Hydrogeology Journal
https://doi.org/10.1007/s10040-019-01979-0

ESSAY

Beyond ‘Day Zero’: insights and lessons from Cape Town (South Africa)

G. Thomas LaVanchy[1] · Michael W. Kerwin[2] · James K. Adamson[3]

Received: 18 December 2018 / Accepted: 15 April 2019

Abstract
Acute water security vulnerability at regional to local scales is becoming increasingly apparent. In 2017, officials in Cape Town, South Africa, designated the term “Day Zero” to demark an exact time when the city’s taps would be switched off due to critically low reservoir levels. Beyond Day Zero, residents would need to converge at communal water collection points to access a 25-L daily ration of water. The particulars of the crisis and stakeholder responses prove informative to other cities.

Keywords Groundwater development · Water security · South Africa

Introduction

An inadequate supply of clean water has significant implications for the health, economy, and food security of associated people and institutional structures. The shape of any particular water crisis is often complex, as evidenced by the range of causes, locations, and consequences. Acute regional-to-local-scale water security vulnerabilities are becoming increasingly apparent around the world. In 2017, officials in Cape Town, South Africa, coined the term “Day Zero” to mark an exact future time when most of the city’s taps would be switched off because of critically low reservoir levels. Beyond Day Zero, all residents would need to access communal water collection points scattered about the city for their ration of water (25 L/day). The reality of such a dystopian scenario in the tenth largest city in Africa (population 3.8 million) and one of the world’s most popular tourist destinations seemed implausible to the outside world, yet was actually discussed by Cape Town water managers as far back as 1990.

Water shortages in major cities are hardly new. Barcelona (Spain) dealt with one in 2008, Perth (Australia) in 2014, and São Paulo (Brazil) in 2015. Rome (Italy), a city designed around water transportation and storage, also experienced severe water shortages in 2017. In each case, drought was only part of the problem. Urban water managers must navigate a confluence of issues—increased demand from population growth, aging infrastructure, competing sectoral interests, and climate change. In Cape Town, consecutive years of record drought exposed a water management plan out of step with changing climate and growing demand. Setting an actual date for when the city could no longer supply residential water proved to be an effective motivation for conservation. It spurred a drastic reduction in water usage and allowed the forecasted Day Zero to be initially pushed back on the calendar, then avoided altogether with the arrival of winter rains. Now citizens and water managers alike are asking the question, *what have we learned?* Answers are illuminative for those in Cape Town and the rest of the world. The purpose of this essay is to draw attention to the particular factors driving water insecurity in Cape Town and contribute to a wider understanding of managing water in an increasingly complex global hydroscape.

Water insecurity in Cape Town: a confluence of factors

Day Zero was fundamentally a reckoning of supply with demand. Cape Town’s geographic position (33.9°S, 18.9°E) and

---

✉ G. Thomas LaVanchy
thomas.lavanchy@okstate.edu

Michael W. Kerwin
mkerwin@du.edu

James K. Adamson
james@northwaterco.com

[1] Department of Geography, Oklahoma State University, Stillwater, OK 74078, USA

[2] Department of Geography & the Environment, University of Denver, Denver, CO 80208, USA

[3] Northwater International, 2 Bolin Heights, Suite D, Chapel Hill, NC 27514, USA

proximity to cold Atlantic currents results in Mediterranean climate characterized by moderate year-round temperatures, persistent winter rainfall, and predictable summer drought. The City of Cape Town's water management system was designed for the predictable climate of the region. It draws from the larger Western Cape Water Supply System (WCWSS), comprised of six inter-linked reservoirs fed by rainfall and runoff from the Boland Mountains to the northeast of Cape Town (Fig. 1).

Until recently this unidimensional system provided sufficient water supply even during moderate drought and population growth. In 2014, the WCWSS system was 97% full and officials saw no need to expand capacity until the 2020s. Three subsequent years of record drought changed that perception. In 2015, reservoir levels peaked at only 71% of total capacity, in 2016 at 60%, and by January 2017 the system held 42%, prompting an introduction of level 3 water restrictions aimed at a 30% reduction in use. Because Cape Town is accustomed to recurring summertime drought, the city regularly imposes water restrictions in correspondence with reservoir storage levels after winter rains. Level 1 water restrictions (10% water savings) are imposed yearly during summer months, and increased restrictions if reservoirs drop to more critical levels. Despite these customary water-saving measures, the collective reservoir supply dropped to 28.6% of capacity by March 2017. Given the persistent rate of consumption, limited available water, and likelihood of no rainfall until June, a system balance of zero appeared imminent. Collectively, Capetonians and the world began counting the days until the taps were shut off. Following are contributing factors that pushed Cape Town to the brink of running out of water.

