IT TAKES A TEAM: HELPING MEGACITIES BUILD WATER SECURITY IN THE FACE OF SOCIO-ECONOMIC AND CLIMATE CHANGE CHALLENGE

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ABBREVIATIONS

ABSTRACT

Megacities in the developed and developing world face different challenges and opportunities than smaller communities. In times of drought, floods, and water stress, the scale of potential economic and social disruption goes well beyond their borders, and they can be helped or hindered in creating resilience by actions of their state and national governments. With climate-related water scarcity, large scale communities dependent upon water imported from vast distances are at particular risk to disruption. In addition, the provision of basic water supply and sanitation is a critical component of public health protection and economic security. Fortunately, there are areas with decades of experience transitioning enormous water systems dependent upon distant imperiled watersheds to more diverse and resilient sources combined with a greater environmental commitment. Moreover, there are communities using innovative methods and appropriate technologies to meet their economic and public health needs. These forward thinking communities can serve as examples and best practices for the rest.

This paper/panel describes the actions and responses taken by four major urban metropolises to growing challenges in their areas. Melbourne, Australia, the greater Los Angeles metropolitan region, US, eThekwini Municipality, South Africa, and Denver, US, have to adapt to a more constrained water future through integrated water management, nature-based solutions, and innovative technologies to provide basic water and sanitation needs, or to extend scarce water supplies. It also discusses what their state and national governments have done to incentivize or impede this transition through historic droughts and into an uncertain climate future. Finally, this paper makes suggestions for what state and national partners can do (and not do) to help large metropolitan areas succeed on their paths to resilience.

1 INTRODUCTION

The history of the rise and fall of civilizations can frequently be traced to the availability of adequate water supplies, and how changes in water availability affected their evolution, their innovation, or their dissolution. So too with the fortunes of cities, large and small. In some cases, cities had and still have ample local and imported water resources. In others, especially with growing populations and the spectre of climate change impacts on their water prospects or predictability, achieving sustainable

water supplies for basic sanitation and sustenance, as well as economic prosperity and quality of life, is more challenging. In some cases, cities have made great strides in improving water supply and/or sanitation and can continue to meet their needs if they implement their plans. In others, there is a need to accelerate the pace and nature of improvements to meet the coming challenges. Many cities have benefited from funding, clear policy and regulation, or other assistance from their state or national governments, but others have been hindered in some way by regulation, the lack of regulation, or the lack of incentives or available funding or staffing.[7]

In the examples that follow, we set forth briefly the stories of four large metropolitan regions with some similar and some different challenges, with an eye toward how the state or national partners helped or hindered the process of creating more resilient water supplies or sanitation, or changed what they were doing to accommodate the needs of the metropolitan region. These efforts stand against a backdrop in some cases of a history of national or state policy makers or regulators pursuing traditional "command and control" approaches to prohibit actions or set tough standards, who then become more strategic partners in helping the large city achieve its vision or stepped back to let the region experiment with innovation. In others, the state had to drive the pace of local efforts through creative policy or regulation coupled with incentives and assistance. In still others, the state or national government learned from the local region and is now sharing that innovation.

We are at the stage of the quest for resilient water supply in the face of climate change, and ever more acute awareness of the need for clean water and adequate sanitation in regions around the developed and developing world, where we need to accelerate the pace of creating resilient supplies to ensure sustainability in the face of population growth and reduced flows or increased flooding.[8] To meet those challenges, intergovernmental strategic partnerships will be essential. Meeting the United Nation's Sustainable Development Goal 6 (SDG6) goal of Clean Water and Sanitation will not be achievable otherwise. While not suggesting a magic formula to deal with these increasingly challenging water problems, we do suggest that there are many creative and useful ways for state and national actors to become more strategic partners with major metropolitan regions hoping to meet the climate challenge. While legal, economic, cultural, and historical factors come into play in how policy makers and regulators do their jobs, the mindset with which they approach it can make a profound difference in outcome.

2 CHALLENGES FACED BY THE MEGA-REGION AND HOW THEIR POLICY AND/OR REGULATORY PARTNERS ENGAGED WITH THEM ON SOLUTIONS

Melbourne, Victoria, Australia:

Melbourne, the capital of Victoria, a state in Australia, is a city with a population of 5.1 million people. Its water supplies are mostly derived from surface water in its major catchment, with large transfers from neighbouring catchments.

