FIRE AND WATER:

A TRANSDISCIPLINARY INVESTIGATION OF WATER GOVERNANCE IN THE LOWER SUNDAYS RIVER VALLEY, SOUTH AFRICA

By

JAI KUMAR CLIFFORD – HOLMES

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Abstract

The implementation of water policy and the integrated management of water face multiple challenges in South Africa (SA), despite the successes of post-apartheid government programmes in which some significant equity, sustainability and efficiency milestones have been met. This study uses a series of intervention processes into municipal water service delivery to explore the context, constraints, and real-world messiness in which local water authorities operate. The equitable provision of drinking water by local government and the collaborative management of untreated water by 'water user associations' are two sites of institutional conflict that have been subjected to broad 'turnaround' and 'transformation' attempts at the national level. This thesis seeks to explore and understand the use of transdisciplinary research in engaging local water authorities in a process of institutional change that increases the likelihood of equitable water supply in the Lower Sundays River Valley (LSRV).

Fieldwork was conducted as part of a broader action research process involving the attempted 'turnaround' of the Sundays River Valley Municipality (SRVM) between 2011 and 2014. A multi-method research approach was employed, which drew on institutional, ethnographic, and systems analyses within an evolving, transdisciplinary methodology. In the single case study research design, qualitative and quantitative data were collected via participant observation, interviews and documentary sources. Analytical methods included system dynamics modelling and an adapted form of the ethnographic tool of 'thick description', which were linked in a governance analysis.

Government interventions into the SRVM failed to take account of the systemic complexity of the municipal operating environment, the interactions of which are described in this study as the 'modes of failure' of local government. These modes included the perpetual 'fire-fighting' responses of municipal officials to crises, and the simultaneous underinvestment in, and over-extension of, water supply infrastructure, which is a rational approach to addressing current water shortages when funds are unavailable for maintenance, refurbishment, or the construction of new infrastructure. The over-burdening of municipalities with technocratic requirements, the presence of gaps in the institutional arrangements governing water supply in the LSRV, and the lack of coordination in government interventions are analysed in this study, with policy recommendations resulting. The primary contribution of this study is in

providing a substantively-contextualised case study that illustrates the value of systemic, engaged, extended, and embedded transdisciplinary research.

Declaration

This thesis is my own original work and has not been submitted in part, or in full, for any degree or examination at any other university. It contains no material previously published or written by other individuals, except where due reference is made and/or acknowledgements are provided in the text. This thesis is submitted for the degree of Doctor of Philosophy in Water Resource Science at Rhodes University, South Africa.

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Acronyms

AENP	Addo Elephant National Park
ANC	African National Congress
AW	Amatola Water board
BOT	build-operate-transfer
BoTT	build, operate, train and transfer
BSP	biodiversity sector plan
CAPEX	capital expenditure
CBA	critical biodiversity areas
CBO	community-based organisation
CDM	Cacadu District Municipality (now SDM)
CEO	Chief Executive Officer
CoGTA	[Department of] Cooperative Governance and Traditional Affairs (previously DPLG)
COSATU	Congress of South African Trade Unions
CMA	Catchment Management Agency
CMF	Catchment Management Forum
CSRS	Cape Sundays River Settlement company
DAFF	Department of Agriculture, Forestry and Fisheries (2009-2014)
DBSA	Development Bank of Southern Africa
DLG	developmental local government
DPLG	Department of Provincial and Local Government (now CoGTA)
DWA	Department of Water Affairs (1956-1994; 2009-2014)
DWAF	Department of Water Affairs and Forestry (1994-2009)
DWS	Department of Water and Sanitation (May 2014 onwards)
FBW	free basic water
FBS	free basic services (including water & sanitation)
FBSan	free basic sanitation
EHP	Environmental Health Practitioner
ES	equitable share
ESA	ecological support areas
GKWS	The 'Greater Kirkwood Water Supply' model (system dynamics model 2)
IAM	infrastructure asset management
IBT	Inter-Basin Transfer

IDP	integrated development plan
ISD	institutional and social development
IT	information technology
K-DEM	The 'Kirkwood Water Demand' model (system dynamics model 3)
LED	local economic development
LM	Local Municipality
LSRV	Lower Sundays River Valley (geographic area)
L-WUA	Lower Sundays River Water User Association (previously SRIB)
MDB	Municipal Demarcation Board
MEC	Member of the Executive Council (provincial parliament)
MFMA	Municipal Finance Management Act (Act 56 of 2003)
MIG	Municipal Infrastructure Grant
MIIF	Municipal Infrastructure Investment Framework
MISA	Municipal Infrastructure Support Agency
MNDT	Mayibuye Ndlovu Development Trust
MoF	The 'Modes of Failure' model (system dynamics model 4)
NEMA	National Environmental Management Act (Act 107 of 1998)
NEMBA	National Environmental Management: Biodiversity Act (Act 10 of 2004)
NGO	non-governmental organisation
NMBM	Nelson Mandela Bay Municipality (metropolitan area incorporating Port Eizabeth, Uitenhage and Disptach).
NP	National Party (apartheid period)
NWA	National Water Act (Act 36 of 1998)
NWRS	National Water Resource Strategy (implementation plan for the NWA)
O&M	operations and maintenance
ORDP	Orange River Development Project
PBS	Paterson Bulk-water Scheme
PFMA	Public Finance Management Act (Act 1 of 1999)
PIA	Project implementing agenct
PMU	Project Management Unit
PSC	Project Steering Committee
PSMs	Problem Structuring Methods
RBIG	Regional Bulk Infrastructure Grant

RDP	Reconstruction and Development Programme
RSC	Regional Services Council
SA	South Africa
SABC	South African Broadcasting Corporation
SACP	South African Communist Party
SALGA	South African Local Government Association
SANCO	South African National Civic Organisation
SANPAD	South Africa Netherlands Research Programme for Alternatives in Development (funding agency)
SANParks	South African National Parks
SDM	Sarah Baartman District Municipality (previously CDM)
SETA	Sector Education and Training Authority
SFWS	Strategic Framework for Water Services (2003)
SLA	Service Level Agreement
SRCC	Sundays River Citrus Company
SRIB	Sundays River Irrigation Board (now L-WUA)
SRVM	Sundays River Valley Municipality (local municipality)
SSA	Support Services Agent
TLC	Transitional Local Council
TNP	'Towards a New Paradigm for Integrated Water Resource Management in South Africa' (research project)
WC/WDM	water conservation/water demand management
WRC	Water Research Commission
WSA	water services authority
WSDP	water services development plan
WSI	water services institution
WSP	water services provider
WSS	water supply scheme (usually in reference to the Greater Kirkwood water supply scheme)
WTW	water treatment works (produces potable water)
WUA	water user association (generic structure as posited in NWA)
WWTW	waste-water treatment works (cleans sewage)

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Grahamstown, January 2015.

Preface

In this preface, I introduce the key themes of this study by drawing on three scenes and a metaphor, which are recounted individually and then interwoven in a brief discussion.[1] Although the three scenes occurred within the space of a year (between December 2010 and December 2011) the combination of the scenes and the explanation of the metaphor provide insight into why I began this research, how I subsequently undertook it, and what the intended contribution of this study is.

Scene 1: An irrigation canal running through Kirkwood, Sundays River Valley Municipality.

In late-2011, I stood alongside an irrigation canal watching water flow through Kirkwood, a small town in the Sundays River Valley Municipality of the Eastern Cape province of South Africa. What I observed was strange for a number of reasons. Here was a naturally drought-prone region that possessed a thriving commercial farming industry that grew one of the thirstiest of crops – citrus – using water transported over a distance of more than 300 km via one of the world's largest inter-basin transfer schemes. And yet, these same irrigation canals that transported raw, untreated water to users in the region ran alongside townships that were frequently without drinking water, often for days at a time. Under the *National Water Act* of 1998 (RSA, 1998), water for basic human needs trumps all other allocation priorities, and yet this was not a case of water being allocated to farming ahead of domestic use. The paradox was that an efficient organisation (and supporting organisational structure at a national level) supported the water resource management that enabled raw water to be in abundant supply in the region, whilst a struggling organisation (and struggling supporting organisational structure at a national and regional level) was responsible for ensuring drinking water was supplied to the residents in the region. The efficient organisation is the Lower Sundays River Water User Association – which is the converted irrigation board responsible for managing bulk water supply in the region. The struggling organisation is the Sundays River Valley Municipality. The paradox of seemingly abundant raw water flowing alongside dry drinking taps was exacerbated by the fact that the water user association was the bulk water supplier to the

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[1] I co-opted this style of presenting a preface using three recollections (or scenes) from Frances Cleaver, who began her book *Development as Bricolage* (2012) in this way.

municipality, and water shortages in Kirkwood were often blamed on the supply agreement between the two organisations.

In February 2010 a 'turnaround' process was initiated in the SRVM to intervene in the municipal management of service delivery functions – with water one of its primary concerns. The 'turnaround' process involved various national government departments, provincial authorities, regional water boards, local civil society organisations, residents and, as of October 2011, a research team led by academics at Rhodes University. I became a part of this research team. Central concerns for the research team were how the water supply situation in Kirkwood could be improved, and what the blockages (or impasses) to improvement were. Over the course of this research, water shortages continued to affect the town of Kirkwood and the surrounding surburbs of Greater Kirkwood, and ultimately played a large part in the dissatisfaction that led to violent protests in Kirkwood in September 2014. These protests saw many of the region's municipal buildings – including its council chambers and engineering services department – burnt to the ground. My involvement in this research team was by and large inspired by the series of events recounted in 'Scene 2' to follow.

Scene 2: A community hall in a suburb of Grahamstown, Makana Municipality.

I became interested in the challenges that local government faced in providing water services in early 2009, when I began volunteering for a small non-profit organisation, called Galela Amanzi (which translates to 'pour the water' in isiXhosa). Run out of Rhodes University, this organisation had a simple objective: to raise funds to install rainwater tanks in historically disadvantaged and water scarce areas in Grahamstown, the main town in the SRVM's neighbouring Makana municipality. As I became more involved in Galela Amanzi, our project began to ask why rainwater tanks were required in the first place, and we soon realised that answers to this question could only be explored via engaging the government authority responsible for providing, and overseeing, water services. An opportunity to do so came in late-2010, when a prolonged drought (combined with numerous infrastructure problems) resulted in water shortages that disproportionately affected the poorer, recently-built parts of Grahamstown East. Inspired to engage local government in a transparent, collaborative manner, Galela Amanzi partnered with several community-based organisations (CBOs) to host a 'water forum' in a community hall located in the suburb of Joza, located in Grahamstown East. We followed the protocol that we believed to be required, and invited the

municipal manager and municipal technical director to address the affected residents. We further issued public notices, and sought and secured the support of other civil society organisations in the area. What transpired at the meeting could be (charitably) referred to as a 'learning experience' for Galela Amanzi and for me, but in truth it was an unmitigated disaster that did more harm to discussions around water in Grahamstown than it did good. The water forum began without any municipal representatives (all of whom had declined to attend). We did have the participation of a number of CBOs and the assistance of a Rhodes professor (a hydrologist of international standing) however, whose presence we requested in order to provide some technical context regarding Grahamstown's water issues. The meeting started to break down within the first half an hour. I watched as a series of things happened that I did not understand at the time, but the effects of which were clear enough: residents began walking out, and arguments between members of the public and our CBO partners became increasingly heated. The arguments became sufficiently volatile for the police to be called and for the forum to prematurely end. In the physical intimidation (but thankfully not violence) that followed outside the hall, the leader of our main CBO partner was threatened, and I was warned 'not to return to the township' with my car licence plate noted. Perhaps most strangely, the professor in attendance was accused of being an 'AWB-funded member of the DA' (acronyms referring to two political parties that hold sufficiently-diverging policy positions for the accusation to be laughable). The following week, I learned that these disruptors and intimidators were all members of the youth league of a South African political party: apparently the local branch of the youth league had perceived our water forum as an attempt to 'derail the township ahead of the local government election' (which was six months away at that time).

The water forum provided my first introduction to the practical politics of water. It further provided motivation for a different approach to my research for my then Masters degree – to somehow learn how water services could be improved from inside service-providing structures, through the use of innovative research approaches. Early the next year I was fortunate to join a research team in which these aims were not just accommodated, but actively encouraged and facilitated (as introduced in 'Scene 3').

Scene 3: A seminar room in the Faculty of Technology, Policy, and Management, Delft University of Technology, the Netherlands.

In mid-2011, I found myself participating in a project initiation workshop at Delft University of Technology in the Netherlands. I had started my masters earlier that same year, and worked with an experienced anthropologist at Rhodes University. I then met an ecologist who had recently started a water-focused action research project with transnational funding from the South African Netherlands Research Programme for Alternatives in Development (SANPAD). The ecologist (Professor Tally Palmer) and the anthropologist (Professor Chris de Wet) had a common interest in transdisciplinary research that engaged complex problems in an integrated manner. The two professors provided the intellectual guidance for my involvement in what became known as 'the SANPAD project'. When I attended the Delft planning workshop for the SANPAD project in mid-2011, I spent most of it vacillating between excitement and nervousness. On the one hand, I was excited to be involved in a project that sought to test the usefulness of an innovative toolkit of methods and approaches, which were aimed at breaching barriers impeding the implementation of integrated water resource management in South Africa. On the other hand, I was also nervous at being the youngest workshop participant, and felt unqualified to participate in the workshop, and unsure of what my contribution to the project could be. I lacked a technical background in water resource science and engineering, and many of the terms used in the workshop's discussions were at once unfamiliar and intimidating (it was only later on in the project that I discovered that I was not alone in my duality regarding the Delft workshop, with several other attendees sharing my enthusiasm and feelings of trepidation).

The SANPAD project provided the intellectual and practical scaffolding for my Masters research (which was subsequently upgraded to this doctoral study), and I benefited immensely from the intellectual generosity of the broader research team under Professor Palmer's leadership. It was also through the SANPAD project that I met Dr Jill Slinger, who introduced me to system dynamics modelling and subsequently became my third doctoral supervisor. Mostly importantly, it was through the SANPAD project that the case study in the Lower Sundays River Valley was initiated and maintained.

I selected these three scenes to preface this thesis as they provide an overview of themes that are central to this study. The first scene presents an empirical problem that, when phrased

prosaically, can be stated as follows: "What are the water issues in the SRVM and how do these issues interact to produce undesirable outcomes that are contrary to the principles of post-apartheid water policy?" The second scene presents the problems attendant to engaged research in the water sector, asking the question "how can interested researchers practically and constructively engage with the politics of water in post-apartheid South Africa?" This second question reflects the SANPAD project's commitment to producing research that is actually utilised in communities of practice, rather that only being 'potentially' useful. The third scene introduces the formative context of this study – the beginnings of my learning in the scientific world – where I had the good fortune of undertaking a doctoral study working collaboratively with three supervisors, engaged in a messy, real-world problem.

The above three themes are interwoven into this study, and influenced the entire project, from its research design to the action research process, and finally through to the presentation of this thesis. The interwoven character of this study reflects the theories of complexity that have profoundly influenced it. The Latin root of the word complexity is *complexus*, meaning woven, braided, or entwined together (Morin, 1992). One of the key metaphors employed in this study developed out of the recognition of complex systems. The metaphor is that of a knotted ball of fishing line, which symbolises a tangled web of relations and variables. Attempts to loosen a knot in one place frequently cause knots to tighten in other places. This knotted ball is multi-causal, and intractable in its entirety, and yet it is possible to loosen, to develop adaptive pathways, and to find ways of working that lead toward social and political stability, rather than creating the conditions for instability.

At a summit hosted by the Ministry of Water and Sanitation in South Africa in mid-2014, Minister Mokonyane committed her ministry and the government department that it oversees to ensuring that its actions were "informed by both the best available science, research and technology, as well as real-life, local experience" (DWS, 2014a). This study aspires to contribute to those aims by using a novel and integrative transdisciplinary approach to draw from the 'real-life', local experience of a contentious water supply case in the Eastern Cape province of South Africa.

Chapter 1 Introduction

1.1 Overview

The challenge of managing water differently from how it was managed in the apartheid era was central to the South African water law reform process initiated by the first democratic government in 1994 (Rowlston, 2011). This process culminated with the promulgation of the *National Water Act* of 1998 (NWA) and the *Water Services Act* of 1997, which were internationally regarded as ambitious and forward-thinking legislation reflective of the broad aims of Integrated Water Resource Management (IWRM) (Schreiner, 2013). As a concept and practice, IWRM strives for "a sustainable approach to water management that recognises its multidimensional character—time, space, multidiscipline and stakeholders—and the necessity to address, embrace and relate these dimensions holistically so that sustainable solutions can be brought about" (Thomas and Durhan, 2003). As such, the aims of the new legislative framework in South Africa included achieving greater equity between (and within) users groups through greater public participation and consultation of all affected stakeholders. This was to be achieved whilst acknowledging the central role of water resources in the environment in order to meet development goals and protect water resources for future generations. These aims were underpinned by the three foundational principles of the NWA, namely: equity; sustainability; and efficiency. Central to these ambitions is the notion of governance, which in the last five years has been further developed and promoted in the global water sector with the concept of 'water governance' (for example: Biswas & Tortajada, 2010; Huitema et al., 2009; Patterson et al., 2013; Rogers & Hall, 2003; Sampford, 2009). In sum, water governance proponents argue that "value-related issues such as responsibility, accountability, transparency, equity and fairness" must be embraced in addition to rules, regulations and formal institutions (Tortajada, 2010: 306); and that water management necessarily extends beyond the reach of governments and the public sector in the contemporary world, and therefore requires the contribution of the private and voluntary sectors (Franks & Cleaver, 2007; Swyngedouw, 2006).

The first implementation plan for the NWA, namely the National Water Resource Strategy of 2004, distilled the policy objectives for managing water resources in South Africa as:

- Achieving equitable access to water
- Achieving water resource protection so as to achieve sustainable use of water
- Achieve effective and efficient use of water (DWAF, 2004).

Proposals to facilitate the achievement of these policy objectives included:

- The positioning of water as an indivisible national asset, with national government as custodian of the nation's water resources thereby holding water resources "in public trust" (Sax, 1970);
- To provide water for basic human needs and to provide water to maintain ecological sustainability as a guaranteed right; and
- The progressive decentralisation of responsibility and authority for water resource management through the creation of appropriate regional and local institutions (DWAF, 2005: 2).

In terms of the delivery of water services, the *Constitution of the Republic of South Africa* of 1996 allocated to local government the role of ensuring that water services are provided to communities within a model of 'developmental local government' (RSA, 1998d). Planning tools and processes – including the Integrated Development Plan and Water Services Development Plan – were intended to be holistic in philosophy, integrated in nature, and have public participation at their core (Haigh, Fox, & Davies-Coleman, 2010).

From this brief historical overview, it should be evident that the principles of equity, historical redress and decentralisation are central to both the legal frameworks governing water and the legal frameworks governing local government in post-apartheid South Africa. However, in spite of some significant equity, sustainability and efficiency milestones in the South African water sector being met, there is wide acknowledgement of the challenges facing successful implementation of water policy and achieving integrated management of water in South Africa. Some of the key challenges include:

- The failure to establish regional institutions for water resource management – called Catchment Management Agencies (CMA) – with only two out of the then 19 water management areas having CMAs by 2012 (Rogers & Luton, 2011);
- The difficulty inherent to converting apartheid-era irrigation boards, which functioned primarily to service commercial agriculture for the white South African population, into democratic water user associations (Brown, 2011; Kemerink, Mendez, Ahlers, Wester, & van der Zaag, 2013);
- On-going leadership challenges in the Department of Water Affairs at both the ministerial and senior management levels (Goldin, 2010; Schreiner, 2013);
- Ensuring aquatic ecosystems have the flow, water quality and structure necessary to sustain ecosystems; and

- The failure to link IWRM to water service delivery in local government, despite the fact that frameworks for doing so were explicitly devised (for example: Haigh, Fox, & Davies-Coleman, 2010). This failure is especially evident in small municipalities in rural settings – which struggle to fulfil their constitutional mandate for 'developmental local government' (including integrated planning), when compared to better equipped metropolitans and large cities (Siddle & Koelble, 2012).

Such challenges have increasingly been conceptualised as 'wicked problems'. Wicked problems are those that cross many domains, sectors and scales, involve many actors, defy simple solutions, and morph over time as a result of attempts to solve them (Rittel & Webber, 1973; Stirzaker, Biggs, Roux, & Cilliers, 2010). Transdisciplinarity has been advanced as a means of engaging wicked problems, such as those affecting water management and water governance (Brown, Harris, & Russel, 2010; Patterson et al., 2013). Proponents of transdisciplinarity argue that discipline-bound attempts to contribute to resolving or loosening wicked problems are inherently limited, as the problems themselves cross disciplinary boundaries and divisions between knowledge-production and implementation. However, transdisciplinarity is an emerging practice and a developing research approach. In April 2011, a water research project began in South Africa with the aim of testing a transdisciplinary approach to engaging intractable water problems. This project was funded by the South Africa Netherlands Research Programme for Alternatives in Development (SANPAD) and was entitled 'From policy to practice: enhancing implementation of water policies for sustainable development' (Palmer, de Wet, Slinger, Linnane, & Rogers, n.d.).

The SANPAD project aimed to use a range of theories, methods, approaches and practices in novel ways to test their usefulness in breaching barriers that were impeding the implementation of IWRM in South Africa. Three case studies that accounted for different governance levels and bio-physical scales were selected. These case studies investigated estuary mouth management in the Great Brak; transboundary catchment management in the Inkomati catchment, and local water governance in the Lower Sundays sub-catchment of the Eastern Cape (Appendix B provides further details about the SANPAD project and its evolution into a project entitled 'Towards a New Paradigm for IWRM in South Africa'). In summary, the SANPAD project sought to test the usefulness of a range of theories, methods, approaches and practices across disciplines in three case studies, with a secondary aim of contributing substantively to addressing problems in the case studies themselves, striving to:

- Loosen problem spaces that have many interdependent, controversial, complex and uncertain elements;
- Co-create knowledge with stakeholders and problem-holders; and
- Enable and empower action and mobility.

1.2 Introduction to the case study in the Lower Sundays River Valley

The Lower Sundays case study was initiated with the support of the Eastern Cape regional water board, Amatola Water, which also played a role as one of Rhodes University's research partners. The SANPAD project provided a basis for collaboration between the two institutions, with the research project providing funding and the water board contributing in-kind support and personnel time. The research team requested that Amatola Water propose an intractable problem that their organisation was facing, which the research team could investigate. The research participants at Amatola Water selected their organisation's involvement in water services in the Sundays River Valley Municipality, which is briefly introduced here.

The Sundays River Valley Municipality (SRVM) is located in the Eastern Cape province of the Republic of South Africa (see Figure 1.1 below). The municipality contains a relatively small population of 54 500 people, distributed amongst urban settlements of around 5 000 – 10 000 people each (Statistics South Africa, 2014). As of 2010, 47% of the population subsisted on a household income of less than R800 per month (approximately US$80), with unemployment estimated at 44% (SRVM, 2010a). Almost half of the municipal population is therefore reliant on social grants from national government and on receiving free basic services (including water and sanitation) from local government. Over a third of South African municipalities are of a similar size and socio-economic character to the SRVM (as described further in sub-sections 3.3.3 and 5.4.1).

The two primary economic drivers in the SRVM are agriculture and eco-tourism, which are also the dominant forms of land use in the region. A quarter of the SRVM is protected due to the area's perceived conservation importance, tourism opportunities, and biodiversity wealth (Vromans, Maree, Holness, & Skowno, 2012). This area is home to the Addo Elephant National Park, which is the third largest national park in SA (*ibid*.). The agricultural activities in the region are predominantly commercial, with both irrigated and dryland agriculture. The irrigated parts of the SRVM are located in the riparian zones around the Lower Sundays

River. Of the 16 650 ha of land under production between 2013 and 2014, around 75% was citrus (see Table C.10).

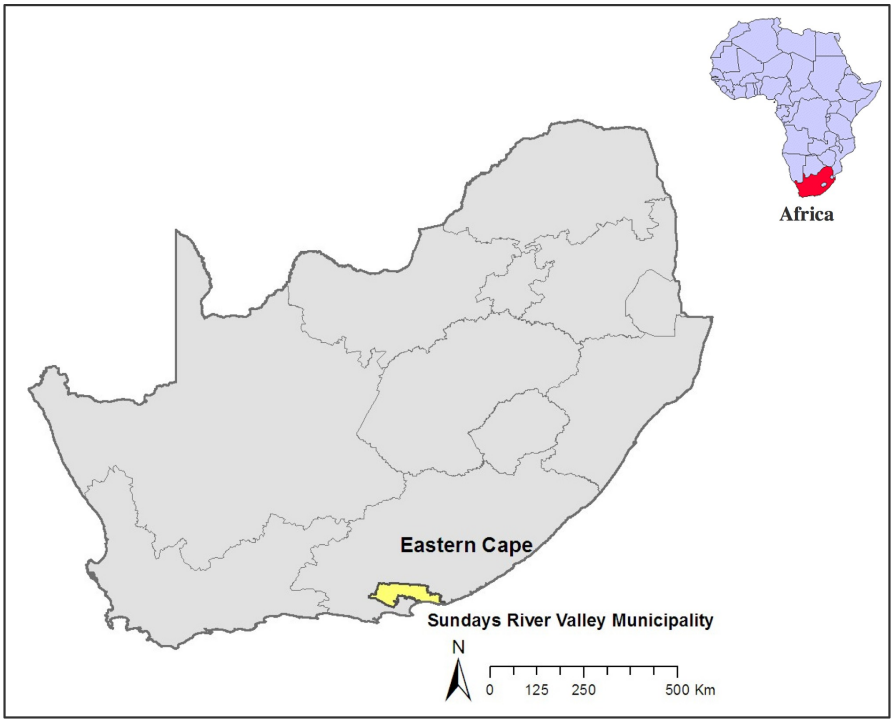

Figure 1.1: Map of the Sundays River Valley Municipality, shown as located within the Eastern Cape province of the Republic of South Africa.

The Sundays River originates in the northern part of the Eastern Cape, flowing for 481kms in a south to south-easterly direction (Wooldridge et al., 2008). The Sundays River catchment has three hydrological sub-divisions (or sub-catchments), namely, the Upper Sundays, Middle Sundays, and the Lower Sundays (see Figure 5.1 and Figure 5.2). The majority of the populated and economically-active parts of the SRVM fall within the Lower Sundays River sub-catchment, constituting the area referred to as the 'Lower Sundays River Valley' in this study (the map provided in Figure 5.1 displays the land uses alongside the relative institutional and biophysical boundaries of the area). The local yield in the LSRV is relatively low and, as a result of seasonal fluctuations, highly variable (DWAF, 2005: 46). Furthermore, the lower reaches of the Sundays River have historically registered high levels of Total Dissolved Solids that significantly affect the water quality in the region (Forbes & Allanson, 1970). Neither the water quality, nor the available yield, could support commercial agriculture as currently undertaken in the LSRV without the intervention of the Orange-Fish-Sundays inter-basin transfer (IBT) scheme. The IBT enables the bulk importing of water from more than 300kms away. The distribution of the imported water is then managed within the LSRV by the Lower Sundays River Water User Association (L-WUA), which acts as the

bulk raw water supplier to commercial farmers and other rural users, in addition to municipalities. The SRVM is one of the two municipalities that receive raw (i.e. untreated) water from the L-WUA ahead of purifying and distributing treated water to municipal residents and users. In 2010, several national and regional government departments initiated intervention processes in the SRVM, following an extended period of financial mismanagement and bankruptcy in which the provision of water services in the municipality had suffered (as demonstrated in the municipal scores of 35% on the 2011 Blue Drop assessment for drinking water quality and management, and 5% on the 2011 Green Drop assessment for wastewater treatment and management (DWA, 2011b, 2011d)).

Amatola Water was one of the actors involved in the municipal 'turnaround strategy' as part of the interventions into the SRVM. The complexities of the SRVM case led to Amatola Water agreeing to partner the SANPAD project team, in order to bring a range of transdisciplinary techniques and processes to bear on Amatola Water's engagement in the SRVM. Three key problem domains emerged from the investigative process of research undertaken between 2011 and 2012 (see Table 1.1). These problem domains were investigated using different concepts and methods, as appropriate in each domain, and in consultation with the affected stakeholders engaged in the research. This emerging process is consistent with one of the primary characteristics of transdisciplinary research – namely, an evolving methodology (Wickson, Carew, & Russell, 2006). Table 1.1 summarises the problem domains, along with the associated concepts and methods.

Table 1.1: Summary of problem domains

Problem domain	Concepts drawn from	Analytical methods utilized
<u>The intervention challenge:</u> What actors were involved, how they were interrelated, and how these actors often made the dynamics in the SRVM more, rather than less, complex	Theories of Complexity (e.g. Cilliers, 2000) Actor / agency (e.g. Agnew, 2011; Bailey, 2001)	Ethnographic (Denzin, 1989; Geertz, 1973; Stewart, 1998) Actor analysis (Hermans, 2005) Historical analysis (Lewis, 2009)
<u>Institutional arrangements:</u> Particularly the arrangement between a local water user association (raw water supplier) and the SRVM (potable water service provider and regulator)	Institutions (e.g. Mehta et al., 1999; North, 1990)	Institutional analysis (e.g. Cleaver, 2012; Mcginnis, 2011; Ostrom, 2005)
<u>Bulk water supply:</u> Supply shortfalls in the Greater Kirkwood region of the SRVM affecting approximately 10 000 residents	Systems thinking (e.g. Meadows, 2011; Richmond, 1993)	System Dynamics modelling (Forrester, 1970; Maani & Cavana, 2007)

Out of an iterative process of problem formulation – moving between theory, methods, and the real world issues affecting water management in the LSRV – emerged an action research process (Ison, 2008; Reason & Bradbury, 2008). This action research process engaged five key groups of actors: the Department of Water Affairs; Amatola Water; the SRVM Technical Division; the Lower Sundays River Water User Association; and a number of water management consultancies employed in the LSRV. The central problem that the research sought to explore was distilled as follows:

> The challenges associated with the equitable distribution of water in a small rural municipality.

The challenges associated with the distribution of water were found to be interwoven with three transitions underway in post-apartheid South Africa:

- The transition from a combined linear and silo approach to water supply, to an integrated approach to the planning and management of water supply and water demand – broadly demonstrated at the local level in the use of Integrated Development Plans and the concept of IWRM linked to water service delivery (e.g. Haigh, Fox, & Davies-Coleman, 2010);
- The transition from a racially segregated, inequitable model of service provision to a model of equitable, 'developmental local government' (including the granting of authority to local government for ensuring that water services are provided to communities) (Republic of South Africa (RSA), 1998d); and
- The transformation of organisations with responsibilities for managing water for single-use purposes (in the form of irrigation boards) to multiple-use water user associations (where water user associations were structured as the most local level of water resource management (e.g. DWAF, n.d.)).

In this study, these transitions are characterised as the wider processes of institutional change within which the aspired 'turnaround' of the SRVM – involving Amatola Water and other developmental actors – are situated. Concepts of 'institutional change', 'complexity', 'systems' and 'agency' are all defined and related in the conceptual framing in Chapter 2.

1.3 Research design units of analysis

This study employs an embedded case study design (defined and described in sub-section 3.3.4) to investigate the challenges faced by local water authorities in the geographic region termed the 'Lower Sundays River Valley' (LSRV). A particular functional focus of the 'raw

water abstraction, water treatment, and bulk water distribution' stage of the urban water cycle was selected for the reasons outlined in sub-section 2.2.1, summarised here as follows:

- Firstly, bulk water supply is a strategic point of overlapping jurisdiction between processes and institutions for water resource management, regional water utilities, raw water suppliers, and water service authorities providing potable water services;
- Secondly, the attempts to improve bulk potable water supply – both in the short and long-term – incorporate the interactions of participating, interested, and affected actors in the planning, managing and operating of bulk water services in the LSRV.

Figure 1.2 represents the overall research context of this study in a bullseye diagram, in which the empirical context is shown in the blue half of the diagram, and the intellectual context in the green half.

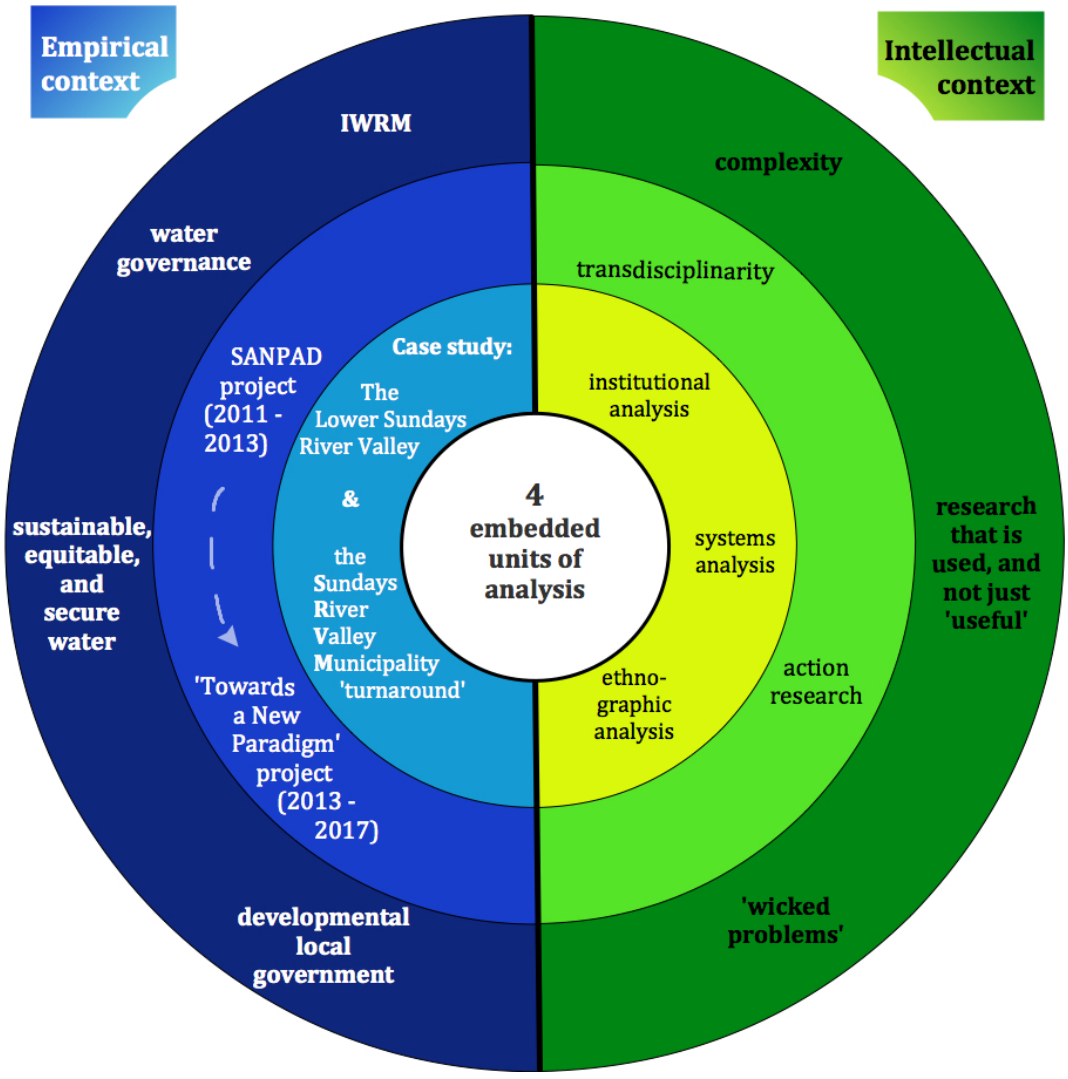

Figure 1.2: Bullseye diagram illustrating the research context, divided between the empirical context – in the blue half of the diagram on the left – and the intellectual context – in the green half of the diagram on the right. Source: own design.

The empirical context is defined by the practical challenges of ensuring that sustainable, equitable and secure water is provided in South Africa (DWA, 2013c), using the principles and practices of IWRM and water governance. Local water authorities additionally operate within a policy context of developmental local government, which ascribes broad powers and responsibilities to local government. The SANPAD project was initiated in 2011 to adopt a transdisciplinary approach to engaging the manifest practical challenges in this empirical context. The intellectual context of this study is influenced by theories of complexity and the conceptualisation of wicked problems, which motivates researchers to produce research that is used, and not just potentially 'useful'. Methodologically, this study evolved through an action research process underpinned by transdisciplinarity and employing three analytical approaches in the form of institutional, systems and ethnographic analyses. The empirical case study context was defined by the SANPAD project's engagement in the LSRV and the project's engagement in the attempted turnaround of the SRVM, in particular. At the centre of Figure 1.2 and at the centre of this study are the "embedded units of analysis" (defined and described in sub-section 3.3.4). These are the four units of analysis that are embedded within the broader case study, which can be summarised as follows:

1. The Amatola Water intervention into the SRVM;
2. The broader intervention dynamics of state actors in relation to local water authorities in the LSRV;
3. The institutional and operational arrangements between the SRVM and the Lower Sundays River Water User Association; and
4. Bulk water management in the Kirkwood water supply scheme (which supplies potable water to the Greater Kirkwood region of the SRVM – see the municipal map in Figure 5.1 and the supply schematic in Figure 5.2).

The four units of analysis were selected through the action research process, which is introduced in the methodology in Chapter 3 (see section 3.4) and is the central focus of Chapter 7. The following two sections define the aims and objectives of this study, and relate these to the chapter structure and the line of argument to follow.

1.4 Research aims and objectives

The primary aim of this study is:

> *To explore and understand the use of transdisciplinary, practice-based research in engaging local water authorities in a process of institutional change that increases the*

likelihood of equitable water supply in the Lower Sundays River Valley, Eastern Cape, South Africa.

How the primary research aim will be met is described in greater detail through the research objectives. Each research objective correlates to specific chapters of this thesis, as summarised in Table 1.2 below.

Table 1.2: Summary of research objectives and the relating chapters

Objective		Relating chapter
Objective 1: To conceptually frame the suite of concepts employed in this study by locating these concepts within the relevant literatures and, thereby, demonstrate how the utilised concepts inter-relate, support, and challenge one another.		2. Conceptual framing
Objective 2: To align the conceptual framing of this study with its methodological framing, which links the methods of institutional, ethnographic and systems analysis (along with their attendant data collection methods) as utilised in this research.		3. Methodology
Objective 3: To characterise water governance in the Lower Sundays River Valley (LSRV) by:		
3.1	Accounting for the wider context of institutional change affecting water governance in the LSRV, in order to situate local water authorities in the LSRV within broader frames of governance, via a historical analysis of governance between 1814 and 2011.	4. Historical analysis
3.2.	To situate local water authorities in the LSRV within the formal institutional domain of state-initiated arrangements in the South African water sector, exploring the 'muddled middle' between developmental local government and integrated water resource management.	5. Water governance
Objective 4: To employ the tool of thick description to the governance and management of bulk water in South Africa, using local water authorities in the LSRV as a case study.		6. Thick descriptions
Objective 5: To analyse how the use of thick description in this study differs to the classic 'Geertzian' approach (Geertz, 1973), by discussing the benefits and limitations of the qualitatively 'thicker' form of thick description developed and applied.		6. Thick descriptions
Objective 6: To design, undertake and evaluate an action research process that incorporates institutional, systems, and ethnographic analyses, toward the goal of achieving greater equity between water users in the LSRV.		7. Action Research process (+ associated appendices)
Objective 7: To reflect on insights and outcomes derived through the transdisciplinary research process, in order to explore how generalisable results and insights from this case are to other cases, and to reflexively critique the application of theory and methods in the study.		8. General discussion and conclusion

1.5 Structure of thesis:

This study is divided into three parts (see Figure 1.3), with each part accounting for particular objectives. Part I constructs and positions the research approach – conceptually and methodologically – within the literature and within research-as-a-practice. Part II establishes an understanding of the localised context of this study in relation to the formal institutional domain of the South African water sector. Part III explores the interaction of the formal and informal institutional domains using ethnographic analyses, and then accounts for the transdisciplinary, action research engagement in the LSRV, showing how the action research process drew on an integrated approach of systems, institutional and ethnographic analyses.

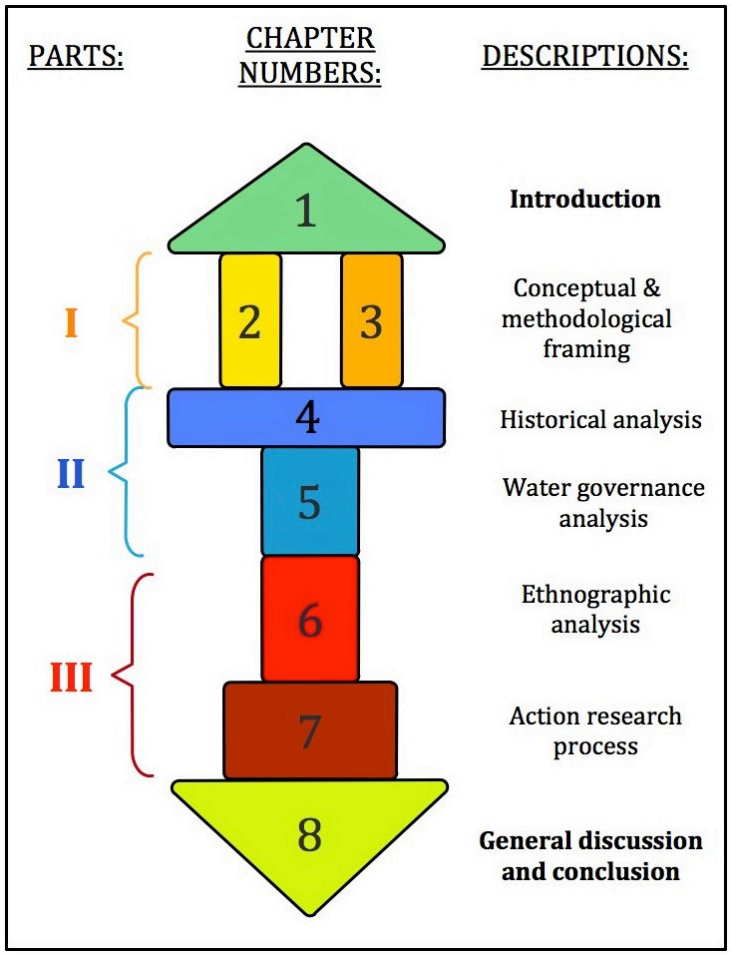

Figure 1.3: Structure of thesis. Source: conceptually drawn from Massy (2013: 12).

The chapters outlined in Figure 1.3 are supported by seven appendices, which are detailed in Table 1.3 and then related to the eight chapters in Table 1.4. To promote ease of reference in printed form, these seven appendices are presently separately in VOLUME 2 of this study.

Table 1.3: Details of appendices

	Appendix title	Appendix details
A	Data sources	Details of case study informants and interviewees, along with other important primary data collected and secondary data drawn upon in this study.
B	Summary of the wider transdisciplinary research context	Description of the two transdisciplinary research projects (the 'SANPAD' project and the 'Towards a New Paradigm') in terms of aims, conceptual framings, methodologies and case studies.
C	Supporting data for Part II	Tables, figures, timelines, and other supporting data for the historical analysis in Chapter 4 and the governance analysis in Chapter 5.
D	System dynamics model 1	Structure and equations of the 'cooperatives' model developed in 2012.
E	System dynamics model 2	Structure and equations of the 'Greater Kirkwood Water Supply' (GKWS) model developed in 2013.
F	System dynamics model 3	Structure and equations of the 'Kirkwood Water Demand' (K-DEM) model developed in 2013.
G	System dynamics model 4	Structure and equations of the 'Modes of Failure' (MoF) model developed in 2014.

Table 1.4: Key relating the eight chapters (1 – 8) of this study to the seven appendices (A – G). SD = system dynamics

	Chapters	Appendices						
		A: Data sources	**B:** Trans - disciplinary context	**C:** Supporting data (for Part II)	**D:** SD Model 1	**E:** SD Model 2	**F:** SD Model 3	**G:** SD Model 4
1	Introduction		■					
2	Conceptual framing		■					
3	Methodological framing	■	■					
4	Historical analysis	■		■				
5	Governance analysis	■		■				
6	Thick descriptions	■	■		■	■		
7	Action research	■	■		■	■	■	■
8	General discussion and Conclusion		■					■

Chapter 2 Conceptual Framing

2.1 Introduction and overview

The objective of this chapter is to conceptually frame the suite of concepts employed in this study, locating these concepts within their relevant literatures, and demonstrating why these concepts were drawn-upon, and how they interrelate, support, and challenge one another.

2.2 Defining the analytical focus of this study as local water authorities in post-apartheid South Africa

In this section, the analytical focus of this study is defined as 'local water authorities in post-apartheid South Africa', with a particular aspect of water management selected as the empirical focus.

2.2.1 The urban water cycle

The interconnected and interrelated nature of water can be illustrated via the urban water cycle. This cycle presents the primary stages of water management (as summarised in Figure 2.1).

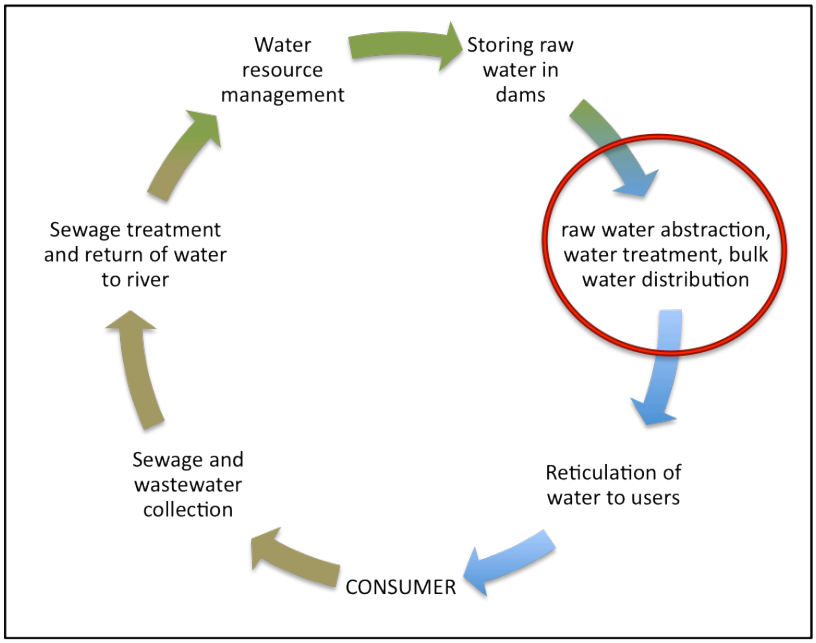

Figure 2.1: Typical urban water cycle – using surface water and conventional treatment processes at both drinking water and sewerage-treatment phases – with the relevant stage of the urban water cycle for this study circled in red.

The water available for human use in an urban area is subject firstly to the broader processes and practices of water resource management, which determine the raw water that is stored or impounded (typically in dams). Water is then abstracted according to rules or norms, and if required, is treated to a potable (drinking water) quality, prior to bulk water distribution. A managing authority of some kind then reticulates the potable water to users. In the use of this water, the consumers produce sewage or wastewater that then requires collection and conveyance to some form of treatment prior to being discharged back into a river.

Conceptualising the flows of water in and out of urban areas as a cycle emphasises the following salient points:

1. Water at a 'local' (i.e. operational scale) is contingent on, and interacts with, the wider water sector and therefore requires a multi-scalar approach (Miranda, Hordijk, & Molina, 2011);
2. The provision of water services cannot be divorced from the management of water resources;
3. Following the above, water should be managed as a system rather than as discrete processes.

This study adopts a particular functional focus of the 'raw water abstraction, water treatment, and bulk water distribution' stage of the urban water cycle (circled in red in Figure 2.1), for the following reasons:

- This stage of the urban water cycle bridges water resource management and water services, and therefore serves as a lens through which to view the interactions between urban and rural water management;
- From a policy and legislative perspective, the 'bulk water stage' (as it will be termed for short) is a point of overlap between the rules and frameworks for resource management, and the rules and frameworks for the management of water services and the provision and regulation of those same water services by local government in post-apartheid South Africa; and lastly
- From a municipal water services perspective, the storage and distribution system often comprises the major expense of a municipal water supply scheme (Department of Housing, 2000: 13).

The bulk water stage is particularly relevant in the Lower Sundays River Valley (LSRV) case study for the following reasons:

1. Potable water services are delivered by the Sundays River Valley Municipality (SRVM) after it abstracts raw water from the canal system managed by the Lower Sundays River Water User Association (L-WUA) (see Figure 5.2 and associated description for details);
2. Between 2011 and 2014, the arrangements for raw water abstraction and supply between the L-WUA and the SRVM have been a significant source of conflict and controversy in the LSRV (see sub-section 5.5.4 and sub-section 6.3.4for details);
3. Two of the six 'Top Risks' identified in the primary planning document for the SRVM are 'insufficient infrastructure for bulk services' and 'aging bulk infrastructure' (SRVM, 2013: 120-1); and
4. Bulk water supply services and the management of regional bulk water projects and schemes are primary functions of Amatola Water, the Eastern Cape water board, which has been involved in bulk water management in the SRVM in various roles since 2010 (as discussed in detail in section 6.4).

In order to analyse the bulk water stage of the urban water cycle in the LSRV, this study conceptually frames local water authorities as operating between two aspirational concepts, namely, 'integrated water resource management' and 'developmental local government', which are briefly defined, discussed, and related to one another in the following sub-sections.

2.2.2 Integrated water resource management

Proponents of 'Integrated Water Resource Management' (IWRM) draw from lists of characteristics and factors relating to water – such as those provided by Savenije (2002) and Sampford (2009) – to argue for multidisciplinary, multi-sectoral, and multi-stakeholder integration in planning, management and decision-making around water (e.g. Lenton & Muller, 2009; Thomas & Durham, 2003). As a concept and practice, IWRM can therefore be defined as striving for

> … a sustainable approach to water management that recognises its multidimensional character — time, space, multidiscipline and stakeholders —and the necessity to address, embrace and relate these dimensions holistically so that sustainable solutions can be brought about (Thomas and Durhan, 2003).

IWRM is not, however, without critique (e.g. Biswas, 2008; Medema, Mcintosh, & Jeffrey, 2008). Biswas (2008) draws from global studies that he argues demonstrate widespread

failures in the implementation of IWRM programmes. One of the reasons for these failures, according to Biswas and the Third World Centre for Water Management, is the number of issues that IWRM attempts to integrate: one review counted at least 41 sets of issues that different authors or institutions considered integrating within the concept of IWRM (Biswas, 2008: 11). The resulting critique is that IWRM is internally inconsistent at the conceptual level in addition to being un-implementable at the operational level (*ibid*.).

As introduced in section 1.1, the broad aims of IWRM are reflected in the *National Water Act* of 1998 (RSA, 1998a), the Water Services Act of 1997 (RSA, 1997) and all the subsequent strategic frameworks and implementation plans in South Africa from the late-1990s onwards (Schreiner, 2013). Recent critiques of IWRM in South Africa (e.g. Mehta et al., 2014) suggest that IWRM fails to acknowledge the intensely political nature of water resource management, whilst other analysts highlight that IWRM has suffered in the adoption and implementation stages in SA (e.g. Garduno, 2011; Schreiner & Hassan, 2011). The concept of IWRM remains highly influential in SA – as seen in the second edition of the National Water Resource Strategy (DWA, 2013c). This study follows a line of scholarship that acknowledges the difficulties in achieving the integrated management of a resource, including the intensely political nature of this management (Dent, 2012; Lenton & Muller, 2009; van der Zaag, 2005). In spite of these difficulties, IWRM contains a valuable set of concepts and practices, which encourages the adoption of systemic perspectives and therefore rightly remains influential in South African water management. In terms of this study, IWRM is therefore of central importance for conceptually framing the way in which local water authorities are *supposed* to function in post-apartheid SA.

2.2.3 Developmental local government

The second concept of central importance in this conceptual framing, developmental local government, is defined by the relevant South African policies as "local government committed to working with citizens and groups within the community to find sustainable ways to meet their social, economic and material needs and improve the quality of their lives" (RSA, 1998d). The four primary characteristics of developmental local government (DLG) are summarised in Box 2.1 below.

Box 2.1: The four characteristics of developmental local government, as envisioned in the 'White Paper on Local Government'. Source: RSA (1998d).

1. Exercising municipal powers and functions in a manner which maximises their impact on social development and economic growth;
2. Playing an integrating and coordinating role to ensure alignment between public (all spheres of government) and private investment within the municipal area;
3. Democratising development; and,
4. Building social capital through providing community leadership and vision, and seeking to empower marginalised and excluded groups within the community.

Like IWRM, the challenges of implementing DLG have been broadly acknowledged (e.g. Monakedi, 2012; van Donk, Swilling, Pieterse, & Parnell, 2008), with some analysts arguing that a level of complexity and unanticipated consequences has emerged in the local government sector that warrants referring to the decentralisation to local government in South Africa as 'a failure' (Siddle & Koelble, 2012). However, like IWRM, the concept of DLG remains influential and in circulation in contemporary SA, and is therefore of central importance for conceptually framing the way in which water services are supposed to be provided by water authorities in post-apartheid SA.

2.2.4 Similarities and overlaps between the concepts of developmental local government and integrated water resource management

Whilst the above introductions to the concepts of DLG and IWRM are intentionally cursory (due to further discussion and analysis below), the following similarities and overlaps between the aspirations of DLG and IWRM are recognisable:

- Both strive for the participation of affected actors in planning and implementation;
- Both speak for efficiency and sustainability;
- Both consciously strive for historical redress;
- Both emphasise the adoption of an integrative, systemic approach; and
- Both emphasise decentralisation and/or the devolution of decision-making to the most local level practicable (i.e. the principle of subsidiarity).

The final similarity between the two concepts is the common implementation challenges, in particular, the significant discrepancy between how these concepts were successfully

designed into policies, laws, and strategies at the national level, but have failed to become embedded at the local (or operational) level in practice. As introduced in section 1.1, the SANPAD research project conceptualised these challenges as 'barriers' to implementation that could possibly be breached using a transdisciplinary process of engaged research. Two of the requirements for exploring the process of 'breaching barriers' are therefore:

1. That particular case studies needed to be selected in order to provide 'test cases' of the policy-practice divide; and
2. That the relation between the intended way in which local water authorities are supposed to function, to the actual way in which these water authorities are functioning, needs to be conceptually explicated in terms of policy design, policy implementation, institutions and agency.

The first requirement, pertaining to case selection, is discussed in sub-section 3.4.2 of the methodology, whilst the second requirement is addressed in this conceptual framing, beginning with the following section (2.3) which draws on institutional theory in order to frame how institutional change is conceptualised in this study.

2.3 Institutional change as occurring in the 'muddled middle'

2.3.1 Defining institutions

A basic definition of institutions is the "established rules, norms, laws and practices and any other arrangement put in place that can influence social change" (North, 1990). One of the challenges with institutions is the diverse ways in which the concept is understood by different disciplines. Sampford (2009) stereotypes these differences using the following examples:

> Lawyers look at institutions and see sets of formal norms, ethicists see informal norms and the values that the institution claims to further; economists see incentives and disincentives…; political scientists see power relations; social psychologists [and social anthropologists] see complex webs of interpersonal and group relationships; and, management theorists see structures… Accordingly, the problems are seen in the deficiency of laws, ethical standards, incentives, etc. and the solutions are seen as lying in remedying those deficiencies (Sampford, 2009: 52).

In dealing with water, the problem of diverse definitions and conceptualisations of institutions is exacerbated by the relevance of all of the above-mentioned disciplines to water management and its governance. This study draws from a range of an institutional theory developed in different theoretical traditions, particularly within natural resource management,

the governance of public goods, and public administration (e.g. Krause, 2009; Ostrom, 1962). The following two sub-sections locate the institutional framing of this study within these different theoretical traditions, in order to explicate how local water authorities are conceptualised as operating in the 'muddled middle'.

2.3.2 Managerialist-functionalist perspectives and processual-dynamic perspectives on institutions

Drawing from Metha et al (1999), we can distinguish between theories that view institutions in 'managerialist' and 'functionalist' terms versus those theories that see institutions in more 'processual' and 'dynamic' terms. Managerialist-functionalist perspectives – which typically emphasise rules, regulations or conventions – have dominated the conception of institutions within natural resource management and the governance of public goods (e.g. Krause, 2009; Ostrom, 1962). Processual-dynamic views of institutions, on the other hand, argue for understandings of institutions that embraces the 'messiness' or complexity that is characteristic of real world interactions. These views have been less prevalent within natural resource management but are prevalent within various social science disciplines (e.g. Cleaver, 2012).

A managerialist-functionalist perspective typically sees institutions as the enabling structures for the implementation of policies – where the policies themselves have been derived from laws and where those laws have been derived from a larger set of constitutional principles, which in theory, were agreed upon by the participating group at large. Policies are thus nested within other policies in what is referred to by some analysts as 'polycentric institutions' (Ostrom, 2010). At the level of an individual project, the managerialist-functionalist perspective presents projects as playing out in a patterned, predictable or controllable way; managers are therefore seen as capable of planning and executing projects in a straightforward, rational planning manner – even in planning projects in complex natural resource management and public good settings (de Wet, 2013). Alternatively, under the processual-dynamic view, any institution is seen as being contested through the individual agency of participating, affected and interested actors. The results of these contestations may be an adaptation of the planned institution, or the results may be completely unrecognizable to what was planned, hoped or expected in the design of the institution. The way in which complexity, uncertainty, and adaptation is incorporated into institutional understandings (and

hence in institutional design and implementation) is therefore one of the central issues around which institutional theorists differ. The following sub-section explores these differences.

2.3.3 Institutional design

The analysis of resources and public goods from an institutional perspective began developing in the 1950s. A crucial juncture was the publication of Hardin's seminal essay 'The Tragedy of the Commons' (1968), which provided the impetus for much of the debate around common pool resources (CPRs). For Hardin, the management of a commons could occur only in two ways: either through state regulation or through privatizing the resource and granting individual property rights. Critiquing the dichotomy of the state on one side as 'the only way', and privatization on the other side as the 'only way', was central to the development of the CPR institutional research thrust of which Elinor Ostrom became the centre (1990: 15). In her early work, Ostrom argued for a 'third way' between the state and market, in which communities and local groups worked together to manage common resources. This work evolved into the Institutional Analysis and Development (IAD) framework (McGinnis, 2011; Ostrom, 2005), which has been enriched and supported through multidisciplinary theoretical and empirical work involving thousands of case studies across different scales and locations (for a review, see: Ostrom, 2010). The central argument proposed by Ostrom and her colleagues is that social-ecological systems are complex, and that the problems of overharvesting and misuse of common pool resources and wider ecological systems are rarely due to a single cause. The IAD framework posited nine design principles for effective and equitable resource management (Ostrom, 2005), which proponents argued could be applied to any institutional problem at any scale. The IAD framework has been widely recognised across diverse disciplines from ecology to economics (see Gunderson & Holling, 2002; Ostrom, 2010). A dominant critique of the design principles is that they appear to posit a blueprint for effective institutions that is too simplistic and generic (Young, 2006). Ostrom (2007a) responded to this critique with an adapted model that asked design questions using a diagnostics approach, rather than advancing principles in a generic fashion.

Cleaver (2012) and her colleagues differ from Ostrom in their approach to institutions. Cleaver critiques the degree to which institutions can be designed or crafted (arguing that the distinction between principles or questions is mostly semantic): instead, Cleaver argues for an understanding of institutional change that embraces plurality and the associated 'messiness'. Central to this 'messiness' is the issue that new institutions are not formed in a

vacuum or "inscribed on to a blank slate, but rather are channelled into particular forms by the authoritative force of what has gone before" (Cleaver, 2012: 203). This channelling motivates adherents to this theory to conceive of processes of institutional transformation and institutional change as inherently 'messy' (Franks & Cleaver, 2007), and to refer to new institutions as 'path dependent' (see Ramalingam et al., 2008: 28-9). The concept of 'path dependence' suggests that whilst a number of options are available over the course of a system's development, once one of these developments becomes entrenched, it impacts on the range of future opportunities for development by constraining future options. The emphasis on 'messiness' and complexity fits within the processual-dynamic approach to institutions described in sub-section 2.3.2. These concepts are sometimes grouped as 'post-institutionalist thinking' (Franks & Cleaver, 2007: 293), but are defined here as 'critical institutionalism' following Cleaver (2012). Cleaver (2012) differentiates the school of thought of critical institutionalism from what she terms 'mainstream institutionalism', into which Ostrom, and Ostrom's colleagues, work can be grouped. A stereotypical representation of the differences between 'mainstream' and 'critical' institutionalism – from Cleaver – is provided in Table 2.1 below.

Table 2.1: Key features of institutional thinking. Adapted from Cleaver (2012: 16).

Features	**School of thought**	
	Mainstream institutionalism	***Critical institutionalism***
Nature of institutions	Formal / public institutions in nested layers with horizontal and vertical linkages	Blurring of boundaries and of scales Blending of logics and forms (e.g. formal / informal)
Formation of institutions	Formed through crafting; Design principles characterise 'robust' institutions	Formed through practice, improvisation, adaptation of previous arrangements;
Nature of decision-making and negotiations	Mainly conducted in public forums	Embedded in everyday life; Shaped by history and politics; Subject to power-plays – conducted behind 'closed doors'
Models of agency	Strategic and purposeful; Individuals as resource appropriators	Agency as relational; exercised consciously and non-consciously – individuals as having complex social identities and emotions
Factors shaping human behaviour in institutions	Information, incentives, rules, sanctions, and repeated interactions	Social structures and power dynamics, relationships, norms and individual creativity
Outcomes	Institutions can be crafted to produce efficient resource management outcomes	Institutions evolve to 'socially fit': functioning may result in access or exclusion from resources

As described in Table 2.1 above, mainline institutionalism differs from critical institutionalism in terms of how the different schools of thought conceive of the nature and formation of institutions, the nature of decision-making and negotiations within institutions, the models of agency employed, and the factors shaping human behaviour and outcomes. However, one of the primary commonalities between institutional analysts studying natural resource management, common pool resources, and water management is an interest in what are termed 'rules-in-form' versus 'rules-in-use' (e.g. Cleaver, 2012; McGinnis, 2011; Ostrom, 2005). Rules-in-form include the formalised policy and the way specific institutions are supposed to function, whilst rules-in-use are understood as informal rules and those rules that are adaptively applied in practice. Rather than conceiving of formal and informal institutional domains as distinct from one another, this study conceptualises institutions in such a way that allows for understanding both informal and formal institutional domains. In contesting the informal-formal divide, complexity-sensitive theorists refer to the 'muddled middle' (Patton, 2011: 180) or 'messy middle' (Mehta et al., 1999: 16), arguing that this is where change or transformation happens. Hence, the empirical focus of this study (local water authorities in the LSRV) is conceptually situated within the muddled middle between formal and informal institutional domains, with the following sub-section distilling the implications of this conceptual framing.

2.3.4 The implications of framing local water authorities in the Lower Sundays River Valley within the 'muddled middle'

Conceptually framing local water authorities in the LSRV within the muddled middle requires developing and positing theoretical understandings of both:

- The informal domain of on-the-ground interactions, in terms of what happens in a particular case in practice, rather than just in theory, and
- The formal institutional domain of state-initiated arrangements for water management.

The first requirement is met through exploring conceptions of agency, using a practical approach to the politics of water and drawing from anthropological approaches to infrastructure (section 2.4). The second requirement is met by drawing on insights and approaches developed in the field of 'water governance' (which is theorised and differentiated from management in section 2.5). The conceptions of both the informal and the formal institutional domains are influenced by theories of complexity and systems, as

described in section 2.6, with the overall conceptual framing of this study summarised in section 2.7.

2.4 Agency

2.4.1 Defining agency and the 'practical politics of waterpower'

Agency, defined here as "the capability or power to be the originator of acts" (Cleaver, 2007: 226), is a distinguishing feature of being human. This study follows Agnew (2011), who draws from multiple social scientists – from social-anthropologists (Bailey, 2001; Ferguson, 1994) to political scientists (Guess, 2008) – in order to emphasise the agency of actors within the water sector. Agnew (2011), collectively refers to the negotiations, competitions and power-plays, in addition to the strategies and alliances of agents in the water sector, as the 'practical politics of waterpower'. Central to Agnew's analysis – and to the social science traditions that he is drawing from – is a critique of reductionist models of human actors, including understandings and theories of human nature that emphasise rationality in the form of unbounded optimization and self-interest. Under such models, humans are 'rational optimizers' who have limitless time, money and resources to consider every option prior to making a decision – and are therefore constantly self-maximizing according to their individual and group interests. Such models emphasize 'unbounded rationality', understood as "decision-making strategies that have little to no regard for the constraints of time, knowledge, and computational capacities that real humans face" (Gigerenzer et al., 1999: 6-7). A corpus of contemporary research supports the argument that humans neither optimise as managers or employees of organisations, nor as individuals within their own lives (e.g. Gigerenzer et al., 1999; Kahneman, 2012; Taleb, 2012). Instead, people try "to satisfy a variety of personal and organisational goals, use standard operating procedures to routinize decision making, and ignore much of the available information to reduce the complexity of the problems they face" (Sterman, 1991: 17). Following this recognition, an increasing number of cognitive scientists, behavioural psychologists, economists, political scientists and systems thinkers now ascribe to a view of 'bounded rationality'. As the systems thinker Dana Meadows (2011: 106) defines it:

> Bounded rationality means that people make quite reasonable decisions based on the information they have. But they don't have perfect information, especially about more distant parts of the system… there are many examples of people acting rationally in their short-term best interests and producing aggregate results that no one likes.

