Chapter 9

Severe water crises: Industry's role and response

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Keywords: drought, economics, industrial water use, sustainability

9.1 INTRODUCTION

Managing water supply during emergencies is a critical part of sustainable water management, and may be more common in the coming decades. Four times in the past decade cities on four continents came face to face with 'Day Zero' when water would run out: in the Murray-Darling Basin, Australia (Breyfogle, 2010); Big Spring, Texas (Martin, 2014); Cape Town, South Africa (Buder, 2019); and Chennai, India (Gupta, 2019). In each case they were saved by a combination of extreme conservation, new water supply technologies, and rain. There were also a number of urban water quality emergencies, including Newark, New Jersey and Flint, Michigan, where aging pipelines conveying incompatible supplies resulted in lead-poisoned water being delivered to thousands of homes. We only know about the events in open societies: it is possible that cities in nations with restricted press freedom experienced similar crises.

These events impacted whole cities and their integrated water systems. None were caused by industry, but industry was itself affected by the water shortages and quality breakdowns. This paper focuses on the role and treatment of industry during a water crisis, laying out general principles for how industry should be treated by government and then providing some examples of how the principles can be implemented.

9.2 RELATIONSHIP BETWEEN INDUSTRY AND WATER

Industry acquires, transforms, and combines materials into products, and influences the water sector in countless ways. These can be divided into (1) impact of industrial production on water supplies, including the use of water and discharge of wastewater; (2) impact of the use of industrial products on the water environment; and (3) industrial equipment manufactured for water supply and treatment.

DOI: 10.2166/9781789060676_0097

Industry is a water consumer, accounting for roughly 19% of water withdrawals world-wide (WWAP, 2019). Industrial uses of water include fabricating, processing, washing, diluting, cooling, transporting a product, incorporating water into a product, and sanitation needs within the manufacturing facility (USGS, 2019). Plant cooling is a major non-consumptive user of withdrawn water, while food processing, paper, and mining are major consumptive users. Industry is a predictable water consumer since industrial facilities operate at planned production rates and is capable of conservation, although many production methods have minimum water needs below which production will cease.

Industry also alters the chemistry of water returned to the environment. Water that leaves industrial facilities, especially chemical and pharmaceutical producers, often carries dangerous by-products that must be removed to prevent damage to downstream facilities. Cities normally require 'pretreatment' in the form of removal or neutralization of these chemicals before industrial effluent can be mixed with other urban wastewater and treated at a wastewater plant.

Water providers influence industry in other ways as well. Companies design products that use water on the basis that the user will have access to water of appropriate quantity and quality. Product design may be further constrained in markets where regulations limit water use and specify wastewater discharge quality. Industry also makes products for the water supply and wastewater treatment industry. The vast infrastructure of 'the urban water cycle' moves water to cities, treats it for use, and then treats the effluent for safe discharge or reuse. While natural conveyances (rivers) and storage systems (snowpack) are integrated into these engineered water systems, industry provides the multi-billion-dollar infrastructure of reservoirs, canals, tanks, pumps, pipes, treatment plants, laboratories, and computerized monitoring and operating systems.

9.3 CURRENT SOURCES OF WATER CRISIS

While societies have always managed their water use around expected deviations in flow and quality, five long-term trends have changed these historical averages, requiring that we update these plans. The first four factors that have influenced the quantity and quality of water available for human use are increases over the past century in the following:

- water infrastructure;
- population and economic output;
- scientific discovery and innovation; and
- greenhouse gas concentration in the atmosphere.

In addition, a growing awareness of the importance of water for 'non-human' (i.e. environmental) purposes constitutes a fifth factor that has further constrained our use of water. As discussed below, these trends have both separate and cumulative impacts, as each influences and is influenced by the other four.

The United States currently supplies the majority of its residents and businesses with water through about 51,000 individual (mostly) public and private water systems (Buckley *et al.*, 2016). Their collective water infrastructure provides year-round use of seasonal water supplies, safeguards public health, protects urban and agricultural regions from flooding, and even brings electric power to many regions. These water systems can also claim credit for reducing morbidity and extending life expectancy over the last century resulting in an explosion of human population. These systems are aging, however, as pipeline corrosion and deteriorating storage and conveyance systems threaten the reliability of the national water infrastructure. Over the next 25 years, US water agencies will be responsible for an estimated $1 trillion USD to restore their systems to meet future needs (AWWA, 2012).