Disruptions to the normally predictable precipitation regime surrounding Cape Town are driven by wintertime shifts in the circumpolar vortex, by distant climatic forcings like the El Niño–Southern Oscillation, and by changes in nearby sea surface temperature (SST). Although these factors periodically result in drought, the years leading up to Day Zero (i.e. 2015–2017) produced historically dry conditions that pushed Cape Town's water management system beyond capacity (Wolski 2018). Now, water managers must consider system changes given the possibility that the magnitude of drought from 2015 to 2107 could represent a new baseline of reduced rainfall, especially if land–ocean climate dynamics have already altered the tracking and intensity of winter storms in the region (Richard et al. 2001). Of equal concern is the possibility that additional disruptions to the winter storm track will enhance regional desertification in the Western Cape (Stringer et al. 2009), and if reinforced by enhanced SST warming (Resplandy et al. 2018), result in a more permanent state of drought that would severely impact rainfall collection in the future—an obvious complication for city water managers.

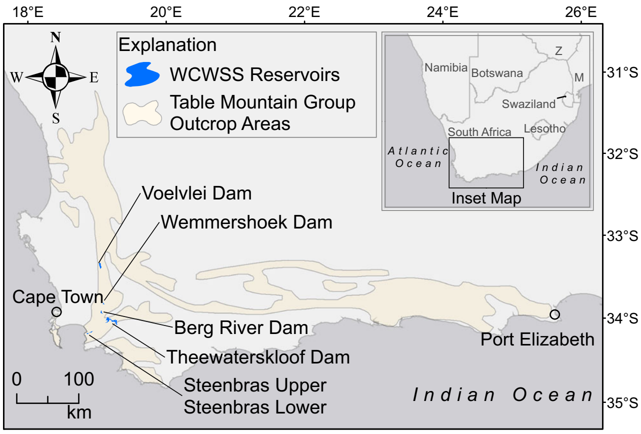

Fig. 1 Site map of Western Cape Water Supply System (WCWSS) reservoirs and the Table Mountain Group aquifer system (Z Zimbabwe, M Mozambique)

Storing runoff in large impoundments is a common approach to water supply in drier parts of the world. The WCWSS provides bulk water supply to Cape Town (324 Mm^3/year), the agricultural sector (144 Mm^3/year), and smaller nearby municipalities (23 Mm^3/year). As far back as 2007, Cape Town identified, evaluated, and assessed an array of intervention scenarios to reconcile water supply and demand. The impetus for this action was a report from the National Department of Water and Sanitation warning that Cape Town would need a new water source by 2015. After months of assessment and evaluation, Cape Town rolled out a strategy that focused entirely on demand management and conservation rather than supply augmentation. The city was confident that water meter replacements, leak detection, and pressure management could enhance their customary conservation strategy for handling droughts and that new water sources would not be required until at least 2025.

In retrospect, this approach proved inadequate and the resulting Day Zero crisis opened the door to criticism that water managers ignored an obvious need for augmented supply. In reality, however, this 2007 policy decision appears to have been strictly economic. A demand management approach is far less expensive and nimbler than the costly, time-consuming process of building out supply. Further, demand management has historically resulted in success for Cape Town. Indeed, small doses of this approach have been practiced yearly, whereby restrictions (and tariffs) are leveled at the onset of the summer (dry) season after the full accounting of winter rains are recognized in the reservoir system. Target amounts for daily consumption during the dry season can be projected to carry the system through to the next rainy season.

What can be learned: mistakes and success?

Failure to diversify Cape Town's water supply system with groundwater, recycled wastewater, or desalinated ocean water certainly was a contributing factor to the Day Zero crisis (Muller 2018). The possibility of functioning without household tap water, even on a temporary basis, provoked a range of responses across Cape Town. Some political leaders and water managers blamed climate change. Others attributed it to poor planning and partisan political dysfunction. Blame aside, many solutions were offered by academics, industry leaders, and armchair hydrologists. Cape Town water managers turned further to conservation using established mechanisms. Level 5 restrictions were imposed late in 2017 to drive collective consumption down to 500 million L/day. This level required each person to limit daily use to 87 L and restricted all outdoor usage. Level 6b restrictions were necessary by February 2018 to decrease daily usage to 450 million L. This tougher 50 L per person per day (L/pp/day) rallied water ambassadors across the city and even incited a Facebook page dedicated to positive peer pressure amongst affluent residents with higher water footprints. Officially, Cape Town deployed an enormous marketing campaign around the mantra “Together we can avoid Day Zero” to inform and compel all to do their part. This expectation was extended to visiting tourists and communicated visually to arrivals at the international airport. Water management devices were installed on the connections of high water users, fines levied for outdoor use violations, and an online map created to highlight households that met targets and expose those who did not. Citizens rallied. By July 2018, total daily demand dropped to 481 million L. This astonishing display of water conservation of 50 L/pp/day outperformed California (USA) during their 2016 drought (average of 412 L/pp/day) and Brisbane (Australia) after their “Millennium Drought” from 1996 to 2010 (167 L/pp/day).