In the language of the founder of 'bounded rationality' – Herbert Simon (1957) – agents are 'blundering satisficers' (where 'satisfice' is a neologism derived from combining 'satisfy' and 'sufficiently'). Hence, rather than being seen as omniscient, rational optimizers, agents are blundering satisficers who attempt to satisfy their needs sufficiently before moving on to the next decision (Meadows, 2011: 7).

2.4.2 Politics and power

The inherently political nature of the governance and management of water is conceptualised here in a broader sense to the common-place (often-pejorative) elision of 'politics' with 'party politics' (although party politics are, of course, incorporated). Instead, politics is seen here as a practical activity (Agnew 2011: 469), underpinned by the question of "who does what to whom for whose benefit?" (Guess, 2008: 25). Bent Flyvbjerg, the Danish planner and social scientist, expands Guess' question in his motivation for an applied social science that continually asks four questions around the nature of 'power':

1. Where are we going?
2. Who gains and who loses, and by which mechanisms of power?
3. Is it [this development / change / transformation] desirable?
4. What should be done? (Flyvbjerg et al., 2012; Flyvbjerg, 2001)

Flyvbjerg's questions are in line with Agnew's conceptualization of politics as "the practical process of working and compromising across competing and antagonistic positions" (Agnew 2011: 468). Such an approach aims to avoid reductionist and abstract characterisations of politics, which typically emphasise zero-sum outcomes and totally oppositional and warring individuals or groups (*ibid*). In contrast, this study draws from conceptualisations of actors that emphasise conditionally cooperative behaviour, where the actors are multifariously motivated in ways that under a rational choice model could only be described as irrational, which features agents as "actual people who could do or who are doing things that affect other people" (Agnew, 2011: 469).

2.4.3 The anthropology of infrastructure

The second analytical aspect of agency is drawn from the discipline of anthropology, which utilises an ethnographic approach to research (defined in sub-section 3.5.2(i)), and which conceives of infrastructure as a fundamentally relational concept that becomes "real infrastructure in relation to organised practices" (Star, 1999: 380). Box 2.2 summarises the ethnographic dimensions of infrastructure that are used in this study.

Box 2.2: Ethnographic dimensions of infrastructure. Drawn from Star (1999: 380-1)

> **1. Embeddedness:** infrastructure is sunk into and inside of other structures, social arrangements and technologies;
>
> **2. Learned as part of membership:** strangers and outsiders encounter infrastructure as a target object to be learned about, with new participants acquiring a naturalised familiarity with its objects, as they become members;
>
> **3. Links with conventions of practice:** infrastructure both shapes and is shaped by the conventions of a community of practice;
>
> **4. Built on an installed base:** infrastructure does not grow from new (it wrestles with the inertia of the installed base and inherits strengths and limitations from that base);
>
> **5. Becomes visible upon breakdown:** the normally-invisible quality of working infrastructure becomes visible when it breaks (even when there are back-up mechanisms or procedures, their existence further highlights the now-visible infrastructure);
>
> **6. Is fixed in modular increments, not all at once or globally:** because infrastructure is big and layered… and because it means different things locally, it is never changed [exclusively] from above. Change takes time and negotiation, and adjustment with other aspects of the system are involved.

The ethnography of infrastructure advanced by Star (1999) has been more recently incorporated into a broader 'anthropology of infrastructure' (for e.g., Elyachar & Mains, 2012; Larkin, 2013; Merrit & Anand, 2011). Water management in general, and the provision of water services in particular, has emerged as one of the focal points of the anthropology of infrastructure (see Anand, 2011, 2012). For Anand (2011), the anthropology of infrastructure provides theoretical tools for exploring "who can get what amounts of water to flow their way given their geophysical location, network of relations, and available tools and technologies". Rather than narrowly conceptualising 'infrapolitical practices to accessing water' as one of the 'weapons of the weak' (as in Scott (1998)), Anand (2011: 557) considers practices (such as illegal connections and the booster pumps used in informal settlements in Mumbai) as "politically mediated acts of unequal… settlement". Using these conceptual tools, the breakdown of infrastructure and supply-demand deficits become "occasions for remaking forms of political claims, technical adjustments in equipment, and realigning institutional and political relations" (Simone, 2012).

However, agency "does not exist in a vacuum but is exercised in a social world in which structure shapes the opportunities and resources available to individuals, in which appropriate ways of being and behaving are not simply a matter of individual choice" (Cleaver, 2007: 226). Understanding how actors exercise their agency at the local level of water management in the LSRV necessitates conceptualising both the agency of actors in practice, and the structures that inform the 'rules of the game'. The latter position acknowledges the on-going debate within social theory about the balance between structure and agency, which has been prominently explored by social theorists like Giddens (1979) and Bourdieu (1992), and more recently built-upon by theorists in a range of fields, including that of 'human development' and natural resource management (e.g. Agrawal & Gibson, 2001; Agrawal, 2005). The conceptions of agency outlined in this section relate to the earlier conceptions of institutions (in section 2.3), which are explored in this study using the analytical framing of water governance, as discussed in section 2.5.

2.5 Water governance

2.5.1 Defining 'governance' and 'water governance'

Whilst no agreed definition of 'governance' exists, the term has significantly evolved from its ancient Greek roots where it was applied to government and simply meant to 'to steer' (Jessop, 1998). After reviewing a selection of governance definitions, Lautze et al. (2011) distil the core concepts of governance as

- The processes involved in decision-making, which
- Take place through institutions (including mechanisms, systems and traditions), and
- Involve multiple actors.

Some of the common features of governance are broadly held to be accountability, transparency, and participatory and decentralized decision-making (Biswas & Tortajada, 2010: 132). The modern conception of governance, in comparison to the ancient definition, extends from government and the public sector to include the private sector and civil society (Franks & Cleaver, 2007; Swyngedouw, 2006).

International organisations began asserting the importance of governance in the water sector in the early 2000s. At the Johannesburg Summit on Sustainable Development in 2002, the Prince of Orange of the Netherlands exemplified the 'governance turn' by stating that "the world water crisis is a crisis of governance – not one of scarcity" (Mollinga, 2008: 9). The

following year, the Global Water Partnership (GWP) released its report on 'Effective Water Governance', in which it conceived of water governance as the "range of political, social, economic and administrative systems that are in place to develop and manage water resources, and delivery of water services, at different levels of society" (Rogers & Hall, 2003: 16). This broad definition has been widely used in policy documents and substantively discussed in academic research (see Baumgartner & Pahl-Wostl, 2013; Lautze et al., 2011; Pahl-Wostl, 2009), albeit with little agreement. One of the main points of contention in the literature is the distinction between 'governance' and 'management' in general, and the distinction between water governance and integrated water resource management in particular. Integrated water resource management (IWRM) predates water governance by more than 30 years (Biswas, 2008), with proponents arguing that "good governance lies at the heart of IWRM" (e.g. van der Zaag, 2005). For this reason, water governance can be seen as a subsidiary component of IWRM. Some proponents of water governance suggest the converse, i.e. that water governance should rather be seen as providing the 'framework' within which IWRM can be applied (Rogers & Hall, 2003). Other analysts critique the many similarities between IWRM and water governance, questioning whether water governance provides anything new, or whether it is really a case of "old wine being recycled into new bottles" (Biswas & Tortajada 2010: 132).

With regards to resource management, 'management' can be broadly understood as referring to "the activities of analysing and monitoring, developing and implementing measures to keep the state of a resource within desirable bounds", whilst resource governance "takes into account the different actors and networks that help formulate and implement... policy and/or policy instruments" (Pahl-Wostl, 2009: 355). From the above, management of water is therefore about water outcomes, whilst governance is about processes, actors and institutions. However, the international proponents of water governance frequently confuse the distinction between outcomes and processes. For example, the GWP's 12 principles for effective water governance are listed as follows:

> Open; Transparent; Participative; Accountable; Effective; Coherent; Efficient; Communicative; Equitable; Integrative; Sustainable; and Ethical (Rogers & Hall, 2003).

Lautze et al. (2011: 4) note that some of the GWP's principles "reflect characteristics of a good process (e.g. open, transparent, participative, communicative and ethical)", whilst other principles "are in fact more associated with water resource outcomes" (e.g. effective,

efficient, equitable, and sustainable). Principles of water governance do not account for potential inconsistencies and do not distinguish between which principles (if any) are necessary and sufficient. As Lautze et al. (2011: 4) ask: "what if increased equity reduces efficiency?... What if high participation leads to the decision to use water unsustainably?" As with all forms of resource management and all aspects of public services, water resource management and water service delivery inevitably involve trade-offs, which have been documented and discussed within a range of literatures (e.g. Crewe & Axelby, 2013; Mollinga, 2008). Such trade-offs can be understood as developmental problems that are inherently political, where 'politics' is seen as a practical activity (Agnew 2011: 469), underpinned by the question of "who does what to whom for whose benefit?" (Guess, 2008: 25). For this reason, contestations and confrontations are central to many social scientists' conceptualisations of water governance. Castro (2007), for example, argues that in practice,

> …[multiple] actors are involved in continuing debates and in socio and political confrontations around how water and essential water services should be governed, by whom, and for whom. These confrontations are at the heart of the process of democratic water governance, which is characterized not only by dialogue and negotiation but also… by… conflict (Castro, 2007: 107).

An additional concern is that both IWRM and water governance aspire to integrate multiple issues, variables, and dynamics, whilst including a range of actors in planning and implementation. Furthermore, proponents of IWRM and advocates of water governance both acknowledge the degree to which water is "conditioned by general politics and is thus influenced by decisions that lie outside of the water sector" (Sampford, 2009: 52). Lenton and Muller (2009) account for this paradox by arguing that the integrated management of water can only work if it does not focus exclusively on water. The holistic ambitions of both approaches (in concert with the wide definitions) therefore risk "encompassing most elements of society in a partnership that is so broad [it defies] any possibility of decision making" (Sampford, 2009: 51).

2.5.2 From policy to legal frameworks to implementation

Following the introduction of water governance provided in sub-section 2.5.1, the concept of 'water governance' can be broadly understood as "reflecting a society's level of competence to implement effective water arrangements through policies, laws, institutions, regulations, and compliance mechanisms" (Iza & Stein, 2009: 7). Clear policies that speak to principles, objectives, and values provide the underpinning for establishing the legal structures, which in turn are required for the operating of effective water institutions in terms of compliance and

enforcement. In order to move towards effective water governance, an enabling environment is required that develops water governance capacities. The guidelines on 'reforming water governance' produced by the International Union for Conservation of Nature (IUCN) argue that the four characteristics of this enabling environment are transparency, accountability, certainty, and the lack of corruption (see Table 2.2).

Table 2.2: Enabling environment for the effective development of water governance capacity at a national level. Drawn from the International Union for Conservation of Nature (IUCN)'s guidelines for 'reforming water governance' (Iza & Stein, 2009: 97-9).

Characteristics	Definitions
Transparency	"Transparency 'allows' stakeholders to gather information that may be critical to uncovering abuses and to defending their interests. Transparent systems have clear procedures for public decision making and open channels of communication between stakeholders and officials, and make a wide range of information available"
Accountability	"Officials must be held accountable for their actions according to the rules of their office... Those who violate the laws and regulations must be brought to justice"
Certainty	"The higher the level of certainty for any given transaction, the greater is the willingness of stakeholders to participate… Certainty is fostered by the rule of law, access to redress in courts and the absence of corruption"
Lack of corruption	Corruption entails the "misuse of the office for private gain. The office is a position of trust in which one receives authority to act on behalf of an institution, be it private or public, or non-profit"

The intention of this section is not to provide a review of water governance (such reviews have been provided elsewhere (e.g., Miranda et al., 2011; Tortajada, 2010a, 2010b)). The theory and practice of water governance is still very much in development, which is evident in the fact that some of the first edited scholarly volumes on water governance have only recently been published (Gunawansa & Bhullar, 2013; Tortajada & Biswas, 2013). Hence, rather than providing a generic review of water governance, this study applies an analytical framing of water governance to water-related issues in the LSRV, which draws on theory and cases contained in the 'water governance' literature. The following sub-section defines how the concept of water governance is operationalised and employed in this chapter.

2.5.3 Defining water governance in this study

Hakan Tropp, manager of the Water Governance facility at the Stockholm International Water Institute, argues that water governance is something very concrete which determines "who gets what water, when, and how" (Tropp, 2005: 11). Tropp's conception of water

governance is far from an idealised theory or political philosophy, and closer to a practical approach to the politics of water that is about "actual people who could do or who are doing things that affect other people" (Agnew, 2011: 469). This conception of water governance is useful at the local, sub-catchment level, where actual people are involved in making practical day-to-day arrangements that do, and do not, facilitate access to water (as is the case in the LSRV). Hence, following Lautze et al. (2011) and Tropp (2005), water governance is conceptualised in this study as consisting of the processes and institutions by which decisions that affect water are made, which collectively determine who gets what water, when and how.

The above definition of water governance requires additional capacities that are outside of the traditional skillset of managers, technicians and scientists in the water sector. Following Tropp (2007), responding to contemporary water governance challenges requires additional 'sociocratic' skills and capacities, in addition to the traditional 'technocratic' skills and capacities in the water sector (as summarised in Table 2.3 below).

Table 2.3: Responding to contemporary water governance challenges: the need for new knowledge and capacity development (drawn from Tropp (2007: 28)). The left-hand column lists the conventional capacities and knowledge held by technocrats, which are compared to the new (sociocratic) knowledge and capacities that need to be further developed in the right-hand column.

Technocratic	**Sociocratic**
Managing 'things'	Managing people and processes
Top-down	Bottom-up
Blueprint	Knowledge sharing
Measurement	Mediation / interpretation
Construction-oriented	Process-oriented
Standardisation	Diversity
Disciplinary knowledge based on technological know-how and natural sciences	Multidisciplinary knowledge based on understanding of society and nature that can facilitate integrative approaches
Physical information is produced pertaining to hydrology, biology, geology, etc.	Socio-economic information is produced pertaining to, for example, income levels and consumptions patterns

As discussed in the introduction to water governance above (sub-section 2.5.1), there are fundamental tensions between the different principles of governance. Following Heller (2008), this tension can partly be attributed to the idea of 'good governance' being pulled in different directions by two groups of stereotyped individuals: on one side are individuals who promote technical efficiency and believe that too much participation can overwhelm

institutions (and the capacity of those institutions to deliver); on the other side are those individuals who emphasise the need for increased participation and argue that "an over-emphasis on institution building crowds out civil society" (Heller, 2008: 107). Heller calls the former 'technocrats' and the latter 'associationalists' (*ibid*.). This critique has been aimed at South African local government by Buccus and Mathekga (2007), amongst others, who argue that government's top-down technocratic approach emphasises local government as a vehicle for service delivery at the expense of (and instead of simultaneously) emphasising local government as a vehicle for participation. Conceptualising these fundamental tensions within governance regimes as being 'tightened' by different individuals and groups assists with understanding why it is so difficult to achieve consensus with public policies to govern water. As Tropp (2007: 28-9) describes it:

> There are many questions that can be posed about how to achieve consensus on public policies to govern water. Unfortunately, doing this in any society creates winners and losers, at least in the short run. Any water governance system should aim for social and political stability. Robust and flexible governance structures should be able to cope with such problems by providing mediation between conflicting water uses, compensation to disfavoured groups, and benefit sharing.

The grounded conceptions of agency employed in this study – in terms of the 'practical politics of waterpower' (see sub-section 2.4.1) and the 'ethnography of infrastructure (see 2.4.3) – provide a strong theoretical base with which to explore the social and political aspects of water governance both as strategic interests and power-plays within formal policy settings, and as interpersonal and interpretive encounters and experiences of local agents in operational settings. Rather than employing a framework for interpreting the goals of stakeholders in the LSRV (i.e. a deductive approach such as the one taken by Vangen and Huxham (2012)), the varied interests and perspectives of stakeholders in the LSRV are explored in this study using ethnographic tools developed in anthropology (using an inductive approach for the reasons explained in sub-section 3.5.2).

2.5.4 Limitations of the governance perspective

One of the primary analytical challenges of the water governance definition developed in the above sub-sections is how to account for differentiation between the policy design (the rules-in-form) and the way in which water is managed in practice (the rules-in-use). The concept of bricolage is adapted from its original formulation by notable anthropologists (particularly Claude Levi-Strauss) and employed here "to explain the combination of practical creativity and constraint in processes of institutional formation" (Cleaver, 2012: 33).

Following Cleaver (2007: 229), institutional bricolage is defined here as "the piecing together… of institutional arrangements from existing norms, practices and relationships." Rather than understanding agents at the local level as simply 'implementing' or 'failing to implement' policy and legislation in a deterministic manner, agents are therefore conceptualised as interpreting, reinterpreting and adapting policy framings to local conditions, including historical contexts and resource conditions. In addition to Cleaver's institutional bricolage (2007, 2012), this conceptualisation draws from the anthropology of development in which policies and programmes are understood as being taken-up, translated, adapted, resisted or contested by local agents (e.g. Long & Long, 1992).

The concepts and framings presented thus far are still inadequate for exploring bulk water issues in the LSRV for two reasons: firstly, the theories and framings inadequately address how water governance (and the associated water management) are unavoidably about individuals and institutions interacting with the physical environment. All water use influences (and is influenced by) a bio-physical base, which does not just respond to anthropogenic impacts in a linear, predictable fashion. The second (related) reason that the conceptual framing developed thus far is inadequate, is that the framing does not account for how individuals and institutions interact with the physical environment through technologies and infrastructures (what Franks and Cleaver (2007) refer to as 'mechanisms of access'). Like the bio-physical base, these mechanisms of access also contain non-linear dynamics that, in turn, influence how human agents interact with the mechanisms. The concepts and framings outlined so far only account for these feedbacks at the qualitative or descriptive level. In order to explore dysfunctional municipal water systems and local-level water management problems in the LSRV more accurately, this study draws from systems theories (Forrester, 1968; Luenberger, 1979; Meadows, 2011) whilst embedding the use of theoretical and methodological systems tools within an understanding of complex, 'wicked problems'.

2.6 Engaging wicked problems: systems theory, complexity and modelling

Given the range of institutional and agency-based dynamics introduced so far, the water problems affecting users in the LSRV can be summarised as multifaceted, rather than mono-causal; and interconnected, rather than independent of one another. Rittel and Webber (1973) characterised situations like this as 'wicked problems': wicked problems are multi-causal with many interdependencies; they evade clear definition and are intellectually and socially complex (Brown et al., 2010; Rittel & Webber, 1973). Crucially, attempts to address wicked

problems often result in unforeseen secondary effects, which change the problem itself: this lack of stability impacts on the capacity for definitive resolution, meaning that wicked problems have no single solution, and must be managed rather than solved. Problems are therefore interwoven and messy. For this reason it is useful to frame the attendant 'messiness' within the language and thinking of theories of complexity, as outlined in the following sub-section.

2.6.1 Complexity

The interest in complex phenomena has led to many theorists referring to a 'complexity turn' in scientific enquiry (Urry, 2005). Complexity lacks an agreed-upon definition and all-encompassing theory, A working definition of complexity, as employed here, is the "interdisciplinary understanding of reality as composed of complex, open systems with transformational potential" (Byrne, 2005 cited in Preiser, 2012). The word complexity comes from the Latin *complexus* – meaning woven, braided, or entwined together (Morin, 1992; Ramalingam et al., 2008) – which is apt given that 'theories of complexity' have themselves been woven together from a range of discoveries made in diverse disciplines (Preiser, 2012: 37), including physics (Gell-Mann, 1994); biology (Maturana & Varela, 1980); and the philosophy of science (Morin, 1992, 2005). The field of complexity can therefore be understood as a broad range of discoveries, theories and concepts grouped under a single, overarching concept. For this reason, we should rather refer to 'theories of complexity' rather than a single 'complexity theory' (Preiser, 2012: 37). As in all fields, there are significant disputes within theories and between theorists, but certain key characteristics are less contested than others. Following Cilliers (2000), the key characteristics of complexity can be summarised as:

- Comprising many interacting components;
- With non-linear processes;
- With feedbacks between components and processes;
- Where scale (temporal and spatial) influences processes and feedbacks; and
- Where small changes can lead to large effects (e.g. spatially and temporally) and vice versa.

Complex phenomena – by definition – arise out of systems. A 'system' is defined here as any collection of interacting elements for which there is a cause-and-effect relationship amongst the elements (Close et al., 2002). In addition to a group of interacting elements, a system "is coherently organized in such a way that it achieves something" (Meadows, 2011: 11).

Following Meadows (2011), a system therefore consists of three kinds of things: elements (also called variables); interconnections; and a function or a purpose. The application of systems theories to the study of water management and governance is explored in the following sub-section.

2.6.2 Systems thinking and water

The concept of 'system' – as introduced above – is inextricably linked to the practice of 'systems thinking'. Systems thinking is based on a holistic worldview that emphasises interrelationships rather than parts, and patterns of behaviour over time, rather than static snapshots. This holistic worldview can be defined as a systems thinking paradigm (as described in Box 2.3 below).

Box 2.3: Descriptions of a 'systems thinking paradigm'. Source: Richmond (1997).

> **Forest thinking:** striving to see the 'big picture' and how the component parts relate and interact;
>
> **Operational thinking:** understanding the 'physics' of operations and how things work and affect each other;
>
> **Dynamic thinking:** recognising that the world is not static and that things change constantly;
>
> **Closed-loop thinking:** recognising that cause and effect are not linear, and that often the end (effect) can influence the means (cause/s).

Applied to water, systems thinking moves away from "looking at isolated situations and their causes, and starts to look at [the water system] as a system made up of interacting parts" (Simonovic, 2009: 68). By doing so, a systems approach aims to mitigate the shortcomings of linear analyses that emphasise a certain relation between a cause and a given effect. In its place, proponents of a systems approach are interested in feedbacks, and the behaviour of a system over time and under different conditions. The characterisation of dynamic systems by time and time evolution allows for representing a given system mathematically using differential equations (Luenberger, 1979). As Musango (2012: 29) points out, "it is these equations that provide the structure for representing time linkages among variables". The primary structural components of a dynamic system are stocks and flows, where stocks are accumulators, and flows are the processes by which quantities move from one stock to another (Forrester, 1968). The dynamic systems approach allows for conceptualising and

quantifying key resources – both material and non-material – that water management and water service provision in the LSRV is dependent upon. The approach draws on, and utilises qualitative and quantitative systems modelling techniques, which the following sub-section explains.

2.6.3 Modelling and learning in complex systems

One of the founders of the field of system dynamics describes the ubiquity of models in everyday life as follows:

> Every person in private life and in business instinctively uses models for decision making. The mental images in one's head about one's surroundings are models. One's head does not contain real families, governments or countries. One uses selected concepts and relationships to represent real systems. A mental image is a model.... All laws are passed on the basis of models... The question is not to use or ignore models. The question is only a choice among alternative models (Forrester, 1970: 4)

In short, a model is a simplification of reality that is at once imperfect and incomplete. For this reason, the statistician George Box famously stated, "essentially, all models are wrong, but some are useful" (Box & Draper, 1987). Phrased more accurately: "models are not true or false, but lie on a continuum of usefulness" (Barlas & Carpenter, 1990). What makes a model useful is less the inclusion of all the possible information, and more the inclusion of what is adjudged to be the most relevant information. As Sterman (1991: 5) put it, whilst a map is a model of a territory, it is not the territory itself, and indeed, "a map as detailed as the territory would be of no use (as well as being hard to fold)". Stirzaker et al. (2010) reason that even if it was technically possible, including all relevant information in a model would not help to solve the kind of complex problems that the water sector faces:

> If we have a model which is just as complex as the system it models, it will be just as difficult to understand as the system itself. We will also not be able to judge if the model actually tracks the system correctly in time and space. It is often therefore better to have a simpler model which we understand, and understand the limitations of, than a complex one we do not understand (Stirzaker et al., 2010: 602).

Following Stirzaker et al. (2010), modelling is conceptualised here as a constant balance between the increasing level of detail and the functional utility of an evolving understanding. A diagrammatic representation of this balance is provided in Figure 2.2, and described here.

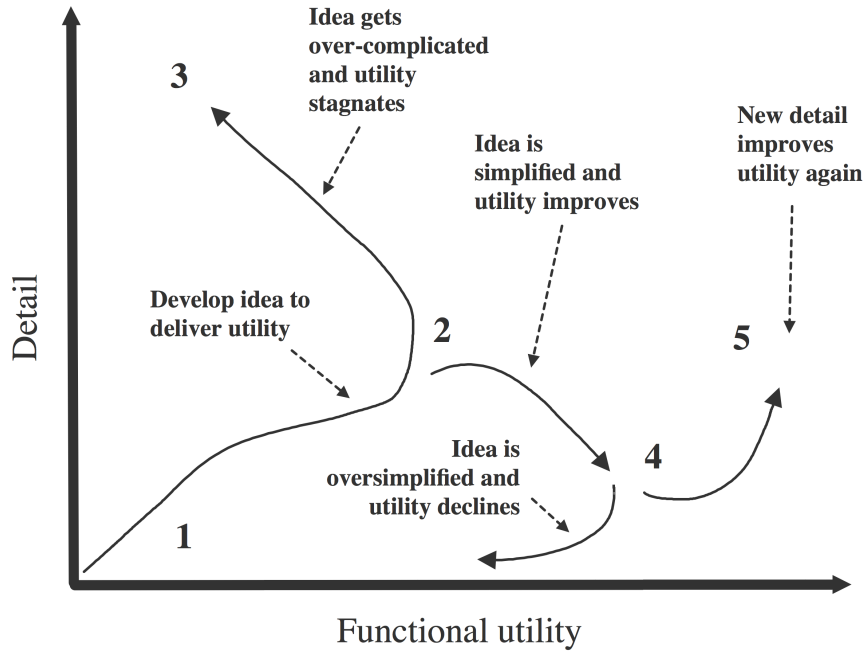

Figure 2.2: The simplicity cycle. Source: redrawn from Stirzaker et al. (2010: 602).

In order to develop something useful, an analyst needs to engage the detail of a particular problem, and thus begins at position **1** in Figure 2.2. At position **2**, an understanding of the problem has been gained that is of some use, but is often perceived as being 'too simple'. Hence, more detail is added, but as that detail is added the idea becomes over-complicated and its utility diminishes as a result (position **3**). As the idea is simplified and becomes more useful again (position **4**), there is the possibility of oversimplification to the extent that the idea becomes less and less useful. So the delicate balance between adding and taking away detail continues in a cycle, with the aim of achieving a point of 'requisite simplicity' (Stirzaker et al., 2010). The simplicity cycle ascribes to the complexity perspective that failures are feedbacks from within a system, and as such, offer information that can be used to adaptively manage the system going forward. Crucially, failures within a system do not mean that all the policies and the associated laws and compliance structures are wrong, and require redesigning: failures could mean that aspects of a policy require adaptation, or that a different implementation programme is required.

From a systems thinking perspective, the real failure is the failure to treat feedbacks as information that can be used to improve future system performance (Meadows, 2011). This adaptive step is emphasised by theorists within fields as diverse as political philosophy and justice ("to ask how things are going and whether they can be improved is a constant and inescapable part of the pursuit of justice" (Sen, 2009: 86)), through to the contemporary

analyses of complex adaptive systems (e.g. Gunderson & Holling, 2002; Ostrom, 2007b) that have resulted in management approaches in use in the South African water sector, including Strategic Adaptive Management (Rogers & Luton, 2011). In sum, under an adaptive management approach, policies become hypotheses, whilst management actions become the experiments to test these hypotheses (Folke, Hahn, Olsson, & Norberg, 2005). Above all else, this experimental position advocates continual learning over final solutions. The promotion of learning processes over the imposition of 'final solutions' is not new. Korten (1980) argued this point following an extensive study of international development assistance programs in the 1970s, whilst Rittel and Webber (1973) conceptualised the impossibility of permanently solving 'wicked problems' in their classic paper on the subject in 1973; furthermore, since the 1990s, the concept of the 'learning organisation' has become increasingly common (Senge & Sterman, 1992; Senge, 1990). In the last decade, learning has explicitly come to the fore in natural resource management, as seen in research into 'social learning' (e.g. Cundill, Cumming, Biggs, & Fabricius, 2011; Reed et al., 2010). Whilst research on social learning in the water sector has been conducted, research initiatives have typically focused at the catchment scale (e.g. The SLIM Project, 2004) and transboundary/regional scales (Pahl-Wostl, 2006), rather than at the municipal and sub-catchment scale equivalent to the LSRV. This study incorporates the philosophy and practice of adaptive management (with its attendant emphasis on learning) into the ethnographic analysis, institutional analysis, and systems modelling approaches. The particular modelling approach selected is outlined below.

2.6.4 System dynamics modelling as a means of engaging wicked problems in the water sector

System dynamics is defined here as "a way of modelling peoples' perceptions of real-world systems based especially on causal relationships and feedback… [that was] developed as a traditional simulation tool but can be used, especially in combination with causal-loop diagrams, as a way of facilitating group discussion" (Mingers & Rosenhead, 2004: 532). System dynamics is variously understood as a paradigm, approach, method, and discipline (see Pruyt, 2006), with the following characteristics:

1. System dynamics characterise systems by time and time evolution, allowing for the artificial representation of a given system using differential equations (Luenberger, 1979);

2. The aim of system dynamics most broadly is to uncover endogenous (i.e. internally-driven) sources of system behaviour (Richardson, 2011);
3. As a method, system dynamics uses computer modelling (simulation) to focus analysis on the information feedback loops that give rise to dynamic behaviour (Ford, 2009);
4. The aim of simulation is towards understanding the impacts of time delays, feedbacks and nonlinearities within complex systems, rather than for prediction and control purposes;
5. Through eliciting and representing mental models about the nature of difficult problems, the creation of formal models and simulation to test different approaches, and methods to sharpen reasoning and improve processes (Sterman, 2000), system dynamics attempts to offset the unanticipated side effects of what Forrester (1970) called the 'counterintuitive behaviour of social systems' and what Meadows (1982), amongst others, called 'policy resistance'.

The overall use of system dynamics as a form of quantitative policy analysis is increasing within the international water sector, but, as a review of system dynamics applications in the water sector demonstrates (Winz et al., 2009), the themes that have traditionally garnered the greatest attention from system dynamics practitioners are those of regional planning and river basin management, and flooding and irrigation (for e.g. Ford, 2009; Fernández & Selma, 2004; Guo et al., 2001; Xu, Takeuchi, Ishidaira, & Zhang, 2002). System dynamics is increasingly employed to investigate the challenges associated with urban water supply. Specific applications of system dynamics to urban water management have focused on municipal water conservation policies (Ahmad & Prashar, 2010); urban water supply in Singapore (Xi & Poh, 2013) and Korea (Park, Jeon, & Jung, 2013); and urban wastewater management (Rehan, Knight, Unger, & Haas, 2013). The participatory use of system dynamics in tandem with other theoretical and methodological approaches to water problems has been more limited (see Stave, 2003, 2010), as has the application of system dynamics to urban water management in the developing world in general, and Africa in particular. The few (published) applications of systems dynamics in the South African water sector include the relation between a municipality and the physical dynamics of an estuary (Slinger, 1996), and as part of modelling the South African Green economy (DEA & UNEP, 2013; Musango, Brent, & Bassi, 2014).

The study departs from the position that complex phenomena are, by their nature, incalculable in their totality. As the statistician options-trader turned-philosopher, Nassim Taleb (2012: 138), colourfully puts it,

> … randomness in the Black Swan domain is intractable… The limit is mathematical, period, and there is no way around it on this planet. What is nonmeasurable and nonpredictable will remain nonmeasurable and nonpredictable no matter how many PhDs with Russian and Indian names you put on the job… There is, in the Black Swan zone, a limit to knowledge that can never be reached, no matter how sophisticated statistical and risk management science ever gets.

Whilst Taleb (2012) emphasises that complexity is an epistemological issue that extends beyond conventional constraints of available data, computer power, and modelling techniques, this study follows Cilliers (2000) and Preiser (2012), in emphasising that complexity relates "to our knowledge as human beings, individuals, persons and citizens" (Morin, 2005: 21), and is therefore an ontological issue pertaining to the nature of reality, in addition to an epistemological issue. But whilst modelling the complexity of a given social ecological systems in all its richness is impossible, we can still learn from the behaviour of complex systems and the non-linear effects of human interactions in these systems. Furthermore, this study holds the position that we can learn both from modelling technical and natural systems, as well as from modelling human behaviour in relation to technical and natural systems. This position is contrary to the view held by some social scientists that we can model natural or technical systems, but that any attempt to model human behaviour in relation to natural or technical systems is pointless (see Sterman, 2000). As Sterman (2000: 38) responds, "this view overestimates our understanding of nature and underestimates the regularities in human decision making".

2.7 Summary of the synthesised conceptual framing of this study

The conceptual framing of this study has situated the analytical focus of 'local water authorities in the Lower Sundays River Valley' within the muddled middle between formal and informal institutional domains. The field of water governance is drawn from in order to explore the formal institutional domain of state-initiated arrangements for water management. The informal domain of on-the-ground interactions is theorised by drawing from conceptions of agency influenced by 'a practical approach to the politics of water' and anthropological approaches to infrastructure. In order to explore dysfunctional municipal water systems and local-level water management problems in terms of human behaviour interacting with physical and technical systems, this study draws from systems theories

(Forrester, 1968; Luenberger, 1979; Meadows, 2011) whilst embedding the use of theoretical and methodological systems tools within an understanding of complex, 'wicked problems'. The key conceptual realms drawn from in this study are therefore institutions, agency, and systems, underpinned by theories of complexity, as visualised in Figure 2.3 below. This conceptual framing serves as the basis for the subsequent methodological framing of this study, which is provided and discussed in Chapter 3.

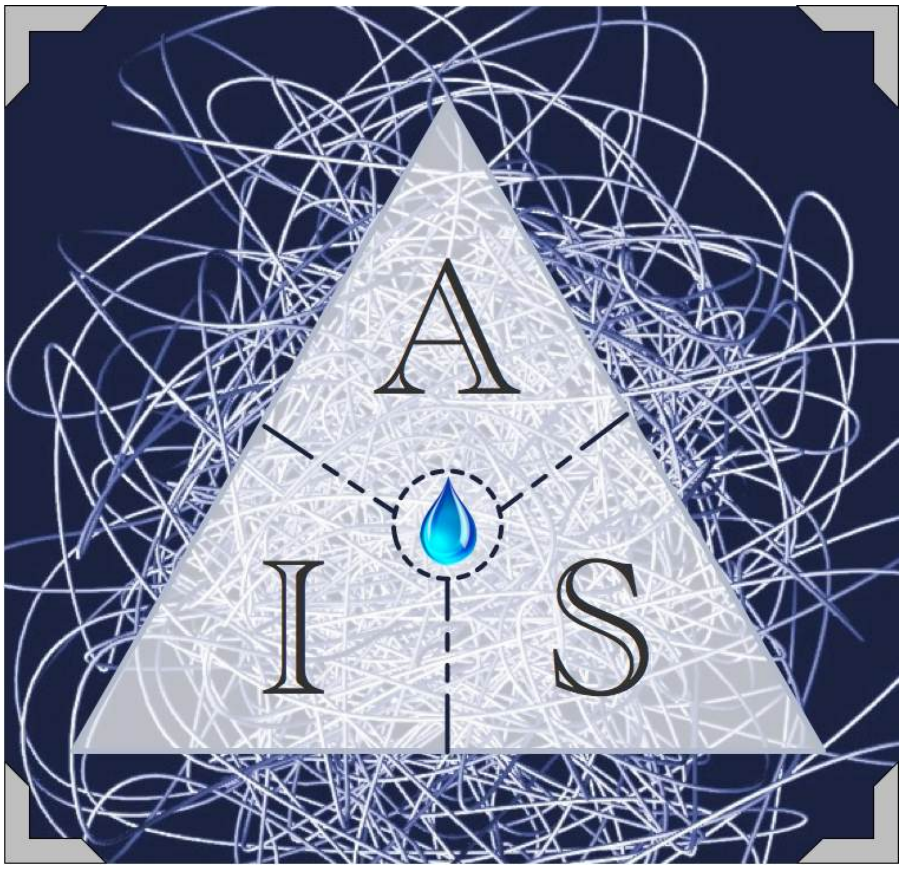

Figure 2.3: Key concepts of agency (A), institutions (I) and systems (S), connected by a common interest in water (represented by the water drop) and underpinned by theories of complexity (represented by the tangled 'mess' behind and interwoven into the conceptual triangle.

Chapter 3 Methodological Framing

3.1 Introduction

Common definitions of methodology distinguish between an overall research approach and the methods utilised, asserting that the former is linked to a paradigm or theoretical framework, whilst the latter refers to "systematic modes, procedures or tools used for collection and analysis of data" (Mackenzie & Knipe, 2006). In the social sciences in particular, methodology is seen as the "principles, theories and values that underpin [an] approach to research" (Somekh & Lewin, 2005: 346), or, as Walter (2006: 35) defines it, the framing of our overall research by the "paradigm in which our theoretical perspective is placed or developed". The notion that a theoretical perspective can be developed over time in order to frame research is consistent with how Ison (2008: 155) conceptualises methodology – as a research practice that arises iteratively from what is done in a given research situation, or "the conscious braiding of theory and practice in a given context". The methodological framing of this study is described in this chapter by

- Accounting for the overall research approach at the paradigmatic level;
- Outlining the research methods and tools by which data were collected and analysed, in relation to the research process; and
- Relating the methodological framing to the conceptual framing of this study – as developed in Chapter 2 (see section 2.7 for summary of conceptual framing).

3.1.1 Research paradigm

The nature of science can be characterised by two opposing poles that hold differing assumptions on human nature, epistemology, ontology and methodology (as summarised in Table 3.1). The paradigmatic position underpinning and framing this study is one in which all of the dualisms in Table 3.1 are held to be inadequate. The research paradigm of this study (and this researcher) is instead informed by three middle-ground approaches that argue for 'both-and' rather than 'either-or'. These middle-ground approaches are briefly outlined in this sub-section.

Firstly, system theorists such as Richmond (1997) posit systems thinking as a paradigm that sees the world in terms of feedbacks and interrelationships (see Box 2.3). As introduced in sub-section 2.6.2, systems theory aims to overcome the atomisation of reductionism and, by

doing so, mitigate the shortcomings of linear analyses that emphasise a certain relation between a cause and a given effect. Morin (1992) argues that systems theory does not constitute a paradigmatic principle, however. Instead, the principle that the concept of 'system' invokes is that of 'holism', which Morin (1992: 372) critiques as follows:

> [Holism] seeks explanation at the level of totality, in opposition to the reductionist paradigm that seeks explanation at the level of elementary components… this "holism" arises from the same simplifying principle as the reductionism to which it is opposed (that is, a simplification of, and reduction to, the whole).

In the place of a concept of 'system', Morin (1992: 371) argues for a 'paradigm of complexity' that mobilises recursive thinking, which he describes as

> … a manner of thinking capable of establishing a dynamic and generative feedback loop between terms or concepts (such as whole and part, order and disorder, observer and observed, system and ecosystem, etc.) that remains complementary *and* antagonistic.

Preiser (2012) follows Morin (1992) and builds on the intellectual scaffolding developed by Cilliers (2000) to advocate for a position of 'critical complexity' that acknowledges the importance (and continuing necessity) of reductionist techniques, yet doing so with a greater recognition of the limitations and assumptions associated with these techniques.

Table 3.1: Characterisation of subjective versus objective poles on the nature of science in terms of how each position responds to or perceives of ontology, epistemology, human nature, and methodology. Source: adapted from Musango (2012: 43).

	Subjective	**Objective**
Ontology: what is the nature of phenomena/reality?	Nominalist: real world exists as a product of appreciation	Realist: external world exists outside of appreciation
Epistemology: what knowledge can we obtain? (and how?)	Anti-positivist (humanist/ interpretivist/constructivist): knowledge is subjective meaning	Positivist: causal laws deducted by objective observer
Human nature: what is the nature of human actions?	Voluntarist: free-will allows humans to shape their environment	Determinist: humans react mechanically to their environment
Methodology: how can we obtain knowledge?	Ideographic: access unique individual insights and interpretations	Nomothetic: measurement of general concepts

Critical complexity offers one form of a middle-range position, but it is asserted at the philosophical level and does not provide a coherent approach (at the methodological level) of

how different research approaches can account for, and contribute to, engaging 'wicked problems' in an action research context.

The second 'middle-ground' approach is called adaptive theory, which "draws on a range of different approaches, paradigms and epistemological positions in social analysis (critical theory, general theory, grounded theory, middle-range theory) but is not reducible to any of them" (Layder, 1998). Adaptive theory emphasises prior theories and models that feed into, and guide research, whilst attending to the generation of theory from the on-going analysis of data (and is thus distinct from 'grounded theory' which emphasises a purely-inductive approach). What is 'adaptive' about adaptive theory is the iterative, on-going nature of the researcher moving between theory and data. Layder (1998: 144) argues that adaptive theory is most applicable to "research which attends to the interweaving of systems elements (settings and contexts of activity) with the micro-features (interpersonal encounters) of social life." Adaptive theory is therefore suited to the conceptual framing of this study in terms of water users and authorities operating in the muddled middle (see sub-section 2.3).

Third, this study draws on the 'pragmatic paradigm', which places 'the research problem' at the centre of the research, and applies all approaches that can facilitate understanding and analysis of the problem (Creswell, 2003). The pragmatic paradigm supports a mixed methods approach that uses "multiple methods, different worldviews, and different assumptions, as well as different forms of data collection and analysis" (*ibid*., 12).

Whilst critical complexity, adaptive theory, and the pragmatic paradigm offer middle-ground approaches in different ways, the common emphasis is on developing situated understandings of complex phenomena that centre on the research problem, and employ reductionist approaches with greater awareness of these approaches' limitations. This paradigmatic position informed (and was informed by) the overarching methodology of this study, namely transdisciplinarity. The following sub-section provides an overview of the methodological framing of this study, following which transdisciplinarity is outlined in section 3.2.

3.1.2 Overview of the methodological framing

As introduced in the discussion of research paradigms above, this study drew from diverse epistemological traditions in order to explore the complex dynamics of interest. The overarching methodology that supported this study was transdisciplinarity, which both

influenced the larger (SANPAD) research project that this study was nested within and facilitated the evolving methodology of this study (as described in section 3.2). The methodological framing of this study is summarised in Figure 3.1 showing a three-part framing, namely:

1. An overarching methodology of transdisciplinarity (described in section 3.2);
2. A research approach drawing on action research traditions and using a case study approach (described in section 3.3); and
3. The integrated use of three analytical methods in the form of institutional analysis, actor and ethnographic analysis, and system analysis (as described in section 3.5).

The remaining sections of this chapter (3.4; 3.6; and 3.7) address research design and process (section 3.4), the uses of certain cross-disciplinary tools (section 3.6), and ethical considerations (section 3.7).

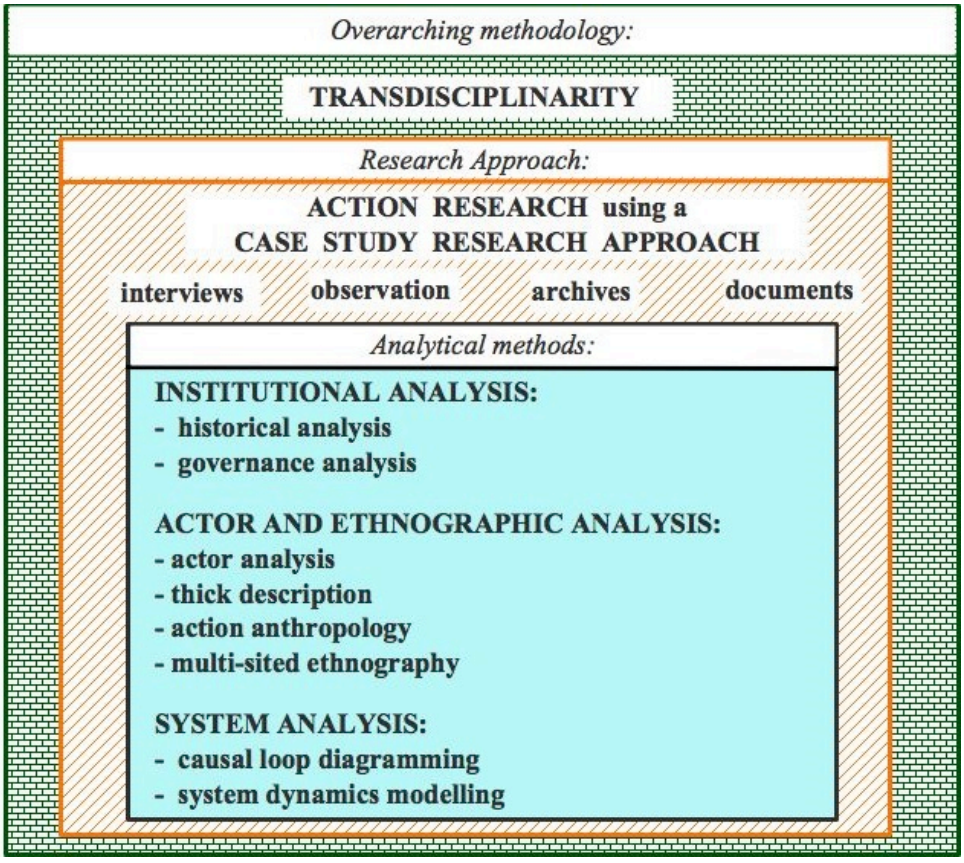

Figure 3.1: Overview of the methodological framing of this study.

3.2 Overarching methodology of transdisciplinarity

Proponents who argue for an approach that facilitates moving across and between disciplines, with the aim of achieving integration, do so on the basis that discipline-bound attempts to loosening wicked problems are inherently limited (Bammer, 2013). These limitations are defined by the acknowledgement that wicked problems contain a breadth and complexity that exceeds the analytical capacity of one discipline, and therefore require the use of multiple methods, with integration and synthesis across disciplines in order to produce a more comprehensive and accurate understanding (Klein, 2007). Research that cuts across disciplines in this manner has been variously referred to as interdisciplinary (Klein, 2007) and cross-disciplinary (Jeffrey, 2003), in addition to transdisciplinary. The distinctions between these research types are contested and subjective: what is characterised as 'interdisciplinary' by some researchers is categorised as 'transdisciplinary' by others (and vice versa). What is more important than the appellation are the research characteristics and practice. This study therefore characterises 'transdisciplinarity' as research that:

- Is context-sensitive and grounded in real problem situations as experienced by resource users and managers (Roux, Stirzaker, Breen, Lefroy, & Cresswell, 2010; Wickson et al., 2006);
- Involves on-going stakeholder collaboration, "acknowledging and incorporating multi-stakeholder perspectives and values" (Roux et al., 2010: 734); and
- Uses more fluid and evolving methodologies than single discipline studies (Wickson et al., 2006).

In addition to the above characteristics, transdisciplinary research practice is understood here as working towards multiple goals, including:

- Active engagement in the problem spaces in which the research is located, in addition to the more conventional targets of academic excellence (such as producing papers for peer-reviewed journals); with
- An explicit focus on learning both within the research team and among the practitioners and stakeholders, as well as between researchers and practitioners; and
- An explicit goal of inculcating a different relationship between science and society that incorporates uncertainty, complexity and the contributions of different actor perspectives and experiences (Pohl & Hirsh Hadorn, 2007; Roux et al., 2010; Wickson et al., 2006).

Following Pohl and Hirsh Hadorn (2007), the object of transdisciplinary research is therefore to deal with a complex, wicked, real-world problem, of which there is no shortage in the realm of water management and governance. Whilst transdisciplinarity is increasingly employed in water research (e.g. Audouin et al., 2013; Brown et al., 2010; Patterson et al., 2013; Roux et al., 2010), it is an emerging practice with the process of actually *doing* transdisciplinary research still under development. The use of multiple methods from different disciplinary traditions (whilst drawing on different forms of knowledge) therefore requires making the tensions that often exist between disciplines and intellectual traditions explicit. For this reason, reflection is central to the undertaking and analysis of transdisciplinary research (Pohl & Hirsh Hadorn, 2007; Wickson et al., 2006).

A transdisciplinary study still requires disciplinary specialisation at multiple points of the research process. According to the four-level hierarchical framing developed by Max-Neef (2005: 8-9), transdisciplinary research is conducted by building-up from the empirical level (exploring what exists), moving to a purposive or pragmatic level (what we are capable of doing), continuing to the normative level (what we want to do), and finishes at the level of values and ethics (how to do what we want to do). The broader transdisciplinary project, within which this study was located, was conceptualised and undertaken with the understanding that transdisciplinarity must contain an engagement with all four of the levels identified by Max-Neef (2005) (see Appendix B). The way in which this study moved between these four levels, and employed disciplinary specialisation at particular points, is discussed as part of the research design in section 3.4. Before the particular research design of this study is discussed, the broader research approach will be outlined in the following section.

3.3 Research approach: Action research using a case study research approach

3.3.1 Action research

The applied research aims of transdisciplinarity have many similarities with action research (Ison, 2008; Reason & Bradbury, 2008; Senge & Scharmer, 2008; Spangenberg, 2011). Action research is understood here as

> … a participatory process concerned with developing practical knowing [which] seeks to bring together action and reflection, theory and practice, in participation with others, in the pursuit of practical solutions to issues of pressing concern to people (Reason & Bradbury, 2008: 4).

Action research is conceptualised in section 7.2, where it is further discussed alongside the particular action research process of this study. Action research additionally influences the practice of 'action anthropology' (see sub-section 3.5.2(iv)) and the systems analytical approach (see sub-section 3.5.3). The remainder of this section (3.3) focuses on explicating the use of a case study research approach in this study, and how action research was undertaken within the case study.

3.3.2 An overview of the case study research approach

The transdisciplinary and action research aims of addressing problems that are context-specific and grounded in real problem situations are consistent with undertaking research using the case study research approach. Case studies allow for exploring "a contemporary phenomenon within its real-life context" (Yin 2009: 17), and provide a means of "testing views directly in relation to phenomena as they unfold in practice" (Flyvbjerg, 2006: 235). Yin (2009: 2) further argues that case studies are a preferred method when ""how" (descriptive) and "why" (explanatory) questions are being posed", in addition to when the researcher has little control over the subject matter (such as particular events being researched). As such, case study research was selected as an appropriate research approach for this study, given that the researcher had little control over the interventions into local water authorities in the Lower Sundays River Valley, with many descriptive and explanatory questions being posed. Following Yin (2009), the two most critical research design issues with the case study approach are (i) whether to use a single case or multiple cases, and (ii) whether to adopt a holistic or embedded case study design. These two issues are explored in sub-section 3.3.3 and 3.3.4 respectively, with an emphasis on the choices made in this study.

3.3.3 The strengths and weaknesses of a single case study design

Whilst the benefits enabled by using multiple cases are relatively obvious (in terms of comparisons between cases), many of the benefits of employing a single case study approach are less immediate. In summary, the three rationales for a single case design are:

1. When dealing with a critical case (in order to test a well-formulated theory)
2. When dealing with an extreme or unique case; and
3. When the case is a typical or representative case (Yin 2009: 47-48).

The focus of this study (local water authorities in the LSRV) is both an extreme and representative case in a number of important ways. As a representative case:

- The LSRV contains one of the 78 water user associations in South Africa that converted from an irrigation board following the promulgation of the *National Water Act* of 1998 (RSA, 1998); and
- The patterns of land-use and socio-political context of the Sundays River Valley Municipality are typical of Category B3 municipalities in South Africa (as outlined in sub-section 5.4.1).

Secondly, the SRVM is an extreme case for a very powerful reason – between 2009 and 2013, the SRVM was the focus of multiple interventions, including

1. The Eastern Cape provincial government assuming control of the municipal administration for an 18-month period (as described in sub-section 4.7.2);
2. National government intervening through a Rapid Response Unit of the Department of Water Affairs (between 2011 and 2012, and then again in 2014); and
3. The regional water board, Amatola Water, undertaking a turnaround process with the SRVM (these interventions are discussed alongside several other key interventions in sub-section 5.5.5 and Chapter 6).

In spite of the range and scale of government intervention between 2009 and 2014, water shortages remained a significant problem in the SRVM throughout 2014, and in September 2014 water services featured as a central grievance in the service delivery protests that led to residents burning down municipal offices and council chambers (see sub-section 6.5.1). The LSRV case therefore offers both extreme *and* representative aspects of the water governance challenges faced by local water authorities in post-apartheid South Africa. The wider implications of this case study are synthesised in the general discussion in Chapter 8.

The final motivation for selecting a single case study design relates to the transdisciplinary and action research aims of this study. As described above (sections 3.2 and 3.3), the combination of transdisciplinarity and action research aims towards engaging applied, real-world problems in participation with affected individuals and organisations. Doing so entails extended interactions with the same individuals and organisations over a number of years. For example, Roux et al. (2010: 739) argue that the long-term commitment required in TD research means that "without a five to ten year time frame, the considerable upfront costs are unlikely to pay off". As such, the decision was consciously made to work with one case study, in a sustained and in-depth manner, rather than to spread resources (both intellectual and financial) across several case studies. Whilst this study is an in-depth exploration of a single case, it is only one case within the broader transdisciplinary research project it has

been influenced by and forms part of. Methodologically outlining the research process of this study, in relation to the broader transdisciplinary project, is provided in section 3.4.

A single-case design does require that the case is located within its context however, in order for insights and understandings to be of application in other cases (Flyvbjerg, 2006a). The contextualisation of this study was performed as part of the integrated ethnographic-institutional-systems analyses (described in section 3.5), and through the general discussion in Chapter 8.

3.3.4 Holistic versus embedded case study design

Following Yin (2009), the second major research design issue for a case study is select a 'holistic' or 'embedded' case study design. A holistic design treats the overall case as a single unit of analysis, which is analysed as a case of some particular phenomena. For example, in a study of urban degeneration, a single neighbourhood could be selected as a case study. With the holistic case study design, urban degeneration would be investigated across the entire neighbourhood. An embedded case study, on the other hand, is designed using several embedded units of analysis that feature as sub-cases within the case. In the neighbourhood example, an embedded case study design would require selecting particular elements (like changing social networks, housing trends, and crime levels) with the exploration of these elements occurring as sub-cases. Both designs offer benefits and dangers. The danger with a holistic design is that "the entire case study may be conducted at an unduly abstract level, lacking sufficiently clear measures of data" (Yin 2009: 50), whereas the potential pitfall with the embedded analysis design is that the case study remains at the scale of analysing embedded units (or sub-cases) and fails to address the driving questions of the overall case study.

Over the course of this study, I selected four inter-linking units of analysis, identified through fieldwork and through the action research process. These four units of analysis were introduced in section 1.3, and can be summarised as follows:

1. Amatola Water's intervention into the SRVM;
2. The institutional and operational arrangements between the SRVM and the Lower Sundays River Water User Association;
3. The broader intervention dynamics of state actors in relation to local water authorities in the LSRV; and

4. Bulk water management in the Greater Kirkwood water supply scheme.

This study analyses the water governance challenges faced by local water authorities in post-apartheid South Africa *through* the integration of insights derived *from* the above four units of analysis. Hence, the four units of analysis are not represented individually (by dedicating a chapter to each unit, for example), but instead are analysed through the integrated use of ethnographic, institutional, and systems analysis within an action research process (as described in sections 3.4 and 3.5 below). As such, this study embodies both embedded and holistic characteristics. Before outlining how the analytical methods were applied within the overall research process, the actual techniques of data collection used in this study are explicated in the remainder of this section.

3.3.5 Overview of data collection techniques

Data collection was undertaken through conducting fieldwork in the LSRV between October 2011 and November 2014 (with primary fieldwork conducted between October 2011 and March 2012). The actors participating in this study included senior officials from the Regional Office of the Department of Water Affairs (DWA); administrative and technical officials from the regional water board in the Eastern Cape (Amatola Water); residents and representatives from community groups within the Sundays River Valley Municipality (SRVM); staff of the Lower Sunday's River Water User Association (L-WUA); members of the Eastern Cape Rapid Response Unit (RRU) of the DWA; consultants employed by the SRVM; and staff and councillors of the SRVM. Both quantitative and qualitative data were collected from these actors and with their participation. Different sources of data and associated data collection techniques were used, including: semi-structured interviews; direct observation; participant observation; documentation; and archival records. These techniques are introduced in the following three sub-sections, respectively.

3.3.6 Interviews

More than 40 semi-structured interviews were undertaken with a range of actors in the case study. These interviews were considered as perspectives rather than factual data, following the acknowledgement that "interviewees' responses are subject to the common problems of bias, poor recall, and poor or inaccurate articulation" (Yin, 2009: 108-9). Multiple interviews were conducted on different occasions between 2011 and 2014 with key actors in the case study. Data from individual interviews were used to provide 'clues' for additional data collection (Bogdan & Taylor, 1975: 73), including through the use of other (more suitable)

data collection strategies outlined below. Over the course of the study, certain interviewees came to function as 'research informants' rather than only 'research participants'. Campbell (1955: 339) describes the use of research informants as a social science technique that emerged out of anthropology and can be defined as follows:

> The technique of the informant means that the social scientist obtains information about the group under study through a member who occupies such a role as to be well informed but who at the same time speaks the social scientist's language.

Relying on key informants is acknowledged as appropriate in situations where "the content of inquiry is such that complete or in-depth information cannot be expected from representative survey respondents" (Kumar, Stern, Anderson, Stern, & Anderson, 1993: 1634). The use of informants can be clearly differentiated from both randomly and representatively sampled interviews. One of the methodological drawbacks associated with the technique is the over-reliance on a single informant, which can result in bias-ridden data. This problem can be partly mitigated using multiple informants from different backgrounds and organisational landscapes (Voss, Tsikriktsis, & Frohlich, 2002). A summary of interviews conducted over the course of this study is provided in Table A.1 of Appendix A (which is where the primary data are curated).

3.3.7 Direct observation and participant observation

Direct observation was undertaken via extended in-depth fieldwork in the LSRV. This method of 'in-residence' fieldwork is drawn from anthropological traditions (Spradley, 1980; Stewart, 1998). Primary fieldwork was conducted over a five-month period between October 2011 and March 2012, during which time I attended municipal and community meetings, strategy sessions, and workshops, in addition to assessments between the DWA and the SRVM (these assessments included the 2011 'Blue Water Services Audit' incorporating the 'Regulatory Performance Management System' and the 'Blue Drop drinking water assessment' – see Table A.2 for details). Attendance at a range of interactions between stakeholders led to taking a more active role in the case study in the manner of participant observation, which was continued intermittently through facilitating and engaging in workshops and meetings in the LSRV until November 2014.

Participant observation can be defined as "the up-close involvement of the researcher in some form of participative role, in the natural, "everyday" setting [being] studied" (Stewart, 1998: 6). Proponents of this method argue that it carries the possibility of perceiving reality

from the main viewpoint of someone "inside" the case study, rather than external to it (Yin, 2009: 112), whilst the limitation of the method is over-involvement in the case study and a negation of research duties (*ibid*.), as well as "the danger of biasing the processes being studied in the direction of the researcher's preconceived preferences" (Gorgens, 2015). Hosting participatory workshops and facilitating meetings (both by myself and as part of the broader SANPAD project) were a central component of participant observation, and all of the stakeholders listed in Table A.1 were invited to, or involved in, at least one of the workshops. These workshops were both actions (as part of the larger action research process) and sources of participant and direct observational data. A summary of the most important direct and participant observation research events is provided in Table A.2. The method of participant observation is further described in relation to ethnographic analyses (see sub-section 3.5.2 below).

3.3.8 Documentation and archival records

Documents were used to corroborate and augment evidence from other sources (Yin, 2009: 112), and included the following:

- Letters and email correspondence (between the SRVM, L-WUA, DWA, AW and RRU);
- Agendas, announcements, and minutes from meetings (involving the above listed actors in addition to resident groups, businesses, and civil society organisations); and
- Administrative documents and technical reports in the form of project proposals, progress reports, annual reports, and infrastructure assessments (all of which are cited as they are used in the text, with references in the bibliography).

Archival records drawn from in the case study included:

- National, provincial and local government census and survey data;
- Organizational records in the SRVM, including budgets and organograms;
- Maps and charts of the geographical area; and
- Historical records between 1702 and 2011 pertaining inter alia to water governance in the LSRV.

3.3.9 Triangulation

The range of data sources and the different collection techniques called for 'triangulation'. Triangulation is the intentional collation of information from several different perspectives,

which includes collecting data from individuals with different levels of experience or gender (Food and Agricultural Organisation, 2011: 1), and "the use of multiple methods, procedures and/or theories to converge on what should or can be done for the complex issue in question" (Roe, 1998: 5). As Cook (1985: 57) argues, triangulating from a variety of perspectives helps surface both what is worth knowing and what is actually known by stakeholders in the study site, in order to "approximate the ultimately unknowable truth". For these reasons, triangulation is widely regarded as desirable in case studies (Flyvbjerg, 2006a; Simons, 2009; Yin, 2009).

3.4 Research design and research process

The procedural elements of the transdisciplinary research process are described in this section in terms of the following activities:

1. Assembling the transdisciplinary research team;
2. Establishing a common way of working among the research team, with team members contributing methods, concepts, tools and approaches into a 'toolbox';
3. Defining the research field (in terms of the Eastern Cape case study);
4. Undertaking initial literature review;
5. Establishing contact with a broad stakeholder group in the case study;
6. Using in-depth interviews, interactive workshops, and embedded research techniques to undertake a deep problem analysis;
7. Selecting particular empirical focuses as the problem areas of individual studies, engaging these problem areas by drawing from the 'toolbox'; and
8. Using multiple opportunities for repeated feedback and reflection on research process and products.

The action research process narrated in section 7.3 provides the broad overview of the research process and the selection of the particular empirical foci in relation to tools and methods (from point 5 onwards). The following sub-sections outline the earlier stages of the transdisciplinary research process (points 1 through 3).

3.4.1 Assembling the transdisciplinary research team

This study began as a nested project within the broader SANPAD project (section 1.1). In brief, the SANPAD project sought to use a range of theories, methods, approaches and practices in novel ways to test their usefulness in breaching barriers that have been impeding

the implementation of 'integrated water resource management' (IWRM) in South Africa. The SANPAD project brought together researchers (students, early-career and experienced researchers) from more than 12 disciplines in the natural, technical and social sciences, with primary specialisations in the following fields: freshwater ecology; anthropology; policy analysis; engineering; environmental science; environmental education; economics; management; information systems; geography; and hydrology. The team assembled in June 2011 in order to establish a common way of working and to formalise the project structure and proposed research plan (see Appendix B for a description of the SANPAD project and this project structure). Team members also contributed concepts, methods, and approaches as 'tools' towards a common project 'toolbox', enabling researchers to iteratively draw from this toolbox according to the particular problem dynamics experienced in the respective case studies.

3.4.2 Defining the research field

The LSRV case study began as the Eastern Cape case study within the broader SANPAD project introduced above. The case study was initiated through drawing on an already-established research partnership between Rhodes University and Amatola Water (the regional water board introduced above). Following the SANPAD project's explicit adoption of transdisciplinarity as an overall methodology, and given the desire to produce research that is actually used (rather than merely potentially useful), the project approached Amatola Water with a proposal of engaging a 'wicked problem' that the organisation was currently facing. The problem identified by Amatola Water was the organisation's involvement in the turnaround of the SRVM's water services between 2010 and 2011. Exploring the nature of Amatola Water's intervention into the SRVM was established at this early stage as the first unit of analysis in this study.

3.4.3 Establishing contact with the relevant actors in the case study

Once the research field had been broadly defined, the next step undertaken by the SANPAD project was establishing contact with the relevant actors within the LRSV. The SANPAD project held introductory meetings with stakeholders in AW, the SRVM, and the L-WUA between August and October 2011, following which the research reported upon in this thesis began.

Semi-structured interviews were undertaken in this initial fieldwork period, leading up to the SANPAD project hosting two workshops (Workshop A:2:15 and A:2:16, Table A.2). The two interactive workshops were facilitated using the Strategic Adaptive Management framework developed by Rogers and Luton (2011). Through these workshops, the problematic aspects of bulk water management in the LSRV were raised and discussed. Out of these discussions, the institutional and operational arrangements between the SRVM and the L-WUA were selected as the second unit of analysis in this study. The third unit of analysis – the broader intervention dynamics of state actors in relation to local water authorities in the LSRV – was selected after three months of in-depth fieldwork in the LSRV, after experiencing and interacting with multiple government departments, consultancies, and civil society organisations, and seeing how these developmental interventions were creating additional dynamics of their own. The fourth and final unit of analysis of this study – bulk water management in the Greater Kirkwood water supply scheme (WSS) – was selected because it sat at the nexus of the other three units of analysis: involving the SRVM, the L-WUA and Amatola Water, in addition to a range of other stakeholders, and was therefore a crucible of the functioning of local water authorities in the LSRV. Section 7.3 accounts for the selection of the particular tools in terms of how these were used to explore and address the four units of analysis of this study. The following two sub-sections discuss two final components of the research design, namely, how disciplinary and transdisciplinary interaction was instituted (sub-section 3.4.4), and how reflexivity was cultivated (sub-section 3.4.5).