While the availability of water has contributed to population growth, the lack of water is a potential constraint to the stability of population centers. According to the United Nations (2019), over two billion people live in countries with high water stress, while roughly four billion people experience severe water scarcity at least one month per year. Water conservation that de-links the connection between and water supply economic activity has become a standard part of the water supply portfolio, and suppliers continually search for new conservation opportunities as well as new water supplies, including recycled water and saline aquifers. Advanced water treatment technologies now allow impaired waters to be made suitable for any purpose. Urban wastewater, storm water, seawater, and brackish groundwater are all considered to be important new water supplies. Improved aquifer modelling supports better resource management, while advances in water quality testing enhance our ability to identify and correct potential problems.

These technological improvements take on even greater significance in the face of climate change, caused by the increased concentrations of greenhouse gases in the atmosphere. Pre-industrial carbon dioxide levels of roughly 280 ppm are now over 400 ppm, growing at a rate of 2 to 3 ppm per year. The resultant rise in average global temperatures has produced heat waves, extreme storms, severe droughts, and reduced snowpack and glacier volumes impacting freshwater flows, while warming water increases the concentration of microbial contaminants and pathogens. Even if the world suddenly discontinued the use of fossil fuels, decades of further warming would occur, increasing the uncertainty around water availability, challenging future plans, and putting at risk hundreds of billions of dollars already invested in water infrastructure.

Compounding the planning process is a growing awareness of the value of water in the environment. The combination of massive water diversions and reduced groundwater infiltration due to urbanization further threatens water-dependent natural systems that, if altered or impaired, could have unforeseen human impacts. Others factors include conversion of forests to farming and expanding use of pesticides. Ecologists describe our era as an 'extinction event.' While humans are not presently experiencing a drop in population, many species are declining and the loss in global biodiversity in general reinforces the importance of apportioning more water to open spaces. The era in which water could be withdrawn from the environment with little thought of the consequences is over.

Each of these trends impacts the others. Economic and population expansion increases demand for high quality water supplies that technological innovation enables through the reuse of wastewater and other non-traditional supplies. Global warming changes how freshwater supplies are naturally replenished, requiring new infrastructure to maintain economic productivity The loss of streams and wetlands and has a cumulative impact on food production and public health.

The cumulative effect of these combined trends is that water management is now more challenging and complicated than ever. Increasingly sophisticated tools are used to model and track water supplies, even as integrated regional systems attempt to use the same H_2O molecules over and over, inserting intermediate treatment, testing, storage, and transfers between uses. Much can go wrong when the quantity and quality of water available is so thoroughly managed. While a diverse water portfolio is more resilient than reliance on a single supply, the potential for failures in system coordination increases. These risks increase when financial capital is in short supply or governance systems are not up to the task, and they multiply still further when water managers stop paying attention or slow down their investment in water infrastructure. In Big Spring, Texas, for example, only immediate regional planning and significant investment in alternative technology were able to avert a water crisis through the implementation of a direct potable reuse program.

9.4 THE ROLE OF INDUSTRY DURING A WATER CRISIS

A water crisis is a sudden or emerging trend in water supply or quality that deviates from expected conditions and imposes actual or potential harm on society. When available water supplies drop to less than 50% of normal, severe stress results. Many cities do not plan past a 50% reduction in supply, considering it too improbable. For example, the City of Santa Cruz, California stops at 50% deficiency from normal peak season demand, calling it a Stage 5 drought condition that is 'an extraordinary crisis threatening health, safety, and security of the community' (2016, p. 8–9). Water quality crises present the same type of challenge, as water users are left without sufficient supplies at the expected quality and price.

While industry is affected by a water crisis, companies can in turn influence the severity of its impact on the community, either positively or negatively. For example, when industry exercises prior rights to water and continues to withdraw water it can exacerbate the effect of a water shortage on local residents. Industry also has the capacity to improve conditions by enhancing water quality, reducing its demand on local supplies or even creating new high-quality sources of water. And while individual facilities may be able to minimize the impacts of a regional water quality crisis, the most effective response involves a combination of actions by industry and government that preserves the benefits industry provides society while mitigating the effects of the crisis.

