUAL CAPACITY
Brackish groundwater	23	79,812	139,627	3	9,050	17	74,629
Brackish surface water	0	0	0	0	0	1	22,403
Ocean water	3	130	562	1	56,007	15	381,791
Total	26	79,942	140,189	4	65,057	33	478,823
Cumulative	--	--	--	30	205,246	63	684,069

Source: California Water Plan 2013

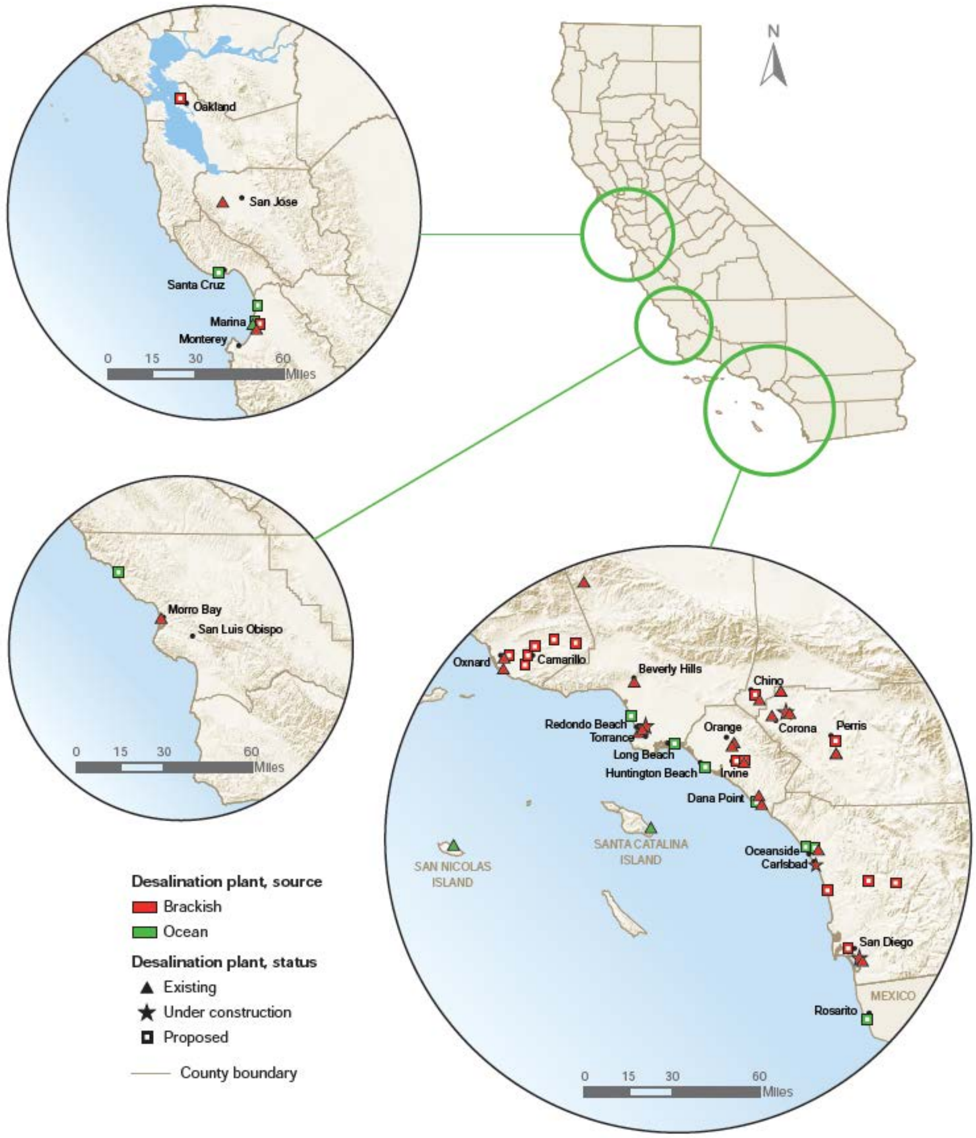
Current state of CA desalination

There are currently 23 groundwater desalination plants in California, of which 22 are in Southern California, with one in the San Francisco Bay area. Plant capacities range from 0.2-15m gallons per day or 226-16,800 acre-feet per year. There are several constraints for groundwater build-out. Brine disposal is a recurring issue. Existing facilities are located near brine disposal lines, such as the Santa Ana Regional Interceptor (SARI), which are treated with other wastewater and discharged into the ocean. Additional expansion is also challenging as groundwater overdraft issues must be considered.

Seawater desalination is currently held in municipal water-supply facilities, including those at Santa Catalina Island, San Nicolas Island, and Marina. There are also facilities at Morro Bay and Santa Barbara, which are currently inactive. Due to the higher expense, seawater-supplied plants only operate intermittently and are seen as an emergency source of water.

The largest desalination facility in the Western Hemisphere is currently under construction by Poseidon Water at Carlsbad. Upon completion in 2016, it is expected to be operated as a public-private partnership and be able to deliver 56k acre-feet every year for the city of San Diego (source: California Water Plan 2013).

Exhibit 54: California Municipal Desalination Facilities

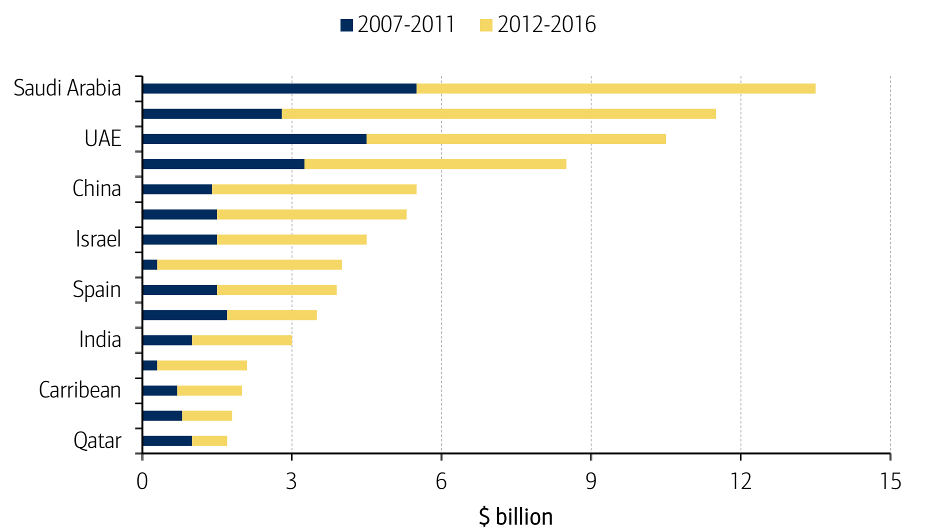


Source: California Water Plan 2013

US$42bn global market by 2025E

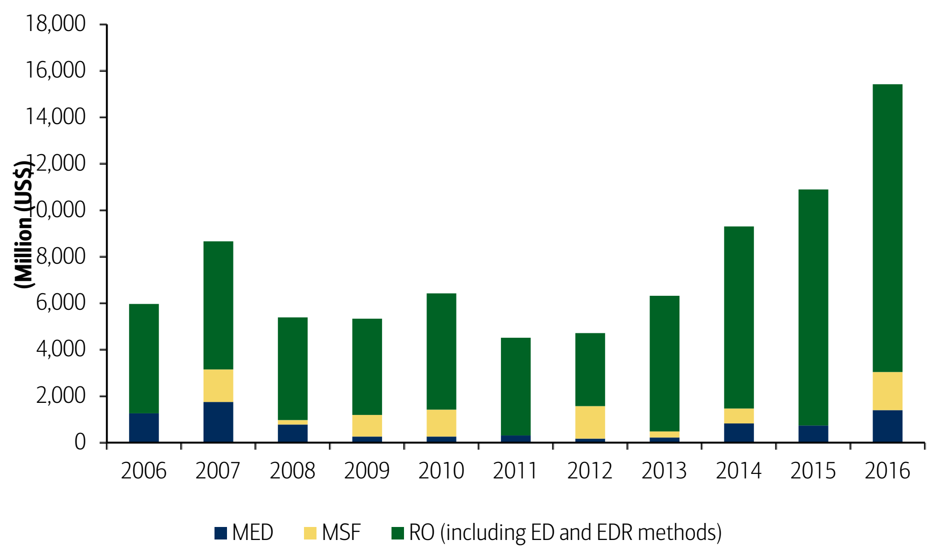
Globally, the desalination market was around US$8bn in 2014 and is expected to grow to US$14bn by 2018 and US$42bn by 2025 (source: Freedonia, GWI, OECD, Delloitte, Japanese Ministry of Economy, Trade and Industry). This reflects a CAGR of around 16%. Contracted desalination capacity has been expanding at a CAGR of 16.8% since 1997 (source: Ministry for Water & Electricity, Saudi Arabia). In 2013, new installed capacity totalled around 6m cubic metres per day (Mm3/d), bringing global total installed capacity to 80.9Mm3/d (source: IDA/GWI). Moreover, 3,800 old plants have been taken offline or decommissioned, which means 6.4Mm3/d of old capacities are ready to be replaced by much higher capacities.

Chart 73: Desalination Market



Source: GWI

Chart 74: Demand Forecast by Desalination Technology

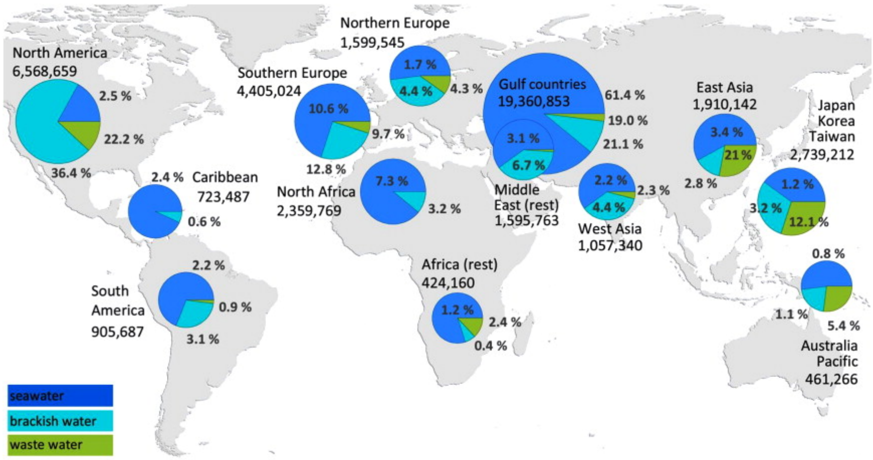


Source: GWI Desalination Data

Desalinated water is increasingly popular in certain regions

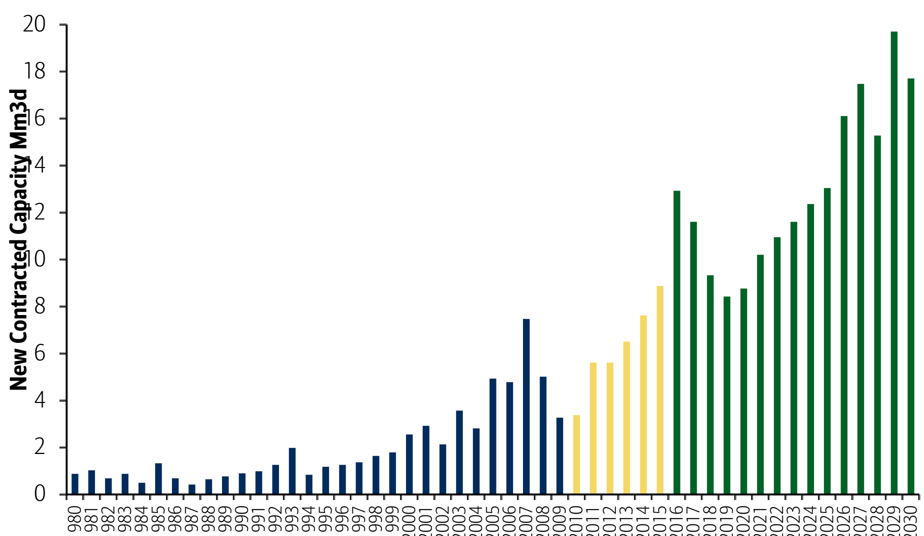
Approximately 1% of the world's population is currently dependent on desalinated water to meet its daily needs (source: GWI). By region, we expect the Gulf States, Australia, Central Asia and the US, and the Mediterranean Rim to be the most naturally pre-disposed to developing desalination as a viable alternative given water shortages and water stress, and their brackish and less saline feedwater. The largest markets are Saudi Arabia, the US, UAE, Australia, China, Kuwait and Israel.

Chart 75: Global desalination capacities in cubic meters per day



Source: Sustainability Science and Engineering, Volume 2, 2010, BofA Merrill Lynch Global Resaerch

Chart 76: Global desalination market forecast (new contracted capacity)



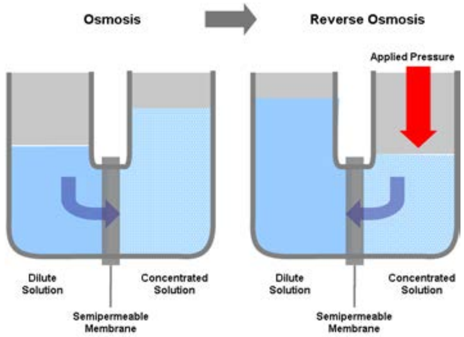
Source: GWI, Hyflux, BoFA Merrill Lynch Global Research

Reverse osmosis technology in the lead

The two major desalination methods are reverse osmosis (RO) and multi-stage flash distillation (MSF). RO used to be at a disadvantage to MSF owing to its higher cost and declining purification effectiveness, due to membrane pollution. However, advances in technology have brought down costs to the extent that as of 2001 it had become the cheaper technology. RO involves passing feedwater through a semi-permeable membrane (semi-permeable barrier sheets) at pressure so that the salt remains on one side and allows pure water to pass to the other.

RO is now becoming the mainstream technology for desalination plants as it offers the following advantages over MSF: (1) smaller energy input; (2) lower construction costs due to the use of simpler construction materials; and (3) greater scalability due to the use of modular units. Advances have also been made in membrane antifouling treatment, enabling a higher rate of removal of boron, which had previously been a problem in seawater desalination.

Chart 77: Reverse osmosis



Source: National Academy of Sciences

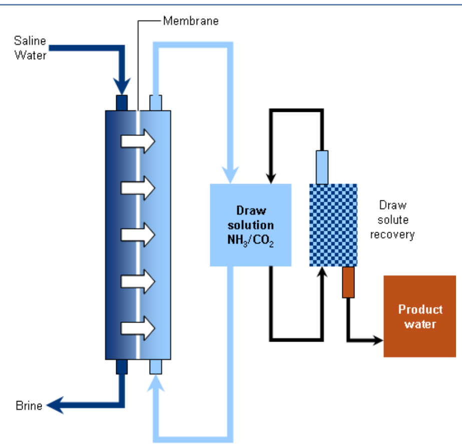
US$8.1bn reverse osmosis market by 2018E

The global reverse osmosis (RO) membranes and system components market is expected to reach US$4.9bn in 2013. BCC Research forecasts the market to reach US$8.1bn by 2018, and register a five-year compound annual growth rate of 10.7% for 2013-18 (source: BCC Research).

Newer technologies becoming commercial

Although RO has gained rapid acceptance, it is only 20% thermodynamically efficient (i.e., 8-20KWh of energy to produce 1,000g of desalinated water). As such, there has been significant R&D activity aimed at addressing concerns about the required energy input. For instance, forward osmosis is being commercially implemented. In the FO process, a draw solution is used to create a driving force for freshwater to pass through the membrane. The technology, according to Modern Water, can reduce energy use and costs by up to 30% and overcomes the fouling limitation inherent in pressure-driven membrane separations. Another option, Vacuum Multi Effect Membrane Distillation, uses processes that combine thermal and membrane technologies in a vacuum to boil the feedwater at lower temperatures (50°C to 80°C).

Chart 78: Forward osmosis



Source: Modern Water

We find it unlikely that membrane distillation will replace RO in the next five years given the price advantage of the incumbent technology. Investment costs for a RO plant are between

US$800 and US$2,500 per m3 of daily production capacity. Ultimately, the selection of a desalination process depends on site-specific conditions, economics, the quality of water to be desalinated, the purpose for which the water is to be used and local engineering experience and skills.

Table 45: Energy requirements for desalination

Process	Total Energy (kW-h/m^3)	Capital Cost ($/m^3/d)	Unit Water ($/m^3)
MSF (without waste heat)	55-57	-	-
MSF (with waste heat)	10-16	1,200-2,500	0.8-1.5*
MED (without waste heat)	40-43	-	-
MED (with waste heat)	6-9	900-1,200	0.6-0.8
SWRO	3-6	900-2,500	0.5-1.2
BWRO	0.5-2.5	800-1,200	0.2-0.4
Innovative Technologies/Hybridisation	<2.0	<800	<0.5

Source: IDA

Table 46: Overview of desalination technologies

Process	Basic Mechanism	Status	Strengths	Weakness	Future
Phase Change	*Salt-Free phase produce*				
Thermal	Steam is salt-free, condenses to form pure water. Energy reused	Major Application	Well established	Energy demand	Strong in 'hybrid' systems
Freeze-thaw	Ice is salt-free, thaws to pure water	Not used	Limited	Energy demand	Unlikely
Voltage Driven	*Salt ion transport*				
Electrodialysis	Ions move through ion selective membranes	Significant for low salt feeds	Well established	Possibly high salts Primary power	Strong but unlikely for seawater
Electro deionization	ED combined with ion exchange resin	Possibly growing	Enhanced ED	As above	As above
Capacitive deionization	Ions absorb and desorb on electrode due to DC voltage	Developmental	Removes minor ions	Possibly high salts Energy recovery	Possible
Pressure Driven	*Water Transport through membrane*				
Reverse Osmosis	Pressure > osmotic pressure, water through polymer film, salts retained	Major application	Established Low energy demand relative to thermal process	Energetic efficiency is low	Strong, with advanced membranes
Forward Osmosis	Water passes to draw solute of high OP. Draw solute regenerated to give water	Operational	Lower energy Ambient pressure	Membrane type	Potentially strong
Thermal-Membrane	Water Vapour Transport				
Membrane Distillation	Heated feed evaporates through hydrophobic microporous membrane	Demonstration	Ambient pressure Low grade heat	Availability of low grade heat	Potentially strong
Bio-enabled	*Cellular Ion Transport*				
Biometric Membranes	Cell wall transports/sorbs ions	Research	Biological process	Development of industrial analogue to biological process	Possible

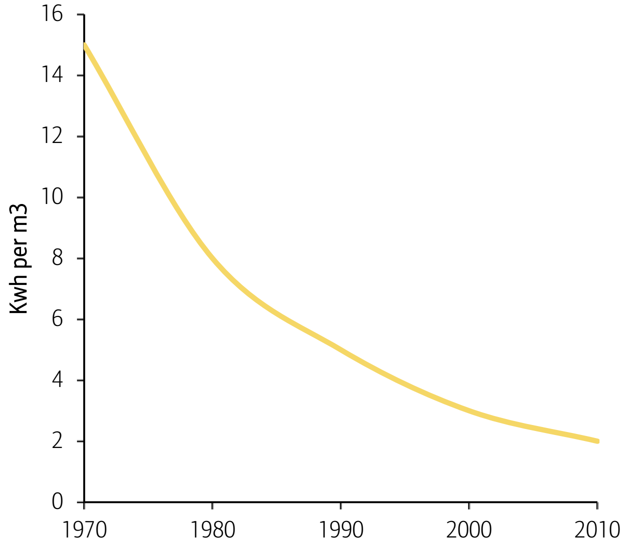
Source: BofA Merrill Lynch Global Research

Significant environmental implications & costs

Despite massive improvements over the past 50 years, desalination is a highly energy-intensive process, with energy constituting up to 60% of the operating and maintenance costs of desalinated water. Currently, the global production of 65.2Mm3 of desalinated water requires at least 75.2TWh per year or 0.4% of global electricity consumption (source: International Renewable Energy Agency).