3.4.4 Disciplinary and transdisciplinary interaction and peer-review

This study utilised both discipline-based and transdisciplinary interaction and peer-review in a number of important ways. Firstly, 20 academic presentations were done over the course of the doctoral study, both to specialist and generalist audiences (see Table B.2 for details). Secondly, specialist peer-review was sought through feedback on papers presented at national and international conferences and colloquia, and through the review of successive drafts of this study by academics and project colleagues. Thirdly, monthly transdisciplinary meetings were held as part of the SANPAD project. These meetings performed the following functions:

- Facilitating a network between researchers working within social-ecological systems predominantly relating to water;
- Enabling interaction between different case studies; and

- Proving a space for presenting and discussing methods, work-in-progress, and particular research dilemmas.

The combination of discipline-based and transdisciplinary interactions and peer review highlights an important aspect of the research design of this study, namely, that discipline-based methods and procedures were complemented with transdisciplinary-based interactions, rather than being replaced by transdisciplinarity. The research process can be best understood as moving between periods of monodisciplinary research (in which a specific discipline or approach was drawn from in a focused fashion), through to periods of multidisciplinary research (in which multiple disciplines and approaches were drawn from), and finally, periods of transdisciplinary research in which insights and understandings were sought across different disciplines and approaches, aiming for synthesis and integration. Following Hurni and Wiesmann (2004), the overall research process is conceptualised as evolving over time, with 'peaks' of transdisciplinary research occurring in between periods of monodiscipilnary and multidisciplinary research (see Figure 3.2).

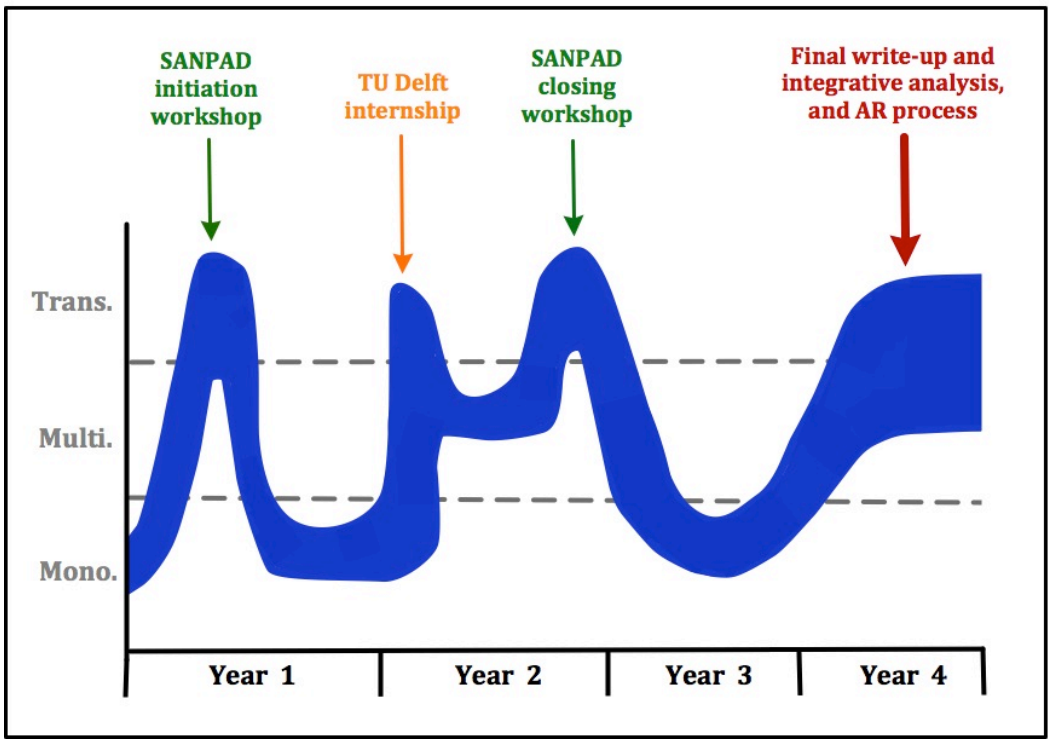

Figure 3.2: The transdisciplinary research process of this study, with periods monodisciplinary (Mono.), multidisciplinary (Multi.), and transdisciplinary (Trans.) research over the four-year period of this study being undertaken. Four periods of transdisciplinary research are noted with arrows. Source: adapted from Hurni and Wiesmann (2004: 40).

3.4.5 Cultivating and practising a reflective research practice

The final part of the research design discussed here is the conscious cultivation of a reflective research practice. To this end, a research diary was kept from June 2011 through to the end of 2014, in which experiences, reactions, frustrations and insights were recorded. Selected incidents, recollections and experiences are related in the 'fieldwork stories' in the ethnographic chapter (see Box 6.1 through to Box 6.8) and discussed within the context of the broader action research narrative in section 7.3. Secondly, reflection was encouraged within the context of the broader transdisciplinary project (as described in sub-section 3.4.4 above), following the understanding that reflection is a fundamental requirement in the undertaking and analysis of transdisciplinary research. A reflective learning process for the on-going analysis of the system dynamics modelling aspects of this study was the third and final part of this practice (see Figure 7.4 and associated description).

3.5 Analytical methods

This section provides an overview of the analytical methods employed in this study, beginning with institutional analysis, then discussing ethnographic and actor analysis, and lastly systems analysis. The order in which these analytical methods are discussed does not reflect the order in which the methods were employed in this study (a description of the latter is provided in the action research narrative in section 7.3).

3.5.1 Institutional analysis

Following the conceptual framing of this study (see section 2.3), a complexity-based view of institutional change stresses the importance of placing local arrangements (of water management and local government) within wider frames of governance, whilst acknowledging that factors impacting on development in any particular setting have occurred at different institutional levels and biophysical scales. The institutional analysis therefore aimed to balance a focus on local complexities with seeking to identify and track the larger processes that inform those local complexities (following Cleaver, 2012: 19). In order to explore *what* these larger processes are, and *how* these processes have impacted (and continue to impact on) the way in which water is managed and governed in the LSRV, two analytical methods were employed, in the form of an historical analysis and a governance analysis. These are respectively outlined below.

(i) Historical analysis:

The historical analysis sought to understand the present challenges facing water services in the LSRV via investigating the roots of these problems in the past. The initial motivation for undertaking an historical analysis of water in the LSRV was linked to the conceptualisation and project design of the broader SANPAD project (see Figure B.1 in Appendix B). The project team agreed that an understanding of localised changes over time was fundamental to addressing intractability in the present. Hence, for each of the three case studies in the SANPAD project, researchers constructed what were termed 'narratives of change' (drawing on the recognition that narrative is a basic form of making sense of experience (see Flyvbjerg, 2004: 299)). The historical analysis of the LSRV that is represented in this study therefore developed out of the initial narrative of change produced for the SANPAD project. The initial narrative of change was produced as follows:

> In November 2012, four researchers (including myself) gathered in a workshop setting in order to develop a draft chronology of events and processes that they saw as fundamental to development in the LSRV. All four researchers had conducted primary fieldwork in the LSRV as part of the SANPAD project, and therefore drew on their individual understandings in tandem with documented historical records (both primary and secondary). These historical records included histories of South Africa focusing on, and sensitive to, the politics of water management, in addition to local-level histories produced by individuals and organisations in the LSRV. The researchers developed a 'draft chronology' over the course of the workshop, which was then analysed for gaps in either local or regional/national scales, across the various time periods.

An additional round of data collection was then undertaken, specifically aimed at addressing the gaps in the historical narrative identified in the workshopping process. Records and other archival resources at the Cory History Library (which specialises in Eastern Cape history) were extensively drawn-upon. A draft narrative of change was produced through this process, and was then used as the basis for the historical analysis developed in this study. By collaboratively producing the draft narrative, additional feedback and peer-review was provided. Additional details on the historical analysis are provided in section 4.1, and so are not repeated here.

(ii) Governance analysis:

In sub-section 2.5.3, water governance was conceptualised as consisting of the processes and institutions by which decisions that affect water are made, which collectively determine who gets what water, when and how. The importance of understanding the governance challenges in the LSRV was motivated by the selection of the four embedded units of analysis (see 3.3.4). All four of these units explored issues at the local scale of the LSRV, with an explicit interest in the interaction between formal and informal institutional domains. The governance analysis focused on situating the management of bulk water in the LSRV within the formal institutional domain, using the following process:

- A literature review of the laws, policies, and strategic frameworks mandating how local water authorities should function, with an emphasis on bulk water management and the provision of potable water services by local government;
- An analysis of the biophysical and infrastructural context of water management in the LSRV;
- An assessment of the processes and institutions by which bulk water in general, and bulk potable water in particular, is managed and governed within the LSRV, in relation to how it should be managed and governed;
- Situating the above assessment within the historical analysis;
- Synthesising and analysing water governance challenges in the LSRV in relation to this assessment; and
- Assessing the state interventions that involved local water authorities in the LSRV between 2009 and 2014 (from the point of acknowledged government crisis in the SRVM to the present) in terms of how these interventions sought to address the identified water governance challenges.

As described in section 2.3, this study conceptually frames institutional change as occurring in the 'muddled middle' between formal and informal institutional domains. The governance analysis summarised above is concerned with establishing an understanding of the localised context of this study in relation to the formal institutional domain of the South African water sector. The actor and ethnographic analyses draws on this established understanding (as described in the following sub-section).

3.5.2 Actor and ethnographic analyses

Following the conceptual framing of agency in section 2.4, this study was undertaken from the position that human beings are meaning-making agents who interpret and respond to their

environment in broadly subjective ways. As such, agents in the LSRV do not respond to legislation and other aspects of the formal institutional domain in a deterministic manner (either simply adhering to, or completely resisting, the rules-in-form). Rather, individuals work within organisations that interact in the muddled middle between the rules-in-form and the rules-in-use (where the latter is understood as informal rules and those rules that are adaptively applied in practice). The adaptive application occurs within a social world that is "complex, multi-faceted and densely compacted" (Layder, 1998: 113); a world in which the nature and modes of social interaction and relationships is of vital importance. The two analytical methods that were employed in this study to explore these behavioural and agent-based aspects were actor analysis and ethnographic analysis (respectively introduced in below).

(i) Actor analysis:

Actor analysis is used in policy analysis in general (i.e. Enserink et al., 2010a), and has been specifically applied in water management (i.e. Hermans, 2005) as a technique for "analysing actors and actor configuration(s) in a policy issue" (Enserink et al., 2010a: 79). Following Enserink et al. (*ibid.*), an actor is defined as

> … a social entity, person or organisation, able to act on or exert influence on a decision… [i.e.] actors are those parties that have a certain interest in the system and/or that have some ability to influence that system, either directly or indirectly.

The basic stages of the actor analysis – as undertaken in this study – can be summarised as:

- Identifying the actors;
- Developing an understanding of the different perspectives on particular problems held by the actors;
- Developing a working understanding of the different interests and motivating factors of the actors; and
- Exploring the network relations – both in the case of formal and informal networks – in order to analyse how the different stakeholders interact.

Three actor identification techniques were employed in order to account for the actors involved in the analysis: snowballing, relational and situational (*ibid.*, 85-6). These techniques were used in the following steps:

> Step 1: Identify full list of actors involved in, influencing, and interested in water management in the LSRV – drawing a boundary at the national level;

Step 2: Develop a downscaled actor list specific to the Eastern Cape (incorporating those actors that could realistically attend workshops in the SRVM); and

Step 3: Develop the actor analysis using the actors who responded to calls for workshop participation, attendance and request for interviews (following the 'social participation approach' identified and outlined in Hermans (2005)).

The actor analysis was undertaken using data collected over the course of the initial interviews and fieldwork undertaken between October 2011 and January 2012. Whilst this analysis provided a useful starting point, it failed to capture the multiple positions and interests of different actors in any substantive way. As Enserink et al. (2010: 102) acknowledge, actor analysis techniques were primarily developed as 'stakeholder analysis' intended for specific project design and implementation assessments. When applied to complex policy problems, actor analysis requires complementary analytical techniques that facilitate a deeper exploration of interactional dynamics between individuals and organisations. To this end, anthropological approaches to the collection and analyses of ethnographic data were employed in this study, as outlined below.

(ii) Introducing ethnographic analyses:

This study deepened the initial actor analysis introduced above through adopting the role of an 'ethnographer' based on the anthropological method. The discipline of anthropology has developed significantly from its founders, with anthropologists no longer taking cultural systems to be coherent, isolatable, and fixed (de Wet, 1998). Anthropologists are now more self-critical and reflexive, seen in the 'ethical turn' and the many neo-Marxist, feminist, postcolonial and 'queer' voices in anthropology (Faubion, 2001: 83). Furthermore, many anthropologists are now concerned with diverse and interdisciplinary themes such as globalisation and development aid (e.g. Crewe & Axelby, 2013), which push the boundaries of the discipline at methodological and theoretical levels. Ethnographic analyses remains, however, at the heart of anthropology, with ethnography characterised by the following seven elements:

1. Ethnographers aim to become embedded in the context that they study through spending extended time in the field, often over the course of repeated visits;
2. Ethnographers typically take their field experiences as the starting point for their analysis, aiming to frame these experiences "in terms of anthropological standards, concepts and debates" (Blasco & Wardle, 2007: 1);

3. Ethnographers employ multiple approaches to data collection including interviews, focus-groups, direct observation and participant observation;
4. Participant observation, in particular, is extensively used – understood here as "the up-close involvement of the researcher in some form of participative role, in the natural, "everyday" setting to be studied" (Stewart, 1998: 6) (which was introduced earlier as a data collection method in sub-section 3.3.7);
5. Ethnographers aim to provide a holistic account, where the ethnographer "synthesizes disparate observations to create a holistic construct", striving for wide-reaching data to produce an account that has 'breadth' (Stewart, 1998: 6);
6. Context sensitivity, which refers to the provision of contextualized explanations for the specific phenomena encountered in the case (because with ethnography, "contextualisation is a non-negotiable" (de Wet, 1998: 9), and
7. Connecting back to theory, by the particular ethnographic analysis resulting in a reconsideration of relevant and interesting theories.

Blasco and Wardle (2007) suggest that the many different ways of presenting ethnographic analyses can be divided into two broad types:

- Reproducing detailed transcripts and creating links between these transcripts; and
- Weaving multiple strands and perspectives employing the "highly structured use of narrative as evidence" (Blasco & Wardle, 2007: 104).

The co-shaping of evidence and argument occurs differently across these types. This study presents its ethnographic analyses using the second type. Through employing narrative as evidence in a highly structured way, the intention is to provide insights that could not be delivered by recounting in-depth descriptions of fieldwork experiences (*ibid*., 105).

(iii) Thick description and the highly structured use of ethnographic data:

Three detailed accounts of different aspects of the case study are explored in this study with the highly structured use of narrative of data. These accounts are produced using an amended form of 'thick descriptions' (Geertz, 1973). Clifford Geertz – the original proponent of the method of thick description – argued that ethnographers face "a multiplicity of complex conceptual structures, many of them… knotted into one another, which [the ethnographer] must contrive to somehow first grasp and then to render" (Geertz, 1973: 10). This study follows Thompson (2001) in suggesting that thick description is a useful tool in policy research: like ethnographers, policy analysts must account for a multiplicity of knotted structures, concepts and lived realities of policy-affected stakeholders. Thompson (2001)

further argues that when employed as a tool in policy analysis, thick description has the potential of conveying the messiness of problems better than the presentation of numerical data alone can. For these reasons, thick description is held to be an appropriate tool for investigating the challenges facing local water authorities in South Africa, using the LSRV as a case study. The way in which each of the three thick descriptions relate to the four units of analysis introduced in sub-section 3.3.4 above is outlined in sub-section 6.1.5.

(iv) Action anthropology:

From an anthropological perspective, attempting to influence social and policy processes is by no means a new aim, as exemplified by 'action anthropology' (Tax, 1975), 'public interest anthropology' (Sanday, 1998), and 'engaged anthropology' (Basch, Saunders, Sharf, & Peacock, 1999). Most recently, this applied edge has been demonstrated in the attempts to craft an 'anthropology of public policy' (Wedel, Shore, Feldman, & Lathrop, 2005). These approaches argue that anthropologists should be practitioners and advocates, rather than confining themselves to scholarly activities. For Tax (1975: 515), the action anthropologist both "wants to help a group of people to solve a problem, and… wants to learn something in the process". Action anthropologists therefore have two interlinked goals of equal importance, namely, to be both observers in the field and possible catalysts: as Tax (1975: 515) put's it, "[action anthropologists] are willing to make things happen, or to help them along, or at least to be catalysts". In this study, the argument that "we can learn many things in this way that we could not learn in any other way" is supported (*ibid*., 1975: 515).

(v) Multi-sited ethnography:

The ethnographic approach has traditionally advocated extended, in-residence fieldwork in a single site (de Wet, 1998; Stewart, 1998). Studying IWRM and water governance issues in the manner outlined in this methodological framing requires a different anthropological approach that is closer to what Marcus (1995) refers to as 'multi-sited ethnography'. Marcus (1995) argues that the study of socio-political and socio-economic phenomena in an increasingly-networked world necessitates moving beyond "conventional single-site location, contextualised by macro-constructions of a larger social order… to multiple sites of observation and participation that cross-cut dichotomies such as the 'local' and the 'global'" (Marcus, 1995: 95). This approach has been applied to the study of IWRM in southern Africa (see Mehta & Movik, 2014) and was applied in this study to enable interactions with policy

makers, politicians and administrators at a local, provincial, and national scale, with attending and participating in workshops and 'dialogues'.

The ethnographic approach in general, and thick description in particular, are interpretivist approaches that position the goal of social analysis as understanding "the social world from the point of view of the people who are the subjects of research at any one point in time" (Layder, 1998: 139). Yet when an interpretivist approach is taken to its extreme, the whole social world can become about inter-subjective meaning and communication. In the case under consideration in this study, extreme intrepretivism could remain stuck at interpreting the interactions of technical officials, residents and other actors – and never account for the interactions between actors and institutions, and between actors, institutions and the physical world. The middle-range theoretical position (as introduced in section 3.1) suggests that

> … social reality is not simply composed of actors' meanings and subjective understandings, but that there exist systemic (or structural) factors which exert considerable influence on the nature of people's lived experiences. The influence of behavioural and system aspects of social life on each other is mutual and their mechanisms and effects are deeply intertwined (Layder, 1998: 86-7).

The deeply intertwined interaction of behaviour and systems aspects of social life provides an additional way of understanding the muddled middle between formal and informal institutional domains. But whilst the position advocated by Layder (1998: 144) is suited to what he terms "the interweaving of … the settings and contexts of activity with the micro-features (interpersonal encounters) of social life", the position does not account for the interweaving of those same elements with the physical world. The third analytical method employed in this study – systems analysis – was selected to fill this methodological gap, as outlined in the following sub-section.

3.5.3 Systems analysis

(i) Systems analysis overview:

Like institutional analysis, systems analysis is an umbrella term for a broad range of qualitative and quantitative approaches that are interested in the underlying patterns and behaviour of interrelated phenomena. The commonality between diverse systems approaches is 'systems thinking' (see sub-section 2.6.2). Systems analysis is frequently grouped into 'hard' and 'soft' approaches, which are briefly discussed here.

The archetypal 'soft' approach is soft systems methodology (SSM), which is based on the concept that human and organisational factors are indistinguishable from the act of problem solving and decision making (Checkland, 2000). Hence, in SSM, the emphasis is on attempting to understand complex processes and interactions, without accepting a unique problem definition (Lane & Oliva, 1998). As such, SSM operates within an interpretivist philosophical paradigm that foregrounds the socio-political and subjective understandings of individuals, using qualitative techniques (Maani & Cavana, 2007).

In contrast, hard systems approaches are typically associated with operations research, systems engineering and cybernetics: these approaches predominantly rely on quantitative data and work within a positivist paradigm that conceives of problems as 'lying in the world' (Maani & Cavana, 2007). For this study, I selected and employed system dynamics, which operates in a middle ground between soft and hard approaches, as conceptually discussed in section 2.6. The following sub-section introduces system dynamics, motivates for its use in comparison to other simulation techniques, and outlines the modelling process.

(ii) Introduction to system dynamics:

System dynamics (SD) was developed in the 1950s, growing out of the fields of control theory, cybernetics and cognate research into nonlinear dynamics that utilized non-linear differential equations (chiefly in the fields of mathematics, physics and engineering). However, the founder of SD – Jay W. Forrester – credits 'the four grandparents of the field' as being strategic decision making, feedback thinking, computer technology and computer simulation (Maani & Cavana, 2007). The explicit focus of SD is on how people interact with the physical world: however, whilst SD has been critiqued as a hard or deterministic systems approach, it significantly differs to systems engineering and accepts the view that system structure only partially, rather than fully, determines human behaviour (Lane, 2000). At the heart of system dynamics is the appreciation of the existence of different sources and different kinds of data: rather than only accepting statistical data in a measured, numerical form, SD draws on data stored descriptively in writing, and data stored mentally in people's heads (Forrester, 1980). These three types of data are used to examine causal structures and dynamic behaviours of systems using both qualitative and quantitative techniques. This study employed both qualitative and quantitative SD techniques, which are outlined here.

(iii) Causal loop diagramming as a qualitative tool:

System dynamics practitioners argue that it is problematic to only discuss systems using words. Dana Meadows – another developer of the system dynamics discipline – argued that:

> …words and sentences must, by necessity, come only one at a time in linear, logical order. Systems happen all at once. They are connected not just in one direction, but in many directions simultaneously. To discuss them properly, it is necessary somehow to use a language that shares some of the same properties as the phenomena under discussion (Meadows, 2011: 5).

The first part of this language is diagramming, beginning with causal loop diagrams. A causal loop diagram (CLD) is a tool for mapping how elements of a situation relate to each other and for exploring non-linear relationships. CLDs aim to address the following questions:

- What are the key variables in the situation of interest?
- How do these variables link to one another?
- How do these variables affect each other?
- Does a variable have a reinforcing or balancing effect on the variables it is linked to?

The basic elements of CLDs are variables and arrows – which can be understood as factors and the links between these factors respectively (Maani & Cavana, 2007: 28) (see Figure 6.4 for an example of a CLD). Generating a CLD can either be the final stage of the systems analysis, or it can be used as the first stage in generating a dynamic hypothesis (i.e. a causal explanation for how different variables influence one another). This dynamic hypothesis is then explored using simulation modeling, which is the second primary SD tool employed in this study.

(iv) System dynamics simulation as a quantitative tool:

System dynamics modeling is one of three main simulation research practices, alongside discrete event simulation and agent-based modelling (Dooley, 2005) (Dooley, 2005). All three simulation practices model 'systems' per se, but they do so in different ways and for different purposes. With discrete event simulation, a system is defined by variables that interrelate and are driven by events, characterised by "events that trigger other events sequentially and probabilistically" (Musango, 2012: 101). In agent-based modeling, individuals and groups are defined in terms of behavioural characteristics and responses, with these behaviours mapped onto a schema: a system is described by agents reacting both to their environment and to one another (Muaz & Hussain, 2011). Lastly, with SD simulation,

'state' variables are identified, quantified and related to other variables through coupled differential equations (Musango, 2012: 101). These state variables (which are also referred to as 'stocks', 'levels' or 'accumulations') are calculated as integral equations: a stock variable is therefore "the accumulation of its inflows minus its outflows over time, starting from its initial value" (Pruyt, 2013: 86) (supplementary methodological notes pertaining to system dynamics modelling are provided in section D.2 of Appendix D).

The selection of SD as a simulation practice occurred as part of the inductive research process as outlined in section 3.4. SD modelling was held to be the most appropriate technique for four primary reasons:

- SD modelling allowed for the use of different data sets and units of management (including hydrological data on rainfall, economic data on social preferences and demand drivers, and engineering data on infrastructural capacities and production rates);
- When detailed and accurate data on any of the above were unavailable (as was often the case), officials' and users' knowledge of system design and experienced 'behaviour over time' could be used for modelling purposes;
- With SD, stakeholders are able to locate themselves and their actions within the "stocks" and "flows" that are used to characterize the system, and so can experience the method as enhancing communication and problem structuring (Stave, 2003); and
- There is a wide and detailed literature and set of supporting techniques for stakeholder participation in the model-building, model analysis and model use stages of SD modelling.

The SD modelling process can be summarised as:

1. Problem structuring and formulation;
2. Conceptualisation – and positing of a 'dynamic hypothesis' using CLDs;
3. Formal model building, by defining key variables, collecting information and data, and developing a simulation model (a list of key data sources used in the modeling process is provided in section A.4 of Appendix A);
4. Model testing and validation;
5. Scenario formulation and policy analysis; and
6. Documentation (Maani & Cavana, 2007; Pruyt, 2013).

This process is performed iteratively, with many feedbacks from the formal model building stages back to the problem structuring stages. The reflective learning tool outlined in sub-section 7.5.1 was used to critically evaluate the models and modelling processes in this study (with the results of this reflection discussed in sub-section 7.7.1).

Four SD models were developed over the course of this study, using the above process. These models account for various aspects of water supply, water demand and the overlapping and interconnected policy issues in the SRVM. Three out of the four SD models were documented (given that the first SD model was used for exploratory purposes, it was not fully documented). The System Dynamics Model Documentation and Assessment Tool (SDM-Doc) (Martinez-Moyano, 2012) was employed, using Java Version 1.0.2. In addition to the representation of the models in this thesis and the associated appendices, each of the three models is documented in an online repository as follows:

- A report (or paper) describing the model is provided;
- The model itself is included in its native Vensim format; and
- An SDM-Doc report is provided in a .zip folder.

The online repository can be accessed at the following link: http://iwr.ru.ac.za/iwr/sanpadlink/index.php?p=CaseStudyDocs/SRVM/CliffordHolmesPhD.

In summary, system dynamics is used in this study as a form of quantitative policy analysis with the aim of supporting policy and decision-making in the SRVM – rather than as a form of scientific modeling that generates results in aid of predicting and forecasting. This distinction between modelling for scientific research purposes and for supporting policy- and decision-making is widely acknowledged (Haag & Kaupenjohann, 2001; Sterman, 1991). Hence, in this study, SD models are used as exploratory decision support tools, and as means of supporting strategic conversations between stakeholders (Howick & Eden, 2010), enabling the researcher and the participating stakeholders to simulate aspects of water supply and water demand, in relation to water services delivery from an operational perspective and the experiences of water services delivery from a resident perspective.

Before the integrated use of system analysis, institutional analysis and ethnographic analysis is summarised in the conclusion in section 3.7, ethical considerations in this research are introduced in section 3.6).

3.6 Ethical considerations of this study

This study acknowledges that the research of contemporary phenomena in their real-life context obligates the researcher to important ethical practices (Yin, 2009: 73). The multifaceted, multi-layered and interlinking dimensions to water management in the LSRV highlight that this is indeed a wicked problem: as such, tackling one aspect of the problem was understood to possibly have unexpected effects and raise issues of uncertainty about other aspects of the problem (Rittel & Webber, 1973). It was also considered that in attempting to disentangle complexities in the case study, the research could disrupt existing coping mechanisms of the SRVM, without providing sufficient measures to deal with such disruption, thereby causing more damage. Hence, the precarious position of the SRVM, as an institution (between 2011 and 2014) has been borne in mind. Ways of mitigating these ethical risks have included:

- Through on-going reflexive practices (see sub-section 3.4.5);
- Gaining feedback from participating stakeholders and research partners (the workshop-structure of the SANPAD project further encouraged this practice);
- As an individual researcher working in an institutional space, research was conducted in such a way that aimed to respect respondents' privacy and confidentiality, taking into account pressures from respondents' peers and the wider institutional settings;
- No respondent was involved in the research process without their free and informed consent;
- All efforts were made to avoid deception and to avoid the undue creation of expectations with regards to the research aims and objectives; and
- Ethical issues that surfaced over the course of the research were extensively discussed with supervisors and other experienced researchers.

It should also be noted that the larger SANPAD project was passed through the Rhodes University Ethics Committee in 2011, prior to any fieldwork being undertaken in the SRVM. Further ethical considerations, in relation to fieldwork and the action research process, are provided in sub-sections 7.7.3 and 8.6.1.

3.7 Summary: relating the methodological and conceptual framings to thesis structure

Transdisciplinary research differs from traditional modes of research where interacting with decision makers is is premised on providing them with information, and where this is seen as

the major contribution of intellectual effort (Bammer, 2005: 11). In contrast, transdiscisciplinary research aims to further involve decision makers and other stakeholders, developing evidence and 'co-researching', aiming to generate research that is actually used, rather than merely useful. Although this study draws on a range of participatory methods that are embedded within a detailed case study, it also aims to understand broader issues, such as the formal institutional domain of state-initiated arrangements for water management, which require institutional analysis in the form of a historical and governance analysis (as described in sub-section 3.5.1). The latter analytical techniques occur as traditional research activities, yet the process of identifying which institutional aspects require study drew from the engaged, action research process. Similarly, the ethnographic approach to embedded fieldwork served both as a basis for the subsequent thick descriptions, as well as enabling a different kind of systems modelling that drew-on the ethnographic research towards a deep problem analysis.

As Figure 3.1 shows, the overarching methodology that supported this study was transdisciplinarity, which was both influenced by the larger (SANPAD) research project that this study was nested within, and which facilitated the evolving methodology of this study (see section 3.2). The research design drew from traditions of action research and employed a case study approach (see section 3.3), enabling multiple methods of data collection. The analytical work of this study was performed using institutional analysis, actor and ethnographic analysis, and system analysis (see section 3.5).

Chapter 4 Historical Analysis

4.1 Introduction

This study departs from the position that in order to understand water challenges in the Lower Sundays River Valley (LSRV) it is necessary to investigate the roots of these problems in the past. This chapter presents the development of water issues in the LSRV over time, in a narrative manner, so as to come to a more grounded understanding of the context and background of these contemporary challenges.

Understanding water governance in the LSRV (including the provision of water services by the SRVM) has to occur within a historically situated framework of changing citizen-state relationships, land ownership, and water resource management and development. Given that water in the LSRV has not been managed at the local scale alone since the early 1900s, this historical analysis needs to account for cross-scale interactions, whilst including the interactions between the governance of water, and governance more broadly. This historical analysis therefore accounts both for changes at multiple scales (local, regional, national, and global), and changes within multiple sectors (local, national and colonial governments, environmental management and the rise of conservation, land-use changes and urban development).

This historical account was developed using a range of primary and secondary sources (see sub-section 3.5.1 for methodological details). A selection of these sources, along with subject matter and brief descriptions, is summarised in Table C.1. The historical analysis is presented here in a chronological format, but makes no pretence at being exhaustive. The adopted approach follows the lead of historians who explore complex phenomena via examining the lines of strategic change in a given subject, rather than exhaustively recounting changes in the manner of an encyclopaedia (Butterfield, 1968). Given that the theoretical basis for the historical approach is rooted in complexity and systems thinking, the emphasis is on how the interrelationships between all of the elements, rather than a single one, determines the whole (Perdue, 1994: 169). There is no single driver – be it technological or environmental change, race or class struggle – that alone can explain the long-term development of the LSRV system. Instead, this chapter develops a contextual account that integrates the elements introduced above.

The historical analysis in this chapter is divided into six periods, extending between 1814 and 2011, and is summarised below:

Period 1: 1814 – 1913: Contested settlement and the roots of inequitable development
Period 2: 1914 – 1947: Local development and land use trajectories in colonial South Africa
Period 3: 1948 – 1989: The rise and fall of apartheid
Period 4: 1990 – 2000: Transition and the changing roles of government
Period 5: 2001 – 2008: The Sundays River Valley Municipality and continuing government transition
Period 6: 2009 – 2011: Municipal challenges and the 'turnaround' of the Sundays River Valley Municipality.

The division of the narrative into these six periods was primarily subjective. As with all periodisation in the study of history, the divisions between the periods are artificial, and are primarily for analytical purchase and ease of representation. Each period is presented in three parts (an overview, followed by the historical narrative, and concluded with a summary of the 'implications for water and local government').

The aim of this chapter is to draw on historical detail in order to build an understanding of context, whilst minimising extraneous considerations and background explanations. To this end, the following three techniques are collectively employed:

- Endnotes are used at points in the text where background information or qualifications are required (all notes are listed at the end of the chapter);
- A timeline is provided as a summary for each of the six periods. The timelines contextualise the main events discussed in the text in relation to major national and regional-scale events (not all of which are discussed in the text for reasons of length). The six timelines are provided in Appendix C;
- Any additional data (including figures and tables) are also provided in Appendix C and cross-referenced in either the text or endnotes.

4.2 Period 1: Contested settlement and the roots of inequitable development (1814 – 1913)

4.2.1 Overview of period 1

The first period of this historical analysis recounts how the landscape of the LSRV was transformed through initial interactions between white colonists and black Africans. These interactions were characterised by struggles for independence, particular ways of life and between value systems and were marked by conflict, commerce, and cooperation. The fierce competition for resources – in the form of arable land, livestock and water – was at the centre of many of the interactions. The ownership of land and changing patterns of wealth that occurred at the local scale in this period (including the first citrus and irrigation investment schemes being formed) reflected the increasing (forced) dependence of black people on the white-owned colonial economy, the impacts of which are still evident in the LSRV today.

4.2.2 Historical narrative for period 1

The year 1814 offers a suitable point of departure for this historical analysis for two reasons: firstly, 1814 was the year in which the Dutch finally ceded control of the Cape Colony to the British (after the colony had changed hands from the British to the Dutch seven times between 1652 and 1814). When the Dutch East India Company (VOC) established the Cape Colony in 1652, it was as a minor part of the Dutch eastern empire originally thought to be little more than a refreshment station for trade vessels.[1] The colony was founded on the idea of absolute separation between European settlers and everyone else, yet such separation could not be absolute for at least three reasons: the necessity of labour in the form of slaves and indentured labourers to work on farms; the allure of the resource-wealth lying inland; and economic interaction in its various forms of trade (Giliomee, 1979; Katzen, 1969). The Dutch ceded control of the Cape Colony to the British in 1814 only after the VOC had become embattled on multiple fronts, trying to manage a burgeoning and complex multi-racial society that had long ceased being a refreshment station.

The second reason why the year 1814 holds particular relevance is that this was the year in which the first farms in the LSRV were 'awarded' to leaders of burger commandos (settler forces): these men had fought in the 1811 and 1812 battles against Xhosa forces in the region, and the farms were seen as rewards for "successfully defeating the Xhosa" (Delport, 2002). The battles in the LSRV region always featured contests over land and local

resources, and in the case of several battles, the outbreaks of war were closely correlated with competition for scarce pastures over times of droughts (Giliomee, 1979; Wilson, 1969). The eastern region of the Cape Colony remained a conflicted, contested zone between Xhosa chiefdoms and settlers into the mid-19th century, but as the 'eastern frontier' was pushed higher and away from the LSRV, the area calmed sufficiently to allow the number of white and black settlers to grow (Grant, 1993: 11). It was in this context that Europeans settled the LSRV, and that farming in the region began.

The LSRV had long been prized as a fertile land. In the 1840s, "maize stalks were reported to have stood more than 5 metres high" (Connor, 2007: 107). Yet farming in the LSRV remained small-scale and primarily subsistence-related until J.S. Kirkwood formed the Sundays River Land and Irrigation Company in 1883. Kirkwood's venture failed to gain sufficient investors for a number of reasons, including the insufficient and unreliable supply of water in the LSRV (Miller, n.d.).[2] Although Kirkwood ultimately filed for bankruptcy, he was the first individual to attempt to create a commercial farming sector in the LSRV.

The mining boom in the Witwatersrand region, which started with the discovery of diamonds in 1868, further developed with the discovery of gold in the 1880s. Discrimination was carefully legislated even from this early point, with the *Gold Act* of 1886 stating that "no coloured person, Coolie, or Chinese, can hold a licence or be in any capacity engaged in working the goldfields, otherwise than in the service of white men" (Hobart Houghton & Dagut, 1972: 15). In the same year that the *Gold Act* was passed, the small village of Bayville in the LSRV recorded a population of 20-30 Europeans and approximately 500 'natives', who were said to be resident in and around the village (Connor, 2007: 107). The neighbouring mission station at Enon had continued to grow, and in 1898 the Moravian missionaries granted the land adjoining Enon to Xhosa converts. This land developed into the community of Bersheba (see map in Figure 5.1). These communities in the LSRV continued to grow informally, without any form of town in the centre of the region, until the town of Kirkwood was established in 1912 (Delport, 2002).

Between 1899 and 1902, the entire country shook with a war that pitted British forces against the two independent Boer republics (the Orange Free State and the Traansvaal Republic). Referred to as the 'Anglo-Boer' or 'South African' War, the British empire armies defeated the Boer republics in the latter's fight for independence, resulting in British sovereignty over the entire landmass of the country (in addition to British control over the mineral wealth of

the Witwatersrand region). After the Anglo-Boer War ended, British entrepreneurs followed Kirkwood's example and established a number of other irrigation companies in the LSRV. The Strathsommers Company was one of the first, and in 1906 the company conducted a census to assess who was living on company lands and with what assets. The census recorded a 'native' population of 1353 people, living in 287 huts, with over 1500 cattle, 2000 goats, and a substantial number of wagons, ploughs, and carts.[3] Following this census – and possibly as a result of the relative wealth – the Strathsommers company decreed that "No Native, Coloured Person, Coolie or Chinaman should be allowed to hold land as owner, tenant or sub-tenant without the permission of the company" (Grant, 1993: 13). The founders of Strathsommers and other irrigation companies in the early 20th century also acknowledged that the LSRV lacked a reliable water supply to support commercial agriculture. To this end, the first weir to be constructed on the lower reaches of the Sundays River (at Korhaansdrift) began construction in 1911 and was completed in 1913. The construction of this infrastructure began at a time in which the recently-formed Union government started supporting commercial irrigation (discussed in period 2 below).

When the Union of South Africa was formally established in 1910 (following British Parliament passing the *South Africa Act* of 1909), South Africa was still "little more than an enlarged self-governing British Colony composed of four smaller self-governing colonies" (Turton et al. 2004: 46). The Union therefore had not gained independence from the British Government. The LSRV area remained under the Cape of Good Hope, with the other three provinces being Natal, Transvaal, and the Orange Free State (see the map in Figure C.2). The fact that the black population of South Africa outnumbered the white population by almost four to one was a subject that was at the heart of South African politics at the time.[4] At the same national convention where the establishment of the union was discussed in 1908, the cape government proposed extending black enfranchisement to the entire country. In the Cape Colony, franchise had historically been extended to the black population, although it was subject to certain economic and educational qualifications.[5] The Cape 'liberals' failed to win support for this proposal, which left unresolved the question of "what are we going to do about the natives?" (Hamilton Fyfe, 1911). The answer came in 1913: "awaking on Friday morning, June 20, 1913, the South African native found himself, not actually a slave, but a pariah in the land of his birth" (Plaatje, 2007: 21). What made the native a pariah was the passing of the *Natives Land Act*, in which African land ownership was confined to a tiny part of South Africa's land surface. The act built on the *Glen Grey Act* of 1894, which had already

restricted land-ownership for any inhabitant other than those of European descent. The philosophy of separation at the heart of the *Natives Land Act* aimed to establish local political and administrative structures in the restricted areas, within which black aspirations could ideally be contained. The effect of the Act was that by 1926, 87% of the country became 'white land', leaving a mere 13% of the land as African reserves (Turton et al. 2004).[6]

4.2.3 Implications for water and local government

A number of important governance shifts occurred when the Dutch finally ceded control of the Cape Colony to the British in 1814. With the establishment of a 'British Crown Colony', the British introduced the freehold tenure of land, which significantly affected the state's control of water resources. As Rowlston (2011: 21) describes it:

> Under English law, all natural rights that were attached to the land, including water, belonged to the landowner. Accordingly, the riparian principle of English-American law, whereby owners of land alongside rivers have commons rights to exclusive and in-perpetuity use of the water in the rivers, was established in the colony's water law.

A second important governance shift was the establishment of local government. With the passing of the *Cape Municipal Ordinance* of 1836, the Dutch system of 'landrosts' was replaced with the British system of councillors, who were elected locally every three years and, in order to provide basic municipal services, were granted the power to tax property holders and businesses within their jurisdiction (Vosloo, 1974). The third important development was the initiation of state-led water management efforts, beginning with the establishment of a hydraulic division under the Commissioner of Public Works in the Cape Colony in 1875 and then, following the passing of the *Irrigation and Conservation of Waters Act* of 1912, the establishment of a Department of Irrigation.[7]

4.3 Period 2: Local development and land use trajectories in colonial South Africa (1914 – 1947)

4.3.1 Overview of period 2

Patterns of local land-use and socio-economic development became established in this period, supported by the stark inequity enshrined in regional and national scale policies. The dominant characteristics of the LSRV today can be seen as developing from these roots. In spite of water shortages, commercial farming began in earnest in this period, with white (often European) farmers receiving increasing support from a segregationist state.

4.3.2 Historical narrative for period 2

A crucial figure in the LSRV's development was Percy Fitzpatrick, whose business interests in land settlement and development were supported by his belief that South Africa had "need of a more closely settled and larger white population" (Meiring 1959: 62).[8] Fitzpatrick visited the LSRV area in 1913, and supposedly recognised its potential for citrus agriculture immediately. He began buying land in the area, with the idea of setting up a scheme that would work where other entrepreneurs had only failed. Fitzpatrick argued for a different approach: "it will be remembered that ours was the first enterprise in South Africa to recognise that settlement would not be a success unless the slow, laborious and expensive preparatory work was done for the settler" (Meiring 1959: 63). Ensuring an adequate supply of water for the settlers was paramount and could be achieved, Fitzpatrick thought, by building a dam above the LSRV to cope with the Sundays River's erratic flows. Fitzpatrick led a delegation of farmers to Cape Town, and proposed that the cape government support the development of a water storage facility expressly to promote commercial agriculture in the LSRV. The lobby successfully resulted in the *Sundays River Storage Project* being sanctioned in 1917, with the cape government loaning funds to the 'Sundays River Irrigation Board', which was an organisation established with the sole purpose of building Lake Mentz (L-WUA, 2007).

The list of problems affecting the construction of Lake Mentz included "lengthy but inadequate surveys, rushed estimates, incomplete scientific data, unobtainable land, insufficient communications, interrupted supplies, unstable foundations and unsuitable sand" (Lavin, 2005: 140). Despite the numerous difficulties, the dam was completed in 1922, becoming the largest privately-managed dam and the second largest dam in South Africa at the time (Lavin, 2005: 139).[9] Whilst the construction of Lake Mentz was underway, Fitzpatrick took over the Cleveland Syndicate and the Addo Land and Irrigation Company, out of which he formed the Cape Sundays River Settlement Company (CSRS). Fitzpatrick used the CSRS to pitch the Sundays River Valley area to Europeans – particularly to British ex-World War 1 servicemen (Urquhart & Klages, 1997: 15). The first settlers of the CSRS started arriving in the LSRV area in 1920, but they faced numerous challenges. For example, a settler commented that "one could not help laughing at the irony of arriving in Addo – the township of an irrigation settlement – in a train consisting of four passenger coaches and 41 water tank wagons" (Lavin, 2005: 140): the two irrigation dams in the area were still under construction, at this point, and Addo even lacked a stable supply of potable water.

Farmers in the CSRS also had to contend with the local elephant population. The CSRS land was adjacent to the Strathmore/Mentone Reserve, which was a natural haven for elephants.[10] Farmers in the LSRV became increasingly desperate in their attempts to ward off elephants (with one farmer even discharging a cannon at an elephant). The farmers argued that it was an "undisputed fact that the elephants were capable of destroying critical water supplies and flattening kilometres of fencing en route" (Urquhart & Klages, 1997: 16). The local farmers associations made frequent requests for the government to completely eradicate "these destructive creatures", and so funds were procured and a renowned elephant hunter was recruited (*ibid*, 8). Major Jan Pretorius began with the brief of complete eradication in 1918, although by 1920 the decision had been made to keep a number of elephants alive in order to maintain the specie (*ibid,* 20-22). The elephant population of the LSRV lived a tenuous existence in the following three decades. The first move to maintain the population in a controlled environment was the proclamation of the Addo Elephant National Park (AENP) in 1931, with the Strathmore/Mentone Forest Reserve at the core (*ibid*, 14).

The culling of the elephant population in the LSRV failed, however, to make a difference to the financial sustainability of the CSRS. By the mid-1920s, Fitzpatrick admitted that with irrigation development, the risks were too large, the problems too many, and the return on investment too slow for any sensible private investor to stomach (Lavin, 2005). One response to these problems was the formation of a coalition of citrus farmers in 1924, called the Sundays River Citrus Co-operative (SRCC), which had the chief objective of "disposing of citrus fruit of members in the most profitable manner" (Meiring, 1959). The cooperative benefited from economies of scale, and by 1925 had a total of 60 members with a combined total of 60 000 citrus trees. The SRCC could not, however, prevent Fitzpatrick's company from being taken over by government in 1925, which signalled the state taking a more active role in irrigation development.

Whilst protecting and developing white commercial interests on one hand, the union government continued to address what it construed as 'the native problem' with the other. The government implemented a number of commissions of enquiry in the 1920s, including the Stallard Commission to investigate the presence of African in towns. The commission concluded that:

> The Native should only be allowed to enter urban areas, which are essentially the white man's creation, when he is willing to enter and minister to the needs of the

> white man, and should depart therefrom, when he ceases so to minister (cited in Mbeki, 1992).

Following the recommendations of the Stallard Commission, national government introduced the *Natives (Urban Areas) Act* in 1923, which provided for the establishment of 'native locations' at the peripheries of towns, and allowed for municipalities to undertake slum clearance programmes. Labour requirements demanded that Africans should be near enough to provide labour: as the chairman of the Economic and Wage Commission of 1925 asked rhetorically, "what is the foundation of agriculture, of mining, of industry generally? To this question there is but one answer: the native" (Union of South Africa, 1925). Following the passing of the *Native Land and Trust Act* in 1936, peri-urban settlements in the LSRV were transferred from Strathsommer's Estate to the Kirkwood Municipality. This transfer had a few positive features, including that people could now receive basic sanitation in addition to other services. The negative aspects of the transfer included that residents were now under municipal control and, as such, "were subject to squatting legislation and possible removal" (Connor, 2007: 122). The first quarter of the twentieth century also saw the formation of several organisations that would become some of the most influential opponents of segregationist and racist government policies. These organisations included the formation of the Communist Party of South Africa in 1921. A few years later, the South African Native National Congress changed its name to the African National Congress (ANC), arguing that Africans had to unite against oppression, or as one of the founders of the ANC, Pixley Seme, put it: "the animosities that exist between... native[s] must be buried and forgotten... We are one people" (Mbeki, 1992). The common struggle against oppressive government was strengthened when the communist party and the ANC began to support each other in the 1920s, through an alliance that would continue to grow throughout the twentieth century.

4.3.3 Implications for water and local government

Whilst the Sundays River Irrigation Board (SRIB) was established in 1917 for the sole purpose of building Lake Mentz (L-WUA, 2007), it evolved into an organisation with management functions that included the operation and maintenance of the bulk water supply system in the LSRV, for the explicit purpose of managing irrigation water to white commercial farmers. In 2003, the SRIB would be transformed into the Lower Sundays River Water User Association (see sub-section 4.6.2 and sub-section 5.3.4) as part of the institutional transformation of water management organisations in post-apartheid South Africa. The SRIB developed alongside the citrus industry in the LSRV between 1917 (at the

point of the SRIB's founding) through to 1947 (the end of the period described in this section). The historical narrative in sub-section 4.3.2 has described how the Sundays River Citrus Co-operative (SRCC) and the SRIB did not co-develop independently of state assistance. The historical narrative further described how water deficits placed constraints on agricultural development (which were only partly improved with the completion of Lake Ment) and how a shortage of good-quality water for human consumption stifled urban development in the LSRV until the 1920s. Municipal infrastructure began to be developed in this period with the formalisation of the Kirkwood Municipality. But the basic services provided by the municipality were increasingly subject to segregationist policies, which saw white urban residents as citizens and everyone else as 'natives' who were required for farm labour, but should otherwise remain on the peripheries of towns. Segregation and the dehumanising treatment of 'natives' as labour were central to the structure and functioning of apartheid, as described in the following period.

4.4 Period 3: The rise and fall of apartheid (1948 – 1989)

4.4.1 Overview of period 3

When the National Party (NP) won the 1948 elections in South Africa, it substantively built on the segregationist policies initiated under Dutch and British colonial rule. The 1950s saw the passing of a range of laws affecting race-relations. In addition to the disastrous and pernicious social impact of these laws, other longstanding effects have included entrenched patterns of segregated development and settlement, economic disenfranchisement and inequitable access to resources – all of which are demonstrated in the LSRV case. On the local scale, this period saw the buying out of commercial farms to facilitate the growth of the Addo Elephant National Park, and the beginning of tourism in the LSRV. The attendant resettlement of farm labourers was one of the drivers of increasing urbanisation. The remaining commercial farms in the LSRV received a major boost through becoming recipients of one of the largest apartheid engineering projects: the Orange-Fish-Sundays Inter-basin Transfer scheme. In the latter half of this period, the apartheid state unravelled as a result of numerous internal and international pressures and contradictions – as the myth of different races being 'separate, but equal' within South African borders was exposed.

4.4.2 Historical narrative for period 3

The NP's election campaign included promising white farmers state protection and higher prices for their products and curbing black urbanisation to address the labour shortages being

experienced on farms. The ANC responded to the NP's election by committing to a resistance campaign. In order to minimise the impact of this resistance (and entrench control over), the state initiated what is best described as "a series of draconian laws specifically aimed at restricting political activity" of black South Africans, which included the *Suppression of Communism Act* of 1950, the 1953 *Public Safety Act* and the *Criminal Law Amendment Act* of 1953 (World Commission on Dams, 2000). Other notable acts at the time were the *Prohibition of Mixed Marriages Act* (1949), the *Immorality Act* (1950), the *Population Registration Act* (1950) and the *Group Areas Act* (1950). Collectively, these laws determined "whom a person could marry; with whom one could have sex; what type of person one was; and where a person must live according to strict racial categorisation" (Turton et al. 2004: 55).

The insidious intentions of apartheid policy were made evident in the *Bantu Education Act* of 1953. The Minister for Native Affairs, and the architect of the act, argued that "education must train and teach people in accordance with their opportunities in life... [and] should not clash with government policy" (Mbeki, 1992).[11] The *Group Areas Act* arguably had the greatest impact on the way in which local government was managed. The act enforced influx control, spatial separation based on race, and mandated a policy of "own management for own areas", all in order to "limit the extent to which affluent white municipalities would bear the financial burden of servicing disadvantaged black areas" (RSA, 1998: 12). With the *Group Areas Development Act* of 1955, the apartheid government began implementing the recommendations of the 'Commission for the Socio-Economic Development of the Bantu Areas' (Union of South Africa, 1955). The commission had acknowledged that the European sector would have to accommodate many millions of unemployed 'Bantus' unless government actively developed the 'Bantu areas'.[12]

The effects of these national policies began to be felt in the LSRV in the late 1950s. At this time, Kirkwood was different to most other South African towns, in that it had six townships in the area, rather than only one. These townships included the four residential areas around the town of Kirkwood – Bontrug, Wistkraal, Wesbank, and DePlaat – in addition to Enon and Bersheba (Connor, 2007; Grant, 1993). The majority of people worked on labour-intensive citrus farms in the vicinity, and the living arrangements carried certain benefits for different parties: by being settled in nearby townships, farmers did not have to house workers, but labourers still resided close to their employers. The residents paid low rates to the

municipality, and water was available from the nearby river. In addition, there were established schools and some residents still owned cattle and goats (Logie, 2011: 121). Yet according to national policy, these areas constituted 'black spots' (i.e. black settlements within designated white areas), and so beginning in 1959, the Kirkwood municipality forcefully relocated over 2000 residents from these areas (Connor, 2007: 134). The painful manner of these evictions can be illustrated through excerpts from a letter written by one evictee, which was addressed to the Secretary for Native Affairs in the capital city of Pretoria: "We have no waggons to load our articles… that place have no water and firewood… and there is no road… even the doctors hardly go there. It has no veld for our goats and cows…" (Connor, 2007: 135-6).

The development of increasingly segregationist policy in the 1950s was not without resistance. After 1949, the ANC shifted to an offensive mode and initiated a range of measures to counter apartheid policy (termed 'defiance campaigns'). One of the first defiance campaigns was the boycott of consumer products, which started with a boycott of oranges in Port Elizabeth that "was designed to put pressure on the citrus-growing farmers along the Sundays River… to treat their workers fairly" (Mbeki, 1992). Non-violent resistance to apartheid became marked by the Sharpeville massacre in 1960.[13] Following riots, demonstrations and protests around the country in reaction to Sharpeville, the SA government banned the ANC and other anti-apartheid movements whilst declaring a state of emergency. The ANC, for its part, announced a shift from non-violent resistance and the beginning of its armed struggle against apartheid. International condemnation of the apartheid state following Sharpeville also played a role in South Africa's departure from the British Commonwealth of Nations and the subsequent formation of the 'Republic of South Africa' in 1961 (Terreblanche, 2002).

Several local developments in the LSRV in the 1950s are also particularly relevant here. One of the local problems in the LSRV was securing the elephant population within the boundaries of the AENP. The first elephant-proof fence was completed in 1954, enclosing an area of approximately 4000 hectares (Meiring 1959). According to Whitehouse and Kerley (2002: 245),

> …throughout 1931-1954 a minimum of 80% of all deaths could be attributed to problems encountered by the elephants whilst outside the park (hunting, train accidents, and other incidents) and, therefore, can be related to the lack of fence.

The fence effectively lowered elephant mortality rates. Between 1954 and 1998, the AENP was expanded on four occasions, with the population increasing from 22 to 284 elephants in this time (Whitehouse & Kerley, 2002: 244). The effective control of the elephant population helped facilitate the growth of the park as a tourism site, which occurred from the 1970s onwards (Connor, 2007), and reduced the competition for land between citrus farmers and elephants. The 1950s also saw the passing of new water-related legislation in South Africa. The 1956 *Water Act* repealed the *Irrigation and Conservation of Waters Act* of 1912. Water management for industrial, urban and agricultural purposes was legislated, with the wilful pollution of water made a statutory offence for the first time. The act also led to the Department of Irrigation being renamed to the 'Department Water Affairs' with an entire organisation restructured (Nel et al., 2007: 79).[14]

The period between 1948 and 1960 can also be characterised as a time when the apartheid state promoted agricultural development by intensifying government control over African labour (Marcus, 1989). The changes in water legislation continued to favour white commercial farmers and landowners, but by the early 1960s, the apartheid state worried that its policies were failing to maintain a strong 'European' presence in the agricultural sector. The 1960 report of the 'Commission of the Inquiry into European Occupancy of Rural Areas' warned that there were dire consequences to Europeans increasingly leaving the agricultural sector in order to seek employment in urban areas:

> ... if the tide does not turn and the growth of the non-white preponderance on the white platteland [rural areas] continues, this state of affairs will in the end hold out a serious threat to white civilisation in this country (Du Toit, 1960: 48).

In response to this perceived threat, the apartheid state sought to simultaneously raise farm productivity (and therefore profitability), whilst reducing the dependency of white farmers on African labour (Marcus, 1989). To achieve these goals, the state supported the mechanisation of white commercial agriculture, as part of a broad embrace of technological innovations (which included tractors, increasingly-efficient irrigation technology, high-yield seeds and pesticides, herbicides and insecticides). In many areas, however, agriculture was still hampered by local environmental constraints. In the LSRV, these constraints were primarily water problems in the form of salinity, and ephemeral and unpredictable flow.[15] These problems were ameliorated by the LSRV being a recipient of water from one of the largest engineering projects in the world at the time: the Orange River Development Project.

The Orange River Development Project (ORDP) was one of the largest projects initiated by the apartheid state in its drive to support agricultural development through mechanisation. The project was initiated in 1962, and sought to increase the storage capacity of dams on the Orange River, in order to distribute the conserved water to drier parts of the country via inter-basin transfer schemes. The stated aim of the project was "to afford new life to the fertile but water-deficient Great Fish River and Sundays River valleys whilst providing crucial services" (World Commission on Dams, 2000).[16] The ORDP had been proposed in 1928 and again in 1950, but on both occasions the project was rejected as too costly. It was ultimately approved in 1962 for a range of political and economic reasons, which the World Commission on Dams (2000: x) summarised as follows:

> The actual decision to plan a comprehensive Orange River Development Project (ORDP)… was triggered by the objective of the Nationalist Party Government to stem the outflow of capital from South Africa. This flight of capital was partially caused by the increasing domestic resistance and international criticism against the Governments Apartheid policies, particularly following the Sharpeville massacre in 1960. The decision to embark on the ORDP was also motivated by the Nationalist Party Government's goal of building a political symbol to Afrikaner Nationalism and a monument to the grand scheme of apartheid at a time when South Africa had just withdrawn from the British Commonwealth.

Farmers in the LSRV welcomed the ORDP as a means of addressing the dual problems of ephemeral flow and salinity. The Sundays River Irrigation Board (SRIB) had raised the dam wall at Lake Mentz for the second time in 1952, in order to cater for the increased demand for irrigation water in the LSRV and the reduction in available supply following the extensive drought in the region (Meiring, 1959). This drought bankrupted many commercial farmers in the LSRV in the 1950s and 1960s, and was one of the factors that led to the concentration of land and capital, both in the LSRV and throughout the South African agrarian sector.[17]

In the water management realm, the 1970s saw a number of noteworthy changes. The 'Commission of Enquiry into Water Matters' released its report at the start of the decade, arguing that the large-scale state subsidization of water management had to end. Agriculture was identified as the sector where changes particularly had to be made, with the commission arguing that there was little scope for significant expansion. The commission also promoted financial instruments, including volume-based payments and intra-scheme water trade for irrigation (van Koppen, 2008), and acknowledged the growing demand for water use in urban

areas. In 1910, urban water use only accounted for 3% of total demand, but by 1965, it had grown to account for 16.5% (Commission of Enquiry into Water Matters, 1970: 26).

The state's change of heart with regards to water management and agriculture can be seen as one part of a series of tacit acknowledgements that apartheid was failing: in the period from 1950 to 1970, the state had opted for a 'direct rule approach', whereby Native Commissioners and Bantu Authorities addressed 'the native problem' with the support of the policy framework of apartheid (Mbeki, 1992). This approach failed to work as desired, so the state responded by implementing an even-more drastic programme of separate development. Known as 'homelands' or 'bantustans', these areas of South Africa were envisaged as self-governing territories that contained only a specific black ethnic group. The ten homelands that were declared are illustrated in the map in Figure C.2. Four of the ten homelands were additionally declared to be 'independent' of South Africa (the independence was nominal in that the homelands were not recognised by any other country as independent and sovereign entities). Crucially, all designated citizens of the homelands had their citizenship replaced with that of their respective homeland, and were thus no longer South African citizens (Terreblanche, 2002). Under this apartheid grand vision, the Xhosa residents of the town of Bersheba (in the LSRV) were thus supposed to move to either the Transkei or Ciskei (the two independent homelands for Xhosas in the eastern part of the Cape province (see Figure C.2)). Yet between the 1970s and 1980s, the Bersheba residents successfully resisted forced relocation to these homelands, and saw out apartheid residing in the LSRV (Japha, 1996).

The cumulative effect of apartheid policies at the local level in the LSRV can be illustrated using select results from the 1980 state census (Central Statistical Services, 1986). Variables assessed in the census pertained to population, levels of education, income, and type of employment, with each variable disaggregated by population group (Black, White, Coloured and Asian). The census recorded a population of 31888 in the Kirkwood magisterial district in 1980, of which 6068 resided in an urban area, and the remainder in 'non-urban' areas.[18] The effects of the *Bantu Education Act* are visible in the levels of education of residents in the Kirkwood district: in 1980, over 34% of the white population had achieved a standard 9 education or higher, with less than 2% of the coloured population, and less than 1% of the black population, achieving the same level (see Table 4.1 below).

Table 4.1: Levels of education of residents of Kirkwood district, by population group (Central Statistical Services, 1986: 112, 121, 138)

	Total population in district (by population group)	Number of individuals with Std. 9 education or higher	% of population group
Black	23582	207	0.9
Coloured	5428	91	1.7
White	2878	982	34.2

The racial distribution of income in the Kirkwood district is equally illustrative of the perverse 'success' of apartheid. The lowest income decile of the white population of Kirkwood in the 1980 census was the category of '2-1199': 14% of the white population of the Kirkwood district fell into this category (i.e. 14% of white residents earned less than R1200 per year, as of 1980). By comparison, 80% of the coloured population and 89% of the black population was in the same decile. In terms of the wealthiest members of Kirkwood, the top decile of the black and coloured populations earned R18000 or more per year: only three black people were in this income category, and only two coloured people. 173 people were in the equivalent category for the white population (equating to 11% of the income earning population of the Kirkwood district).[19] In summary, there was a stark distribution of income in the Kirkwood district in 1980: the vast majority of coloured and black people were impoverished, and very few were wealthy, whilst a minority of the white population was poor, the majority were middle class, and more than 10% were extremely wealthy.

Two developments in the early 1980s began to significantly change the landscape of the LSRV. Between 1980 and 1985, the first land purchases towards a 'Greater Addo Elephant National Park' were made (Connor, 2007). Conservationists and zoologists argued for the development of a 'mega-park' on the basis that the growing elephant population and important endemic vegetation in the LSRV warranted conservation and could support a large tourism industry. Alongside the conversion of commercial farms to eco-conservation and tourism ran a parallel process of concerted irrigation development in the LSRV. When the Wellington Grove pump station became operational in 1978, water could finally be conveyed from the Hendrik Verwoerd dam to Lake Mentz, via the Orange-Fish-Sundays inter-basin transfer scheme and the Skoenmakers River (L-WUA, 2007 - see Figure 5.2). Thousands of hectares of additional land could now be irrigated, without the constraints of erratic water supply and low-quality agricultural water that had plagued the LSRV for so long.

On the national level, the 1980s was a turbulent decade characterised by a schizophrenic attitude towards change: on the one hand, the apartheid state acknowledged the need to change and initiated a new constitutional dispensation in South Africa; on the other hand, the state was unwilling to relinquish control and became increasingly repressive and authoritarian. The three aspects of reform that are particularly relevant for this discussion are the Tri-cameral parliament, Black Local Authorities and Regional Services Councils, all of which were enshrined in the 1983 constitution. The Tri-cameral parliament established separate chambers for white, coloured and Indian populations in South Africa, in a nominal 'power-sharing' agreement that maintained the executive authority and control of the apartheid state. By the mid-1980s, President P.W. Botha tacitly acknowledged that black self-government in the homelands had failed, and that black citizens of the homelands could re-apply for South African citizenship (Terreblanche, 2002). To off-set the fact that the black population was still excluded from participating in the Tri-cameral parliament (and with the self-governing territories ceasing to even provide the façade of 'separate development') the NP introduced an additional institution called 'Black Local Authorities' (BLA). The viability of BLAs was doubtful from the start: the local authorities had limited sources of revenue to fund their operations, given the poverty of black urban areas and the erosion of black property rights, which meant that property taxes could not be relied upon (Poto, 1988). Instead, BLAs tried to fund their operations by charging rent to black residents: the subsequent rent boycotts became another means of powerful protest by black residents of the apartheid state's attempts to reform whilst maintaining executive power.

The new constitutional dispensation post-1983 initiated a process of decentralisation, which President Botha described in a 1985 speech in the following way: "the devolution of power to local government institutions for the various population groups is a constitutional mechanism to maintain the interests of minority groups in a heterogeneous environment" (de Beer & Lourens, 1995: 78). The 1983 constitution asserted two principles, namely, "self-determination over own affairs and joint decision-making on general affairs" (*ibid*, p.78). General affairs included those that affected more than one population group, such as bulk water supply infrastructure. The third new institution founded in the 1983 Constitution that is discussed here – Regional Services Councils (RSC) – was one of the institutions supposed to address these general affairs at the local scale. The LSRV was serviced by the Algoa Regional Services Council, which began operating in 1987. A central function of an RSC was to disburse funding that national government made available to local bodies within the

area under the RSC's jurisdiction. These local bodies were allowed to apply for funding to support capital projects (many of which were bulk water infrastructure and sanitation projects).[20] The 'Bontrug town committee' was awarded the greatest portion of the RSC funds allocated to the Kirkwood district. These funds enabled the first water infrastructure to be installed in Bontrug – a total of 30 years after the forced removals of farm labourers from the townships in the immediate vicinity of the town of Kirkwood to Bontrug (Logie, 2011: 122).

Resistance to the new constitutional dispensation took many forms. Following the inauguration of the Tri-cameral parliament, with its continued exclusion of the black population from decision-making, the United Democratic Front (UDF) was founded. The UDF provided an umbrella group for civil society organisations of all kinds who united under the banner of a common anti-apartheid struggle. Many organisations collaborated to make 'the townships ungovernable', including by promoting the rent boycotts that crippled BLAs. Meanwhile the ANC's military wing continued its programmes of sabotage. The apartheid government responded to these various resistances with brutality: President Botha called a State of Emergency that extended from 1984 to 1986, during which time South African Defence Force soldiers were deployed to townships, political disappearances increased rapidly, and anyone could be detained for lengthy periods without trial.

Following the condemnation of the Soweto Uprising in 1976 (when protesting schoolchildren were shot by policemen), the NP faced increasing international pressure, ranging from economic sanctions and disinvestment campaigns to extensive travel restrictions for all South Africans. Whilst the 1983 constitution was designed to show that the NP was pro-reform, by mid-1985 it was a clearly a case of 'too little too late'. Following the United States Congress passing the *Comprehensive Anti-Apartheid Act* and following international banks recalling all governmental loans, the apartheid government faced even further international isolation and inevitable bankruptcy. [21]

The last half of the 1980s was a time characterised by violence in South African townships, the over-extension of the South African Defence Force in the 'Border War', and negotiations – many of which were undertaken in secret. It took until 1989 for the hardliner NP faction (led by President Botha) to be replaced by a faction willing to negotiate with anti-apartheid organisations, release political prisoners, and begin to dismantle the apartheid state.

