www.water-alternatives.org Volume 9 | Issue 2

Moss, T. 2016. Conserving water and preserving infrastructures between dictatorship and democracy in Berlin.
Water Alternatives 9(2): 250-271

Conserving Water and Preserving Infrastructures between Dictatorship and Democracy in Berlin

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ABSTRACT: This paper sheds a long-term perspective on the politics of water infrastructure in 20th century Berlin, focusing on how water conservation became enrolled in the political agendas of very diverse regimes, from the Weimar Republic to the present day. The paper poses the following three questions: firstly, in what socio-technical and political contexts have strategies of water conservation emerged (and disappeared) in Berlin? Secondly, what meanings have been attributed to these strategies and how were they politically appropriated? Thirdly, what continuities and changes to water-saving strategies can be traced across Berlin's turbulent 20th century history? These questions are addressed with an empirical analysis of four periods of Berlin's water infrastructure history: a) an era of expansion (1920-1935) about harnessing (regional) water for (urban) prosperity, b) an era of national autarky (1936-1945) about enrolling urban water in the Nazi cause, c) an era of division (1948-1989) about reordering truncated water flows in divided West and East Berlin, and d) an era of reunification (1990-present) in which expansionism has confronted environmentalism, giving rise to contestation over the desirability of water conservation. This empirical analysis is framed conceptually in terms of a dialogue between notions of obdurate socio-technical systems and dynamic socio-material assemblages.

KEYWORDS: Water politics, water conservation, infrastructure history, path dependence, assemblage, Berlin

INTRODUCTION

This paper explores the relationship between water, infrastructure and political rule through the lens of a long-term case study of Berlin from 1920 to the present day. Berlin's volatile political history across the twentieth century, marked by multiple, dramatic regime shifts, lends itself to a study of continuity and change in the way water and water infrastructures are governed. The city's public water supply system had, by the creation of Greater Berlin in 1920, developed from the original micro-network of 1856 into an integrated infrastructure system supplying the burgeoning city with primarily groundwater via a web of waterworks, pumping stations and water pipes. This urban water supply system has remained essentially unchanged to this day. Extended, modernised and repaired to meet the changing needs of the city, Berlin's water infrastructure system has co-existed with the Weimar Republic, the Nazi regime, a divided West and East Berlin and the reunified city post-1990. Its survival across five highly diverse political regimes – spanning democratic capitalism, fascist dictatorship and state socialism – dispels any simplistic reading of Wittfogel's (1957) notion that water and water infrastructures predetermine a particular type of political rule. At the same time, this resilience to regime change challenges us to consider what it is that enabled Berlin's water infrastructures to survive – and, indeed, flourish – under such varying political circumstances.

One way of explaining this is in terms of the path dependence of a dominant socio-technical system. From this perspective Berlin's water supply infrastructure – comprising a 'seamless web' (Hughes, 1986) of pipes, regulations, utilities, H_20, meters, consumers etc. – developed over the years a degree of dependency, by virtue of sunk costs and increasing returns, which made it resilient against any alternative system (cf. Hughes, 1983; Summerton, 1994). Here, political volatility is contrasted with infrastructural obduracy. Interest is directed at exploring how the stability of the city's water infrastructure not only enabled its own survival, but also that of the different political regimes it served. How did it get enrolled in stabilising or protecting certain forms of political rule? In what ways did the particular properties of water and water infrastructures – both material and non-material – influence the governance of water and, indeed, the city as a whole under each of the political regimes?

A second way is to question the apparent stability of Berlin's water infrastructure system by conceiving its development as a continuous process of adaptation and reorientation to accommodate multiple threats to its viability encountered throughout the course of its history. This perspective would interpret the survival of the city's water infrastructure as a result not so much of the costs of switching to an alternative, but rather of repeated efforts to reassemble the existing configuration of material and non-material components in order to meet ever-new challenges, whether political, socio-economic, environmental or cultural (cf. DeLanda, 2006; McFarlane, 2011). Here, the interest lies in identifying factors which threatened to destabilise the existing system and exploring how social actors attempted to re-stabilise it by adaptation, resistance or renewal. In terms of the relationship between water, infrastructure and rule, this raises questions about how far political circumstances – ranging from local politics, national regimes to geopolitical contexts – did make a difference to the way water was perceived, represented, managed and used.

This paper pursues both lines of enquiry in order to explore continuity and change at the nexus between water infrastructures and (urban) political rule. It uses well-established knowledge on the obduracy and path dependence of socio-technical systems to help explain the overall durability of Berlin's water infrastructure across multiple regimes. At the same time, it engages with a more recent literature on the socio-materiality of cities in order to highlight the contingency, uncertainty and unruliness encountered in attempts to stabilise infrastructure around a particular socio-material assemblage. The conceptual ambition is to tentatively explore ways of coupling these two approaches.

Empirically, the paper follows the issue of water conservation and how and why it was addressed, or discarded, during the period under study. This focus on water conservation is justified for three reasons. Firstly, it offers an interesting insight into the relationship between water use and the use of water infrastructures, exploring how far the stability of the water infrastructure took precedence over the stability of regional water resources. Secondly, it lends itself to a long-term analysis far better than the study of a water technology, which would tend to be rooted in a particular time. Thirdly, water conservation is an issue which allows us to consider water shortages – whether perceived or predicted – as threats to the stability of the socio-technical system/socio-material assemblage, exploring when and why saving water was considered a suitable response.

Three questions guide our exploration of water conservation across Berlin's recent history:

1. In what socio-technical and political contexts have strategies of water conservation emerged (and disappeared) in Berlin?
2. What meanings have been attributed to these strategies and how were they politically appropriated?
3. What continuities and changes to water-saving strategies can be traced across Berlin's turbulent 20th century history?

The empirical research used to answer these questions is based on a systematic document analysis of all the articles on Berlin's water supply system published in the relevant professional journals appearing between 1920 and 2010. This rich data source was supplemented by an analysis of utility reports, grey literature and published research relating to the history of water management in Berlin.

The empirical part of the paper is structured chronologically, addressing four relatively distinct eras of Berlin's water infrastructure history. These refer to a) an era of expansion (1920-1935) about harnessing (regional) water for (urban) prosperity, b) an era of national autarky (1936-1945) about enrolling urban water in the Nazi cause, c) an era of division (1948-1989) about re-ordering truncated water flows in divided West and East Berlin, and d) an era of reunification (1990-present) in which expansionism has confronted environmentalism, giving rise to contestation over the desirability of water conservation. The paper concludes by looking across these eras to identify the multiple meanings and political framings surrounding water conservation, discuss the relationship between water, infrastructure and rule in Berlin's recent history and reflect on the value of combining path dependence and assemblage approaches in analysing continuity and change to urban infrastructures.

CONCEPTUALISING CONTINUITY AND CHANGE IN URBAN WATER INFRASTRUCTURES

Investigating the relationship between water, infrastructure and political rule calls for insightful ways of conceptualising socio-materiality. Analytical approaches need to be able to describe or explain how power relations get encoded in material structures. This entails, for instance, tracing how the design of physical infrastructures or the direction of water flows can be attributed to the impact of powerful social actors or institutions. Conversely, such approaches need to consider how materiality can influence power relations and political regimes. This 'work' by physical artefacts, such as leaking water pipes or water-saving appliances, can restrict or enable human action, whether directly and materially or indirectly and discursively. As Anand (2015: 308) puts it, water is subject "not only to the political regimes of humans but also to politics affected by the materials and histories of the city's water infrastructure".

In search of ways of conceptualising historically specific socio-material formations of water and its relationship to political rule we have selected two bodies of knowledge which are sensitive to notions of continuity and change but which address these in a very different manner. The first is the literature originating from historians of technology – and later taken up by science and technology studies – on the emergence, stabilisation and path dependence of large-scale, socio-technical systems. The second is a more recent literature involving post-structuralist thinkers in human geography and other disciplines on processes of assemblage, in which heterogeneous 'things' – whether human or nonhuman, organic or inorganic, material or discursive – interact to produce or challenge particular socio-material configurations.

Analysing the obduracy and resilience of modern urban infrastructure systems has for some time held a strong appeal for social scientists and historians (Summerton, 1994; van Laak, 2001; Hommels, 2005). Since the 1980s historians of technology have come a long way in providing explanations for the emergence and subsequent stabilisation of so-called Large Technical Systems (LTS), from their early beginnings in the hands of inventors, entrepreneurs and financiers to the large-scale urban networks developed in Europe and the United States by the early 20th century (Hughes, 1983, 1987; Tarr and Dupuy, 1988; Melosi, 2000). Fundamental to the obduracy of these systems, this research agrees, are their socio-technical characteristics. A socio-technical system, such as a water supply network, comprises not merely a series of physical artefacts and technologies, but also the organised and individual actors involved in providing and using the service, institutional rules and norms for operating the system, cultural values and the economic resources to construct and maintain it, to mention only the most prominent system attributes (Hughes, 1983; Summerton, 1994; Star, 1999; Rohracher, 2007). These attributes interact in a 'seamless web' to create, stabilise and, subsequently, sustain a particular socio-technical configuration. Socio-technical systems become thereby particularly prone to path dependence: once established they prove intrinsically resistant to radical change. Explaining socio-technical change – or lack of change – in terms of path dependence is central to the LTS literature.