An even larger hurdle for Cape Town in reducing consumption was its shared water allocations with the agriculture sector. Valuable fruit and wine farms in the Western Cape constitute nearly 25% of the demand on the WCWSS. The inherent tug between Cape Town and agriculture became acute during the arc of Day Zero due to the politics inscribed in water governance. Within South Africa, the responsibility for bulk water supply and power to make water allocations to agriculture lie with the national government, while municipalities are responsible for water delivery at the local level. (The Western Cape is the only province in South Africa run by the opposition party). Despite an alarming drop in reservoir levels over 2015–2016, water allocations to agriculture remained unchanged. Not until 2017 did the National Department of Water and Sanitation free up water supply to Cape Town by way of temporary agricultural transfers. Undoubtedly, this allowed Day Zero to be avoided, albeit with severe financial consequences for farmers who were unable to irrigate valuable crops.

Incrementally shrinking water targets allowed Cape Town to avoid Day Zero, but is not realistic as a long-term management strategy. Although conservation will be required for future success, stringent water targets actually produce thin margins from which to respond to drought anomalies. For Cape Town to thrive socially, economically, and environmentally, a diversified portfolio for water provisioning must be sought.

A role for groundwater

Managing water requires a long view and persistent commitment. Time shows us that governments change, climates change, and residents are quick to grow weary of austerity measurements. How then is long-term water security accomplished? In Cape Town, planning for a future with warmer temperatures, inconsistent rainfall, and higher demand necessitates a multidimensional approach with solutions that are flexible and resilient to the changing environment—be it built or natural.

Groundwater is arguably the most important natural resource of the Western Cape and should be understood as a resource to be explored and managed as a water savings account. Three primary aquifers provide opportunity to augment Cape Town’s existing water supply and provide emergency supplies to prevent drought-related disaster. The largest of these is the Table Mountain Group (TMG) aquifer, which is relatively well studied, considering its limited development.

The Ordovician to Carboniferous age sandstone bedrock formations outcrop across an area the size of Switzerland (Fig. 1) and soak up as much as 50% of annual rainfall in some localities (Duah 2010). Up to 4,000 m thick, the TMG aquifer stores billions of cubic meters of freshwater and dwarfs the 570 million m^3 storage capacity of the six reservoirs of the WCWSS. It can be conservatively estimated that greater than 1 billion m^3/year of recharge occurs across the regional TMG outcrop areas, which is over three times greater than Cape Town’s bulk water demand. The quantities of water available in the TMG is no secret, Cape Town has been investigating the aquifer for decades and drilled exploratory wells long before any mention of Day Zero. Although groundwater abstraction from the TMG is part of the city’s current plan, there are reasons why pumping from the TMG aquifer has only recently begun.

The question of renewable water resources and sustainable yield is a sensitive one, as aquifer replenishment and flow varies spatially and temporally, especially in a complex and regional aquifer like the TMG. Studies have indicated that the aquifer has filled up over decades to many thousands of years (Wu 2005). Misjudging or misunderstanding the recharge and dynamics of local groundwater behavior when commissioning a well field presents potential consequences to ecosystems, streams, and other active and passive uses of the aquifer. Already, several large well fields in the aquifer have caused drawdown impacts of greater severity than originally predicted by experts. Sensitive fynbos ecosystems dependent on the aquifer have many ecologists concerned about a rush to capitalize on this largely untapped aquifer resource. Additionally, water quality presents a potential challenge to existing infrastructure given the lower pH and corrosive nature of the groundwater. There are certainly a host of scientific, technical, and operational considerations that need to be addressed to incorporate groundwater into a system traditionally supplied by surface water.

A successful vertical borehole in the TMG aquifer can potentially yield 0.3–1.0% of the daily demand of Cape Town; however, it would take a large number of such wells spread across a large geographic area to meet the regular bulk water demand, not to mention the arduous task of managing the resource and mitigating impacts. This equation changes, however, when the restricted allocation demand scenario is considered (Vrba and Renaud 2016). During intense drought conditions, a well field(s) with a reasonable number of wells could be strategically deployed to provide sufficient water, avoiding the subject of Day Zero. In these instances, groundwater could be exploited for a short period, perhaps as long as several years in an extreme case, before allowing the aquifer to replenish and recover until needed again.