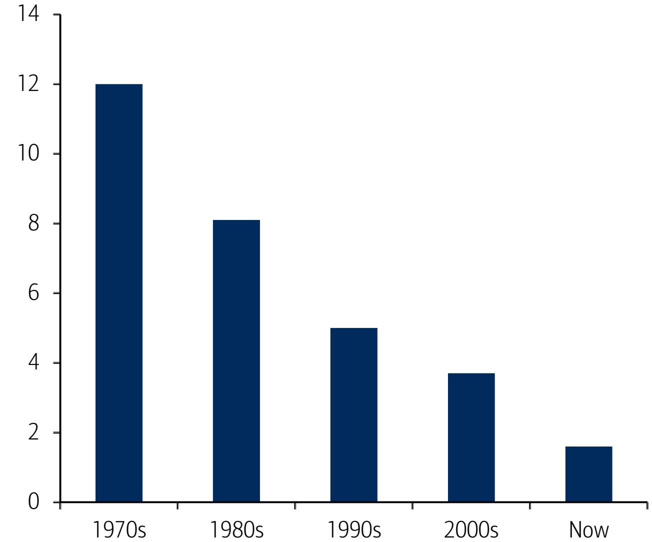
Since the 1970s, RO energy consumption has decreased almost 10-fold. Since 1996, continuous RO innovation in pre-treatment, filter design, and energy recovery has reduced the energy consumption per unit of water by a factor of four. The cost of desalination has decreased to US$0.5/m3, while market prices for desalinated water are typically between US$1/m3 and US$2/m3.

Chart 79: Reduction in RO power consumption, 1970-2010



Source: World Bank adapted from Elimelech and Phillip 2011

Chart 80: Electricity consumption for desalination (kWh/m3)

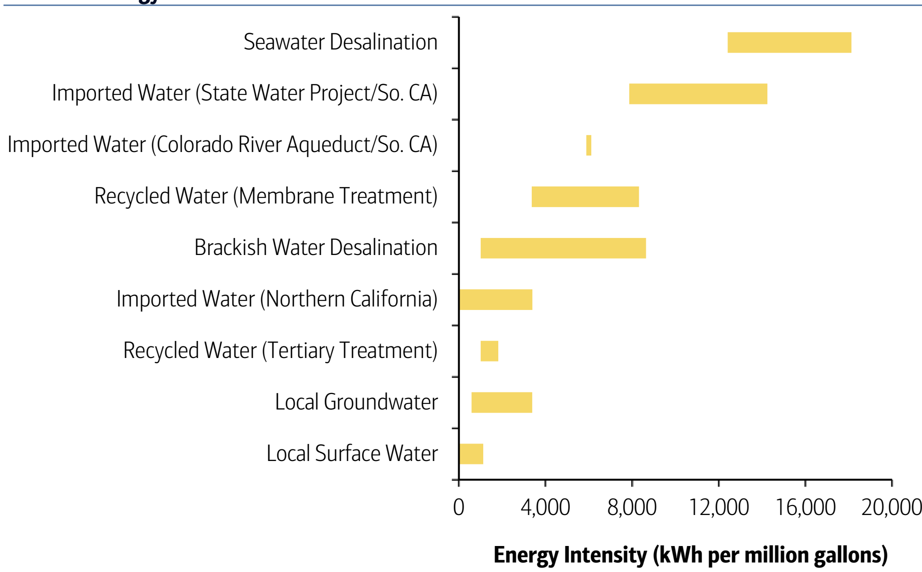


Source: Toray, BofA Merrill Lynch Global research

Energy-driven cost variability

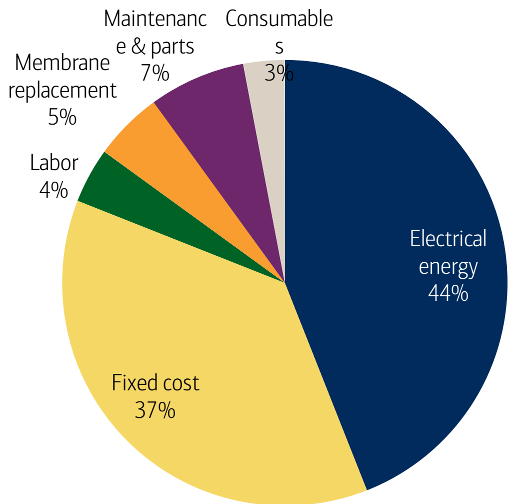
Energy accounts for around 36% to 60% of the operational cost of a desalination plant depending on the technology (source: NRC, Wangnick 2002, PPIC 2013). At these rates, a 25% increase in energy costs would increase the cost of produced water by 9-15% (source: PPIC 2013). Without a reduction of the amount of energy used, desalination costs will be volatile as the price of energy fluctuates.

Chart 81: Energy and GHG Emissions from seawater desalination in California



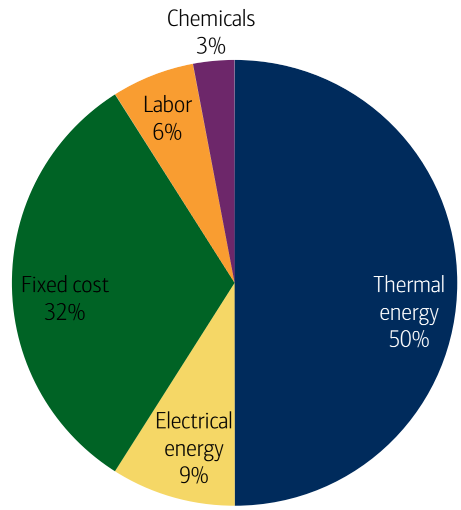
Source: PPIC 2013

Chart 82: Typical costs for a reverse-osmosis desalination plant



Source: PPIC

Chart 83: Typical costs for a very large seawater thermal desalination plant



Source: PPIC

Potential to increase GHG emission

The energy-intensive nature of desalination will invariably increase greenhouse gas (GHG) emissions. Expanding California's desalination capacity by the planned 514m gallons per day (MGD) would increase energy use by around 2,800GWh per year, versus California's total electricity use of 270,000GWh in 2011. This equates to a 1% increase in electricity consumption, leading to an increase in emissions of 1MMTCO2e every year (source: PPIC 2013).

Table 47: Theoretical Emissions Associated with Proposed Desalination Plants in California

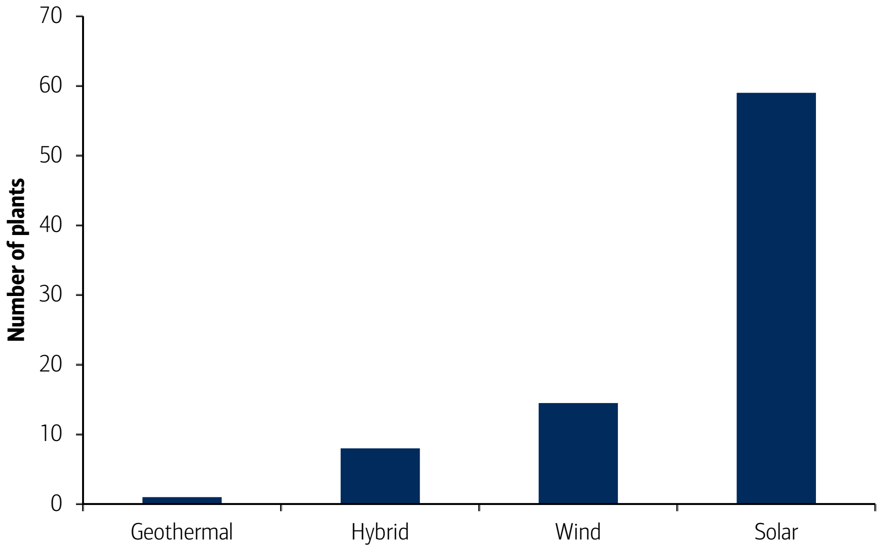
Project Partners	Location	Capacity (MGD)	Energy Use (MWh per day)	Emissions (MMT CO2e per yr)
East Bay Municipal Utilities District, San Francisco Public Utilities Commission, Contra Costa Water District, Santa Clara Valley Water District, Zone 7 Water Agency	Pittsburgh	19.8	300	0.03
City of Santa Cruz, Soquel Creek Water District	Santa Cruz	5	75	0.007
DeepWater, LLC	Moss Landing	2.5	38	0.003
The People's Moss Landing Water Desal Project	Moss Landing	25	380	0.03
California American Water	North Marina	10	150	0.01
California Water Service Company	Not known	9	140	0.01
Ocean View Plaza	Monterey	0.25	3.8	0.003
Monterey Peninsula Water Management District	Del Monte Beach, Monterey	2	30	0.0003
Seawater Desalination Vessel	Monterey Bay	20	300	0.06
Cambria Community Services District/U.S. Army Corps of Engineers	Cambria	0.6	9	0.0008
Arroyo Grande, Grover Beach, Oceano Community Services District	Oceano	2	30	0.003
West Basin Municipal Water District	El Segundo	18	270	0.03
Poseidon Resources	Huntington Beach	50	750	0.08
Municipal Water District of Orange County, Laguna Beach County Water District, Moulton Niguel Water District, City of San Clemente, City of San Juan Capistrano, South Coast Water District	Dana Point	15	230	0.03
City of Oceanside	City of Oceanside	10	150	0.02
Poseidon Resources, San Diego County Water Authority	Carlsbad	50	750	0.09
San Diego County Water Authority	Camp Pendleton	150	2,300	0.3
NSC Agua	Rosarito, Mexico	100	1,500	0.08
San Diego County Water Authority	Rosarito, Mexico	25	380	0.3
	Total	514	7,700	1

Source: PPIC 2013

Solar desalination has potential

Powering desalination plants with renewable energy has been gaining traction over the years. For instance, solar has been used to distil brackish and seawater for over a century. In greenhouse solar still, saline water is heated and evaporated with solar radiation in a basin, in which water vapour condenses on a sloping glass roof that covers the basin (source: PPIC 2013).

Chart 84: Global renewable energy seawater desalination plants by energy source, 2010

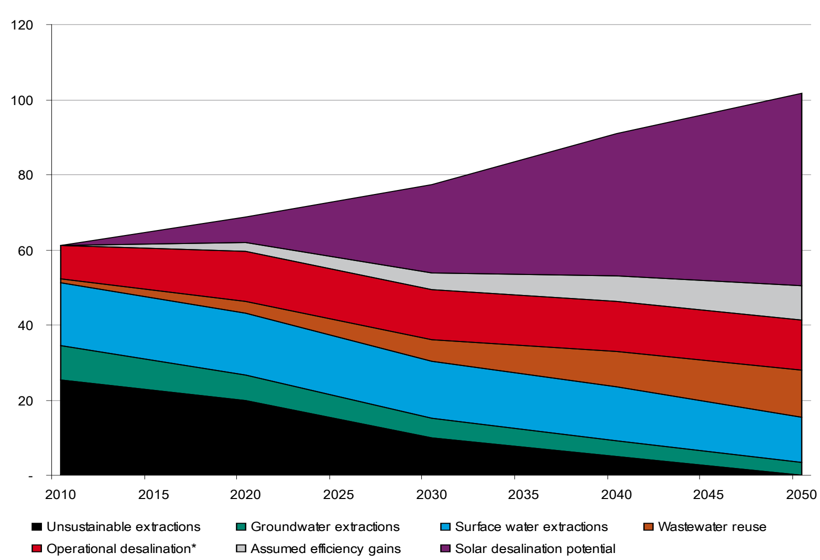


Source: PPIC 2013

Saudi Arabia's solar powered desalination initiative

The Arabian Peninsula has been a good example, highlighting the intersection of water supply and energy availability challenges. Saudi Arabia currently burns 1.5m barrels of oil per day – about 13% of its daily production – to power 10.1Mm3/d of desalination capacity in operation as of 2012. Cognisant of the Kingdom's outstanding solar resources and the opportunity cost of burning oil otherwise destined for export, the country's leadership has embarked on a three-phase initiative to grow its solar-powered desalination base by at least 300,000m3/d by 2020. It is clear from our research, however, that the plans under consideration are not sufficient to address the Kingdom's long-term water needs.

Chart 85: Water supply sources for Saudi Arabia (Mm3/d)



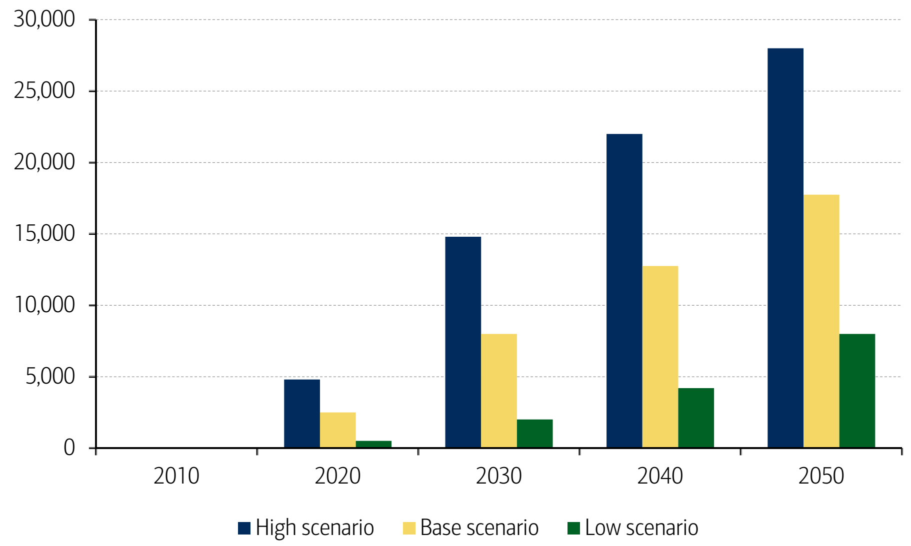
* Based on plants in operation in 2010. Incremental capacity through 2020 based on plants under construction or planned

Source: BofA Merrill Lynch Global Research estimates, Fichtner 2011 (MENA Regional Water Outlook, prepared for World Bank)

Up to 68GW of solar desalination in Saudi Arabia

We estimate that as much as 68GW of solar PV could be installed in Saudi Arabia by 2050 to power desalination plants necessary to offset increasing water scarcity. Over 90% of that total will most likely be installed between 2020 and 2050, as the near-term prospects for solar desalination are still subdued. Of the 3.3Mm3/d of desalination capacity currently either under construction or planned for completion by 2020, only about 10% is slated to be solar powered as of October 2012. This includes the Al Khafji reverse osmosis plant under construction, which will be the largest solar-powered desalination plant in the world when it comes into service in 2017E.

Chart 86: PV installation scenarios necessary to power desalination demand (MW)



Source: BofA Merrill Lynch Global Research estimates, Fichtner 2011

Solar desalination in motion in California

California has developed the first solar thermal desalination solutions in the US and is in the process of expanding operations. A company called WaterFX is taking the contaminated irrigation runoff that is drained from farms, and putting it in solar-heated tanks that steam the water, separating the freshwater from the salt and minerals. Its demonstration plant went online in 2014 in the Panoche Water and Drainage district. The expansion project, called HydroRevolution, aims to produce 1.6bn gallons (5,000 acre-feet) per year (source: WaterFX). The phase change technology currently in development would be much less energy intensive than reverse osmosis, and could cost US$450 per acre-foot versus US$1,900-3,000 for conventional desalination (source: SF Gate).

Potential environmental and wildlife impact

In addition to GHGs, another concern of desalination is the impact of brine, a highly saline by-product of desalination. High salinity levels at discharge points can have a detrimental impact on coastal and marine wildlife. This could have a knock-on impact on bears and fishermen via the reduction of fish populations (source: PPIC 2012, UC Sacramento, DWR). While 35,000 TDS is the average salinity of ocean water, many species can only survive within a narrow range of fluctuations. Marine biologists are currently investigating the potential impact of brine discharge on marine wildlife (source: California Water Plan 2013)

Impingement and entrainment is another problem

Another potential problem is the impingement and entrainment of aquatic organisms during feedwater intake. This occurs when wildlife are pulled or sucked into desalination screens and filters. Relative impact will be dependent on water depth and general design, which could be of a regulatory concern during the planning stages (source: UC Sacramento, DWR).

Reuse and recycling

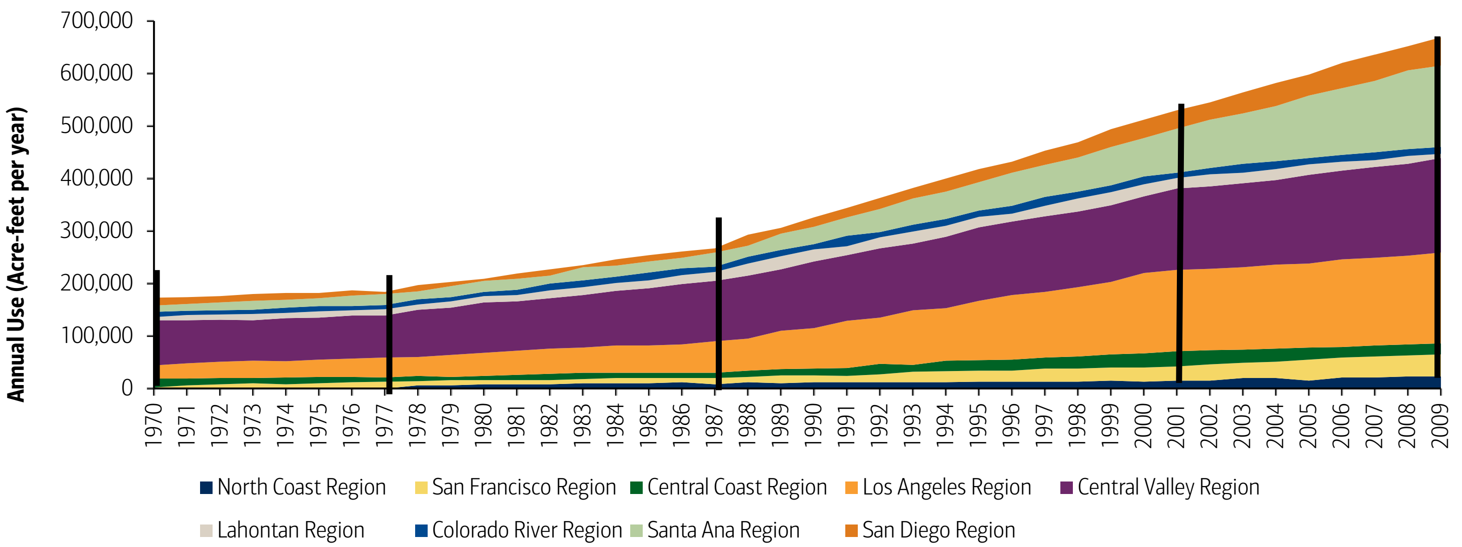
The use of recycled water or the reuse of process water within an industrial facility can play an important part in reducing commercial, industrial & institutional (CII) demand. Recycled water provides 209,500 acre-feet (af) of fresh water a year to CII sectors, including power plants, to California already (source: California Water Plan 2013). Saline water use from coastal sources also provides additional water primarily to the mining and steam electric power plants, estimated at 14.5maf (4.7tn gallons) per year (source: California Department of Water Resources 2014). Hence water reuse and recycling opportunities exist in almost all industrial plants and could grow in focus as a solution in the state, in our view.