Governments face a choice on where to supply water when it is scarce. Direct human consumption is an obvious priority, but industrial, commercial, governmental, and agricultural users all make a claim on limited supplies. During a severe water crisis, regional or national governments will likely seek to control the distribution of available supplies. These efforts, however, are unlikely to be fully efficient, leaving the health of many at risk – especially poor families located in remote regions.

For this reason, one primary reason to supply water to industry during times of drought is due to the wages it pays to its employees. Well over 300 million people work in industry, which accounts for over 22% of employment in lower middle-income and richer nations (ILO, 2018). In times of water crisis, families with even a small amount of money have options to purchase water or water-saving appliances, or to buy water treatment devices or water substitutes that could help see them through a water crisis.

A related argument in favor of maintaining at least a minimal flow of water to industry during extreme water shortages is that industries that cease production could lose markets and market share as a result of a temporary cessation of water supply. On the reasonable expectation that wet years will return, and the continuing importance of regional economic activity, one should keep industry alive even in a water crisis as a matter of long-term planning for the region. This is a longer-term perspective than the immediate value of maintaining employment and wages, but equally important. Buder (2019) notes that about 30,000 mostly low-income jobs were lost during the Cape Town crisis.

Note that the argument for maintaining a minimum water supply to industry in a water crisis is not based on the value of the goods that industry provides. Local industry may occasionally demand water to provide essential products like medicine, just as farmers sometimes need water to keep crops from drying up or rotting in the field. Water provided to these uses can be justified. But regardless of the products they manufacture, the wages industry pays to local residents provide an important resource that facilitates a 'bottom-up' response to critical shortage.

9.5 POLICY APPROACHES TO INDUSTRIAL WATER SUPPLY BEFORE AND DURING A WATER CRISIS

While government bears the primary responsibility to prepare for a water crisis, industry has a larger capacity than any other sector to identify, acquire, and treat its own supplies. In doing so, industry can assist both in long-term planning as well as in emergency response consistent with a sustainability ethic that emphasizes industry's role and impacts on its region of activity.

9.5.1 Participate in planning

Successfully developing and implementing a resilient regional water supply program is a costly, long-term effort. Both government and industry operate in a budget-constrained environment where large investments to address future problems are frequently deferred for years – even decades. Industry can play an influential role in accelerating water infrastructure projects by helping to evaluate planning assumptions and advocating for timely implementation of projects that lower regional risk. From industry's perspective, investment in a secure water supply is an insurance policy for their operations as well as those of nearby suppliers and customers. They can use their resources and regional influence to support and promote such investments.

With respect to water quality, industry can also help by reviewing the adequacy of water quality testing systems and encouraging regulators to stay up to date on emergency response planning, including mutual aid and other networked responses. And industry can encourage and participate in table-top scenarios and other exercises that rehearse the regional response to an emergency.

9.5.2 Public–private partnerships

Beyond this advisory role, industry can also participate directly in a public–private partnership for water supply and treatment facilities. This open-ended role can include any aspect of project design, construction, ownership, and/or operation. With its financial and technical resources, industry can help build projects that would otherwise be out of reach to regional government. For example, one risk associated with the development of alternative water supplies is that during normal and wet years the new, more expensive, supply may not be needed. By helping to fund the facility, industry can reduce the burden of the 'stranded investment' ensuring that the cost is recouped despite its intermittent operation and revenue generation.

Another form of industrial public–private partnership, common in agriculture, is joint underwriting of water conservation projects. Industry can invest in long-term, large-scale projects like extensive replacement of leaking water mains in exchange for access to some portion of the water conserved.

9.5.3 Restrictions on industrial water use

During a water crisis, government has the primary responsibility to manage water supplies in a way that best protects society. However, as noted earlier, government action can be augmented by the behavior of other members of the community, including companies and their employees – provided that they continue to receive wages.