The Millennium Drought in Australia (late 1996 to 2010) was a threshold event for Melbourne's water managers. It was the longest and most severe drought on record and affected most of southern and eastern Australia. Melbourne's catchments experienced reductions in average annual inflows of approximately 30 - 50% across the full 13 year period. In addition, in 2006/07 after 10 years of below average rainfall, the region experienced its lowest ever inflow year. Across Victoria, inflows to river basins and reservoirs were just 26% of the long-term average streamflows and that period was followed by another consecutive string of dry years (DELWP, 2016). These conditions were worse than those predicted to occur in 2050 under the worst-case climate change scenarios.

Effectively, for Melbourne, the Millennium Drought was not only an event to be managed through at the time – it was also 'the portent of things to come.' As a result, building resilience to water scarcity became a critical objective of the Victorian government and governments around Australia.

In Australia, state governments are responsible for land and water management. They set the policy framework for water management and own urban water utilities. They provide strong policy guidance to utilities on how their functions must be undertaken and have established regulators (including health, environmental and economic) to ensure that these functions are undertaken to standards set by the state government efficiently and effectively. For Melbourne, the policy framework for water provision is set by the Victorian state government and water services are provided by a single wholesale water, sewerage and regional stormwater manager and three retail water and sewerage utilities – all government owned. Local governments are responsible for local stormwater management and statutory land planning.

In response to the drought, the Victorian Government reviewed its approach to water management and the issue of Melbourne water supply. The new policy, *Our Water, Our Future* (Victorian State Government, 2007) shifted the focus for water management in Melbourne, outlining a policy framework for increasing resilience through:

- Augmenting and diversifying Melbourne's water supplies with the construction of the biggest desalination plant in the southern hemisphere
- Making better use of existing supplies through networking water supply systems – establishing a more effective water grid
- Encouraging the use of recycled water and stormwater including through the government setting targets for the non-potable use of recycled water for water utilities
- Supporting water conservation programs to reduce demand and setting indicative targets for household consumption (i.e., a target of 155 litres (L) per person per day)

As a result of this combined with water restrictions, water use in Melbourne dropped by more than 26% on pre-drought levels. This saved over 250 gigalitres between 2002 and 2007 allowing authorities time to augment supplies (Office of Living Victoria, 2013) with the desalination plant and improved connections. Moreover, despite the return to wetter conditions in 2011, water usage has remained at near the target of 155L per person per day. In 2018/19, average water usage was 162L per person per day (DELWP, 2020), showing that many of the water savings initiatives have effectively become "hard-wired in" and that Melburnians remain committed to water conservation. In addition, Melbourne now recycles 18% of its effluent for irrigation and household outdoor use and toilet flushing. (ESC 2019).

This policy approach to increasing the resilience of water supply continues today as Melbourne faces the combined challenges of increased population growth and climate change. Its population is predicted to rise, by two thirds, to 8.5 million by 2050. In that period, catchment yields are expected to reduce by 10% to 30% due to climate change. (Melbourne Water, 2017). In addition, since the Millennium Drought, urban communities are far more aware of the significance of green space and the importance of water in the landscape to health and wellbeing, potentially creating an additional demand for water to provide for this purpose. (This has been particularly emphasized in recent times as people have been confined to their local suburbs during Covid 19 conditions.)

To deal with these contemporary challenges, the Victorian state government has evolved its policy position further to encourage and facilitate a more integrated approach to urban water management (Victorian State Government, 2016) – seeking to use stormwater and recycled water fit-for-purpose water sources for irrigated agriculture, industrial use and for parks and reserves. Whilst Melbourne water customers pay the full costs of their water services (including capital, operating and government dividends and the costs of economic dividends), the state government has provided some funds to incentivise integrated water cycle management (IWM), to encourage water managers to

collaborate and work with statutory land and city planners and assist in pilot projects. They have established a framework and provided funding for the establishment of IWM forums and the development of IWM plans covering most of the city – including both growth and infill areas (DELWP, 2017). These require water utiltities to collaborate with local governments and planning authorities to determine priorities for better integration, agree on priority projects and establish arrangements to build and manage them. The government has also subsidised a number of pilot projects.

As a result of both the strong state government policy environment and the proactive approach to its implementation taken by water utilities, Melbourne is moving towards a future where water supply, wastewater management and stormwater management are planned and managed in an integrated way creating a diverse set of fit-for-purpose water supplies at both local and system scales, where liveability is maintained through the provision of green space and where Melburnians are encouraged to conserve water. This has really come about through ongoing strong relationships between the state government and its water utilities with a common understanding of the problem, based on the relatively recent experience (and "scars") from the Millennium Drought. This, together with the predicted climate change impacts, has created a real and shared imperative for all to cooperate to deal with it.