The concept of path dependence was initially developed by economic historians (David, 1985; Arthur, 1994) and more recently taken up by political scientists (Pierson, 2000a; Deeg, 2001) to explain self-reinforcing and positive feedback mechanisms in a political system, characterised by lock-in to a dominant trajectory. These feedback mechanisms are generally regarded to comprise four main features: large setup costs, learning effects, coordination effects and adaptive expectations (Arthur, 1994: 112-114). Martin Melosi uses the concept of path dependence in his book *The Sanitary City* (2000) to help explain why choices in American cities over water supply, wastewater and solid waste taken in the early to mid-19th century constrained the choices available in the late 20th century. The essence of path dependence is that relatively insignificant events in the past can, by virtue of the consolidation processes they set in motion, substantially reduce the options for development in the future. In the case of water and sanitation systems in US cities, "[i]t was not so much that flawed technologies were chosen initially, but that systems were designed to be permanent, to resist change in order to justify their worth to the contemporary community. In essence, the systems lacked flexibility [...]" (Melosi, 2000: 426). With reference to Germany between 1914 and 1970 Dirk van Laak echoes this thinking by observing "a striking discrepancy between the discontinuity of political history on the one hand and the continuity in building and expanding infrastructures on the other" (2001: 389).

In terms of power relations, path dependence is regarded by much of this research not as an inherent quality of a socio-technical system, but as the result of often highly political processes (Becker et al., 2016). Social actors in a position to impose rules upon others exploit opportunities to inscribe positive feedback mechanisms in their favour. Water utilities, for example, often defend the established socio-technical system they manage in terms of the specialist expertise required to run it, thus claiming their own indispensability. In Pierson's words, the "employment of power often generates positive feedback" (2000b: 77). Thus, agency determined by power relations can create preferred paths more likely to reproduce in the future. This deliberation is reflected in the notion of 'path creation' by 'mindful deviation' from an existing development path or the constitution of a new one (Garud et al., 2010: 760). Work on path creation focuses on how established paths become questioned and how "'self-reinforcing mechanisms' are strategically manipulated and 'lock-in' is but a temporary stabilization of paths in-the-making" (ibid). Rather than seeing path dependence primarily as a force constraining human action, this recent literature on path creation is interested in paths as both the medium and outcome of human interaction.

Such a relational understanding of path dependence begins to resonate with our second body of literature, on the socio-materiality of cities. Many social scientists are today (re-)discovering an interest in the material and its dynamic relationship with social structures and processes. Proponents of this 'material turn' are keen to emphasise that this is no return to notions of technological determinism. As Karen Bakker and Gavin Bridge warn, "the resurgence of the material after a decade of social constructionism should be reason for pause, since it raises spectres of worn-out dualisms, resurgent physicalism, object fetishism and environmental determinism" (2006: 8; cf. Latham and McCormack, 2004). Work on assemblages, inspired by the writings of Deleuze and Guattari (1988) and actor-network theory (Latour, 2005), embraces, instead, a relational understanding of material and non-material elements never working separately, but always in some particular socio-material configuration, or assemblage. This 'radical relationality' of assemblage thinking is interested not in what an isolated artefact is, but in the capacities it develops and the agency it exercises through its interaction with other things, whether material or non-material (DeLanda, 2006; Moss et al., 2016). As the name implies, assemblage is concerned with processes of assembling, whereby heterogeneous elements are brought into connection with others, get separated or become reconnected in new assemblages (Deleuze and Parnet, 2007). These relations between entities are conceived in a non-deterministic way. Hegemonic rule, for instance, is not something readily explained by the mere existence of particular social structures, but is contingent upon the multiple ways in which power gets mediated through socio-material relations (Müller, 2015). Assemblage thinking directs attention, therefore, to "forms of power through which particular relations are held stable, fall apart, are contested and are reassembled" (Anderson et al., 2012: 180).

Assemblage research is, consequently, highly attentive to the fluidity and contingency of socio-material configurations. Assemblages are constantly subject to processes of stabilisation and destabilisation as their components change or disappear (Latour, 2005; DeLanda, 2006; Bender, 2010). At the same time, assemblage is used to consider the relationship between change and stability. Assembling is understood as an ongoing process not only of forming, but also of sustaining, associations between various entities (Anderson et al., 2012; Müller, 2015). By analysing both the continuous process of change and the provisional holding together of entities, assemblage research can help explain how "orders endure across differences and amid transformations" (Anderson et al., 2012: 173). Obduracy of a socio-material configuration is explained, from this vantage point, as a product not of path dependence, but of highly dynamic and contingent interactions between its entities. These entities exercise agency not only through the assemblages they form, but also via their own properties (Anderson et al., 2012). This is an important distinction between assemblages and actor-networks. Assemblage thinking eschews holistic notions of a 'seamless web' in favour of a differentiated picture which entertains agency being performed by the individual components of an assemblage as well as through their interaction (DeLanda, 2006). It follows that "one and the same assemblage can have components working to stabilise its identity as well as components forcing it to change" (DeLanda, 2006: 12).

Assemblage thinking has in recent years become a focal point for innovative research on socio-technical and urban transitions, as illustrated by the heated debate in five consecutive editions of the journal *City* (2/2011 to 6/2011). Its appeal to scholars working at the interface of human geography and science and technology studies can be attributed to it being able to relate to, and build on, a rich tapestry of previous work covering the 'reconfiguration' of socio-technical systems (for example Summerton, 1994), infrastructures as 'socio-technical assemblies' (Graham and Marvin, 2001), the coevolution of cities and large technical systems (e.g. Coutard, 1999; Coutard et al., 2005) and 'socio-environmental assemblages' of urban political ecology (Heynen et al., 2006). An assemblage approach is being used explicitly in much recent research on urban infrastructures, not only to analyse the dynamics (McFarlane 2011), but also the obduracy of their socio-material configurations (Maassen, 2012). Maassen (2012) invites us to explore the heterogeneity of lock-in from a relational perspective in order to understand how different actors' strategies and materialities create lock-in at particular times in particular places. This highlights the potential relevance of assemblage thinking for historical accounts of urban infrastructures, which is our focus of attention.

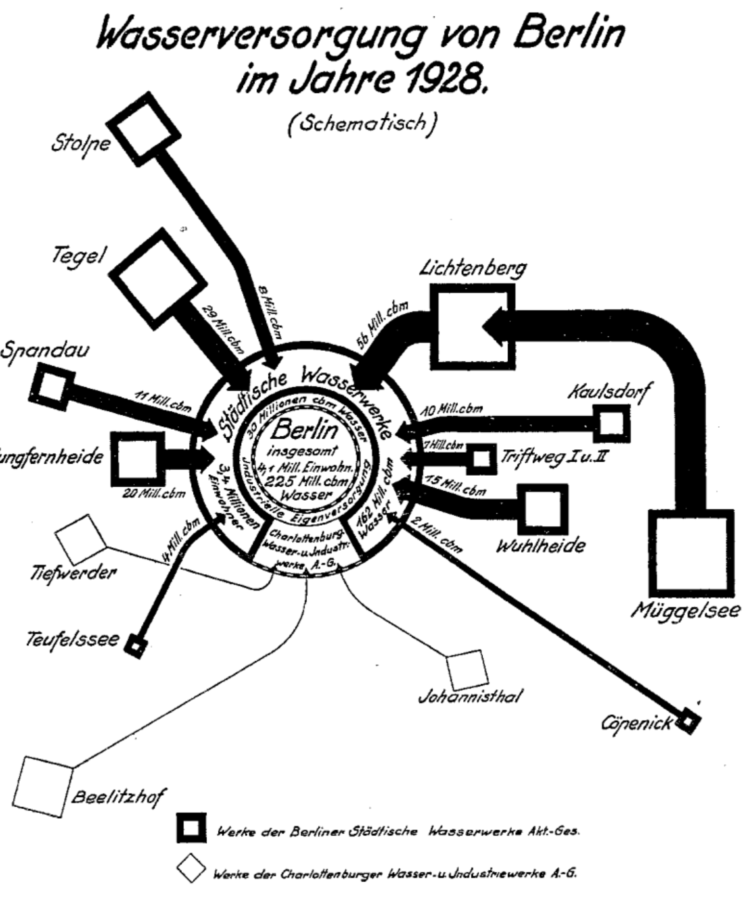
In terms of the relationship between water, infrastructures and rule, assemblage thinking encourages us to consider how material resources, as well as human actors, can exert agency. Terms such as 'vital materialism' or 'thing-power' (Bennett, 2010) give voice to the conviction that nonhuman artefacts can and do make a big difference, for instance in challenging or supporting a socio-technical regime. Examples in the literature range from the 'hard-wiring' of urban poverty via the materialities of water services in informal settlements in Mumbai (McFarlane, 2011) to the ways in which water can prove 'uncooperative' to commodification (Bakker, 2004). Water and water infrastructures are, from this perspective, not simply products of social construction or production, but develop their own agency, through associations between their components, in particular spatial and temporal contexts. It follows that power relations between materiality and society are not one-directional: powerful social actors may be able to create new socio-material assemblages, but the physical capacity of a water supply network or the depletion of regional water resources can restrict or disrupt human action.