Groundwater development can be complemented with managed recharge from seasonally available surface water and wastewater sources to increase availability and mitigate negative impacts associated with larger-scale abstraction. This approach is already occurring in the Atlantis aquifer and appears to be the intended management approach by the city in the Cape Flats aquifer. The regional zones of higher porosity and permeability in the TGM bedrock may also present an opportunity to preserve critical seasonal surface water. Surplus seasonal flows could be stored in the subsurface reservoirs, perhaps through a network of wells. In addition to reducing evaporation losses, this integrated surface and subsurface approach would provide a further buffer to drought and certainly warrants further evaluation.

Accessing groundwater with traditional wells may not represent the most effective approach to abstraction from a discontinuous fractured bedrock aquifer when serving a large global city. Given advancement in subsurface technologies, the TMG geology appears better suited for subsurface tunneling solutions to access groundwater stored within the aquifer. From local-scale single tunnels that target a fault zone, to a regional tunnel network, nontraditional opportunities are worth consideration.

Summary and perspective

Drought and water crises have impacted several major cities over the past decade. Cape Town's brush with Day Zero, however, is unique in how rapidly its water management plan became unstable, as well as the unprecedented human response of water conservation. With reservoir levels peaking to nearly 75% of capacity at the end of the 2018 rainy season, Cape Town will likely avoid another water supply catastrophe. However, the city must grapple with the fact that reliable, repetitive storms may no longer inundate the region each winter and that climate model projections for the late twenty-first century warn of even less annual precipitation, including wet days and extreme high precipitation events (Abiodun et al. 2017). Inevitably, the city must accept that reservoir storage alone is incapable of maintaining water stability for the various sectors dependent on the WCWSS and that reliance on residents to drastically reduce consumption is tenuous and further complicated by the consumption needs of >1.5 million annual tourists who may be unwilling to participate in extreme conservation measures.

Cape Town must adopt a groundwater management approach that is adaptable and can evolve as more is learned about the aquifer(s). It must avoid an arbitrary approach to aquifer management based solely on a water-budget balance, and systematically define solutions unique to each area of the aquifer that balance the impacts with the benefits of groundwater use (Green et al. 2011). Even if drought conditions temporarily abate, Cape Town must have redundancy in its water supply by embracing groundwater withdrawal, limited desalination, and wastewater recycling. In this manner, Cape Town could rise as a regional leader in the responsible and sustainable management and protection of the most important natural resource in South Africa's Cape provinces. More broadly, Cape Town's journey to the brink of water catastrophe can serve as an example, and to some degree, an inspiration to other global cities.

Acknowledgements The authors are grateful to the associate editor and the editorial team at *Hydrogeology Journal*.

References

Abiodun BJ, Adegoke J, Abatan AA, Ibe CA, Egbebiyi TS, Engelbrecht F, Pinto I (2017) Potential impacts of climate change on extreme precipitation over four African coastal cities. Clim Change 143(3–4):399–413. https://doi.org/10.1007/s10584-017-2001-5

Duah A (2010) Sustainable utilization of the Table Mountain Group Aquifers. PhD Thesis, University of the Western Cape, South Africa, 182 pp

Green TR, Taniguchi M, Kooi H, Gurdak JJ, Allen DM, Hiscock KM, Treidel H, Aureli A (2011) Beneath the surface of global change: impacts of climate change on groundwater. J Hydrol 405:532–560. https://doi.org/10.1016/j.jhydrol.2011.05.002

Muller M (2018) Lessons from Cape Town's drought. Nature 559:174–176

Resplandy L, Keeling RF, Eddebbar Y, Brooks MK, Wang R, Bopp L, Long MC, Dunne JP, Koeve W, Oschlies A (2018) Quantification of ocean heat uptake from changes in atmospheric O_2 and CO_2 composition. Nature 563:105–108. https://doi.org/10.1038/s41586-018-0651-8

Richard Y, Fauchereau N, Poccard I, Rouault M, Trzaska S (2001) 20th century droughts in southern Africa: spatial and temporal variability, teleconnections with oceanic and atmospheric conditions. Int J Climatol 21(7):873–885

Stringer LC, Dyer JC, Reed MS, Dougill AJ, Twyman C, Mkwambisi D (2009) Adaptations to climate change, drought and desertification: local insights to enhance policy in southern Africa. Environ Sci Pol 12(7):748–765. https://doi.org/10.1016/j.envsci.2009.04.002

Vrba J, Renaud FG (2016) Overview of groundwater for emergency use and human security. Hydrogeol J 24:273–276. https://doi.org/10.1007/s10040-015-1355-x

Wolski P (2018) How severe is Cape Town's "day zero" drought? Significance 15(2):24–27. https://doi.org/10.1111/j.1740-9713.2018.01127.x

Wu Y (2005) Groundwater recharge estimation in Table Mountain Group Aquifer Systems with a case study of Kammanassie. PhD Thesis, University of the Western Cape, South Africa, 308 pp