670,000 acre-feet pa, scope for more reuse

California is gradually increasing its integration of municipal recycled water into supply portfolio. Municipal recycled water benefits the state and individual water users by reducing long-distance water conveyance needs, providing local water supplies, and being a drought-resistant resource (source: California Water Plan 2013).

The most recent statewide recycled water survey identified the annual reuse of 670,000 acre-feet of municipal wastewater, representing approximately 13% of the 5 million acre-feet of municipal wastewater produced each year in California (source: SWRCB, DWR 2012). In addition, more than 100 California communities were using recycled water for agricultural and landscape irrigation (source: PPIC, NDRC 2014). Overall this nearly represents a 4x increase compared to the 175,000 af reused in 1970 and we expect the trend of using recycled water to continue growing in California, especially in light of the recent drought-crisis.

Chart 87: Recycled municipal water in California since 1970



Source: SWRCB and DWR 2012, California Water Plan 2013

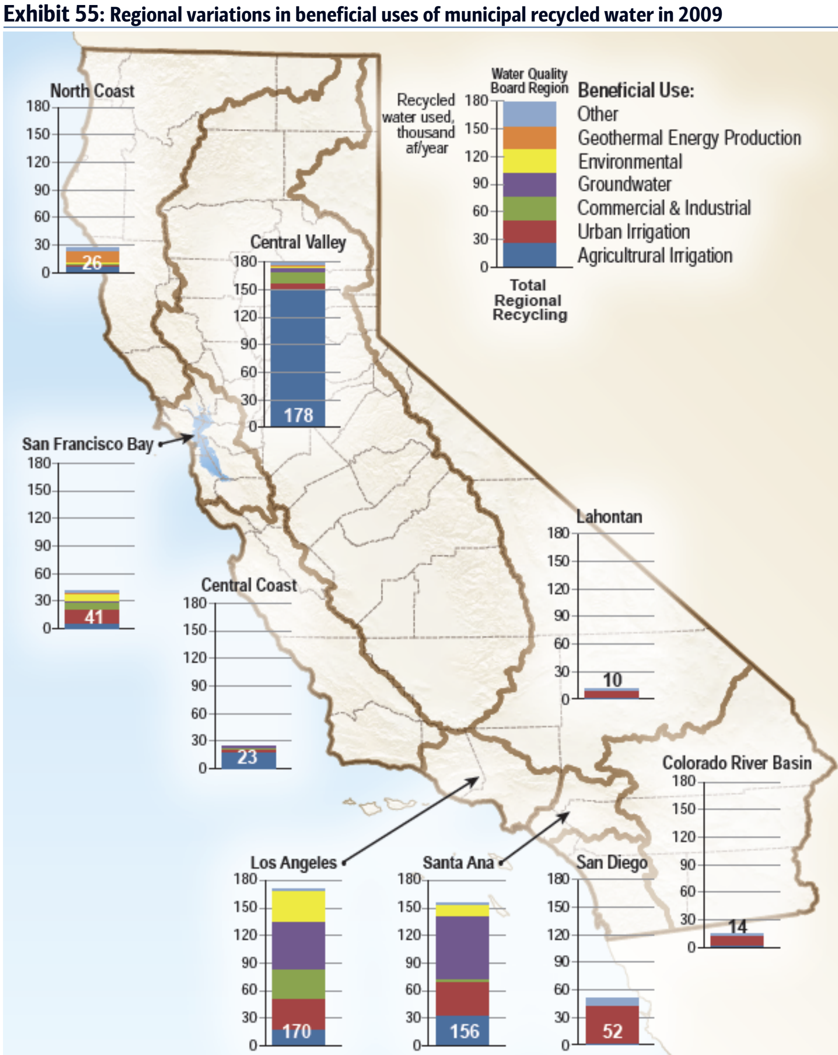
More emphasis on "fit for purpose" additional uses

The Californian recycled water community is also placing greater emphasis on matching wastewater treatment levels to water quality requirements for the planned reuse, referred to as "fit for purpose" (US Environmental Protection Agency 2012). This concept is where more rigorous treatment (and more energy-intensive processes) is reserved for uses with higher human or food production contact to minimize pathogen or chemical of emerging concern contact. Conversely, less-treated wastewater has been safely used for decades in many agricultural reuse applications, which is the largest category of recycled water use in California. Greater reuse of secondary-treated wastewater in agriculture and environmental settings, where additional "natural treatment" can augment wastewater plant treatment, may provide additional solutions for meeting the 2020E and 2030E recycled water targets, in our view (source: California Water Plan 2013).

Recycling occurs statewide, concentrated within three regions…

It is also important to stress that recycling of municipal wastewater is generally a statewide phenomenon and occurs throughout California. Only 7 of the state's 58 counties do not have identified recycling projects (source: California Water Plan 2013). Unsurprisingly the highest countywide volumes of recycled water occur in parts of the state where local water resources are strained, population densities are high, or wastewater disposal is problematic. Hence the Santa Ana, Central Valley and Los Angeles regions represented c.90% of total recycled municipal water in the latest survey (source: California Water Plan 2013)

Exhibit 55: Regional variations in beneficial uses of municipal recycled water in 2009



Source: California Water Plan 2013

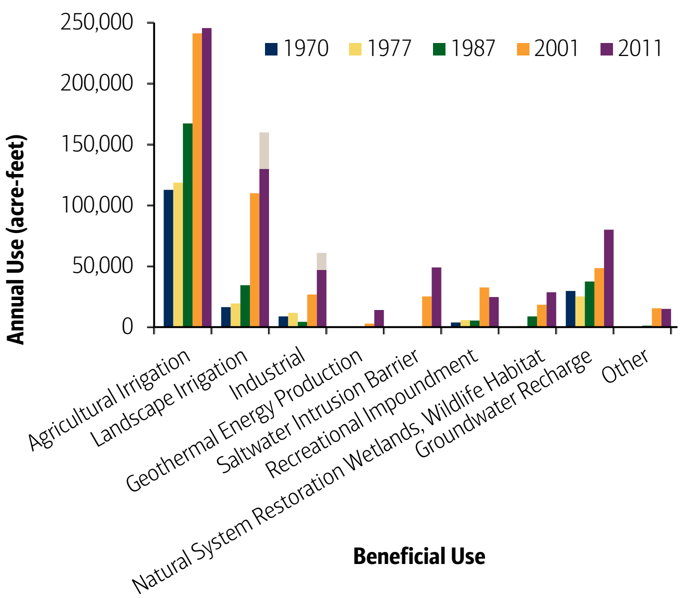
....but reuse now expanding outside these regions

That said, water reuse is expanding beyond the 3 traditional regions mentioned, driven in part by the drought but also by efforts to develop a more reliable, local water supply. Water utilities in Northern and Southern California have already made investments in recycled water, and many are seeking to expand their recycled water supplies. For example, in Northern California, the city of Santa Rosa currently recycles between 90-100% of the 23,000 acre-feet of wastewater it produces each year (City of Santa Rosa 2011). Likewise, the Orange County Water District and Orange County Sanitation District operate a recycled water plant that produces up to 72,000 acre-feet per year; plans call for an increase in production to 103,000 acre-feet per year by 2015 (source: PPIC NDRC 2014)

Irrigation is the leading beneficiary

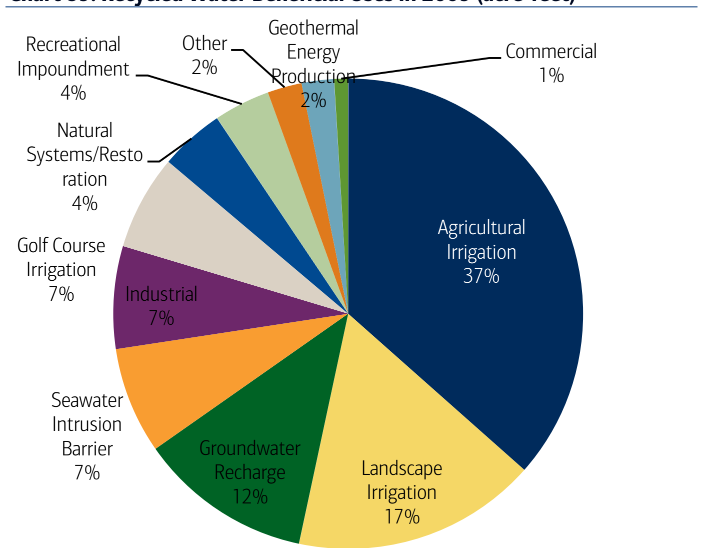
The main beneficiary of recycled water in California continues to be irrigation (agriculture, landscape and golf) accounting for 61% of all acre-feet used in the latest survey, and the second largest beneficiary was groundwater recharge (source: California Department of Water Resources). However it is important to note the nuances in categories that have benefitted the most vis-à-vis percentage growth in recycled water since 1970. It has been landscape irrigation that has seen the largest uptick growing from c.5% in 1970 to 17% by 2009.

Chart 88: Recycled water statewide beneficial use change since 1970



Source: SWRCB and DWR 2012

Chart 89: Recycled Water Beneficial Uses in 2009 (acre-feet)

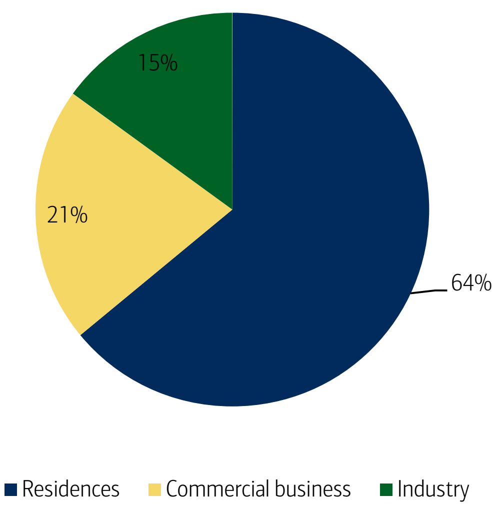


Source: State Water Resources Control Board; California Department of Water Resources

1.7 million acre-feet recycled water potential by 2030E

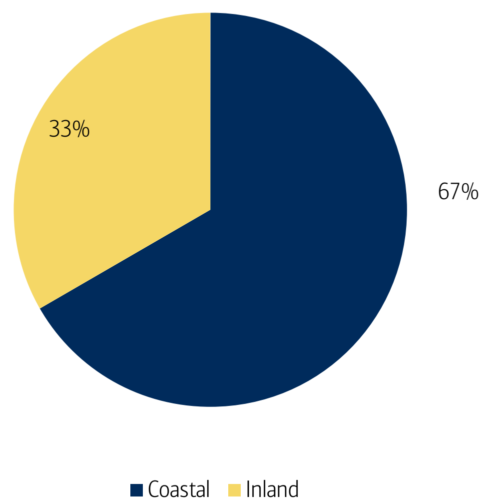
The recycled water potential in 2030E ranges from 1.4 million to 1.7 million acre-feet per year or about 23% of the estimated available municipal wastewater (source: PPIC NDRC 2014). Of this, 0.9 million to 1.4 million af (62 percent to 82 percent) of the additional recycled water would be from discharges that would otherwise be lost to the ocean, saline bays, or brackish bodies of water.

Chart 90: Water reuse potential by type



Source: State Water Resources Control Board; California Department of Water Resources

Chart 91: Water reuse potential by region



Source: State Water Resources Control Board; California Department of Water Resources

US$11bn of investments in infrastructures required

However to add 1.4 million to 1.7 million acre-feet per year of recycled water a capital investment of between $9 billion and $11 billion would be required (in US$2003). This is because of the current variability of local conditions and their effect on treatment and distribution costs. The current estimated range of capital and operational costs of water recycling range from $300 to $1,300 per acre-feet of recycled water, but in some cases costs are above this range. For example, the upper end of the current unit costs for recycled water projects comes from cost estimates recently prepared for two Southern California projects, in San Diego and Oxnard. Costs per acre-feet for those projects are estimated to be between $1,191 and $1,900 (Fikes 2012; Wenner 2012). These higher end, urban projects highlight the increasing costs of implementing recycled water projects in the state, in our view

Water management solutions

Water management has assumed greater importance in recent years as a strategy to improve efficiency and the sustainable use of resources. There is growing recognition that the current water crisis is as much a consequence of weak policies and poor management as natural scarcity. Effective water management enables users to cut their demand, mitigate the risks associated with shortages and reduce the need for capex-intensive solutions.

In our view, a number of companies are well placed to benefit from the theme of water management due to their involvement in areas such as "more crop per drop", irrigation, drought-resistant seeds and crops, precision agriculture, "big data", smart metering and household water efficiency.

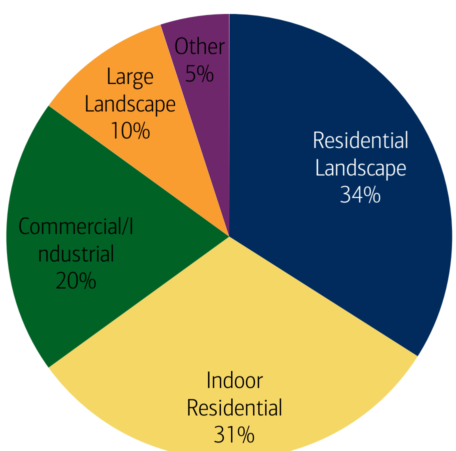
Household water – 35-70% savings potential

Household water management is a rapidly growing sector, comprising companies that provide the technology and services to improve end-use efficiency for residential customers. Companies providing high-efficiency equipment including showers, faucets, toilets and other residential and commercial appliances may benefit as water prices rise, limits to economic supply are reached, new regulations are adopted and awareness of efficiency potential increases.

California household water uses

In California, residential landscaping accounts for the greatest proportion of urban water use at 34%. Residential indoor use is next at 31%. Household water consists of three main components (grey water, yellow water and brown water) each with diverse properties. While faeces-contaminated brown water contains most of the organic substances, urine-contaminated yellow water contains nearly all the soluble nutrients, such as nitrogen, phosphorus, potassium etc. Grey water is domestic wastewater generated from dishwashing, laundry and bathing. Different uses can be derived from each type of waste water. Grey water has received the most attention as it can be channelled back into the household water cycle or be allowed to drain back into the soil for groundwater recharge.

Chart 92: Statewide Urban Water Use: Eight-Year Average, 1998-2005



Source: California Water Plan 2013

Table 48: Statewide Urban Water Uses

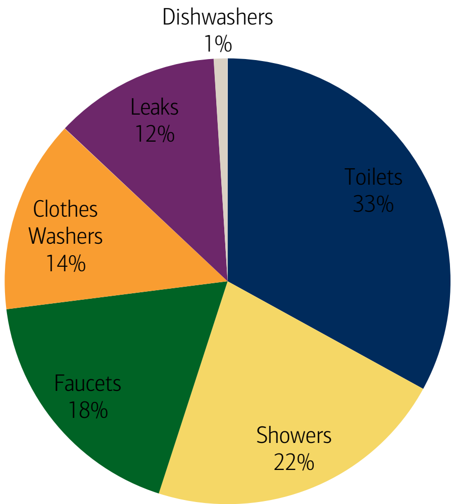
Sector	Percentage	Volume
Residential landscape	34%	3.0 maf
Large landscape	10%	0.9 maf
Indoor residential	31%	2.7 maf
Commercial, institutional, and industrial	20%	1.7 maf
Other	5%	0.5 maf
Total	100%	8.8 maf

Source: California Water Plan 2013

20% indoor residential savings potential

According to the latest California Water Plan published in 2013, the potential water savings for indoor household uses are 20%. This assumes state average baseline indoor water use to be 71gpcd, and potential savings of up to 15gpcd. While urban water use in California has already decreased due to conservation efforts instituted in 2014 and 2015, we see additional room for improvement.

Chart 93: Estimated Indoor Residential Water Use in California (Year 2000)



Source: California Water Plan 2013

Table 49: Potential Savings for Indoor Residential Water Use

Use	Savings
Toilets	5 gpcd
Showers	1 gpcd
Leaks	3 gpcd
Faucets	1 gpcd
Clothes washers	5 gpcd
Total	**15 gpcd**

Source: California Water Plan 2013

gpcd = gallons per capita per day

Efficiency measures could reduce demand by 70% across US

A separate study by the American Water Works Association shows that the total efficiency gains on average in the US can be even higher. By installing more efficient water fixtures and regularly checking for leaks, households can reduce daily indoor per-capita water use by 35-70% (source: American Water Works Association, US EPA).

Table 50: Household water use statistics – daily US average vs. efficient water use average

Use	Daily average g per capita	% daily use	Daily efficient* g per capita	% daily use
Showers	11.6	16.8%	8.8	19.5%
Clothes washers	15.0	21.7%	10.0	22.1%
Dishwashers	1.1	1.4%	8.2	1.5%
Toilets	18.5	26.7%	0.7	18.0%
Baths	1.2	1.7%	1.2	2.7%
Leaks	9.5	13.7%	4.0	8.8%
Faucets	10.9	15.7%	10.8	23.9%
Other domestic	1.6	2.2%	1.6	3.4%
Total Use	69.3 gallons		45.2 gallons	

Source: American Water Works Association, BofA Merrill Lynch Global Research. * By installing more efficient water fixtures and regularly checking for leaks.

Clothes washers make up 14-18% of indoor use – only 20% are efficient

Washing machines account for 14-18% of indoor residential water use, or about 9-10.5gpcd. Only 20% of homes studied in 2007 were using efficient washers, meaning there is significant potential for water use reduction. Water efficiency is measured in gallons to wash each cubic food of laundry, or a water factor. The US Department of Energy has set a maximum water factor of 6 for top-loading machines and 4.5 for front-loading machines by 2018. Conventional washers have wash factors of 12-13 (source: California Water Plan 2013). We expect the drought to be another driver for the replacement cycle.