Both approaches for conceptualising continuity and change in urban infrastructures – path dependence and assemblage thinking – offer, we have argued here, promising avenues for reinterpreting the relationship between water, infrastructure and rule. Drawing on a common relational and socio-technical understanding of infrastructures, they nevertheless explain continuity and change in very distinct ways, targeting self-reinforcing mechanisms, on the one hand, and dynamic connections, on the other. In the following section we use both concepts in our case study of Berlin to investigate how the issue of water conservation got mobilised, appropriated and discarded across multiple political regimes.

HARNESSING (REGIONAL) WATER FOR (URBAN) EXPANSION, CA. 1920-1935

With the creation of Greater Berlin in October 1920, amalgamating its surrounding communities, the city expanded massively in size from 66 km² to 878 km². Its population doubled to 3.8 million, making it the world's third largest city, after New York and London. At the time, the enlarged city´s water supply services were provided primarily by two utilities, the Berliner Städtische Wasserwerke AG belonging to the city of Berlin and the privately-owned Charlottenburger Wasser-und Industriewerke AG (Bärthel, 1997). The principal source of water was – then, as today – groundwater, primarily derived from bank infiltration from the Spree and Havel rivers passing through the city. The political priorities of successive socialist and centre-left city governments during the Weimar Republic were to integrate the water supply networks across the newly amalgamated city, to extend public water supplies to the new housing estates on the urban periphery and to accommodate for rapid further growth in population and, thus, in water demand. All these objectives required – in the eyes of the city's water managers – harnessing the region's water resources more effectively in order to serve the growing city with the water it needed (see Figure 1).

Figure 1. The region's waterworks of 1928 feeding an ever-thirsty Berlin, distinguishing between those belonging to the municipal Berliner Städtische Wasserwerke AG (bold cubes) and to the private Charlottenburger Wasser - und Industriewerke AG (diamonds) (Kühne, 1929: 7)



Emboldened by urban growth and a recovering economy in the mid-1920s, the director of the Berliner Städtische Wasserwerke drew up a plan in 1926 setting out his long-term predictions for Berlin's water consumption and the responses he proposed (Kühne, 1926). Based on the assumption that Berlin's population would double again by 1954, topping 7.5 million, he calculated by extrapolation that annual water use would reach 341 million m^3, twice the 1925 level of 174 million m^3 (see Figure 2). For the year 2000 he ventured to predict that a staggering population of 12 million in Berlin would consume some 800 million m^3 of water each year (Kühne, 1926). Symptomatic of this growth-fixated approach to future water needs is that it overlooked the fact – clearly visible in Figure 2 – that past water consumption in Berlin had not been constantly rising but had proved highly fluctual, strongly influenced by volatile economic performance.

Figure 2. Real (pre-1926) and predicted (post-1925) water use in Berlin, 1913-1954 (dotted lines), as a corollary of population growth (unbroken line) (Kühne, 1926: 7).

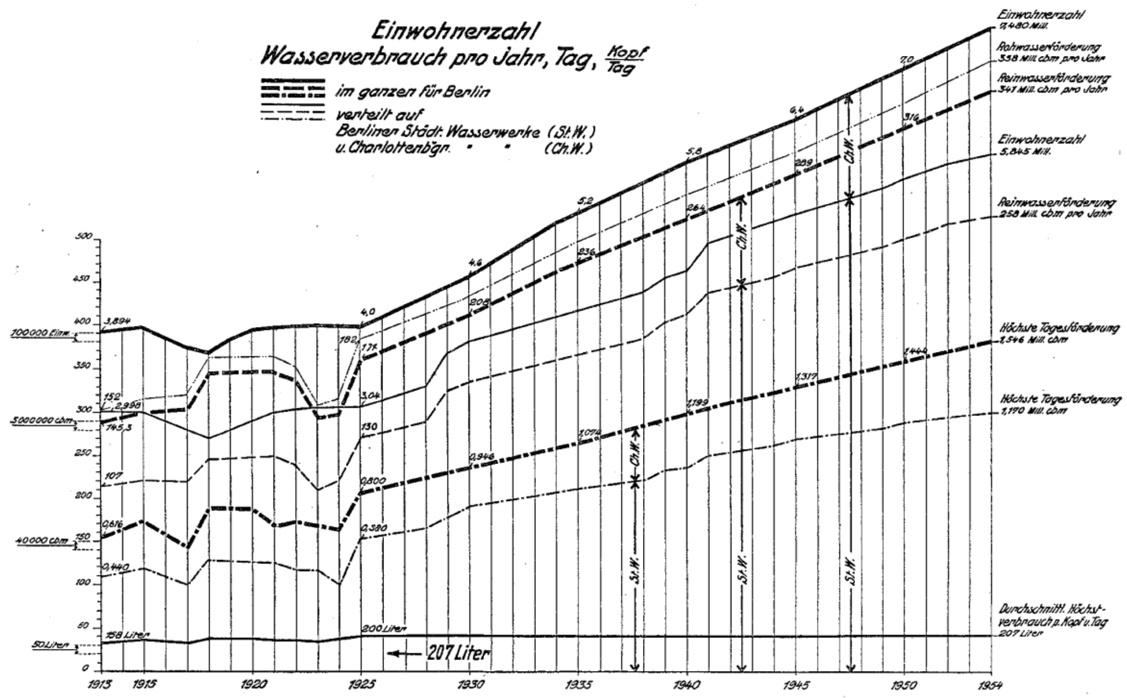


Abb. 4.

This speculative musing on Berlin's future water needs would not warrant much attention had it not provided the justification for an ambitious plan for network expansion and water exploitation. Kühne's plan envisaged maximising the use of all available water resources from the Spree and Havel rivers by means of upstream reservoirs and groundwater infiltration as well as pumping water from the Oder River via a new 12 km pipeline to meet peak demand in the summer (see Figure 3). Julius Denner, a specialist in groundwater management in the city, later conferred with this view that Berlin faced no choice but to build up its water infrastructure fast to meet the ever-growing demand:

> The artificial replenishment of groundwater reserves in combination with the major retention basin plans in the upper Spree and Havel as well as the newly planned canals drawing on water from the Oder appear to me as the only option and measure to maintain the water balance of the Spree and Havel, and thereby the water supply […] for Greater Berlin satisfactorily in the long term (Denner, 1934: 465) [translation by the author].

Saving water was understood in this context in terms of 'capture': i.e. retaining (river) water in the region for urban use to prevent it being 'lost' downstream. There was no mention of the limits posed by such unbridled urban growth or to the damaging effects increased water abstraction might have on the region's water-based landscapes. There was no consideration at all that reducing water demand might be part of the solution. The problem was framed by the utility director as an engineering challenge to serve the thirsty city. In terms of the relationship between water, infrastructure and rule, Kühne's plan is emblematic of the priority accorded to securing adequate supplies of water to Berlin over and above any concern for the water shortages this might entail elsewhere. The recently enlarged city provided the political authority to entertain such ambitions. Predictions of its further rapid growth were used to justify extending the infrastructure to harness additional water. In assemblage terms, Kühne had effectively constructed an association of entities – including water, statistical data, waterworks and municipal expansionism – which appeared to provide the solution to a problem of water supply security. As it turned out, the schemes set out by Kühne remained largely on paper. Contrary to expectations, Berlin's population grew only modestly during the 1920s and 1930s. The Depression in 1929 seriously dented the growth curve for water use over the following years and, with it, the aspiration to further regionalise Berlin's water infrastructure (Hünerberg, 1955: 42). Population and economic development proved, in practice, to be uncooperative components of the expansionist agenda.

Figure 3. Interbasin transfer plan of 1926, showing possible pipelines (dotted lines) to transfer water between the Elbe, Havel, Spree and Oder rivers (Kühne, 1926: 5).