However, it has not all been smooth sailing - there have been mistakes along the way and lessons to be learnt. For example, the mandating of water recycling targets by the state, whilst increasing the volume of recycled water used, skewed investment towards higher cost projects that were often unsuccessful in achieving their objectives so customers paid more than they should (Productivity Commission, 2020).

In addition, the government has drawn the line at potable use of recycled water and will not allow it at this time. This means that potable reuse (whether indirect or direct) cannot be considered by water utilities even if it is the best and least cost solution – it also means that using recycled water for non-potable use requires a separate distribution network (often known as purple pipes) making these options far more expensive than they could be.

Finally, achieving the policy outcomes of integrated water management requires collaboration in a range of new spheres and at a range of scales – collaboration between policy-makers and regulators, between water managers and city planners, between water utilities and local governments. Whilst there is serious enthusiam for the IWM approach from water utilities and a number of local governments , it is early days and it will take some time to break down the institutional silos and formalise new relationships in ways that will embed the approach as 'the normal approach to business' by all players. They are still learning how to establish these relationships, manage them in the long term and importantly how to share the costs and risks of this new approach to water management.

Greater Los Angeles Metropolitan Region, California, US:

The greater Los Angeles metropolitan region of California, US, is home to over 14 million people, with over 4 million in the City of Los Angeles (City), and over 10 million in the County of Los Angeles (County) living in more than 80 communities. The City has its own water supply and sanitation departments, while the County's communities are served by a multitude of different water supply departments and is largely served by a special district that collectively manages wastewater, the Los Angeles County Sanitation Districts (LACSD). The County also manages a decades old system for stormwater capture and replenishment of many of the region's groundwater basins, while other agencies do so locally, including the City. The region is highly dependent upon imported water from hundreds of miles away which is provided via the Metropolitan Water District of California (Metropolitan), the largest wholesale water provider in the nation, and the City of Los Angeles Aqueduct from the Owens Valley.[9]

Already quite advanced in conservation, recycling, and stormwater capture, especially since the drought of 1986-1992, the region remains extremely vulnerable to disruption of imported water supply due to natural disasters, infrastructure failures, or the longer and deeper droughts predicted for California

and the other western basins feeding the Colorado River under various climate change scenarios. During and since the most recent drought (2011-2017), the City and County have greatly expanded both their aspirations and their plans. For example, the County developed and passed a $300 million/year funding measure to implement a massive multi-year effort to build multi-benefit projects to capture stormwater for water supply replenishment, to increase urban greening, to protect water quality in the area's receiving waters, and to provide flood control. (LA County, 2020). Metropolitan has partnered with the LACSD and others to propose what will be the largest groundwater replenishment project with recycled water in the world. (Metropolitan APC, 2020). The City, under Mayor Garcetti's leadership, has augmented its already ambitious Water Directive, which aims to dramatically cut reliance on imported supplies by 70% by 2035 through a combination of conservation, water recycling, stormwater capture, and cleanup of legacy groundwater contamination, including a commitment to recycle 100% of the City's wastewater. (EauMega, 2015; LA Green Plan, 2019).

As the most recent drought—the worst in California's recorded history--hit California (in addition to the longer term and continuing drought on the Colorado River system), the state stepped in to accelerate the pace of progress on conservation, water recycling, and stormwater capture across the state through the California Water Action Plan.[10]

The state's efforts included a range of funding, legislation, regulation, and operational help. Two examples of note here were measures to use the traditional regulatory authority of the State Water Resources Control Board (Board)[11] more creatively to strategically assist large urban areas adapt to climate change and increased risk of longer and deeper droughts. With respect to water recycling, the Board offered over $1.5 billion in grants and reduced interest 1% loans to help move projects from the drawing board to construction. It also issued statewide permitting standards for advanced recycled water use to speed permitting and enable bigger vision.[12] To help with stormwater capture, the state devised an innovative permitting option to incentivize multi-benefit actions to capture stormwater for flood control, water supply, water quality, and urban greening with scarce local dollars.