Leaks – one in five homes losing more than 17gpcd

Californian households are losing 7-10gpcd to leaks, with one in five households losing more than 17 gpcd. 14% of homes were losing 17gpcd, and 7% were losing more than 34gpcd. This also indicates that leaks are occurring in a concentrated number of homes. This could be remedied with advanced metering infrastructure (AMI) to monitor and detect leaks in real time. Remedying this at households with high leak rates could result in 6-7.5gpcd of savings (source: California Water Plan 2013).

Faucets

Faucets account for 18% of indoor water use, or 11-12gpcd. Federal standards set in 1994 set a maximum flow rate of 2.5gpm, but newer ones can operate on as low as 0.5gpm. Savings can be achieved with low-flow fixtures as well as consumer education.

Water meters - mandatory by 2025

In 2004, the California legislature passed AB 2572 adding to SB 229 by requiring urban water utilities to meter all municipal and industrial users by 2025 and charge metered customers based on the actual volume of water delivered. Investor-owned utilities were added to this in 2009 (source: PPIC 2014).

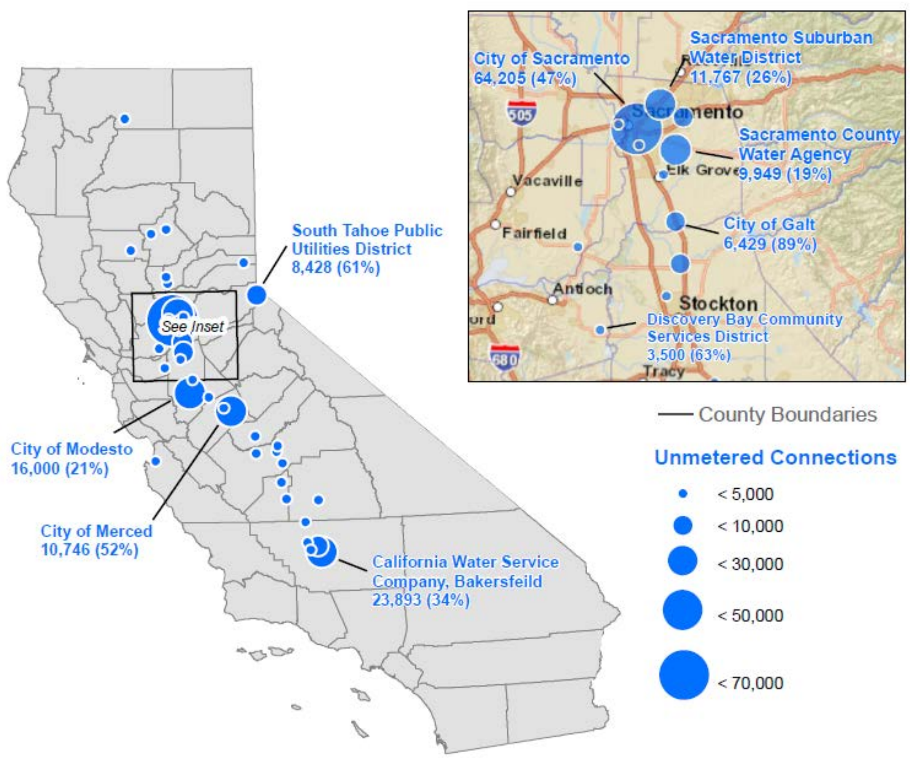
Considerable progress

California utilities have made considerable progress on metering in most areas. For instance, Fresno passed an amendment to a law prohibiting the reading of water meters for billing purposes for single-family residential users, and the city is now completely metering and charging customers based on their water use (City of Fresno 2014).

Still 219,000 unmetered households

Nonetheless, there are still 219,000 unmetered connections across 39 water utilities all over the state (source: DWR 2014). At the same time, the majority of multi-family units have a single meter for all units. Metering in combination with effective pricing structures has the potential to reduce water use by 15-20% (source: PPIC 2014).

Exhibit 56: Unmetered connections in California



Source: PPIC 2014

Sacramento – 64k households unmetered

The city of Sacramento is one of the worst offenders with 64k unmetered connections, or 47% of total. By the time they complete their meter installation programme, the city will have spent more than US$416mn to install 110,000 meters and make other related infrastructure upgrades (PPIC 2014, Morain 2014).

Table 51: List of utilities with unmetered connections in California

Agency	Number of Connections	Number of Unmetered Connections	Percentage Unmetered
Atwater, City of	8,000	3,500	44%
Bakman Water Company	2,234	1,775	79%
California Water Service Company, Bakersfield	69,980	23,893	34%
California Water Service Company, Chico	28,500	250	1%
California Water Service Company, Marysville	3,612	1,045	29%
California Water Service Company, Selma	6,229	2,139	34%
California Water Service Company, Willows	2,550	45	2%
Clovis, City of	31,000	500	2%
Corcoran, City of	3,277	1,656	51%
Del Oro Water Company	7,968	514	6%
Delano, City of	9,097	3,343	37%
Discovery Bay Community Services District	5,600	3,500	63%
Elk Grove Water District	12,256	305	2%
Fruitridge Vista Water Company	4,709	3,976	84%
Galt, City of	7,187	6,429	89%
Golden State Water Company Arden Cordova	16,252	2,569	16%
Hanford, City of	15,923	2,462	15%
Kerman, City of	3,318	1,277	38%
Lodi, City of Public Works Department	18,675	5,425	29%
Madera, City of	15,133	2,980	20%
Marina Coast Water District	7,816	1,090	14%
Merced, City of	20,733	10,746	52%
Modesto, City of	77,000	16,000	21%
Mount Shasta, City of	1,700	1,700	100%
Oildale Mutual Water Company	8,120	6,060	75%
Olivehurst Public Utilities District	6,483	1,209	19%
Porterville, City of	14,820	480	3%
Rio Vista, city of	4,046	3,720	92%
Ripon, City of	4,774	2,316	49%
Sacramento County Water Agency	51,381	9,949	19%
Sacramento Suburban Water District	45,853	11,767	26%
Sacramento, City of	135,580	64,205	47%
San Joaquin County	5,971	3,718	62%
Shafter, City of	4,303	3,833	89%
South Tahoe Public Utilities District	13,930	8,428	61%
Truckee-Donner Public Utilities District	12,549	912	7%
Turlock, City of	18,908	705	4%
Vaughn Water Company	9,590	667	7%
West Sacramento, City of	14,670	4,345	30%
TOTAL	**729,727**	**219,433**	**30%**

Source: PPIC 2014

Sub-metering, room for savings

According to the US Census Bureau, around 12mn Californians live in multi-family housing, which tends to be measured with a single meter. This accounts for 31% of all housing units in the state. Sub-metering as the unit level could save 96k acre-feet per year, or 20 gallons per unit (source: PPIC 2014)

2mn acre-feet of potential savings by 2020

Combining potential water demand savings across residential indoor, water loss control, landscaping, and other sectors, California has the potential to reduce urban water demand by more than 2maf by 2020 (source: California Water Plan 2013).

Table 52: Projected Savings by Sector

Demand Reduction Sectors	Reduction	Projected Savings in 2020
Large landscape	3 gpcd	148,000 af
Commercial, industrial, and institutional	5 gpcd	170,000 af
Residential indoor	15 gpcd	739,000 af
Residential landscape	16 gpcd	789,000 af
Water loss control	5 gpcd	200,000 af
Total	44 gpcd	2,046,000 af

Source: California Water Plan 2013

Best practice is good, but incentives will be key

One of the principal policy levers of water conservation available to governments and water utilities is to impose a volumetric water charge on households. This requires that (1) households have water meters (ideally smart meters) and (2) that household water bills depend on the amount of water consumed. Water-efficiency best-practice voluntary standards, legislation and subsidies will be critical for the growth of this industry. Some examples include:

- **WaterSense** in the US helps people save water with a product label and tips on saving water around the home. To date, WaterSense estimates that it has enabled the saving of a cumulative 287bn gallons of water and US$4.7bn in water and energy bills. By the end of 2011, reductions of 38.4bn kWh of electricity and 13m metric tons of carbon dioxide were achieved through the use of WaterSense labelled products.

- **The US Green Building Council and LEED is** an internationally recognised green building certification system known as the Leadership in Energy and Environmental Design certificate. The LEED promotes a whole building approach to sustainability by recognising performance in key areas including water efficiency.

> WaterSense has enabled the saving of a cumulative 287bn gallons of water and US$4.7bn in water and energy bills

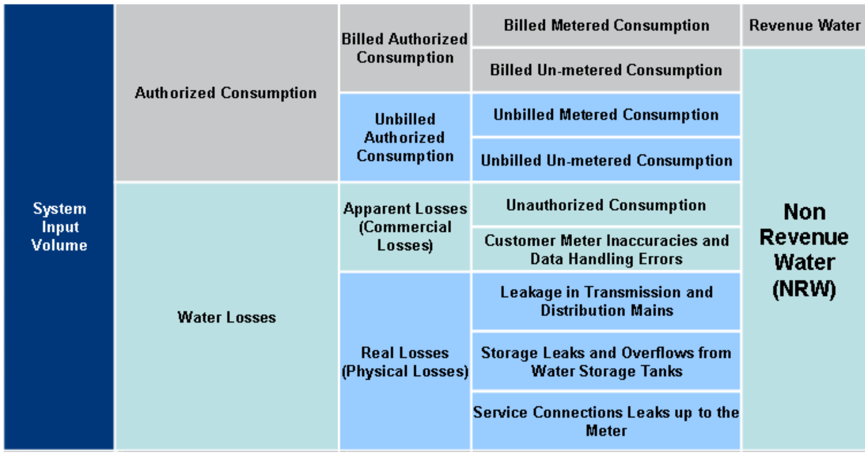
Water meters – tapped for 19% CAGR

In the water market, growing demand and greater awareness propelled by this year's US drought should drive basic and smart downstream meter installations in order to combat leakage and lost revenue.

Metering – "what gets measured gets managed"

In addition to tackling the huge issue of non-revenue water (NRW) like leaks, there is an increasing realisation that companies can conserve water and reduce costs with more data – which is fuelling the growing application of demand-side management. However, existing mechanical water meters (90-95% of the global market) provide limited information on the real-time status of water availability and quality. Moreover, little information is shared, which leads to water stress for downstream users.

Chart 94: Non-revenue water (NRW)



Source: Smart water Networks Forum, BofA Merrill Lynch Global Research

Smart water meters are part of the solution

'Smart' water meters – advanced sensor networks and automation systems – are a solution to water wastage. Smart water meters are data-logging devices that enable commercial and residential customers to enhance efficiency and analyse water flow in order to detect abnormal water usage or leakage. Smart water metering systems differ from their traditional counterparts in that they allow for continuous real-time monitoring of water consumption as opposed to manual readings that are updated on a monthly or even quarterly or half-yearly basis.

- Advanced meter infrastructure (AMI) consists of water meters capable of two-way communication over a fixed network with other smart devices and stakeholders active in water systems. Stakeholders include utilities and utility customers.

- Basic meters do not feature communication capability but water utilities will continue to demand basic meters, in our opinion.

- Distribution automation (DA) hardware and software allows utilities to influence water flows and usage between the distribution substation and end user.

- Technologies include advanced and smart water meters and communication modules; advanced systems including handheld, mobile, and fixed network collection technologies; meter data management software; knowledge application solutions.

Table 53: Smart water management at three levels

Environment	Utilities	Companies
Water resource mapping and availability	Water quality and usage	Water usage tracking
Water quality monitoring and management (surface and subsurface)	Discharge, combined sewer overflow	Water quality control (into and within plants, discharges)
Land use analysis	Asset management	Supply-chain optimisation
Extraction monitoring (surface and subsurface)	"Smart levees" and levee monitoring systems	Energy management
Flood control	Weather event assimilation	Business process improvements
	Energy management	Metrics and management

Source: IBM, BofA Merrill Lynch Global Research

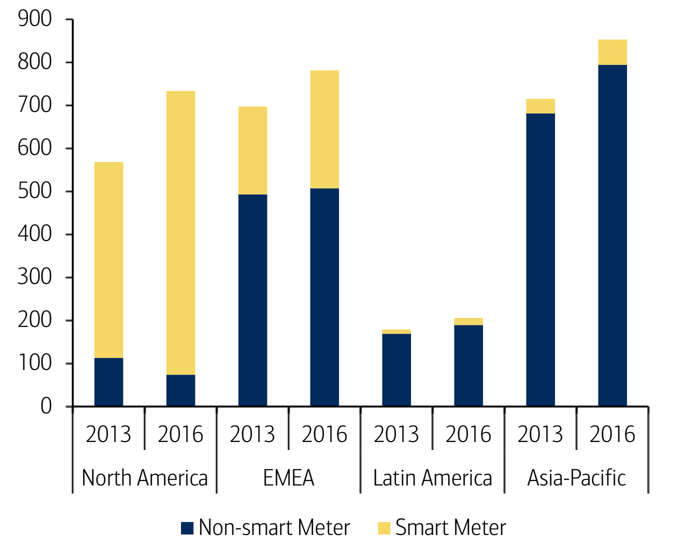
Water meters tapped for growth

At less than 20% of annual smart meter shipments combined through 2016, the market for smart water meters appears small on an absolute basis. However, the nature of demand drivers in each segment suggests installation growth rates that exceed those of the smart electricity segment. We forecast an 18.8% CAGR for water meters, driven by a 25% increase in demand for water worldwide when access and leakage concerns are at an all-time high, on our forecasts.

Growth in basic and smart meters

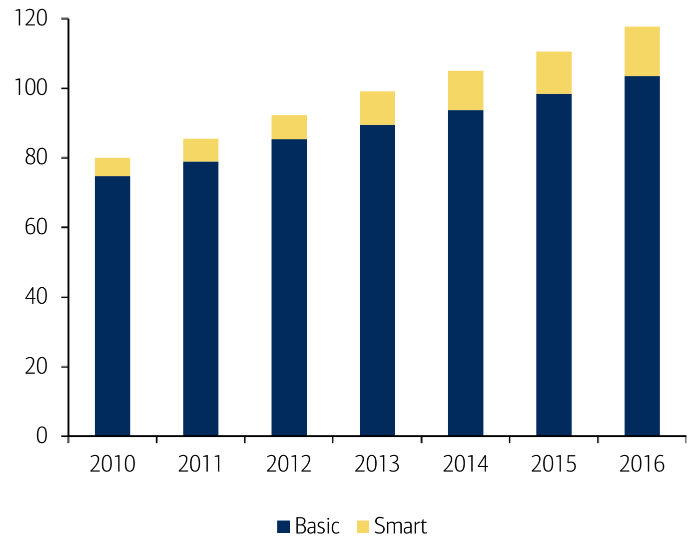
The global smart meters market is estimated to reach US$18.2bn by 2019, growing at a 10.2% CAGR from 2014. The largest market is North America, driven by smart metering mandates from California and Texas (source: Research and Markets). In 2012, global shipments of smart meters reached 100m units, rising by 31.6% over 2011 (source: Huidian Research). Given that water is an under-metered sector versus gas and electricity, we expect basic water meters to enjoy a 5.4% CAGR in 2011-16E.

Chart 95: Global meter market in GBP mn



Source: Elster 2013

Chart 96: Annual water meter installations globally (millions of meters)



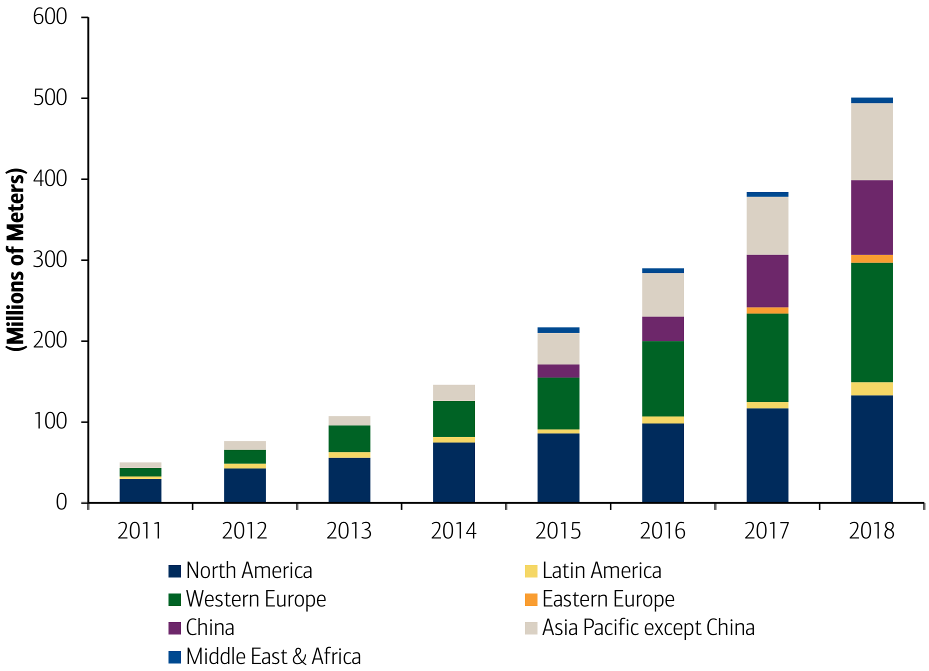
Source: Industry sources, BofA Merrill Lynch Global Research estimates

California adopting smart meters, but huge room for further penetration

A 2010 survey of California water utilities conducted by the Association of California Water Agencies showed that half of respondents had installed some form of AMR or AMI meters. However, penetration is low – 42% have AMR meters installed in less than 10% of their systems. More than 60% of respondents said that initial costs were a concern, but 80% cited reduced meter reading costs as an expected benefit (source: PPIC 2014).

After converting to AMI, the city of Santa Maria reduced water losses from 6% to 2%. Similarly, the city of Sacramento detected leaks, which it then repaired, saving 236m gallons of water over two years (source: DWR 2013).

Chart 97: Smart meters with an MDM by region, world markets: 2010-2018



Source: Pike Research

Water, water (leaking) everywhere

We expect the global market for smart water meters to reach US$6.6bn in annual spending by 2025, up from US$2.8bn today as utilities seek substantial cost savings and lost revenue opportunities from leakage and unmetered usage. In the US alone, the EPA reports that 6bn gallons of water are lost from leaks every year. Globally, the World Bank estimates that costs from unmetered water total US$14bn pa. On the revenue side, Itron estimates that water utilities lose around US$500mn per day globally in non-revenue water.

Table 54: Meter ASPs by segment based on estimated 2011 prices

	Basic	Smart	
		One - way	**Two -way**
Electricity	$33	$50	$130
Gas	$61	$117	
Water	$30	$64	

Source: Industry sources, BofA Merrill Lynch Global Research estimates

Many challenges remain

There are still a number of challenges to mass adoption of smart water meters. Most notable is the lack of an adequate IT and telecommunications infrastructure outside urban environments. Without sufficient bandwidth, the information promised by such technology cannot be transferred effectively and will be a barrier to growth.