The ability to maintain a functioning industrial sector during water shortages should be integrated into water supply reduction strategies well in advance of a crisis. The State of California provides a framework for emergency reduction strategies that gives local jurisdictions the ability to set aside water for industry even during the most extreme events. After setting aside water for domestic use, sanitation, and fire protection,

> 'the regulations may establish priorities in the use of water for other purposes and provide for the allocation, distribution, and delivery of water for such other purposes….' (CA Water Code Section 354)

Cities and regions plan in advance as to how they will implement these powers. As an example, the City of Santa Cruz, California serves roughly 80,000 people in a system that is hydrologically independent from other regional and state-wide supply systems, and preferentially allocates water for industry in its drought emergency curtailment plan.

Table 9.1 Water supply allocation and customer reduction goals (Santa Cruz, CA)

Normal Peak Season Demand = 2,473 mil gal	No Deficiency		Stage 2 15% Deficiency		Stage 3 25% Deficiency		Stage 4 35% Deficiency		Stage 5 50% Deficiency	
	Delivery		Delivery		Delivery		Delivery		Delivery	
Customer Category:	%	Volume (mil gal)	%	Volume (mil gal)	%	Volume (mil gal)	%	Volume (mil gal)	%	Volume (mil gal)
Single Family Residential	100	1,031	84%	864	73%	753	62%	639	48%	495
Multiple Residential	100	524	87%	454	78%	411	69%	361	55%	287
Business	100	438	95%	416	92%	402	87%	381	70%	307
UC Santa Cruz	100	132	85%	113	76%	100	66%	87	52%	68
Other Industrial	100	23	95%	22	90%	21	85%	20	67%	15
Municipal	100	48	76%	36	57%	27	41%	20	28%	14
Irrigation	100	110	64%	70	34%	37	12%	13	0%	0
Golf Course Irrigation	100	106	73%	78	51%	54	34%	36	20%	21
Coast Agriculture	100	59	95%	56	90%	53	85%	50	67%	40
Other	100	2	95%	2	90%	2	50%	1	50%	1
Total	**100**	**2,473**	**85%**	**2,111**	**75%**	**1,861**	**65%**	**1,607**	**50%**	**1,247**
Demand Reduction %, Million gallons	**0**	**0**	**15%**	**-362**	**25%**	**-612**	**35%**	**-866**	**50%**	**-1,226**

Source: 2015 Santa Cruz Urban Water Management Plan (2016).

Santa Cruz allocates water to the various sectors through a process that is cognizant of water limits, urban planning goals, economic trends, state and regional water conservation rules, and rate structures. In Table 9.1, 'No Deficiency' indicates the full amount (100%) of water each sector utilizes during 'normal/wet' years when their use is constrained only by price, and 'Stage 5 50% Deficiency' indicates the percentage of normal water supply delivered to each sector during a Stage 5 Drought—the worst-case drought scenario in which the community as a whole has only half as much water available.

Deliveries are not cut 50% across the board. The sectors receiving the largest proportion of their shares are Business (commercial and industrial), Other Industrial (light industrial production facilities including the technology sector), and Coast Agriculture. Collectively, these sectors are required to reduce their water use by about one-third of normal usage. By contrast, Golf Course Irrigation (20%) and Municipal usage (28%) are reduced to only one fourth or one-fifth of their normal usage, while residential and commercial Irrigation (0%) is eliminated entirely. This plan is consistent with maintaining industrial production during a water crisis, which should enable companies to continue to operate and to pay their employees.

9.5.4 Voluntary reductions and quality improvement

The plan described above envisioned a maximum water reduction of 50%. Some cities have recently confronted even more severe shortages. Should supplies drop below half their normal amount, it is likely that Santa Cruz would need to revisit their allocation formulas and consider further mandatory cutbacks. In that case, industry can help by reducing water consumption voluntarily to a greater degree than required. Industry also has the capacity to improve the quality of effluent leaving its facilities, which can become a valuable emergency source of water through further treatment and reuse. This approach could be implemented as part of a larger process of public–private cooperation to manage the water crisis.

9.6 CONCLUSION

There is today an increasing possibility of extreme water shortages and water quality events that present a crisis to cities and their regions. While industry is not the sole cause of these water-related crises, it can play a positive role in preparing for and coping with water shortages. Industry can advocate for long-term public water investments, engage in public–private partnerships, and maintain a flow of wages to employees during a severe crisis. By thinking of its post-use water effluent as a possible source of usable water, it can improve effluent quality, thereby increasing the region's usable supply of water in a crisis.

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