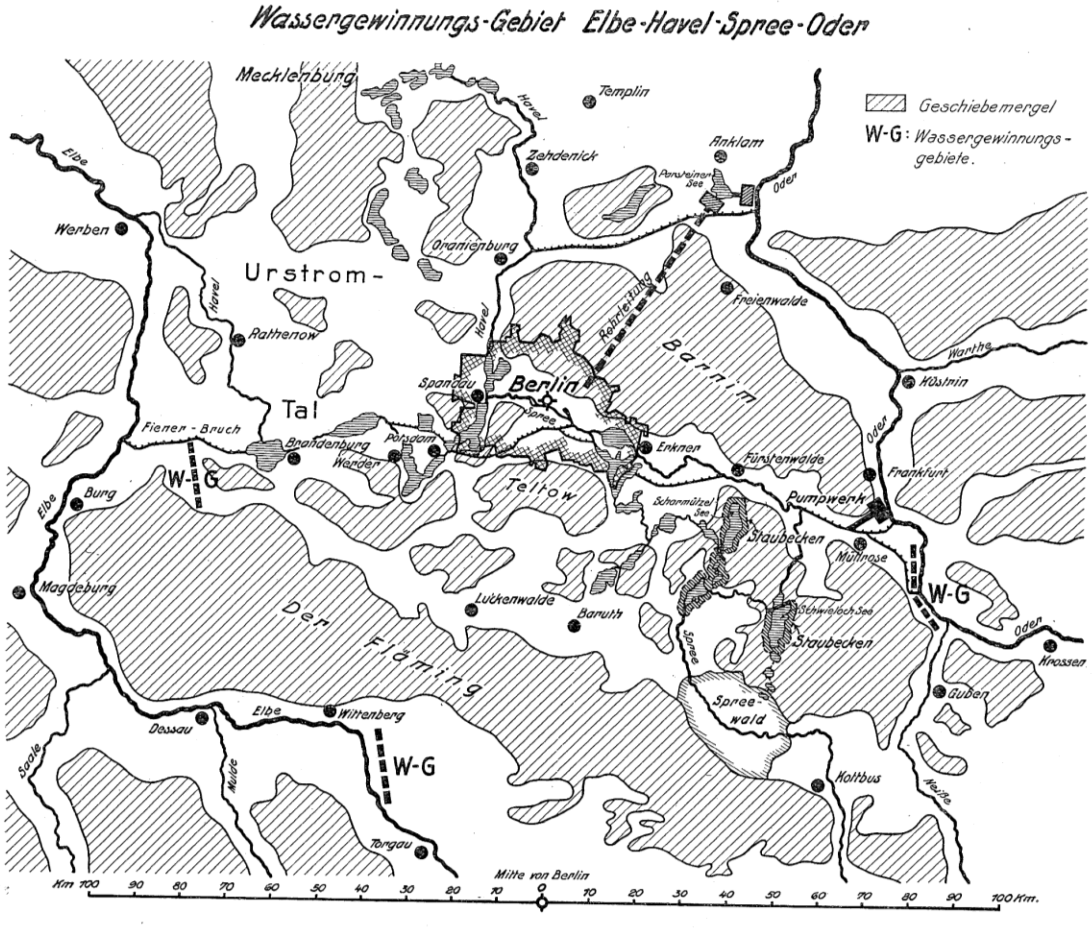


Abb. 3.

ENROLLING WATER FOR TERRITORIAL DEVELOPMENT, CONQUEST AND PROTECTION, CA. 1936-1945

Whereas debate on Berlin's water supply during the Weimar Republic was oriented entirely around the city and its hinterland, the shift to Nazi rule brought with it the subordination of urban water policy to the new national regime. Articles published in professional journals no longer addressed Berlin's water infrastructure in isolation, but how it could fit and serve the new national order. Within the emergent National Socialist discourses on water, the issue of saving water was – interestingly – picked up in three ways, relating to the 'desertification' of Germany, the spatial organisation of water resources for territorial conquest and protecting water supply systems from wartime destruction.

In September 1936 the landscape architect Alwin Seifert published his provocative article entitled "The desertification of Germany" in the National Socialist journal for engineers, *Deutsche Technik*, accompanied by a written endorsement by Fritz Todt, who was at that time Inspector General for German Roads (Seifert, 1936). Based on the experience of 'dust-bowls' in the USA and USSR, Seifert argued that Germany could no longer afford to overexploit its national water resources. He was less interested in the effect on water supply than on how water-based landscapes were being damaged as a result of intrusive engineering and excessive pollution from water use. His environmental arguments were couched in political criticism of the limits of technological fixes to meet water shortages and the exploitative nature of profit-oriented liberalism. Though challenging many practices of water exploitation underpinning the Nazi regime, he appealed explicitly to National Socialist ideology in making his case: "Leaders of water management in the Third Reich should consider that their action will not only determine the physical well-being of the German people, but also the existence or nonexistence of the German soul (*Seelenhaltung*)" (Seifert, 1936: 491) [translation by the author]. Seifert and his supporters reaped substantial criticism from the engineering fraternity, which argued along established lines that any water shortages should be met by technological innovation for more effective abstraction and treatment. This reaction is illustrative of a path-dependent mode of thinking, which resisted consideration of a new, disturbing entity: water-based landscapes potentially threatened by water abstraction.

Agreement between the two sides of the debate was reached, interestingly, over the understanding of water being a limiting factor to Germany's expansionist aims. 'Lack of water' became inextricably linked to the aggressive lament of 'lack of living space (*Lebensraum*)' (cf. Blackbourn, 2006). In this frame, saving water took on a distinctly nationalist purpose: "None of the water which the sky gives us should continue to be wasted. None of this water should reach the sea before it has provided the maximum possible use for the needs of the German people" (Franzius, 1938: 56) [translation by the author]. To this end, the Nazi regime looked for ways of reorganising national water management so as to serve Germany's territorial ambitions more effectively. The result was a plan, finalised in 1938, to manage water resources around river basin units (see Figure 4). In each of the 15 river basin units in Germany administrative agencies were set up, called Wasserwirtschaftsstellen, whose task it was to map water availability across their basin, identify existing and potential water shortages and propose measures to combat these, such as retention basins or areas (Wechmann, 1938; Meyer, 1944). This initiative to reorganise water management was developed from the beginning in close collaboration with spatial planners, who were entrusted with providing the structural conditions to maximise the use of space for the German *Volk* (Heiser, 1938). In this debate, Berlin's water supply was addressed primarily as a drain on the water availability of the region's river basins. Indeed, the first Wasserwirtschaftsstellen to be set up were for the Havel and Spree basins, serving Berlin (Schroeder, 1936). Even the newly appointed technical director of Berlin's water utility, Karl Kasper, set the city's water needs firmly in the context of national interests (Kasper, 1940). In this discourse, water was construed as a component of national security by virtue of its critical relationship with territorial development. The city's water infrastructures, by contrast, were peripheral to this new assemblage designed to bolster the Nazi regime.

The third discourse on water conservation was in preparation for the effects of militarisation and wartime destruction. The rapid growth of armaments production in Berlin up until 1944 was accompanied by a massive increase in water demand, which the city's water utility, the Berliner Städtische Wasserwerke AG, was committed to meeting at all costs (Kasper, 1940). This task was further complicated by the chronic pollution of Berlin's watercourses caused by unbridled industrial production, especially in the arms sector. As in the 1920s, but for different reasons, the solutions proposed were along the lines of increasing capacity for water retention rather than encouraging industry or households to use less water. Of further concern to the water utility was the vulnerability of its water supply infrastructure to aerial bombardment. To meet this threat, measures were taken to improve the air-raid protection of plants, for instance by building reinforced pumping stations underground (see Figure 5). Temporary disruption of service was to be minimised by creating more connections between different parts of the supply network, so as to make it more resilient to attack (Hünerberg, 1955). The responses to the anticipated vulnerability of Berlin's water supply during the war were, therefore, oriented around preserving the supply infrastructure rather than conserving water. Where necessary, this infrastructure was reconfigured materially – whether through physical reinforcement or network connectivity – as part of a resilience strategy. The director of Berlin's water utility, Karl Kasper, picked no bones about the political motivation for his action: "In the spirit of national socialist work for the common good and comradeship we want to march on along the set path so that we water specialists, too, can do our bit for victory" (Kasper, 1940: 624).

Figure 4. Map of 15 water agencies (*Wasserwirtschaftsstellen*) oriented around river basins in Germany and beyond, 1938 (Wechmann, 1938: 173).