Cost of smart meter adoption

While AMI addresses many issues in water management, the cost of implementation has been a hindrance to faster adoption. The deployment of a smart water metering system entails upfront costs such as communications infrastructure, data management applications, and analytic software. The per-unit cost of AMI will vary greatly depending on scale and existing infrastructure. Within the US, this cost is around US$300 per smart meter with distribution automation costing an additional US$65 per unit (source: SGCC, SGIG). The payback periods in studies in the US and Australia have been in the range of 3-10 years.

Water meters and volumetric tariffs can reduce water consumption

A study by the University of Australia in 2009 concluded that volumetric water charges increase the probability of engaging in water-saving activities, such as turning off the tap while brushing teeth, watering the garden at the coolest part of the day, and collecting/recycling rainwater and wastewater. In the same survey, respondents listed seven factors that would reduce water consumption: 1) practical information on how to save water; 2) money savings; 3) environmental benefits; 4) availability of water-efficient products; 5) confidence in water-efficiency labels; 6) lower-cost water-efficiency equipment; and 7) mandatory water restriction.

Apps can also help

The use of mobile apps on smartphones can also help consumers better manage their water, in our view. For instance "Dropcountr" is an app that connects customers to their utility companies on their mobile devices. This then allows them to see how much water they are using and hence set goals and reminders on the app to save water, money and time in the long run (source: Dropcountr).

Apps have also been created by developers in California in light of the ongoing drought crisis. "Waste No Water" and "VizSafe" are local crowdsourced apps to report the mismanagement of water or "drought-shame"; they allow users to take a photo of homeowners, with leaky sprinklers for instance, and forward it onto the relevant water conservation departments with a location (source: VizSafe, Waste No Water). We also see scope, driven by increased IoT adoption, for apps to be connected to smart meters and to utilise the big data in these to augment water efficiency.

Table 55: Water conservation mobile apps

Name	Description
Drip Detective	Will show exactly how much water is running down the drain and takes a few seconds to quickly and accurately show you the amount of water and the cost associated with any water leak.
Dropcountr	Connects people to their utilities company on their mobile devices. Their mobile and web applications help water utilities and their customers save water, save money and save time.
Eve Ecosystem	Monitors soil moisture throughout the yard, then takes control to optimize watering .
H20 Tracker	Water conservation game that helps you estimate water use in and around your house so you can conserve, save money and earn points. It track your water use and score.
Hydros	The smart irrigation controller that self schedules using users specific lawn and garden conditions and weather forecasts to save water.
VizSAFE	Crowdsourced tool that's always that helps users instantly post and share videos and photos to support the community. It has now been widely used a forum for "drought shaming".
Waste No Water	San Diego app allowing users to report water violations with photos e.g. leaky sprinklers, defective pipes, and faulty irrigation systems, and send them to the Water Conservation Department with a GPS location
Waterprint	Calculates the amount of water imbedded in daily activities
Watersmart Software	Leverages utility meter data to better communicate with residential customers about their water usage.

Source: Company reports, BofA Merrill Lynch Global Research

Agriculture: more crop per drop

Given that agriculture accounts for 80% of human water use in California, increased efficiency, the "more crop per drop" theme will grow in importance in a climate change and extreme weather constrained world. Increasing efficiency through better irrigation methods, precision agriculture, and drought-resistant seeds and enhanced fertilisation methods are all ways to increase yields while reducing water use.

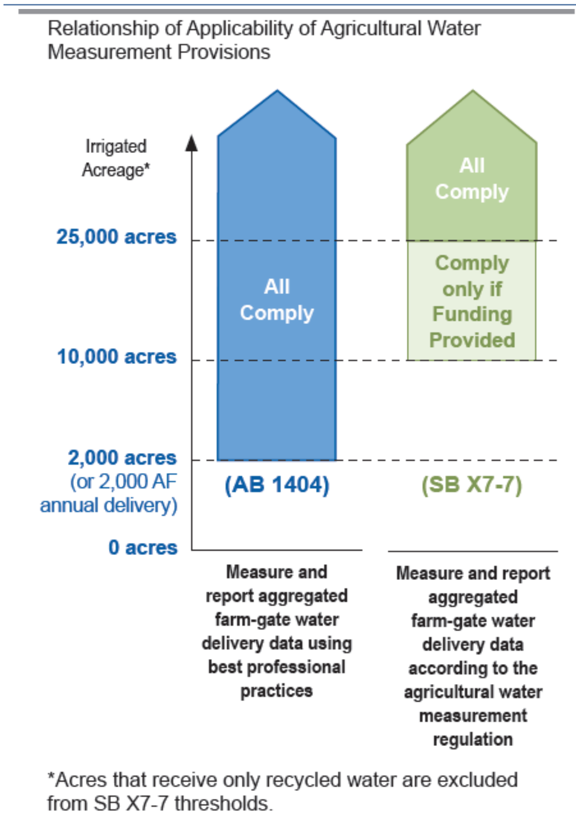
Efficient use signed into law

California is the fifth-largest food producer in the world with US$46bn of output in 2013. It produces virtually all of the US's almonds, artichokes, lemons, pistachios and processed tomatoes. Although agriculture currently makes up only 2% of the state's GDP, it employs around 0.5m people on 77,900 farms, generating US$46bn in output and supporting US$100bn in economic activity (source: CDFA, USDA, NASS). All this is supported by 9m acres of irrigated land, with requires 34m acre-feet (maf) of water, or about one-third of the available surface water supplies (California Department of Water Resources Agricultural Water Use 2012a). Because of this, the state has passed two laws enforcing efficiency for agricultural end users:

- AB 1404 – Signed into law in 2007; agricultural water suppliers must submit a water use report to DWR. Those providing 2,000 acre-feet or more surface water must submit on an annual basis. Those serving 2,000 acres or more of land must submit monthly. This measures water delivered to customers within the delivery system.

- SB X7-7 – Signed into law in 2009; suppliers providing water to 10,000 or more acres of land must measure water delivered to customers. This sets criteria and accuracy standards for farm-gate measurement and reporting (source: California Water Plan 2013)

Exhibit 57: AB 1404 vs SB X7-7



Source: California Water Plan 2013

More efficient irrigation

Irrigation provides approximately 40% of the world's food including most of its horticultural output from an estimated 20% of agricultural land (Source: FAO). Given the strong pressure to produce more with less, and a growing awareness of the environmental impact of agriculture, we are seeing a rethink of current strategies for intensifying agriculture in favour of more efficient irrigation.

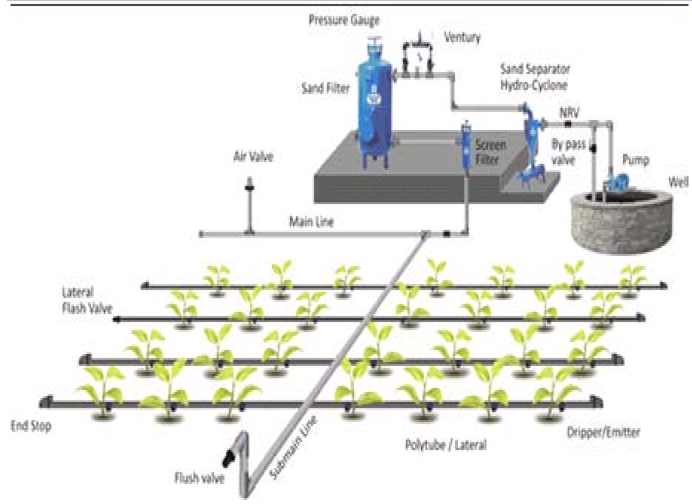
US$5.6bn global irrigation market

The irrigation market is estimated to be worth US$5.6bn, equally split between agriculture and lawn and garden. There is huge room for improved efficiency with gravity flow/furrow irrigation accounting for 91% of irrigation globally, followed by sprinklers (8%) and low-volume methods (1%). More efficient techniques, such as mechanised irrigation (e.g., low elevation spray elevation (LESA), offer hope and have captured a 46% market share in the US (source: Lindsay, Aquastat). For the agricultural irrigation segment, Valmont and Lindsay dominate with some 73% of global market share (source: Lindsay).

Exhibit 58: Centre pivot irrigation

Source: University of Maryland, BofA Merrill Lynch Global Research

Exhibit 59: Micro-irrigation system components



Source: Kothari Agritech

Centre pivots through to micro-irrigation

We see significant opportunities in the development of more efficient forms of irrigation. Centre pivots rotate around a centre point and so their coverage areas are circular and provide considerable advantages over older methods – such as furrow and gravity-fed irrigation – as they conserve water, energy, and labour while increasing or stabilising crop production. Other lower-cost beneficiaries include micro-irrigation, trickle irrigation, daily flow irrigation, drop irrigation, SIP (sub-irrigated planter) irrigation and diurnal irrigation – all of which fall into the more crop per drop category. The choice of irrigation technology will depend on the level of local economic development, the hydrological situation, political and social institutions, management skills, financial resources and popular attitudes to water.

Table 56: Overview of main types of irrigation

Type	Overview
Surface irrigation	Based on the principle of moving water on land by simple gravity in order to wet it, either partially or completely, before infiltrating. Often this type of irrigation leads to the run-off of chemicals and fertilisers.
Sprinkler Irrigation	Consists of a pipe network, through which water moves under pressure before being delivered to the crop via sprinkler nozzles.
Localised Irrigation	A system whereby the water is distributed under low pressure through a piped network, in a pre-determined pattern, and applies water as a small discharge to each plan. There are three main categories: Drip irrigators: drip emitters are used to apply water slowly to the soil surface Spray or micro-sprinkler irrigation: applies water slowly to the roots of plants through a network of valves, pipes, tubing and emitters Bubbler irrigation: a small stream is applied to flood small basins or the soil adjacent to individual trees
Spate Irrigation	Random irrigation using the floodwater of a normally dry water course or riverbed.

Source: Aquastat, BofA Merrill Lynch Global Research

Next-gen irrigation is on the increase

We have been seeing significant conversion of conventional water delivery systems to next-gen irrigation systems. According to the California Farm Water Coalition, San Joaquin farmers invested more than US$1.5bn in high-efficiency irrigation equipment. Almost all trees and vines since 1990 use micro-irrigation. Crop areas irrigated using this method grew from 1.26mn to 3.12mn acres, or a 150% increase (source: California Water Plan 2013). Low volume irrigation (drop and micro sprinklers) solutions appear to be highly effective. Research on drip irrigation in alfalfa has shown water use reduction of 2-3%, while yields have increased 19-35% (source: Crop Life American 2012).

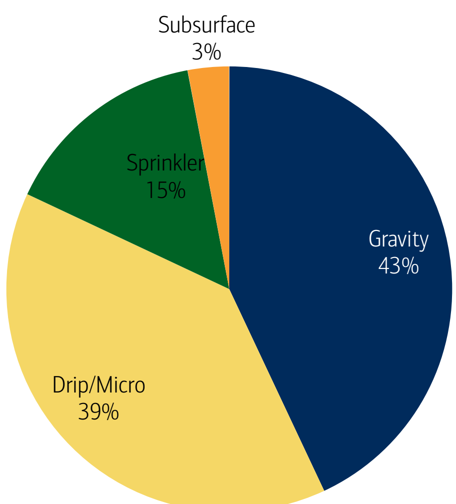
Table 57: Trends in irrigation method area in California (in million acres)

	1991		2001		2010		Change from 1991 to 2010	
Irrigation Method	Area (MA)	% of Total	Area (MA)	% of Total	Area (MA)	% of Total	Percent Change in Acreage and Reduction/Increase of Area	
Gravity (furrow flood)	5.54	67	4.04	50	3.53	43	-36%	-2.01 MA
Sprinkler	1.43	17	1.28	16	1.24	15	-13%	-0.19 MA
Drip/micro	1.26	15	2.69	33	3.12	39	150%	+1.86 MA
Subsurface	0.05	1	0.15	2	0.24	3	380%	+0.19 MA
Total	8.28	100	8.16	100	8.13	100	2.01 MA reduction in gravity systems 1.86 MA increase in pressurized systems	

Source: California Water Plan 2013

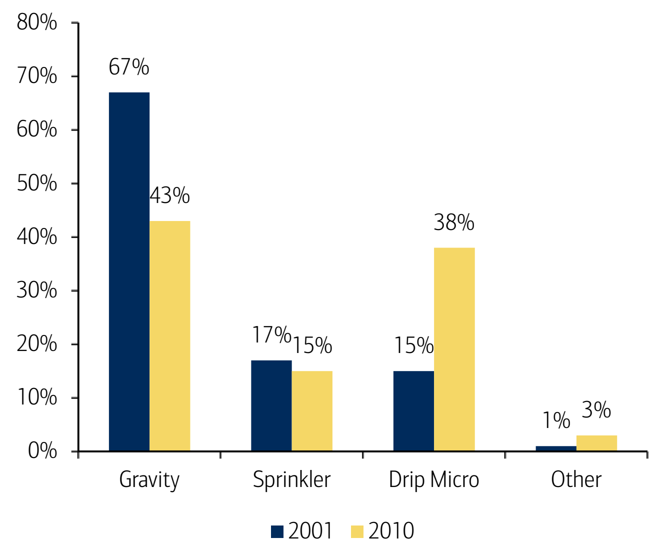
Note: MA = million acres

Chart 98: Acres of irrigated agricultural land by irrigation method in California in 2010



Source: California Water Plan 2013

Chart 99: Statewide trends in Irrigation methods



Source: California Water Plan 2013

Precision agriculture, "big data" solutions – a US$6.34bn opportunity

Precision agriculture is the technology optimising the use of resources, such as water, fertilisers, pesticides and seeds, to increase production and profits. Developments in machine-to-machine (M2M) technologies and information automation have made precision agriculture a viable method, which is expected to become a US$4.55bn market by 2020E and US$6.34bn by 2022E, up from US$1.5-2.0bn today (source: MarketsandMarkets, Research and Markets). M2M solutions comprise sensors that collect event data from machines, and communicate it over a wireless network for processing by a software application, which is typically centralised. The software can then prescribe actions and affect behaviour that is specific to the environment of interest, in the most advantageous manner.

US is the most mature market – 70-80% penetration

In developed markets, which are characterised by high levels of mechanisation – technologically advanced farming solutions are seeing the fastest sales growth in the ag equipment space. The US is the most mature market for precision agriculture, with c.70% penetration of precision technologies and c.80% of farms of >500 acres using precision agriculture (source: Alix Partners).

Table 58: Major companies and products in precision agriculture

Company	Agriculture only or diversified	Ticker	Precision ag products & services
AGCO Corp.	Agriculture	NYSE: AGCO	Challenger, Fendt, Massey Ferguson, & Valtra Series— Product lines of tractors, harvesters, tillage, and application equipment
AgJunction Inc.	Agriculture	TSX: AJX	Outback Guidance, Satloc, AJ Cloud Services
Agrium Inc.	Agriculture	NYSE: AGU	Variety of seeds, herbicides, fungicides, insecticides, and seed care chemical solutions
Buhler Industries Inc	Agriculture	TSX: BUI	Versatile & Farm King—Tractors and other agricultural machinery
Deere & Company	Agriculture	NYSE: DE	Comprehensive tractors, harvesters, and sprayers with section control and variable rate application. Displays (Greenstar), guidance control solutions, and software solutions (APEX Farm Management)
Dupont Inc.	Diversified	NYSE: DD	Pioneer—Development of an agronomy software solution to assist in field management; Encirca
Exel Industries Société Anonyme	Agriculture	ENXTPA: EXE	Specialty sprayers and tractors. Leader in niche markets like high clearance tractors
Lindsay Corporation	Agriculture	NYSE: LNN	Zimmatic Irrigation Line—Variable Rate Irrigation system with software for remote irrigation mgmt
Monsanto Company	Agriculture	NYSE: MON	Climate Corp platform; FieldScripts Software—Variable Rate Planting Prescription Software
MTS Systems Corp.	Diversified	Nasdaq: MTSC	Specialized GPS guidance sensors and hardware for Precision Agriculture
Raven Industries Inc	Diversified	Nasdaq: RAVN	Viper4, Viper Pro, Envizio Pro Series, & Raven VT—Field Computers, CruzerII Series, SmartTrax Series & Phoenix GPS—Autosteer hardwares & application, boom, planter/seeder, & harvest control hardwares
Topcon Corporation	Diversified	OTC:TOPCF	Guidance systems, application control systems, field data collectors, GPS receivers, and field management software
Trimble Navigation ltd.	Diversified	Nasdaq: TRMB	GreenSeeker—Crop health assessment sensor, Connected Farm—Field Management software solution & data management, application control, yield monitoring, and water control systems
Yara International ASA	Diversified	OTC: YAR	ZIM Series—Water sensor technologies for precision irrigation systems

Source: FOCUS Investment Banking, Capital iQ, BofA Merrill Lynch Global Research

Precision agriculture in California

Californian growers are making extensive use of satellite weather information and forecasting systems to view data including evapotranspiration (ET) and soil moisture for irrigation scheduling. Users are making more than 70,000 inquiries per year to the California Irrigation Management Information System (CIMIS), and to the Department of Water Resources, which makes this available (source: California Water Plan 2013).

What is precision agriculture?

Precision agriculture (PA) is a farming management concept based on observing, measuring and responding to inter and intra-field variability in crops. It encompasses a range of technologies including:

- Guidance systems (e.g., global navigation satellite system (GNSS), global positioning systems (GPS), global information systems (GIS))
- Remote sensing (e.g., hand-held and satellite-based sensing)
- Variable rate technologies (VRT) (e.g., variable rate fertiliser, variable rate pesticide, and variable rate seeding).

Optimising field-level management and big data analytics

PA aims to optimise field-level management with regard to three factors:

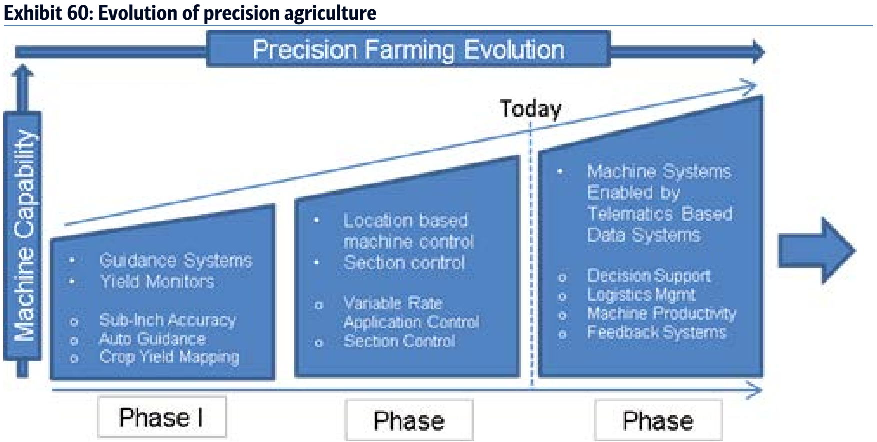
- Crop science: matching farming practices more closely to crop needs and agricultural inputs (e.g., fertiliser inputs);
- Environmental protection: by reducing environmental risks and footprint of farming (e.g., limiting leaching of nitrogen);
- Economics: by boosting competitiveness through more efficient practices (e.g., improved management of fertiliser usage and other inputs).