The setting of--or even setting a deadline for setting--statewide recycling rules enabled and incentivized local water agencies to envision bigger projects involving indirect or direct potable reuse (advanced reuse). Historically, to achieve an advanced reuse permit of any size meant navigating individual regional water quality board and drinking water regional staff to negotiate a permit. The permits could vary greatly in requirements, and perhaps more significantly, took a great and unpredictable amount of time to obtain. Setting statewide rules through robust stakeholder processes that used expert panels allowed the state to set standards that protect public health while enabling projects to be planned with the confidence that they would be permitted. To take just two examples, because of the standards set for groundwater recharge in 2014, reservoir water augmentation in 2018, and the promise of Direct Potable Reuse regulations by 2023, the City of Los Angeles was able to commit to recycle 100% of its wastewater by 2035 and the Metropolitan Water District partnered with the Los Angeles County Sanitation Districts to propose what will be the largest recycled water groundwater augmentation project in the world.[13] The regulations gave both the City and Metropolitan the confidence to envision more efficiently integrating recycling at a larger scale into their systems in the long-run through replenishing their groundwater and augmenting existing drinking water systems rather than planning thousands of miles of separate expensive and disruptive "purple" piping. They also didn't have to guess what the local level permitting agencies might require and how long it would take to gain a successful permit.

With respect to stormwater capture, the Los Angeles Regional Water Quality Control Board developed and the State Board approved a provision in the Los Angeles County Municipal Separate Storm Sewer System permit (MS4), a permit traditionally focused only on water quality in receiving waters, to allow for certain flexibility in timing and other measures for local agencies who chose to commit to larger scale multiple benefit actions rather than simply meeting meeting water quality

standards. The multiple benefits include enhanced flood control (through diverting flows), groundwater supplies (through retention and percolation), water quality (through retaining water that would otherwise flow to the ocean carrying pollutants), and urban greening. The permit allows some flexibility in compliance time because these projects require more time and effort across traditional silos, and cost more but can achieve greater benefit. The permit was an effort by the state regulatory agency to help create incentives for doing the hard work of working collaboratively across a vast area at a watershed scale.[14] While by no means the determining factor, the incentives played some part in stakeholders proposing and supporting a countywide funding measure to fund multi-benefit projects that may not have happened otherwise.[15]

In summary, the greater Los Angeles area is accelerating its climate adaptation plans and programs to meet the challenge of climate change. State regulators are using their authorities to incentivize and help accelerate those actions through setting standards at the statewide level that allow for efficient and more predictable planning, and through allowing flexibility in permitting when presented with creative multi-benefit approaches.

Denver, Colorado, US:

The Denver, Colorado, US metropolitan area covers 8,300 square miles (21,600 square kilometers) and is home to almost 3 million people. The largest water provider in the area, Denver Water, serves 1.5 million people in the city and surrounding suburbs. Established in 1918, it is the State of Colorado's oldest and largest water utility, funded by water rates and new tap fees, not taxes.

The utility's water supplies come from local in-basin sources in the South Platte River watershed and from out-of-basin diversions from the Colorado River watershed flowing in large and expensive tunnels and pipelines carved through the Rocky Mountains under the Continental Divide (Denver Water). This is an area of the US where climate change impacts on water supplies are projected to be severe. In the Colorado River basin, climate scientists project a 20-30% decrease in flows by 2050 and a 35-55% reduction by 2100. (Udall & Overpeck, 2017). The South Platte River Basin picture is similar with decreases in the 10-34% range by mid-century. (DHS Climate Change, 2015; WWA Climate Change in CO, 2014).

The state-based allocation system for water rights applicable to Denver Water's sources is called "prior appropriation," otherwise known as "first in time, first in right." This means that when supplies are low, only those water rights with senior priorities are allowed to divert. There is no "share and share alike" concept in this water allocation scheme. While some of Denver's in-basin water sources have senior priorities, others do not, and virtually all of the out-of-basin sources are quite junior in the overall system. As a result, climate change impacts can be more than just incremental, and potentially devastating. The utility is also subject to intergovernmental agreements that require maximum reuse of its out-of-basin supplies. (CRCA, 2013).

Like other major municipal water suppliers, Denver Water is moving toward a OneWater approach (One Water), similar to Integrated Water Cycle Management in other parts of the world, and utilizing recycled water to the extent possible to reduce reliance on imported supplies and decrease treatment costs by using "fit for purpose" water rather than highly treated drinking water for uses like toilet flushing or outdoor use. (Denver Post, 2017). New commercial and industrial development within the Denver Water service area have plans for the use of recycled water, including the new National Western Complex and Denver Water's own corporate campus. (Tap, 2018).