4.4.3 Implications for water and local government

The passing of the 1956 *Water Act* resulted in an entire re-organisation of the newly-named 'Department of Water Affairs'. Water management for industrial, urban and agricultural purposes was legislated and a new system of classifying water resources into 'public' and 'private' categories was initiated (Nel et al., 2007: 79). By asserting the riparian rights of landowners, the 1956 *Water Act* linked the ownership of land with preferential access to water resources (Turton et al., 2004: 377). In predominantly rural areas like the LSRV, the result of this legislation was that rights and access to water remained entrenched in the hands of the minority white farmers who, as a result of the previous land acts and segregationist policies, owned the majority of land adjacent to watercourses. The provision of water services was similarly skewed towards benefiting the white population of South Africa: by separating black areas from centres of commerce and industry, the *Group Areas Act* (and associated legislation) reserved the majority of the municipal revenue base for white areas (RSA, 1998), thereby ensuring that urban water services were preferentially provided to the white population. Although the failure of the homelands and the 'independent' states, coupled with increasing economic challenges, motivated the apartheid government to begin a broad decentralisation programme in the 1980s, it was a case of far too little, far too late.

4.5 Period 4: Transition and the changing role of government (1990 – 2000)

4.5.1 Overview of period 4

In the hopeful decade of the 1990s the apartheid state was comprehensively dismantled, liberation fighters became politicians, and the South African political landscape was broadly transformed. In 1994, the ANC was elected to power in the first democratic elections, and entered into a 'Tri-partite alliance' with the South African Communist Party and the Congress of South African Trade Unions. The remainder of the decade was marked by significant constitutional and national-level changes that affected, amongst other things, the way in which local government was structured, the statutory frameworks governing water (including the provision of water services), and the eradication of the discriminatory basis upon which the entire previous governance structures were built.

4.5.2 Historical narrative for period 4

A defining point in the ending of formal apartheid was the unbanning of opposition parties and the release of Mandela from jail in early 1990, by the newly-instated NP president (F.W.

de Klerk). When the 'Convention for a Democratic South Africa' was convened in December 1991, the negotiations between the ANC and NP were made public for the first time (negotiations that had been occurring in some shape or form since 1984, but always in private).[22] The many potential pitfalls in this process were successfully navigated and led to an interim constitution being adopted in 1993. The following year, the first democratic national elections were held and universal adult suffrage was attained for the first time in South Africa's history. The ANC was voted into power, with Mandela as president in a power-sharing agreement with the NP. The ANC received additional grassroots support by formalising a 'tri-partite alliance', in which it partnered with the South African Communist Party (SACP) and the Congress of South African Trade Unions (COSATU). Under this first post-apartheid government, the *Constitution of the Republic of South Africa* (RSA, 1996) was adopted. The founding provisions of the constitution assert that South Africa is one sovereign democratic state founded on the following values:

> Human dignity, equality, non-racialism and non-sexism, supremacy of the constitution and the rule of law, universal adult suffrage and a national common voters roll, regular elections, and a multi-party system of democratic government (Republic of South Africa, 1996: 1243).

The constitution is a far-reaching document at the heart of the South African legal system. The following two elements are particularly relevant to water management and water services as explored in this study: firstly, the constitution specified three spheres of government (national, provincial, and municipal) that are independent of one another but interrelated through the principle of 'cooperative governance', with the responsibility for ensuring water services are provided delegated to the municipal sphere; secondly, access to water for basic human needs was stipulated as one of a group of basic human rights, which also included the right to an environment that is not harmful to any South African's health. In terms of water management, these constitutional principles began to be codified into policy and legislative frameworks through the water law reform process (initiated in 1995 and discussed further in sub-section 5.3.2). The resulting *National Water Act* of 1998 (RSA, 1998a) was underpinned by the three foundational principles of 'equity', 'efficiency' and 'sustainability', which were pithily summarised in the slogan "some, for all, forever" (Rowlston, 2011). New water management institutions were required to achieve these new objectives: the *National Water Act* stipulated the establishment of regional and local organisations in the form of 'catchment management agencies' (CMAs) and 'water user associations' (WUAs), which would be empowered to play diverse water management roles. The ideal of decentralising water management as far as possible reflected the desire for

community participation and stakeholder engagement in all levels of water management decision-making, towards enhancing local-level accountability. These same ideals drove the decentralisation of water services that was stipulated in the *Water Services Act* of 1997.

As discussed earlier, a central precept of post-apartheid South Africa was the unification of the country, meaning that the self-governing homelands were re-integrated as part of the country. The resulting integration left the new Eastern Cape province with a particularly heterogeneous character, which included the Port Elizabeth/Uitenhage metropolitan, the areas of South Africa traditionally known as the Eastern Province (including the LSRV), as well as parts of the inland Karoo region in the north-west, and the ex-homelands of the Transkei and Ciskei in the east. In the mid-1990s, the post-apartheid government contracted the Port Elizabeth-based Employment Research Unit (ERU) to assess the state of housing and infrastructural services in the diverse province that was now the Eastern Cape (Horn, Lloyd, & Levin, 1996). The resulting ERU report is a useful reference (and is discussed here) for two purposes: firstly, the report compares the performance of the Eastern Cape with the other eight provinces of South Africa against a number of socio-economic development indicators; secondly, the report usefully situates access to water in the LSRV in relation to access to water more broadly in the Eastern Cape, at the point of the new constitutional dispensation in 1996.

The Eastern Cape is the second largest province in South Africa, comprising 13% of the country's total surface area (around 170000 km^2). The government census of 1991 calculated the life expectancy in the province as 59.6 years, whereas the national figure was set at 63.4 years. As of 1993, the personal per capita income in the Eastern Cape was only 53% of the average for South Africa as a whole (R1359 against R2566). An additional indicator of interest is the Human Development Index (HDI) – a measure of the relative socio-economic development of countries that is an alternative to GDP. In 1993, the index for the Eastern Cape province was calculated as 0.48 out of a possible 1.0, which was less than 75% of the average HDI of South Africa at the time (Horn et al., 1996: 7-8). In terms of the LSRV, the report estimated the Kirkwood district's population as 42139, which reflected a population increase of more than 10000 people (or more than 30%) from the estimates given in the 1980 census (*ibid.,* p.70). The ERU's report also pointed towards a trend of rapid urbanisation in the LSRV. Whilst in 1980, only 6000 of the Kirkwood district's 32000 people resided in an

urban area (Central Statistical Services, 1986), by 1995, an estimated 23319 people were urbanised (Horn et al., 1996: 70).

In 1995, there was above-average access to water in the LSRV in relation to access to water more broadly in the Eastern Cape (as illustrated in Table 4.2, which is calculated by drawing on source data contained in Table C.5). As Table 4.2 shows, 74% of households in urban areas of the LSRV had access to water via a household connection in 1995, whilst 14% of households in the LSRV accessed water via a communal tap (the Eastern Cape average was 53% and 27% respectively).

In terms of access to water in rural areas, the provincial average for households with water in their homes was 0.3% in 1995, with the majority of households using a communal water supply. In comparison, just over 2% of households in non-urban areas in the LSRV had a household water connection, and 37% used a communal water supply. The figure of 74% of urban households in the LSRV having access to a household water connection in 1995 should be read with a number of caveats: firstly, the ERU report also identified at least 7600 people squatting in the vicinity of small towns in the LSRV, and a resulting housing backlog in excess of 1200 households (*ibid.,* p.87-8); secondly, these figures only took into account the existence of water infrastructure, and not the quality of the service being provided (even in terms of whether water was actually flowing from taps).

Table 4.2: Household access to water in the LSRV compared to averaged statistics for household access in the Eastern Cape province in 1995, differentiated by urban and non-urban areas, and by 'in home' and 'communal' water connections. Source: Horn et al. (1996: 16, 24, 70).

	LSRV urban areas	**Eastern Cape urban areas**	**LSRV non-urban areas**	**Eastern Cape non-urban areas**
% of households with water in home	74	53.4	2.3	0.3
% of households with communal water supply	14	27	37.2	51

The above statistics provide a perspective on the developmental needs in the LSRV, Eastern Cape and country more broadly. The post-apartheid government's plan for tackling these developmental challenges included multiple large-scale projects (such as the Reconstruction and Development Programme that was initiated in 1994), in addition to restructuring government such that local government was at the epicentre of development (de Visser, 2005). The process towards a unified system of local government was initiated when the

Local Government Negotiating Forum (LGNF) was convened in the early 1990s: through this process, participants from the NP finally acknowledged that black local authorities (introduced in sub-section 4.4.2) were completely unviable, and that the demarcations promoted by apartheid policy deprived these authorities from significant sources of revenue, which only resulted in dependence on national government. In March 1992, "the idea of joint administrations for neighbouring 'white' and 'black', 'coloured' or 'Indian' local government bodies was expressed as an attainable ideal and [became] the first steps towards true restructuring" (de Beer & Lourens, 1995: 94). Following the LGNF, the *Local Government Transition Act* of 1993 formally repealed all race-based local government legislation, and contained an agreement for 'one municipality-one taxbase' (de Beer & Lourens, 1995: 150). With the publication of the 'White Paper on Local Government' in 1998, the concept of 'developmental local government' was formalised, and the principles of accountability and equitable provision of services was promoted. A range of local government legislation was promulgated between 1998 and 2000 – including the *Municipal Structures Act* of 1998 and the *Municipal Systems Act* of 2000, which stipulated the introduction of ward committees, performance management, and 'integrated development planning' for municipalities (all of which are discussed in detail in section 5.4.3). Following the passing of this legislation, the first democratic local government elections were held in December 2000. In the LSRV, the elections marked the start of a new institution – the Sundays River Valley Municipality – which is central to this study (and to the analysis in the following two historical periods of this chapter).[23]

4.6 Period 5: The Sundays River Valley Municipality and continuing government transitions (2001 – 2008)

4.6.1 Overview of period 5

In this period, changes at the national scale consistently impacted on the way in which water was managed (and required to be managed) in the LSRV, including the way that water services were provided within the geographic and functional boundaries specified as the Sundays River Valley Municipality.

4.6.2 Historical narrative for period 5

The Sundays River Valley Municipality (SRVM) began functioning in 2001 as one of nine local municipalities within the Cacadu District Municipality. A broad socio-economic overview of the municipality is provided in Table 4.3.

Table 4.3: Basic municipal statistics for the Sundays River Valley Municipality at point of initiation in 2001. Source: Statistics South Africa (2014).

Total population	43914	people
Number of households	10761	households
Average household size	3.9	people/household
Unemployment measure	34.1%	% economically active population
Piped water (inside dwelling)	13.2%	% households
Flush toilet connected to sewerage	22.7%	% households

The pattern of urbanization continued in this period, partly driven by the expansion of the AENP. Between 1997 and 2005, a total of 130 000 ha of land was purchased for the AENP (Connors, 2007: 254). An authoritative estimate of the number of farmworkers displaced by the expansion of the AENP over this period is 499 – although Connors (2007) suggests that this figure should be taken as minimum amount that would likely quadruple if the farmworkers' families were included in the count. Many of these farmworkers and their families moved to urban areas in the SRVM, which began to place additional pressure on the newly-formed SRVM as the municipal service provider.

The small Kirkwood municipality was used as the base for the newly-formed SRVM. The changes in municipal demarcation between 2001 and 2011 are illustrated in the map in Figure 5.6 (sub-section 5.4.2). The area served included the town of Paterson (and its surrounding communities), as well as areas that were previously served by the Algoa Regional Service Council and various transitional local councils. As well as catering to a wider geographical area, the municipality was tasked with providing a broader array of services as part of the policy of 'developmental local government' asserted in the 1990s. In addition to the core functions of water and sanitation, electricity provision, and refuse collection, the SRVM's duties therefore included a range of community services and engagement in local economic development (see section 5.4.3 for details of municipal services).

Water management institutions were also envisioned to play a transformed role in the early 2000s. A particularly noteworthy institutional change in the SRVM was the conversion of the Sundays River Irrigation Board to a water user association in 2003. The *National Water Act* of 1998 required all irrigation boards to convert to water user associations, which were intended to be more democratic institutions that could support economic and political

transformation. Irrigation boards developed in the twentieth century through the assistance of successive colonial and apartheid administrations, in order to support the provision of agricultural water to the predominantly white commercial farming sector in South Africa (DWAF, n.d.-b). As a result of this pattern of development, irrigation boards (and their members) also owned the majority of infrastructure for bulk water supply in rural areas. Water user associations (WUA) were intended as an institutional form that could support the expansion of agricultural development to include a larger number of 'resource poor' farmers (also known as 'black emerging farmers'). Following the gazetting of the Lower Sundays River Water User Association (L-WUA) in 2003, 'emerging farmers' now sat on the Management Committee of the organisation. However, early attempts to develop irrigation schemes for 'resource poor' farmers in the area failed.[24]

The land reform failures in the LSRV at this time were indicative of the large-scale difficulties that land-reform policies had at the national level. The Reconstruction and Development Programme (RDP) had promised to redistribute a third of South Africa's 85 million hectares of agricultural land within 15 years of the programme's implementation in 1995 (Rumney, 2005: 412). Although the left-leaning RDP was replaced with a more market-centred programme in 1997 – called the Growth, Employment and Redistribution strategy (GEAR) – key redistributive programmes like land reform remained on the agenda, albeit with little success. A further redistributive programme of the RDP and GEAR that had more success was Black Economic Empowerment (BEE), which emphasised the creation of black company owners as well as requiring management staff of companies and organs of state to strive to be representative of South Africa's racial demographics (Rumney, 2005). The presence of the black emerging farmers on the management committee of the L-WUA's was an example of that.

Whilst the primary role of the L-WUA remained the provision of raw water to the commercial farming sector in the LSRV, it also acted as the bulk raw water supplier for the SRVM and the Nelson Mandela Bay Municipality. Tensions between the raw water supplier and the local municipality had been building for a number of years: since 1997, the Sundays River Irrigation Board had been warning the Kirkwood municipality about the inability of the municipal water supply system to keep up with the burgeoning household demand for water in Kirkwood. Between 2010 and 2012, the Kirkwood water supply system would become the focal point of conflict between the L-WUA and the SRVM.

A further water management innovation was the release of the first National Water Resource Strategy (NWRS) in 2004 (DWAF, 2004). The NWRS was the implementation plan for the *National Water Act*, and part of the strategy was the division of South Africa into 19 'water management areas' (WMA). The SRVM is located within the Lower Sundays River sub-catchment in the Tsitsikamma to Keiskamma WMA (see sub-section 5.3.4 for details). One of the purposes of dividing the country into WMAs was to provide the biophysical boundaries within which catchment management agencies (CMAs) could be established. The failure to establish a CMA in the Tsitsikamma to Keiskamma WMA meant that the Department of Water Affairs (DWA) regional office continued to play all the protection, allocation, and mediation roles that a CMA could, in principle, perform.

In other areas of water management, DWA continued attempting to downscale its operations. When DWA celebrated providing the ten millionth South African with access to safe water in 2005, a milestone was reached that symbolised the ending of DWA's direct role in water service provision, and the handing over of responsibility to local government (Rowlston, 2011: 6). The *Division of Revenue Act* of 2002 provided the financial model for local government water services, including a redistributive mechanism whereby revenue was transferred from the National Treasury, to local municipalities, called 'equitable share' (Muller, 2009). The way in which water services should be managed, regulated and financed was further codified in 2003 with the gazetting of the 'Strategic Framework for Water Services' (DWAF, 2003).

A key water services programme – designed at the national level for municipal implementation – was Free Basic Water (FBW), which strove to provide a 'lifeline' minimum quantity of 25 litres per person, per day. The FBW programme was implemented and supported within the "framework of the Department of Provincial and Local Government's (DPLG) broad programme to support local government transformation" (Muller, 2008: 78). In addition to water, the broader programme grouped the provision of basic sanitation, refuse-collection, and electricity into a package of 'free basic services' (FBS). Therefore, FBW was part of a larger 'social wage', which is the full package of state-provided services, which in addition to formal welfare grants, constitute South Africa's 'social security framework' (Booysen, 2009: 112; Muller, 2008: 75). A 2005 survey by the DPLG reported that the majority of municipalities were implementing FBW policies

(Atkinson, 2007), and overall nationally-collected statistics recorded considerable improvement in overall 'access to water' in this same period.[25]

These successes were, however, tempered by the cracks in the local government model that became increasingly evident in the lead-up to the second local government elections in March 2006. In the SRVM, for example, all service delivery grounded to a halt in the weeks following the elections, with the municipal offices closing for three days after councillors and senior officials were held hostage by protesters. One of the provincial newspapers reported that "the people wanted Mpumelelo Tiyo as mayor, while the ANC Cacadu and provincial executives wanted Vuyokazi Tshaka" (Matavire, 2006). The SRVM was not an aberrant case in this regard: five other municipalities in the Eastern Cape were also paralysed by infighting in the ANC over this same period (*Ibid*.). The protests in the SRVM – seemingly over the delivery of houses in several communities and the choice of ANC mayor – were only one example of thousands of protests throughout South Africa at the time.[26] Analyses of the main causes of the protests in the period between 2004 and 2007 identified a number of key issues (cf. Atkinson, 2007; Booysen, 2009; Muller, 2009), which are considered briefly here.

The most obvious of the causes – namely, ineffectiveness of municipal service delivery – can be illustrated with a few key statistics. In terms of water quality, the Minister of Water Affairs and Forestry, Buyelwa Sonjica, noted in 2006 that "63 percent of municipalities could not confirm that they met the drinking water quality guidelines" (Atkinson, 2007: 61). Financial mismanagement was a serious issue within virtually all municipalities: in the 2005-6 financial year only 2 percent of local governments were awarded clean audits by the Auditor General of South Africa (Booysen, 2009: 113). A related issue was the fact that municipalities were failing both to recover costs and to spend allocated budgets. Municipal capacity in the form of qualified, skilled staff members was one of the reasons why this was the case. In the SRVM, the municipal engineer retired in 2007, after which only various junior technicians replaced him in an 'acting' capacity. A 2008 skills audit by the SA Institute for Civil Engineering (SAICE) found that the SRVM was an indicative, rather than aberrant, case in this regard. The audit reported that "of all 283 municipalities [surveyed]… 83 had no civil engineers, technologists or technicians on their staff [and a] further 48 employed only one civil technician each" (Bisseker, 2012). The SAICE Chief Executive additionally blamed national government's policy of cadre deployment for allowing unqualified people to fill technical positions (*ibid*.). Cadre deployment was the ruling party's

policy of installing ANC-connected (and supposedly loyal) in key government positions, which had become inextricably linked to BEE.

Two of the other main causes of municipal protests were poor responsiveness to citizens' grievances by government officials, and "the conspicuous consumption entailed by a culture of self-enrichment on the part of municipal councillors and staff" (Atkinson, 2007: 53). Many analysts argued that this culture of self-enrichment was inextricably tied with high levels of corruption: according to a survey of government officials in the Eastern Cape (conducted by an NGO, the Public Service Accountability Monitor), 29 percent of surveyed officials said they had witnessed the theft of public resources by government officials, whilst 23 percent said that 'all' or 'most' of their fellow government officials in the province were involved in corruption (Allen, Mattes, & Millie, 2005). Lastly, even the ruling party acknowledged the role of political factions within protests. The ANC Secretary-General (Kgalema Motlanthe) noted in an internal report to the National General Council that "with most, if not all of these protests, it has been members of the ANC that have played a leading role in establishing parallel structures outside the [ANC] movement, including in the form of 'concerned residents' groups" (Motlanthe, 2005). The internal divisions in the ANC featured heavily in the run-up to the ANC's 52nd National Conference, held in Polokwane in December 2007. For the first time in the ANC's history, there was open-campaigning in the style of an American presidential election, in which a faction led by Jacob Zuma challenged the incumbent ANC leadership led by the current ANC president, and president of South Africa at the time, Thabo Mbeki.[27] By 2008, contestations between varying party-political interests were evident in all three spheres of South African government. In the SRVM, the combination of factionalism in the municipal council and (mis)management in the municipal administration continued to plague the SRVM until the municipality declared bankruptcy and was placed under provincial administration in 2010.

4.6.3 Implications for water and local government

The initiation and immediate assumption of service delivery responsibilities by local government were introduced in this period, along with the transformation of irrigation boards into water user associations. Whilst the conversion of the SRIB into the L-WUA resulting in the organisation continuing with its primary role of bulk water provision to commercial farmers, municipal water services were now provided across a wider geographical area and as one of a broad array of services that included electricity provision, refuse collection,

community and health services, and local economic development. These services were provided in a context of endemic skills shortages in the public sector and a political environment characterised by factionalism and power-plays. The cumulative effect of these dynamics on local water service provision in the SRVM is explored in the sixth, and final, period of this historical analysis.

4.7 Period 6: Municipal challenges and the 'turnaround' of the Sundays River Valley Municipality (2009 – 2011)

4.7.1 Overview of period 6

Period 6 contains the greatest degree of 'local level' events in the historical narrative in this chapter: from the low point of financial mismanagement that led to the SRVM filing for bankruptcy and being placed under provincial administration, through to the various 'turnaround' processes, programmes and projects up until October 2011. This period can also be characterised by continuing developments within the Department of Water Affairs (DWA), and increasing recognition within national government departments of the dysfunction in local government.

4.7.2 Historical narrative for period 6

The SRVM was beset by financial troubles and controversy from the very beginning of 2009. In March, the council voted to suspend the SRVM municipal manager on charges of gross misconduct and mismanagement (Masondo, 2009b). Service delivery had continued to decline over the time of the municipal manager's contract.[28] The pervasive financial issues in the municipality were acknowledged when the municipal council approved the first 'financial recovery plan' for the SRVM in June 2009. The requirement to improve municipal functioning was becoming increasingly pressing, with five violent service delivery protests between April to June (Masondo, 2009b). The protests continued into July, when they also became more heavily politicized: after the SRVM council officially dismissed its municipal manager in July 2009, all municipal buildings in the main town of Kirkwood had to be closed, with all "staff told to go home because of fears of violence" (Masondo, 2009b).

In the following months, the municipal council and administration were involved in numerous scandals, including a service delivery protest over the slow roll-out of a housing project turned violent when "about 500 disgruntled residents barricaded roads with burning tyres and set alight a councillor's office" (Ndoni, 2009b). The ANC regional secretariat

intervened in the SRVM in October 2009, demanding that the municipal council reinstate the dismissed municipal manager. When the SRVM major refused, the ANC regional secretariat demanded that she step down.[29] During this time, municipal administration ground to a complete halt as municipal offices were forced to close again. Resident groups in the SRVM and the majority of the SRVM council supported the dismissal of the municipal manager, in opposition to the ANC regional secretariat, and so the impasse was moved to the Port Elizabeth High Court. The infighting between the provincial ANC authorities and the municipal ANC councillors gained the attention of national government: the deputy-minister of the Department of Cooperative Governance and Traditional Affairs (CoGTA) – the national department in which local government is situated – admitted that his department was concerned that "tensions in the ANC often lead to tensions in municipalities" (de Kock, 2009a). The deputy minister announced that an overhaul of local government was underway.[30] Two months later, CoGTA released its Local Government Turnaround Strategy (LGTAS), with the acknowledgement that local government "is a sector that is perceived to be incompetent, disorganised and riddled with corruption and maladministration" (Siddle & Koelble, 2012: 9).

In the last quarter of 2009, the monthly municipal income was around R 2.5 million, but monthly expenses were around R4 million (de Kock, 2009b), telephone connections to the municipality had been suspended by the state telecommunications company (Telkom), and the municipality's electrical contractor refusing to carry out repairs to the grid due to non-payment (The Herald, 2009). There were also numerous water crises in this period, with the Moses Mabida township in Kirkwood frequently without water for days at a time (Ndoni, 2009a). A forensic audit of SRVM's finances found that the municipality was 'rife with corruption' – the audit revealed that 59 municipal employees (around 20 percent of SRVM's employees) were registered as 'suppliers' on the municipal database, leading to extensive conflict of interest. The most serious financial misconduct, however, was the use of R9 million grant funding from the Department of Water Affairs to cover municipal operational expenses, instead of being spent on the intended bulk water infrastructure project between Addo and Paterson (Masondo, 2009a). In short, the SRVM in this period illustrated why local government was (and still is) perceived to be 'incompetent, disorganised and riddled with corruption and maladministration'.

In January 2010, the Port Elizabeth High Court ruled that the municipal manager's reinstatement by regional ANC authorities was improper, allowing the SRVM to dismiss the manager for the second, and final, time. Immediately afterwards, the municipality was placed under 'provincial administration' (Ndoni, 2010).[31] The administrator appointed to oversee the municipal 'turnaround' process later commented that at the time of her appointment, the SRVM "was technically insolvent with only R24 in the bank… service delivery was at rock bottom, credit control weak and staff was demoralised" (Miti, 2012).[32]

Despite the level of disorganisation and dysfunction that the now-dismissed municipal manager left the SRVM in, he was promoted by ANC provincial authorities, leading the Shadow Deputy Minister of CoGTA (James Lorimer) to later address parliament using the dismissed municipal manager's promotion as the quintessential example of the perverse harm of the ANC's policy of cadre deployment: Lorimer recounted to parliament how after being dismissed from the SRVM on multiple charges of financial misconduct, this individual was appointed by the Eastern Cape provincial government to head a programme to improve municipalities' financial management (called 'Operation Clean Audit'), following which he was appointed as acting Municipal Manager, and later Municipal Manager, in several Eastern Cape municipalities (Lorimer, 2011).

One adjustment to the policy of cadre deployment did occur in mid-2011, contained in the *Municipal Systems Amendment Act* (RSA, 2011b). The amendments prohibited managers from holding senior positions in political parties whilst in municipal employment, and also stipulated that senior management positions in local government could only be filled by individuals with the adequate qualifications and experience. The SRVM, however, remained without a technical director for the remainder of 2011. A new municipal council began work in the SRVM in May 2011, following the local government elections that month. New municipal boundaries were also proclaimed, which once again extended the SRVM's required service area. The municipal boundary was now extended to incorporate the district management areas that were previously serviced by the Cacadu District Municipality (see the municipal boundary map in Figure 5.6).

The provincially-appointed municipal administrator remained in the SRVM until December 2011. She instituted a broad range of programmes during her tenure. Some of the service delivery-related attempts at improving water supply included the regional water board in the

Eastern Cape (Amatola Water) becoming implementing agent for the Paterson bulk water scheme (Amatola Water, 2010). Amatola Water was also contracted to submit a strategy to assist the SRVM in its capacity as the area's water service authority. The strategy took the form of a 'support proposal', and was accepted by the SRVM council in December 2010 (Amatola Water, 2011a). This support proposal represented part of Amatola Water's expansion over this same period, in line with the organisation's mandate to support the water service function of local government.[33] The requirement to support municipalities had become increasingly urgent given the apparent lack of capacity in many municipalities to adequately provide water services. DWA needed to balance between providing support, and acting as national regulator. One of the ways that this was done was through incentive-based regulations, which strove to use rewards and penalties to publically recognise the performance of water service authorities. The Blue and Green Drop certification programmes (regulating drinking water and wastewater respectively) were the key programmes of these incentive-based regulations: the first assessments were conducted nationally in 2009, with the first assessments in the SRVM undertaken in 2010. In these assessments, the SRVM scored 35.5 percent for Blue Drop, and 5.6 percent for Green Drop (DWA, 2011a, 2011b). In municipalities that performed particularly poorly, DWA instituted a further measure in the form of emergency 'rapid response units' (RRU) (DWA, 2011b). The SRVM was one of six municipalities in the Eastern Cape selected for the RRU intervention on the basis of its Green Drop score of 5.6 percent, with the first meetings between the RRU and SRVM officials occurring in September 2011.

In this same period, DWA also acknowledged the limited transformation that had occurred within water user associations (WUA) in South Africa. In terms of irrigation boards, this transformation is required to demonstrate how the organisation differs to the way in which it functioned in the colonial and apartheid eras. In 2011, DWA funded a project entitled 'Development of business plans for water user associations', which aimed to support further transformation within WUAs.[34] Seven organisations in the Eastern Cape (including the L-WUA) were selected to participate. For the L-WUA, the intention of the project was to explore the substantive transformation of the WUA's operations, rather than only focusing on transformation in terms of the demographic composition of the organisations' management committees and boards. The project was initiated in September 2011, in the same month that the RRU intervention in the SRVM began, and the same month that the provincial

administrator in the SRVM publically proclaimed that the SRVM was "on the mend" (de Kock, 2011).

4.7.3 Implications for water and local government

This period contextualised the SRVM being placed under provincial administration within the increasing recognition of local government dysfunction and the failures of decentralisation, both within national government departments and by South African citizens more broadly. These recognitions acknowledged that legislated institutional reform for the management and governance of local water authorities had failed to materialise in transformed operations. Although the SRVM was proclaimed to be 'on the mend' in late-2011, the municipal 'turnaround' was still in its earliest stages when the SANPAD project began its action research process in October 2011: the municipal council was still in its first six months of operating; many interventions – including the RRU – were just beginning; the municipality remained under provincial administration, and it continued to face multiple service delivery challenges.

4.8 Discussion

The following discussion distils some of the common themes in this historical analysis, and provides an overarching analysis that is taken forward into the following chapters.

4.8.1 Overview

The results of the 2011 national census portray the SRVM as an area with decreasing unemployment, an increasing number of households, and a greater number of households with piped water and flush toilets (see Table C.7 for a comparison of 2011 and 2001 census results for the SRVM). The improved results demonstrate an upward trend that is indicative of the improving socio-economic situation in SA on the whole. South Africa's achievements between 1990 and 2011 include a political settlement that avoided civil war and resulted in a functioning democracy, and the development of an inclusive constitution that places progressive duties on the state to provide (amongst other things) a social grant system that is a safety net for many of SA's poorest citizens, in addition to a comprehensive 'social wage' package that has seen overall access to water, electricity and sanitation greatly improve. Between the 1980s and 1990s, state services were expanded from prioritising services to four million people, to attempting to provide services for over 44 million people. Yet these

achievements have to be balanced alongside another reality, which Justice Edwin Cameron of the Constitutional Court recently characterised as including

> … [a] race rhetoric that often substitutes for performance… institutional decay and infrastructural disintegration that have reached dismaying proportions, [and] the shameless looting of our public assets by many politicians and government officials (cited in Leon, 2013).

Many observers of contemporary SA remark on the confusing dualities that co-exist in the country, recently described by a prominent apartheid-era journalist as follows:

> If South Africa does not leave you full of ambivalence you have not been paying attention. It is a country where the ruling alliance includes the Communist Party, but the real economic power is capitalist; where corruption is rampant but a vigorous press reports it; where the constitutional court legalised gay marriage and lesbians are gang raped; where the [shopping] malls are populated by a multiracial consumer class, and millions live in shacks. It is inspiring and dispiriting (Keller, 2013).[35]

As this historical analysis of the LSRV has shown, local government is a reflection of the broader South African context described by Cameron and Keller above. Derek Powell, who was Deputy Director-General and head of the Governance, Policy, and Research Division of the Department for Provincial and Local Government (DPLG) until 2009, characterises local government as a sector in which

> … peaceful electoral competition [coexists] with violent public protests, racial group areas endure in fact, even if not in law, pockets of good governance survive amidst systemic corruption and mismanagement, and national policy goals consistently exceed local government's capacity to deliver them (Powell, 2012: 11).

Some political analysts point toward service delivery protests and other manifestations of discontent as being less about poverty (understood as 'a lack of means'), and more about the "seething sense of injustice" that is fuelled by the "glaring disparities that assault people day in and out" (Marais, 2011: 4). SA continues to have one of the highest inequality rates in the world, ranking on the Gini index as the most unequal country in the world in 2006 and 2009.[36] As of 2009, the top decile of the South African population accounted for "58% of income, while the bottom decile accounted for 0.5% and the bottom half less than 8%" (World Bank, 2014b: 1). The Gini index portrays South Africa as being a more unequal place than it was during apartheid. There remains an unavoidable racial dimension to this inequality, given that the majority of poor South Africans are still black, whilst the majority of wealthy South Africans are still white. The fact that a racial dimension remains prominent is understandable given the 340 years of colonial and apartheid history, during which time

economic development was actively promoted and state-supported for white populations, whilst actively suppressed for all non-white populations. Race relations in SA have always been an indivisible political and economic issue, which can be further illustrated by discussing two inter-related aspects of the LSRV case: the first aspect pertains to urban development, whilst the second aspect pertains to rural development of the commercial farming sector.

4.8.2 Urban development in the Lower Sundays River Valley

The small towns in the LSRV developed along different trajectories: some, like Addo, started as the township of an irrigation settlement; others, like Enon, centred around missions stations (or were founded by mission converts, as in the case of Bersheba). The development of Kirkwood as the LSRV's urban centre might have occurred in fits and starts, but it has always acted as a bridge between rural and urban aspects of the LSRV (Grant, 1993). Kirkwood residents have historically relied on agriculture for employment, either directly or indirectly, with many of the poorer residents labourers on farms. As discussed in periods 2 and 3 of this chapter, black residents of urban areas were subjected to an increasingly tight series of labour regulations and urban control in the twentieth century. Reasons for this included that the apartheid government vacillated between fearing that there were too few black labourers on commercial farms in 1948, and then fearing that there were too many black labourers and too few white farmers in rural areas by 1960. Control measures used by the apartheid state included the pass system, and forced relocations (evident in the LSRV with the black spot clearance policies affecting Bersheba, and the relocation of residents from Kirkwood settlements to Bontrug). The removals and the supposed temporary existence of black populations in urban areas also facilitated an unequal development of water provision infrastructure, sometimes even in neighbouring communities. For example, as a designated coloured area, Enon had basic water infrastructure laid in the 1970s, whilst the neighbouring (black) community of Bersheba, did not (Japha, 1996). Such differentiation was legally defensible through apartheid legislation (and particularly the *Group Areas Act* of 1950). As discussed in period 4 and 5, this legislation reserved the majority of municipal revenue for white areas (in the LSRV, predominantly the town of Kirkwood). Seen in this light, it is understandable why housing continues to be such a sensitive and contentious issue in the LSRV and throughout South Africa more broadly (including being at the centre of many service delivery protests).

4.8.3 Rural development in the Lower Sundays River Valley

From a rural development perspective, this chapter has also provided an overview of how the largely impoverished black population in the LSRV developed. Many historians have argued that what ended the 'black peasant road to capitalism' was a combination of three factors: growing market competition against heavily subsidised white farmer's products; erosion of resource rights; and degrading tenancy arrangements on white-owned farms (see Terreblanche, 2002). As discussed in periods 2 and 3 of this chapter, the 'native problem' was not just about the black population outnumbering the white population in South Africa: it was also about the danger of an open market that would bring the black population into competition with the white. At the beginning of the Union of South Africa, the London-based publication *South Africa Today*, described the problem as follows: "Certainly the native does compete 'unfairly' with the European; his needs are so much smaller. ... if there were no outcry from the whites he would be employed, because of his cheapness" (Hamilton Fyfe, 1911). At the local scale, the historical legacy is further complicated by the fact that it is not possible to say that all commercial farming families in the LSRV took land 'by the barrel of a gun'. Many of the citrus farming families began with young British emigrants arriving in the 1920s, who invested their livelihoods in Fitzpatrick's Cape Sundays River Settlement Company (Connor, 2007; Meiring, 1959; Miller, n.d.). As Lavin (2005) illustrates, before state support became the norm in the mid-1920s, there was significant private investment and personal risk involved in these schemes. Three generations on, the surviving families are some of the biggest citrus farmers (and largest employers) in the region. Yet the fact remains that this land could only be settled in the first place as a result of the wars of dispossession and the promulgation of racist legislation (outlined in periods 1, 2 and 3 of this chapter). In sum, the complexity of land settlement patterns and resource ownership can partly be attributed to the institutional context that developed in the colonial era and was furthered during apartheid, which allowed for the entrepreneurial ambitions of a specific demographic to be advanced, predominantly to the exclusion of other groups.

4.8.4 Technological innovations

This chapter has also described how a number of technological innovations have been central to the development of the area. The low yield of the Sunday's River catchment was a primary constraint on irrigation development in the LSRV, and remained so until water could be transported to the LSRV from the Orange River, via the Orange-Fish-Sundays Inter-basin Transfer scheme. This is one example of where infrastructure supported the growth of a

particular sector (in this case agriculture). Other technological changes in the LSRV allowed for different sectors to develop parallel to one another: as discussed in period 3, the Armstrong fence was the decisive variable in separating farmers from elephants, and in doing so, facilitated the contemporaneous development of the citrus industry and Addo Elephant National Park, which remain the two primary economic drivers in the LSRV today.

The history of the LSRV cannot, however, be described in solely political, economic or technological terms. Following the editors of the Oxford History of South Africa, the central theme of LSRV history (and of South Africa on the whole) is better understood as "interaction between peoples of diverse origins, languages, technologies, ideologies, and social systems, meeting on South African soil" (Wilson & Thompson, 1969: v). In the two earliest periods assessed in this chapter, interactions often took the form of cooperation, competition and conflict over resources, specifically land and livestock. Many of the drivers of these interactions had an international dimension (for example, the global markets for ivory incentivized elephant hunting in the 18th and 19th centuries, whilst the European demand for citrus from the southern hemisphere incentivized farmers to begin citrus development in the LSRV). Similarly, the competition over control of mineral rights in the Witwatersrand region was a factor in the Anglo-Boer war at the turn of the 20th century; the settlement of the LSRV in the 1920s was as much about colonial control as it was about irrigation development; and the global demand for eco-tourism has helped drive the expansion of the AENP between 1980 and today.

4.8.5 Complexity and institutional change

In the analysis of Tainter (2011), complexity develops within societies partly as a response to solving arising problems:

> Confronted with problems, we often respond by developing more complex technologies, establishing new institutions, adding more specialists or bureaucratic levels to an institution, increasing organisation or regulation, or gathering and processing more information (Tainter, 2011: 90).

Hence, the process of addressing one set of problems becomes the genesis of another set of problems (which is one of the characterisations of a 'wicked problems' (as introduced in section 2.6). Following a similar line of argument, Bar-Yam (1997) argues that globally, societies have travelled along a 'complexity transition' from the early development of hierarchies (which enabled coordination of activities and therefore achieved developmental progress), through to the breakdown of hierarchies in favour of networks.

This historical analysis has illustrated how water is now governed and managed within a network in SA, rather than within hierarchical command-and-control structures. Networks place different collaborative governance requirements on all actors, because the governance and management of water within a network creates new dynamics as it attempts to solve current challenges. Since the 1960s, the scale and interrelatedness of problems affecting the water sector have grown (in many cases exponentially): as these problems have grown in scale and interrelatedness, DWA has also changed, with a general migration of water-related skills out of government and into consultancies (Dent, 2012). According to van Koppen and Schreiner (2014: 551),

> Many white male engineers and hydrologists left the department for the private sector, or retired [in this period]. While the influx of new black and female staff met national transformation goals, many of the new staff had little experience in water management. The department became increasingly dependent on consultants for the technical skills required. Continuity was further weakened by high levels of staff turnover and job vacancies, including at the senior level.

A schematic depiction of these twin dynamics is provided in Figure 4.1 below.[37]

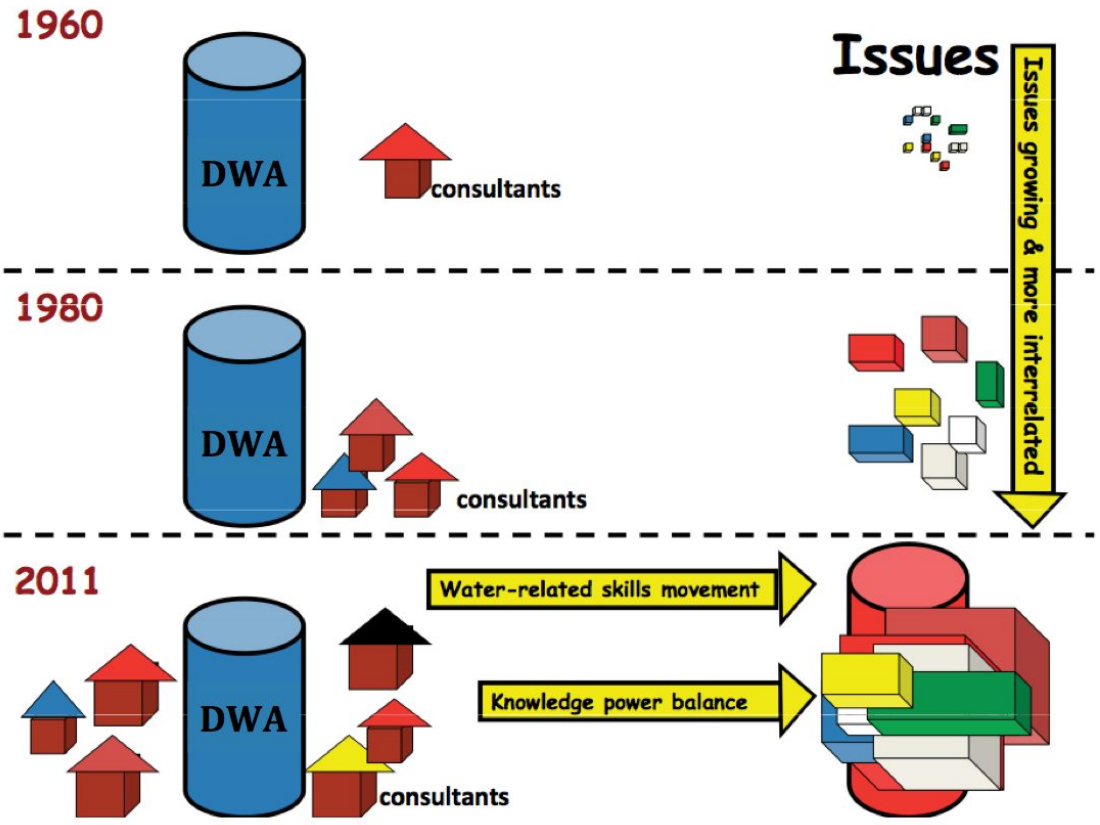

Figure 4.1: Schematic depiction of the migration of water skills and knowledge in South Africa, as affecting the Department of Water Affairs (DWA) between 1960 and 2011. This is depicted alongside a growing number and interrelatedness of issues affecting the water sector in this same period. Source: adapted from Dent (2012).

Lastly, it is often remarked by South African analysts that the governance challenges in the post-apartheid era are markedly different to the apartheid challenges (when a single, obvious issue of segregation and discrimination along racial lines provided something to either fight against, or fight for). In many senses, apartheid South Africa was a bipolar society that was a mirror of the twentieth-century Cold War between the USA and the Soviet Union. The challenges now facing South Africa are broader and more complex. The historian Niall Ferguson (2012) argues that the world is actually a more dangerous place now than it was during the Cold War,

> … when the principal threat to mankind was the calculable risk of a worst-case outcome to a simple two-player game. Today we face more uncertainty than calculable risk. Such is the result of exchanging a bipolar world for a networked one (Ferguson, 2012: 145).

The greater uncertainties in South Africa affect all aspects of local government and water management, and place significant analytical and practical demands on the local water authorities and stakeholders.

4.8.6 Conclusion

To conclude, and to return to the central themes of this historical narrative, this chapter has contextualised the reworking of municipalities into 'developmental local government', and the establishment of world-class water management policy and legislation in post-apartheid South Africa. These changes – many of them at the highest institutional levels within a nation-state – have substantively re-structured the formal institutional domain of South African water governance. However, at the point of the SANPAD project beginning research in the LSRV in October 2011, many water taps in Kirkwood still ran dry on a frequent basis and the SRVM was still under provincial administration: the gap between the reality of water services on the ground, and the ideals of the *National Water Act* and the *Constitution* was painfully evident. The following chapter provides an analysis of this gap in terms of the relevant legislative structures, policy frameworks, physical supply systems, and resource base, in order to further explore the specifics of local water authorities in the LSRV, and the complexity of the attempted 'turnaround' of the SRVM.

Notes for historical analysis:

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[1] The Netherlands States-General had granted sovereign rights to the Dutch East India Company (VOC) to "make treaties, wage war, administer stations, and appoint military and civilian officials" (Katzen, 1969: 185).

[2] In addition to failing to resolve the inadequate water supplies for irrigated agriculture, Kirkwood's scheme was also unable to compete with other investment opportunities in South Africa at the time – including a booming ostrich industry inland from the LSRV in the Karoo region (Miller, n.d.), and the mining boom in the Witwatersrand area up north (Delport, 2002).

[3] The asset list for the 'native population' living on Strathsomer's company landed included 1545 head of cattle, 2066 goats, 182 pigs, 192 dogs, 20 wagons, 52 ploughs, 15 carts, 15 donkeys, 1 horse, and 14 guns (Meiring, 1959: 44). This list demonstrates the relative wealth of the 'native' population of this area of the LSRV, which is noteworthy given the Rinderpest epidemic that swept through Africa in the 1890s (reaching South Africa in February 1896). Rinderpest resulted in the death of over 2.5 million cattle in South Africa in total before being finally eradicated in 1905 (Mack, 1970: 216).

[4] The first census of the Union of South Africa recorded a population of 5 973 394, of which 1.2 million were 'European / White' and 4.6 million were 'other than European or white', with just over 4 million people classified as 'Bantus' (Hobart Houghton & Dagut, 1972: 146).

[5] Vosloo (1974: 32) argues that the economic and educational qualifications on black suffrage were set high enough that they effectively maintained white voting supremacy anyway.

[6] In addition to prohibiting black people from purchasing land within areas classified as 'white', the *Natives Land Act* provided for a fine of £100 or six-month's imprisonment to any farmer convicted of accommodating a native on his farm (Plaatje, 2007: 148). A further consequence of the *Natives Land Act* was the attendant difficulty it placed on Xhosa cattle owners (who were no longer able to graze or even keep their cattle in white areas without being paying exorbitant fees).

[7] It is important to note that the *Irrigation and Conservation of Waters Act* of 1912 was only intended to control water use by the white colonists. As Rowlston (2011: 21) notes in a review of water law in South Africa from 1652 to 1998, the 1912 act paid "no attention, and [made] no provision for, the ways in which the indigeneous populations developed, used, managed and allocated water, controlled its quality or ensured its productive use".

[8] It is worth noting that the belief that South Africa had "need of a more closely settled and larger white population" (Meiring 1959: 62) was shared with the arch-imperialist Cecil John Rhodes (who promoted irrigation development and settled agriculture as a means of spreading British civilisation in Africa). Rhodes helped fund Fitzpatrick's early entrepreneurial ventures " (Lavin, 2005).

[9] The government subsidy for Lake Mentz amounted to over £560 000 (Beinart, 2003: 189).

[10] The Strathmore/Mentone reserve was originally one of the portions of 'Crown land' that had been set aside in 1890 as a forest reserve protected under British law (Beinart, 2003).

[11] The promoter of the *Bantu Education Act* (who was the Minister for Native Affairs at the time) was Hendrik Verwoerd. In a speech to parliament, Verwoerd asked "what was the use of teaching the Bantu child mathematics which it could not use in life?" Verwoerd would later become Prime Minister of South Africa, and become more broadly known as the 'architect of apartheid'.

[12] The 'Commission for the Socio-Economic Development of the Bantu' called for development programmes that aimed to create fully-diversified economies, including development corporations ('charged with the promotion of Bantu enterprises'), and educational, social and welfare services (Union of South Africa, 1955: 207-8).

[13] The Sharpeville massacre occurred when a group of around 10 000 people gathered to protest segregationist policies at a police station in Sharpeville in March 1960. The protests escalated, with the police opening fire on protesters (the vast majority of whom were unarmed).

[14] See Timeline C.7 for a summary of changes to the Department of Water Affairs between 1875 and 2014. These changes are further discussed in sub-section 4.4.3. Note that in this study, the 'Department of Water Affairs' and the acronym 'DWA' is used throughout.

[15] The erratic flow of the Sundays River was a characteristic of the river originating in the Karoo, subjecting downstream areas to flash floods and droughts. The problem of salinity was also a feature of the dry, hot Karoo climate and the geology through which the river traversed, and the attendant evaporation that resulted in a high salt content, which was often unsuitable for irrigation (L-WUA, 2007). A profile of the Sundays River catchment is provided in section 5.2.

[16] The stated benefits of the project included the following: hydroelectric power (chiefly for industrial use); irrigation (aiming to increase agricultural production); supply of water to cities in the Free State province and Eastern Cape region, flood control (World Commission on Dams, 2000).

[17] The concentration of land and capital were also encouraged by state policies aimed at raising per-farm productivity, and a range of market conditions that demanded economies of scale to ensure profitability (Marcus, 1989). The concentration of capital is evident in the decrease in the number of farm units in South Africa, which decreased from 116,800 in 1950 to 75,500 in 1976 (Marcus, 1989: 7). As the number of farms decreased, the relative size of farms increased: the average farm unit size rose in physical terms from 736 ha in 1951, to 978 ha in 1970, and 1134 ha in 1976 (Marcus, 1989: 7).

[18] In the 1980 census, 'urban' was defined as "areas with some or other form of local authority" (Central Statistical Services, 1986: x).

[19] The supporting data (pertaining to income in the Kirkwood magisterial district) is contained in Table C.3 and Table C.4 and is drawn from Central Statistical Services (1986).

[20] The total amount disbursed to local bodies in the Algoa region grew from R651513 in the 1987-1988 financial year, to over R29 million in the 1990-1991 period (Auditor-General of South Africa, 1991). The ten local bodies in the Kirkwood district that were awarded funding between 1987 and 1991 are listed in Table C.6, which demonstrates that the majority of the local bodies were townships in the LSRV.

[21] The recalling of government loans by international banks – including Chase Manhattan – and the passing of the Comprehensive Anti-Apartheid Act by the United States Congress are reported in Giliomee (2012).

[22] (Juta's Statutes Editors, 2010)

[23] This period (period 4) ends without a concluding section on the 'implications for water and local government' because these implications are effectively the focus of the entire period.

[24] The status of the resource-poor farmer irrigation schemes and land reform schemes in the LSRV in the mid-2000s is discussed in sub-section 6.3.5 (with further details in endnote 18).

[25] The 2005 survey by the Department of Provincial and Local Government (DPLG) noted that 81 percent of municipalities reported that they were implementing the FBW policy (Atkinson, 2007). Overall access to water in South Africa improved from 84.9 percent in 2002, to 88.9 percent in 2006 (Statistics South Africa, 2012: 28). Yet a provincial disaggregation provides a more nuanced picture: in the Eastern Cape, access to water supply was recorded as increasing from 56.3 percent to 70.4 percent in this same period (see Figure C.1).

[26] According to Duncan and Valley (2009), a total of 9809 peaceful protests and 954 'unrest related gatherings' were reported nationally between March 2005 and February 2006, which was significantly higher than the 5966 protests reported in the preceding year (Booysen, 2009).

[27] Mbeki had the support of the incumbent cabinet, the majority of the National Executive Committee of the ANC, and several key provinces; Zuma, on the other hand, had gained the support of the leadership of the trade unions and communist party, along with the increasingly-militant ANC Youth League, amongst others (Fikeni, 2009). The result was that at the ANC's national elective conference in December 2007, Mbeki was voted out of power in an overwhelming victory for a new ANC leadership under Zuma. Whilst there were few noticeable policy changes in this power-shift (*ibid*.), the Polokwane conference signalled the division of the ANC into different factions, and left the future of the ruling party's 'Tripartite alliance' (with the communist party and trade unions) on uncertain grounds.

[28] In mid-2009, the municipality reviewed its capacity to perform the Water Service Provider (WSP) functions (in an internal review that is required under Section 78 of the *Municipal Systems Act* of 2000 (SRVM, 2010: 7)) – see point (i) of sub-section 5.5.4. Over this same period, an engineer was deployed to the SRVM as part of the Siyenza Manye programme of the Development Bank of Southern Africa (see sub-section 5.5.5 of the governance analysis).

[29] In October 2009, the ANC regional secretariat intervened to try and reinstate the dismissed municipal manager: as a result of this supposed reinstatement, the municipal manager returned to his office in the SRVM and refused to leave. When the ANC-elected Mayor in the SRVM maintained that the municipal manager had been legally dismissed by the SRVM municipal council, the regional ANC authorities called for the mayor to be removed from her post. The ANC regional secretary Nosisa Siwendu disseminated a letter to Eastern Cape newspapers stating that the "ANC can no longer trust [the SRVM mayor]" as she had acted "against the mandate of the ANC" (de Kock, 2009a).

[30] The overhaul of the local government sector included the compiling of a frank 'State of Local Government' report (CoGTA, 2009b), which informed the 'Local Government Turnaround Strategy' that CoGTA released in December of 2009 (CoGTA, 2009a).

[31] Section 139 of the Constitution allows for provincial intervention in local government when a municipality fails to meet legislative requirements (RSA, 1996). This dramatic intervention allows provincial government to assume responsibility for municipal functions, dissolve the municipal council and appoint an administrator (the latter being the situation in the SRVM between February 2010 and December 2011).

[32] The administrator appointed by the Eastern Cape provincial government – Vuyo Zitumane – had earned the nickname of 'Mrs Fix-It' within government circles, due to her previous successes with other dysfunctional government departments (Miti, 2012).

[33] Amatola Water is introduced as an organisation in sub-section 5.3.5. Given how central Amatola Water was to the action research component of this study, it is discussed in detail in the third thick description (presented in section 6.4 of this study).

[34] The project entitled 'Development of business plans for water user associations' (funded by the Department of Water Affairs) also featured in the action research process, and is discussed in sub-section 5.5.5 (of the governance analysis) and in sub-section 6.3.5, endnote 28 and Box 6.4 in the second thick description.

[35] The apartheid-era journalist quoted here is an American named Bill Keller, who went on to become an executive editor of the New York Times, and has subsequently maintained an interest in South Africa.

[36] The Gini index, where 0 implies perfect equality, and 100 represents perfect equality, is one of the most popular measures of inequality. South Africa's average score between 1993 and 2009 on the

Gini index is 61.9, with South Africa ranking as the most unequal country in the world in 2006 and 2009 (see Table C.8).

[37] In a similar vein to Dent (2012), Mehta et al. (2014) also describe the skills migration problem (from DWA to consultancies), as one of the key challenges facing IWRM in South Africa:

> One of the key challenges in South Africa is the erosion of the knowledge and skills base of the responsible department, namely the Department of Water Affairs, which is 'held captive' by a plethora of consultancy agencies that have monopolized the critical skills necessary to execute routine water management tasks (Mehta et al., 2014: 537).

Chapter 5 Governance Analysis

5.1 Introduction

This chapter provides a water governance analysis of the Lower Sundays River Valley (LSRV), with a functional focus on the bulk water stage of the urban water cycle (for reasons explicated in section 1.3 and 2.2). As outlined in sub-section 2.5.3, this study conceptualises and defines water governance as consisting of the processes and institutions by which decisions that affect water are made, which collectively determine who gets what water, when and how. This chapter is concerned with situating the challenges faced by local water authorities and water users in the LSRV within an understanding of the formal institutional domain that governs water resources and the provision of water services in post-apartheid South Africa. It is only once this has been achieved that the four embedded units of analysis in this case study can be properly explored through the detailed thick descriptions in Chapter 6 of this study

Table 5.1: The three objectives of the water governance analysis in this chapter, with description of how what analytical prerequisites are for each objective and how the objectives are met.

	Objective	Analytical prerequisites	Associated sections
1	Establish understanding of the formal institutional domain for water governance as designed and regulated at the state-level.	1.1. Perform literature review of the laws, policies, strategic frameworks, and norms and standards governing water.	See Table A.3; Table A.4; Table A.5;
		1.2 Employ historically-situated understanding of socio-political context of *national* rule-setting.	Chapter 4
		1.3. Develop normative model for how improved service delivery was aspired to function within developmental local government.	5.5.1
2	Establish understanding of the processes and institutions by which bulk water is governed within the LSRV by the interacting local water authorities, regulators, users and funders.	2.1. Develop and draw on grounded understanding of biophysical and infrastructural context of water in the LSRV.	5.2
		2.2. Analyse primary and secondary data collected between 2011 and 2014 relating to how bulk water is managed in the LSRV.	Data collection: 3.3
		2.3. Employ historically-situated understanding of socio-political context of *local* rule-setting.	Chapter 4
3	Assess governance challenges in the LSRV in terms of the gap between the desired and actual situation.	3.1. Compare outcomes of meeting objectives [1] and [2].	5.5
		3.2. Analyse 'gaps' using normative model developed in sub-section 5.5.1.	Chapter 6; Chapter 7; Chapter 8

5.2 Biophysical and infrastructural context

Bulk water supply is reliant on the availability of water, the health of the associated water resources, and the infrastructural systems that transport water. This section assesses the biophysical and infrastructural context of bulk water supply in the LSRV.

5.2.1 Overview of the Sundays River catchment

The Sundays River originates in the Sneeuberg mountains in the northern part of the Eastern Cape province of South Africa. The 481km-long river flows in a south to south-easterly direction, terminating in Algoa Bay in the region of the Nelson Mandela Bay Municipality (Wooldridge et al., 2008). The Sundays River catchment has three hydrological sub-divisions (or sub-catchments): the Upper Sundays, Middle Sundays, and the Lower Sundays (see Figure 5.1 and Figure 5.2). Darlington Dam (first named Lake Mentz, as described in section 4.3) is located at the bottom of the Middle Sundays sub-catchment. The catchment area of the Sundays River basin is 20990 km^2, and has a bimodal rainfall character with the northern part receiving as much as 1000mm annual rainfall and the southern part around 400mm (Kotsedi, Adams, & Snow, 2012). The southern part of the catchment constitutes the Lower Sundays sub-catchment, which is coded as the N40 Water Management Area (DWAF, 2005). The surface water yield in the Lower Sundays sub-catchment is 14 million m^3/a, whilst groundwater yield is 2 million m^3/a. The local yield in the Lower Sundays is therefore relatively low and, as a result of seasonal fluctuations, highly variable (DWAF, 2005: 46). The lower reaches of the Sundays River have historically registered high levels of Total Dissolved Solids (TDS), which significantly affect the water quality in the Lower Sundays sub-catchment (Forbes & Allanson, 1970). The saline base flows in the Sundays River can be attributed to:

- The flat topography (particular in the semi-arid Karoo where the Sundays River rises);
- The low mean annual runoff and the high evaporation rate (DWAF, 2005); and
- The geological origin of the Sundays River, which results in groundwater (and therefore base flows) with naturally-high levels of TDS (Forbes & Allanson, 1970).

The natural conditions of the lower catchment of the Sundays River have been profoundly altered by the presence of large-scale irrigation both within the LSRV and upstream of it. The single greatest impact on the river system is the quantity of water constantly transferred into the LSRV from the Orange River, which is discussed in the following sub-section.

5.2.2 The Orange-Fish-Sundays inter-basin transfer scheme

The development of the Orange-Fish-Sundays inter-basin transfer scheme (IBT) was introduced in sub-section 4.4.2. The IBT enables water from the Gariep Dam on the Orange River to be transferred to the Great Fish River, via the 83km-long Orange-Fish Tunnel. Water is diverted into a canal at Elandsdrift Dam, which then flows through the Cookhouse Tunnel, discharging into the Little Fish River. Thereafter, water flows a short distance to the De Mistkraal Weir, where water destined for the Lower Sundays is diverted into the Skoenmaker's Canal, ultimately discharging into Darlington Dam (see the map in Figure 5.1 and the diagram in Figure 5.2). A total of 575 million m^3/a is transferred from the Gariep Dam into the Great Fish River catchment, around 75% of which is used for agricultural purposes along the Great and Little Fish Rivers, and for domestic supply to towns in those areas. Of the remaining portion (around 123 million m^3/a) that is predominantly transferred into the Middle Sundays sub-catchment, the majority (around 93%) is released from Darlington Dam into the Lower Sundays (see Table 5.2).

Table 5.2: Transfers to the Middle and Lower Sundays sub-catchments (million m^3/a) in base year 2000, 1:50 year assurance (i.e. 98% assurance of supply) NMBM = Nelson Mandela Bay Municipality. Source: (DWAF, 2005).

Hydro-logical Sub-division	Transfers from upstream	Other transfers in	Total transfers in	Notes on transfers in	Trans-fers out down-stream	Freshen-ing transfers out down-stream	Other trans-fers out	Total trans-fers out	Notes on transfer out
Middle Sundays	5	123	128	From Upper Little Fish	115	0	0	115	To Lower Sundays
Lower Sundays	115	0	115	From Middle Sundays	0	7	11	18	To NMBM and flows to sea

The IBT affects both the flow regime and water quality in the lower reaches of the Sundays River. The discharge from Darlington Dam is regulated, creating an unnatural flow regime and changing the character of water resources in the Lower Sundays (Nel, 2006). The transfers into the Sundays River also reduces, via a dilution effect, the naturally-high levels of salinity in the lower reaches (Pedersen, Madsen, & Skotner, 2007). The subsequent improvement in water quality has been of a particular benefit to commercial farmers in the region since the LSRV started receiving water from the IBT in the 1980s (L-WUA, 2007).

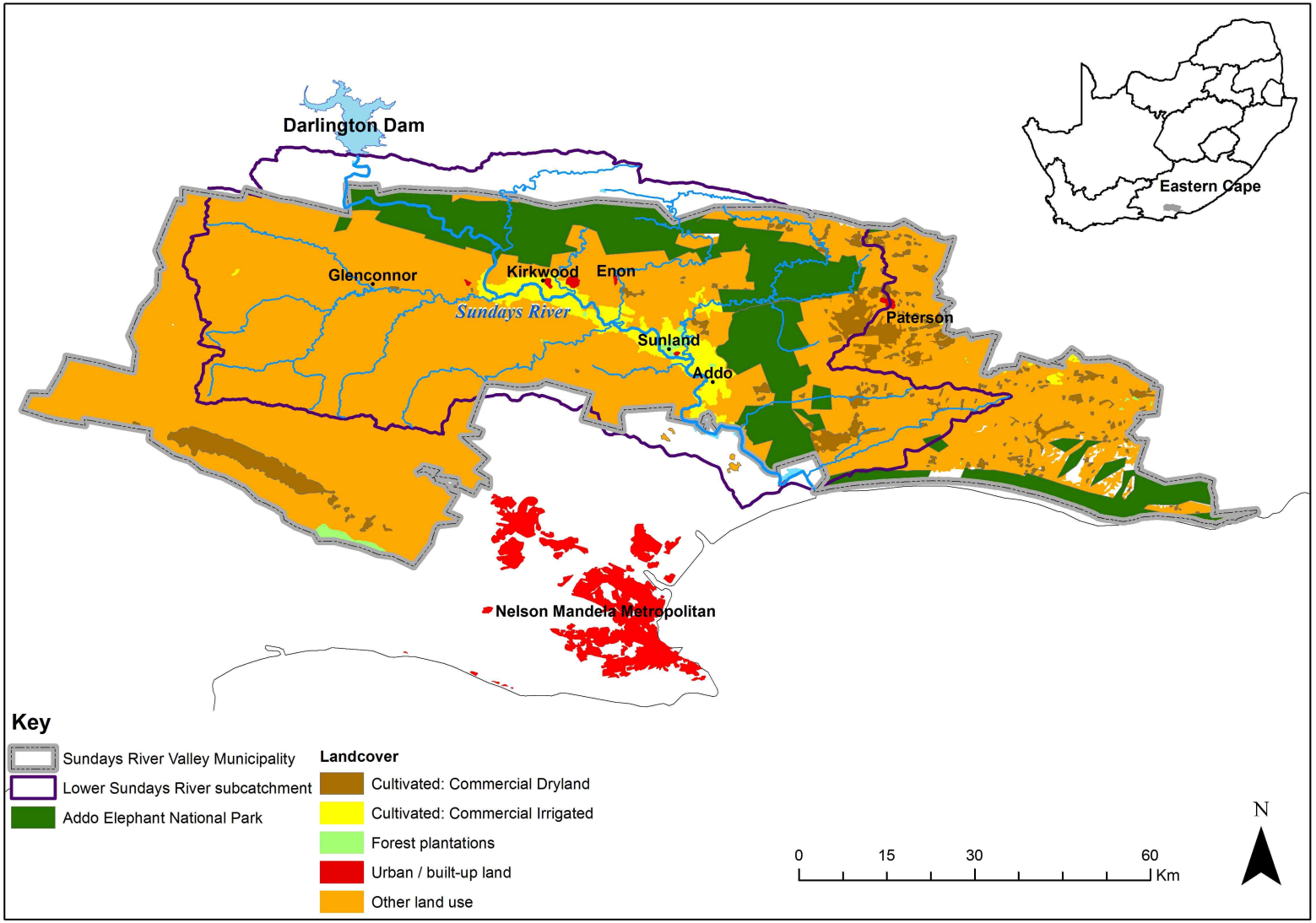


Figure 5.1: Map of the Lower Sundays River Valley, showing the Lower Sundays River subcatchment (N40) in relation to the boundary of the Sundays River Valley Municipality. Primary land uses in the region are listed according to landcover types with the extent of the Addo Elephant National Park visible.