It also provides farmers with a wealth of information to build up a record of their farm; improve decision-making; foster greater traceability; enhance marketing of farm products; improve lease arrangements and relationships with landlords; and enhance the inherent quality of farm products (e.g., protein level in bread-flour wheat).

Evolving from single machine focus to ecosystem approach

PA is evolving from a single machine-based approach to an integrated system of connected vehicles and devices characterised by simplicity (user interface and experience), connectivity (telematics platform), open standards (data systems) and integration (into machines) (source: CNH).

Exhibit 60: Evolution of precision agriculture



Source: CNH

Precision agriculture in practice

Precision agriculture typically utilises technologies such as GPS, yield monitoring and mapping, soil sampling and variable rate (VRT) application, remote sensing, crop scouting, and geographic information systems. At the front-end sensing stage, tractors, combines and trucks are outfitted with sensors and GPS-tracking devices. This allows for site-specific crop management and VRT application of seeds, fertilisers, water, herbicides and pesticides, so farmers apply resources only where they are needed. Sensors and cameras are also distributed around the field and in the soil itself, which monitors environmental factors such as wind speed, temperature, sun light, precipitation, humidity, soil moisture, and air pressure. Variable rate irrigation management would be possible and allow farmers to conserve water usage. For example, the centralised analytics can turn irrigation sprinklers on or off, at variable degrees, and focus on precise areas of the field, based on weather, soil moisture, and state of the crop canopy.

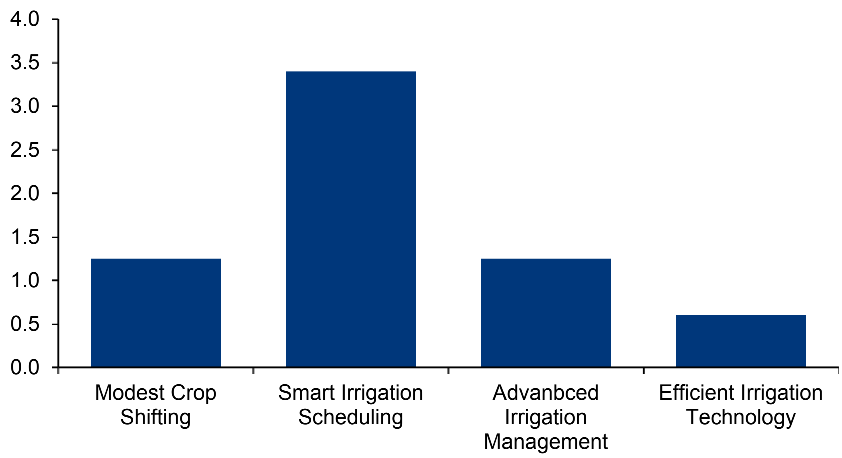
Smart irrigation/precision agriculture effectiveness

Analysis by the Pacific Institute evaluates scenarios for improving agricultural water-use efficiency, with a focus on the Sacramento-San Joaquin Delta in California. Four scenarios for improving the water-use efficiency of the agricultural sector were evaluated:

- Modest Crop Shifting – shifting a small percentage of lower-value, water-intensive crops to higher-value, water-efficient crops.
- Smart Irrigation Scheduling – using irrigation scheduling information that helps farmers more precisely irrigate to meet crop water needs and boost production.
- Advanced Irrigation Management – applying advanced management methods that save water, such as regulated deficit irrigation.
- Efficient Irrigation Technology – shifting a fraction of the crops irrigated using flood irrigation to sprinkler and drip systems.

The highest water savings were seen to occur from smart irrigation.

Chart 100: Water Savings by Scenario



Source: Pacific Institute

Up to US$2.7bn gains from agricultural water efficiency

The CALFED Programmatic Record of Decision (ROD) reported that water efficiency improvements in agriculture could yield savings of 120-563k acre-feet per year. This would equate to savings of US$0.3-2.7bn out to 2030E. This assumed on-farm water efficiency would improve to 85% (source: California Water Plan 2013).

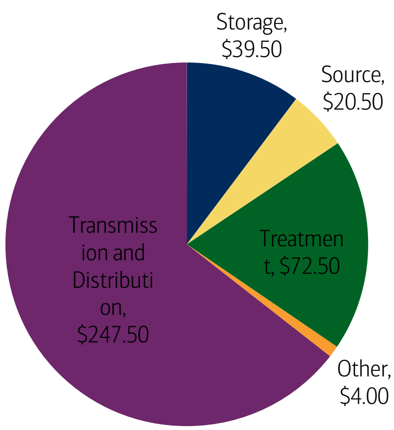
Infrastructure & supply solutions

We believe water infrastructure investments are needed to achieve long-term water sustainability. This includes rainwater capture, groundwater and surface water storage build-out, as well as restoring pre-existing water systems. Companies involved in areas including engineering, procurement, construction and consulting, pipes, pumps and valves, and water, wastewater and sewage treatment utilities could be enablers.

US$1tn needed for US water infrastructure over 25Y

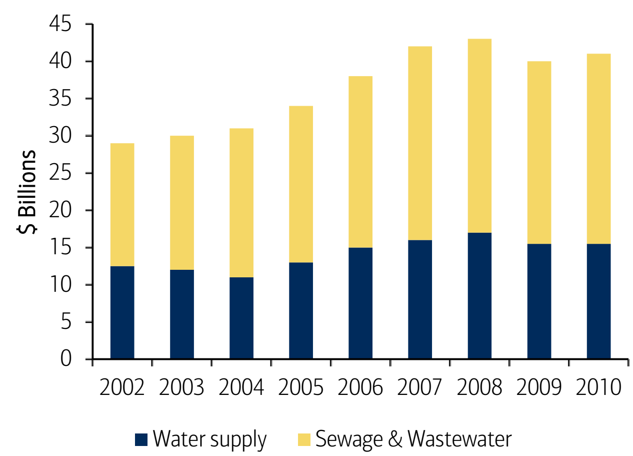
The US requires US$1tn in water infrastructure investments over the next 25 years to maintain even the current levels of water service. The country's drinking water infrastructure was built over 50 years ago, with a large proportion approaching or having exceeded its useful life (source: AWWA 2012). The US EPA, for instance, estimates that US$384bn would be required to 2030 simply to address infrastructure shortcomings – and an additional US$335bn to improve the systems. The American Society of Civil Engineers currently ranks both the nation's drinking water and wastewater infrastructure as D-. Huge investments are needed in drinking-water treatment plants and distribution lines, sewer lines and storage facilities.

Chart 101: US water infrastructure investment needs (in $bn)



Source: US EPA

Chart 102: US water infrastructure spending, 2002-10

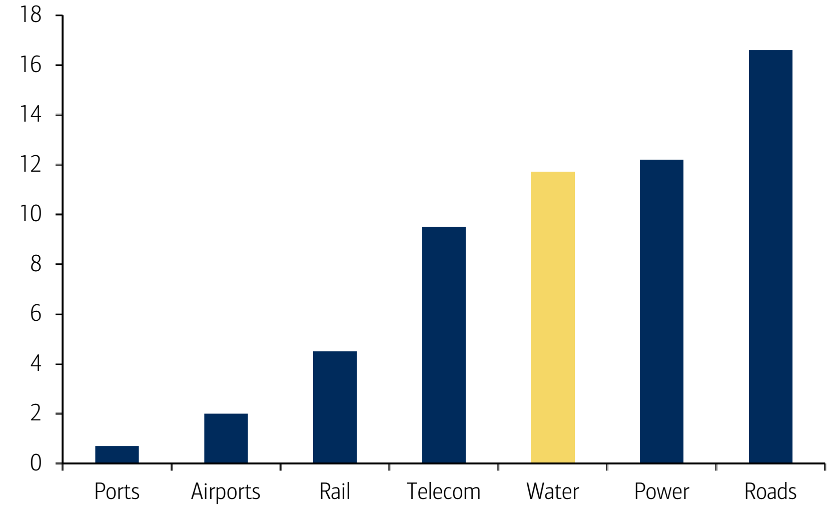


Source: US Census Bureau, BofA Merrill Lynch Global Research

US$11.7tn in global water and sanitation investments needed to 2030E

On a global scale, we need US$11.7tn water and sanitation investment out to 2030E (Source: McKinsey, E&Y). In the developed markets, the primary cause is crumbling and incomplete infrastructure similar to the case in California. For EMs, the challenge is building out basic water infrastructure, with water infrastructure three times more expensive to build and maintain than electricity infrastructure (Source: IBM). Overcoming the neglect and under-financing of earlier years could cost 0.35%-1.2% of GDP pa over the next 20 years (source: OECD).

Chart 103: Global infrastructure demand by 2030 (in US$tn)

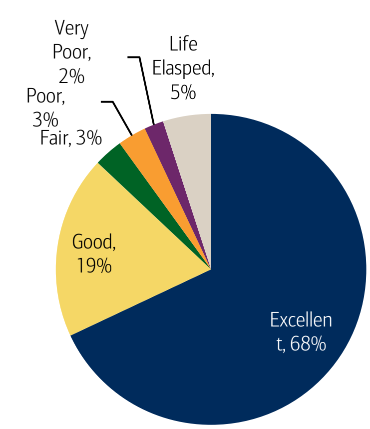


Source: McKinsey, E&Y

US$2.6bn of water lost every year

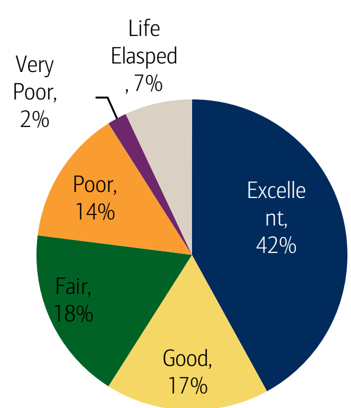
The US has c.1m miles (1.6m km) of water pipelines – with a major water main breaking every two minutes, with 2tn gallons of treated water lost every year at a cost of US$2.6bn. With regard to the US's 800k (1.28m km) miles of sewer mains, 900bn gallons of untreated sewage are discharged every year. Without renewal or replacement of existing systems, 44% of pipes will be classified as poor, very poor or life elapsed by 2020 (source: American Water).

Chart 104: Percentage of water pipes in the US by classification (1980)



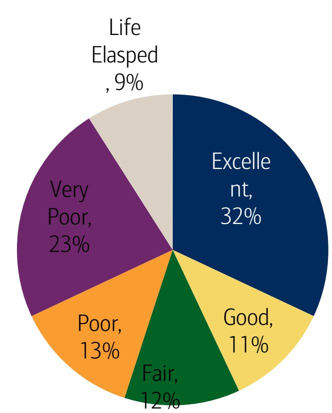
Source: American Water Works based on US EPA, BofA Merrill Lynch Global Research

Chart 105: Percentage of water pipes in the US by classification (2000)



Source: American Water Works based on US EPA, BofA Merrill Lynch Global Research

Chart 106: Percentage of water pipes in the US by classification (2020)



Source: American Water Works based on US EPA, BofA Merrill Lynch Global Research

The US's ageing drinking-water systems have been under-funded for many years and require huge investment. A major water main breaks every two minutes in the US.

Cash-strapped municipalities starting to look to private sector

Positively, there are growing signs that large US public municipal water utilities are willing to contract with the private sector on the back of financial constraints and insufficient public funding, ageing infrastructure, increasing EPA regulations and less "emotional attachment" to water by municipalities. The private sector is already playing a greater role in areas such as advisory services, municipal players are increasingly open to partnerships, and the acquisition pipeline is looking more robust.

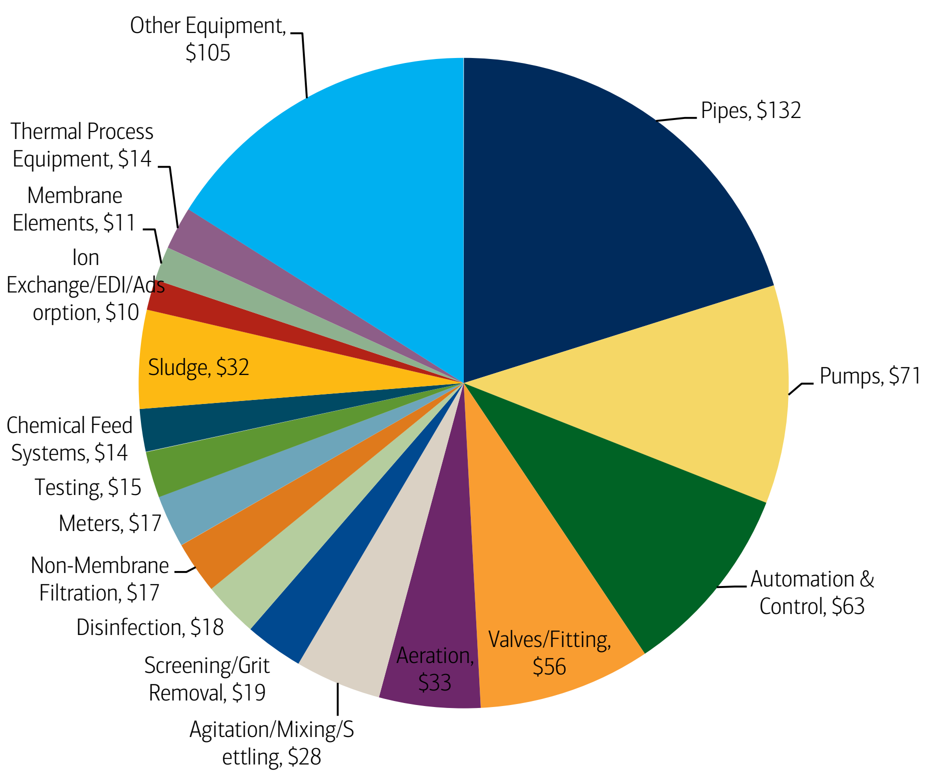
Up to 30% of water investments to come from private sector in the next 3-5Y

The private sector will play an increasingly important role in developing and running water infrastructure and is expected to account for 30% of water investments in the next 3-5 years (Source: Global Water Fund). Full cost pricing – and increasing tariffs, taxes and transfers – is being used to address funding gaps and to strike a balance between infrastructure and financing needs, improving service provision levels for stakeholders, and profitable growth opportunities for corporates.

Water equipment to be US$655bn market by 2018E

Global water equipment capex is expected to be a US$655bn market from 2013-18 with pipes (US$132bn), pumps (US$71bn), automation and control (US$63bn), valves and fittings (US$56bn) and aeration (US$33bn) accounting for the largest segments. There will be a significant increase in spending as the late cycle business returns to previous trends, with industrial spend outpacing municipal spend (source: GWI Global Water Market 2014).

Chart 107: US$655bn global water equipment market (2013-2018E)



Source: GWI

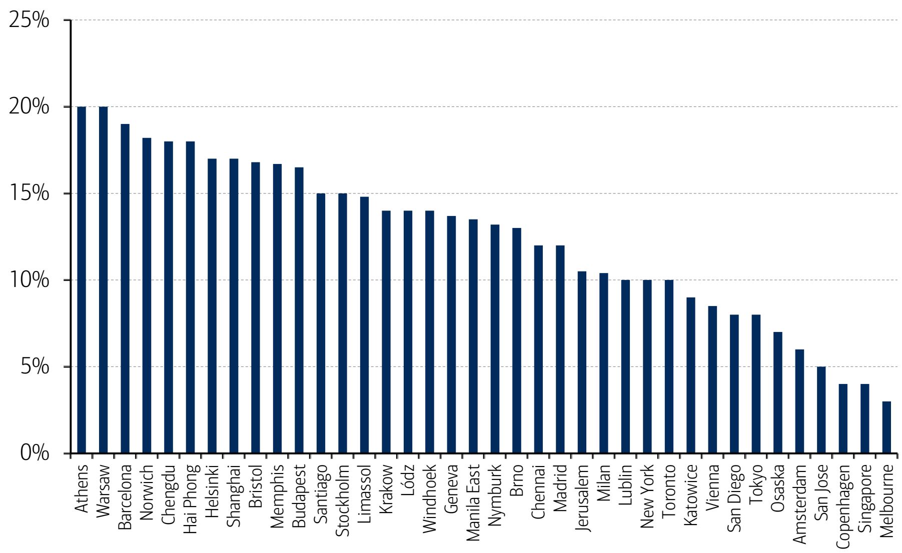
Global water utilities to grow to US$923bn by 2019E, 3.6% CAGR

The global water utilities industry is expected to grow at a 3.6% CAGR to reach US$923.4bn by 2019 (vs. US$774.8bn in 2014) (Source: MarketLine). Growth rates are low but stable for the highly fragmented sector where around only 10% of customers are served by investor-owned companies – and performance depends on regulatory factors as well as fundamental drivers of revenue and cost. But we see significant opportunities in Brazil and China – where water is increasingly a long-term secular growth story – as well as in the US.

Leaks everywhere, up to 10% lost water in CA

Water loss or non-revenue water (NRW) is a considerable problem around the world, even in developed markets like California. According to a 2009 report by Southern California Edison, around 10% of the total volume of water supplied in California is lost to leaks, or 0.88maf (0.29tn gallons). This is enough to supply water to San Francisco's 7m residents for a year and a half. Addressing California's water loss will require water suppliers and customers to invest in the ageing water distribution system (source: California Water Plan 2013).

Chart 108: NRW is an issue in many developed market cities



Source: Smart water Networks Forum, BofA Merrill Lynch Global Research

Utilities can reduce NRW

NRW comprises three components: physical losses including leakage and overflow; commercial (or apparent) losses caused by customer meter under-registration, data-handling errors, and theft of the utility for operation purposes and water used for free by certain consumer groups; and unbilled authorised consumption. All are considerable issues for every water utility because they are a straight hit to the top line.

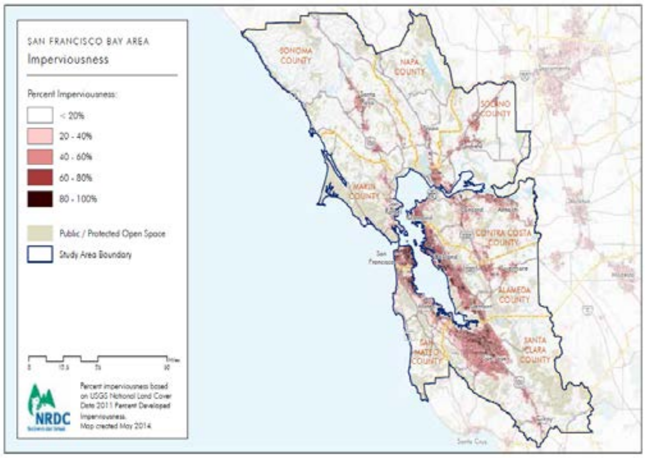
Given that the majority of water distributors rely on municipal contracts and funds to conduct their investments, there are growing opportunities for affordable management practices rather than expensive replacement projects. Water utilities primarily compare their estimated current level of leakage with a notional economic level of leakage – the point at which the cost of reducing leakage is equal to the benefit gained from further leakage reduction.