The State of Colorado regulates drinking water supplies and the use of reclaimed water under the federal Safe Drinking Water Act and Clean Water Act and the Colorado Water Quality Control Act.[16] Regulation is administered by the Department of Public Health and Environment and its Water Quality Control Division. Use of reclaimed water is currently limited to non-potable uses, but investigation of direct potable reuse is underway.

Colorado water regulators are directed by statute to "encourage" the use of reclaimed domestic wastewater and graywater,[17] but in practice, the regulators have not been particularly encouraging, being dragged reluctantly into accepting proposed new uses and technologies. The primary mission of drinking water regulators to protect the public health makes it much safer to say no than yes to proposals for new reclaimed water uses and incorporation of new technology. After the widely publicized problems with lead-contaminated drinking water in Flint, Michigan, water quality regulators are concerned not only about protection of public health, but also about their own potential personal liability if they approve innovative new methodologies or uses that do not turn out well.[18]

Denver Water has been increasing its reclaimed water capacity for the past 20 years but finds the regulatory environment conservative. For example, when planning for its new corporate campus to utilize the OneWater approach, Denver Water found that the regulatory framework would not accommodate the use of reclaimed domestic wastewater to flush toilets, and regulators not inclined to change the rules. This regulatory impasse prompted state legislation in 2018 that directed the state regulators to promulgate rules to allow such uses.[19] Other bills also passed that year to allow reclaimed water use for irrigation of edible crops and cultivation of hemp.[20] This piecemeal legislative approach to expansion of the regulatory structure does not allow for the full and beneficial application of expertise in the regulating agency, and is less than ideal. A much more deliberate and collaborative process is now underway in Colorado to address a new regulatory framework for direct potable reuse of water that includes agency personnel, multiple stakeholders, technical experts, and an outside facilitator.

Restricted and inadequate funding is a primary factor inhibiting the ability of Colorado state regulators to think creatively and work with prospective reclaimed water users to both protect the public health and allow reuse. In Colorado, one person in the Water Quality Control Division works half time on reuse regulation. That time is understandably devoted primarily to regulatory oversight, with virtually no ability to investigate proposed new uses or technologies. To address this problem, Denver Water and two other state agencies that focus on water supply and sustainability have pooled funding to provide support for one additional full-time employee at the Water Quality Control Division to focus on reuse. Outside funding is also being provided for a facilitator to work with the regulatory agency on the stakeholder outreach component of the evaluation of potable reuse.

Denver's experience underscores the adverse impact of lack of funding and understaffing at the water quality regulatory agency. Without adequate resources to allow investigation of potential new uses of recycled water and innovative approaches, progress on more complete and efficient utilization of water is reduced. This problem can be mitigated with targeted provision of funding by other agencies and regulated entities, but adequate direct state funding support for the regulatory agency would be preferable and not subject to charges of conflicts of interest. Water quality regulators will be better able to consider new projects and weigh competing interests if they fully appreciate the value of resilience in municipal water supplies and the connection with reuse of water. Appropriate regulation of sensible recycled water projects with full protection of public health will allow water providers to more effectively utilize existing supplies, create resilience, and reduce stress on already over-appropriated systems. As described in the section of this paper on the greater Los Angeles metropolitan area, an integrated approach in which all parties are tasked with achieving multiple goals, including both public health protection and the conservation of overall water supplies, is likely to result in a better outcome.

eThekwini, KwaZulu-Natal, South Africa:

The eThekwini water story illustrates both the challenges and triumphs of transitioning from the Apartheid doctrine of race-based discriminatory servicing to a human rights approach in now Democratic South Africa. The latter is defined by the desire for universal servicing based on the difficult balance between a pro-growth aspiration and pro-poor agenda. From a national policy perspective, the Water Services Act (1997) and the National Water Act (1998) became the legislative enablers for water and sanitation governance, planning and delivery. One of the pillars of the Apartheid legacy is race and gender based inequality. In modern times, South Africa's economic strategy choices have deepened

the inequality, which continues to manifest itself in the supply of water and sanitation services. However, considerable progress has been made in water and sanitation service delivery in South Africa, where legislative and policy frameworks for water services are some of the most progressive in the world.[21]