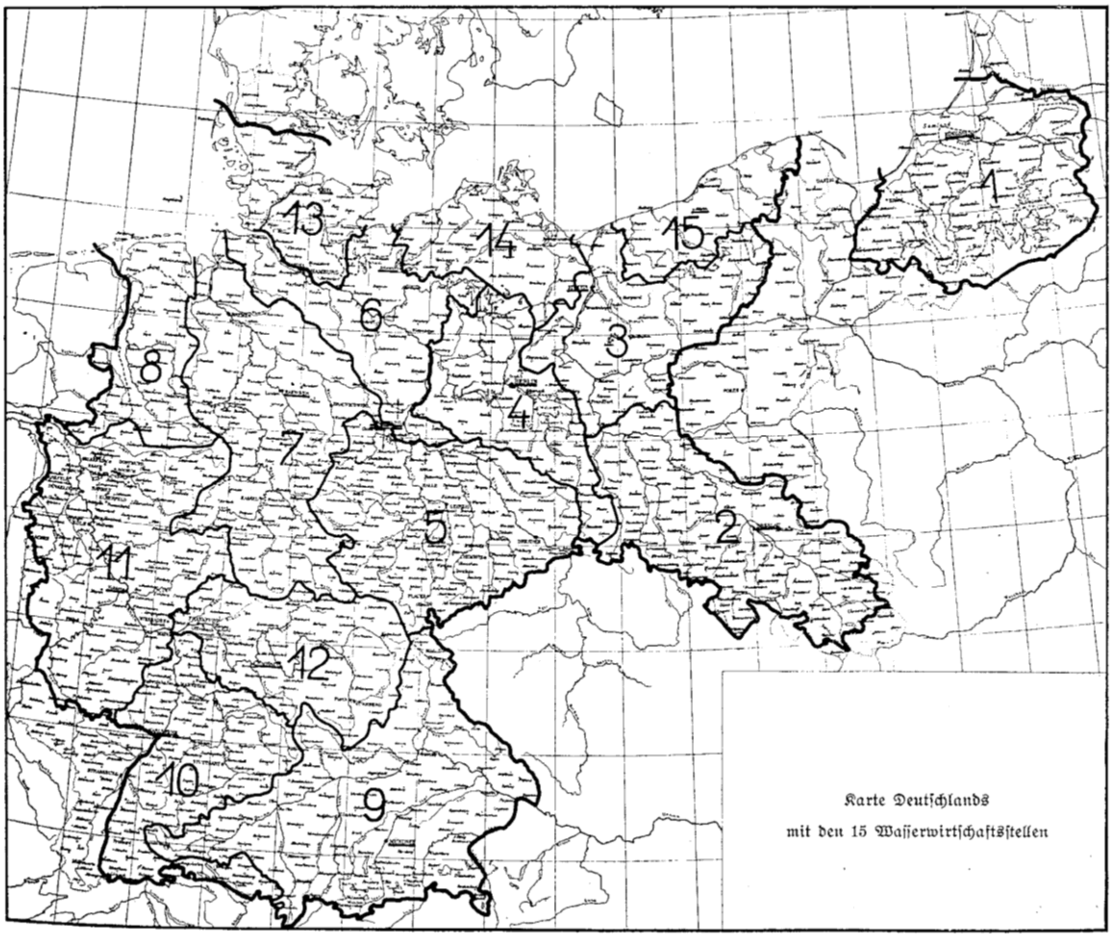
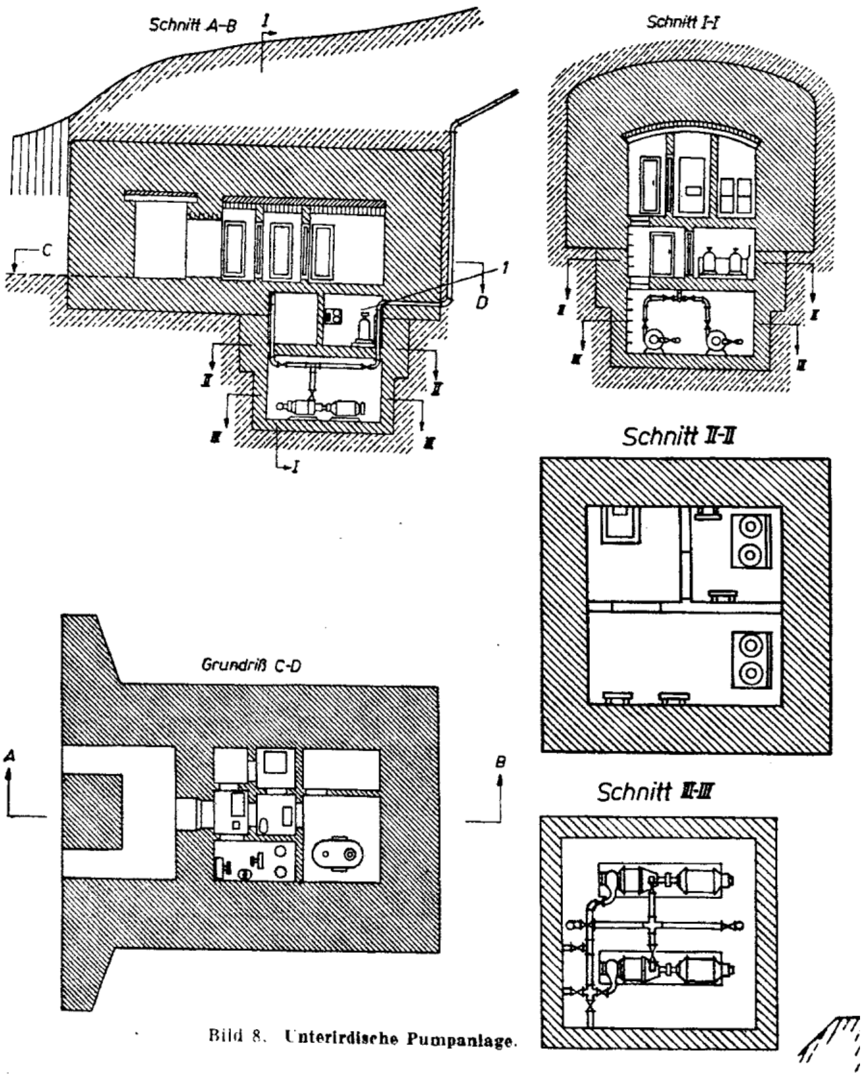


Figure 5. Diagram showing cross-sections of an underground pumping station, 1941, to illustrate reinforced concrete protection from aerial bombardment (Pohl, 1941: 304).



REORDERING TRUNCATED WATER FLOWS IN A DIVIDED CITY, 1948-1989

In fact, disruption of Berlin's water supply network by wartime bombardment proved to be modest (Moss, 2009). Water services never collapsed completely, even in the final days of the war (Bärthel, 1997: 188-189). What proved more disruptive in the longer term was the blockade of West Berlin in 1948/49 and the subsequent division of the city. The story of how the political division into a state-socialist East Berlin and democratic-capitalist West Berlin affected the city's infrastructure systems, both physically and organisationally, has been told elsewhere (Moss, 2009). Of interest to us here is whether the sudden separation of one water supply system into two halves in 1949 generated interest in water conservation and, if so, in what ways. Both West and East Berlin, with their respective water utilities, needed to secure water supply across their own territory. Given the increasing unreliability of cross-border water exchanges in the 1950s, both sides were keen to reduce the vulnerability of their own system. The response of both was, firstly, to extend supply capacity and, secondly, to reorder their supply networks around the new political geography of division. In the interest of sustaining both political regimes, the physical infrastructures were, once again, extended and reconfigured.

West Berlin

West Berlin's initial position was far inferior (Bärthel, 1997: 195). Of the city's 15 waterworks, only 7 were located in the western sector (see Figure 6), although West Berlin was considerably larger than East Berlin in both geographical size and population. Together they provided 633,000 m^3 per day, only half the per capita amount available for East Berliners (Kalweit, 1998: 202). To avert a major supply crisis the West Berlin water utility, the Berliner Wasserbetriebe (BWB), launched a capacity-building programme with the backing of the Allied occupying powers. This entailed building new waterworks and extending existing ones in the territory of West Berlin and reordering the supply network around the new geography of the 'island city' (Bärthel, 1997: 284; Moss, 2009). Between 1949 and 1973 some 451 million DM were invested in West Berlin's water supply infrastructure (Tessendorff, 1973b: 511). As a result, water supply capacity increased by 64% between 1949 and 1975 to 1,040,000 m^3 per day (Bärthel, 1997: 279) and leakage from water mains was reduced from 11.7% in 1950 to just 3.8% in 1966 (Hünerberg, 1967: 1218). Indicative of the insular mentality nurtured by political division, the BWB's technical director, Kurt Hünerberg (1953-1970), argued against the need to consider afresh the plans of his predecessor in the 1920s to transfer water from the Oder River (Hünerberg, 1959). He wanted to avoid creating new dependencies on the East German authorities, preferring solutions limited to the territory over which he had some control. Here, we can observe the tailoring of an existing socio-technical assemblage originally constructed around the region's water resources to accommodate the new political and territorial context of a truncated city. This is powerfully represented in the schematic diagram of the divided supply systems in 1953 (Figure 6), in sharp contrast to the original of 1928 (cf. Figure 1).