Utilities usually estimate when pipes need replacing from a number of variables – age, soil type, etc., but this is time-consuming and inefficient. There are a number of small private companies involved in providing IT-orientated infrastructure management solutions. The technology ranges from stethoscope-like devices that are pressed against the asphalt to detect leakage to miniature sensors that are inserted into the sewer mains. We see this as an exciting segment of supply-side water management.

Storm capture can offset 60% of home irrigation demand

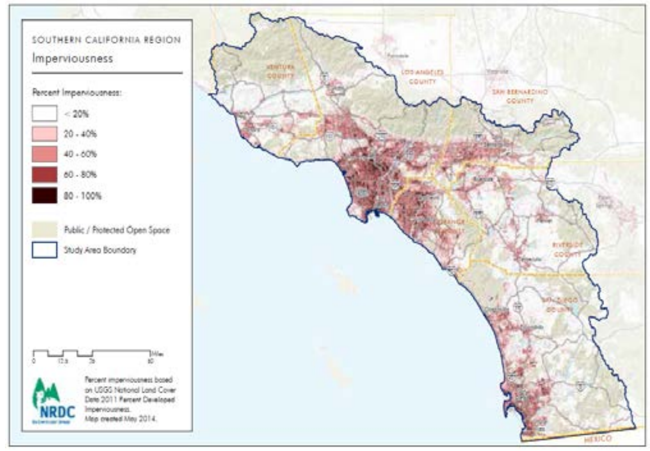
Stormwater capture is the collection of runoff from impervious places in urban and suburban areas and allowing it to infiltrate groundwater supplies or harvesting it in rain barrels or cisterns. Capturing runoff in places like Southern California and San Francisco Bay area could increase water supplies by 630k acre-feet year, or the amount used by the city of Los Angeles in an entire year (source: NDRC 2014). The California Single Family Home Water Use Efficiency Study showed that the average family can offset nearly 60% of its residential irrigation demand by expanding the use its grey-water system and utilising storm capture (source: California Water Plan 2013).

Exhibit 61: Impervious surface cover with San Francisco Bay area



Source: NDRC 2014

Exhibit 62: Impervious surface cover with Southern California area



Source: NDRC 2014

Low investment for non-potable uses

Residential use of rainwater runoff and reuse of grey water does not require high infrastructure investments that are typical of traditional water treatment or desalination. Non-potable uses such as toilets, showers and washing cars are practical end-uses given that they are required year-round. This is even more economically viable in places where the rainy season extends into the irrigation season or where the locally supplied water is expensive or unreliable (source: California Water Plan 2013).

Water pollution reduction achieved

Other benefits of urban stormwater runoff management include reducing surface water pollution and improving flood protection. Stormwater itself increases flood risk, but pollutants in urban stormwater runoff can degrade groundwater quality. Good stormwater management practices can reduce both (source: California Water Plan 2013).

One inch of rain=10bn gallons of runoff in LA

Every inch of rain in Los Angeles County can generate more than 10bn gallons (30k acre feet) of stormwater, which runs into the Pacific Ocean. This presents a tremendous opportunity to increase water supplies. Los Angeles County Flood Control District is already capturing and recharging around 54k acre-feet of rain every year in the Central and West Coast groundwater basins of the region. Yet there is still room for further penetration. The Water Replenishment District of Southern California imports around 30k acre-feet of water per year, while 180k acre-feet of stormwater runs into the ocean from its service area (source: NDRC 2014).

Potential to increase supplies by 420-630k af

The Natural Resources Defense Council (NDRC) estimates that stormwater capture in Southern California and San Francisco Bay can increase water supplies by 420-630k acre-feet per annum, enough to supply the city of Los Angeles for an entire year. In areas overlying groundwater basins used for municipal water supply, runoff can be easily captured and stored for use (source: NDRC 2014)

Surface storage

Most of California's water reservoirs were constructed 40 years ago, and the number of new reservoirs has been declining steadily since then. Having adequate storage is critical for both stabilising water delivery as well as providing a backup supply for emergencies. The state has around 200 surface storage reservoirs larger than 10k acre-feet, with a combined storage capacity of more than 41maf (13tn gallons), in addition to numerous smaller ones (source: California Water Plan 2013). Nonetheless, the maintenance and build-out of additional reliable capacity will be required for long-term water sustainability.

Groundwater infrastructure build-out

Groundwater is one of the main sources of water supply in California, accounting for 30% of total on average, and up to half in dry years. Three in four people derive at least part of their drinking water from groundwater. Many smaller towns and cities such as Fresno and Davis rely 100% on groundwater for their drinking-water supplies, totalling 6m of the total Californian population (source: State Water Resources Control Board 2013). While public water supply systems alone use about 13,000 wells to supply water to the public, very few new groundwater reservoirs have been built in recent times (California Department of Water Resources 2013b). Only six were constructed in the 1980s and 1990s, and only three have been completed since 2000. They include:

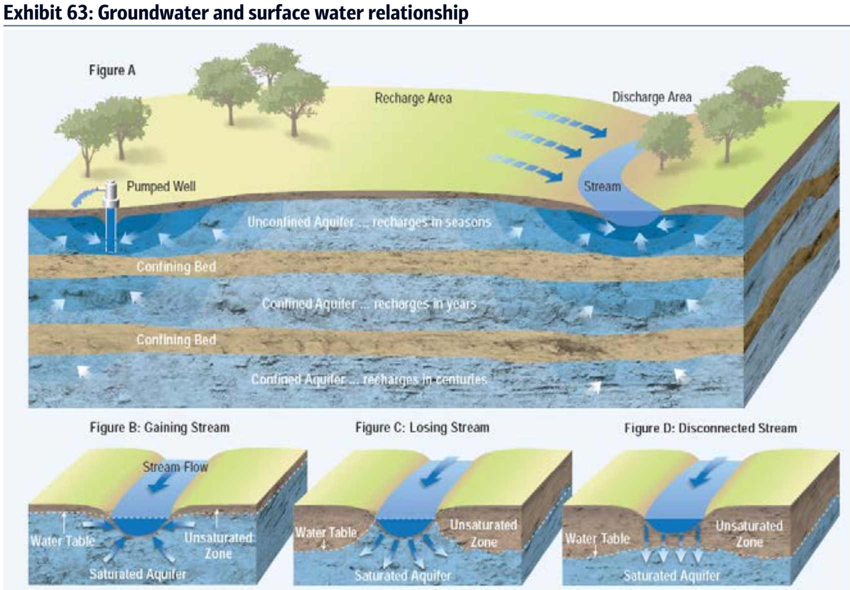
- 2010 – The US Bureau of Reclamation's Warren H Brock Storage Reservoir, on the north side of the All-American Canal in Imperial County.
- 2003 – San Diego County Water Authority's Olivenhain Reservoir.
- 2000 – Metropolitan Water District of Southern California's Diamond Valley Reservoir.
- 1999 – The US Army Corps of Engineers' and Orange County Flood Control District's Seven Oaks Reservoir.
- 1998 – Contra Costa Water District's Los Vaqueros Reservoir. (source: California Water Plan 2013)

30m California, three-quarters of the population, receive at least part of their drinking water from groundwater (source: California Water Plan 2013).

Conjunctive water management

Conjunctive management arranges surface water and groundwater supplies in an integrated system to improve the availability and reliability of water. While the two sources are often managed separately, they are actually a highly interdependent system of watersheds and groundwater basins. Conjunctive management usually entails changing the timing of flow of existing water sources and managing where it is stored rather than generate new water supply. Benefits include improving local or regional water supply reliability, increasing flood protection, meeting environmental needs, improving groundwater quality, countering land subsidence, or reducing groundwater overdraft (source: California Water Plan 2013).

Exhibit 63: Groundwater and surface water relationship



Source: California Water Plan 2013

Table 59: Potential benefits of conjunctive management implementation

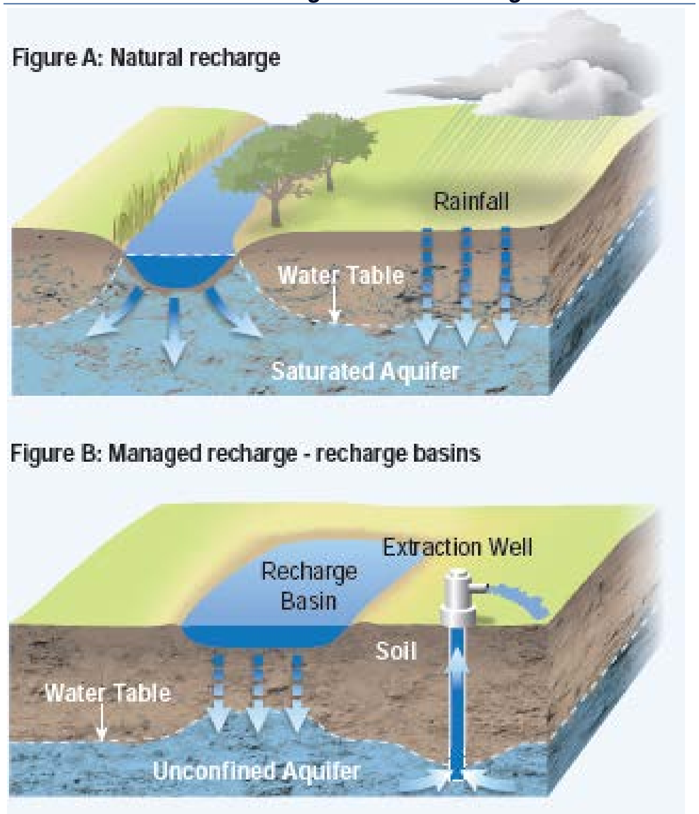
Potential Benefit of Managed Groundwater Storage	Example	Major Constraints
Improved local water supply reliability	Imported surface water supplies and/or floodflows are recharged to local alluvial groundwater basin during wet years/ seasons, increasing local water supply reliability.	Availability of surface water supplies. Limited capacity to capture and recharge high volume, short duration floodflows. Water quality concern of the recharged water and the impact to the aquifer itself.
Improved statewide water supply reliability	Groundwater storage in the northern part of the state might be used as backup supplies to allow more aggressive operation of surface storages such as Oroville and Shasta reservoirs by permitting reduced carryover storages so that more floodflows in the wet seasons could be captured. This would increase SWP and CVP operational flexibility and could result in improved statewide water supply reliability and sustainability. The reduced carryover storage would be replaced annually by utilizing groundwater storage.	Availability of a multi-regional/statewide conjunctive water management tool to model surface water and groundwater (including water temperature) responses accurately and to evaluate the proposed management strategy for its benefits, the impacts on third parties and the environment, project cost, etc. Legal and water rights issues (associated impacts perhaps could be mitigated by compensation to injured parties if any, using the above tool if it were available).
Drought relief for urban water users and potential induced groundwater recharge	Groundwater substitution transfer and agricultural water transfer. Irrigators who are willing sellers stop a specific amount of surface water diversion and pump an equivalent amount of groundwater to replace surface water. As a result, more surface water becomes available downstream for purchase. Groundwater eventually recovers from increased streamflow to the groundwater system.	A lack of a widely recognized mathematical model to accurately quantify the impact on other groundwater and surface water users and the environment. Potential land subsidence and its quantification and evaluation.
Protection from salt water intrusion	Recharge groundwater using captured floodflows or recycled water in the vicinity of salt water interface to raise groundwater levels and prevent migration of saline water into freshwater production portions of the aquifer.	Availability of freshwater supply. Considerable infrastructure requirements.
Improved flood control and groundwater storage	Development of detention ponds at proposed residential subdivisions located in the groundwater recharge protection areas can offset the increased urban runoff due to the development while maintaining natural groundwater recharge.	Possible water quality problems at detention ponds requiring effective urban stormwater management. Requiring adoption of local ordinance or legislation to support implementation.

Source: California Water Plan 2013

Managed recharge

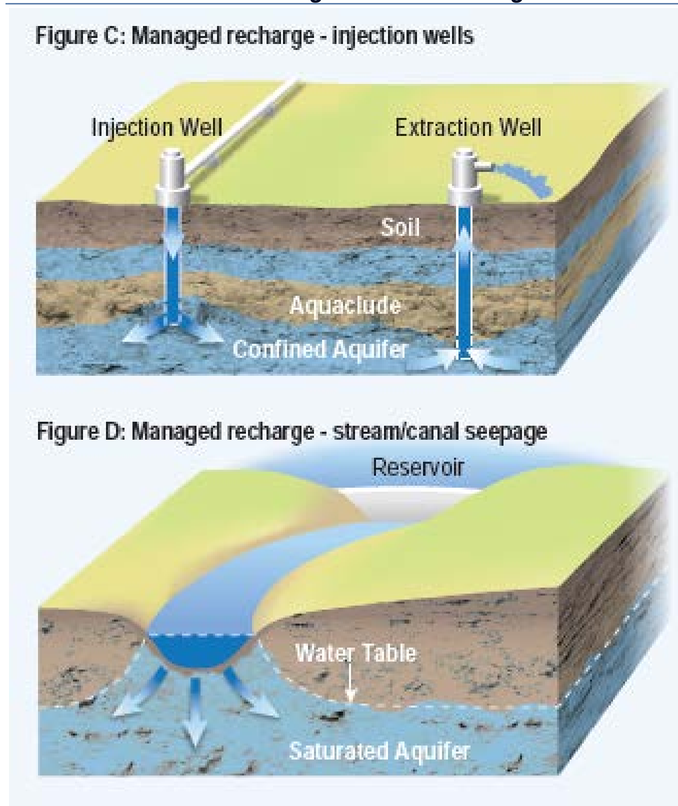
Groundwater can also be artificially recharged using the managed recharge method. This is when water is placed into constructed recharge or spreading basins, of when water is injected below the surface through wells. This process can also happen naturally when rainfall or surface water recharges groundwater through connected water networks (source: California Water Plan 2013). Similar to other groundwater management methods, this can achieve greater water availability and stability by increasing storage (source: Water Corporation).

Exhibit 64: Groundwater Recharge: Natural and Managed



Source: California Water Plan 2013

Exhibit 65: Groundwater Recharge: Natural and Managed



Source: California Water Plan 2013

EMs leading the way in water infrastructure investments

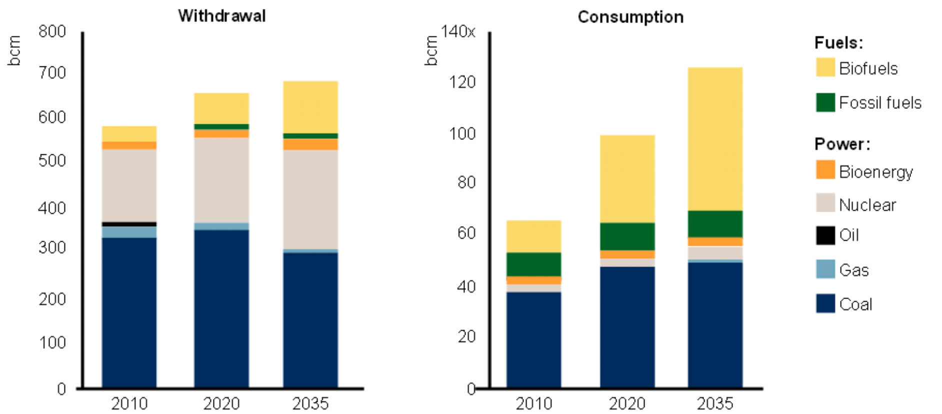
Growth in water infrastructure investments is still coming from emerging markets. The top five emerging countries contributed US$132.7bn to the global water utilities industry in 2014, expanding at a CAGR of 6.3% in 2007-11. The top five emerging countries are expected to reach a value of US$170.2bn in 2019, achieving a CAGR of 5.1% over 2014-19. China has been leading the market with US$61.7bn in water investments in 2014, followed by Brazil and India with US$32bn and US$23.5bn, respectively. This trend is expected to continue through to 2019E (source: MarketLine).

Water-friendly energy solutions

Some 90% of global power generation is water intensive, accounting for 15% of the world's water withdrawals (583bn m^3), which is expected to rise by 20% over the next 20 years (source: IEA). Increasing energy demand and the boom in nascent water-intensive energy sources such as shale are partly responsible for this growth in demand.

Less than 10% of California's electricity generation came from wind and solar in 2014, with more than more than 10,000 GwH from solar and 13,000 GwH from wind (source: California Energy Commission). California and Hawaii have been flagged as the US states with the greatest potential for more solar adoption. We believe the drought could be one of many catalysts for California's transition towards water-friendly sources of energy production.

Exhibit 66: Global water use for energy production by fuel type

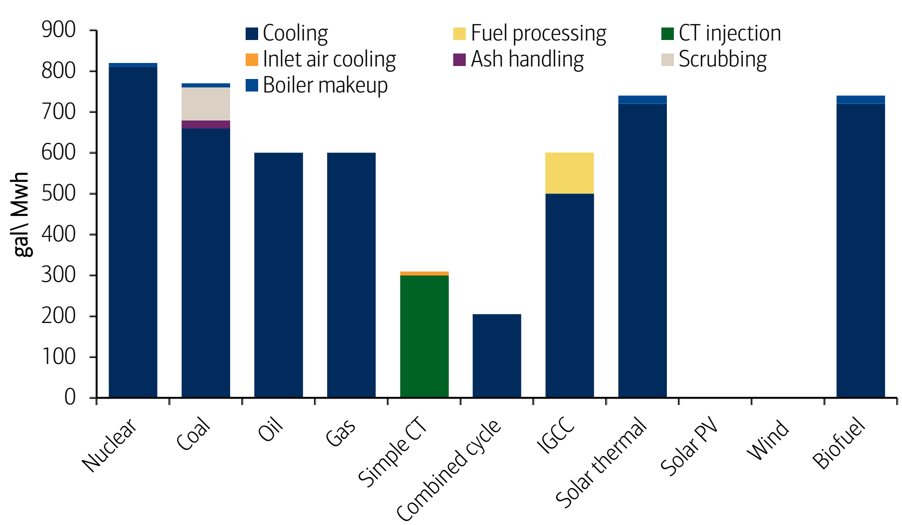


Source: IEA WEO 2012

Wind and solar energy use minimal amounts of water

From a water perspective, power generated from solar PV and wind is the most sustainable choice, having the lowest operational and water consumption footprint (i.e. water use per unit of electricity generated). Solar and wind power generation requires only 55-85 gallons per MWh – about one-tenth and one-sixth of that needed for nuclear power and coal, respectively (source: EPRI). Nuclear, coal, oil and gas are used by thermal power plants, all consuming 500 gallons of water or more per MWh (source: EFRI).

Chart 109: Water use by plant type



Source: EPRI, BofA Merrill Lynch Global Research

Most of this water is used as a cooling mechanism in thermal plants. However, in solar PV it is only utilised periodically to wash the panels. With wind power generation, water is not considered during the lifecycle of the project, only at the initial stage in terms of the impact of construction on surrounding marine wildlife. Wind and solar thus have a significant advantage over fossil fuels in that they do not pose the same water scarcity and treatment challenges, and lessen the burden on the water-energy nexus.