The eThekwini Municipality, with Durban at its centre, is a metropolitan municipality with a population of 3.5 million people. In 2001 the population was 3 million people but rapid urbanisation and the inward migration of people from neighbouring municipalities was leading to population growth putting pressure on water resources (of which 75,000 were new rural households, with 60,000 having no access to improved water services). The Water and Sanitation Unit (EWS) in eThekwini Municipality[22] has dealt with a complex fabric of challenges over the years. The synergistic relationship and coexistence between national and local levels of government has demonstrated how practice at a local level can shape water and sanitation policy. This section shares some of the many innovative interventions which have led to successful policy formulation and influenced water governance, access to water services for the poor, and dealt with water security. In many ways the City of eThekwini has been a pioneering demonstration site for the national Water Law and policy imperatives. Acting with a reasonable degree of independence as a Water Services Authority, it has introduced some world class innovations in this domain. They include:

- **Pioneering concepts of Human Right to water:** One of the important legacies of its Apartheid history results in eThekwini Municipality facing with high levels of race-based poverty and unemployment. Approximately 40% of the residents earn less than $2 a day (Macloed, 2013). This required innovative approaches for providing water to the more than half a million residents who lacked access to water services, by setting a tariff structure that recognized the social, political and economic costs of pursuing payment for water. Also disrupting many norms of issues related to informality and poverty, EM saw every person and household as a customer. It believed that besides improving health of its citizens, it would also contribute to economic growth and reduction in vandalism of infrastructure. Using fiscal transfers and cross-subsidisation smartly, they demonstrated that it was financially viable to provide water services to this unserved population. While the right to water was recognized, the execution of such was a challenge. In 2001, encouraged in part by the eThekwini Municipality's experiment, the South African government formalised a policy decision to provide 6,000 litres of free basic water (FBW) per household per month to poor citizens.
- **Pioneering different levels of services:** Giving effect to the FBW water policy meant that eThekweni had to come up with some smart technical solutions. The Municipality was the first in the world to introduce four levels of water services. These were aligned to the sanitation offering as well, which ultimately also led to the Free Basic Sanitation Policy (FBS) (DWAF, 2009).[23] The interventions include elements such as mechanical and electronic dispensation devices, trickle feed water technology to a very novel water bailiff support program. This was achieved within a progressive rising block tariff where the first block was the FBW component. These interventions have not only given direction to national policy, norms and standards and practice, but also influenced globally practice in the developing world.
- **Driving sanitation innovation:** EWS has made significant and important strides in the provision of sanitation services to its residents since the introduction of free basic sanitation policy (DWAF, 2009). Inheriting around more than 30,000 Ventilated Improved Pit (VIP) latrine (an improved form of on-site dry sanitation technology) toilets through the Municipal boundary demarcation process and further in the period up to 2011, pioneering nearly 90,000 Urine diversion alternating twin pit VIP (UDATPVIPs), the city was faced with several challenges on sustainability. Unlike water, sanitation reared a greater challenge and opportunity within its sanitation edge approach. It was clear that a newer and disruptive approach was required. Some of these interventions were as follows:
    - Introducing the world's first coordinated and organised faecal sludge and pit emptying management strategy, where on a five year cycle (based on operation and economics) the city offered a free emptying service for onsite dry sanitation systems.
    - Further driving innovation, instilling a sense of circular economy approach where faecal sludges were designed to be processed to valuable by-products. It introduced technology that can process 12 tons of sludge a day into organically safe pellets as a fertiliser. Linked with this was attempts to harvest urine and recover the nutrients for reuse in agriculture in

an attempt to transform human waste into forms that are unrecognisable and therefore socially acceptable.
- Introduced the concept of the 'sanitation waterborne edge' which defined the boundary of cost-effective water borne sewerage. The sanitation edge defined the extent to which existing infrastructure and topography would be able to be accommodate new developments within the boundary. Everything outside this boundary was planned to serviced through innovative decentralised sanitation systems.
- Leading the search for an innovative off-grid and non-sewered sanitation solution.

Till now, the Municipal and National policy perspectives have been locked into a very linear engineering pathway of the developed world. Leading and demonstrating this inclusive and circular economy approach which has been so badly needed in the developed world has had a catalytic impact on both National and international policy and best practice. These actions have prompted the current review of the national Sanitation Policy and the Water Services Act to include some of these transformative approaches.

eThekwini is an important example of a City's transition to becoming a leading player in the democratic dispensation to provide universal accessed water and sanitation services. Unravelling its own deep settlement segregation successes under the Apartheid regime, eThekwini has received several international and national accolades and awards for its work, including the prestigious Stockholm Industry Water Prize and is considered as a global municipal laboratory highlighting the need for more dignified sanitation and market economy of human waste as a resource. Like all endeavours, there has also been a fair share of failures as a consequence of shifting power bases, politics, governance and poor leadership. However, while solving its own problems, it has also contributed to global and national policy and practice in a remarkable tapestry and mosaic of cutting edge technical, social and environmental solutions.