Figure 6. The divided water supply networks of West and East Berlin and their respective waterworks, 1953 (Hünerberg, 1955: 40).

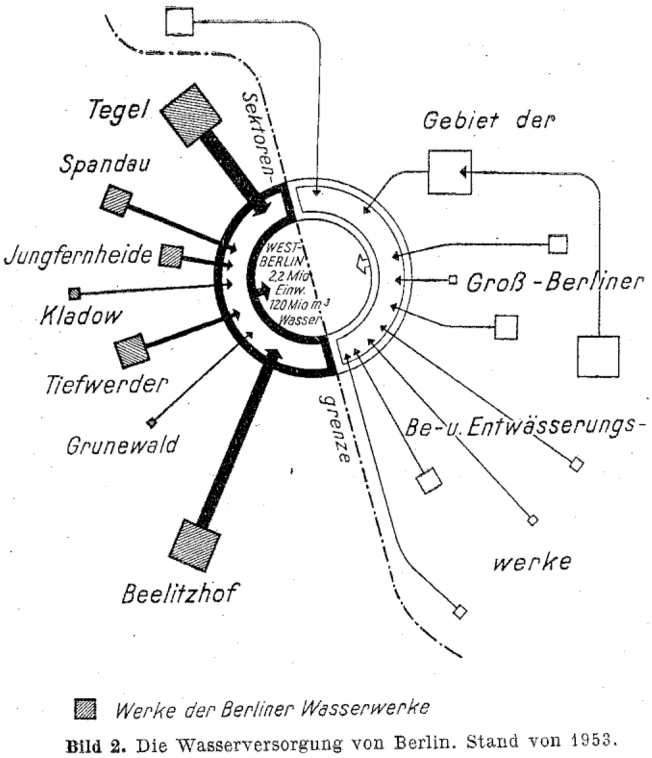
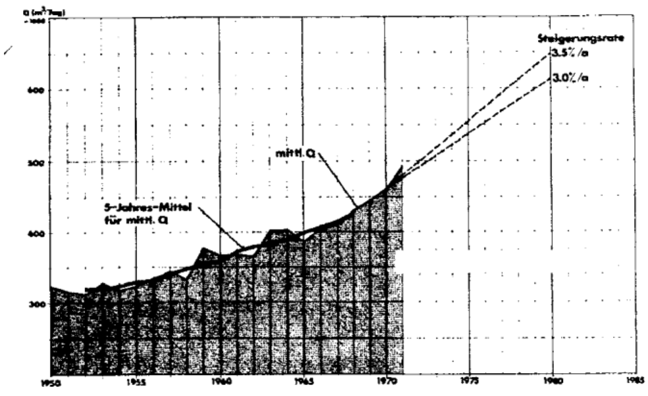


Bild 2. Die Wasserversorgung von Berlin. Stand von 1953.

With the economic recovery of West Berlin water use increased by between 3.0% and 3.7% each year between 1951 and 1973, despite the city's population remaining constant at around 2.15 million during this period (Tessendorff, 1973a: 2). Apart from industrial production it was changes in household water consumption which were driving this growth curve, as more homes were built with baths or showers, more households could afford washing machines and dishwashers and more people sought recreation in their allotments, which required watering. The post-war consumer mentality (Pfister, 1994) found powerful expression in practices of water use. This all created problems of peak demand during hot spells, topping 1 million m^3 per day during a heatwave in the summer of 1973 (Tessendorff, 1973b: 506). The response of the BWB's new technical director, Heinz Tessendorff (1971-1995), echoed the supply-oriented strategy from the 1920s (see Figure 7). He predicted growth in demand to continue at the same level, reaching a maximum of 1.2 million m^3 per day (Tessendorff, 1973a: 5). Once again, the response was not to attempt to limit demand, but to satisfy it with new waterworks (at Riemeisterfenn) and extensions to existing ones (at Tegel and Kladow) in combination with increased artificial replenishment of groundwater. The only measures to restrict water use were targeted at private companies with their own abstraction licences, but only to protect groundwater resources for the BWB's own public water supply. Voices arguing for water conservation measures in the city as a whole were gradually gaining credence in the city from the 1970s onwards (cf. Kirchhof, 2015), but they had no significant influence on water supply strategy. Beyond appeals to create more incentives to save water at times of water stress only a few pilot projects to experiment with water-saving technologies were inaugurated with public backing in the late 1980s. What we can observe in West Berlin, therefore, is the reassembling of a water supply strategy reminiscent of the 1920s that was based on infrastructure expansion, oriented around the urban territory to be served and driven by predictions of strong growth in demand. These predictions, however, once again proved unreliable. After peaking at 190 million m^3 in 1976, water use fell to 173 million m^3 in 1980, with a peak daily demand of only 744,000 m^3 – a mere 63% of the figure predicted just seven years previously (Der Senator für Stadtentwicklung und Umweltschutz, 1982: 283).

Figure 7. Water use in West Berlin: Real (1950-1972, shaded area) and predicted (1973-1980, dotted lines) (Tessendorff, 1973a: 2)



East Berlin

In significant ways East Berlin's experience of water supply challenges was the complete opposite of that in West Berlin. East Berlin had the lion's share of the water supply capacity in 1949: 715,000 m^3 per day for a population of only 1.2 million. It had the relative luxury of being able to expand the network spatially into the surrounding German Democratic Republic (GDR). At the same time, however, it did not benefit from massive infrastructure investment programmes in the 1950s and 1960s. This was owing partly to the low priority accorded to East Berlin's water network in the state planning system in the early years of the GDR, but partly also to unclear organisational responsibility for investments in water infrastructure throughout the 1950s (van der Wal and Kraemer, 1991). As a result, water supply capacity in East Berlin declined by nearly 40% – to just 430,000 m^3 per day – by 1972 (Fiedler, 1986: 62; cf. Bärthel, 1997: 202-203).

This changed after 1973, when water infrastructures became an integral part of major house construction programmes of successive five-year plans (Bärthel, 1997: 206-213). The director of the East Berlin water utility (VEB Wasserversorgung und Abwasserbehandlung Berlin), Eberhard Thurner, announced that supplying water to the new housing estates was top priority, commanding 50% of its annual investments (Thurner, 1974). Between 1976 and 1980 the housing construction programme required the utility to increase its investments by 214% (Lidzba, 1977: 238). Buoyed by calculations that water consumption in the new, modern flats would be at around 250 l per person per day (over double today's figure for Berlin), the response was – as in West Berlin – to boost supply capacity (Schleusing, 1987: 99). This indeed grew sharply to 1.15 million m^3 per day by 1985 (Fiedler, 1986: 62; cf. Bärthel's figure of 940,000 m^3 per day in 1989, 1997: 233).

Parallel to the re-emergence of the supply-building logic in East Berlin, however, was a national debate on the need to save water in the name of 'socialist rationalisation'. From the 1950s and throughout the GDR there was discussion in professional circles of water shortages as a potential limit to national economic growth. The call, substantiated in a number of five-year plans, was to 'rationalise' water management. This involved in part not only conventional strategies to build retention reservoirs or protect groundwater resources, but also less familiar measures to install water-saving appliances in homes and businesses, reuse wastewater in agriculture and use greywater for non-potable purposes (Reichelt, 1982). On a national level, the water-saving dimensions to this policy ran into criticism for ideological reasons. The subordination of economic and spatial development to the availability of water resources was accused of running counter to dialectical materialism, whereby humans should be empowered to change nature to their benefit (Gromeyer, 1955). Water efficiency measures did, however, get introduced in East Berlin, with the water utility entering into a number of 'rationalisation contracts' with local industry (Schulze-Warnecke and Schönfelder, 1974). The targets for maximum water use by factories party to such agreements did help in levelling off industrial demand for water in East Berlin between 1965 and 1974, despite a 45% increase in production (ibid); however a number of problems limited their effectiveness. Many factory managers preferred to pay the fine rather than cut consumption, whilst the so-called water commissioners sent to inspect factories were often faced with poor monitoring procedures and unsympathetic management (ibid: 410). Overall, their efforts made little impact: East Germany's water consumption – at 350 l per capita in 1989 – ranked one of the highest in Europe (Böhme, 1990: 39). Although there clearly were efforts by water managers in East Berlin to introduce water conservation as part of a socialist water supply regime, this component of the adjusted assemblage was only tolerated so long as the existing supply infrastructure proved insufficient to meet peak demand. When this situation was rectified following substantive investments in the infrastructure from the 1970s onwards, saving water became dispensable to the reinforced infrastructure-oriented assemblage. As in West Berlin, it was the supply-driven logic of infrastructure provision that proved powerfully path dependent.