The second National Water Resource Strategy (DWA, 2013b) acknowledges that whilst these irrigation schemes are central to the agricultural economy in the Eastern Cape, there are significant sustainability issues. The strategy states that "irrigating with water transferred from the Orange River has mobilised naturally occurring salts in the soils of the Upper Fish and Sundays catchments" (DWA, 2013a: 14), and warns that additional irrigation should only occur in the lower reaches of the Sundays catchment (in order to minimise further salinisation). In addition to natural catchment salinity, water in the IBT becomes progressively more saline downstream as a result of irrigation return flows (DWAF, 2005: 41-3). The conceptual diagram of the overall water supply system (provided in Figure 5.2 below) includes a simplified schematic of the Orange-Fish-Sundays IBT showing the deterioration of water quality throughout the system.

In summary, the IBT can be characterised by the following:

- The agricultural sector in the Eastern Cape (along the Great Fish and Little Fish rivers and the lower reaches of the Sundays River) has grown reliant on the bulk water transfers from the Orange River that are delivered via the IBT;
- The Nelson Mandela Bay (metropolitan) Municipality has become increasingly reliant on water transfers from the IBT to supply increased potable water demand for urban and industrial development in the area (Algoa WSS: Strategy Steering Committee, 2014);
- The IBT reflects a large investment of national finances from the 1960s onwards;
- The IBT operates across a distance in excess of 300km and in variable conditions of fluctuating water quality.

The above range of factors has incentivized a high degree of technical efficiency in the operating and managing of the IBT (demonstrated by DWA developing a computer model to carefully manage the water quality and quantity: this model was developed and utilised in the 1990s before such modelling became common (L-WUA, 2007)). As illustrated in Figure 5.2, DWA is the managing authority for the IBT up until (and including) Darlington Dam. Once water is released from Darlington Dam, the available water is predominantly diverted into an irrigation scheme, which is described in sub-section 5.2.4 below, after a brief profile of the land use practices and biodiversity in the LSRV.

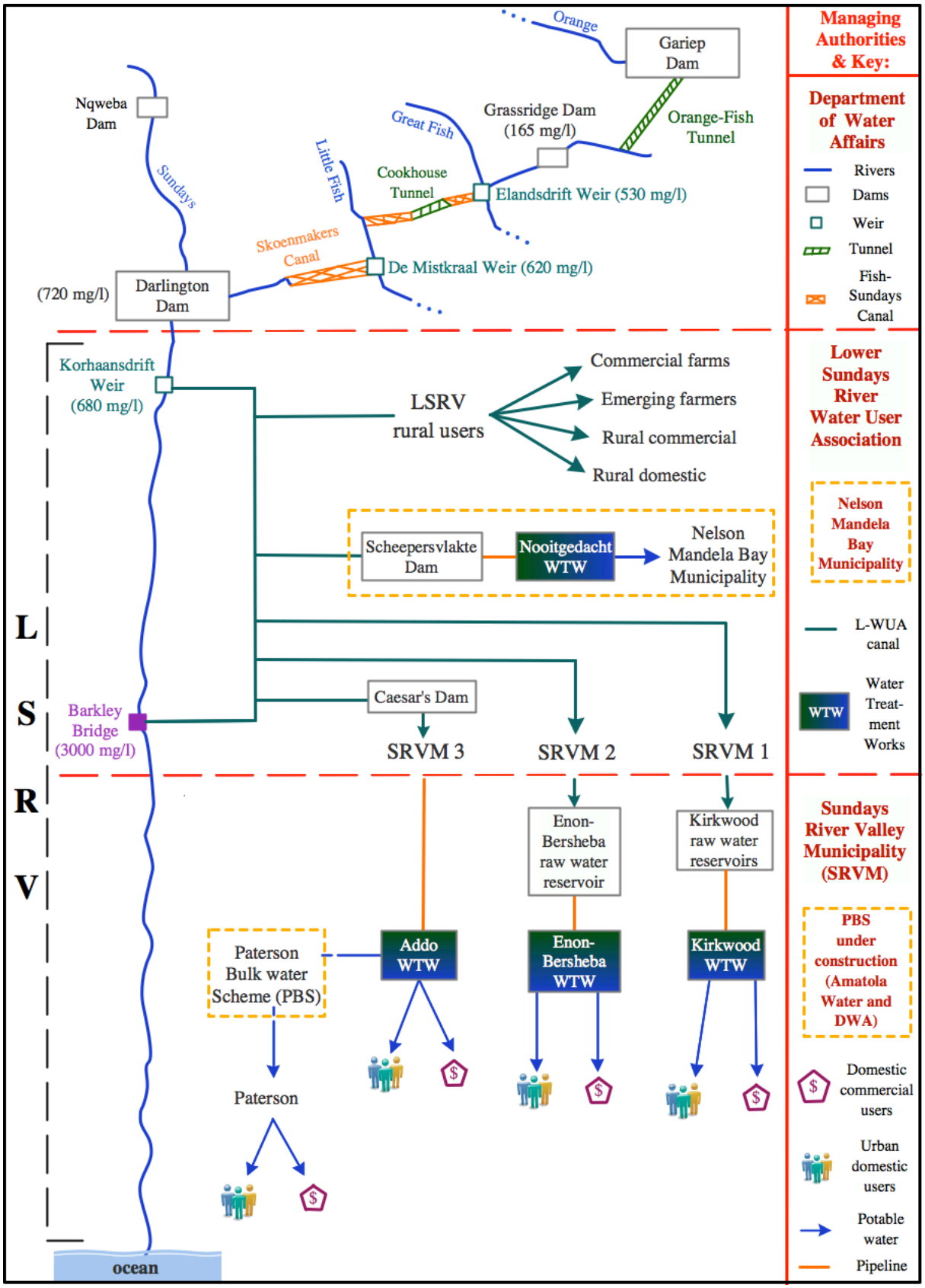


Figure 5.2: Conceptual diagram of overall water supply system from the Gariep Dam to the Lower Sundays River Valley (LSRV) – showing primary users and managing authorities in three parts: the Orange-Fish-Sundays Inter-basin transfer (IBT) scheme; the Lower Sundays River Water User Association's (L-WUA) irrigation scheme; and the three potable water schemes operated by the Sundays River Valley Municipality (SRVM) that receive water from the Orange River. Deteriorating water quality is demonstrated through salinity levels (in mg/l), with data drawn from DWAF (2005: 43).

5.2.3 Land uses and biodiversity in the Lower Sundays River Valley

The primary land uses in the LSRV are agriculture and eco-tourism, with few urban settlements and small towns, and limited industrial activities (Kotsedi et al., 2012) (see Figure 5.1). The citrus industry is one of the two primary economic drivers in the LSRV (as introduced in section 1.2 and Chapter 4) with the second economic driver – eco-tourism – developing more recently around the Addo Elephant National Park (AENP). As of 2012, over 24% of the municipal area is formally recognised as a 'Protected Area' (Vromans et al., 2012: 24). The protected status is a result of conservation importance, tourism opportunities, and biodiversity wealth (given that the LSRV is within the Albany biodiversity 'hotspot', which is part of the Maputaland-Pondoland-Albany area recognised by Conservation International as a global biodiversity hotspot (ibid., 8)).

Whilst there are no estuaries within the boundaries of the SRVM, portions of the Sundays Estuary lie along the western boundary of the municipality. As of 2012, the Sundays Estuary is ranked number 39 (out of 250) for its conservation importance in South Africa (Vromans et al., 2012: 14). Given that estuaries are heavily impacted by upstream land-uses and activities, environmental management of the Sundays Estuary is required *within* the boundaries of the SRVM (to mitigate the effects of soil erosion, siltation, sedimentation and pollution on the estuary). However, little work has been done on the environmental water quality in the Lower Sundays since the IBT became operational (with the exception of Muller, 2013). The vast majority of available water diverted from the Lower Sundays River into the irrigation scheme is managed by the Lower Sundays River Water User Association (as described in following sub-section).

5.2.4 Bulk water management within the Lower Sundays River Valley

The Lower Sundays River Water User Association (L-WUA) manages, maintains and operates the majority of the bulk (raw) water supply infrastructure within the LSRV, including the weirs, balancing dams and canal network. A schematic of the L-WUA's supply system is provided in the middle section of Figure 5.2, and a map is provided in Figure 5.3. The L-WUA operates over 1000 delivery points divided between 112 zones in the Lower Sundays (L-WUA, 2007:3), with a scheduled irrigated area of 16 664 hectares (ha) and a water quota of 9 000 m^3/ha/a (DWAF, 2005: Appendix 10-3). Although the majority of users in the area are commercial irrigators, there are a number of additional users of bulk water, including emerging farmers and rural domestic users (such as farm houses and houses

adjacent to rural commercial users). Citrus pack-houses and juicing factories constitute the primary rural commercial users of water in the area. The L-WUA also acts as the bulk water service provider to two municipalities: the SRVM and the Nelson Mandela Bay (metropolitan) Municipality (NMBM). The map provided in Figure 5.1 demonstrates the comparative size of the urban areas in these two municipalities, which is reflected in the subsequent water demand. In the 2010-2011 year, the volume of water abstracted by the NMBM from the Lower Sundays was over 28 million m^3 (L-WUA, 2012), whilst the SRVM abstracted a comparatively minor volume of 3.6 million m^3 (SRVM, 2010). The institutional aspects of the supply arrangements between the L-WUA and these two municipalities are discussed further in sub-section 5.3.4. With the exception of Nooitgedacht WTW (see the middle section of Figure 5.2), the remainder of the NMBM's water supply system falls outside of the LSRV. The following sub-section therefore focuses on potable water supply within the LSRV, by the SRVM.

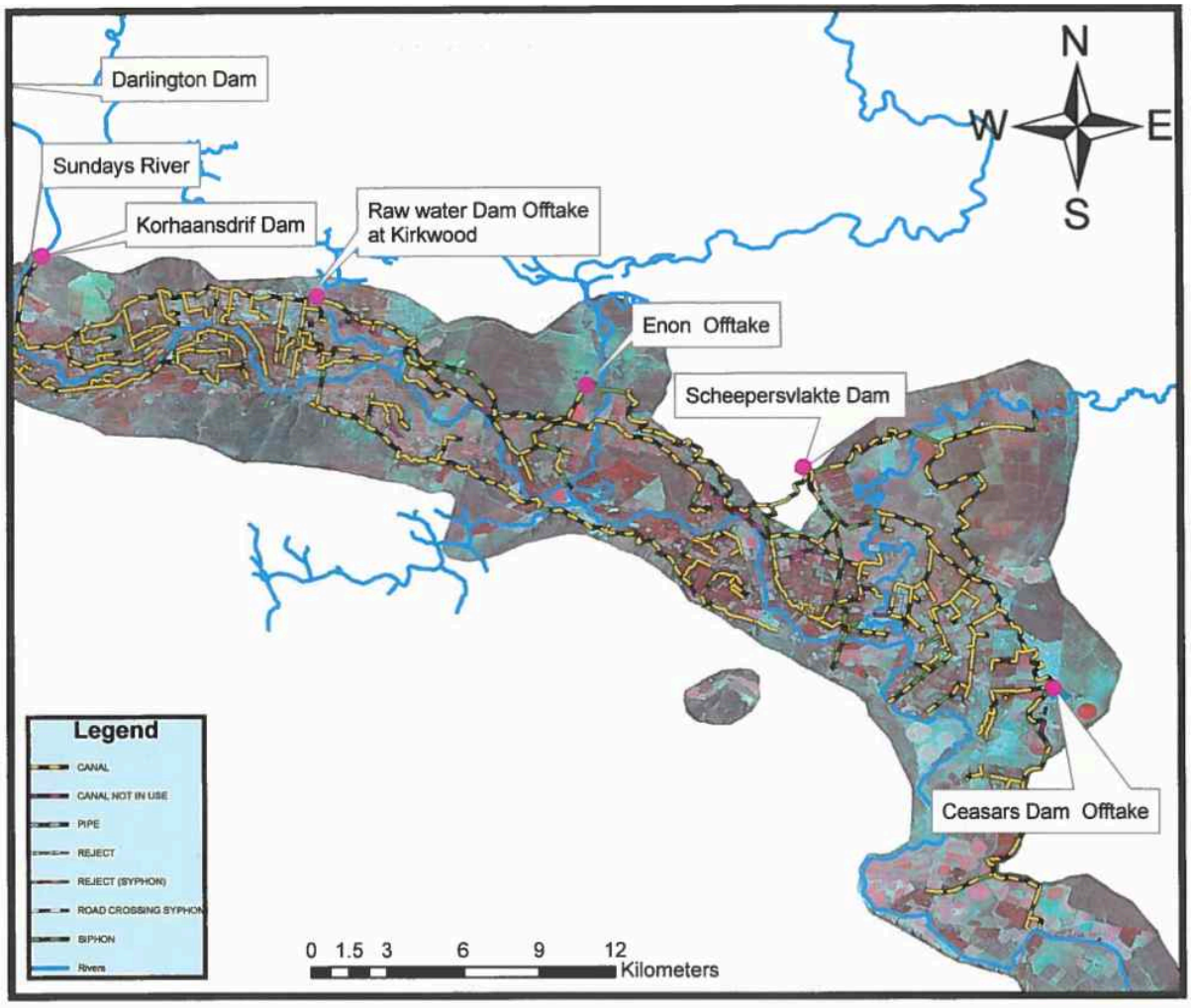


Figure 5.3: Map of the irrigation canal system operated and maintained by the Lower Sundays River Water User Association (L-WUA), with strategic points pertaining to municipal supply demarcated with pink dots and call-out boxes. Source: reproduced from L-WUA (2013).

5.2.5 Water supply within the Sundays River Valley Municipality

The L-WUA delivers water to three of the four primary water supply schemes operated by the SRVM (as summarised in Table 5.3 and diagrammatically represented in the bottom section of Figure 5.2).

Table 5.3: The four water supply schemes operated by the Sundays River Valley Municipality (SRVM), identified by the main town and surrounding communities supplied by each scheme, along with supply sources and average annual abstraction rate (in million m3/a, or mcm/a). Source: adapted from SRVM (2010).

Supply scheme	Communities	Average annual abstraction as of 2010 (mcm/a)	Supply source
Addo	Addo town, Langbos, Molly Blackburn, Noluthando, Nomathamsanqa, and Valencia.	1.123	Orange River, via the Orange-Fish-Sundays transfer scheme and the L-WUA.
Enon / Bersheba	Enon, Bersheba.	0.183	
Kirkwood	Aqua Park, Bersig, Emsengeni, Kirkwood town, Moses Mabida, informal settlement areas.	2.025	
Paterson	Kwazenzele, Moreson, Paterson town.	0.31	Ground water (*Paterson Bulk water scheme under construction*).

The supply schemes at Addo, Enon and Kirkwood abstract raw (i.e. untreated) water directly from the L-WUA's irrigation canals, and then treat this water to a potable (i.e. drinkable) water quality ahead of distributing to communities through the municipal reticulation networks. The fourth water supply scheme operated by the SRVM (Paterson) has historically relied on groundwater as its raw water source: groundwater is abstracted via four boreholes, and treated at a small WTW ahead of distribution to the communities of Kwazenele, Moreson and Paterson town (SRVM, 2010). The combination of increasing domestic demand in Paterson, decreasing abstraction rates and increasing abstraction costs motivated the SRVM and DWA to begin construction of a regional bulk water supply scheme in 2009 (SRVM, 2010). The construction of the Paterson Bulkwater Supply scheme (PBS) has been overseen by Amatola Water, with funding from DWA and the participation of the SRVM. The PBS scheme will connect the Addo WTW with the communities of Paterson (as in Figure 5.2), which will result in the reliance of all communities in both the Addo and Paterson areas on potable water treated at the Addo WTW (and by association, full reliance on raw water abstracted from Caesar's Dam in the L-WUA system).

5.2.6 Summary of biophysical and infrastructural context of bulk water supply in the Lower Sundays River Valley

This section has provided a brief water resource profile of the lower reaches of the Sundays River, and accounted for water availability for agricultural, commercial and domestic use in the LSRV, and by the SRVM. In summary:

1. Water available for anthropogenic use in the LSRV is predominantly transferred into the region via the Orange-Fish-Sundays IBT;
2. The L-WUA is the bulk *raw* water provider within the LSRV, with the SRVM performing the bulk *potable* water function as part of being the (potable) water service provider for the region;
3. Water demand in the LSRV is driven by the commercial agricultural sector, with a comparatively minor demand for raw water from the SRVM;
4. The long-term, heavy irrigation in the Fish and Sundays catchments is exacerbating salinization, with potentially large future impacts on the LSRV irrigation scheme;
5. The management of water supply from the Gariep Dam to the taps of residents in the SRVM occurs within an inter-organisational network consisting of various actors, including the DWA, the L-WUA, and the SRVM, with Amatola Water providing technical support.

To begin moving from management of water to the governance challenges, the following section (5.3) describes the primary institutional arrangements in the South African water sector from the national level to the local level. The institutional arrangements introduced in section 5.3 are then related to local government institutions and processes in section 5.4, in order for the governance challenges in the LSRV to be discussed in section 5.5.

5.3 Primary institutional arrangements

5.3.1 The Constitution

The *Constitution of the Republic of South Africa* (RSA, 1996) is the supreme law in South Africa, and is therefore at the heart of the South African legal system. The preamble of the Constitutions asserts that the Constitution must be used "to improve the quality of life of all citizens" (RSA, 1996: 1243). Regarding water, the Constitution states the following:

- Everyone has the right to have access to sufficient water;
- Everyone has the right to an environment that is not harmful to their health or well-being;
- The environment must be protected for the benefit of all people living now and in the future; and
- National government is the custodian of the sources of water, such as rivers, groundwater and dams (DWAF, n.d.-a: 7).

The Constitution specified three spheres of government (national, provincial, and municipal), legislating that whilst these spheres are independent of one another, they must interact according to the principle of 'cooperative governance'. Whilst national government is the custodian of all water (re)sources, the Constitution devolved to local government the responsibility for ensuring that water services are provided to citizens. The Constitution further prohibits national or provincial government from making laws that impede a municipality's ability to exercise its powers or perform its function (RSA, 1996).

The Constitution chooses unequivocally to make local government the epicentre of development and provides it with a strong institutional status (and independence). Many analysts have critiqued this choice of making local government the epicentre of state-driven development (e.g. de Visser, 2005; Schmidt, 2008), arguing that behind the choice lies an uncritical claim that decentralisation to local government is good for development. More contemporary analysts and commentators argue that there has been a 'failure of decentralisation in South Africa' (e.g. Siddle & Koelble, 2012), with others arguing that widespread implementation challenges (particular in terms of water service delivery) amount to a Constitutional crisis (e.g. Muller, 2014). In order to assess these claims and arguments through a governance analysis of water supply in the LSRV case, we need to account for the primary institutional arrangements in the water sector and then discuss these arrangements in

relation to the local government legislative framework (the former is accounted for in sub-sections 5.4.2 to 5.4.5, with the latter then discussed in sub-section 5.4.6).

5.3.2 Water resources management overview

Having introduced the constitutional context above, this sub-section explores the primary institutional arrangements in the water sector, in order to specifically examine the interactions across and between the two water laws in South Africa, namely, the *National Water Act* of 1998 and the *Water Services Act* of 1997. The primary institutional relationships, as relevant in the LSRV case, are summarised in Figure 5.4.

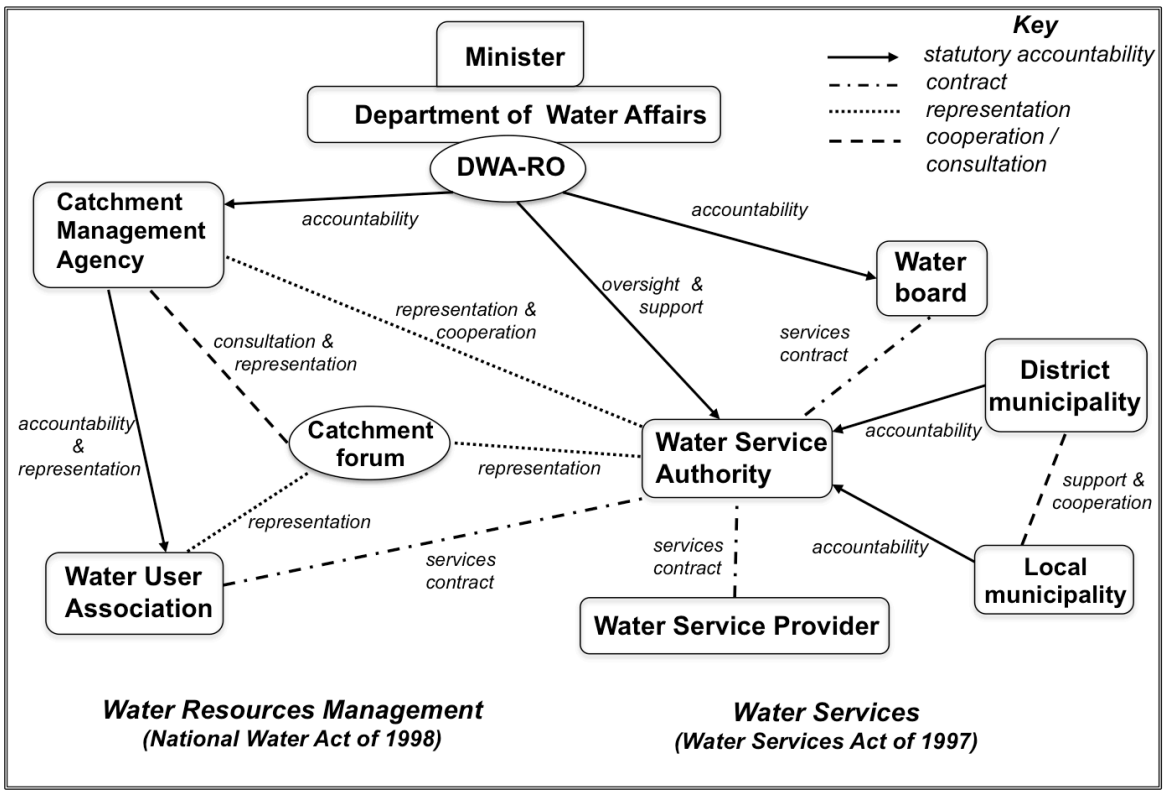


Figure 5.4: Primary institutional arrangements between water sector institutions. The direction of the 'accountability' arrows is from superior to subordinate organisations; DWA-RO = Department of Water Affairs Regional Office. Source: adapted from Pegram and Mazibuko (2003).

As introduced in sub-section 4.5.2, the water sector was one of the first to substantively reimagine itself in relation to the new constitutional dispensation that defined post-apartheid South Africa (Mackay & Ashton, 2004). In 1995, the Minister of Water Affairs (Kader Asmal) initiated a water law reform process, which aspired to change the inequitable distribution of South African water resources in an environmentally sustainable and ecologically-sound manner. The resulting *National Water Act* of 1998 (RSA, 1998a) was written to be consistent with a series of principles that were published out of the water law

reform process (see Box 5.1). The three foundational principles of 'equity', 'efficiency' and 'sustainability' (pithily summarised in the slogan "some, for all, forever" (Rowlston, 2011)) were taken forward and became the underpinning for the *National Water Act* (NWA).

The many changes in the NWA included:

- The decoupling of access to, and ownership of, water and land (eradicating a legal system of ownership of water based on riparian rights, as enshrined in the 1956 *Water Act*);
- Facilitating the management of water resources at the biophysical level of catchments rather than only at institutional boundaries, and
- Establishing a series of resource protection mechanisms.

Crucially, the NWA positions the Minister for Water Affairs and DWA as the national custodians of water resources, tasked with the responsibility of ensuring that water resources are 'protected, used, developed, conserved, managed and controlled for the benefit of all persons': the ordering of this wording was purposefully selected to emphasise that the protection of water resources is a prerequisite for all the others (Rowlston, 2011: 45).

Box 5.1: Summary of select principles from the 'Fundamental Principles and Objectives for a New Water Law for South Africa. Source: RSA (1996b).

> Principle 5: Recognise unity of the water cycle and the interdependence of elements.
>
> Principle 8: The water required to ensure that all people have access to sufficient water shall be reserved.
>
> Principle 10: The water required to meet basic human needs (Principle 8) and the needs of the environment (identified as "The Reserve") enjoys priority of use by right. The use of water for all other purposes is subject to authorisation.
>
> Principle 22: The institutional framework for water management shall as far as possible be simple, pragmatic, and understandable. It shall be self-driven and minimise the necessity for State intervention.
>
> Principle 26: Water services regulation to be consistent with and supportive of the broader local government framework.
>
> Principle 27: Although water service provision is a distinct and separate activity, it should be consistent with the goals of water resource management.

The three means for 'calculating the desired future state of the resource' included:

1. Stipulating the management class;
2. Setting resource quality objectives; and

3. Implementing the reserve (the quantity of water in a river for basic human needs and for protecting ecological functioning at a given quality objective level).

In order to allocate which users got how much water, of what quality and in what time period, a second set of tools were designed to enable DWA to licence and regulate water uses (these licences are, for reasons of scope, not discussed here).

The overall implementation plan for the NWA is supposed to be contained in a 'National Water Resource Strategy' (NWRS): the NWA tasked national government (through DWA) with creating this strategy through a consultative process and revising the strategy every five years. Institutionally, the NWA specified that this strategy must "contain objectives for the establishment of institutions to undertake water resource management… and determine the inter-relationship between [these] institutions" (DWAF, n.d.: 7). The first NWRS (DWAF, 2004) divided South Africa into 19 water management areas (WMA) – which were the regional and catchment areas within which water should be managed – with the intention of establishing a catchment management agency (CMA) in each WMA (De la Harp et al., n.d.). The most local-level institution for water resource management stipulated in the NWA were water user associations (WUA), which are outlined further in sub-section 5.3.4.

As introduced in sub-section 5.3.1, the Constitution established national government as the custodian of all water resources but it devolved to local government the responsibility for ensuring that water services are provided to citizens. Hence, whilst the Reserve legally requires that water is made available for Basic Human Needs ahead of any other allocation, the NWA does not by itself deal with how this water is provided to citizens in the form of water services. The provision of water services, and the interaction between water resource management institutions and water services institutions, is discussed in the following sub-section.

5.3.3 Water services overview

The second water law in South Africa, the *Water Services Act* of 1997 (RSA, 1997), drove the decentralisation of water services from the national to the local (and regional) level: the drive to decentralise water services as far as possible was consistent with the overall decentralisation of water management in post-apartheid SA (which reflected the desire for community participation and stakeholder engagement at all levels of water management decision-making, towards enhancing local-level accountability). The Water Services Act

sought to provide institutional separation between policy-making, regulatory power and service provision roles in the delivery of water services, with the key institutions being water service authorities (WSAs), water service providers (WSPs) and water boards. As Figure 5.4 illustrates, the institutions of WSAs, WSPs, and water boards were collectively designed to progressively assume the responsibility of direct service provision that was previously led by DWA: in short, the Water Services Act envisioned a smaller DWA that would primarily play a regulatory role (DWAF, 2003).

Following the Constitution (RSA, 1996), the Water Services Act specified that local government should be the WSA, with the following primary responsibilities:

- Ensuring access;
- Planning (in particular through the Water Services Development Plan);
- Regulation of water service providers within its area of jurisdiction; and
- Provision (either by regulating an external WSP, or by acting as the WSP itself). (DWAF, 2003: 11-12)

In providing access to water services for all people within the WSA's jurisdiction, Section 11(1) of the Water Services Act specifies a that a WSA's duty is to "progressively ensuring efficient, affordable, economical and sustainable access to water services" (RSA, 1997: 18). Each of these characteristics can be further described as:

- Efficient (well-organised);
- Affordable (reasonably priced);
- Economical (cheap to run); and
- Sustainable (can keep going) (DWAF, 2002b: 28).

The Water Services Act is consistent with the Constitution (RSA, 1996) and the NWA in asserting the following:

> Section 3(1): Everyone has a right of access to basic water supply and basic sanitation;
> Section 3(2): Every water services institution must take reasonable measures to realise these rights; and
> Section 3(3): Every water service authority must, in its water services development plan, provide for measures to realise these rights (RSA, 1997: 10).

Section 5 of the Water Services Act contains one of the most important statutory requirements for water service provision, namely that the provision of basic water supply and basic sanitation are to have preference:

> If the water services provided by a water services institution are unable to meet the requirements of all its existing consumers, it must give preference to the provision of basic water supply and basic sanitation to them (RSA, 1997: 14).

National government set the overall framework detailing the institutional relationship between a WSA and a WSP in the 'Strategic Framework for Water Services' (DWAF, 2003). As the WSA for its area of jurisdiction, local government has the authority to decide whether to act as the WSP themselves, or whether to outsource this role to another agent (DWAF, 2003). Where the WSA chooses to act as the WSP, the Strategic Framework for Water Services required an institutional separation between the provision and regulatory aspects of a municipality's water services. In order to provide criteria to enable self-regulation, the municipality must have a service contract or business plan in place between the WSA and WSP. In cases where an 'external agency' is providing a municipality with raw water, a particular form of service contract should be in place, namely a 'water resource supply contract' (DWAF, 2003: 9). This contract should outline the terms of delivery as well as the roles and responsibilities of the respective actors, specifically as applies to the provision of this water as drinking water.

Figure 5.4 illustrates the desired interaction between water resource management institutions (in the form of CMAs and WUAs) and water services institutions. The desired interaction reflected Principle 27 of the 'Fundamental Principles for a New Water Law' (RSA, 1996b), which aspired for consistency between water services and water resource management (see Box 5.1). Decentralisation in water resource management was therefore designed to support decentralisation in local government, through the coordination of plans and strategies between CMAs and WSAs (DWAF, n.d.:18), and through water services institutions participating in multi-stakeholder forums (such as catchment forums).

In-line with Principle 26 of the 'Fundamental Principles', the Strategic Framework for Water Services was designed to be "consistent with and supportive of the broader local government framework" (see Box 5.1). This broader local government framework was only gazetted between 1998 and 2003: hence, the provision and regulation of water services occurs across and between *both* the water sector *and* local government. The governance arrangements pertaining to the latter are discussed further along with the explication of the local government legislative framework in section 5.4. Before doing so, this section completes an overview of the primary institutional arrangements in the water sector in the following three sub-sections:

Sub-section 5.3.4, which discusses CMAs and WUAs in relation to the LSRV;
Sub-section 5.3.5, which discusses water boards in relation to the SRVM;
Sub-section 5.3.6, which introduces the regulation of the water sector.

5.3.4 Regional and local-level water resource management (catchment management agencies and water user associations)

The progressive decentralization of responsibility and authority for water resource management in post-apartheid South Africa motivated for the creation of appropriate regional and local institutions (DWAF, 2005: 2). The NWA specified that these institutions were to be statutory bodies (i.e. established by government notice). The regional institutions were CMAs that were to be overseen by a governing board appointed by the Minister, with the requirement that all stakeholders (including current and potential user groups), along with these stakeholders' diverse interests, must be represented on the board (DWAF, n.d.-a: 37).

The initial functions of a gazetted CMA include:

- Investigating, advising on, and promoting community participation in, the protection, use, development, conservation, management and control of the water resources in its water management area;
- Developing a catchment management strategy that is consistent with the NWRS; and
- Promoting coordination between implementation of its catchment management strategy with implementation of water services development plans of municipalities.

The NWA stipulates that the Minister can delegate additional functions to CMAs, in addition to the initial functions listed above. These additional functions include "acting as the 'responsible authority' [in the water management area], relating to water use and allocation of water" (DWAF, n.d.-a: 38). In water management areas where CMAs are not yet established, the NWA requires the DWA regional office to continue to perform all catchment management and associated duties.

As of 2012, only two CMAs were operational in SA, with the relevant WMA for the LSRV (the Tsitsikamma to Keiskamma WMA) continuing to be managed by the regional office of the Department of Water Affairs (DWAF, 2004). Between 2012 and 2013, the 19 WMAs in SW were reduced to a total of nine WMAs, which were gazetted with the second NWRS (DWA, 2013b) (the implications of this re-centralisation are discussed in sub-section 5.5.4). Whilst there is no CMA in any of the water management areas in the Eastern Cape province, a

WUA has been active in the Lower Sundays region since 2003, and so is discussed here. Chapter 8 of the NWA introduces WUAs as follows:

> Although water user associations are water management institutions their primary purpose, unlike catchment management agencies, is not water management. They operate at a restricted localised level, and are in effect co-operative associations of individual water users who wish to undertake water-related activities for their mutual benefit (RSA, 1998a: 98).

Like CMAs, a WUA is a statutory body that requires ministerial ratification for the institution to be established. There are two main types of WUAs: single-sector associations, which comprise of a group of similar users (say emerging famers) and therefore act in the interests of those users, and multi-sector associations, which comprised of "a group of different users, for example industry, farming, mining and so on, and act in the interests of the different users" (DWAF, n.d.-a: 39).

The typical functions that a WUA performs are contingent on the particular purpose(s) for which it was established. The following are some of the most important functions of WUA that were identified in the NWA:

- To construct, operate and maintain waterworks for supplying water;
- The protection of and/or prevention of water from any water resources being wasted or contaminated;
- To prevent unlawful water use; and
- To regulate the flow of a watercourse (DWAF, n.d.-a: 39).

The NWA stipulates that membership to a WUA is voluntary and is governed by a constitution, which, once adopted, is binding on all its members (*ibid.,* 34; 32). A Management Committee, or governing board, oversees the functioning of a WUA and appoints staff to manage the day-to-day business and operations of the organisation. The majority of WUAs were former irrigation boards that, like the Sundays River Irrigation Board in the LSRV, had been established and maintained in order to provide water to white commercial farmers in apartheid South Africa (van Koppen, 2008). In order to facilitate the transformation of these irrigation boards into democratic water user associations, the Minister issued guidelines for how irrigation boards should "reform their operational area and management structure to be more representative of the demographics of the area, in terms of race and gender" (DWAF, n.d.-b: 32). The Sundays River Irrigation Board converted into the Lower Sundays River Water User Association (L-WUA) in 2003, five years after the promulgation of the NWA in 1998. Becoming a member of the L-WUA is governed by its

constitution, with a Management Committee appointed to oversee the organisation. The L-WUA's Management Committee is structured in the following way:

- The area served by the L-WUA is divided into sub-districts: the Management Committee consists of a member representing each sub-district (Section 14.1 of Schedule 5 – L-WUA Constitution);
- Representation on the L-WUA's Management Committee is divided between 'elected membership' and 'nominated membership';
- Elected members include the irrigated areas and emerging farmers (the latter are represented by three members on the Management Committee (Section 14.1); with
- Nominated members coming from the additional four sub-districts – and are nominated by the communities or organisations that they are representing (Section 14.10).

As one of the water users in the L-WUA's area of operation, the SRVM is one of the four sub-districts stipulated in Section 14.10 of the L-WUA's constitution. The other three sub-districts are listed in its constitution as being:

1. The Nelson Mandela Bay Municipality,
2. 'Recreation, Tourism and the Environment',
3. 'Development'.

In order to further assess the governance challenges of the water supply arrangement between the L-WUA and the SRVM, it is necessary to first frame municipal water service provision within local government legislation (which is done in section 5.4). The following sub-section continues with its overview of the primary institutional arrangements in the water sector, by introducing the institution of water boards and the relevant water board in the Eastern Cape.

5.3.5 Amatola Water and the institution of 'Water boards'

Water boards are the third major water services institution stipulated in the Water Services Act (see Figure 5.4). Section 29 of the *Water Services Act* defines the 'primary activity of water boards' as being "to provide water services to other water services institutions within its service area" (RSA, 1997). The predominant water service that is provided is bulk water services. The permissable secondary activities of water boards are broadly defined in Section 30 of the Water Services Act as including, but not being limited to, the following:

- Providing management services, training and other support services to water services institutions, in order to promote co-operation in the provision of water services [Section 30(2)(*a*)];
- Providing catchment management services to or on behalf of the responsible authorities [Section 30(2)(*c*)]; and
- Acting as the water services provider to consumers (with the approval of the WSA having jurisdiction in the area) [Section 30(2)(*d*)] (RSA, 1997).

Importantly, the *Water Services Act* only permits water boards to perform activities other than its primary activity if it does not limit the board's capacity to perform its primary activity (for example by 'financially prejudicing' itself). The most relevant water board that features in this study is Amatola Water (AW), which began as a non-profit, national government business enterprise in 1998. The primary business of AW to begin with was bulk water service provision (both potable and untreated water) to municipalities in the Amatole region of the Eastern Cape. By 2008, Amatola's original service area of 11000km^2 had been increased to over 45000km^2 (Amatola Water, 2014a). Organisational revenue increased from R88 million in 2006 to R250 million in 2010 (getnews, 2012), as the organisation began transitioning from a small regional water utility to a large provincial water utility (Amatola Water, 2011a). A central part of the expansion over this period was an increase in AW's secondary business (i.e. outside of bulk water service provision), in line with its stated organizational aim to support local municipalities in the water services sector (Amatola Water, 2014a). Given that the SRVM lies outside of AW's gazetted operational area (see map in Amatola Water (2013)), AW can only provide secondary support to the SRVM. The nature of this secondary support is central to the third thick description (section 6.4).

The final aspect of the primary institutional arrangements in the water sector described in this section pertains to the regulation of the water sector.

5.3.6 The regulation of the water sector

The essential, non-substitutable, variable, and interconnected nature of water (see Savenije, 2002) requires careful regulation for effective water governance. Water regulation in South Africa broadly encompasses the following activities:

- Water use authorisation;
- Drinking water quality and wastewater discharge regulation;
- Infrastructure regulations;

- Regulation of corporate governance;
- Regulation of qualification;
- Regulation of competition; and
- Economic and social regulation (DWA, 2013b: 70).

As the custodian of water resources, DWA currently performs many important regulatory functions (although the second NWRS reaffirmed the vision of the National Water Act that "elements of these regulatory functions will be transferred to CMAs in due course" (DWA, 2013b: 70). A host of other organs of state are involved in the regulation of the water sector (as summarised in Figure C.3).

In terms of water services more specifically, DWA is the national water services regulator and is responsible for regulating the performance and compliance of water service authorities against the 'Compulsory National Standards' (see Box 5.2). The 'Strategic Framework for Water Services' (DWAF, 2003) outlines the process that DWA is expected to follow when a WSA fails to confirm to its legislative requirements.

Box 5.2: Selected 'Compulsory National Standards' for Quality Water Services, as set by Department of Water Affairs and Forestry (DWAF) in 2002. Source: DWAF (2002a).

3. Basic Water Supply:
The minimum standard for basic water supply services is…
(b) a minimum quantity of potable water of 25 litres per person per day or 6 kilolitres per household per month –
(i) at a minimum flow rate of not less than 10 litres per minute;
(ii) within 200 metres of a household; and
(iii) with an effectiveness such that no consumer is without a supply for more than seven full days in a year.

4. Interruption in the Provision of Water Services:
A water services institution must take steps to ensure that where the water services usually provided by or on behalf of that water services institution are interrupted for a period of more than 24 hours…, a consumer has access to alternative water services comprising –
(a) at least 10 litres of potable water per person per day;

10. Water Services Audit:
(1) A water services authority must include a water services audit in its annual report on the implementation of its water services development plan [WSDP] required in terms of section 18(1) of the [Water Services] Act.

16. Reporting Non-Compliance:
A water services institution must have a consumer service to which non-compliance with these regulations can be reported.

The 'Strategic Framework' asserts that when a WSA expresses an intention to comply but is constrained for practical and logistical reasons, then DWA will support the WSA in terms of the policies set-out in Section 8 of the Strategic Framework. If a WSA fails to respond to a request for compliance – yet is deemed to have the necessary capacity to comply – then DWA can use any of the following approaches:

1. 'Name and shame' – in which DWA publicises a WSA's failure to comply in an attempt to use public pressure as an incentive for compliance;
2. Apply financial pressure – in which DWA holds back capital funds (together with National Treasury, DPLG [now CoGTA] and provincial government);
3. If the above two approaches fail to ensure compliance, DWA can intervene directly, including by running the water services of a WSA for a limited period of time. Any intervention of this kind should be coordinated with provincial government and DPLG [now CoGTA]; and
4. Lastly, DWA can initiate legal action to prohibit municipalities from undertaking certain actions or to oblige municipalities to undertake certain actions (*ibid*., 52-3).

Although the Strategic Framework states that DWA will "develop an intervention strategy which conforms to the policies set out in this Strategic Framework and other relevant national policies and legislation" (*ibid*., 2003: 52), no such intervention strategy has been produced.

In the Eastern Cape, water services regulation is overseen by the Directorate for 'Water Regulation & Use' in the DWA-Regional Office. This directorate is composed of four sub-directorates that are overseen by a Director's office. The sub-directorate of 'Water Services Technical Regulation, Compliance and Enforcement' (highlighted in red in Figure 5.5 below) is tasked with the aim of "ensuring technical regulation of water services in the Eastern Cape".

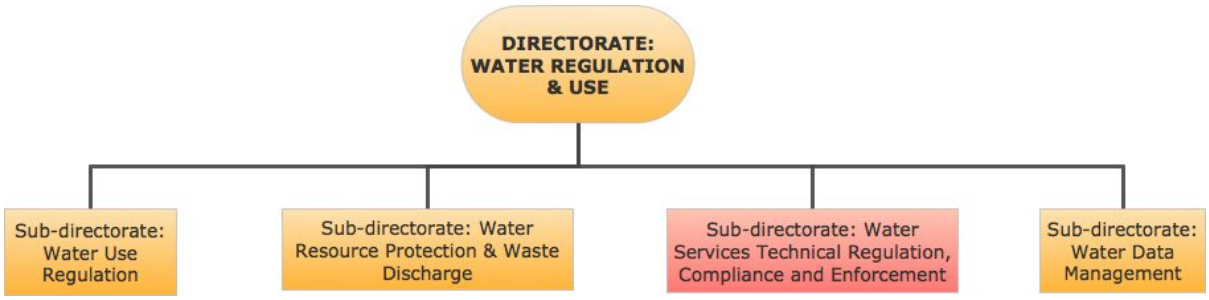


Figure 5.5. Organogram of the Water Regulation & Use Directorate of the Department of Water Affairs Eastern Cape Regional Office in the Eastern Cape (as of July 2012). The sub-directorate highlighted in red is discussed further in sub-section 6.5.1.

The divisions of the 'Water Services Technical Regulation, Compliance and Enforcement' sub-directorate are summarised in a further organogram in Figure 6.3, in a discussion that relates this directorate to regulation of water services in the SRVM (see point (iv) in sub-section 6.5.3).

5.3.7 Summary of primary institutional arrangements in the water sector

This section has provided an overview of the primary institutional arrangements in the water sector beginning with the constitutional context, and then focusing on the interactions across and between the institutions stipulated in the two main water laws in South Africa [Note that the third water law – the Water Research Act (No.34 of 1971) is not examined here, due to its limited influence in the LSRV except through the funding agency established by the act (the Water Research Commission)]. The structure and function of catchment management agencies, water user associations, water boards, water service authorities, and water services providers has been outlined, in relation to the national government departments (specifically DWA). The following section locates the SRVM within the local government legislative framework, and describes the institutional connections to the water sector.

5.4 The Sundays River Valley Municipality within the local government legislative framework

As introduced in sub-section 5.3.1, the responsibility for ensuring water services are provided is constitutionally vested in local government with DWA acting as the custodian for water sources and as the regulator and overseer of all water affairs. The provision and regulation of water services by local government occurs within the broader legislative framework that governs local government. This framework is composed of the following four primary laws:

The Municipal Structures Act (No. 117 of 1998)
The Municipal Demarcation Act (No. 27 of 1998)
The Municipal Systems Act (No. 32 of 2000)
The Municipal Finance Management Act (No. 56 of 2003)

This section locates the governance of water services in the SRVM within the legislative framework composed of the above four laws. Each law is introduced in its own sub-section.

5.4.1 The Municipal Structures Act

The foundational act in the local government legislative framework is the *Municipal Structures Act* (RSA, 1998), which defines the primary decision-making structure in local

government – namely the municipal council – and details the separate powers and functions of the officials who participate in that structure. Registered voters select these officials (called 'councillors') in a mixed system of proportional representation and ward constituency. 'Wards' are the different geographic regions of a municipality – and are represented by ward councillors – with the other half of the councillors proportionally representing the political parties that contested the most recent municipal elections. These elected councillors are distinct from the employed individuals who make-up the administration of a municipality: the division of roles and responsibilities between elected and employed officials is further defined in the *Municipal Systems Act* (RSA, 2000) – discussed in greater detail in a sub-section 5.4.3.

The *Municipal Structures Act* (RSA, 1998) divides local government using the following classificatory framework that was first stipulated in the *Constitution* (RSA, 1996):

Category A: Metropolitans
Category B: Local municipalities
Category C: District municipalities

Between January 2001 (following the first local government election) and May 2011 (before the third local government elections), a total of 283 municipalities existed in South Africa: six metropolitans, 231 local municipalities, and 46 district municipalities (CoGTA, 2009b). The municipal classification framework recognized the heterogeneity of the South African landscape, particularly in relation to the peculiar patterns of segregated development that were introduced in the historical analysis in the preceding chapter. Hence, the *Municipal Structures Act* (RSA, 1998) stipulated that given the size and financial resources of 'Category A' municipalities, they would be the only tier of local government within their area of operation, whilst each 'Category B' municipality would be grouped with an average of another four municipalities into a district. Each district was then placed under the jurisdiction of a 'Category C' municipality, in a nested institutional structure designed to support local municipalities (World Bank, 2009). However, Category B municipalities ranged from cities large enough to be metropolitans to small rural municipalities consisting of several villages. The large variations in budget-size, areas of operation, and levels of service provision in Category B municipalities motivated for further classificatory frameworks being developed in the late-2000s, which are particularly relevant to the SRVM case.

The first major classification of municipalities was by the Department of Cooperative Governance and Traditional Affairs (CoGTA), which is the national government department

that is responsible for overseeing the local government sector. In its 2009 'State of Local Government' report (CoGTA, 2009b), CoGTA posited a classificatory framework based on three indices – functionality, socio-economic profile, and the backlog of basic services – defined in order "to inform a differentiated approach to the management and governance of our municipalities across the rural and urban landscape of the country" (CoGTA, 2009b: 76). The 2009 assessment focused on the 231 local municipalities and ranked these Category B municipalities into the following four classes:

Class 1: Most vulnerable
Class 2: Second most vulnerable
Class 3: Second highest performing
Class 4: Highest performing

A second classificatory framework (also published in 2009) was developed as part of the 'Municipal Infrastructure Investment Framework' (World Bank, 2009), but has subsequently been widely utilised by government departments and agencies (as discussed in CoGTA, 2009a; Municipal Demarcation Board, 2013). In developing the Municipal Infrastructure Investment Framework (MIIF), the participating actors (including the World Bank, the Development Bank of Southern Africa, and several government departments) acknowledged that different investment strategies were required for different categories of municipality. The designers of the MIIF therefore divided municipalities into seven categories, ranging from Category A, Category B1 to B4, and C1 and C2 (these categories are detailed in Table C.9 in Appendix C). Table 5.4 summarises the SRVM's position in relation to the three municipal classification frameworks introduced above. Before assessing whether the SRVM fits within these categorisations, it is useful to summarise some of the generic challenges that municipalities within the categorisation as the SRVM supposedly face.

According to CoGTA (2009b), typical socio-economic challenges faced by Category B3 and Class 2 municipalities include:

- Low-levels of economic development within the municipality and associated high-levels of unemployment and poverty faced by municipal residents;
- Commercial farming sectors are characterised by an in-migration of farm labourers and seasonal employment, but otherwise have a typically stable (or declining) population.

Generic management challenges faced by Category B3 municipalities include:

- Difficulty with attracting and retaining skilled managers, professionals and technicians (CoGTA, 2009b: 22) – particularly in remote areas with "inadequate housing, schooling, and networking opportunities" (World Bank, 2009: 30); and
- A sufficiently-high population density within small towns to warrant technical solutions (in the form of piped water and water-borne sanitation), but inadequate revenue generation to independently support the provision of these services (i.e. the minority rate-paying population cannot effectively cross-subsidise the majority poor population).

The implication of the challenges listed above is that most category B3 municipalities are vulnerable: they provide many free basic services to a largely-impoverished population and, to do so, these municipalities are reliant on national government for grants and subsidies. The following sub-section assesses whether the SRVM fits within the categorisations in Table 5.4, and relates the SRVM to the generic challenges introduced above.

Table 5.4: Summary of the Sundays River Valley Municipality's (SRVM) position in three municipal classification frameworks, with brief description of each framework, the number of municipalities in the same category of the SRVM, and description of category.

Categorisation	Date	Description	Categorisation of the SRVM	No. in category	Description and characteristics of category
Municipal Structures Act	1998	Division of local government into Categories A, B, and C municipalities	B	231	Local municipality (LM) – 1 of 9 LMs grouped under the Cacadu District Municipality
Department of Cooperative Governance and Traditional Affairs (CoGTA) vulnerability-performance classification	2009	Four-part municipal classification developed by CoGTA, based on functionality, socio-economic profile and basic services backlog	Class 2	58	Second-most vulnerable category of municipality. Characteristics of commercial farming areas; small service towns; low population densities
Municipal Infrastructure Investment Framework	2009	Seven-part municipal classification developed to support differentiated infrastructure investment strategies.	Category B3	111	LMs with relatively small and primarily-urban population; no single large town as core urban settlement; rural areas are characterised by commercial farms

The map provided in Figure 5.1 offer a suitable starting point for assessing whether the SRVM is an archetypal category B3 municipality. The following characteristics are evident:

- Whilst the overall population density in the SRVM is low, the majority of the population resides in small towns;
- These towns are longitudinally spread across the SRVM's territory;
- The towns have a sufficiently high population density to warrant technical supply solutions (in the form of piped water and water-borne sanitation);
- A significant proportion of the rural areas are dominated by commercial farming, with the riparian zones of the Sundays River mostly occupied by commercial irrigated farming; and
- The second primary land-use is conservation and eco-tourism, dominated by the Addo Elephant National Park (AENP).

As introduced in sub-section 4.6.2, the AENP expanded ten times in size between 1980 and 2012. The majority of the expanded territory was converted from cultivated land following the purchase of commercial farms by the state, with these farms subsequently rehabilitated for conservation and eco-tourism purposes (Connor, 2007). The effect of this transition was the migration of farm labourers, who previously lived on farms, towards towns.

5.4.2 The Municipal Demarcation Act

The second piece of the municipal legislative framework was gazetted in 1998 in the form of the *Municipal Demarcation Act* (RSA, 1998a). This act established the Municipal Demarcation Board (MDB) as an independent authority that was tasked with assisting the state to redraw the municipal boundaries of post-apartheid South Africa. The MDB was a particularly crucial intervention given South Africa's divided history in which harsh spatial segregation was implemented through legislation that included the *Native Lands Act* of 1913 and the *Group Areas Act* of 1950 (see sub-sections 4.3.2 and 4.4.2 respectively). The MDB began redrawing the municipal boundaries by conglomerating the existing local authorities in South Africa (reducing the number of local authorities from 800 – in 1994 – to less than 300 municipalities – in 2000 (Mathoho, 2013)). The MDB's mandate, broadly, is to support local government to fulfil its constitutional function as a development agent and service provider. The MDB does this by assessing the municipality's capacity to provide services to the areas within its jurisdiction, as well as assessing the financial viability of the municipal tax-base (Mathoho, 2013). In making such assessments, the MDB is required to engage municipal structures and residents in consultation (Ramutsindela, 2008).

In terms of the LSRV, from the 1950s to 2000, Kirkwood municipality provided a small set of services in a localised fashion to residents immediately surrounding the town of Kirkwood. In the transitional post-apartheid period (from 1994 to 2000), the Kirkwood local council only served this small area, which is illustrated in yellow in Figure 5.6.

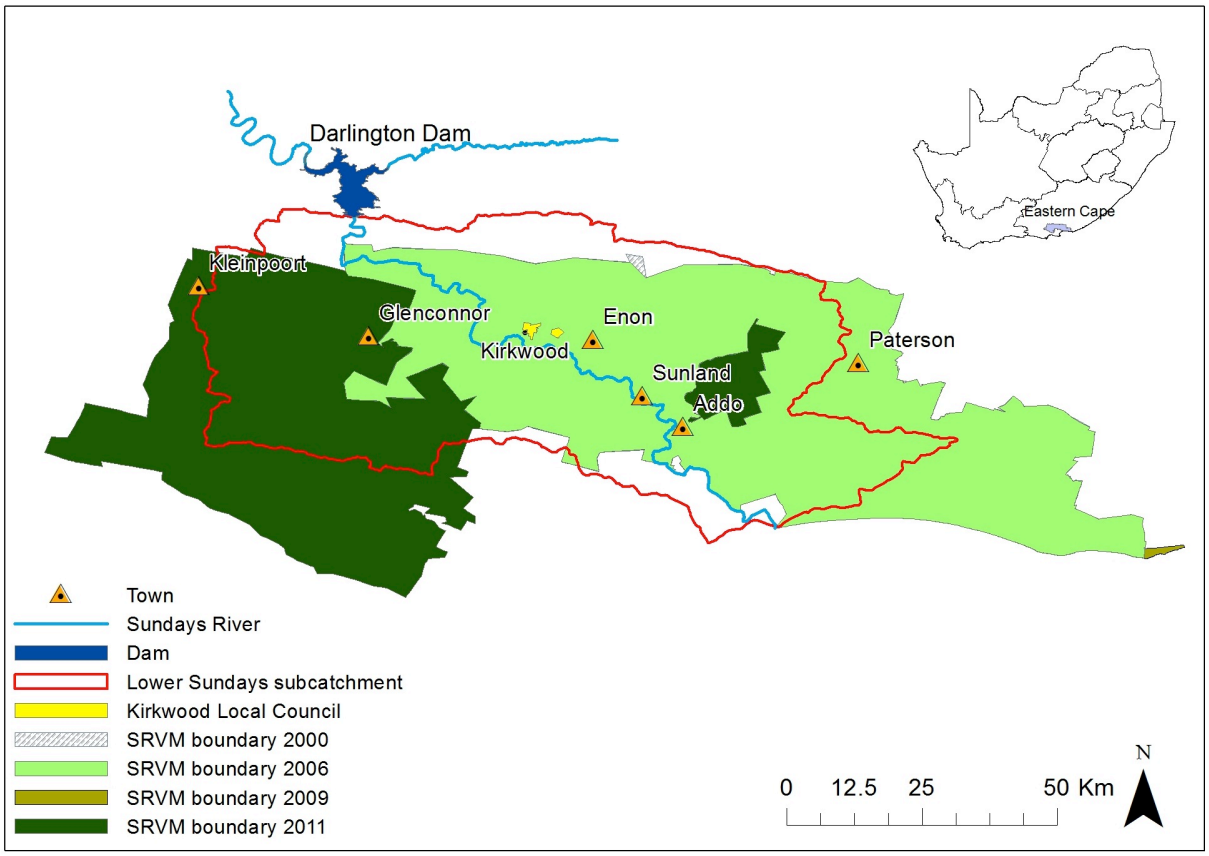


Figure 5.6: Map showing the changing municipal boundaries of the Sundays River Valley Municipality (SRVM) between 2000 and 2011, in relation to the Lower Sundays subcatchment.

When the SRVM came into existence in 2000, the new municipal boundaries included the urban settlements of Enon, Addo, and Paterson. These urban settlements were previously managed under other structures (Paterson, for example, was grouped under the Alexandria district (Horn et al., 1996)). In 2011, following the third local government elections (and with the SRVM still under provincial administration) the municipal boundaries of the SRVM again increased to include a rural area that up until this point, was managed by the Cacadu District Municipality (CDM). This rural area, illustrated in dark green in Figure 5.6, was previously a 'district management area' that fell outside of any local municipality's area of jurisdiction, and, as such, had services provided by CDM. The SRVM therefore assumed the water service authority and water service provider roles to these new, predominantly-rural regions – meaning that it was required to now provide services to the communities in these regions.

As introduced above, one of the functions of the MDB is supposed to assess whether a municipality can provide services – including water services – to the areas within its jurisdiction ahead of assigning any further areas to the municipality. To this end, the MDB conducts periodic 'capacity assessment's of all South African municipalities. The last assessment focused on the 2010/2011 municipal financial year (MDB, 2013). A summary of the SRVM's results are presented in Table C.12 (Appendix C), where the results are compared against the averages for Category B3 municipalities. The capacity assessment highlighted that in the 2010/2011 financial year, more than 55% of municipal staff performed 'governance and administration' functions in the SRVM, which was almost double the average for category B3 municipalities. In comparison, only 1.2% of the SRVM staff performed 'water services' functions, which was less than one-tenth of the average for category B3 municipalities (MDB, 2013). This capacity assessment would suggest that the SRVM was inadequately prepared for delivering services to additional areas.

The way these services are supposed to be delivered by municipalities (at the operational and management level) – is legislated through the third component of the local government legislative framework, which is discussed in the following sub-section.

5.4.3 The Municipal Systems Act

The *Municipal Systems Act* of 2000 regulates key municipal organisational, planning, participatory and service delivery systems (RSA, 2000). In this act, the overall aims of 'developmental local government' are linked with the municipal structures set forth in the *Municipal Structures Act* of 1998, providing the governance framework for how local government is supposed to function (as summarised in Table 5.5 below).

Table 5.5: Summary of the municipal governance framework. Source: adapted from National Treasury (2004: 6).

	Responsible for	**Oversight over**	**Accountable to**
Council	Approving policy and budget	Mayor	Municipal residents (i.e. public)
Mayor	Policy, budgets, outcomes, management of / oversight over Municipal Manager	Municipal Manager	Council; public
Municipal Manager	Outputs and implementation	Administration	Mayor; council; public
Chief Financial Officer	Financial outputs	Financial management	Municipal manager
Technical Director	Infrastructure and planning outputs	Technical management	Municipal manager

The two components of South African municipalities are the municipal council (incorporating political parties and resident representation), and the municipal administration. Municipal councillors are elected (in terms of the *Municipal Structures Act*), whereas municipal administrators are employed (in terms of the *Municipal Systems Act*). As Table 5.5 illustrates, the municipal council is the primary decision-making body, which is responsible for approving policies and the municipal budget. The most senior councillors are the mayor, the chief whip, and the speaker of the council (collectively referred to as the 'troika', illustrated in Figure 5.7).

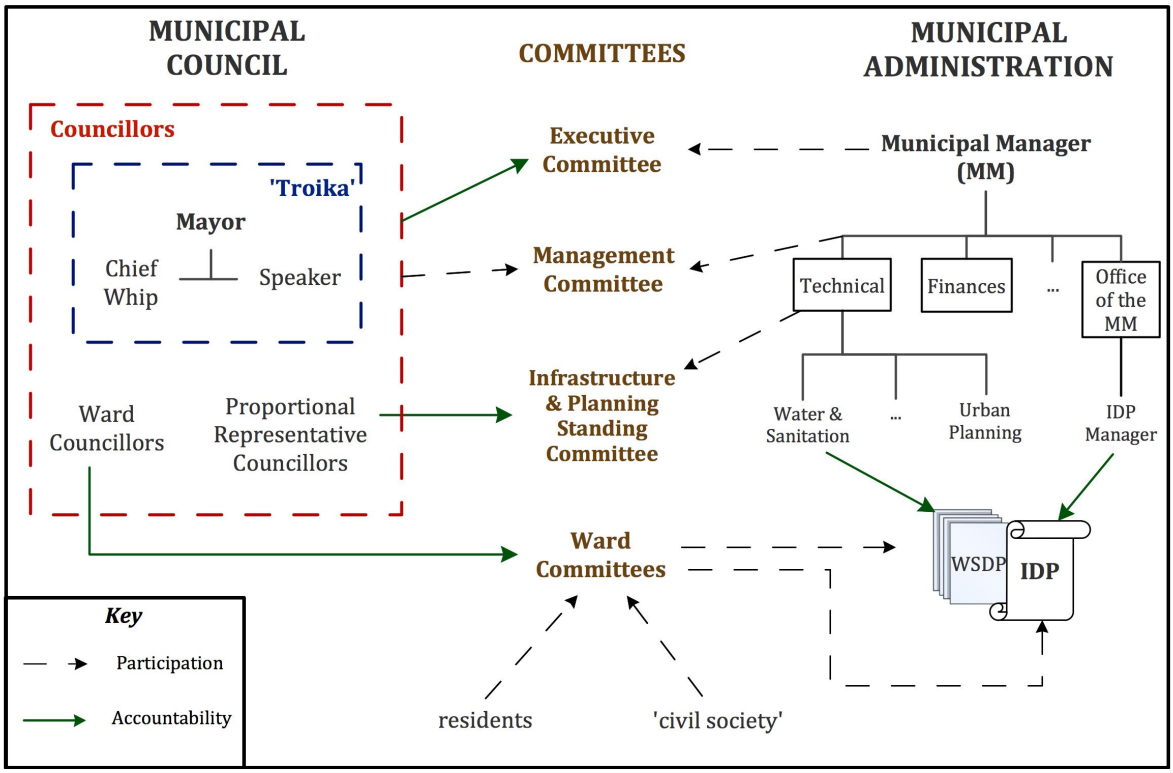


Figure 5.7: Conceptual diagram of relationships between actors in the Sundays River Valley Municipality (SRVM), showing the decision-making bodies that link the municipal council and the municipal administration. Solid green lines denote responsibility for a particular process, committee or council; black dashed lines denote participation in a process, committee or council. WSDP = Water Services Development Plan; IDP = Integrated Development Plan. Source: own design.

Municipal legislation allows for two different types of councillors: proportional representatives and ward councillors (as introduced in sub-section 5.4.1). The former proportionally represent the political parties that contested the most recent municipal elections, whilst the latter directly represent different geographic regions of the municipality (RSA, 1998). Of the 16 councillors elected in the 2011 local government elections in the SRVM, 12 were ANC councillors, three were Democratic Alliance (DA) councillors, and one councillor was independent. As is required under the *Municipal Structures Act*, half of the councillors were proportional representatives, and the other half, ward councillors.

One of the most important functions of a municipal council is to appoint a municipal manager. The municipal manager heads the administrative component of the municipality and acts as the accounting officer (RSA, 1998b). The municipal manager is responsible for implementing the municipal policies, via overseeing the internal operations of a municipality. The *Municipal Systems Act* requires the internal operations to be functionally divided between directorates, which in the SRVM include directorates for technical, financial, community and corporate services (amongst others).

The administrative and political components of a municipality are linked via a number of consultative bodies (grouped in Figure 5.7 under the category of 'committees'). These committees provide input to the primary decision-making body (the municipal council), with the exception of the executive committee (which is empowered to make certain decisions without going through the municipal council). The most important committees with regards to water services are the management committee (where all general management affairs are tabled) and the Portfolio Standing Committees (in particular, the Infrastructural and Planning Standing Committee, which is where the majority of water management-related issues are discussed). The council elects one of its members to chair this portfolio standing committee, with members of the SRVM technical directorate serving on the committee.

In the conceptual diagram in Figure 5.7, the 'water and sanitation' function is presented as a sub-division of the technical services directorate of the SRVM. However, the responsibility for delivering water and sanitation services is only one of the technical directorate's responsibilities, which extend to storm-water management, urban planning, roads, electricity, and housing. Hence, the operations of the water and sanitation sub-division is dependent both on the functioning of the other sub-divisions within the technical directorate, as well as on the operations of other directorates, including the following:

- Community Services, which oversees the Environmental Health Practitioners (responsible for testing potable water quality);
- Financial Services, which manages all aspects of credit, payments, and administration of capital and operational grants for SRVM's water services;
- Supply Chain Management, which manages procurement processes;
- Corporate Services, which acts as the municipal's human resources department, and is therefore involved in all staffing matters; and

- The Office of the Municipal Manager, which manages public participation, including the creation and annual revision of an Integrated Development Plan (IDP).

The primary means of individual residents and civil society groups interacting with the municipality is through ward committees, which are convened and chaired by the ward's respective ward councillor. These committees are designed to enable resident concerns to be escalated from the street-level upwards, in order to gain the attention of the municipality *through* the ward councillors. The latter are then responsible for referring any issues to the relevant municipal committee or, in the case of the most serious issues, to the municipal council. The ward committee structure has an additional and important function as part of 'developmental local government': ward committees are also designed to be the vehicles for public participation in municipal planning, particularly with regards to the Integrated Development Plan (IDP), the Water Services Development Plan (WSDP), and the Spatial Development Framework (SDF), which are briefly described here.

The *Municipal Systems Act* (RSA, 2000) stipulates that all municipalities must have an 'Integrated Development Plan' (IDP) that is annually updated: the IDP is envisioned to be a public planning tool that is responsive to local priorities and needs, which is created through public interaction between the municipality as an institution, municipal residents and other interested stakeholders. The IDP is also, as the name suggests, envisioned as a means of achieving integration across the different sectors of municipal management and service provision: hence, IDPs should include a status quo of municipal services, targets for provision of future services, local economic development, and relevant aspects of environmental management. In terms of water services, the *Water Services Act* (RSA, 1997) and the Strategic Framework for Water Services (Department of Water Affairs and Forestry (DWAF), 2003) stipulate that a municipality must create a 'Water Services Development Plan' (WSDP), which is used as the primary instrument for planning in the water services sector of a municipality. The WSDP is envisioned as a supplementary document to a municipality's IDP, which should consist of a more detailed elaboration on the status quo and future plans for water services and sanitation (Haigh, Fox, & Davies-Coleman, 2010). The responsibility for the WSDP lies with the water service authority (i.e. local government), with WSDPs required to include the following details:

- The quantity of water services provided;
- The levels of services rendered;
- The cost recovery programmes in place;

- The tariff structures utilised;
- The water quality sampling programme instituted, and results;
- The municipality's water conservation and demand management programme (DWAF, 2002b)

Following the constitutional requirement that it is the duty of local government to "promote a safe and healthy environment" (RSA, 1996), local government is also required to prepare Environmental Management Plans that account for how the institution plans to implement integrated environmental management (Mazibuko & Pegram, 2006: 32). These environmental management plans should be consistent with a municipality's WSDP and with the catchment management strategy of the water management area(s) in which the local government institution is situated. A summary of the additional roles of local government in environmental management is provided in Box 5.3.