3. THOUGHTS ON SOLUTIONS, LESSONS LEARNED, AND THE PATH FORWARD

The pain and disruption that climate change is bringing with increasing velocity requires that we all rethink our separate roles and work together more intentionally. The same holds true to meet the necessity and aspiration embodied in the global SDG6 goals. The lessons below come out of the discussion above and can serve as a reminder of how all levels of government can work better together to get better together on behalf of the communities they serve.

National or state policymakers and/or regulators can see themselves as overseers, or as partners with a different role. In some cases, they can set policy that enables the local region to meet its ambitious water and sanitation goals while maintaining their roles as guardians of public health and the environment or economic policy. In others, they can set policy or regulation without taking into account the broader societal or economic issues at stake and can hinder a region's ability to meet its multiple goals. Some allow the flexibility to innovate, and others do not. The difference can stem from historic governance models, historic relationships, or the individuals sitting in individual roles. It can be one of structure or of mindset. The relationships described above cover the gamut.

In Victoria, whilst the government provided a sound policy framework which incentivised collaboration and integration, some of its more detailed top down decisions, e.g., mandating recycling targets and banning direct potable reuse, may have led to a more costly solutions (e.g., purple pipe) for large scale recycled water use. The Denver, Colorado experience shows how inadequately resourced state regulators tasked solely with water quality concerns can hinder the ability of municipal providers to move toward resilience, but the legislature and Denver itself helped to shift that dynamic. The California examples sought to encourage recycled water use of all kinds through public health protective regulations adopted in an intensive science and stakeholder-based process and unleashed the ability to plan for much larger projects after recognizing that "one-off" permit setting was too unpredictable. In the case of stormwater capture, both Victoria and California tried to play a helpful role in expanding

stormwater capture and urban greening in the different ways available to them under their governance models. And, in South Africa, the eThekwini Municipality pilotted innovative methods for achieving tremendous acceleration of the provision of safe water and sanitation to the greatest number of people at the lowest cost that has been adopted and promoted elsewhere by the national government—a great story of respectful interplay between levels of government on behalf of progress.

Some lessons include :

- National or statewide standards can either hinder or assist regions in making progress. Policymakers and regulators should approach their work with open minds and develop a suite of tools to *assist* their large communities facing threats from climate change or the lack of affordable water and sanitation. The scale of problems and solutions, as well as the impact that success will have on the overall health of the nation, requires an approach that helps the regions succeed. Policy and regulation need not just be about stopping "bad' things, or prescribing "good" things; they can be used strategically in partnership with localities to incentivize innovation and assist with resilience.

- Effective collaboration needs a shared understanding of problems and commitment by all players – governments, water utilities and local governments -- to solving them. Whilst they have their separate roles, they are all bound to the bigger picture goals and can then more effectively assist in achieving multiple objectives for their communities. For example, tasking both water quality regulators and water provider agencies with both public health protection and water supply resilience can result in better outcomes sooner as the solutions to both are sought in tandem.

- With growing challenges and complexity, opportunity must be taken to disrupt the norms such that integated solutions can be found at all levels of governance. In that same vein, innovation can be encouraged to drive better and more economical results for society as a whole. Responses to water security can only be realised through dynamic water governance, where there is equitable access to water, a recognized right to water, and innovative transitions in policy, regulation and institutional management of water and its challenges.

- Inclusivity, whether of marginalized community members or of the local governments themselves, in discussing and creating new tools and policy should be encouraged with an open mind to achieve the best results and tailor solutions to local needs and abilities.

- Tools can include the use of pilot projects, allowing outside funding for policy or regulatory staff or increasing that funding, incentives for multi-benefit projects, incentives for innovative policy or programs, and active promotion and assistance in such projects or programs. Demonstrating leadership at the local level also can build good political will for scaling up solutions as in the case of the Free Basic Services approaches from eThekwini.

- Policy and regulatory agencies need to balance understandably conservative public health protection while keeping up with changing technology or methods of service delivery that can enable greater reuse of scarce water resources as well as innovative methods for achieving safe drinking water access and sanitation. This has to be aligned to technology development both to assure public health protection and find more economical ways to achieve progress on water supply and sanitation goals.