EXPANSIONISM MEETS ENVIRONMENTALISM IN A REUNITED CITY, 1990-PRESENT

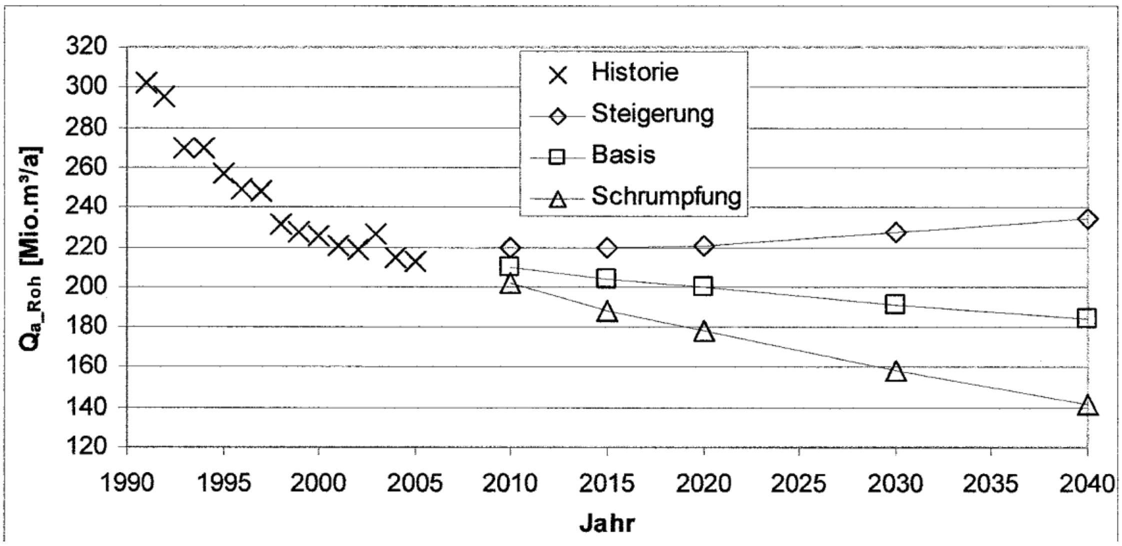
The reunification of Germany – and of Berlin – in 1990 focused attention on addressing the legacies of division, also in the water sector. Following informal exchanges in late 1989, the two utilities of West and East Berlin entered a formal collaborative agreement in October 1990, which culminated in the amalgamation of the VEB WAB Berlin into the BWB in 1992 (Bärthel, 1997: 292-296; Moss, 2009). Reconnecting the physical infrastructures of both sides was completed even faster and smoother.

Plans for Berlin's water supply system were – yet again – framed by predictions of dramatic growth to population levels and water demand. The city-state government envisaged Berlin's population growing from 3.4 million to 4.8 million by 2020 (Senatsverwaltung für Stadtentwicklung und Umweltschutz, n.d.). Together with the predicted relocation of business to Berlin as Europe's new metropolis this was interpreted as precipitating serious water supply shortages in the future. A 'negative scenario' envisaged annual water use rising to 430 million m^3 with maximum demand of 1.6 million m^3 per day far exceeding the existing supply capacity of 1.45 million m^3 (ibid: 40). The report observed grimly: "Supplying the population with water will become increasingly unreliable, so that water supply will soon become a limiting factor for population and urban development" (ibid: 42) [translation by the author]. The response of the city authorities was, intriguingly, a combination of supply-enhancing and demand-minimising measures. On the one hand, water supply was to be secured by ensuring sufficient water flows from the region into the city and replenishing groundwater resources. On the other hand, water conservation was to play a significant role, in response to increasing pressure from environmentalists. This took the form of a water-saving campaign, targeting households and business, to reduce water use to at least 10% below the average West German levels of 220 l per capita in total and 130 l per capita for households (ibid: 51) and pilot projects to demonstrate the viability of various water recycling technologies. Examples of such model projects included Block 6 in the borough of Kreuzberg, which has practised rainwater retention and use as well as greywater recycling since 1990, and a high-rise apartment block in the borough of Marzahn, where the impact of introducing water-saving appliances and water meters on water consumption was evaluated (Sommer, 1996).

The plan of the region's water utilities of September 1991, by contrast, gave little credence to water conservation as part of the solution to the projected supply problem (Arbeitsgruppe Wasserversorgung, 1991). It was grounded on the assumption that water use would remain constant at 250 l per capita and day. So long as Berlin's population did not exceed 4 million, the document argued, there would be no need to take water-saving measures. Huge investment plans were launched by the BWB in successive years to increase water supply capacity, as well as to refurbish and extend the network. The figure of 2.5 billion DM for the period 1992-1980 announced in 1992 was revised upwards in 1993 to 4.0 billion DM for the period 1993-2003, only to be reduced back to 2.5 billion DM a year later following criticisms that such levels were unaffordable (Tessendorff, 1995: 557). The supply-oriented logic, as expressed in infrastructure investment and expansion, appeared in the early 1990s fully entrenched and, indeed, invigorated by the reunification agenda of upgrading the East Berlin supply network.

The projections of growth, by both the city authorities and the BWB, proved – yet again – wholly unfounded in practice. Rather than attracting new business, the reunited city lost 50% of its industrial workforce within the space of a few years. The population did not increase sharply, but rather stagnated. People no longer consumed the amounts of water they had in the past but, in response to rising water charges resulting from infrastructure investments to meet EU urban wastewater regulations and with the help of water-saving appliances, reduced their water use significantly (Moss, 2003). As a result of all these factors levels of water distributed by the BWB fell dramatically – by around 27% – from over 300 million m^3 in 1990 to 218 million m^3 in 2006 (Möller and Burgschweiger, 2008: 49). Industrial water use in the city dropped by over 50% between 1991 and 1995 alone (Meißner and Prehn, 1997: 114). Per capita consumption by households fell from 140 l per person in 1991 to just 111 l in 2005, well below the city government's target (Möller and Burgschweiger, 2008: 48). Water consumption had, in assemblage terminology, suddenly become an uncooperative entity, failing to perform as expected and requiring a major reordering of the established associations involved in providing water to the city. One effect has been on the planning regime. Reeling from the reality check of declining water use, the latest water concept devised by the BWB in cooperation with the city government in 2008 is uncharacteristically modest and circumspect. Instead of predicting straight lines of strong, uninterrupted growth for both urban population and water demand, as in past plans, it works with diverse scenarios that envisage development trajectories by 2040 ranging between substantial shrinkage and very modest growth (ibid) (see Figure 8). Even the 'boom scenario' does not envisage water use rising above 235 million m^3 per year; the 'shrinking scenario' is as low as 141 million m^3 (ibid: 49).

Figure 8. Water distribution by the BWB: real, 1990-2005 (crosses) and predicted, 2010-2040 ('boom': diamonds; 'basis': cubes; 'shrinking': triangles) (Möller and Burgschweiger, 2008: 49)



A second effect has been on the water utility's strongly path-dependent strategy of extending supply capacity. As water use declined sharply soon after reunification, the BWB for probably the first time in its history actively pursued a policy of reducing supply capacity. Between 1990 and 2008 it closed down seven of its 16 waterworks in order to meet the declining demand. For some of these, the option to be reopened remains, to allow for any sharp increases in demand in the wake of climate change or unexpected urban growth. The BWB reduced its supply capacity partly to save money (particularly important to its shareholders following partial privatisation in 1999), and partly to deal with the unfamiliar problem of overcapacity in the network, which is causing problems for its functionality in terms of maintaining adequate water pressure and standards of hygiene (Moss, 2003). Against this backdrop of reduced water use and underutilised infrastructure, the value of water conservation has become highly ambivalent. For environmentalists, continued water conservation is necessary to safeguard regional water resources in the long term and to adapt to the impacts of global warming. In the words of one proponent: "I appeal urgently to the citizens to save water at all costs" (Löper, Märkische Allgemeine Zeitung, April 2007) [translation by the author]. For infrastructure managers, saving more water only exacerbates the problem of overcapacity in the networks, resulting in higher unit costs for the consumer to pay for alleviation measures. The view here is: "It is ultimately in the citizen's own interest to shower more often" (Schlüter, Tageszeitung, April 2007) [translation by the author]. The fact that both opinions were voiced in the same month and for the same region indicates just how contested water conservation has become. These two, largely disconnected discourses are currently competing for attention, with each of them promoting a particular assemblage around the city's water supply. The 'infrastructure' discourse seeks to preserve the existing socio-technical system by enrolling sufficient water consumption to keep the network fully functional and volume costs low. The 'ecological' discourse, by contrast, is attempting to construct a new assemblage around the region's water resources, drawing on climate change, water-based landscapes and sustainability concerns as active entities. Echoes of the pre-war era can be detected in both.