Box 5.3: Summarised roles of local government in environmental management. Source: Mazibuko and Pegram (2006: 32).

- To promote integrated environmental management within its areas of jurisdiction;
- To promote environmental health based on national and provincial legislation;
- To consider and provide comments on high impact developments within its area of jurisdiction, subject to Environmental Impact Assessments (which may have an impact on water resources);
- To coordinate comments on Environmental Impact Assessments;
- To identify environmental risks and hazards that require priority intervention, and

Furthermore, a municipality's environmental management plan should also be consistent with municipal Biodiversity Sector Plans, which are required under the *National Environmental Management: Biodiversity Act* of 2004 (RSA, 2004). These Biodiversity Sector Plans are intended to support land-use and decision-making at the municipal scale (particularly in critical biodiversity zones, as explicated in sub-section 5.2.3). All land-use assessments and spatial planning should be consistent with the municipal spatial development framework (SDF), which is the last municipal planning tool discussed here. The legislation governing the creation of SDFs was recently revised with the passing of the *Spatial Land Use and Management Act* (SPLUMA) of 2013 (RSA, 2013), which asserted the following:

- That the Municipal Council of a municipality must adopt a municipal spatial development framework for the municipality [SPLUMA Section 20(1)], and

- That the "municipal spatial development framework must be prepared as part of a municipality's integrated development plan in accordance with the provisions of the Municipal Systems Act" [SPLUMA Section 20(2)].

Section 21 of SPLUMA requires a municipality's spatial development framework to:

- Be a written and spatial representation of a five-year spatial development plan;
- Include a longer-term spatial development vision statement accounting for a 10 to 20 year period;
- Identify current and future structuring and restructuring elements of the spatial form of the municipality (including 'development corridors, activity spines and economic nodes');
- "Identify, quantify and provide location requirements of engineering infrastructure and services provision for existing and future development needs for the next five years";
- Include a strategic assessment of environment pressures and opportunities within the municipal area; and to,
- Determine a capital expenditure framework for the municipality's development programmes, including an implementation plan outlining budgets and resources for implementation.

The final point in the above list further relates the SDF to municipal financial management and planning, which is the final component of the legislative framework for South African municipalities discussed in this governance analysis.

5.4.4 Municipal financial management

In this sub-section, the *Municipal Finance Management Act* of 2003 (RSA, 2003) is related to the provision of water services. The *Municipal Finance Management Act* (MFMA) regulates all municipal financial matters and is closely linked to the *Municipal Systems Act* (RSA, 2000). For example, although the annual reassessment of the municipal budget is separate from the preparatory processes that are required in annually revising the IDP, national government requires that these two processes be "fully aligned and consistent with each other" (National Treasury 2004: 11). The municipal financial framework for water services is first described in this sub-section along with the sources of funding available to local government.

(i) The financial framework for water services:

The financial framework for water services was first stipulated in the *Strategic Framework for Water Services* (DWAF, 2003), and is consistent with the highly decentralised fiscal framework established in the MFMA. The primary components of the framework are illustrated in Figure 5.8 and are discussed below.

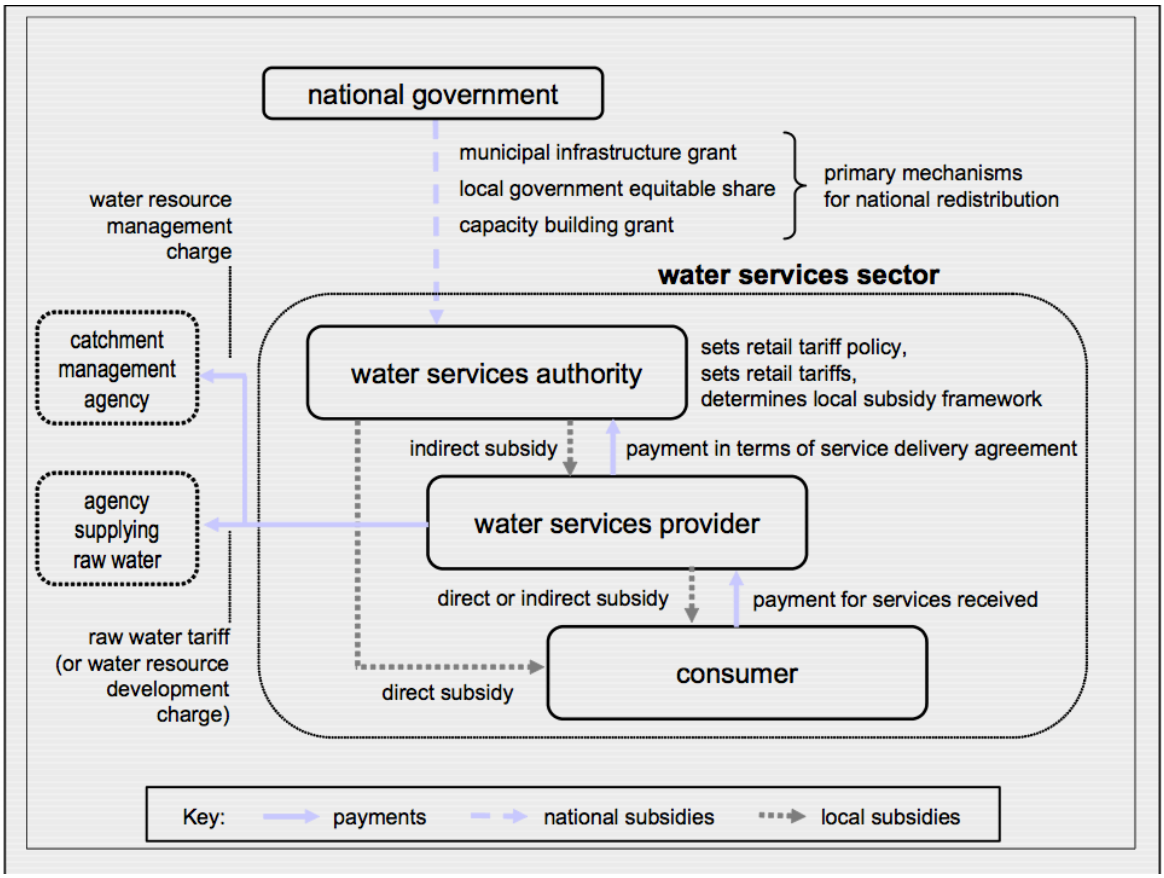


Figure 5.8: The financial framework in the water services sector, emphasising the differentiated financing of water services authorities and water services providers, in relation to national government and other key organisations. Source: reproduced from DWAF (2003: 25).

Within the financial framework for water services, national government plays two primary roles: firstly, it acts as a funding distributor, and secondly, it acts as the regulator. The government department responsible for distributing funding is the National Treasury, which does so according to the formulae and requirements set in the *Division of Revenue Act* (which is revised and enacted on an annual basis). According to the National Treasury, the perception that municipalities are supposed to be self-sufficient or largely 'self-funded' is both widespread and mistaken: on the contrary,

> … the fiscal arrangements set out in chapter 13 of the Constitution provide that local government is 'entitled to an equitable share of revenue raised nationally' and may also receive additional conditional transfers from national and provincial government. In addition, the Constitution also requires that municipalities raise their own revenues from service fees, property rates, surcharges and other taxes, levies and duties (National Treasury, 2011: 36-7)

The different sources of funding available to local government are summarised in Table 5.6 below, alongside the constitutional provisions and the governing legislation. In short, these diverse forms of financing mean that small municipalities like the SRVM should not be called 'non-viable' in terms of access to financial resources (National Treasury, 2011: 36). The employment of those financial resources, in terms of the capacity to effectively utilise finances, is discussed in sub-section 5.4.4 (iii).

Table 5.6: Summary of sources of funding available to local government. Source: reproduced from National Treasury (2011: 36).

Source of local government funding	Constitutional provisions	Governing legislation
Municipal own revenue sources		
Rates on property	Section 229 and 227(2)	Municipal Property Rates Act
Surcharges on fees for services provided by or on behalf of the municipality	Section 229 and 227(2)	Municipal Fiscal Powers and Functions Act
Service charges/ fees	Section 229 and 227(2)	Municipal Systems Act Municipal Finance Management Act Electricity Act and Electricity Regulation Act National Water Act Provincial land use planning ordinances
Other taxes, levies or duties	Section 229 and 227(2)	Municipal Fiscal Powers and Functions Act
Administrative fees		Municipal Systems Act
Fines		National Road Traffic Act
Borrowing	Section 230A	Municipal Finance Management Act
Credit control and debt collection		Municipal Systems Act
Transfers from national and provincial government		
Local government equitable share of nationally collected revenues	Section 214 and 227	Intergovernmental Fiscal Relations Act The annual Division of Revenue Act
Fuel levy sharing with metropolitan municipalities	Section 229(1)(b)	The annual Taxation Laws Amendment Act
Conditional grants from national government	Section 214(c), 226(3) and 227(1)(c)	Intergovernmental Fiscal Relations Act The annual Division of Revenue Act The annual National Appropriation Act
Conditional grants from provincial government	Section 226	The annual Division of Revenue Act The annual Appropriation Act of the relevant province

As Table 5.6 shows, an additional source of local government funding is through borrowing (i.e. fundraising on the financial markets). However, the vast majority of infrastructural financing in South Africa is still provided to local municipalities through national government transfers rather than through public-private partnerships or through fundraising on financial

markets (Ruiters, 2013). National government uses a number of redistributive mechanisms to fund municipalities, including the municipal infrastructure grant and local government equitable share. The municipal infrastructure grant (MIG) is a conditional capital grant, contingent on municipalities applying for specific projects (such as a new water treatment works), whilst local government equitable share is an operating grant that is a portion of the national revenue fund (equitable share is allocated to all spheres of government in South Africa in order to support service delivery and administrative functioning (DWAF, 2003: 25).

In terms of its regulatory role, national government provides conditions for the use of MIG and determines the norms and standards for the setting of tariffs, through a cooperative process involving DWA and National Treasury. Financial regulation is also undertaken by the Auditor-General of South Africa (AGSA): the AGSA is one of the six 'Chapter 9 institutions' tasked with "supporting constitutional democracy" (and is therefore protected as an independent institution under the Constitution (RSA, 1996)).

The 'water services sector' outlined in Figure 5.8 consists of water service authorities (WSAs), water services providers (WSPs), and consumers. The distinction between WSA and WSP has already been introduced (see sub-section 5.3.3): as the WSA, local government performs key financial functions in the water services sector including setting tariff structures and subsidies, whilst the WSP is responsible for providing the actual potable water services to consumers. The financial flows between the WSA and WSP, in the form of subsidies and payments, must be contractually agreed upon in a service delivery agreement between the two institutions, even if the two institutions operate within the same organisation. The delivery cost of water borne by the WSP includes the purchase of raw water to the supply agency where applicable: in the LSRV, this supply agency is the Lower Sundays River Water User Association (L-WUA). The price of raw water is set by the L-WUA to include water resource management charges, which are levied by DWA.

The operational subsidies paid by national government to WSAs, through the redistributive mechanisms listed in this sub-section, are considered in the following sub-section.

(ii) Indigent register and the SRVM's portion of equitable share:

National Treasury calculates the value of a municipality's equitable share grant by taking into account a range of criteria, one of the most important of which is the percentage of poor

households within a given municipality's jurisdiction. Poor households are referred to in local government parlance as 'indigents', with each municipality qualifying what constitutes an indigent household in its area. Indigent households are supposed to receive the full suite of Free Basic Services (FBS) that the municipality offers, including Free Basic Water (FBW). In order to support local government to provide FBS, the National Treasury requires municipalities to submit a list of confirmed indigents – known as the 'indigent register' – which is then used as one of the determining criterion for the amount of equitable share received by the municipality in the future. The indigent registration process (summarised in Figure 5.9) is therefore of central importance to the operations of a municipality. As Figure 5.9 shows, the process begins with poor households submitting to the SRVM their application forms along with associated documentation pertaining to total household income. When the municipality has confirmed the veracity of the applications, successful households are added to the indigent register (steps 2 and 3). The SRVM submits its updated indigent register to national government on an annual basis (step 4), and awaits approval from National Treasury (step 5). Once approved, the municipality receives its amended equitable share grant and increased operational budget (step 6). The difficulties and controversies of this process, as applied in the SRVM, are discussed in sub-section 6.2.5).

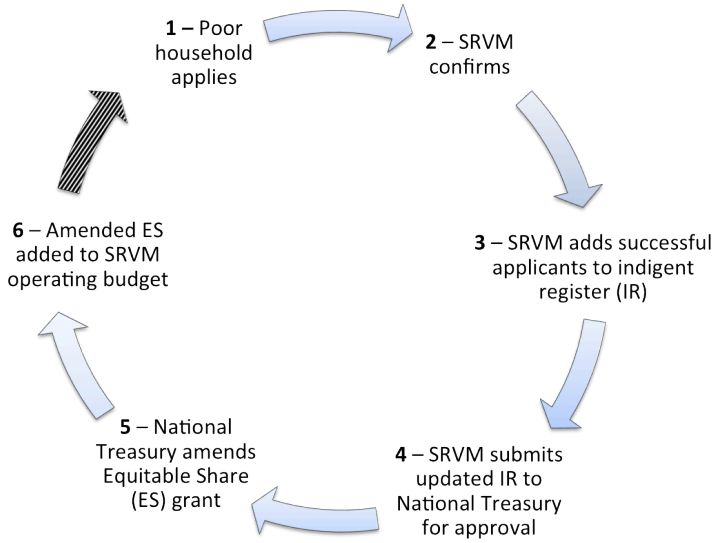


Figure 5.9: The indigent registration process of the Sundays River Valley Municipality (SRVM). Source: own design.

Procedurally, it is important to note that an increase in the SRVM's equitable share grant would not necessarily result in an increase in operating budget for the SRVM's water services. In principle, an increase in equitable share derived from an expanded indigent register should be spent on the provision of FBS to the poor households in the SRVM. In

practice, however, the larger equitable share grant can be spent on any other aspect of municipal management (including salaries), unless an additional financial management policy of 'ring-fencing' is implemented. Ring-fencing refers to the policy of separating a particular aspect of operational management from the general budget, in order to ensure that income is only spent on the associated costs of providing the good or service. In the water sector, ring-fencing therefore refers to water-related income being cordoned-off, and made available exclusively for water-related expenditure and reinvestment. National government regulation of ring-fencing (in relation to local government expenditure) is discussed further in sub-section 5.5.3, in part of the analysis of the governance challenges affecting local water authorities in the LSRV.

5.4.5 Summary of local government legislation

This section (5.4) has outlined the processes and institutions within which the provision of water services by local government occurs. This section has demonstrated how institutional divisions between policy-making, regulation and service delivery functions are statutorily in place, both vertically (i.e. from national government to local government) and horizontally (i.e. between sectors at the local government scale). However, as introduced in section 4.8 of the historical analysis, a vast difference exists between the policy (in terms of how local-level water management and water service provision is supposed to function and interrelate) and how, in practice, these structures and functions are governed, and subsequently managed.

The following section draws from the description of the governance context of local water authorities in this chapter, in order to posit a model of developmental local government and to distil five inter-linking governance challenges, which have manifested in particular ways in the LSRV case.

5.5 Governance challenges evident in the Lower Sundays River Valley

This section returns to the conceptual framing developed in Chapter 2, in which local water authorities were posited as working in the 'muddled middle' between the formal institutional domain and the informal institutional domain, influenced by aspirational polices of integrated water resource management (IWRM) and developmental local government (DLG) (see section 2.3). This section draws from the governance analysis provided in this chapter and applies the conceptual framing to posit a normative model of developmental local government (DLG). The normative model for DLG synthesises key parts of the local government system (as outlined in section 5.4), and relates these to the broader processes and institutions that are designed to support service delivery within South Africa (as explicated in the primary institutional arrangements in the water sector outlined in section 5.3). This distilled model of DLG is used as the basis for discussing five inter-related governance challenges, which are described as the critical governance challenges affecting local water authorities in the LSRV.

5.5.1 Developmental local government

Following Mackay and Ashton (2004), development is understood here in terms of a gradual progression of people and societies, in which people's expectations change as their needs are met, leading to new needs, and new attempts to satisfy these needs. In a developmental service delivery model (see Figure 5.10), the goal of 'improved service delivery' is achieved through the participation of end users and the capacity of service delivery agents. For the end users, the goal is improved service delivery which results in an 'improved quality of life' that allows recipients to then articulate a different set of expectations, which leads to new needs to be satisfied. This cycle is represented in the bottom-half of the diagram in Figure 5.10 below. For the service delivery agents, the outcome is an improved capacity to deliver services, which leads to different support and training requirements and expectations on the part of the agents, resulting in new support and training needs to enable the agents to meet the amended needs of the end users (represented by black arrows in the top half of the diagram in Figure 5.10). The overall aim of the DLG model posited here is the following: To achieve a virtuous cycle in which empowered local citizens participate in, and benefit from, improved service delivery from increasingly skilled and efficient local water service providers, with effective water governance contributing to social and political stability.

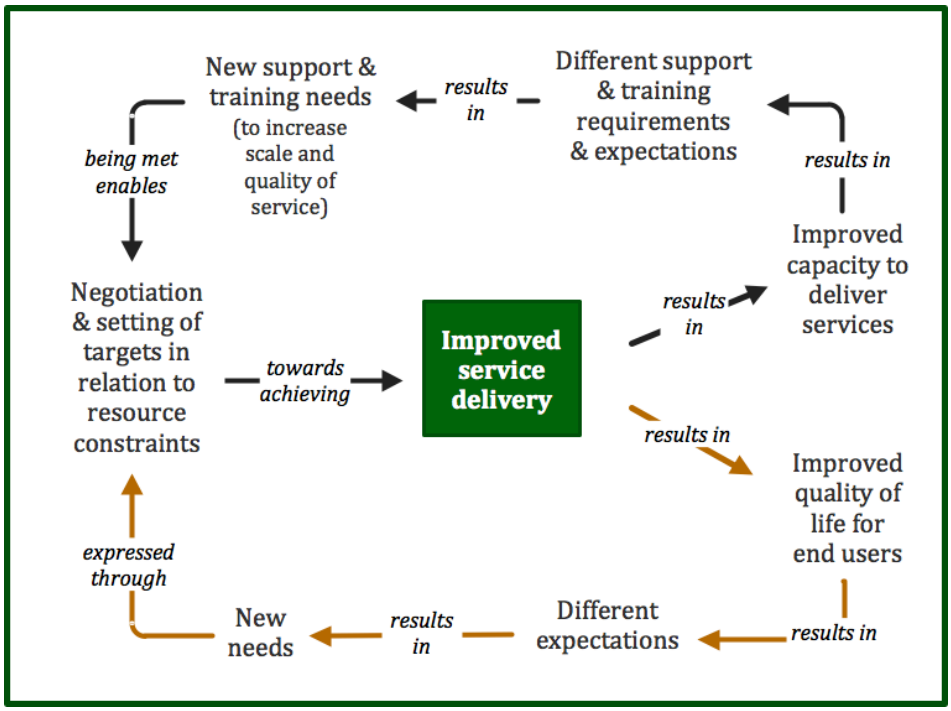


Figure 5.10: Schematic diagram of the intended cycles of the developmental local government model, in which improved service delivery results in an improved quality of life for end users (residents and other stakeholders), and increased capacity to deliver services by officials. Conceptually inspired by Mackay and Ashton (2004:3)

The service delivery mandate of municipalities is influenced by national and provincial government (in addition to other organs of state), in a number of important ways, including through DWA regulation, funding, and support-provision (see Figure 5.11).

The influences of national and regional actors on the DLG model can be summarised as follows. As custodian of South Africa's water resources, national government is responsible for protecting water resources and providing accurate assessments of available water, and, in tandem with regional water utilities / water boards, national government provides regional bulk infrastructure where required. These roles enable local government to set targets for improved service delivery in relation to available resources and bulk infrastructure, and in negotiation with the end users. These targets are additionally influenced by aligning local plans (such as the integrated development and the water services development plan) with regional and national plans and strategies.

Other roles performed by national government include:

1. Establishing consultative institutions that support end users to articulate new needs (including through supporting Ward Committees, Integrated Development Planning, and Spatial Development Frameworks);

2. Through assessments and audits, providing support and training to local government officials to meet the officials' new needs, which in turn allows the officials to function more effectively and provide better services, and
3. Regulating the performance of service delivery agents and the experiences of service by the end users.

The institutional benefits of the virtuous cycles in this posited DLG model include the following:

1. Decreasing reliance on national government and external agents for support and interventions (other than for regulation, funding and oversight purposes);
2. Empowerment of the service delivery agents to become better able to solve service delivery problems on their own, and therefore provide increased levels of services whilst relying on national government less; and
3. Empowerment of end users who actively participate in the negotiations and consultations for target-setting, and are rewarded by experiencing improved service delivery and therefore become motivated to participate more.

However, violent service delivery protests in the SRVM in September 2014 – in which water services played a part (SAPA, 2014) – suggests that the combination of increasing participation and increasingly-skilled service delivery agents is failing to lead to a virtuous cycle with the outcome of improved service delivery. Recent research on service delivery protests across South Africa, which "confirms that protests are becoming more frequent, more widespread and more violent" (van Vuuren, 2013: 14), further suggests that the SRVM is an indicative, rather than extreme, case. One interpretation of this trend is that many municipalities in South Africa are stuck in a vicious cycle, rather than a virtuous cycle. This vicious cycle is driven by disempowered local residents receiving intermittent and variable water services from increasingly stressed and overloaded 'fire-fighting' water service providers, with ineffective water governance contributing to social and political instability, continually requiring state and external agent intervention and bailout. Part III of this study draws on extensive ethnographic and operational data pertaining to on-the-ground water service delivery in the LSRV, in order to argue that water services in the SRVM are stuck in this vicious cycle.

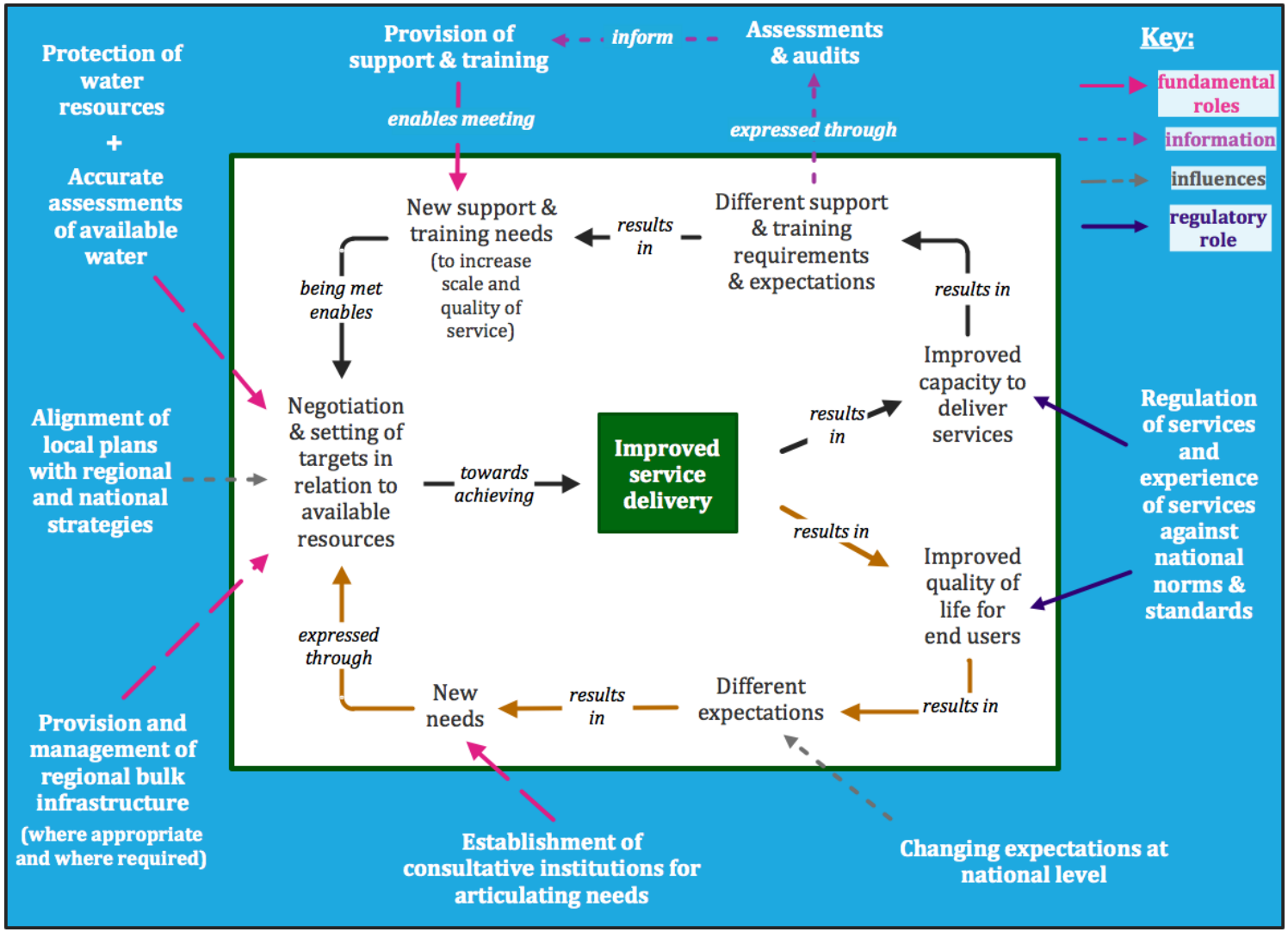


Figure 5.11: Developmental local government model (as in Figure 5.10) expanded to show the different roles that other organs of state are expected to play, in order to support local government in its service delivery mandate.

The remainder of Chapter 5 builds the argument that this vicious cycle has five governance dimensions, which are the critical governance challenges affecting local water authorities in the LSRV. The five governance challenges are inter-related and connected to all three spheres of government in South Africa – national, provincial, and municipal – and are summarised in Figure 5.12 below.

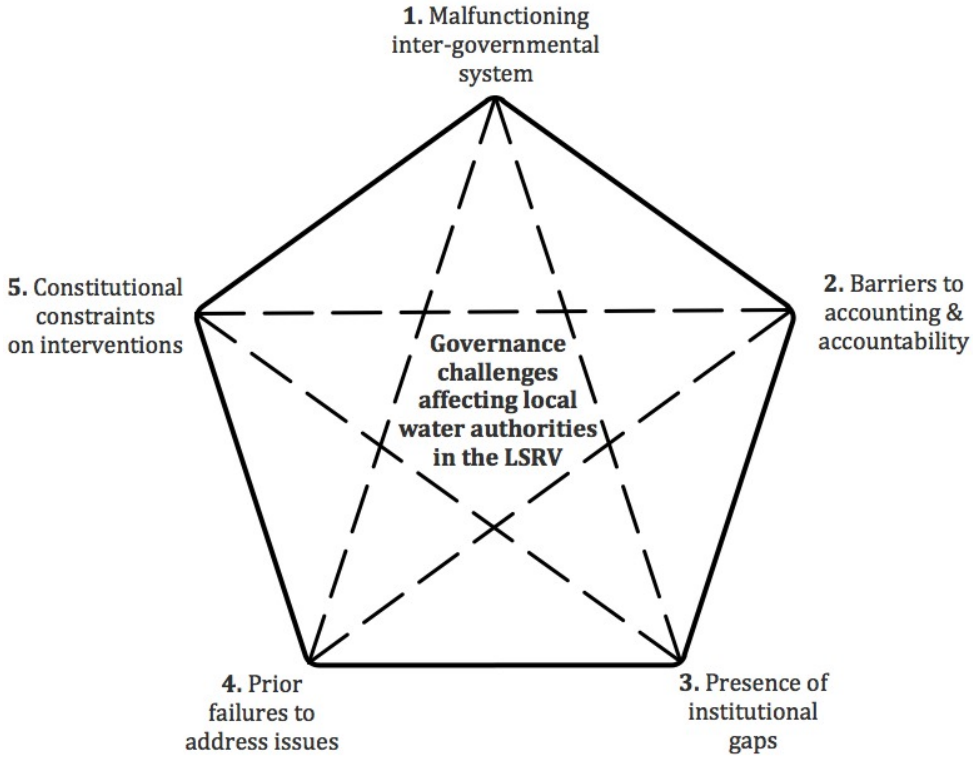


Figure 5.12: Five inter-related governance challenges affecting the functioning of local water authorities in the Lower Sundays River Valley (LSRV), numbered according to the order that these governance challenges are discussed in section 5.5. Source: own design.

The first governance challenge pertains to the mal-functioning of the intergovernmental system established in post-apartheid South Africa (discussed in sub-section 5.5.3). This governance challenge is closely related to the second challenge, which pertains to the barriers affecting accounting and accountability (discussed in sub-section 5.5.3). Accountability is further impacted by the third governance challenge, the presence of institutional gaps, which are found in the formal institutional arrangements for bulk water management in the LSRV. Rather than being confined to the local level, sub-section 5.5.4 demonstrates how the institutional gaps in the LSRV are reflected in the proposals for institutional reform in the second National Water Resource Strategy (DWA, 2013c) and the National Water Policy Review (DWA, 2013b), and are therefore nationally-relevant. The current proposals for institutional reform relate to the fourth governance challenge, which consists of the prior

failures to address issues that are central to water management and water service provision (sub-section 5.5.5). In terms of local water authorities, these failures are inextricably linked to the constitutional constraints on interventions, which is the fifth and final governance challenge discussed in this chapter (in sub-section 5.5.6).

5.5.2 Governance challenge 1: Malfunctioning inter-governmental system in South Africa

The challenges of the inter-governmental system in South Africa were discussed in the National Development Plan (NPC, 2012), using a water services example (see Box 5.4). The National Planning Commission (NPC) used the example in Box 5.4 to demonstrate the complexity of the inter-governmental system in South Africa, but warned that it should not be read as an indictment of inter-governmental systems (NPC, 2012: 51): rather, the example illustrates the NPC's argument that "the public needs a clearer sense of who is accountable for what".

Inter-governmental relations in South Africa cannot be seen outside of the principle of cooperative governance, enshrined in Section 41 of the Constitution (RSA, 1996). The Department of Cooperative Governance and Traditional Affairs (CoGTA), which oversees cooperative governance in South Africa, acknowledged in 2009 that the local government sector was in need of 'a turnaround' (CoGTA, 2009a). One of the reasons for this turnaround was the uncoordinated intervention process into local government, in which multiple government departments intervened in overlapping and counter-productive ways – again stressing the mal-functioning inter-governmental system in South Africa.

Box 5.4: Excerpt from the Executive Summary of the National Development Plan 2030, produced by the National Planning Commission (NPC), (NPC, 2012: 50-1).

> The water in a town is found to be undrinkable.
> The media blames the Minister of Water Affairs.
> The community blames the mayor.
> The mayor blames the head of the water utility.
> The head of the water utility blames the technical engineer.
> The engineer says that the maintenance budget has been cut for the past three years and now the water is undrinkable.
> The head of finance in the municipality says that the budget was cut because personnel costs have crowded out maintenance expenditure.
> The mayor argues that the salary structure is negotiated at a national level by the South African Local Government Association [SALGA].
> The association [SALGA] says that municipalities can opt out of these agreements if they are unaffordable.
> And so on.

The difficulties of the South African water sector transitioning from the "the principle of co-operative governance to the practice of co-operative governance" have also long been acknowledged (e.g. Mackay & Ashton, 2004). Although the Intergovernmental Relations Act (RSA, 2005) provides structures for facilitating formal intergovernmental disputes, these structures are inadequately utilised at the expense of accountability, as in the water services example in Box 5.4. The governance challenge of accounting and accountability is further discussed in the following sub-section.

5.5.3 Governance challenge 2: Barriers to accounting and accountability

This sub-section begins with a discussion of two dimensions of accountability, namely 'social accountability' and 'financial accountability', before discussing accounting and infrastructure management. The Centre for Social Accountability in South Africa usefully defines social accountability as the

> … right to obtain justifications and explanations for the way in which public resources are managed (whether by public officials or private service providers) and to obtain justifications for the way in which these resources serve to progressively realise people's human rights (in particular their socio-economic rights). This definition requires that officials take corrective action in response to instances of the ineffective use or abuse of resources in order to prevent their recurrence (*cited in* Thinyane & Coulson, 2012: 4).

This definition of social accountability can be understood in terms of the municipal governance framework, in which accountability is distributed across the Municipal Council, Mayor, Municipal Manager, and Executive Managers (see Table 5.5), where all individuals holding municipal positions are answerable to the local communities that they serve. This definition of social accountability hinges on the management of public resources, and therefore is fundamentally about financial accountability. In the 2012-13 financial year, only 9% of South African municipalities received a clean audit, with the Auditor General of South Africa (AGSA) reporting that improper and wasted expenditure amounted to R21.5bn (Stone, 2014). Irregular and improper expenditure is any expenditure not in line with the law, which at a municipal scale, is regulated under the MFMA (see sub-section 5.4.4). In a recent report to Parliament (Parliamentary Monitoring Group (PMG), 2014a), the AGSA used the following examples to illustrate what constitutes irregular expenditure:

> [Where] one was supposed to pay a supplier within 30 days and it was done only after the 30th day… Where a tender was supposed to have been advertised for a month, but instead was only advertised for one week… where [a municipality] was

> supposed to source three quotations, but only one was sourced… [and] where suppliers… had been awarded a contract without having tax clearance certificates.

All of the above cases count as irregular expenditure and not misappropriation of funds, yet these two categories are often grouped together and confused in the media (*ibid*., 2014a). A more serious aspect to this governance challenge is the regulatory powers and functions of the AGSA. As a Chapter Nine institution, the AGSA is tasked with "supporting constitutional democracy" (as introduced in 5.4.4(i)), but it has limited actual powers: in the above-mentioned parliamentary report, the Senior Audit Manager in the Water and Sanitation Portfolio of the AGSA stated simply that the AGSA "could only recommend and try to influence, and nothing more" (*ibid*., 2014a).

The challenge of accounting and accountability highlights that the financial struggles in many municipalities relates to the poor implementation performance of grant-funded projects, which leads to under-spending of infrastructural grants – rather than the availability of grants: as of February 2014, only 18% of the Municipal Water Infrastructure Grants transferred from DWA to municipalities had been spent, leading DWA to argue that "it was a risky exercise to continuously transfer funds where there was no capacity to spend" (PMG), 2014b). According to DWA, the primary challenges relate to a lack of accountability, particularly at the local government level (*ibid*.). To address these challenges, DWA's recommendations included the following:

- Municipalities "enhancing planning, improving accountability and setting up implementation agencies" (*ibid*.);
- DWA prioritising projects in order to start with the projects that could be completed quickest; and
- DWA to "spend more time on the control and reporting mechanisms", including by initiating standardised reporting mechanisms that municipalities would complete on a monthly basis (*ibid*.).

One of the punitive measures available to DWA and National Treasury is to withhold funds from non-compliant local municipalities (*ibid*.) – but this option is evidently undesirable given that it compounds cash-flow problems within municipalities (in the case of operating budgets) and inhibits infrastructure development (in the case of capital projects).

A further dimension to the accounting challenge developed out of a gap in the *Municipal Finance Management Act* (MFMA) (RSA, 2003), which was publically acknowledged in

2007, but inadequately addressed. Under the MFMA and associated legislation, capital grants awarded to municipalities by National Treasury have historically carried no conditions requiring municipalities to budget for on-going operations and maintenance (CSIR & CIDB, 2007: 14). This gap in financial regulation was identified even within the governing principles and practices for municipal finances, as contained within the Generally Accepted Municipal Accounting Practice (GAMAP). As of 2007, GAMAP required municipalities to depreciate assets (such that the declining value was reflected in municipal accounts), but GAMAP did not

> … require that a depreciation model… be used that will determine adequately the funding to be put aside each year to meet future liabilities for infrastructure renewal… [nor] does GAMAP prescribe that the money actually be put aside (CSIR & CIDB, 2007: 14).

In 2008, National Treasury attempted to fill this gap by publishing guidelines for 'Local Government Capital Asset Management' that were consistent with the MFMA (National Treasury, 2008). These guidelines have inadequately addressed the problem of 'asset stripping' (the overuse and under-maintenance of infrastructure), with asset deterioration continuing to be a significant challenge for municipalities (Joubert, Plessis, von Holdt, & Fourie, 2014). A recent proposal to address these infrastructural challenges is to separate the supply chain for the delivery and maintenance of municipal infrastructure "from the supply chain for all other kinds of municipal goods and services" (Watermeyer, Wall, & Pirie, 2013: 2). This proposal follows the promulgation of 'Draft regulations for the Public Finance Management Act' (PFMA) (RSA, 2012), which separates the supply chain management system for the delivery and maintenance of infrastructure from that of general goods and services, but which has only been applied to national and provincial government at this point, and not yet to local government and the MFMA (Watermeyer et al., 2013). Whilst often unstated, these governance measures also seek to address corruption within state procurement processes. As the National Planning Commission (NPC) acknowledged:

> Government's procurement policies blur the line in matters of corruption, and the state procurement systems has become overly bureaucratised. The emphasis on compliance by box-ticking makes the system costly, burdensome, ineffective and prone to fraud (NPC, 2012: 47).

The bureaucratisation of these procurement processes further inhibits social accountability at the municipal scale, where residents and local stakeholders are confronted with burdensome documentation that makes it difficult to obtain the justifications and explanations for the way in which public resources are spent.

The last aspect of the financial accountability governance challenge discussed here relates back to the challenge of intergovernmental relations: as described in the sub-section on the MFMA (5.4.4), the decentralised fiscal framework in South Africa is a significant feature of its intergovernmental relations, and this provides local government autonomy "with respect to how the municipal infrastructure grant and the local government equitable share are allocated" (DWAF, 2003: 25). This autonomy has extended to mandating ring-fencing, and whether a certain percentage of municipal budgets is spent on the maintenance and management of infrastructure, but there are signs that that local autonomy is being retracted: at the 2014 Water and Sanitation Summit, Minister Mokonyane stated that national government would introduce legislation requiring water service authorities to set aside at least 7% of their total budgets towards the maintenance and management of infrastructure, saying that "we [DWA] will no longer hear about the excuses of ageing or non-functioning water infrastructure" (infrastructurene.ws, 2014a).

5.5.4 Governance challenge 3: Presence of institutional gaps in the Lower Sundays River Valley

The third governance challenge discussed here manifests in three institutional arenas in which local water authorities in the LSRV operate: the first arena is the water services unit within the SRVM; the second arena is in the interaction between the SRVM and the L-WUA; and the third arena is regional water resource management.

(i) Lack of institutional separation between service provision and regulatory roles in the Sundays River Valley Municipality:

In mid-2009, the SRVM reviewed its capacity to perform the water service provider (WSP) function, in an internal review that is required under Section 78 of the *Municipal Systems Act* (RSA, 2000) (introduced in 5.4.3). This review was undertaken by the Municipal Council, at a time in which it was facing financial and political upheaval (as discussed in sub-section 4.7.2 of the historical analysis). The council resolved that the municipality would continue performing the WSP function (SRVM, 2010: 7), in spite of the significant water and sanitation challenges that the municipality was facing, and in spite of it implementing a financial recovery plan. However, the SRVM did not implement the institutional separation between its water service authority (WSA) and its WSP functions that is required under the *Water Services Act* (RSA, 1997) and the Strategic Framework for Water Services (DWAF,

2003). In effect, this institutional conflation has meant that the service provision and regulation roles of the SRVM have been conflated, with no service delivery agreement between the two parts of the organisation (as required within the financial framework for water services, discussed in sub-section 5.4.4). Institutionally, the absence of a distinct 'water unit' within the SRVM makes the SRVM's water services reliant on the broader functioning (or lack thereof) of the municipality.

(ii) Lack of service contract between the Lower Sundays River Water User Association (L-WUA) and the Sundays River Valley Municipality:

The second institutional gap exists between the SRVM and the L-WUA: as discussed in sub-section 5.3.4, the SRVM is one of the nominated district members of the L-WUA, according to the rules set in the L-WUA's constitution. The arrangement between the L-WUA and the SRVM is diagrammatically represented in Figure 5.13, which shows the institutional arrangements for bulk water supply in the LSRV as the 'rules-in-use'. The rules-in-use summarised in Figure 5.13 can be contrasted with the rules-in-form that are diagrammatically represented in Figure 5.14 (the distinction between rules-in-form and rules-in-use is provided in sub-section 2.3.3). The L-WUA performs a particular function for the SRVM, namely, acting as the agency supply raw water to the municipality. In terms of institutional design, the L-WUA is therefore a bulk water service provider (WSP) for the municipality. The municipality is the WSA, and under the *Water Services Act* (RSA, 1997) is therefore required to oversee the bulk-WSP function performed by the water user association. This regulatory function should be performed according to a service level agreement (SLA) and a water service provider business plan (WSP-BP) signed by the L-WUA and the SRVM.

The institutional gap between the SRVM and the L-WUA is mirrored in the institutional gap within the SRVM, where the WSA and WSP functions are conflated (as discussed in point (i) above). The operational implications of these two institutional gaps feature heavily in Part III of this study, and are returned to in sub-sections 6.3.4 and 7.4.

(iii) Lack of a catchment management agency:

The third institutional gap discussed here pertains to water resource management, and the lack of an established catchment management agency (CMA). The desired powers and functions of CMAs were introduced in sub-section 5.3.4, in terms of the central role of CMAs as a form

of decentralised water resource management, as envisioned in the *National Water Act* of 1998 (RSA, 1998a). Decentralisation in water resource management was designed to support decentralisation in local government: one of the initial functions of a CMA was to coordinate the implementation of its catchment management strategy (CMS) with the implementation of local municipalities' water services development plans (DWAF, n.d.-b: 18). Similarly, a municipality's spatial, environmental management, and water services planning should all take into account the catchment management strategies of the CMA.

In the Water Research Commission-funded report 'Evaluation of the opportunities for cooperative governance between catchment management agencies and local government (Mazibuko & Pegram, 2006), the authors demonstrate the positive overlap of the roles of CMAs and municipalities, whilst emphasising that CMAs are not water service institutions, and municipalities are not water resource management institutions: hence, cooperation between the two institutions is critical. As discussed in sub-section 5.3.4, no CMA has been established in the water management area in which the LSRV is situated. Hence, following the *National Water Act* (RSA, 1998a), the DWA regional office has continued to perform all catchment management duties, despite the regional office in the Eastern Cape being overloaded and under-capacitated (as discussed further in sub-section 6.5.3). The institutional gap left by the lack of a CMA additionally deprives the L-WUA and the SRVM from an institutional arena in which the two organisations would both participate and be required to contribute to institutional processes.

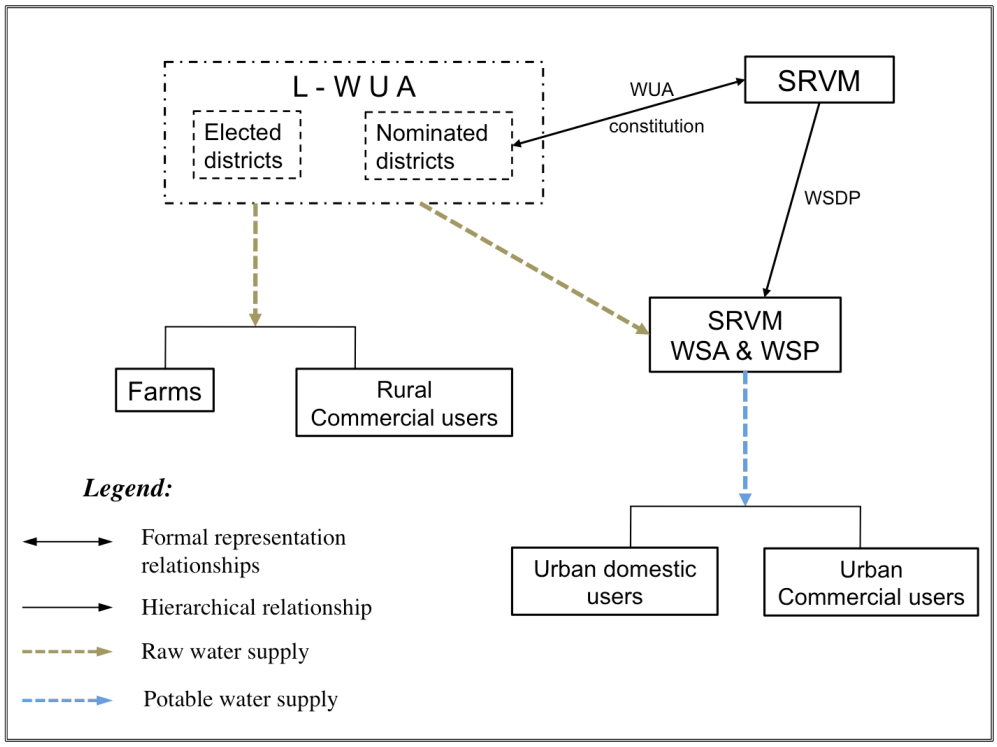


Figure 5.13: The rules-in-use governing the water supply arrangement between the Lower Sundays River Water User Association (L-WUA) and the Sundays River Valley Municipality (SRVM), illustrating how there is no separation between the water service provider (WSP) and water service authority (WSA) functions of the municipality, and how the only institutional arrangement between the SRVM and the L-WUA is the water user association's (WUA) constitution. WSDP = water services development plan.

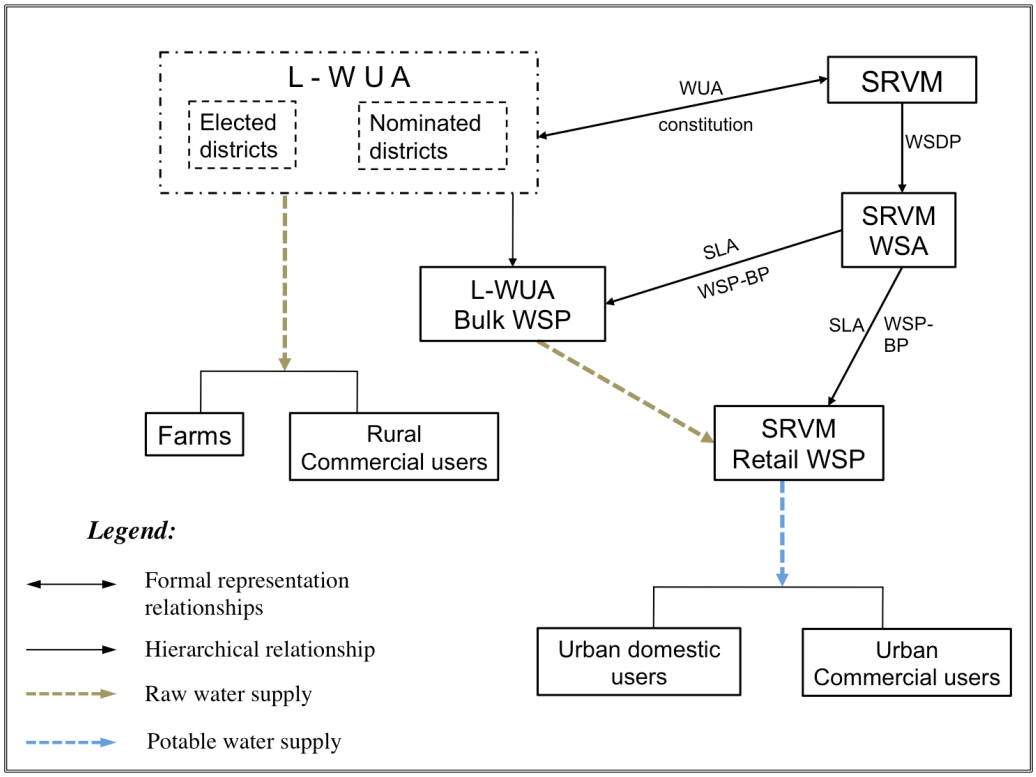


Figure 5.14: The rules-in-form governing the water supply arrangement between the Lower Sundays River Water User Association (L-WUA) and the Sundays River Valley Municipality (SRVM), illustrating

the intended two additional institutions: the L-WUA bulk water service provider (WSP) institution, and the distinction between the SRVM water service authority (WSA) and the SRVM retail WSP. The governing contracts between the WSA and WSPs should include service level agreements (SLA) and business plans (BP), whilst the water services development plan (WSDP) should define the relationship between the SRVM and the WSA.

(iv) Proposed institutional reform

The institutional gaps that are evident in the LSRV are relevant throughout SA, and are reflected in the proposals for institutional reform in the second National Water Resource Strategy (DWA, 2013c) and the National Water Policy Review (DWA, 2013b). A summary of the revised roles and responsibilities of water institutions according to the second edition of the National Water Resource Strategy (NWRS) is provided in Box 5.5, which specifically addresses the challenges related to bulk water services. The 2013 strategy acknowledged the weak performance of municipalities and governance problems in existing water boards (such as Amatola Water), in addition to the challenges of water user association.

Box 5.5: Excerpt from the National Water Resource Strategy 2 (June 2013 edition), on the revised roles and responsibilities of water institutions. Source: DWA (2013c: 102)**.**

> Section 16.1.6: Review of the roles and responsibilities of water institutions, including regional water utilities and water user associations
>
> An institutional model needs to be considered that will adequately respond to the challenges related to bulk services which include the following:
>
> - Weak performance in the management of water supply and sanitation services by many municipalities, which compromises services.
> - Lack of clarity regarding responsibilities for water resources development at the local and regional level, and for regional bulk services outside of the existing water board service areas.
> - Governance and performance-related problems within some of the existing water boards.
>
> Consideration is being given to the consolidation of existing water boards into Regional Water Utilities to manage regional water resources and regional bulk water and wastewater infrastructure…

The 'review' of water institutions referenced in the NWRS was the National Water Policy Review (DWA, 2013b), which has asserted revised policy positions on the roles and responsibilities of water user associations, water boards and municipalities. In the 2015 Parliamentary session, DWA will present the 'General Water Laws Amendment Bill', which will consolidate the National Water Act and the Water Services Act (PMG), 2014a).

In terms of water user associations, the National Water Policy Review (NWPR) stated that:

> It is recognised… that old irrigation boards have often failed to meaningfully transform to WUAs and participate in or achieve the transformation goals of the NWA. Transformed Irrigation Boards have also failed in achieving the adequate participation of other users such as municipalities (DWA, 2013b: 19).

This critique of WUAs is consistent with other studies and reports challenging the role of water user associations as "vehicles for transformation" in South Africa (e.g. Kemerink et al., 2013). The NWPR stated that WUAs and Irrigation Boards "are to be dissolved, with appropriate functions related to a state-owned water scheme being delegated to a CMA or Regional Water Utility". In terms of water boards, the NWPR states that water boards will also transform: accordingly, Amatola Water has announced that it is "is in the process of preparing... itself for [its] transformation into a regional water utility with expanded functions and gazetted area" (Amatola Water, 2013: 6). The position of the NWPR on municipalities is that of revised powers and functions:

> Water Service Authority's powers and functions will be determined by the Department of Cooperative Governance and Traditional Affairs (CoGTA) and the DWA (DWA, 2013b: 19).

This position is contrary to the local autonomy currently granted to municipalities under Section 78 of the *Municipal Systems Act* (RSA, 2000), as discussed in (i) of this sub-section. In line with the NWPR, the Minister of Water and Sanitation (appointed in May 2014) has asserted national government "will move away from a one size fits all approach where every district or local municipality has the powers and functions of a water service authority, but questionable viability and capacity" (infrastructurene.ws, 2014b). The current Minister of Water and Sanitation was appointed as part of the new executive, following the SA national elections in May 2014. The new presidential cabinet saw the fourth change to the government ministry overseeing water affairs since 1994 (for a timeline of these changes see Timeline C.7). The ministerial changes reversed the consolidation in 2009 of the Department of Water Affairs with the Department of Environmental Affairs into one ministry, which was a move that was intended to provide greater coordination and integration between the two departments (Centre for Environmental Rights, 2014).

5.5.5 Governance challenge 4: Prior failures to address issues

The context in which local water authorities in the LSRV operate has been influenced by multiple policy-level interventions in the last decade: this sub-section focuses on policy interventions occurring between 2008 and 2012, in the period directly leading-up to the institutional reforms discussed in the above sub-section. The focus is on those interventions that were either explicitly aimed at, or involved, the transformation and turnaround of local water authorities, in terms of their relevance for bulk water management in the LSRV (as summarised in Table 5.7).

The first intervention listed in Table 5.7 is the Siyenza Manye programme, which was launched with funding from the Development Bank of Southern Africa (DBSA) in 2008. The Siyenza Manje programme deployed "experts to municipalities to assist with the implementation of infrastructure projects, planning and financial capacity building" (World Bank, 2009: 30). A more specific aim of this programme in the Eastern Cape has been as a mediating layer between local municipalities and consulting engineers (discussed further in sub-section 6.5.3), with an engineer assigned to the SRVM in 2009 under the auspices of this programme.

A primary factor for the DBSA-funded Siyenza Manje programme was the skills shortage within local municipalities, which was recognised as inhibiting service delivery. The broader challenges of local government were acknowledged in a frank 'State of Local Government' report compiled in 2009 (CoGTA, 2009b), following which CoGTA released its 'Local Government Turnaround Strategy' (CoGTA, 2009a) (as introduced in sub-section 4.7.2). The poor state of financial management (and subsequently, of service delivery) in the SRVM led to the municipality being placed under provincial administration in 2010, which saw multiple interventions into municipal water services occur (including Amatola Water undertaking a turnaround strategy and the Rapid Response Unit of DWA undertaking emergency work). The concern with the inadequate transformation of water user associations led to a DWA-funded project being initiated in 2011 (which is described further in sub-section 6.3.5). Lastly, with the passing of the *Municipal Systems Amendment Act* (RSA, 2011) in July 2011, the CoGTA minister was granted additional powers to regulate the appointments and dismissals of "municipal managers and those directly accountable to them" (van Niekerk, 2012: 61), which was aiming at counteracting municipal staffing problems.

Table 5.7: Summary of state interventions. DWA = Department of Water Affairs; CoGTA = Department of Cooperative Governance and Traditional Affairs; DBSA = Development Bank of Southern Africa (DBSA); WUA = water user associations; L-WUA = Lower Sundays River Water User Association; AW = Amatola Water; SRVM = Sundays River Valley Municipality.

Government intervention	Date	Leading agent	Relevance for bulk water supply in the Lower Sundays River Valley (LSRV)
Siyenza Manje and the Municipal Infrastructure Support Agency	2008	DBSA, then CoGTA (2012)	Technical official (engineer) deployed from DBSA to the SRVM to assist with project management (including water and sanitation infrastructure) and associated matters in the SRVM Technical Directorate.
Local Government Turnaround Strategy (LGTAS)	2009	CoGTA	Proposed plan for systemic 'turnaround' of local government sector, towards improved service delivery: interventions into local government to be coordinated through CoGTA, with nine strategies other aiming towards improved service delivery.
Provincial intervention into the SRVM	2010 – 2011	Provincial department of CoGTA	Provincial administrator contracted on a short-term basis as acting municipal manager to oversee turnaround; as regional water board, AW contracted to assist with 'turnaround strategy' and business plan.
Turnaround strategy for SRVM water services	2010 – 2012	Amatola Water (AW)	AW supporting turnaround of SRVM water services through above-mentioned measures (discussed further in sub-section 6.4.2).
'Rapid Response Unit'	2011 – 2012	DWA	Initiated in 2011 to provide assistance to the SRVM on an emergency basis, aimed at sanitation towards improving performance in Green Drop assessment but with additional focus on drinking water management (discussed further in Chapter 6).
'Development of WUA business plans' project			L-WUA required to produce business plan outlining how its operations would become reflect transformational goals (discussed further in sub-section 6.3.5).
Municipal Systems Amendment Act (No. 7 of 2011)	2011	The Presidency	CoGTA granted additional powers to regulate appointements and dismissals of municipal managers and senior managers in municipalities, with constraints on municipal employees and officials playing multiple roles in businesses, political parties and municipal management.

The above interventions highlight that prior to the institutional reforms from 2013 onwards, multiple interventions had been initiated across and between different organs of state. Interventions into local government are subject to the constitutional provision that provides local government with autonomy, which is discussed as a dimension of the fifth and final governance challenge.

5.5.6 Governance challenge 5: constitutional constraints on interventions

The autonomy of local government as an independent sphere of government has been introduced at a number of points in this governance analysis (beginning with sub-section 5.3.1). The 'Carolina case' (Chief Luthuli Municipality) provides a salient example of these constitutional challenges. In 2012, contamination in the Chief Luthuli Municipality's water supply led to DWA needing to intervene. In the subsequent court case, the Minister for Water and Environmental Affairs stated the following:

> While the department [DWA] accepts ... its role as regulator and custodian of water resources ... it is worth noting that in terms of the Water Services Act: 'Every water services authority has a duty to all consumers or potential consumers in its area of jurisdiction to progressively ensure efficient, affordable, economical and sustainable access to water services'. The municipalities fall within the definition of water services authorities, and are therefore responsible for ensuring access to water services in their areas of jurisdiction. We have stated this fact in court ... In fact the department, in accordance with its regulatory function, had conducted a thorough assessment of the treatment-plant capabilities and shortcomings in the Chief Albert Luthuli municipality late last year as part of the Blue Drop audits prior to the contamination problem and had made recommendations for urgent improvements (Mail & Guardian, 2012).

The Minister acknowledged that DWA was now having to force many local government institutions to 'do their jobs' (Mail & Guardian, 2012) , but the above quote also highlights DWA's limited response to non-compliance in terms of 'recommending urgent improvements'. As discussed in sub-section 5.3.6, DWA has lacked an intervention strategy since the passing of the Strategic Framework for Water Services in 2003 (DWAF, 2003), which has exacerbated the larger problem of how and when national government can intervene in the local government mandate of water services. The Constitution states that "national or a provincial government may not compromise or impede a municipality's ability to exercise its powers or performs its functions" (RSA, 1996), but even when local government is evidently struggling (or failing), the Constitution requires provincial government to intervene (under Section 139 of the Constitution). In January 2014, following four deaths in a service delivery protest in the North West province, Muller (2014: 1) argued that provincial government is ill-suited to this task of intervention because

> … provincial governments do not have water supply and electricity functions. So they do not have the ability to monitor, much less intervene, in the provision of those two basic services.

Muller (2014) argues that adjusting how and when national government, or regional water utilities, can intervene in local government functions amounts to a 'Constitution crisis' that requires constitutional amendments.

5.6 Conclusion and way forward

This chapter has situated the challenges faced by local water authorities and water users in the LSRV within an understanding of the formal institutional domain that governs water resources and the provision of water services in post-apartheid South Africa. The motivation to do so followed the conceptual framing of this study (see section 2.3), which posited a complexity-based view of institutional change that stressed the importance of placing local arrangements (of water management and local government) within wider frames of governance, whilst acknowledging that factors impacting on development in any particular setting have occurred at different institutional levels and biophysical scales. The institutional analysis therefore aimed to balance a focus on local complexities with seeking to identify and track the larger processes that inform those local complexities (following Cleaver, 2012: 19). In order to explore *what* these larger processes are, and *how* these processes have impacted (and continue to impact on) the way in which water is managed and governed in the LSRV, two analytical methods were employed in Part II, in the form of an historical analysis (Chapter 4) and a governance analysis (Chapter 5).

The five inter-related governance challenges discussed in Section 5.5 of this chapter have highlighted the complexity of the formal institutional domain of state-initiated arrangements in the water sector. These governance challenges all have historical antecedents, in terms of how water and local government functioned in the apartheid and colonial eras, and the post-apartheid policies that aimed for historical redress (which were explored in Chapter 4). Rather than the combination of increasing participation and increasingly-skilled service delivery agents working in a virtuous cycle towards the outcome of improved service delivery, a vicious cycle is evident in which ineffective water governance contributes to social and political instability, continually requiring state and external agent intervention and bailout. In order to explore the dynamics of this vicious cycle, we need to understand how this cycle has persisted in spite of extensive government interventions and policy reforms: to this end, the LSRV provides an engaging case in which institutional change in the 'muddled middle' can be explored, toward understanding the vicious cycles affecting local water authorities in South Africa. Part III of this study draws on extensive ethnographic and operational data pertaining to on-the-ground water service delivery in the LSRV in order to explore the vicious

cycle, and to account for an action research process that sought to engage local water authorities in the LSRV. The following chapter employs an ethnographic tool of 'thick description' to explore the LSRV case.

Chapter 6 Thick Descriptions

The conceptual and methodological framing of this study posited human beings as meaning-making agents who interpret and respond to their environment in broadly subjective ways (see section 2.4 and sub-section 3.5.2). As such, agents in the Lower Sundays River Valley (LSRV) are not expected to respond to legislation and other aspects of the formal institutional domain in a deterministic manner (by simply adhering to, or completely resisting, the rules-in-form as described in Chapter 5). Rather, individuals work within organisations that interact in the muddled middle between the rules-in-form and the rules-in-use (where the latter is understood as informal rules and those rules that are adaptively applied in practice). The adaptive application occurs within a social world that is "complex, multi-faceted and densely compacted" (Layder, 1998: 113); a world in which the nature and modes of social interaction and relationships are of vital importance. This chapter draws on the ethnographic tool of thick description, which developed in anthropology but has been employed by the broader social science community (as discussed in section 6.1). Three thick descriptions are then recounted in sections 6.2, 6.3 and 6.4, and discussed in section 6.5 through employing concepts developed in the framework in Chapter 2, and drawing on the historical and governance analyses of Part II. Section 6.6 reflects on the methodological use of thick description, and moves into the action research process.

6.1 Introduction: how and why thick descriptions are used in this study

6.1.1 Beginning at the end: the Kirkwood protests of September 2014

On the 23rd September 2014, violent service delivery protests began in the Sundays River Valley Municipality (SRVM), in which municipal offices and infrastructure in the Kirkwood region were set alight by protestors and burned to the ground. The media reported several reasons for the protests, including that "residents were protesting over water cuts that had lasted for about three weeks" (SAPA, 2014), and that "Kirkwood residents [were] furious at the Sunday's River Valley Local Municipality writing off more [than] R80 million after awarding tenders to companies who had allegedly failed to deliver services" (Sesant, 2014). The protests occurred more than three years after provincial government placed the SRVM under administrative review, which was one of a host of government interventions into the SRVM. The Kirkwood protests in September 2014 occurred towards the end of the research process reported upon in this study. In this chapter, I construct an interpretive account that draws on fieldwork data collected between 2011 and 2014, with the aim of exploring the

September 2014 protests in Kirkwood not as as an event, but as a dramatic manifestation of a systemic problem that has developed over time. To do so, an ethnographic approach is drawn from (the ethnographic research approach, which is arguably at the heart of anthropology, was introduced and defined in sub-section 3.5.2). This chapter employs a particular ethnographic tool, namely 'thick description'. The remainder of section 6.1 defines the tool of thick description, outlines its early and contemporary proponents, and summarises the benefits and limitations of thick description in terms of its use in this study.

6.1.2 What is thick description?

Learning about Balinese cockfights is almost a rite of passage in undergraduate anthropology education – both for the lecturer who (often poker-faced) stands in front of a class recounting how Balinese men like playing with their cocks, and for the students forced to suppress guffaws at the many double-entendres on hand. More than a suitable launching point for talking about Balinese culture, the cockfight frequently serves as the introduction to the anthropologist Clifford Geertz, who drew on it for his theory of thick description (Geertz, 1973). For Geertz (1994: 123-124), "the culture of a people is an ensemble of texts, themselves ensembles, which the anthropologist strains to read over the shoulders of those to whom they properly belong". Anthropological data should therefore be seen as anthropologists' "own constructions of other people's constructions of what they and their compatriots are up to" (Geertz, 1973: 9), rather than being reported as objective findings. This argument extends beyond merely emphasising the inherent subjectivity of ethnographic data: in the Geertzian tradition, an ethnography is an interpretation *of* interpretations (Denzin & Lincoln, 2008: 24). Geertz drew from the philosopher Gilbert Ryle (1968) and the distinction between thick and thin accounts using the example of a twitch and a wink. Whilst a twitch can be explained with a cursory description of muscle contractions around the eye, a wink can be loaded with meaning (perhaps romantically suggestive, possibly humorous, or both). In analysing the action of a wink (as a metaphor for a cultural act), the anthropologist "must interpret what the intention behind the movement was… [which] can only be based on a thorough understanding of the context of the situation" (Thompson, 2001: 66). Thorough understanding is derived by exploring layers of meaning in cultural acts, hence, a Geertzian ethnography should contain data that "arouses the bafflement, the intense curiosity and interest, that necessitates the interpretation of cultures" (Greenblatt, 1997: 15). This interpretive practice makes it possible to "widen out into enormous complexities of social experience" from relatively simple incidents (Geertz, 1973: 19), rather than attempting to

provide a full explanation of a particular culture or cultural act. The resulting analysis "cannot be conclusive but should be convincing" (Blasco & Wardle, 2007: 204). Cultural analysis is therefore "not an experimental science in search of law but an interpretive one in search of meaning" (Geertz, 1973: 5).