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[7] The metropolitan regions we address each have different governance structures and relationships with their national or state governments which is beyond the scope of this short paper. For our purposes, we will refer to national or state governments by the locally appropriate title. Similarly, each example has a different governance model for policymaking or regulation, e.g., a parliamentary system vs. presidential model, or a more centralized vs, decentralized model that we cannot fully distinguish in this paper.

[8] In some regions, especially those dependent upon snowpack for storage, increased temperature will lead to decreased runoff even with a similar amount of precipitation overall. The stress this creates on storage dependent and imported water systems will be great. In others, predictions are for less precipitation overall, an even greater challenge. See, e.g., (Udall & Overpeck, 2017, pp.2404-2418).

[9] Over 50% of Southern California's water is imported from the Colorado River (which crosses seven US states and Mexico), the San Joaquin and Sacramento Rivers via massive state and federal water projects, and the Eastern Sierras via the Los Angeles Aqueduct. Los Angeles at times is 90% dependent upon imported water sources. (EauMega, 2015).

[10] The state's stepped up role stemmed in part from a recognition that the geophysical record indicated that the state was subject to far longer drought cycles in history than during the time period of record (1895-present). State officials were also inspired by the Australian experience, which had had a similar seeming 3-4 year drought cycle during recorded history, but then suffered its "Millennial Drought" in the mid-1990s to mid-2000s (referred to elsewhere in this paper). At the same time, increasingly dire projections about how climate change threatened the state's snowpack, had spawned a state plan under Governor Jerry Brown's leadership to vastly increase all forms of integrated water management to prepare for the increasingly looming threat to the state's water supply (California, 2014).

[11] The State Water Resources Control Board has regulatory and financial assistance authority for the state's water quality, drinking water, and water rights programs. The water quality programs are organized through regional water boards who do permitting, and the state board sets policies, can do statewide permits, and reviews appeals of regional board permits. For simplicity they are referred to as one.

[12] The state issued regulations for outdoor irrigation and agricultural use (2014), Indirect Potable Reuse (IPR)-Groundwater recharge (2014), IPR-Reservoir augmentation (2018). Direct Potable Reuse regulations are due in 2023. The legislature set the deadlines for the latter rules to assure progress. (SWRCB, 2019).

[13] Orange County Water District's Groundwater Replenishment System (GWRS) is currently the largest, treating 120,000 acre feet/year.

[14] That creativity was challenged in court but has so far been successfully defended. The ongoing and important question will be whether water quality goals are actually achieved in a reasonable time in addition to the other multiple benefits.

[15] Measure W passed and will generate $300 million/yr for multi-benefit projects, including requirements for in the inclusion of equity considerations into grant awards. (LA County).

[16] Colo. Rev. Stat. § 25-8-101, et seq.

[17] Colo. Rev. Stat. § 25-8-205(1)(f) and (g).

[18] State public health officials in Michigan, as well as the former Governor, have been sued personally for actions alleged to have resulted in toxic water from the Flint River being supplied to Flint residents, causing a major health crisis. The lawsuit is pending. See https://imla.org/2020/08/immunity-michigan-governor-and-state-local-officials-are-subject-to-tort-liability-for-their-flint-water-actions/. Many of the same officials were also criminally charged by the Michigan Attorney General's Office, and while those charges were withdrawn, they may be refiled. See https://www.freep.com/story/news/local/michigan/2019/06/13/flint-water-crisis-criminal-charges-dismissed/1445849001/. The facts of the Flint crisis and the role of state health department officials may be unusual, but has nonetheless given rise to concern among other health department personnel.

[19] Colorado House Bill 18-1069.

[20] Colorado House Bill 18-1093; Colorado Senate Bill 18-038.

[21] Water is considered a social good, fundamental to transformation and development in the country. The South African Bill of Rights adopts a rights based approach to many aspects, one of which is the right to access to water. It was one of the first countries to constitutionally provide for the human right to water, even before the UN declaration. This aspect is further given effect through the water policy instruments namely the Water Act 1998 and Water Services Act 1997.

[22] The implementation of the Municipal Services Act led to the amalgamation of water and sewerage functions into one department called eThekweni Water and Sanitation unit (EWS). In terms of water governance, the Municipality is the Water Authority, in a three tier

management arrangement where the 1st tier is National (Department of Water and Sanitation) responsible for managing bulk raw water and regulations, with Water Boards as second tier with the responsibility of supply bulk treated drinking water.

[23] Underpinning these offerings or interventions was a strong community acceptance and customer management.