CONCLUSIONS: WATER CONSERVATION BETWEEN CONTROL AND UNRULINESS

Looking across these four eras of Berlin's water infrastructure history, we conclude this study by identifying the multiple meanings and political framings surrounding water conservation, discussing the relationship between water, infrastructure and rule and reflecting on what path dependence and assemblage approaches can reveal about continuity and change to urban infrastructures.

The first observation to be made is that the history of water conservation in 20th century Berlin is strikingly fluid. In the diverse political regimes portrayed here, saving water was neither a continuous feature of urban infrastructure policy nor completely discounted. Water conservation entered debates on, and responses to, water supply problems at particular times only to disappear again when deemed surplus to requirements. What emerges very clearly from the empirical analysis is the priority of water managers in the city's water utilities (and, to a lesser extent, the city authorities) across all political regimes to keep their infrastructure system fully functional. Preserving urban water infrastructures almost always took precedence over conserving regional water resources. Any restrictions on water use posed by the physical inaccessibility or degradation of water resources could, in the eyes of these water managers, be addressed by using technology to abstract more water from more distant sources. In a socio-material sense, the material properties of water only took on social relevance, making it an 'agent' in policy debates, when it threatened – by its absence or unavailability – to disrupt water supply services. This absence could be of a discursive nature, as in debates on 'desertification' in the 1930s or on water demand scenarios throughout the century, but also very real, as in the case of West Berlin following the blockade of 1948/49. On these occasions, when the existing socio-technical assemblage got briefly destabilised, efforts to stabilise the system were still driven by the desire to secure the city's infrastructure and the service it provided. Encouraging consumers to use less water was generally a measure of last resort. The high degree of continuity of this approach across multiple regimes is indicative of strong path dependence. What is important to note, though, is that this path dependence appears to have been driven less by the sheer physicality of the waterworks and distribution networks – as evidenced by the relative ease of restructuring them for a divided city – and more by the supply-oriented logic underpinning the actions of water managers. Nevertheless, physical infrastructures were widely perceived by those responsible for water services as controllable, and water resources as unruly. The massive drop in water consumption since the 1990s would appear to confirm this view of water as a volatile – and, therefore, unreliable – entity of a socio-technical assemblage. The greater (perceived) controllability of infrastructure would indicate why the relationship between water, infrastructure and rule was generally asymmetrical, in favour of mutual benefits between infrastructure and political rule.

Water conservation may have played only a part-time role in the considerations of urban water managers in Berlin, but it came in many guises. The second striking observation to be made from looking across the 20th century is that conserving water meant different things to different people at different times. Water conservation took on multiple meanings beyond today's conventional understanding of consumers using less water. It could refer to capturing or retaining water in the region, protecting water resources from pollution or disruption, more 'rational' use by industry or households, replenishing groundwater resources or recycling water on a local or regional scale. The water resources referred to differed in each instance, as did the notion of 'saving', encouraging us to interrogate water conservation in terms of the 'what', 'where' and 'how' it conceals. The multiple meanings of water conservation, we can also observe, were never politically benign, but were framed discursively to fulfil particular interests: the 'why' and 'for whom' of future enquiry. In the context of Nazi ideology water conservation was construed as a precondition for territorial colonisation, protecting 'German' landscapes and supporting arms production. In post-war East Berlin it was used to help improve economic productivity and also to offset water service disruptions prompted by the deteriorating quality of the supply network. Since reunification, water conservation has been promoted, rather, as a way of securing regional water resources, protecting water-based ecosystems and adapting to climate change. The prevalence of water-saving discourses in this broader sense and the perceived threat they posed to supply-oriented logics were reflected in several conflicts they generated under different regimes. These conflict lines ran, for instance, between landscape architects and water engineers over the 'desertification' thesis in the 1930s, between proponents of water 'rationalisation' and defenders of dialectical materialism in East Germany as well as between the 'ecological position' and the 'infrastructure position' with regard to water conservation today. So far, however, such challenges have never seriously threatened the compact between the infrastructure systems and the infrastructure managers, regardless of political regime.

Striving for advantage in contestations over water conservation draws attention to our third key observation: the power of discourse and the ways in which water and water infrastructures got represented. Here, assemblage thinking proved helpful in analysing how material and non-material elements were drawn into association with one another to justify particular infrastructure policies. Perhaps the most prominent example is the repeated use of predictions of population growth and rising water demand to advocate extending water supply capacity. The materiality of major water infrastructures, reflected in their sunk costs and spatial embeddedness, calls for long-term planning and investment. This tends to privilege long-term predictions as a key tool in managing water infrastructures. These predictions of water needs proved, however, wildly inaccurate in Berlin. The figures presented as water requirements did not represent any real, material water amounts, but rather social constructions of water employed to justify infrastructure investments. The supply-oriented assemblages constructed around imaginations of future water flows and urban developments and analyses of current capacity deficits proved a remarkably effective and persistent way of exercising political control over water policy.

Predicting urban developments against the contextual backdrop of such a volatile political economy was, one must acknowledge, extremely difficult. This brings us to our fourth observation, relating to the importance of space in shaping the relationship between water, infrastructure and political rule. The Berlin case illustrates well how shifting spatial contexts – whether socio-economic, geopolitical or environmental – influenced the provision of water supply services and consideration of water conservation. For instance, we can point to the influence of urban development projections of the 1920s, of the spatial ideology of National Socialism or of the Cold War division of Europe on the design of Berlin’s water supply infrastructure. From this perspective water conservation was, until recently, promoted not by the city’s own utilities or authorities but rather, ironically, by authoritarian national governments. Such an observation directs attention towards the multi-scalar interplay of international, national and local politics in shaping water policy. Another way of considering spatiality is, conversely, to reveal how water and water infrastructures – in their various socio-material assemblages – have shaped spatial structures in different ways at different times. Examples from our case study include plans to extend Berlin’s water supply catchment to include the Oder River, the river basin units created by the National Socialists, West Berlin’s new waterworks reinforcing spatial separation from the GDR and model projects of water recycling as small-scale places of experimentation.

Finally, we reflect on the core issue of temporality; in particular, the relationship between continuity and change in Berlin’s water infrastructure history. We began this paper by setting the obduracy of the city’s water supply system against the volatility of its political order. The survival – and, indeed, continuous development – of the city’s water infrastructures across five highly diverse political regimes, as demonstrated throughout the paper, is indicative of strong path dependence to its particular socio-technical configuration. It seems, at first sight, to confirm a simple reading of infrastructural progress resilient to political influence, suggesting that the relationship between infrastructure and rule is, even, irrelevant to its development trajectory. However, our more nuanced analysis of continuity and change, guided by the assemblage approach and its dynamic and relational understanding of socio-technical configurations, has revealed considerable movement beneath the apparent stability. During each of the five political regimes in post-1920 Berlin some entities of the assemblage providing water to the city changed radically, whilst others emerged or else lost significance. These entities were sometimes human – such as practices of water use or discourses of water shortage – and sometimes non-human – such as truncated supply networks or technical malfunctioning through underuse. What we observed was that the political nature of each regime, far from being irrelevant, became mirrored in the city's water infrastructure. In processes of reassembling the existing socio-technical configuration political ideologies and priorities got taken up and materialised in the water supply system. Water managers, in particular in the city's water utilities, proved adept at this process of reassembling, realigning their system to survive and prosper under new political-economic circumstances. At these points the contingency of an apparently obdurate order was clearly revealed. Some entities of the assemblage changed, sometimes quite dramatically, whilst others proved more obdurate. Periods of relative transition involved a reordering of the relations between changing and obdurate components, not simultaneous change to all components. Conversely, periods of relative stability might have appeared static, but concealed similar processes of readjustment to the assemblage to meet changes to one or more of its components.

These findings encourage us to think of continuity and change not as terms depicting distinct eras, but as continuous processes evident in different degrees in different entities at different times. From this perspective we should, in future, explore path dependence not so much in whole socio-technical configurations, but rather in certain parts of them. Similarly, we should seek to identify transition not just in whole systems, but in their distinct components. Research on path dependence could, thus, be applied to greater effect in a more subtle and differentiated way, whilst research on assemblage could be used to provide a deeper understanding of historical processes of continuity, as well as change. Combining the two approaches with care, our study suggests, is a fruitful venture for future scholarship on the political history of water infrastructures.

ACKNOWLEDGEMENTS

The conceptual part of this paper was funded by the Leibniz Institute of Research on Society and Space (IRS), Erkner, Germany, within the framework of a research project where the author explored ways of conceptualising the socio-materiality of urban infrastructures. The author would like to express his thanks to the three anonymous reviewers and the guest editors for their highly valuable suggestions for improving an earlier version of this paper.

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