Thick description has been discussed and critiqued extensively within anthropological literature (for thick description and Balinese culture, see Roseberry (1982) and Guggenheim (1994); for Geertz's theoretical programme, see Shankman et al. (1984); for debates around ethnocentrism, see Geertz (1986) and Rorty (1986)). In short, critiques of thick description from within the discipline of anthropology draw attention to the fact that thick descriptions of cultures are often impoverished of historical and socio-economic context, and hence (in spite of its name) thick description offers curiously 'thin' accounts of the very phenomena it purports to interpret in detail (Guggenheim, 1994; Roseberry, 1982; Shankman et al., 1984). In spite of the critiques *within* anthropology, thick description has more recently been adopted with some fervour *outside* of its founding discipline. In the last two decades, thick description has been promoted as applicable to a range of fields, from qualitative research more broadly (Atkinson & Delamont, 2005; Denzin, 1989), to literary criticism more specifically (Greenblatt, 1997). It has also been incorporated into Flyvbjerg's conception of 'a social science that matters' (Flyvbjerg, 2004, 2006), and applied to policy analysis (Thompson, 2001). The following sub-section explores this contemporary uptake of thick description in order to account for the way in which this tool was employed in this study.

6.1.3 Contemporary uptake of the tool of thick description

For the editors of the *Sage Handbook of Qualitative Research* (Denzin & Lincoln, 2008), thick description is one of the five ways in which qualitative research can be distinguished from quantitative research. The book's editors argue that thick descriptions of social worlds, which direct attention to the specifics of particular cases, are more valuable to qualitative researchers than they are to quantitative researchers (given that quantitative researchers are typically interested in developing generalisations out of a sample of specific cases) (*ibid*.). The argument against the research practice of attempting to explain complex phenomena through generalisation is sometimes traced back to the philosopher Friedrich Nietzsche. In his book *The Gay Science* ([1882] 1974:), Nietzsche described researchers who are

> … curious to a vice, investigators to the point of cruelty, with uninhibited fingers for the unfathomable, with teeth and stomachs for the most indigestible... collectors from morning till late, misers of our riches and our crammed drawers.

Nietzsche argued that "above all, one should not wish to divest existence of its rich ambiguity" (Nietzsche, [1882] 1974: 335). Flyvbjerg draws heavily on these Nietzschean perspectives, emphasising the value of ambiguity in qualitative case studies (Flyvbjerg, 2006), and motivating for a wide collection of source material and a knowledge of details in the research of complex social phenomena (Flyvbjerg, 2004). One of Flyvbjerg's methodological guidelines urges researchers to "emphasize little things… [because] small questions often lead to big answers" (*Ibid*, 295). For these reasons, Flyvbjerg positions thick descriptions as a crucial part of what he terms a 'social science that matters' (Flyvbjerg et al., 2012; Flyvbjerg, 2001).

For the above theorists, thick description engenders verisimilitude, where "the voices, feelings, actions, and meanings of interacting individuals are heard" (Denzin, 1989: 83). Such interactions contribute to the complexity of human agency in social-ecological systems. Thick description has therefore been a useful tool in this research precisely because of the way in which the messiness of problems are grappled with and then rendered. As Geertz put it, ethnographers face "a multiplicity of complex conceptual structures, many of them… knotted into one another, which [they] must contrive to somehow first grasp and then to render" (1973: 10). According to Thompson (2001), whose argument is built on here, policy analysts are like ethnographers, in that they too must account for a multiplicity of knotted structures, concepts and lived realities of policy-affected stakeholders. Thompson (2001) further argues that when employed as a tool in policy analysis, thick description has the potential of conveying the messiness of problems better than the presentation of numerical data alone can. For these reasons, thick description is held to be an appropriate tool for investigating the challenges facing local water authorities in South Africa. The following sub-section outlines the particular way in which thick description is used in this study.

6.1.4 Chapter objectives

This chapter has two objectives that contribute to the overall aim of this study:

- To employ the tool of thick description to the governance and management of bulk water in South Africa, using local water authorities in the LSRV as a case study; and
- To analyse how the use of thick description in this study differs from the classic 'Geertzian' approach, by discussing the benefits and limitations of the qualitatively 'thicker' form of thick description developed and applied in this study.

The first chapter objective is met by developing three thick descriptions. These three thick descriptions are interrelated and inter-dependent; feature an overlapping set of actors (predominantly research informants, participants, and interviewees); and they draw on research conducted between 2011 and 2014 (with an emphasis on the in-depth fieldwork conducted between October 2011 and October 2012). Following the approach advocated by Denzin (1989) and Thompson (2001), each thick description:

1. Recounts the simple event that acts as the starting point of the thick description;
2. Explores the context of the event;
3. Investigates the actors' intentions and meanings that organised the event and the associated actions;
4. Traces the evolution and development of the event; and
5. Presents the event (and the associated analysis) as a text that has been constructed from field notes and other collected data, and interpreted for the wider purposes of this study.

The use of thick description in this chapter both builds on, and draws from, the historical analysis developed in Chapter 4 and the governance analysis provided in Chapter 5. These preceding chapters assist with the second, third and fourth points in the above list, reducing the need to provide contextual and background information pertaining to actor dynamics throughout this chapter.

Each of the three thick descriptions is supported by standalone endnotes. These endnotes provide additional background information, qualifications and contextualisation, and feature cross-references between the thick descriptions and specific data sets and sources tabulated in Appendix A, and between the thick descriptions and the material in Chapters 4 and 5. For the coherence of the telling of these thick descriptions, the endnotes for each thick description are

separately provided at the end of each thick description (i.e. at the end of sections 6.2, 6.3, and 6.4).

Eight 'fieldwork stories' are also presented in this chapter. For anthropologists, fieldwork stories function to "ambiguate the agency of the ethnographer by presenting them as children who undergo a process of socialisation and acculturation" and therefore "do a discipline-wide job of justification and legitimation" (Blasco & Wardle, 2007: 149-150). Each fieldwork story is related in the first-person (as a story or experience) and is presented in one of a series of numbered textboxes that are interspersed throughout the chapter. These fieldwork stories:

- Act as windows into the research process;
- Help account for how rapport, "that mysterious necessity of anthropological fieldwork" (Geertz, 1994: 98), was built with informants; and
- Locate the thick descriptions within the context of the broader action research of this study.

Section 6.6 of this chapter addresses the second chapter objective, which is to discuss the benefits and limitations of the 'thickened' form of thick description developed in this study. This section argues that this 'thicker' form of thick description can be used as one form of ethnographic research that contributes to a deeper problem analysis of complex policy dynamics.

6.1.5 Overview of three thick descriptions in this study

This chapter explores the processes of management and practice involving bulk water supply in the LSRV, incorporating the interactions of participating, interested, and affected actors in the planning, managing and operating of bulk water services. This empirical focus is used to provide insights into the overall challenges of the municipal turnaround in the SRVM, and in doing so, aims to develop insights into the complexities of water governance in post-apartheid South Africa. These three thick descriptions provide a rich contextual background for the action research process that is at the centre of this study, and which is introduced through the accounts of fieldwork experiences interwoven into the thick descriptions. Each of the three thick descriptions is summarised here.

The first thick description pertains to the internal operational challenges over the time of the municipal turnaround (2010-2011), focusing on how different actors accommodated for and tried to work within the operational challenges that the municipality faced in providing

potable water services. As with all three thick descriptions, a specific event is used as the starting point. This first thick description involves the SRVM releasing a public notice warning residents that the municipality's tap water was unsafe for drinking purposes, and therefore required household-level treatment. The rumour that the SRVM had run out of chemicals to treat its water was perceived by certain members of the public as a further indicator that the municipality was failing to perform the most basic water service delivery functions. Internally, the technical directorate maintained that the problem lay with access to the municipal budget (controlled by the financial directorate), whilst the financial directorate maintained that the problem lay with technical directorate's planning and maintenance programme. How did different stakeholders make sense of the municipality running out of chemicals to treat its own water, and what preceded and followed this incident? The internal operations of the municipality are explored in this thick description with particular focus on the water-related interactions between the technical and financial directorates, and between these directorates and the other agents upon whom the municipality is reliant.

The second thick description pertains to the interaction between the local bulk water supplier of raw water, the Lower Sundays River Water User Association, the municipality, and particular civil society organisations and activists in the main town of Kirkwood. The starting event of this thick description involves a local businessperson forcing open the sluice gate that controls the raw water supply between the Lower Sundays River Water User Association canals and the municipal water treatment works. The motivations for this action, the repercussions, and the surrounding civil society-government interrelations are described in terms of the institutional arrangements, conflict management strategies and coping mechanisms of the participating actors.

The third thick description focuses on a programme to increase the storage dams in the Greater Kirkwood water supply scheme, through a multilateral funding arrangement between the SRVM, the Department of Water Affairs, and the regional water board (Amatola Water). The starting event is a multi-stakeholder meeting that was held in the SRVM in July 2012 as part of the awarding of a multi-million rand infrastructure grant. A stakeholder was ejected from the meeting by an apparent ally, resulting in the meeting prematurely ending, the awarding of the grant being placed on hold, and the relationship between the stakeholders facing damage. The dynamics of the meeting, the resulting fallout between the actors, and the subsequent resolution are examined in detail in this thick description. The multiple stories around what happened at this meeting, and the ways in which actors drew meaning from the

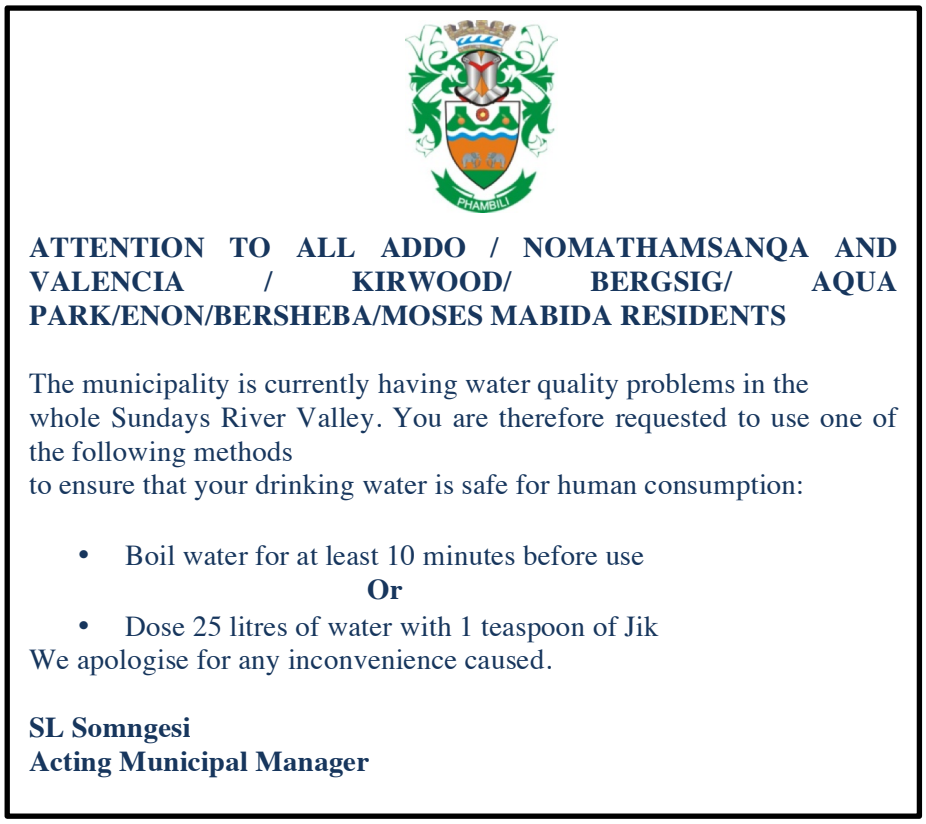
event, provides insights into institutional change and actor dynamics in the case study. Lastly, this thick description explores the institutional arrangements and dynamics of the three participating actors, and provides an account of the shifting role of Amatola Water in water service provision and support services both within the SRVM, and in the Eastern Cape province more broadly.

The selection of these three thick descriptions was both intentional and strategic. Each thick description casts analytical light both backwards (towards interpreting past events) and forwards (towards future challenges). At the case study level, the three thick descriptions and the eight fieldwork stories were selected for the operational, institutional and socio-political dimensions of local water authorities in the LSRV that they illuminate. Importantly, the qualitative data and the associated analysis contained in this chapter relate to the broader action research process that is central to this study. The thick descriptions and the fieldwork experiences therefore provided a rich contextual background for the action research process (which is recounted in the following chapter of this thesis). Lastly, the development of a 'thicker' form of thick description is inherently transdisciplinary, and is a central part of the overall methodology of this study (as introduced in section 3.5 and concluded in section 8.5).

6.2 Thick description 1: internal operations

6.2.1 The incident

On the 24th January 2012, the SRVM issued public warnings that "the municipality is currently having water quality problems in the whole Sundays River Valley." Issued on behalf of the Acting Municipal Manager, the notice requested residents either to boil their water or to treat it with bleach as a precaution to ensure that the water would be safe for human consumption (this public warning is informally referred to as a 'boil notice' and is reproduced in Figure 6.1 below).



ATTENTION TO ALL ADDO / NOMATHAMSANQA AND VALENCIA / KIRWOOD/ BERGSIG/ AQUA PARK/ENON/BERSHEBA/MOSES MABIDA RESIDENTS

The municipality is currently having water quality problems in the whole Sundays River Valley. You are therefore requested to use one of the following methods
to ensure that your drinking water is safe for human consumption:

- Boil water for at least 10 minutes before use

Or

- Dose 25 litres of water with 1 teaspoon of Jik

We apologise for any inconvenience caused.

SL Somngesi
Acting Municipal Manager

Figure 6.1: Copy of the public notice issued by the Acting Municipal Manager of the Sundays River Valley Municipality in January 2012.

Whilst the official statement attributed the boil notice to unspecified 'water quality problems', various members of the business establishment and civil society in Kirkwood believed there was a more specific cause. The municipality was rumoured to have run out of chemicals to treat its water as a result of being unable to service its bills, which was further exacerbated by an inability to procure credit to cover the lack of cash flow. The following thick description

explores how it was that the SRVM ran out of chemicals to treat its water between late-2011 and early 2012, and how this shortage of chemicals and finances were addressed. Key questions that are asked include 'why were no operational or emergency funds available?'; 'why could the municipality not gain credit?'; and most importantly, 'what can this incident – along with the subsequent and interconnected events – show about the internal operations of the municipality between December 2010 and early 2013?'

The official responsible for ensuring the chemical supplies were maintained was the SRVM Water and Sanitation Technician. In his explanation of what happened, he recounted a list of problems that contributed to the problem, including:

- There was no standing order in operation between the municipality and the chemicals supplier (a company called Water Technologies).
- The technical division placed an order roughly every two months. The technical division calculated and submitted the order to the financial division, and the supply chain section of the municipality then places the order with the supplier.
- Water Technologies was to be paid within 30 days, or they will not deliver.
- The chemicals were delivered by Water Technologies within a period of 7 to 10 working days following placement of the order.
- The technician in charge was to place an order when the chemicals are between 20-30% capacity

Although the above process was done on an ad-hoc and largely record-free basis, the technical division maintains that over times of the municipality running out of chemicals, the problem lies with the financial division having insufficient funds available to pay the company – not in the storage or ordering process from the technical division's side. The Water and Sanitation Technician argued that this was just another example of where the capacity to do his job was undermined by a lack of operational funds. The acting Technical Director at the time provided a further explanation, in which he blamed the chemical shortage on two interconnected and mutually-reinforcing factors. The first factor was the increased demand for potable water in the SRVM (resulting in doubling the rate at which the municipal WTW consumed chemicals). The second factor was that the municipality had run out of finances for operational expenditure. The SRVM officials explained that there was some problem with the municipality gaining access to its portion of Equitable Share (introduced in sub-section 5.4.4). National Treasury was allegedly withholding the Equitable Share. The reasons why this was the case were initially opaque. Everyone seemed to be given a different

explanation, with even the councillors within the municipality confused as to the causes. A senior ANC official in the municipality expressed his frustration as follows:

> I think the major problem is that the different departments seem to be working in silos – I get different stories from each department as to why we almost ran out of chemicals.

The different departments, referred to by the councillor, included the technical directorate, the financial directorate, and the community services division (through which the boil notice was issued). When faced with the lack of ability to pay its bills, the municipality's first priority was to find money to pay the chemicals supply-company. The municipality appealed to two actors for assistance with the chemicals bill (amounting to just over R230 000): the first actor was the Rapid Response Unit (RRU) of the DWA, and the second was Amatola Water.[1] As part of the RRU's intervention into the SRVM, DWA had provided a R1 million grant that was to be designated for spending on 'quick wins' – easily-achievable, management-related solutions to the problems faced by the SRVM's water services. Water Technology was paid through this grant with the administrative assistance of Amatola Water. Although the payment provided some immediate relief, a member of the technical directorate acknowledged that the financial bailout was a short-term, undesirable solution. "What would have happened if we did not have the DWA RRU? Being 'bailed out' like this is obviously not a sustainable solution," he said.

Between February and June 2012, further explanations as to how the municipality had splipped into bankruptcy surfaced. These explanations go deeper into what led to the boil notice being issued, and provide insight into the internal operations of the SRVM over the turnaround period between 2010 and early 2012. What emerged from these explanations was a story of how the municipality simultaneously lost both its primary income streams that financed the operational expenditure of the SRVM. As described in sub-section 5.4.4, the financial framework of the SRVM works in accordance with *the Municipal Financial Management Act* of 2003, and is designed on two forms of income being available to cover its day-to-day expenses. The first is the revenue generated from rates (i.e. income from local services provided to residents); the second is Equitable Share. In late 2011 – prior to the boil notice being issued in January 2012 – the municipality had its Equitable Share grant withheld by National Treasury at the same time as the municipality ceasing to issue bills to residents. The outcome of the two funding schemes drying up simultaneously was that the municipality received absolutely no income. The available reserve funds in the SRVM were rapidly

depleted in an attempt to cover the monthly expenses, whilst the majority of larger bills (like the Water Technology chemicals bill) were left unpaid. At this point, the municipality was in crisis mode. An official from the technical directorate expressed his concern as to whether even basic operational expenses (such as ensuring sufficient fuel in municipal cars) could be met. The Chief Financial Officer's greatest concern at this time was to keep the municipality from shutting down due to an inability to pay its staff. So why had the SRVM ceased to issue bills, and why was its Equitable Share grant withheld by the National Treasury?

In mid-2011, the SRVM changed the accounting system used in the municipality from Abacus to a Pastel software package. The new software package and its installation process was supposedly funded by the Eastern Cape provincial government (based out of the province's legislative capital, Bhisho [2]). Municipal officials allegedly challenged the necessity of the new software, arguing that Abacus adequately performed the basic functions required by the municipality. But it was not the software itself that proved problematic – it was the installation and implementation process of the new system being used by the SRVM financial directorate. According to a senior accountant in the SRVM financial directorate, "the service provider responsible for installing the software has not done a good job." He explained that the installation process was "improperly managed", and there was "little or no training involved." The professional service provider in question was a consultancy that had been appointed by Bhisho. The SRVM accountant complained that the consultancy was inexperienced in working with local government, and apparently had only worked in the private sector before. The consultants did not, therefore, know the peculiar stresses and requirements placed on the system in a municipal environment. The result of the software transition was a general inability to use the system in the immediate aftermath. Although data could be *accessed* on the system, there were many problems with being able to *withdraw* relevant data in order to issue bills. According to the same SRVM accountant, the result was that roughly R7.5 million in revenue was lost.

Why the National Treasury withheld the SRVM's Equitable Share grant can be explained as follows. According to the SRVM accountant, at the centre of the Equitable Share problem was a mix-up between municipal officials and the auditors from the National Treasury. The auditors had reviewed the municipal finances for the 2010-2011 financial year, and had miscounted a particular item. The municipality was found to have underspent by R3 million on their Municipal Infrastructure Grant (MIG), and somehow this figure was added to the R7

million that the SRVM owed to DWA. The National Treasury then read a discrepancy between the SRVM's claim that it only owed R7 million and the auditors record of an outstanding figure of R10 million. National Treasury construed the R3 million as 'undeclared' finances in the SRVM budget, and exacted a penalty on the SRVM, which was to withhold the payment of a portion of its Equitable Share.[3] Therefore, according to the SRVM accountant, the SRVM was the helpless victim of an auditing mistake. By the time the mistake was identified, the audit process was officially closed and therefore could not be amended without accusations of 'tampering'. The SRVM CFO and municipal manager apparently wrote letters to the National Treasury to clarify the mistake, but the damage was done. It was several months before the bureaucratic processes yielded and the Equitable Share was released. The emergency was compounded by the lack of so-called 'credit-worthiness' of the municipality. Following the turnaround of the municipality and the period of being under provincial administration, the municipality was deemed financially unviable and therefore could not secure loans or bank overdrafts of any form, even for emergency expenditure like chemicals for the municipal WTWs.

In summary, the chemicals incident provides an example of where everyone – and no one – was to blame. The official responsible for maintaining chemical stocks in the technical directorate argued that he submitted bills to the financial directorate, which then failed to process them and failed to notify him that there were no finances to pay for these basic purchases. The financial directorate, in turn, said that they had not received due notice from the technical directorate, but, more importantly, argued that there was no money available. The causes for there being no money available were variously attributed to provincial government for installing the software; auditors (for the auditing error); and the National Treasury (for erroneously withholding the SRVM's Equitable Share grant and then failing to release the grant timeously).

In order to further explore whether the chemicals incident is atypical or whether it is indicative of a wider set of problems in the SRVM, the focus of this thick description broadens out in the following sub-sections to encompass the internal operations of the SRVM, within which the chemicals debacle played out. The following sub-sections will further discuss the day-to-day working environment in the technical directorate, dimensions of the staffing problems in the SRVM, the rifts that existed between this directorate and the financial directorate, and the impact of a new technical director starting in the SRVM in mid-2012.

6.2.2 The day-to-day working environment in the technical directorate

The majority of the officials with designated 'water and sanitation' roles are within the technical directorate of the SRVM (see sub-section 5.4.3), and so the internal operations of this directorate offer an appropriate point of departure.[4] When interviewed in late-2011, one of the officials who worked in the directorate the longest said the following:

> When I started working here, I used to have a plan of what I was going to do each day. But as time went on, I realised that it was pointless [having a plan], because you never got to stick to it. Unexpected things always came up… so now I just come to work at 06h30 and leave around 18h00, and what I get done in a day, I get done.

A colleague of the above-quoted official similarly observed that "currently the status of this municipality is that we are running after the emergencies and not planning." Technical directorate officials often lamented the dynamic whereby new appointments for meetings arose, and everything else had to be suspended or re-arranged, such that the departmental calendar was in a constant state of flux.[5] For these reasons, most of the technical officials reported that they felt they were not in control of their own time. This lack of control appeared to be due to a combination of interconnected factors, including the presence of constant emergencies and unexpected events, and the technical officials being at the whim of other officials and agents, both within the municipality and outside it, as described here.

Over the course of the turnaround period, attending to constant emergencies became the norm for the SRVM technical directorate. These emergencies were extensive both in number and in complexity, crossing all aspects of water supply and sanitation management. Often more demanding than these technical emergencies was the unofficial duties that technical officials were constantly called to fulil, such as mediating roles. For example, one of my municipal informants in early February 2012 described how the acting technical director was "called away to deal with a crisis where he was held hostage by a group of ex-councillors in one of the communities of the SRVM". The acting technical director spent the afternoon in a police station with a lawyer trying to mediate between conflicting actors in order to get a particular project working again.[6] This crisis happened the day before a Department of Water Affairs (DWA) assessment, calling the acting director away from the final data collection that was required for the assessment. The technical official who recounted this incident said that being an under-staffed department in a small municipality, there was no one available to take the director's place, so the municipality suffered in the DWA assessment. This DWA assessment

was a particularly important fieldwork event (and is described in the fieldwork story in Box 6.1).

Box 6.1: Fieldwork story 1 – the 2011 'Blue Water Services Audit' performed by the Department of Water Affairs (DWA)

In early November 2011, DWA dispatched three officials to the SRVM to assess the municipality under the Regulatory Performance Management System (RPMS) and Blue Drop regulatory programmes (in a joint-assessment referred to as the 'Blue Water Services Audit'). At this point I had only been in the field for two (somewhat-overwhelming) weeks, but I happened to be in the right place at the right time when several municipal officials were discussing the imminent DWA assessments: I was told that the assessments usually last a few hours and are mostly bureaucratic and therefore hardly exciting, but I was invited to attend nonetheless. I later found out that the assessments are typically 'tick-box' exercises, where the DWA assessors ask the municipal officials to submit specific documentation (a list of which is emailed to the municipality several weeks in advance). The assessment is typically followed by a quick site visit to one of the water treatment works, with the entire process completed in a half-day. Instead of following this standard protocol, the DWA assessors sat with the municipal officials in the council chambers for nine hours (from 10h00 to 19h00), explaining why each item of documentation was required and querying how the SRVM managed various aspects of its water unit. I stayed throughout the assessment, taking many pages of notes on my laptop, asking a few questions, but for the most part just observing. The assessors and the majority of the municipal staff remained in the council chambers for the sporadic tea times and over the meal breaks (in which food was served in the chambers), allowing for informal conversation and interactions. The next day, the municipal server malfunctioned, so the technical officials emailed follow-up reports to the DWA assessors off of my laptop. For me, the assessment provided an immensely useful window into the SRVM's water services, and marked the point at which my key group of municipal informants stopped being research 'subjects' and started becoming individuals and professionals with whom I was engaged in an action research process.

To a senior DWA official, who had worked in water management in the Eastern Cape for 20 years, the wider problem introduced in the account of the technical official being 'held hostage' is that of technical officials getting drawn into municipal politics. He argued that this dynamic is particularly prevalent in small rural municipalities, where "the politicians need someone from the technical division to come hold their hands in case they get asked a technical question by a community member or government official". The number of meetings that technical officials were required to attend was something that the officials frequently lamented. As one technical official remarked:

> There are so many of these committees and meetings – South African Local Government Association, Department of Cooperative Governance and Traditional Affairs, Department of Human Settlements, Department of Water Affairs – and we need to attend all of them.

According to this technical official, most of the meetings at the provincial level also require a representative from the technical directorate to be present – and attending these meetings entails hours spent travelling and many other opportunity costs. Furthermore, because of the constant need to be dealing with emergencies, many of the technical directorate officials described a disturbing pattern whereby new meetings were scheduled over currently prioritised ones, which had a knock-on effect of requiring the whole schedule to be suspended or re-arranged. But according to the senior DWA official quoted above, municipalities often fail to attend the most important meetings:

> These people never turn up at the bilateral meetings [between DWA and municipalities] – or if they turn up they are junior officials who don't know about anything at the management level…

In conversation with me, the DWA official provided an example of the most recent bilateral meeting held in mid-2013. The meeting was between DWA and four municipalities, and was attended by 18 DWA officials including officials at the deputy-director level. According to the DWA official, only one representative from all four of the invited municipalities arrived. Our transdisciplinary research project experienced this aspect of municipal management first-hand on a number of occasions, one incident of which is recounted in Box 6.2 below.

Box 6.2: Fieldwork story 2 – meetings

In February 2013, our transdisciplinary research project had arranged to host a follow-up workshop between DWA, the bulk water supplier in the region, and the municipality, regarding a recurrent multi-actor bulk water supply problem in the SRVM (described in detail in sub-section 7.4). In the immediate lead-up to the workshop, it transpired that there were three other meetings in the Eastern Cape that municipal officials were required to be present at *on the same day*. The municipal technical officials had divided themselves in order to be represented at all the meetings, reducing their capacity to make decisions at any of the meetings, including the SANPAD workshop. In responding to the delay of the SANPAD workshop, a manager in the regional DWA office emailed the municipality (cc'ing all the workshop participants into the email) saying that the municipal officials "had to be smart in prioritizing who attends meetings/workshops arranged for municipalities around the water sector." The manager noted that one of the meetings on this day was the Eastern Cape Water Committee, which is strategic in nature and only holds meetings twice a year. The manager argued that DWA could not be prescriptive with who attended what meetings, but that the municipality needed to plan ahead and balance service-delivery with legislative requirements.

From the perspective of several of the consulting engineers who were employed by national government as part of the Rapid Response Unit (RRU) intervention into the SRVM, "meetings do not count as work". According to these engineers, the technical officials of the SRVM should be at the municipal water-works, involved in fixing and maintaining

dysfunctional infrastructure, and actively undertaking the planning, budgeting, monitoring and reporting aspects of municipal administration that are required of the technical directorate. In short, the RRU engineers argued that technical officials should be actively 'doing' rather than meeting and talking to people about doing these things. The consulting engineers recommended that, as a rule, meetings should be kept to a minimum and should be tightly chaired and managed so as to avoid wasting time.

Whilst municipal officials broadly agreed with the recommendations of the consulting engineers, the technical directorate's management of meetings was noticeably hampered by multiple administrative challenges. Over the course of fieldwork between October 2011 and February 2012, I experienced how frequently municipal officials' email accounts were rendered inaccessible (due to the municipal computer server suffering constant problems and shutdowns). I witnessed how these computer problems often prevented meaningful preparation ahead of scheduled meetings and complicated basic tasks, such as confirming the dates and times of meetings. A further possible reason why this level of disorganisation persisted in the technical directorate in this period was the lack of an administrative manager and secretary. In the nine-month period between October 2011 and June 2012, the administrative officer in the technical directorate was on sick leave under a report of being 'injured on duty'.[7] There was no replacement for the administrative officer over this time, meaning that the officials in the technical directorate managed their own diaries. The lack of administrative capacity in the technical directorate was one of a host of staffing issues that the SRVM faced, which are explored in greater detail in the following sub-section.

6.2.3 Staffing

The staffing issues in the technical directorate offer insights into the different types of staffing capacity problems that the municipality faced more broadly. These issues included vacancies (where required posts are unfilled), the skill set of the currently-employed staff members, the training of these staff members, and the motivation of staff members (both positive and negative).

The most obvious staffing problem in the technical directorate as of October 2011 was vacancy. The municipality employed too few plant operators (also called 'process controllers') to enable the water treatment works to operate at full capacity, and several key management posts remained unfilled. Most noticeably, the technical directorate lacked a

qualified engineer to head the division (a technician was acting director between July 2011 and June 2012).[8] There were many perspectives as to why the municipality struggled to recruit qualified engineers – ranging from the availability of qualified applicants, to the salary-level, to the political appointment processes (these broader staffing problems are considered further in sub-section 6.5.3). A councillor in the SRVM summed-up the numerous aspects of why he believed municipal engineers were scarce as follows:

> No one wants to come to a small rural municipal in the boondocks - particularly one that already has a bad reputation for municipal mismanagement. Small municipalities like ours struggle to recruit qualified engineers…

A new technical director started in the SRVM several months after the councillor's above comment (the impact of this appointment is described in sub-section 6.2.6). The skill set of the staff members currently employed in the technical directorate was the second obvious dimension to the municipal staffing challenges. Several of the key management-level positions in the municipality were filled by junior officials on a 'temporary' basis – in some cases, this temporary situation had extended over a number of years and become the norm. A senior DWA informant described this problem to me as follows:

> I've been around this business for a while, and I see people applying for the position for the sake of the position – not knowing the work it will entail. Sometimes they are unaware of what they are getting themselves into, which is wrong – you should surely know what you're getting yourself into. In the municipal environment, a lot of people are inexperienced when they get into positions like those in the technical division, they jump in the deep end and you've gotta swim from day 1: and sometimes some of them sink, and they don't make it. This is one of the biggest problems in local government – the incompetence in positions… I've had a lot of interaction with Sundays River [municipality] and I have to say that a lot of the problems there are exactly that: incompetency.

A businessman who was actively involved with municipal management in the SRVM added further nuance to this perspective, when he described the following to me in late 2011:

> I asked one of the [acting] technical directors: 'what's a pipe reducer?', a reducer being the thing that takes a larger pipe to a smaller one - connected by a flange. And he didn't know what I was talking about. That is why there is no stock available - the people managing just don't have the skills. The people on the ground level are under one helluva pressure. They are the physical worker who needs to dig the trench, who needs to do the work. But, on the management level, the skills just don't exist.

The two responses to a skills-deficit in the SRVM were to either employ more skilled officials or to further train the current employees. Over the course of the turnaround period, at least two of the officials in the technical directorate were studying for their Masters degrees on a

part-time basis, providing a local example of a trend throughout local government.[9] Several of the technicians at the water treatment plants also attended training under the Sector Education Training Authority (SETA) for the municipal water sector. All of my municipal informants expressed dissatisfaction and exhaustion with their current workload and working conditions, in spite of attending these training programmes. One informant in the technical directorate said that from his perspective, there was actually an incentive to avoid working hard and being efficient in local municipalities. This informant described how officials within the municipality did not treat one another as professionals, saying that "too many people at this institution want to take shortcuts and not follow the statutory requirements." The official argued that he was currently performing the roles of several of his colleagues, who were avoiding doing their jobs as a result of being overworked themselves, lacking the required skills, or lacking the motivation. The net effect of his compensating for his colleagues' workload was that he felt stuck in a discouraging cycle, whereby the more work that he did effectively, the more additional work he was given, and the more projects he was asked to provide assistance to, and the less he could therefore focus on his own work.[10] He said that the lack of buy-in from his colleagues and from other divisions in the municipality meant that he was "over putting in the extra effort". From now on, he said he would just do what was in his job description.

According to the same senior DWA official quoted above, when good employees in small local municipalities are unsupported, it provides little incentive for them to remain motivated. Referring to one such dedicated official, the DWA employee said that

> … if they [the municipality] don't give him the proper support, then in six months time – that enthusiasm, that gusto, it's going to all go, and that means as soon as a better position comes up he's gone.

In December 2012, almost precisely six months after the DWA informant made this prediction, the dedicated municipal official in question left the local municipality that he worked at in the Eastern Cape, in order to take up a better job offer in another province.[11]

The vast majority of my informants from civil society, the district municipality, and consultancies also argued that too-large a percentage of the SRVM budget is spent on staffing each year. These informants all complained that by their analysis, any increase in municipal budget appears to be spent on increasing the number of support (i.e. non-technical) staff in the municipality. A local businessman involved in the Kirkwood Ratepayers' Association (who

had tracked the municipal budget over the 2009 to 2012 financial years) argued that "the municipality always says they need more staff… but you can run this town [Kirkwood] with half the staff they've got [doing so]. There are too many people doing nothing." These informants argued that municipal salaries should first and foremost be spent on core (i.e. service delivery related) functions, rather than support functions. The informants pointed out that the support services provided by the municipality (ranging from the local libraries to maintenance of commonages) were nowhere near as vital as the core services. A senior CDM official expressed this as follows: "I'm saying that the municipality should focus on delivering services – basic services, municipal services – not all this other stuff. To my mind, it's job creation". The decision to employ more support service and administrative staff in the municipality, rather than water supply and sanitation staff (for example) is taken at a municipal council level, and is therefore largely out of the technical directorate's hands (these issues are further discussed in section 6.5).

Many of the other problems raised in this thick description, both staffing and otherwise, illustrate the multiple overlaps between the financial and technical directorates in the internal operations of the SRVM water unit. The following sub-section examines the interdepartmental relations between these two directorates, exploring the rifts that were experienced over the course of fieldwork in the SRVM between October 2011 and October 2012.

6.2.4 Interactions between the financial and technical directorates

The chemicals debacle demonstrated the divide between the financial and technical directorates, where even senior councillors within the municipality complained that they would get very different explanations from the two divisions as to where the problems and causes of the crisis lay. This led to several councillors and many of my other informants lamenting the fact that municipal departments appear to be "working in silos". The divided nature of municipal management would lead to disagreements where, for example, an official from the technical directorate would say that he had submitted a claims form to the financial division, and complained that he had not received a response for months, whilst the financial division would complain that the technical directorate had not submitted the required forms. When trying to resolve difficulties and disagreements such as these, a recurring pattern would play out in meetings, which an official from the technical division observed as follows:

> When the CFO [Chief Financial Officer] is present in meetings, everyone agrees with her and with what she's saying, then when she leaves the meeting, everyone disagrees [with her] and starts muttering and complaining, saying "you know, this CFO…"

Another technical official said that in his view, the financial division dominates the other departments: "In this municipality, the financial division is up-top, and everything else is underneath." The perception that the financial directorate is superior to the other directorates is only one example of the interdepartmental problems in the SRVM that affected water service provision. Of related concern is the way in which the financial directorate does not see itself as being a part of the water sector in the SRVM. A consultant who worked closely with the SRVM over the course of the RRU engagement and then on a contract afterwards, described how she made a habit of visiting the CFO whenever she was in Kirkwood, "in order to try and reinforce the point that the financial division is central to water services in the municipality." This consultant was aware of how the DWA assessed municipalities on the interactions between the technical supply of water and the financial administration of water service delivery. The DWA officials who performed the 2011 Blue Water Services Audit in the SRVM frequently asked the technical directorate why the CFO was not present at the assessment.

The interaction between these two directorates in the SRVM is consistent with a broader institutional problem in the SRVM, which is that there is no cohesive water unit in the municipality. As discussed in sub-section 5.4.3, the provision and regulation of water services is a diffuse function shared across five municipal directorates, including Community Services, Corporate Services, and the Office of the Municipal Manager, in addition to the financial and technical directorates. The lack of a cohesive water unit seemed to be exacerbated by a basic geographic issue in the SRVM, which is the physical location of the technical directorate's offices in the Greater Kirkwood area, in relation to the rest of the municipal offices. The technical directorate is located in Moses Mabida, about 5 kms from the main municipal offices that are located in the middle of the town of Kirkwood, which is where the council chambers, municipal manager's office, financial directorate, and the rest of the municipal departments are based (see the map of the Greater Kirkwood region in Figure 7.9). The physical separation of the offices meant that technical officials in general (and the managers and director in particular) constantly move between the two locales.[12] In late-2011, I often found the Acting Technical Director working from his laptop at a vacant secretary's table in the Local Economic Development (LED) office. This physical separation seemed to

particularly take its toll during the late-2011 to early 2012 period in which the municipal telephones and internet were dysfunctional, requiring the acting technical director to handle administrative matters on a more face-to-face basis to compensate for the reduced telecommunications facilities.[13]

One of the issues that required the explicit interaction of the technical and financial directorates was the municipal operational budget. As the historical analysis introduced, the financial situation of the SRVM was such that the municipality only had R24 in the bank at the time of the provincial administrator starting in early 2010 (see sub-section 4.7.2). The attempts to increase the operational budget are described in the following sub-section.

6.2.5 Attempts to increase the operational budget

Whilst under provincial administration, the municipality undertook a number of programmes that aimed to proactively increase the operational budget. Some of these programmes were outsourced (including a financial recovery programme aimed at bill collection). A technical official commented that these programmes typically "fell flat", only achieving around 20% debt collection.[14] Several other programmes aimed to increase the size of the Equitable Share grant that the SRVM received, through increasing the number of indigent households on the municipal indigent register. In an interview in mid-2012, the municipal CFO reported that "in the 2012-2013 year, we had only 2400 households (of an estimated 6000 poor households) registering. About 90% were re-registering households." Assessing the number of poor households is further complicated by discrepancies in the population data. The municipal estimate of the population of the SRVM between 2012 and 2013 was around 42 000, whereas the 2011 'Statistics South Africa Census' reported over 51,000 people.[15] The CFO acknowledged the difficulty of increasing the number of indigent households on the register, saying "I can't put my finger on why this [the indigent registration process] is failing".

One of the other programmes initiated by the SRVM was the Infrastructure and Basic Service Delivery Cooperatives. The cooperatives were envisioned to play a number of roles in municipal service delivery, including indigent registration. The municipality promoted the cooperatives project between late-2011 and early-2012 as a win-win situation with the following benefits:

- By employing local residents and supporting these residents to form cooperatives, the municipality was fulfilling its local economic development of job creation;

- By equipping the cooperatives to perform minor leak detection and repair, the municipality could reduce bulk water losses throughout its distribution network; and
- By tasking the cooperatives to take meter readings, deliver municipal bills, and register indigent households, the municipality could increase its operational revenue.

The rationale for making indigent registration one of the functions of the cooperatives was that members of the cooperatives themselves came from indigent communities in the SRVM, and so they should be able to know how to get residents to enrol as indigent households. Over the course of the trial period (from December 2011 to February 2012), the cooperatives still struggled to register indigent households. In several of the meetings between the municipality and the cooperatives that I attended over this period, the cooperatives argued that the requirements in the SRVM's Indigent Policy are too stringent and actually prevent municipal residents from being willing and/or able to sign-up.[16] In response, municipal officials from both the technical and financial divisions argued that the paperwork required in the registration process is not onerous and that, instead, other factors were preventing households from signing-up. One of the hypotheses commonly mentioned by municipal officials was the erroneous perception of municipal residents that they are unable to work if they are on the indigent register.[17]

The cooperatives project also provided insight into other aspects of the internal operations of the SRVM. The cooperatives were classified as an 'Institutional and Social Development' project in water management, which aimed to simultaneously address multiple problems faced by the municipality. These included a high rate of unemployment, a negative perception of the municipal management during the period of being under provincial administration, and a broad range of administrative and minor technical issues that hampered water service delivery. To sponsor the training of the co-operatives, the SRVM used DWA-awarded funds that were earmarked for programmes that supported 'revenue generation' in the municipality. Yet to many of the technical division informants, the cooperatives project was more of a political project and public relations campaign than it was a programme aimed at either generating increased revenue (through indigent registration) or legitimately fixing leaks. Although categorised as a Local Economic Development (LED) programme, the cooperatives project was primarily driven by officials within the technical directorate, which was mandated to drive the programme whilst the LED director was on sick leave over the course of the entire project planning and initiation period. Several of my informants within the technical directorate described the cooperatives project as being "a burden… [that was] thrust upon

them" by the acting municipal manager (who was deployed by provincial government over the turnaround period). An official from the technical division even alleged that maintenance funds were withheld from the technical directorate in order to support the cooperatives programme (and then were not used as a result of the programme discontinuing). For their part, the cooperatives saw themselves as small businesses that were denied the opportunity to work efficiently with the SRVM. At a heated meeting between the cooperatives and municipal officials in November 2011, representatives from several cooperatives said: "We are in business with this institution. The municipality must not mess us around." The charges the cooperatives wanted to levy for each role they performed were deemed too high by the municipality, whilst the tariffs the municipality were willing to pay were deemed too low by the cooperatives. In the negotiations that followed – which ultimately led to the charges being set at the municipal-level – the Acting Municipal Manager concluded with the following statement:

> If we [senior municipal management] wanted to get service providers, we would have gone for contractors – but this cooperatives project is part of the social responsibility of the municipality.

In summary, the cooperatives programme was one of several programmes that were aimed to increase the operational budget of the SRVM, towards ensuring the financial viability of the municipal water unit (with further issues pertaining to the operational budget analysed in sub-section 6.5.5). This first thick description has introduced a range of issues that interacted to collectively produce the chemicals debacle in the SRVM, including issues of staff capacity, financial management, revenue generation, and institutional relations. The penultimate sub-section of this first thick description uses the initial work-programme that was adopted by the new technical director, who started in the SRVM in July 2012, to continue analysing the internal operations of the municipality. The many basic issues that the new technical director sought to address demonstrates the level of dysfunction and disorganization in the technical directorate prior to his arrival, in addition to highlighting various aspects of the internal operations and financial management in the SRVM that help explain the chemicals debacle and the struggles the SRVM faced in bulk potable water management.

6.2.6 The new technical director

The new technical director – called Sizwe in this study – started work in the SRVM seven months after the SRVM's period of provincial administration had ended, and five months after one of the SRVM councillors remarked that "no engineer would want to work in the

boondocks". Whilst the new technical director was a relatively young civil engineer (in his mid-thirties), he had worked in both Eastern Cape local and provincial government and was thus both experienced and skilled. He encountered a range of problems in his first month of working, which he illustrated using the following example in an interview:

> If there's a burst pipe in town on Saturday, you can't do anything until Monday. And then on Monday it's just a matter of getting quotes. And then you need to get that order signed by various officials, and then if you're lucky, [replacement parts] will arrive on Tuesday… We've lost four days before we can get a replacement part, and that's not even installing it… We don't have spares: I am trying to get a container here with a requisition book, so that when people need to get a replacement part, they can get one from our stores. But step 1 is the budget… [and] the biggest problem is how the budget is [currently] structured: you can't trace anything… The budget is simply too high level, it contains very little to help tell me what's happening on the ground: our budgets are broken down by line items only at the level of 'electricity', 'bulk water purchases', not broken down to line items… showing, for example, that we have six pipes or however many number of butterfly valves.

Sizwe argued that many of the immediate problems facing the technical directorate were not necessarily complex:

> A lot of the problems are actually so trivial… Everything is done but then it gets lost. Arguments between departments then become based on hearsay. Even the way [interdepartmental] memos are taken, they can't be traced…

Sizwe listed a range of ways in which he was trying to address these basic administrative problems, which included

> … implementing a reference number system for memos, so that you can see which department (and which division within that department) the memo was sent from, as well as what date it was sent and received.

Whilst putting this system into place was important, it required someone to be handling administration for the technical directorate. One of Sizwe's first management interventions was to arrange for a new administrator to be employed within the technical directorate, to replace the previous staff member who until this point, had remained on sick leave. The new administrator acted as a personal assistant for the technical director (managing his schedule and other equivalent duties) in addition to providing administrative support for the overall directorate. The management of project documentation and paperwork was another area of concern to Sizwe: "Often we have everything, I'll admit, our department just doesn't know where to find it. It's a culture that we basically need to change". Prior to Sizwe starting, an older member of the technical directorate acted as the institutional memory for the directorate

(he was jokingly referred to as the department's archives). To worsen matters, this official admitted that he himself had no electronic back-ups of the department's data, further adding to the vulnerability of that institutional memory given that should his laptop ever be stolen or irreparably damaged, much of the department's data would be lost. Partly to address this possibility, and to establish protocols for preventing the institutional memory for projects being vested in one person, Sizwe aimed to establish project files and paper trails:

> For every project, there will be a project folder - with categories for accounts, agendas, business plans, [technical] drawings, emails, faxes, GIS maps, minutes, photos, presentations, reports, scans, spreadsheets… so it's basically anything to do with a particular project, keeping it filed and together, so that we create an institutional memory.

In other cases, Sizwe adapted to the constraints of his job. Several of the most pertinent examples included adapting to the network problems in the SRVM by using a webmail account and a cellular-based modem rather than being reliant on the still-erratic SRVM email system, and creating a works-order to account for routine operational expenditure that was currently unplanned and therefore un-budgetted. As Sizwe put it:

> With a works order… we can see how much we have used of particular supplies in the 2011-2012 year, and then we can use those figures as baseline figures for orders for the 2012-2013 year. It will only be baseline figures, but it's better than we're currently doing."

In the first month of work, Sizwe acknowledged that the organisational structure of the technical directorate required attention. Referring to the organogram for his department, Sizwe said:

> I've had to throw that thing out. It's a wish list basically. It can't be implemented… Basically what the organogram has now deals with Kirkwood - but it doesn't account for how spread out our municipality is… From one end of the municipality to the other, it's almost 100kms. How much working time do we lose in a day? So operationally, if we need to replace a small part on the other side of the municipality, then it requires losing one of our few officials for half a day in order to travel there and back… it's very uneconomical… So we need an organogram that accounts for people being based at different ends of the municipality, with a supervisor that has his own team. There is no 'upper and lower valley' distinction - where there is such a distinction, it's conglomerated into one post.

Sizwe argued that the addition of the two rural settlements of Glenconnor and Kleinpoort - which were District Management Areas until they were incorporated into the SRVM in May 2011 (see sub-section 5.4.2) made the technical management of the municipality even more operationally unrealistic. In order to monitor or maintain infrastructure and to attend any

required site meetings, municipal officials needed to travel up to 140kms in a day. Sizwe sought to adjust for these challenges through incorporating two major distinctions into the revised organogram. The first distinction entailed splitting the technical directorate between operational and maintenance functions and project management functions, so that certain staff members would perform one function or the other. The second distinction aimed to separate the water service authority (WSA) and water service provider (WSP) functions of the municipal water unit, which was introduced as the second institutional gap in sub-section 5.5.4. The seriousness of this institutional division is examined in further depth in sub-section 6.3.4 of the second thick description.

In summary, Sizwe adopted a proactive and pragmatic approach to many of the problems facing the SRVM technical directorate, yet he was also the first to concede the interwoven nature of these problems and the fact that his interventions were therefore limited in their effects. In describing these challenges, Sizwe sought to highlight what he saw as systemic issues, specifically problems endemic to the municipal system, where there are unexpected feedbacks across and between these issues, and where many of these issues were outside of the control of officials in the technical directorate. In this regard, Sizwe's perspectives were similar to many other government officials' and consultants', who also accounted for what they saw as the systemic challenges facing municipal management. The discussion in section 6.5 synthesises these accounts of systemic challenges, and analyses how they pertain to the internal operations of the SRVM in relation to the two other thick descriptions, and the governance challenges identified in section 5.5.

6.2.7 Conclusion to thick description 1

This first thick description has described the internal operations of the SRVM by focusing on the challenges facing the technical directorate between October 2011 and July 2012. The following issues were introduced:

- The day-to-day working environment of the technical directorate of the SRVM;
- The many staffing issues faced by the technical directorate;
- The effects of the physical and institutional divisions between the technical directorate and the rest of the municipality;
- The attempts to increase the operational budget of the SRVM (and the associated limitations); and
- The work programme adopted by the new technical director.

The first thick description has also touched on the many interactions of the diffused water unit in the SRVM with a range of governmental and non-governmental actors. The following two thick descriptions focus on the interactions between the SRVM and a number of other key actors within a broader set of institutional arrangements. The second thick description focuses on interactions between the SRVM, business and civil society organisations, and the Lower Sundays River Water User Association (L-WUA), whilst the third and final thick description focuses on the interactions between the SRVM and the various organs of government that were involved in the 'turnaround' of the SRVM (including Amatola Water, DWA and the Rapid Response Unit).

Notes for Thick Description 1:

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[1] The 'rapid response units' (RRU) of the Department of Water Affairs (DWA) were introduced in sub-section 4.7.2. The RRUs were instituted by DWA to assist municipalities that performed particularly poorly on an emergency basis (DWA, 2011b). The SRVM was one of six municipalities in the Eastern Cape selected for the RRU intervention on the basis of the its Green Drop score of 5.6 percent in the 2011 assessment (DWA, 2011a, 2011b), with the first meetings between the RRU and SRVM officials occurring in September 2011.

[2] The capital of the Eastern Cape province was formerly known as 'Bisho' and now called 'Bhisho' (the Xhosa word for 'buffalo').

[3] The second governance challenge (barriers to accounting and accountability - sub-section 5.5.3) introduced the punitive measure by which National Treasury witholds funds from non-compliant local municipalities (PMG), 2014b). As noted, this punitive measure is undesirable given that it compounds existing cash-flow problems within municipalities. However, it is one of the few punitive measures available to National Treasury, and illustrates the governance challenges entailed in the decentralised fiscal framework that grants significant authority (and autonomy) to local government, and therefore is also a product of the mal-functioning inter-governmental system in South Africa (sub-section 5.5.2).

[4] The SRVM technical directorate was also where the majority of my primary research informants were employed, with most of my fieldwork in the SRVM undertaken within the technical directorate, or in collaboration with officials from the technical directorate.

[5] This complaint of the SRVM technical directorate (that the department's schedule was in a constant state of flux) was mirrored by a senior official in the national office of the Department of Water Affairs, who admitted to one of my colleagues in the SANPAD project that the national office functioned in the same manner.

[6] The dispute was exacerbated by the fact that an ex-municipal councillor was allegedly involved – and the acting technical director was required to mediate between current and past elected officials.

[7] Other officials in the technical division mentioned that the administrative officer's reason for being on sick leave as a result of being 'injured on duty' was filed as 'stress-related'. I never met this administrative officer, nor was I able to corroborate the assertions that the officer's sick leave was stress-related. What was evident though was that there was no staff member dedicated to administration in the technical directorate between late 2011 and mid-2012 (until the new technical director started – as described in sub-section 6.2.6).

[8] As noted earlier, the last qualified engineer in the SRVM retired in 2007 (see sub-section 4.6.2 above). It is also noteworthy that over the course of my initial fieldwork (October 2011 to February

2012), the acting technical director played a double-role, where he was both acting technical director and acting municipal manager for several months – further reducing the amount of time he could spend on infrastructure and planning issues.

[9] One of the prejudices with which I (unknowingly) began fieldwork was that the majority of my research participants would not have postgraduate degrees, and would actually discriminate against me, on the basis that I was studying further rather than choosing to be 'in practice'. The reality was quite the opposite: the first person I met in the technical directorate of the SRVM was half-way through his Masters degree in engineering, whilst one of my contacts at Amatola Water was in the early stages of an MBA. Over the course of fieldwork, every second or third government official and management consultant that I met was studying part-time. One of the engineering consultants with whom I later collaborated (see Box 6.4) was writing-up his PhD thesis part-time, and I was pleasantly surprised to find that his knowledge of complexity theory was far deeper than my own. With this consultant, as with at least four government officials, our conversations in future months would vacillate between topics pertaining to the LSRV and research themes of common interest. It transpired that my experiences were supported by data from national capacity assessments: the Municipal Demarcation Board periodically undertakes a Municipal Capacity Assessment (as introduced in sub-section 5.4.2 and Table C.12), with the assessment of the 2010/2011 financial year showing that top management in municipalities across South Africa are increasingly qualified, for example, in 2008, "35% of all municipal managers had a qualification above a bachelor's degree; by 2011 this had to 63% of all municipal managers" (Berkowitz, 2012: 1).

[10] The discouraging cycle described by this municipal official – whereby the more work that he did effectively, the more additional work he was given, and the more projects he was asked to provide assistance to, and the less he could therefore focus on his own work – should actually *not* be a reinforcing feedback, because the less this official could focus on his own work, the less work he could do effectively, resulting in him being given less additional work and being asked to provide assistance to less projects, meaning that he should therefore be able to focus on his own work more (in system dynamics terms, this is a balancing, rather than a reinforcing feedback loop – see the causal loop diagram in Figure 6.4 and the associated description for further details).

[11] The municipal official in question worked for Makana Municipality, rather than SRVM, and was discussed between myself and the senior DWA official (informant A:1:1) because we were talking about staffing issues in Eastern Cape local government more broadly (rather than just about the SRVM). Makana Municipality is a particularly relevant comparative case to the SRVM for two reasons. Firstly, Rhodes University is based in Grahamstown (the urban core of Makana Municipality). Makana Municipality was therefore the main local government institution with which I interacted whilst I volunteered for the civil society project introduced in Scene 2 of the preface. Secondly, in April 2013 the SANPAD project expanded into the 'Towards a New Paradigm' project, with Makana Municipality becoming the second Eastern Cape case study in this project (as described in Appendix B).

[12] Note that the technical directorate in Moses Mabida was based in one of the municipal buildings burned to the ground in the September 2014 service delivery protests (as discussed further in sub-section 6.5.1).

[13] According to a councillor in the Cacadu District Municipality, one of the reasons why basic communication services in the municipality were dysfunctional over this period was as a result of municipal non-payment of its bills to the national telecommunications parastatal, Telkom. This issue was also reported in provincial media in late-2009 (The Herald, 2009).

[14] The sensitivity of the financial situation of the municipality at the point of this interview with the CFO prohibited me from finding any form of documentary validation for the CFO's assertions here. However, multiple municipal informants spoke to the limited success of the debt recovery programmes, although they did not (or could not) quantify the results.

[15] The population of the SRVM between the 2001 and 2011 national censuses is contained in Table C.7 of Appendix C.

[16] The Infrastructure and Basic Service Delivery Cooperatives were a major programme in the SRVM between November 2011 and February 2012 (i.e. over my earliest period of fieldwork). For this reason, I attended and participated in a number of meetings and workshops attended by municipal officials and the cooperatives, in addition to conducting focus group discussions with all five cooperatives (referenced in A:2:5 – A:2:9 in Table A.2). However, as described in the action research process (sub-section 7.3.1), the cooperatives project was piloted until February 2012 and then placed under review. The project was central to the system dynamics modelling endeavour described in sub-section 7.5.3, but because it became less relevant over the course of my fieldwork and the subsequent selection of the units of analysis in this study, the project is not extensively discussed here.

[17] Due to the focus of my study, I did not interview households within the SRVM myself, and therefore cannot comment with authority on these different perspectives. Lara Molony surveyed and interviewed a sample of poor households in two townships in the SRVM as part of her masters study, which was part of the broader SANPAD project (Molony, 2014). Molony found that the SRVM Indigent Policy requires households' earnings to be between R100 and R1800 per month in order to qualify as indigent households (*ibid*., 122). Over 73% of the households surveyed in Nomathamsanqa and Aqua Park (the two townships in Molony's study) were registered, with the primary reason for individuals not registering was their monthly earnings exceeded R1800 (*ibid*., 124).

6.3 Thick description 2: The Greater Kirkwood water supply scheme and the Lower Sundays River Water User Association

6.3.1 The incident

Extended water shortages continued to affect the Kirkwood water supply scheme through January 2012. One particularly hot and dry weekend, when the water outages continued and the drinking water reservoirs were depleted, a local businessman saw that there was still water in the L-WUA canal but that the sluice gate separating the canal and the Kirkwood water treatment works (WTW) was locked (see schematic in Figure 7.8). Out of frustration at the lack of progress in resolving these shortages, the businessman used a pair of bolt-cutters to force open the padlocks that secured the sluice gate, in order to allow the canal water to fill up the raw water dams below the WTW.[1] The following weekend (facing another water outage and a more secure mechanism on the sluice gate, placed by the L-WUA) the same businessman used a generator-powered angle-grinder to cut open the lock securing the sluice gate. The SRVM technical officials at the WTW turned on the pumps from the raw water dams to the WTW in order to treat and distribute the water. The L-WUA responded by bringing legal action against the local businessman - including charges of damaging L-WUA-owned property. Furthermore, the L-WUA threatened legal action against the municipality for the theft of raw water, acknowledging that whilst municipal officials had not cut open the sluice gates themselves, the municipality had taken advantage of the situation by switching on the WTW pumps and, as such, they were complicit.

A technical official from the municipality described the problem as follows:

> The police personnel investigating the cutting of the locks asked us, as the SRVM, 'what are we doing to get away from the situation?' I said to the L-WUA CEO, 'can't you as the L-WUA assist us in giving us water on a Sunday to avoid ratepayers from cutting the locks?'

Another technical official described the problem as follows:

> We know there's long term, historical issues between our municipality and the L-WUA. We know that we should have done more in the past – we acknowledge the current shortage, and we have tried dealing with the off-site storage issue in Kirkwood, via applying for, and receiving money for storage dams in Kirkwood… Attending [L-WUA management committee] meetings is not going to help: all we

> want is to have an SLA [service level agreement] with the L-WUA that says this is what they are expecting of us, and this is what we are expecting of them.

Speaking after the event, a junior municipal official conceded that the businessman had done what they, as municipal employees, had wanted to do for some time – which was to force open the sluice gates between the L-WUA canal and the WTW on weekends – but were too afraid of facing legal action and losing their jobs if they did so. The local businessman who cut the locks was never fined though, because in his words, the charges were "thrown out of court because I was acting in the public interest".[2]

The Rapid Response Unit (RRU) intervention into the SRVM's water services was still on-going at this time. One of the immediate reactions of the municipal officials was therefore to approach the RRU team with the problem (in the same way that the RRU was approached over the course of the chemicals incident outlined in section 6.2). The RRU response was two-fold: a rapid infrastructural assessment and a proposal for examining the institutional arrangement between the DWA, the L-WUA and the SRVM.[3] In the rapid assessment, the Kirkwood raw water dams were identified by the RRU engineers as being the source of the immediate problem of running out of water on weekends. The report produced by the RRU engineers proposed expanding the raw water storage capacity of the Kirkwood WTW through building an additional reservoir.[4] In order for the proposal to have an effect on the water shortages, the standard funding process needed to be followed (applying for emergency financing, appointing consultants once financing is approved, with consultants then appointing contractors, who then construct the reservoir). In short, the proposed infrastructural fix would take a minimum of 18 months, and did not attempt to address the operations of the WTW or provide any coping measures that could be performed by the municipality in the interim period prior to the new reservoir becoming operational.

According to the RRU engineers, the best way of beginning to address the institutional issues between the DWA, the L-WUA and the SRVM was to examine the abstraction licences. The RRU engineers, in conversation with the Amatola Water officials, proposed that the following questions be immediately addressed:

- Were the abstraction licences for the Kirkwood water supply scheme recorded under the SRVM or L-WUA?
- Which organisation should have the licences in this situation?
- How should any licencing problem be resolved?

The institutional arrangement between the L-WUA and the SRVM was therefore initially construed as a legal issue centred on water licences. One of the RRU team members made an additional suggestion that the RRU and the SRVM should seek to "escalate the problem to the National DWA office and [to] the Minister", in order to highlight the difficulties underpinning how the L-WUA and SRVM interacted.

The sluice-cutting incident marked one of the lowest points in the relationship between municipal employees and L-WUA officials, in addition to bringing to the fore the problematic nature of the water supply arrangement between the SRVM and the L-WUA. In this thick description, the sluice-cutting incident is explored along with the associated reactions (and interactions) of the various actors, with the following line of argument:

- First, the background of the civil society activism that culminated with a businessman cutting open the Kirkwood sluice gates is provided (sub-section 6.3.2);
- Second, characteristics of the way in which civil society organisations in the LSRV interacted with the SRVM around service delivery are explored (sub-section 6.3.3);
- Third, the contractual arrangement and the lack of a formal 'service level agreement' between the SRVM and the L-WUA is described and analysed (sub-section 6.3.4).

The fourth and final sub-section of this thick description describes the broader interactions between the municipality and the L-WUA, with a specific emphasis on the common and diverging interests of the two organisations, and how these reflect on the bulkwater supply issues in the LSRV (sub-section 6.3.5).

6.3.2 The involvement of the Kirkwood Ratepayers' Association

Businesspeople in Kirkwood were involved in the local water supply scheme for a number of years prior to the sluice-cutting incidents, primarily through the lobbying force and organisational involvement of the Kirkwood Ratepayers' Association (RPA). In 2011, the RPA had extended its involvement to the point of facilitating an interim arrangement between the L-WUA and the SRVM, which included the municipality installing a new sluice gate as a short-term coping measure. The motivations for the RPA's involvement – along with the means of facilitation and coercion adopted by the RPA – are described here.

As of 2011, members of the RPA included the owners of several local businesses in Kirkwood, ranging from guesthouses, to restaurants, shops and suppliers of agricultural

products. One of the most heavily-involved businesspeople described his activism as arising from necessity:

> There was a stage where we were about one and a half to two days per week without water in town, in all the areas, because of water reservoirs not being filled up; inadequate sizes of sluices that open up to fill these water dams; bad management of pumps that trip out over night; [and because] at weekends and at night there's no staff on duty - they work Monday to Friday work hours only. So then the dams run empty or one of the pumps slip and then they only discover it when there's no water in the taps…

The businesspeople all complained that water disruptions were negatively affecting their businesses. Some of the examples provided in interviews included:

- Guesthouses that had to turn away customers due to inadequate water and sanitation facilities;
- Staff members not being able to use the toilets on site, and going home instead;
- Steam ovens, compressors and other mechanical equipment in shops and supermarkets becoming dysfunctional.

Several of the businesspeople acknowledged that the far greater problem was the human right infringement of residents being without access to water for days at a time. As one businessman put it:

> We felt that we needed to do something. Nobody in the community stands up and says 'listen, this is unacceptable'. The poor person who has a house in the township… if he goes to the municipality, they will give him a 110 excuses.

In additional to carrying financial clout – as stakeholders that the municipality could not easily ignore – many of the Kirkwood businesspeople were technically skilled both from a financial management and from an engineering perspective, so they could (and would) challenge the municipal officials on the answers they were given to their queries (as described further in sub-section 6.3.3). A number of businessmen's involvement extended to the operational realm:

> On Monday morning we were at the reservoirs; on Thursday we were at the reservoirs, checking the levels, making sure that the dams were properly filled… we even supplied the petrol for the pumps at one time.

In mid-2011, after monitoring the water supply situation and sometimes even turning on and off equipment at the Kirkwood WTW, several of the businesspeople decided to facilitate a series of meetings between the L-WUA and the SRVM to try and improve the water supply

impasse. In November 2011, one of the instigators described the facilitation process as follows:

> When speaking to the [L-WUA] CEO about this, and after he'd said he was not going to open the sluice gates, I said "Please: I know that you've written letters how many times to the municipality and that they don't react, but we've got a humanitarian crisis facing us." And then the CEO started to understand what was happening, and he said "okay, I'll make a plan". Then me and [another RPA member] had a second meeting with the L-WUA - with some of the members of their board who are farmers, and we put an action plan in place, a medium term action plan, until we could open up the larger outlet, which is now in place… It's been completed two weeks ago: but still, this week they haven't used that larger outlet. So I went to one of the councillors and asked them to check it. Because we are now approaching summer, and the water consumption will rise, and what's the point of us fighting to get the larger outlet if it's not being used?