Table 60: Energy-water relationship matrix

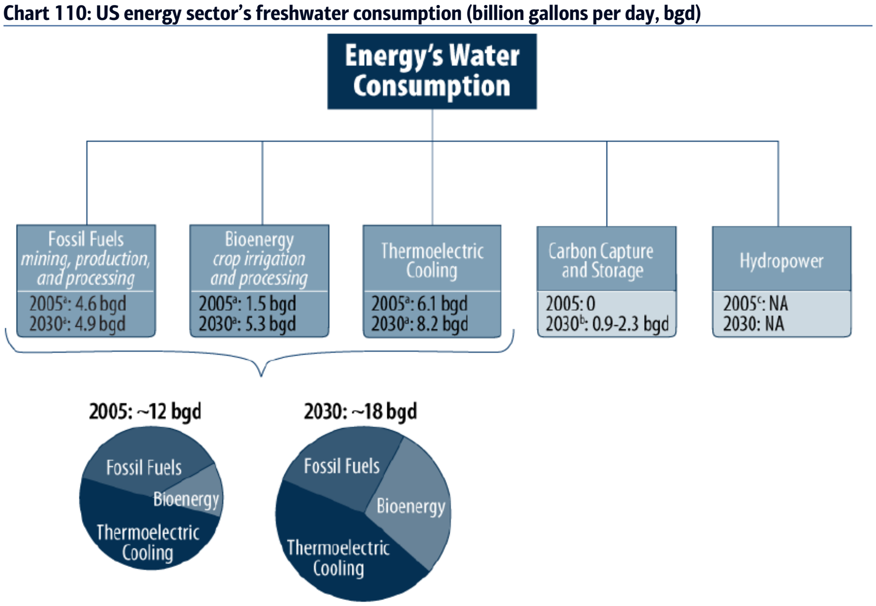
Energy element	Connection to water use / scarcity	Connection to water quality
Energy Extraction and Production		
Oil and Gas Exploration	Water for drilling, completion and fracturing	Impact on shallow groundwater quality
Oil and Gas Production	Surface water and groundwater for cooling and scrubbing	Produced water can impact surface and groundwater
Coal and Uranium Mining	Mining operation can generate large quantities of water	Tailings and drainage can impact surface water and groundwater
Electric Power Generation		
Thermal electric (fossil, biomass, nuclear)	Surface water and groundwater for cooling and scrubbing	Thermal and air emissions impact surface waters and ecology
Hydro-electric	Reservoirs lose large quantities to evaporation	Can impact water temperatures, quality and ecology
Solar PV and Wind	None during operation; minimal water use for panel and blade washing	
Refining and Processing		
Traditional Oil and Gas refining	Water needed to refined oil and gas	End use can impact water quality
Biofuels and Ethanol	Water for growing and refining	Refinery waste-water treatment
Synfuels and Hydrogen	Water for synthesis or steam reforming	Wastewater treatment
Energy Transportation and Storage		
Energy Pipelines	Water for hydrostatic testing	Wastewater requires treatment
Coal Slurry Pipelines	Water for slurry transport, water not returned	Final water is poor quality, requires treatment
Barge Transport of Energy		Spills or accidents impact water quality
Oil and Gas Storage Caverns	Slurry mining of caverns requires large quantities of water	Slurry disposal impacts water quality and ecology

Source: BofA Merrill Lynch Global Research

US – energy to account for 85% of 2005-30E water consumption growth

The US energy sector accounts for 44% of water withdrawals and 6% of water consumed in the US, mainly via cooling for thermo-electric plants (source: Congressional Research Service). However, energy is set to be the fastest-growing water consumer and is expected to account for 85% of domestic water consumption growth from 2005 to 2030E (source: CRS). This will put additional pressure on water in the US, which we do not think the nation can afford, as we have highlighted with the example of California. Hence, shifting the current composition of power generation towards a more water-friendly mix is an important long-term solution.

Chart 110: US energy sector's freshwater consumption (billion gallons per day, bgd)



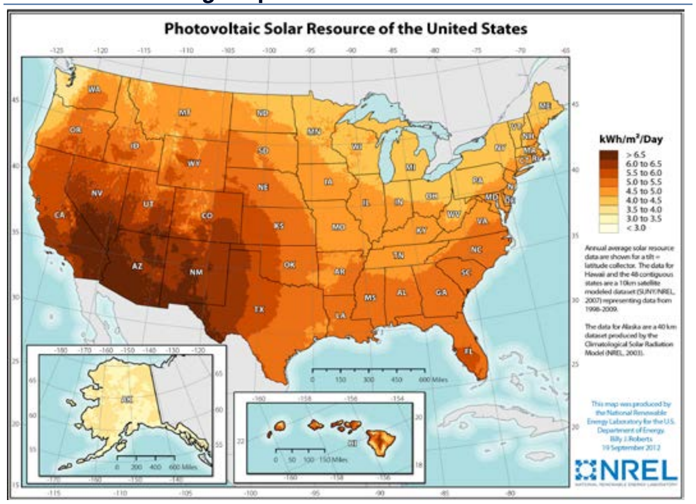
Source: Congressional Research Service (CRS)

US is rich in renewables resources

Solar has great potential in the South West

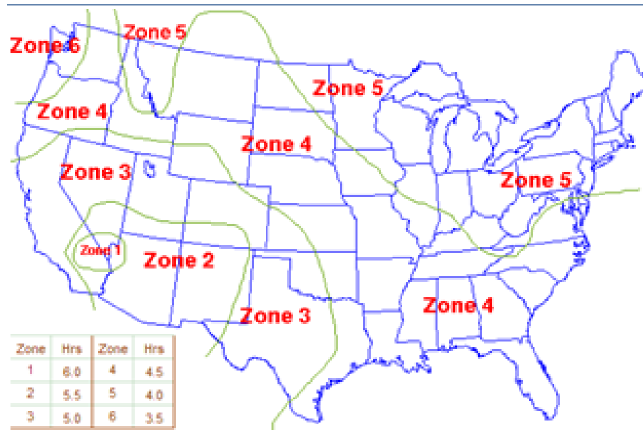
The US enjoys great solar resources in the South / South West, and we expect increasingly efficient solar panels to help drive performance vis-à-vis converting sunlight to energy. Counties in Southern California bordering Nevada and Arizona have the greatest amount of solar resources in the state, benefiting from an average of c.6kWh/m² per day (source: NREL). In addition, Southern California has counties that are the only "Zone 1" solar insolation regions in the US i.e. it has approximately 6 full sun hours a day (source: Wholesalesolar).

Chart 111: Solar has great potential in South / South-West



Source: NREL

Exhibit 67: Solar insolation - full sun hours less in North / North-East

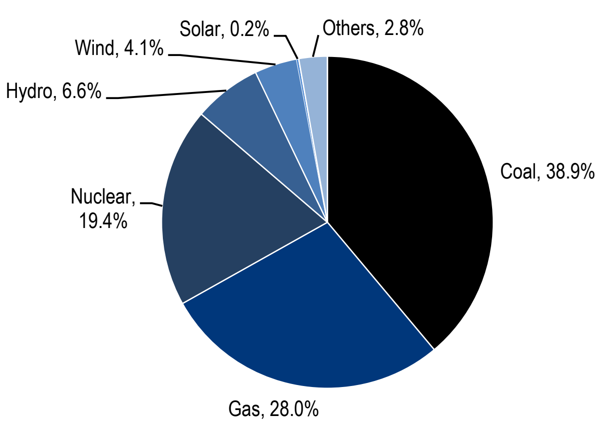


Source: www.wholesalesolar.com, NB: Winter figures for daily solar gain may be from 25% to 50% LESS than average.

Wind penetration still very low in the US

As per the charts below, wind penetration in the US is still very low and there is enough room to keep installing wind without any major risks to the grid (as an example, Spain and Portugal have c20-25% generation from wind compared to c4% in the US and there have been no grid issues in Spain/Portugal so far).

Chart 112: US 2013 electricity generation by source



Source: EIA data, BofAML Global Research

California's transition to water-friendly energy

In 2014, less than 10% of the state's electricity generation came from wind and solar, the most water-friendly sources of production (source: California Energy Commission). This is significant because the Southwest (including California) and Hawaii have been flagged as the two regions with the greatest opportunities to adopt more solar power by the CRS. Therefore, we expect wind & solar as a percentage of total power generation in California to increase, driving improved water efficiency-use in the state's energy sector.

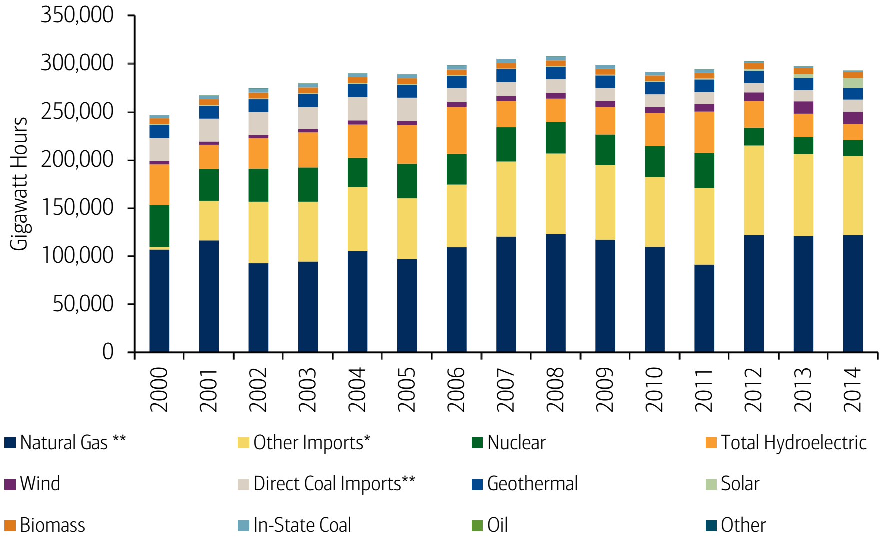
Table 61: US water opportunities and challenges in meeting energy demand with renewables

Region	Opportunities	Challenges
Southwest	High quality solar and geo/thermal resources	Water constraints and drought vulnerability favour more expensive, water efficient use of these renewable resources
Northwest	Generates most of its electricity from hydropower	diversifying to include more wind in light of environmental protections, increasing off stream uses and climate change effects on hydropower
Great Plains	May reduce water competitions among the thermoelectric and agricultural sectors by exploiting wind power to produce electricity	Grid balancing and transmission of that electricity, especially to other regions, may pose constraints. Increases in irrigation to support bioenergy crops may tax stressed aquifers
Southeast	Could reduce its dependence on coal and nuclear fuel and decrease its vulnerability to electricity. Interruptions during drought by producing electricity from biomass and photovoltaics	
Midwest	Could reduce competition between the thermoelectric and agricultural sectors and reduce the regional energy sector's low flow, drought and flood vulnerability by exploiting its wind resources	Overcoming significant regulatory transmission issues participating in the production of bioenergy crops, in particularly corn for ethanol, raising water quality concerns, including that excess nutrients in agricultural runoff are feeding the growth of the "dead zone" in the Gulf of Mexico
Northeast		Is not experiencing a regional issue with energy's growing water consumption, however, fracturing in shale gas formations is raising quality concerns
Hawaii	Could transition to water efficient power generation technologies to protect limited freshwater resources consumed in thermoelectric generation, which is dominated by oil-fuelled power plants	
Coastal regions, including Alaska	Potential to develop offshore wind, tidal energy, waves or ocean thermal gradient to reduce energy's onshore water use and land requirements	Public opposition, transmission challenges, resource availability mismatched with demand and natural hazards.

Source: CRS

We also believe the drought in California could be a catalyst for a transition away from water-intensive hydroelectricity power generation, towards more water-friendly sources such as wind & solar. Hydroelectricity production typically supplies 14-19% of the state's electricity (source: Pacific Institute). However, with less water available to generate hydroelectricity in California, renewable sources are increasingly being used to make up the difference. For instance, the renewables capacity added in 2013 and 2014, especially solar, made up for about 55% of diminished hydro-generation alone (source: Pacific Institute).

Chart 113: California Electrical Energy Generation Total Production, by Resource Type (GwH)



Source: California Energy Commission
*generation located physically out-of-state
**based on reported ownership shares and contractual arrangements for power purchases by California utilities

Golden State leading the US renewables charge

California generated more than 10,000GwH of solar energy and just under 6,000MW of installed solar capacity by end-2014 (source: California Energy Commission). The majority of renewable projects, both installed and approved, are solar-based. In fact, the world's largest solar farm, Solar Star, is located in Southern California (source: California Energy Commission). It has a 579MW installed capacity, comprising 1.7mn solar panels made by SunPower.

In addition, wind energy makes up a significant part of the state's renewables composition. In 2014, it generated c.13, 000GwH of wind energy and had c.6,000MW of installed wind capacity (source: California Energy Commission). The Alta Wind Energy Center is the largest onshore wind farm in the world (ex. China) with current capacity of 1,548MW, which could be developed to 3,000MW by 2040E (source: CES).

Wind could save California 18bn water gallons pa

If the state switched all its fossil fuel (coal and natural gas) energy production to wind, this could cut water consumption by 18 billion gallons annually, or roughly 45 days' worth of savings provided by the current Californian restrictions on household water use (source: American Wind Energy Association). Wind energy alone saved 2.5 billion gallons of water in California in 2014. This works out at c.65 gallons per person, 200 gallons per household or the equivalent of 20 billion bottles of water (source: AWEA).

Table 62: Large renewable projects in California

Project Name	Description
The Geyser	15 % of California's renewable energy (725MW) is generated via the world's largest geothermal facility at "The Geyser", located along the Sonoma and Lake County border.
Antelope Valley Solar Ranch	A 230MW PV solar generation project which is expected to provide 482 Gigawatt-hours of clean energy per year
California Flats Solar Project	A 280 megawatt (MW) AC solar project in Monterey that uses thin film semiconductor technology, has the capacity to power 100,000 homes in a year.
Solar Star	World's largest solar farm / power plant, 579 megawatt (MW) of installed capacity, 1.7mn solar panels
Genesis Solar Energy Centre	A 250MW solar generation facility that uses concentrating solar power (CSP) technology
The Ocotillo Wind facility	A 265 MW project they sells 100% of generated electricity to San Diego Gas & Electric
California Valley Solar Ranch	A 250 MW solar project in San Luis Obispo County which can power 100,000 homes.
Altamont Pass Wind Farm	Consisting of old generation turbines some of which will be repowered with the Golden Hills Project and the Patterson Pass Project
Alta Wind Energy Center	Nation's largest wind facility located at Tehachapi Pass, supplies 1,548 megawatts (MW) to SCE, will be developed to 3,000 MW through 2040
San Gorgonio Pass Wind Farm	Third largest windfarm with about 3,200 wind turbines with hundreds due for replacement

Source: Company filings, California Energy Commission (CES)

Table 63: Approved Large Solar projects

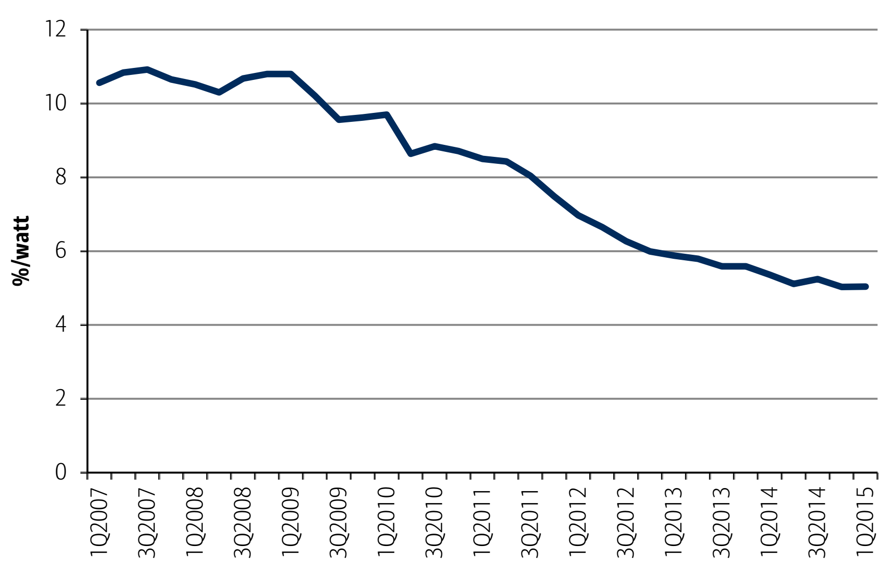
Projects	MW
Blythe Solar Power Project	485
Desert Sunlight Solar Farm Project	550
Genesis Solar Energy Project	250
Ivanpah Solar Electric Generating System	370
McCoy Solar Energy Project	750
Stateline Solar Farm Project	300
Abengoa Mojave Solar Project	250
Centinela Solar Energy Project	275
Imperial Solar Energy Center South	200
Imperial Solar Energy Center West	250

Source: California Energy Commission (CES)

Cost of solar has halved in California

The cost of solar for consumers in California has decreased substantially in recent years, reflecting the wider global trend. The average cost per watt fell from US$10.56 in Q1 2007 to US$5.04 in Q1 2015 vis-à-vis completed systems (source: California Solar Initiative). In our view, this highlights the increasingly compelling economics of cleantech and that it is no longer a high-cost maintenance energy source. We expect solar installation costs to continue to fall leading to greater potential uptake by Californian residents, especially in the rooftop solar space. For instance, California installed more rooftop solar capacity in 2013 alone (2000MW) than in the previous 30 years combined (1000MW) (source: California Solar Energy Industries Association).

Chart 114: Average completed system costs for the California Solar Initiative (US$ per watt)



Source: California Solar Initiative Statistics

Regulation also driving state-wide renewables adoption

California established a Renewables Portfolio Standard (RPS) programme in 2002, with the goal of increasing the percentage of renewable energy in the state's electricity mix to 20% of retail sales by 2017E. The standard has been revised several times since then with the goal of driving greater uptake of renewable energy production. The latest RPS revision in 2011 codified 33% of retail sales as the latest target by 2020E.

Table 64: Timeline of California's Renewables Portfolio Standard

Year	Action
2002	Senate Bill 1078 establishes the RPS program, requiring 20% of retail sales from renewable energy by 2017.
2003	Energy Action Plan I accelerated the 20% deadline to 2010.
2005	Energy Action Plan II recommends a further goal of 33% by 2020.
2006	Senate Bill 107 codified the accelerated 20% by 2010 deadline into law.
2008	Governor Schwarzenegger issues Executive Order S-14-08 requiring 33% renewables by 2020.
2009	Governor Schwarzenegger issues Executive Order S-21-09 directing the California Air Resources Board, under its AB 32 authority, to adopt regulations by July 31, 2010, consistent with the 33% renewable energy target established in Executive Order S-14-08.
2011	Senate Bill X1-2 codifies 33% by 2020 RPS.

Source: California Energy Commission

Furthermore, Jerry Brown recently called for a 50% RPS target by 2030E in his inaugural address in January 2015 (source: Governor of California Office). Other state drivers include the California Solar Initiative, which provides more than US$2bn worth of incentives to help consumers install solar photovoltaic systems (source: CSI). Overall, we believe regulatory factors should continue to drive renewables adoption in California.

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