The businesspeople were involved in negotiating an extended period of water supply for a four-week period whilst the larger sluice gate (or outlet) was constructed. During this period, one businessman recalled how he and the other RPA members tried to hold the municipal officials accountable to the arrangement between the SRVM and the L-WUA: "We pressured the municipality to get this done… We were on the ball, doing follow-ups two to three times a week, sending SMSs, speaking to councillors etc." In the months following the successful installation of the new sluice gate, many of these businesspeople continued to be frustrated by reoccurring water shortages, with the final outpouring of frustration demonstrated in the cutting open of the sluice gate seven months later, in January 2012. The extended involvement of this small group of businesspeople demonstrates that the latter incident was not a random act undertaken without premeditation or background. Before exploring the broader institutional context of the incident from the L-WUA and municipality's perspectives, it is worth exploring why members of the RPA were willing and able to play the role that they did.

6.3.3 The background knowledge, previous experience, skills and contacts of members of the ratepayer's association

Members of the Kirkwood RPA represent a number of interest groups that pay rates to the SRVM. The official aim of the organisation is "to promote and protect the interests and welfare of the members of the association."[5] The members of the association typically include house-owners and residents of the Greater Kirkwood area (predominantly residents living in the town of Kirkwood) and business owners. However, the RPA is connected to the commercial farming community in the SRVM in a number of ways. Many business owners in

the main town of Kirkwood either previously or currently own and/or live on farms, or own and/or manage urban businesses that predominantly supply services to commercial farmers. In addition, over the course of my fieldwork between 2011 and 2014, the chairperson of the RPA was an employee of a major pack house and citrus company in the LSRV. The interactions between the RPA and the commercial farming community led to the RPA evolving into a lobby group that unofficially represented a broader set of interests than those immediately affecting Kirkwood-based businesses and homeowners. This was demonstrated in the period leading up to the SRVM being placed under provincial administration, when members of the RPA were involved in bringing charges against the incumbent municipal manager for personally mismanaging municipal finances.[6]

For many businesspeople and farm owners, the bulk water supply issues in Kirkwood were only one example of poor technical management in the SRVM (with electricity, storm-water management, and roads being other frequently-complained about aspects of technical service delivery). All of my research informants who were farm-owners spoke of their frustrations in dealing with the SRVM on any of these technical matters, demonstrated in the following quote:

> We [as farmers] only require the bloody municipality to do one thing, and that's to look after the roads: we've got tourists travelling to stay in our guest houses in little hired cars that are hardly designed for off-road environments, and it's actually starting to affect our businesses now… It's reached such a bad point that we paid over R10 000 to grade our own dirt roads – which is a service that we pay the municipality to perform…

Private expenditure on what local businesspeople perceived to be official municipal functions was a common theme with my informants from the farming and business communities. Another local businessman complained that he too was about to spend R20 000 on fixing the gravel road leading to his property, due to systematic neglect and in spite of repeated requests for assistance from the SRVM roads division. Individual generators on private property and household-purchased rainwater tanks are equivalent examples for electricity and water respectively. These informants questioned what the point of paying municipal rates was for services that were often completely absent, and for which residents would need to spend more money on themselves.[7]

The state of the roads was an economic concern that many of the farmers raised, particularly those in the citrus industry. In 2011, the owner of a citrus pack-house in the SRVM asserted that:

> Five years ago 80% of the fruit was exported by rail from the stations - now, with no trains running, everything goes by road transport to the harbours. If you look at the road infrastructure of the Sundays River Valley, the damage it has caused to the food industry is close to R100 million a year.

The secondary damage referenced by the pack-house owner is allegedly caused by the rattling of packed fruit whilst being transported by trucks on pothole-filled and poorly-graded roads. Hence, business owners in the LSRV reported paying for the non-delivery of services twice: firstly, by bearing the direct costs of alternative means of service delivery; secondly, by bearing the indirect costs incurred from poor municipal service delivery (seen in the guest house and in-transit citrus damage examples – resulting from the poor maintenance of roads – introduced above). Over the course of the municipal turnaround (and the poor service delivery in this period), several of my informants in the RPA responded to these rising costs by founding a new organisation, the 'Sundays River Business Chamber', as an offshoot of the RPA. The business chamber was envisaged as a lobby group that would specifically represent business interests in Kirkwood rather than these interests being represented under the broader category of 'ratepayers'.

In addition to the above factors that *motivated* members of the RPA to become engaged in local water supply problems, there were a number of reasons why the RPA was *able* to play the role that it did:

1. Members of the RPA were primarily of a similar age, race and gender, and spoke the same language as the majority of the management staff of the L-WUA (namely middle-aged Afrikaans-speaking white males);
2. Several of the active members of the RPA had technical expertise in financial and infrastructural management that allowed them to use the same jargon in their discussions about common infrastructural issues with the L-WUA; and
3. Members of the RPA were familiar with the ways in which the L-WUA functioned as an organisation, having dealt with L-WUA officials in other business or organisational settings.[8]

In summary, RPA members were equipped to interact with the L-WUA in a way that most other civil society organisations were not, as a combination of their background knowledge,

previous experiences, and awareness of the sentiments of the farming and business communities at large. In initiating meetings between the L-WUA staff and municipal officials, members of the RPA could draw on the social capital generated from the above factors.

The responses of municipal officials (both elected and employed) to the RPA interventions were not homogenous. For example, some of the councillors that were my informants supported the RPA interventions, whilst other councillors did not. One of the Democratic Alliance (DA) councillors in the municipality is a retired packhouse owner, citrus farmer, and previous member of the RPA, who attended a number of the meetings that I had with members of the RPA between 2011 and 2012. [9] Whilst this councillor was careful to stipulate that he occupied multiple positions and wanted to avoid conflicts of interest, he was vocal in his support of the RPA. Another councillor with whom I interacted was far more critical of the RPA, bluntly stating that "the RPA mustn't act like they are the only ratepayers in this municipality". The critical councillor was a member of the African National Congress (ANC). There were inevitable tensions between councillors from different parties and the RPA as a result. The reactions of the technical directorate officials to the RPA interventions were similarly diverse. Over the course of my fieldwork, I experienced officials being tacitly supportive of certain RPA's actions (such as the cutting of the sluice-gates), at other times I witnessed how the officials were annoyed or offended by something that a RPA member did or said. And yet in early 2014, I also participated in workshops where members of the RPA and Sundays River Business Chamber were especially invited by the SRVM technical director to attend and contribute.[10]

Having reviewed the civil society basis of the sluice-cutting incident in greater detail, the remainder of this thick description interprets the complexities of the institutional arrangements governing the interactions between the L-WUA and the SRVM. The L-WUA is the only bulk water supplier to the SRVM. As such, the institutional arrangement between the two actors is highly important to the functioning of the water unit in the SRVM. The following sub-section of this thick description describes the existing institutional arrangements between the L-WUA and the SRVM.

6.3.4 The existing institutional arrangements between the municipality and the water user association over the course of the sluice-cutting incident

As introduced in sub-section 5.3.4, the L-WUA is overseen by a management committee that acts as the intermediary between the board of the L-WUA and the management staff who handle the day-to-day operations of the organisation. The SRVM, as an organisation, holds an elected position on this management committee. The councillor who represented the SRVM on the management committee over the time of the sluice-cutting incident had been nominated by the SRVM over the course of the previous administration (2006-2011), and had continued to hold the position whilst water shortages in Kirkwood had become endemic in the period between 2010 and 2012. According to this councillor, he was selected as the municipal representative because he had interacted with farmers in previous community work, and when he became a councillor, the other members of the council said the following to him: "You know how to work with those white people and farmers, so you should sit on the [L-WUA] Management Committee". This councillor indicated that he had worked with a number of agricultural projects under the Ministry of Agriculture (and Land Redistribution), and that he owned a "small piece of land somewhere in the valley". These qualifications aside, the councillor readily admitted to possessing very little (if any) technical knowledge of water management. What he lacked in technical knowledge he made up for in political cache however, as a well-known ANC party leader with anti-apartheid 'struggle credentials'.[11]

From 2003 to mid-2012, the L-WUA held management committee meetings every second month, and then in the latter half of 2012, it shifted to holding monthly meetings. According to the CEO of the L-WUA, as of October 2012, the SRVM had only been represented at ten of the bi-monthly meetings in the past eight years (i.e. the municipality has been represented at less than 20% of the Management Committee meetings). The councillor acknowledged that he seldom attended the meetings due to other engagements, yet he frequently voiced his criticism of the bulk water supply arrangement in the SRVM, even asking RRU officials in a workshop in February 2012 whether "the L-WUA is really required in this post-apartheid era?"[12] According to the L-WUA, the municipality had not used the management committee as a forum for airing these discontents and as a space for conflict resolution, which is an intended function of this structure.

Over the time of the sluice-cutting incident, there was additional confusion in the SRVM as to whether the municipality could hold one or two positions on the management committee.

Municipal officials argued that it would be pointless for anyone other than the elected councillor to attend the management committee meetings, as any additional representative would have no 'say' in the proceedings due to being them not being recognised as a nominated member. The L-WUA in turn argued that statements like this were contrary to the association's policy that the SRVM should elect the most suitable representative possible – and that the power to select this representative lies with the municipality and not the L-WUA (as introduced in sub-section 5.3.4).

From the L-WUA's perspective, the municipality's non-attendance at the management committee meetings was indicative of the noncommittal behaviour of the municipality toward resolving the Kirkwood water shortages. The most egregious issue, from the L-WUA's perspective, was the longstanding nature of the Kirkwood water shortages. As one of the L-WUA officials put it:

> We have warned the municipality since 1997, saying that it's off-site storage at Kirkwood is inadequate – and we have the letters to prove it. They need up to 14 days off-site storage for our winter maintenance period.

According to the L-WUA, supplying the Kirkwood system with water every weekend would require paying L-WUA staff overtime for the opening and closing of the sluice gates. The increased operational costs would have to be borne by all water users in the area, including the farming community and the Nelson Mandela Bay Municipality (NMBM), who managed their water supply such that they did not require water to be delivered on weekends.[13] As the CEO had consistently stated, the L-WUA had warned the old Kirkwood Municipality (which then became the SRVM in 2001) about the impending shortages, and so the L-WUA has given the municipality more than enough time to plan for increasing the municipal infrastructural capacity to meet demand. In the months preceding the sluice-cutting incident in 2012, the L-WUA also indicated that the future volume of water required by the municipality still needed to be assessed and determined. The L-WUA argued that these assessments were particularly required for the Kirkwood system, where the volume of abstracted water had increased over the four years, such that the total volume used by the SRVM was now substantially more than its allocation. In conversation with me, and in meetings and workshops that I attended, the L-WUA officials accounted for the expanding demand for raw water in Kirkwood as being driven by the new housing developments in the area. But the real frustration most frequently voiced by the L-WUA staff was that the municipal officials did not appear capable of handling the bulk water supply that the L-WUA delivered to the

Kirkwood WTW. As one L-WUA staff member put it, "we know that the SRVM do not manage their system, and that's why they run out of water faster than they should." The problem was not just demand-driven, but also operational.

Some of the indicators of municipal mismanagement perceived by the L-WUA staff included that the bulk water components of the Greater Kirkwood water supply scheme (WSS) were frequently misbalanced, with the raw water dams empty on Friday afternoon when the L-WUA raw water supply schedule ends for the week (rather than the WTW process controllers being prepared for the weekend by ensuring that the raw water dams are full by the close of business on Friday afternoon). This misbalancing of the Greater Kirkwood WSS by the municipality was a longstanding concern of the RPA as well (see sub-section 6.3.2). Another indicator of municipal incompetence perceived by the L-WUA was the filing of late requests, which L-WUA staff complained are often received only *after* the L-WUA has done the overall calculations for the entire system. According to the L-WUA officials, they have typically managed this problem by estimating the municipal consumption for the particular week, and calculating accordingly, even in lieu of a request from the municipality. The L-WUA staff complained that they cannot play this 'guessing game' for all users (which would entail calculating demand for over 1000 individual delivery points).

To the L-WUA, however, the supply of water to the SRVM and the associated shortages in the Kirkwood system were relatively minor problems, given the extent of the other challenges faced by the organisation. As introduced in sub-section 5.2.4, the raw water supplied to the SRVM is only a fraction of the total quantity supplied to all users in the area by the L-WUA, and so judged by quantity alone, the SRVM is a minor user (especially in comparison to the agricultural users in the region, and in comparison to the quantity of water supplied to the NMBM). The SRVM officials, on the other hand, took an understandably different position to the priorities of the L-WUA. As one technical official put it:

> I don't think it is helpful to speak about how the raw water supplied to the SRVM is only a tiny portion of the total water supplied by the water user association: speaking about the relatively small amount of water used by the SRVM ignores that that small amount is used for drinking water. It's important… and a matter of life and death – in a way that citrus trees being watered certainly isn't.

The perceptions of *what* counts as a water supply problem to *whom* (in relation to the different water constituencies in the LSRV) is discussed as an evolving political problem in sub-section 6.5.6.

The SRVM officials tacitly acknowledged that the L-WUA continues to favour commercial farming in its operations in a range of ways, including in the language typically used by technical officials and councillors over the course of fieldwork to refer to the L-WUA: for example, many of the technical officials and the ANC councillors in the SRVM would refer in discussions to the L-WUA staff as 'those farmers'. This is despite the fact that the L-WUA staff members are technicians employed to operate a water delivery system – albeit a system where the primary users, and therefore funders, are commercial irrigators – but are not usually farmers themselves.[14] Additionally, most of my municipal informants referred to the L-WUA in conversation as 'the irrigation board' (the more democratically-titled 'Water User Association' was rarely used except in formal settings), with the same informants typically referring to the infrastructure operated by the L-WUA as 'the irrigation scheme'. Furthermore, the municipal technical officials took exception to the fact that the measurement units of hectares are employed by the L-WUA in all their dealings. Whilst hectares are a standard form of measurement in agriculture, the municipality deals in the volumetric measurements standard for drinking water (litres, KL and ML).[15] Some members of the SRVM's technical division interpreted the use of hectares as a form of 'control' by the L-WUA, arguing that this is indicative of how the L-WUA demands to operate according to its own rules and conveniences.

At the November 2011 Blue Water Services Audit (introduced in the fieldwork story in Box 6.1 and discussed further in the fieldwork story in Box 6.3), the DWA assessors also questioned why the L-WUA still billed the municipality in hectares rather than ML, but the assessors were far more interested in why water shortages in Kirkwood remained endemic, and what the municipality was doing about it. The assessors asked to see the contract between the L-WUA and the SRVM, referencing the relevant legislation that requires a Service Level Agreement (SLA) to be in place between a water service authority and a water service provider (as discussed in sub-section 5.5.4). To the DWA officials, it appeared strange that a bulk water supplier could legitimately curtail the supply of raw water to a municipality, when the municipality carries the legal responsibility to ensure that a basic supply of potable water is provided to residents within its area of jurisdiction *at all times*. In order to address the strange situation, the DWA assessors asked to see the documentation outlining the current institutional arrangement that was replacing an SLA between the L-WUA and the municipality. The only arrangement between the L-WUA and the SRVM at this time was in the form of the L-WUA's constitution. As the CEO of the L-WUA put it:

> The SRVM is a member of this association - they have a representative that sits on the management committee in terms of the constitution. Why would DWA want an SLA? … We have got our rules, and we stick to our rules.

Despite the fact that the constitution was currently serving in the place of an SLA, the municipal officials did not have a copy of the constitution on file in the technical directorate over the course of the Blue Water Services Audit, and therefore needed to ask for it elsewhere.[16] The result was that the DWA assessors asked more questions about the institutional arrangement than they did provide guidance. Some of these questions included:

- Is the L-WUA a water service provider to the municipality?
- If so, why is the municipality not regulating the L-WUA, given that the SRVM is the water service authority for the region?
- Such regulation should occur in line with the conditions of an agreed-upon contract - so why was the municipality not proactively developing a contract with the L-WUA?
- If the municipality *was* developing such a contract, what documentary evidence could the municipal officials provide as proof?[17]

These issues and queries were raised in November 2011, but the full weight of them only became apparent with the continued water outages in Kirkwood that culminated in the sluice-cutting incident in January 2012. The fieldwork story in Box 6.3 recounts my personal experience of the institutional issues discussed in the 2011 assessment.

Box 6.3: Fieldwork story 3 – institutional conflations

I spent much of the nine hours of the Blue Water Services Audit in November 2011 taking notes whilst trying to make sense of the jargon and alphabet-soup (in the form of acronyms and abbreviations) that constitutes local government legislation and water services. When the assessors started asking questions about the institutional arrangement between the SRVM and the L-WUA, I was surprised to find that my own confusion was mirrored by the municipal officials in attendance: which actor was the regulator and why? Given that I was still in the early stages of my fieldwork, I commented very little (if at all) and instead made a note that the institutional confusion was some sort of a missing arrangement that could provide a potential intervention point for our action research project.

The first thick description (section 6.2) explored the internal operations of the municipality, which provides an interpretive account of the context of municipal management at the time of the November 2011 assessment. In order to further explore the bulk water supply issues that are central to this second thick description, the other activities of the L-WUA need to be described further. The following sub-section describes these other activities through the

perspectives of staff and associated stakeholders, focusing on whether the roles played by the L-WUA differ to the roles the organisation played as an irrigation board.

6.3.5 The common interests of, and broader interactions between, the municipality and the water user association

Given that the L-WUA and the SRVM were the two major water service providing organisations in the region, this sub-section describes and analyses the common interests of, and the broader arrangements between, the two organisations. This sub-section specifically analyses how the L-WUA interacts with municipalities and municipal mandates, in order to explore whether the Kirkwood water supply scheme, which led to the sluice-cutting incident at the beginning of this thick description, is an isolated case.

The first common interest described here is empowerment programmes within the LSRV. Empowering historically disadvantaged individuals is a common interest for a number of reasons. Under its mandate as 'developmental local government', the SRVM is one of the spheres of government tasked with reducing socio-economic disparities in the region (see sub-section 2.2.3), whilst providing support to resource poor farmers (who are also referred to as 'emerging farmers') is one of the desired functions of a transformed irrigation board in post-apartheid South Africa (DWAF, n.d.). Three emerging farmers sit on the L-WUA's management committee, and had so since 2003, in spite of the majority of the earlier programmes to support the establishment of resource poor farmer irrigation schemes having failed: a 2005 report recorded widespread failure both in land reform (or redistribution) and resource poor farmer irrigation schemes in the LSRV (DWAF, 2005). The DWA report referenced all four of the land reform schemes as unsuccessful, with stated reasons including that the emerging farmers had failed to create sustainable operations and were unable to cover their variable costs. In particular, they were unable to pay their electricity bills and cover their raw water charges owed to the L-WUA. The report also referenced four resource-poor farmer irrigation schemes, which were either stuck in the application phase, or were listed as awaiting development partners.[18]

The largest potential development in the LSRV is called 'Barkley Bridge' (and was the largest of the four resource-poor farmer irrigation schemes discussed in the 2005 report). Barkley Bridge was allocated 3000 ha of irrigable land, with the 2005 report stated that this development was stymied by insufficient demand from end-users, which DWA was allegedly

waiting for prior to approving the development (DWAF, 2005: 256). In May 2013, a senior DWA official in the Eastern Cape explained to me why he believed the Barkley Bridge development had still failed to materialise. The DWA official said that the proposed scheme was to be fully-owned by black emerging farmers, and that both the directors in his office and the L-WUA supported the development. This official also argued that a number of factors were in the the project's favour:

> This will be hard work, but there's a market for a scheme like this; there's the correct support and the infrastructure and requirements of technical capacity by incoming farmers can be developed incrementally.

The DWA official warned that if the development does not happen, the LSRV could lose the additional 3000ha of scheduled irrigation to another competing area or development.[19] The DWA official argued that the major political force slowing the Barkley Bridge development was DAFF [the Department of Agriculture, Forestry, and Fisheries], which was required to support the project ahead of its implementation, but DAFF wanted to focus on developments in the poorer Mzimvubu area of the Eastern Cape. The tragedy of this project, according to the DWA official, was that the majority of the developments in the Mzimvubu area had failed, whilst comparatively, the Barkley Bridge development could be operational far quicker than other proposed schemes and stood a far greater chance of success.

In spite of its prominence, size, and the potential boost for emerging farmers in the LSRV, the Barkley Bridge development has been caught in a nine-year impasse between multiple government departments. Yet whilst Barkley Bridge is indicative of struggling government-led empowerment programmes in the LSRV, it is by no means representative of *all* empowerment programmes in the region. Eight of the functional Black Economic Empowerment (BEE) farms in the LSRV are supported by the Sundays River Citrus Company (Barnes, 2012). The Sundays River Citrus Company (SRCC) is a key actor in the LSRV for a number of reasons. For example, the organisation packs and exports around half of all citrus annually produced in the LSRV, and as of 2012, was the largest single packer and exporter of citrus fruit in the southern hemisphere (SRCC, 2014)).[20] The BEE farms in the LSRV are managed by beneficiaries who were previously employed on SRCC farms and, for the most part, farm on government-owned land that is leased to the beneficiaries, with administrative support and mentorship from the SRCC. In 2012, the Sundays River Farming Trust (which four of the eight BEE farms supported by the SRCC are grouped under) purchased the land that they previously leased from the government, becoming the owners of

277 hectares (SABC, 2012a). The eight BEE farms produced about 13% of the SRCC's total production in 2012 (equivalent to 1 million 15kg export cartons) (SRCC, 2014), in what *Farmer's Weekly* magazine described as a project "aimed at bringing emerging farmers into the commercial cycle [which] is that rarity – one that actually works" (Barnes, 2012: 1). According to the L-WUA CEO, as of May 2014 about eight to nine percent of all water supplied by the L-WUA to farmers in the region goes to emerging farmers.[21] The SRCC said it wanted to see this grow, and stated that through its public-private partnership model of BEE farming, and with the "active support of government and its growers" it aimed to transfer "at least 30% of the productive land currently delivering to SRCC into the hands of previously disadvantaged individuals within the next four years" (SRCC, 2014: 1).

The largest of the four farms in the Sundays River Farming Trust – Luthando Farm – can be used to illustrate two other aspects of common interest to the L-WUA and the SRVM. Firstly, Luthando is one of the many farms with its own on-site treatment facilities for potable water. As the general manager described it:

> We abstract from the irrigation canal, pump up to our storage dams, purify [the raw water] on site and then gravity-feed to the households on our farm. We order water on Thursdays and we don't have a problem with the water user association… We don't run out of water.

By providing potable water to households, Luthando Farm is not reliant on the delivery of water services by the SRVM and therefore performs its own water service provider function. Under the governance arrangements described in sub-sections 5.3.3 and 5.5.4, the SRVM is the water service authority (WSA) and should, therefore, be regulating all water services within its jurisdiction. There are many hostels, households, and other forms of residences on farms in the LSRV that are supplied with potable water by the managers of the farms on which they are based. The lack of regulatory oversight of this decentralised water service provision is arguably a further institutional gap in the LSRV.[22]

The second illustrative aspect of Luthando Farm is found in the general manager quoted above, who was a successful entrepreneur and farmer, and who has served as an elected member on the L-WUA's Management Committee for the last five years. As a black, Xhosa-speaking woman, the Luthando Farm manager is representative of successful transformation programmes in the LSRV, and demonstrated some of the ways in which the agrarian landscape of the LSRV is indeed transforming.

The next common interest of the SRVM and the L-WUA discussed here is environmental management within the LSRV. Environmental management is part of the SRVM's mandate, particularly in terms of spatial planning and development (see sub-section 5.4.3), and "promoting environmental issues" is one of the stated objectives of the L-WUA. Furthermore, the *National Water Act* of 1998 (RSA, 1998) makes provision for either DWA or an existing catchment management agency to assign water resource and/or catchment management duties to a water user association (DWAF, n.d.) (see sub-section 5.3.4). When I discussed catchment management activities with a member of the L-WUA staff in 2012, he responded that the L-WUA relies minimally on the local catchment for its water supply – and so there is little need and no incentive for the organisation to take on catchment management roles (in addition to the organisation having no spare capacity for performing such roles). By comparison, other WUAs and irrigation boards in South Africa manage alien invasive vegetation clearing programmes in their areas (including the neighbouring irrigation board to the L-WUA – the Gamtoos Irrigation Board). The L-WUA staff conceded that the primary reason why the organisation engages in few (if any) catchment management activities is because there is little need for them to do so (given that the vast majority of the water that is managed by the L-WUA comes from the Orange River system, and is delivered via the Orange-Fish-Sundays inter-basin transfer scheme (see sub-section 5.2.2)). The SRCC contended that whilst alien invasive vegetation might not be a concern for the L-WUA, it is actually a regional problem that requires urgent action: the SRCC argues that "the threat of invasive alien vegetation in the Sundays River Valley is tremendous and far-reaching", and that "... flow in the Sundays River Valley will be seriously reduced over the years, resulting in an increase in saline penetration and destruction of the fragile marine environment at the estuary" (SRCC, 2014).[23] In response, the SRCC founded a company in partnership with the Mayibuye Ndlovu Development Trust, which turned harvested alien vegetation into compost that is then sold to citrus farmers and other commercial buyers in the region.[24]

In summary, the core area of concern to the L-WUA – namely, managing its water supply from the Orange-Fish-Sundays inter-basin transfer scheme – was not affected by the threat of alien-invasive vegetation because of the fact that water is diverted at Korhaansdrift Weir, where-after it is delivered to users through a network of canals. Hence, from the L-WUA's perspective, managing an alien-invasive vegetation clearing programme would be an additional, rather than complementary, programme. The SRVM, on the other hand, is required to have a 'Municipal Invasive Alien Species Control Plan' in relation to the Biodiversity

Sector Plans and its Environmental Management Plans (see sub-section 5.4.3) and could therefore benefit from partnering with Mayibuye Ndlovu Compost and the SRCC in this regard.

As described above, the members of the farming community (who I interviewed or who were my informants) typically portrayed the SRVM as being an institution that primarily cost them money for which they were provided little material benefit or services (see sub-section 6.3.3). In addition, members of the farming community were concerned about the negative effects of municipal service delivery failure on commercial farming. One of these threats was sewage-spillages in the Addo region of the LSRV. These sewage-spillages had the potential to contaminate farming produce bound for export to the European Union. This was the one issue raised by the Farmers' Association in the area, after they had declined to attend a research workshop in the SRVM (on the basis that municipal water management was neither of great concern nor interest to them).[25] Eight months after the chairman of the Farmer's Association raised this issue with me, the threat of raw sewage to citrus farming in the area became a national news item, with the South African Broadcasting Corporation running a television and online story on the issue in July 2012 (SABC, 2012b). At a workshop in 2012, and in response to this issue, the CEO of the L-WUA stated that if the agricultural sector in the LSRV declines, "then you might as well as switch out the lights as you leave the room", because that would be the end of the local economy.[26] The L-WUA staff appeared to be proud of the role that their organisation played in 'keeping the commercial lights in the LSRV on'. They also appeared proud of the way their organisation had developed over the course of the twentieth century. Yet this pride was typically expressed alongside frustration and concerns of the impingement of national government on the local functioning and independence of the L-WUA, which is illustrated in the following account provided by a senior L-WUA official:

> Most of the infrastructure that was created was built around the 1950s: this was done on a loan that the irrigation board obtained from the department [of water affairs], and we had to repay that loan, which was done, so the full amount has been repaid to the department. We also in that time period built Darlington Dam, and raised it a second time in 1952… on a similar basis, via loans from the department and it was repaid to the department. In the early 1980s, DWAF came here and said that we have to make job opportunities for 1000 people - and [they said that] as the state we cannot work on private property, we have to work on state property: so we said okay fine we'll give you the dam, and we'll give you Korhaansdrift Weir, and we'll give you the section of the canal from Korhaans Weir to Hessie's Corner, with the understanding that maybe we'll get it back when the work's been done. Unfortunately we didn't get it back, they now charge us return on assets, and depreciation on the very f***ing things we gave them - for nothing, after paying the

> loans [that we got from them] and they are currently the owners of Darlington, Korhaans weir, and the canal to Hessie's Corner.

The L-WUA staffers were not the only individuals connected to the association who were vocal in their criticisms of government. These criticisms were expressed by the governing board of the L-WUA in the association's annual reports (L-WUA, 2011, 2012) . For example, in the 2010-2011 report, the chairman spoke of the "totally excessive increase in [DWA] water charges", and discussed the "sudden introduction of new corporate legislation", which he described as only "one element of the maze of ever-new legislation being introduced and requiring compliance by our Association" (L-WUA, 2011). In the 2011-2012 report, the chairman described some of the L-WUA's key concerns as follows:

> Our key concerns rest not only on the supply of water but also where possible on the protection of the existing rights of water user licences as well as attempting to contain wherever possible the additional fees and obligations which those in authority continually seek to impose on existing users (L-WUA, 2012).

Many of the obligations placed on the L-WUA by national government were part of emphasising how the organisation differs to the apartheid-era irrigation board, which was institutionally referred to as the 'transformation' of the organisation. The most prominent of the efforts undertaken to further transformation in water user associations over the course of my fieldwork in the LRSV between 2011 and 2013 was a project entitled 'The Development of Water User Association Business Plans in the Eastern Cape'.[27] This was part of a DWA-funded project facilitated at the national level by a professional service provider, who then sub-contracted a regional service provider to consult with WUAs in the Eastern Cape. The project aimed to further the transformation of water user association – in line with Chapter 8 and Schedule 5 of the National Water Act (RSA, 1998) – with seven organisations in the Eastern Cape selected to participate on a prioritisation basis.[28] For the L-WUA, the intention of the project was to explore the substantive transformation of its operations, rather than focusing on transformation only in terms of the demographic composition of the association's management committee and governing board. The SANPAD project became connected to this project (see Box 6.4), out of which an informal collaboration with the DWA project arose.

Box 6.4: Fieldwork story 4 – interacting with the 'transformation of water user associations' project

> In May 2012, I planned to return to the LSRV to follow-up on progress in the municipality, with particular interest on the interactions between the L-WUA and the SRVM. A member of our broader SANPAD project put me in contact with a consultant based in East London, with whom she had interacted on a Water Research Commission project. The consultant in question was sub-contracted by a professional service provider employed on the DWA-funded 'transformation of water user associations' project. In the subsequent meetings with this consultant, we began discussing how the Kirkwood shortages could be used as a potential focus for a project that the L-WUA could include in their business plan.

The informal collaboration between the DWA project and our SANPAD project became a part of the action research process (discussed in detail in Chapter 7). A central part of this action research process was the proposal to craft an institutional arrangement between the L-WUA and the SRVM, given the contested nature of the supply arrangement between the two organisations (as discussed in the governance challenge outlined in sub-section 5.5.4). The process of working on this institutional arrangement raised a number of issues about the interactions between the L-WUA and municipalities. In workshops, the L-WUA would typically emphasise that the only real problem between themselves and the SRVM was the Kirkwood water supply scheme. As one of the L-WUA officials said:

> Only Kirkwood has the problem, none of the other two supply zones have a problem. Why don't they have a problem? All three are supplied by [the] L-WUA. The answer is that Addo and Enon have large enough raw water storage dams and facilities.

Two other aspects of the L-WUA supply system provide insight into whether the problems in Kirkwood are unique or specific. The first case pertains to the Nooitgedacht WTW owned and operated by the Nelson Mandela Bay Municipality (NMBM); the second, to the Addo supply scheme in the SRVM.

(i) Water supply to the Nooitgedacht water treatment works:

The L-WUA supplied water to the NMBM via Scheepersvlakte Dam, where-after the metropolitan municipality abstracted water to the Nooitgedacht water treatment works. According to the L-WUA officials,

> Scheepersvlakte dam… initially was a balancing dam in our system, and then when Port Elizabeth went through the drought period it became their [DWA's] dam overnight – simple letter, change of ownership – done.

As displayed in Table 5.2, transfers out of the LSRV to the NMBM amounted to 11 million m^3/a in the year 2000 (DWAF, 2005). Between 2000 and 2014, however, the volume of water abstracted by the NMBM dramatically increased, with the metropolitan abstracting over 31 million m^3 in the 2013-2014 year (L-WUA, 2014). This increase in demand from the NMBM was primarily due to drought conditions that restricted its other supply sources (DWA, 2011a). As part of the metropolitan's reconciliation strategy in the face of drought conditions, DWA awarded it an emergency licence to abstract as much as 58.3 million m^3/a for the next 20 years, in addition to awarding it a drought relief grant of R450 million to expand the Nooitgedacht WTW.[29] The threefold increase in the the quantity of water abstracted by the NMBM, the L-WUA's account of the change of ownership of Scheepersvlakte dam, along with the L-WUA officials complaining that the representative from the NMBM rarely attended its management committee meetings, all provided reasons for the water user association officials to describe the NMBM in the same terms as the SRVM.

(ii) The Addo water supply scheme and reliance on Caesar's Dam:

As outlined in Figure 5.2, two of the main components of the Addo bulk water supply system are Caesar's Dam and the Addo water treatment works (WTW). The former acts as the raw water storage reservoir for the Addo WTW, which abstracts directly from the dam in order to treat water to a potable level for the communities of Addo. The potential complication arises out of the fact that Caesar's Dam is owned by the L-WUA and is operated as part of the L-WUA's system. Although it is typically described as a 'balancing dam' in the L-WUA's system, it is actually an end-point that only serves the SRVM. For this reason, there is limited incentive for the L-WUA to maintain the dam, because it is of no use to the commercial farmers who are the majority user group in the L-WUA. The SRVM, on the other hand, is increasingly reliant on Caesar's Dam as a raw water storage facility for two reasons: firstly, overall water demand in the Addo area has greatly increased over the past five years – particularly as new housing developments have been connected to the municipal reticulation system and as the municipality eradicated service delivery backlogs. Secondly, the water demand from the Addo WTW is scheduled to further increase when the Paterson Bulk Water Scheme (PBS) is completed. As introduced in sub-section 5.2.5, the PBS is intended to deliver potable water to all communities in Paterson, replacing the current bulk water supply system. The current supply source (groundwater) and current bulk water supply infrastructure (boreholes) are only intended to remain as a back-up supply. The result of this development will be the full-scale reliance of all communities in both Addo *and* Paterson on potable water

treated at the Addo WTW (and as a result, full-scale reliance on the use of Caesar dam for raw water storage).

Several actors (including consultants to the SRVM and the L-WUA officials) have expressed their doubts as to whether Caesar's Dam has adequate capacity to meet the increased demand placed on the facility by the above two developments. Concerns relating to the capacity include that the dam has never been rehabilitated and has been poorly maintained (resulting in its current overgrown condition). The capacity of the dam is therefore decreasing, with it noticeably emptying over periods of peak demand.[30] The capacity of Caesar's Dam needs to be assessed in order to plan for an expansion or rehabilitation of the facility. If the capacity of Caesar's Dam is insufficient to meet the increased abstraction by the SRVM, it is likely that the communities of Addo and Paterson will face similar disruptions to their water supply as those communities supplied by the Kirkwood system have faced. Institutionally, the issue is complicated by the L-WUA ownership of the facility however, which will possibly give rise to debates over how the work will be financed and managed.

Both Caesar's Dam and Scheepersvlakte Dam provide examples of where infrastructure originally built for the sole use of an irrigation scheme are now predominantly used by other sectors (specifically, municipalities). Given that the L-WUA is an association of members, the officials employed by the association are instructed to execute the business of the organisation, as agreed by the management committee and its governing board. Historically, neither the NMBM nor the SRVM have actively participated in these management committee meetings, and hence do not use the structures to motivate for a change in the operations (and even attitude) of L-WUA officials. The continued agricultural focus of the L-WUA is a reason why the SRVM officials gave for rarely attending the management committee meetings, but a further reason from the L-WUA's side is the lack of appreciation of its role as a bulk raw water service provider to municipalities (see Box 6.5 and the action research process in Chapter 7).

Box 6.5: Fieldwork story 5 – discovering how the water user association did not know the Water Services Act

The fieldwork story in Box 6.3 introduced the institutional confusion between the water user association, the municipality and the Department of Water Affairs (DWA), and how this institutional confusion led to the recognition that there was a missing arrangement between the L-WUA and the municipality, which could provide an intervention point for our action research project. The facilitating context of another project working in the region (on the transformation of water user associations) was introduced in the fieldwork story in Box 6.4, with details of the subsequent action research process provided in Chapter 7. Over the course of this action research process, it became apparent that officials at the L-WUA were unaware of their organisation's institutional status as a bulk raw water service provider, and the fact that this role was regulated under the *Water Services Act* of 1997, rather than the *National Water Act* of 1998 (see 5.5.4). At one point, a senior official at the L-WUA conceded that traditionally, they "had not dealt with the *Water Services Act*, and were unaware of its stipulations". I initially treated this as a site-specific problem in the LSRV, but I subsequently discovered that the desired institutional arrangement between the L-WUA and the SRVM actually fell between five pieces of legislation and several strategic frameworks, in addition to being assessed under three different regulatory frameworks (see sub-section 7.4.2). I began to recognise that there were multiple overlapping governance challenges entailed in regulating bulk water services between the *National Water Act*, the *Water Services Act* and the legislative framework for local government, and this led to my undertaking a governance analysis (as contained in Chapter 5).

6.3.6 Conclusion to thick description 2

The second thick description has focused on describing the interactions between the SRVM, business and civil society organisations, and the L-WUA, using the sluice-cutting incident in 2012 as a starting point. This thick description has introduced the following:

- The context of the sluice-cutting incidents and the historical interactions of the L-WUA and the SRVM;
- The strategies and alliances of the group of actors involved in the sluice-cutting incidents, focusing on the Kirkwood RPA and the Sundays River Business Chamber; and
- The institutional and operational issues affecting the bulk water supply arrangement between the L-WUA and the SRVM, focusing on the Greater Kirkwood water supply scheme.

Although the L-WUA is technically a multi-sector association (see sub-section 5.3.4), and should therefore act in the interests of different users (DWAF, n.d.-a: 39), this thick description has described how the core function of the L-WUA has remained the supply of raw water to irrigators in the LSRV. In tandem with the operational challenges of the SRVM,

this has meant that the two organisations that are the central local water authorities in the LSRV have continued operating in parallel realms, rather than in the spirit of cooperative governance as envisioned in the Constitution (see 5.3.1).

Finally, this second thick description has introduced the actor dynamics of the SRVM and the L-WUA in relation to the Greater Kirkwood water supply scheme. The L-WUA officials argued that the key problem in Kirkwood was the capacity of the raw water dams, and that the SRVM should expand this capacity as a matter of urgency. The third description uses a funding programme for increasing the capacity of these raw water dams to account for the further complexity of inter-governmental relations (in terms of the nuances of the institutional arrangements governing the funding arrangement, and the various compounding issues of the multiple agents involved). In particular, the third thick description uses Amatola Water's engagement in the Kirkwood water supply scheme project as the starting point for exploring the organisations' involvement in the SRVM turnaround between 2011 and 2014.

Notes for Thick Description 2:

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[1] I was never able to ascertain the degree to which this businessman was acting on behalf of, or with the explicit consent of, the broader business community in Kirkwood. That said, all of the businesspeople with whom I interacted over the course of my fieldwork in this period expressed frustration at the ongoing water shortages, and were vocal in critiquing the apparent lack of municipal responses to these water shortages.

[2] In late-2014, I heard from two different businessmen in the Kirkwood region that the charges went to the Grahamstown High Court, but that a ruling that the businessman had 'acted in the public interest' was passed. Earlier in 2014, I had attended a workshop in which both the businessman in question, and the L-WUA officials who were pressing the charges against him, were present. I observed them interacting cordially, and without apparent animosity.

[3] These two proposals were made by RRU engineers over the course of a meeting attended by SRVM, RRU and Amatola Water officials in February 2012. The meeting was held at Rhodes University in Grahamstown (*listed in* A:2:4 in Table A.2), and was facilitated by the SANPAD project. Up until this point, the RRU interventions and the Amatola Water interventions into the SRVM were frequently failing to engage one another (with multiple overlaps between the interventions – discussed in further detail in the third thick description). The February meeting was called as a way of our project trying to be involved in minimising unproductive overlaps. Grahamstown was selected as a meeting venue because it is half-way between East London (where Amatola Water and several of the RRU engineers are based) and Kirkwood (where the municipal offices are based).

[4] The first RRU report on the Kirkwood WTW was by D. Slabbert entitled 'Sundays River Valley Municipality – Kirkwood – Additional Raw Water Storage Pond: Report. Rapid Response Unit, Department of Water Affairs'. The report was internally produced for the SRVM, and dated May 2012.

[5] This is the stated objective of the Kirkwood Ratepayers' Association (RPA), as contained in the organisation's constitution (dated 2010).

[6] The mismanagement of municipal finances over the course of this municipal manager's time in office is described in sub-section 4.7.2 of the historical analysis.

[7] For a potential response by ratepayers to this situation, see the strategy of a 'rates boycott' discussed in sub-section 6.5.6.

[8] The typical description of the L-WUA staff were that they technically efficient and competent, but that they were also inflexible. One farmer described how he had requested the L-WUA to move the allocation of water from one of his two farms to the other. He said that the response was a straightforward 'no' from the L-WUA CEO. After recounting a similar story, another member of the RPA memorably said: "There's no getting away from it: the [L-WUA] CEO has everyone in this valley by the short and curlies." This sentiment of feeling like the farming community 'owed' the L-WUA was mirrored by other farmers with whom I interacted, with one of them complaining that, "we as the clients pay his salary, but the L-WUA CEO acts like we all owe him something."

[9] As of 2014, the Democratic Alliance (DA) is the official opposition party both at the national level in South Africa, and at the municipal level in the SRVM.

[10] The workshop in question here is referenced in Table A.2 (no. A:2:20).

[11] In post-apartheid South Africa, 'Struggle credentials' refer to individuals who were involved in the liberation struggle: i.e. the fight against apartheid that involved organisations including the South African Communist Party, the United Democratic Front and the African National Congress (see sub-section 4.4.2 of the historical analysis.

[12] Workshop reference: A:2:3 in Table A.2.

[13] The L-WUA started supplying the Kirkwood water supply scheme (WSS) on a seven-day basis around April 2014 (as described by the L-WUA CEO in a meeting in May 2014: meeting A:2:22 referenced in Table A.2). Further details about why residents supplied by the Kirkwood WSS continued to face water shortages, in spite of being supplied with raw water by the L-WUA over weekends, is provided in section 7.6.

[14] There are a number of linguistic resonances of interest here, including that in Xhosa, the words 'amakhulu' (meaning 'farmers') and 'isikhulu' (meaning 'Afrikaans') are very similar. So the word 'farmers' can be (and sometimes is) used as a synonym for Afrikaners and, by extension, for 'whites'. My thanks to my multilingual, anthropologist supervisor (Prof. Chris de Wet) for this insight.

[15] Measuring irrigation water in hectares is a standard practice in agriculture, and is based on a scheduled (i.e. defined) irrigated area (measured in hectares) and an allocated water quota per hectare. As described in sub-section 5.2.4, the LSRV has a scheduled irrigated area of 16 664 hectares, with a water quota of 9000 m^3 per hectare per year (m^3/ha/a). Hence, one hectare = 9000 m^3 = 9 ML.

[16] After my participation in the November 2011 stage of the assessment, I was asked by the technical officials if I had a copy of the L-WUA constitution – and if so, could I please email it to them ahead of submitting their supporting documentation to the DWA assessors in January 2012. The description of the internal operations of the SRVM (in sub-section 6.2.2) provides insights into why this important document was not on-file in the technical directorate at this time.

[17] The DWA assessors involved in the RPMS and Blue Drop assessment in 2011 asked for documentary proof because all claims made by a water service authority are required by DWA to be backed-up with supporting data and / or policies.

[18] The four 'resource-poor farmer irrigation schemes' referenced in the report were:

- Vaalhoedskraal (188 ha)

- Enon Mission (296 ha)
- Addo (690 ha)
- Barkley Bridge (3000 ha identified) (DWAF, 2005: 258 - Appendix 9 –1).

The first development was still in the application phase. With the second and third developments, the L-WUA staff were referenced as saying that another stakeholder (like Department of Land Affairs) needs to be responsible for getting "aspirant resource-poor farmers together, to create a need for development, and [to find] willing development partners." (DWAF, 2005: 256 - Appendix 8 –1).

[19] At the time of interviewing this DWA official in May 2013, a detailed water resource reconciliation study for the Orange River system was underway: this study was initiated in 2012, and seeks to "reassess all possible future demand that could reasonably be supplied from the Orange River, and the ultimate yield potential of the system through the addition of various options, but with full consideration of the ecological requirements and international obligations" (DWA, 2013: 3). The National Water Resource Strategy acknowledged that "the available yield for this system has been fully allocated, and there is no prospect of additional water for allocation without storage volumes increased. This will come at signficant cost" (DWA, 2013: 2).

[20] The Sundays River Citrus Company was originally founded as the 'Sundays River Citrus Co-operative' in 1924. The organisation is fully-owned by the citrus farmers who use the packing facilities, meaning that all citrus producers, including BEE farmers, have access to packing facilities and company benefits (proportional to their contribution to the total packed and exported product).

[21] This was said in meeting A:2:22 referenced in Table A.2.

[22] Although this institutional gap is important, this study focuses on the areas that the SRVM is actively providing water services to (in particularly, the urban settlements), and so this issue is only flagged here. Between 2012 and 2013, the South African Human Rights Commission (SAHRC) held hearings in all nine provinces on access to water and sanitation. Recommendation 2.1.8.1 pertained to farm workers, in which they recommended the following: "An amendment of legislation governing farm labourers is required to ensure that they do not fall in a legislative gap that leads to the lack of service delivery for labourers on private land (i.e. legislation must ensure access to services)." (SAHRC), 2014b: 20).

[23] As discussed in sub-section 5.2.3, the Sundays Estuary is ranked in the top 20% of estuaries in South Africa, in terms of its conservation importance.

[24] The compost company discussed here is called Mayibuye Ndlovu Compost, and was formed out of a partnership between the SRCC and the Mayibuye Ndlovu Development Trust (MNDT). The MNDT was established as a forum for 'conservation-based community development projects', and is supported by the South African National Parks (SANParks). Mayibuye Ndlovu Compost generates employment from clearing alien invasive vegetation (similar to how the national Working for Water programme functions), but then uses the harvested alien vegetation to produce compost (SRCC, 2014). The prevalence of alien-invasive plant species in South Africa (and the associated negative effects on available water supply) is well documented (Vromans et al., 2012).

[25] To state this point more accurately, it was the Chairman of the Sundays River Farmers' Association who said that municipal water management was neither of great concern nor interest to them, with the exception of wastewater treatment and sewage-spills (in late-2011). Whilst I interacted with other citrus farmers and businesspeople on an individual basis, I did not meet with other members of the Farmers' Association until October 2014, and so could not gauge how representative of the broader association the chairman's views were until the very end of this research. As sub-section 7.6.4 demonstrates, it took the September 2014 service delivery protests in Kirkwood to get the commercial farming community to become actively involved in municipal water service delivery.

[26] Workshop A:2:18 referenced in Table A.2. In the action research process that I was involved in (subsequent to the September 2014 protests), several commercial farmers in the region argued that

sewage-spills into the irrigation canals now posed one of the most serious economic threats to the citrus industry (as described in sub-section 7.6.4).

[27] The project entitled ‘‘The Development of Water User Association Business Plans in the Eastern Cape’ was referenced as ‘Project No. WP 10503’ by the Department of Water Affairs.

[28] Out of the seven WUAs selected for participation in the DWA project (WP 10503), the L-WUA was one of four organisations that was previously an irrigation board (the others were the Great Fish WUA, the Kat River WUA, and the Gamtoos River WUA). The remaining three organisations are known as ‘smallholder’ types of WUA and comprise mainly emerging farmers in rural villages or around small towns.

[29] As part of the reconciliation strategy for the NMBM region, DWA awarded an emergency licence allowing the NMBM to use a maximum of 58.3 million m^3/a from the Orange-Fish-Sundays IBT, beginning in 2011, with the provision that after 20 years the licence would be reduced back to 22 million m^3/a (DWA, 2011a: xii). In addition, DWA awarded the NMBM with a ‘Municipal Drought Relief Grant’ of R450 million to expand the Nooitgedacht WTW (DWA, 2012), with the NMM planning to increase the capacity of the WTW by over 60% (from 85Ml/d to 140Ml/d by July 2016) (Algoa WSS: Strategy Steering Committee, 2014). The Nooitgedacht WTW is one of eight WTW that supply the NMBM with potable water, but is the only one that is supplied with water from the Orange-Fish-Sundays inter-basin transfer scheme.

[30] The concerns of the capacity of Caesar’s Dam were expressed by consultants as part of the RRU intervention into the SRVM, in addition to L-WUA technical officials, at a research meeting in February 2013 (referenced as meeting A:2:24 in Table A.2). This is the same meeting introduced in Box 6.2: we had planned a follow-up workshop between the L-WUA and the SRVM, with the participation of a number of consultants and DWA, but we settled for a meeting instead, due to the reasons outlined in Box 6.2.

6.4 Thick description 3: Amatola Water and contentious 'turnaround' programmes in the Sundays River Valley Municipality

6.4.1 The incident

In June 2012, a meeting was convened by the DWA and hosted in Kirkwood. Attendees at the meeting included Amatola Water (AW), the SRVM, regional officials from the DWA, and two other local municipalities.[1] The subject of the meeting was the successful awarding of Regional Bulk Infrastructure Grants by national government to municipalities in the Cacadu District Municipality. The SRVM was one of three municipalities within the district municipality to receive Regional Bulk Infrastructure Grant (RBIG) funding for the 2012-2013 financial year, which was intended for spending on large-scale infrastructure projects that were overseen by DWA.[2] The SRVM's grant was earmarked to increase the storage capacity of the raw water dams at the Kirkwood water treatment works (WTW). In principle, the granting of these funds was a positive development, as the funding represented an infrastructural solution to the endemic water supply shortages (as outlined in the second thick description). AW had assisted the SRVM with their application for the RBIG funding, supporting the submission of a funding proposal to the Department of Water Affairs (DWA). The SRVM was successful in gaining an initial grant, and the June 2012 meeting was intended as a 'handover event'. Over the course of the meeting, however, the SRVM Municipal Manager requested that the Amatola Water officials leave the conference room so that he could directly address the DWA officials. The municipal manager (who had started in the municipality in March 2012) then demanded to know from the DWA officials why Amatola Water had to be the project implementing agent, asking, "why can the municipality not lead the project itself?" DWA responded that it was now an internal policy of the Department to assign Water Boards to be the project implementing agents for all RBIG projects that are awarded to municipalities. The need for this policy had arisen out of prior mismanagement of funds by municipalities along with other issues surrounding poor implementation of RBIG projects, and was now an internal DWA policy being implemented throughout South Africa.

A DBSA representative was also present at the meeting. He recalled the municipal manager as arguing that the financial mismanagement of which the municipality was being accused was now in the past, and that the municipality is now capable of running its own projects.

According to a number of other research participants who attended the meeting, the municipal manager additionally challenged the DWA saying: "why doesn't DWA trust the municipality?" and "Why are you treating us like a naughty child? Give us the money directly and we will handle the procurement processes and the appointment of the consultants". The municipal manager argued that his municipality was attempting to build capacity now (implying that the use of AW as implementing agents would inhibit this capacity building). When DWA stuck to their policy, the municipal manager threatened to get the political arm of the municipality involved, including the Mayor. Thereafter, the meeting was postponed without resolution and without the officials from Amatola Water being invited to return to the meeting – as a result, the awarding of the funds to the SRVM and the initialisation of the project itself was placed on hold.

This thick description explores the issues affecting the RBIG funding by providing an account of the shifting role of the regional water board – Amatola Water (AW) – in water service provision and support services in the SRVM. The diverse roles that AW played in relation to the SRVM's water services are described in terms of the evolving institutional arrangements between the municipality, AW and DWA. The relationship between AW and the SRVM is also of particular interest in this study as a result of how the Eastern Cape case study of the SANPAD project was initiated (see sub-section 3.4.2 and Appendix B). In order to describe what precipitated the fallout between AW and SRVM in June 2012, and how this relates to the broader inter-governmental and intervention dynamics in the SRVM, the background of the relationship between SRVM and AW is introduced in the following sub-section.

6.4.2 Background to Amatola Water's engagement with the municipality

At the time of AW beginning to work with the SRVM in December 2010, the muncipality had been under administration for 10 months, and AW was tasked with assisting the municipality in producing a 'turnaround' strategy for the SRVM's water services, as part of the wider turnaround process underway in the municipality (Amatola Water, 2011: 35). According to numerous municipal stakeholders interviewed in late 2011, high expectations and hopes came with AW's intervention: the overwhelming feeling appeared to be one of relief, summarised by one stakeholder who literally said "well thank goodness Amatola Water is here…". This initial period can be characterised as a time in which Amatola Water was cast in the saviour role. Even at this point, however, there were different explanations of what had initiated AW's presence in the municipality:

1. The ‘financial management’ explanation: a senior official from the DWA Regional Office in the Eastern Cape said that he requested Amatola Water’s presence in the SRVM following financial mismanagement of DWA-awarded funds by the municipality, between 2009 and 2010. This was the explanation cited by councillors in the Cacadu District Municipality and officials from DWA.
2. The ‘cynical explanation’: that AW was canvassing for new business (an opinion held by some members of civil society within the SRVM) - and that AW was taking advantage of the dysfunctional state that water services in the SRVM were in, in order to sell a bunch of over-priced services to the municipality.
3. The ‘nepotism explanation’ (as relayed to SANPAD researchers – in confidence – by another member of the municipal staff): according to this explanation, one of the officials employed in the provincial-led turnaround of the SRVM was a close personal friend of a senior AW official, and AW’s intervention into the SRVM was an ad-hoc project that developed out of a request for assistance, but without providing a clear mandate of how or to what specific end.

The above explanations provide the context of why many participants within the municipality admitted that they did not know what the exact nature of AW’s engagement in the SRVM was. This confusion was compounded by the lack of a publicly-available contract showing the institutional arrangement between the SRVM and AW. Some interviewed stakeholders spoke of a Service Level Agreement (SLA); others spoke of a Memorandum of Understanding (MoU); others referred to a business plan that would be used to procure funding; still others spoke of another form of contract (either developed and signed, or in the process of development).

In the November 2011 Blue Water Services Audit (introduced in Box 6.1), I observed how the participating municipal officials made constant reference to the service level agreement that had supposedly been signed between their organisation (as the SRVM) and AW. During tea breaks at this very assessment, and away from the DWA officials, several of these same SRVM officials described how the high expectations and hopes that were initially vested in the relationship between AW and SRVM were waning. These officials noted that a year into the arrangement, there seemed to be little evidence of progress in the SRVM’s water services. But at this point in time, the public presentation of the arrangement between AW and SRVM was still overwhelmingly positive (as seen in the reference to an SLA in the assessments run by the DWA): the tone was: “AW is here to help us, so don’t worry if we don’t have x, y, or z

down right now - we will soon". From AW's side, my primary research informant responded that

> … the main thing that the SRVM officials don't always realise is that we are happy to assist, but they [the SRVM] must also help us [AW officials] with valuations and support to get funds.

The message from AW was that they were willing and able to assist, but as an organisation, they had to cover their operational costs. Officials were keen to emphasise that this was not a profit-driven motive: at both the management and operational level, all the AW research participants demonstrated awareness that their organisation could not be sucked into footing the bill of doing unpaid, volunteer work in the Eastern Cape water sector – because doing so would bankrupt their organisation. [3]

At the very first research workshop facilitated by the SANPAD project in the SRVM in October 2011, a regional manager for AW spoke of his organisation's 'exceptionalism' within water boards in South Africa: he argued that national government was calling on AW to perform functions that the majority of other water boards in South Africa were not performing (and that as a result, AW was playing an innovative role and in some ways, even piloting new powers and functions for water boards).[4] In summary, the manager emphasised that AW is now playing a particular developmental role within the Eastern Cape, rather than just consulting or providing technical support services to municipalities. Furthermore, he hinted that national-level discussions were underway, to explore the possibility of AW receiving an equitable share grant in the same way that municipalities do.[5]

At a follow-up workshop facilitated by the SANPAD project, a participating senior DWA official commented on this developmental role played by AW by recounting the case of O.R. Tambo District Municipality.[6] Similar to SRVM, this municipality was a Water Service Authority whose services had steadily declined in quality, becoming bad enough to warrant an intervention by the Minister for Water Affairs. The Minister tasked a water board to regulate and support the district municipality, with both the Durban-based water board - Umgeni Water - and AW competing for the contract. According to the senior DWA official, Umgeni Water turned down the contract because they wanted to have the right to 'hire and fire' accordingly, and they also demanded control over the budget and procurement practices of the district municipality. AW - on the other hand - did not make these demands, and were awarded the contract. The DWA official recounted the following:

> Amatola [Water] got their fingers badly burnt here, because they have not been paid for their services and the water services in the DM [district municipality] barely improved. It's gotten bad enough that Amatola has written to the Minister asking to be relieved of their duties.

The DWA official said he could not comment on whether AW was making the same mistake in the SRVM, but that he thought the organisation had to be wary of over-extension and becoming "financially exposed due to non-payment of services rendered". Whilst there were a few signs of the deterioration of the relationship between AW and SRVM in late-2011 and early-2012 (over the course of the above-mentioned workshops), actual conflict only became explicit at the RBIG meeting in June 2012. The resulting fallout between the actors, and the subsequent 'resolution' are examined in the following two sub-sections of this thick description.

6.4.3 Unpacking the events at the June 2012 meeting

Although the SANPAD project did not have any researchers present at the June 2012 meeting, it became evident afterwards that the meeting was a potential turning-point in the relationship between AW and SRVM.[7] As such, insights into the sources of the officials' and Municipal Manager's discontent were of definite interest. When interviewing the various participating parties as to what caused the divisions in the meeting, several key informants in the technical division raised the following issues.

The municipal officials complained that Amatola Water's logo was displayed more prominently on project documentation – such as proposals, monthly reports and engineering design reports. Another official commented that the AW's logo might be largely displayed in the middle of the page, with SRVM's logo relegated to a position of lesser-importance: a smaller size in the bottom left hand corner. The municipal technical officials were annoyed that their organization was not being treated as the client or accorded the respect they deserved.[8] As one technical official put it: "we resent being treated like this and not being given due recognition for being the client." To illustrate his point, the technical official provided an example of one of the consultancies hosting a project 'handover' meeting at their offices – rather than the meeting being hosted at municipal offices or on-site at the treatment works (which is the where such meetings are normally held). As a result, the SRVM technical officials had had to travel to Port Elizabeth to attend the meeting, rather than the consultants traveling to the municipality.

A few days later, another member of the SRVM technical division gave his explanation for the course of events: the SRVM Municipal Manager was new, he said, and the meeting was really about the municipal manager demonstrating his authority – "throwing his weight around" – testing to see how far he could push the various funding agencies and government departments upon which the SRVM was reliant, but from which he (the municipal manager) hoped the SRVM would become more independent. An official from the financial directorate supported this point of view, saying that the municipal manager wanted to challenge the image of the SRVM as a 'bad customer': suppliers and contractors were still treating the municipality as a bad customer because of the SRVM's recent history of defaulting on payments and general indebtedness. Many suppliers and contractors would only interact with the SRVM on a cash-on-delivery basis. An Eastern Cape-based consultant with the RRU further corroborated this, saying that he would only take contracts with municipalities with assured payment via bank-guaranteed cheques or payment up-front.[9] This same issue underpinned the chemicals incident in the first thick description.

My informants at AW, for their part, spoke of the embarrassment of being told to leave the room in front of senior DWA officials – saying that they were the ones being treated like "naughty little children who were expelled from the room whilst the adults talked". One of the AW officials confided that the real reason for the SRVM municipal manager wanting full control over the RBIG project was to ensure that the municipality could appoint whoever they wanted (the implication being, more pointedly, whoever the municipal manager wanted). The official went on to broaden this point to the generic level:

> Municipal managers do not like the water boards in South Africa (including Amatola Water), because if a water board runs the project, the local municipalities cannot control the tender appointment process.

According to this official, control of tender processes were at the centre of the disputes between most municipal managers and regional water boards. The AW official spoke of an undercurrent of resentment towards DWA within his organisation, because the Eastern Cape DWA office was consistently putting AW in the 'firing line' between themselves (DWA) and municipalities – and the sort of disputes arising out of the RBIG meeting were increasingly inevitable as a result.

Lastly, the senior DWA officials who attended the meeting were apparently unimpressed with the SRVM's behaviour, allegedly reminding the municipal manager that the SRVM still owed

DWA over R4 million for the Paterson bulk water supply scheme, and was therefore in no position to be making demands about how additional grants should be managed.[10]

6.4.4 Outcomes and 'resolution' of the meeting

All three actors (DWA, AW, and SRVM) stuck to their stated positions for a number of weeks, but within a month of the June 2012 meeting, the municipal manager agreed to sign the agreement, empowering AW to act as the implementing agent for the RBIG project. There are various explanatory stories for why the impasse was broken, illustrating the different ways in which the actors made sense of the dispute, which are are explored in this sub-section.

The AW official who was my closest informant in the organisation described the cause of the dispute as being a case of mistaken identity on the SRVM's part: the SRVM municipal manager had supposedly mistaken a consultancy that was present at the meeting to be acting for the SRVM, when in fact this consultancy was present for a different project for one of the other municipalities present at the meeting. The SRVM Municipal Manager had been offended that he and his officials were not privy to the selection processes of the consultants - especially given the discontents around how several consultancies had treated the SRVM as a secondary client. The AW officials were not given the opportunity to resolve this misunderstanding at the meeting – they were effectively told to step outside, and the meeting was adjourned in their absence. When officials from Amatola Water explained the above to the SRVM municipal manager after the event, the issue was supposedly resolved.

According to several officials in the SRVM technical division, however, the resolution of the dispute was less a result of a now-resolved misunderstanding and more of a calculated move on the part of the SRVM. As an official from the Project Management Unit within the SRVM technical division stated:

> We knew that we would not get the basic infrastructure grant money unless we gave in – so the municipal manager chose to abide with water affairs' regulations… for Amatola Water to be the implementing agent for the project.

As this SRVM official described it, the SRVM capitulated and agreed to sign-off on the project as long as the participating parties agreed upon certain criteria, the most prominent of which were:

- The inclusion of the SRVM in monthly project updates;
- The SRVM participating in contractor selection; and

- The SRVM being treated like the primary customer by, for example, the municipality being represented more prominently on the cover of project documentation.

The SRVM would not, however, require control over the entire RBIG project in order to sign the initial project documentation (as was the municipal manager's initial demand in the June 2012 meeting). However, it took a further 19 months for the scoping report of this RBIG project to be released for stakeholder engagement, despite the immediate (and very pressing) water supply problems at the Kirkwood WTW. The following two sub-sections why this was the case, via contextualising the June 2012 meeting (and the subsequent events described above) within the shifting role that AW has played in the SRVM between 2010 and 2014, and within the context of the internal challenges faced by AW.

6.4.5 The shifting role of Amatola Water between 2010 and 2014

By the time of the June 2012 meeting, AW was playing multiple roles within the SRVM, in addition to that of implementing agent for the Kirkwood RBIG project and support-provider in the SRVM 'turnaround' process. One of these additional roles was as the 'implementing agent' in the Paterson bulk water supply scheme – which was a role that DWA recruited AW to perform, following the financial mismanagement of DWA-awarded funds to the SRVM for this project between 2009 and 2010.[11] A second role, which is focused on here, is AW's participation in the DWA Rapid Response Unit (RRU) for the Eastern Cape. The RRU task team primarily consisted of consultants that the DWA deployed to struggling municipalities in the Eastern Cape.[12] Between 2010 and 2011, the Eastern Cape RRU was overseen by another South African water board (Umgeni Water, based in the Kwazulu Natal province), but AW was due to take over the 'project implementing agent' role of the RRU in the Eastern Cape by early 2012. What resulted was a confusing set of institutional arrangements, whereby Umgeni Water was overseeing consultants who were still finishing their RRU contract before AW formally took over, and where AW planned to continue working with some of the consultants but not others. Different actors in the SRVM expressed their uncertainty over the timeline of the transition from one water board to the next, and also questioned how a particular R1 million grant from DWA was spent. This grant was awarded to the SRVM by DWA, as part of the RRU process: in December 2011, DWA, the SRVM and AW signed a 'Tripartite Funding Agreement', which authorised AW to oversee the spending of the grant in the SRVM. The grant was to be spent on so-called 'quick wins', which were described as easily-achievable, management-related solutions to various issues concerning the SRVM's water services.[13] There were, however, contentions over what the R1 million grant had been

spent on, including what professional fees were paid with this grant, and whether there had been replication of efforts between the original work that AW had conducted in the SRVM, and what the RRU consultants were being paid to do.

My interpretation of the above is that the overlaps between the three roles that AW played (as a support agent to the SRVM, as implementing agent for RBIG projects, and then as implementing agent for the RRU) added to the role confusion that already existed and created fertile ground for the contentions that ignited in the June 2012 meeting. This role confusion was further exacerbated by the lack of a publically available Memorandum of Understanding (MoU) or a Service Level Agreement between the municipality and AW. Several of the participating RRU consultants with whom the SANPAD project interacted between October 2011 and July 2012 also questioned the lack of an MoU, leading to the events described in the fieldwork story in Box 6.6.

Box 6.6: Fieldwork story 6 – the SANPAD project, consultants, and 'being used'

Once we had selected the governance gap between the municipality and the L-WUA as a focal point in the action research process (see Box 6.4 and Box 6.5), I began looking for possible workshop participants to assist in the action research aim of bridging this governance gap. My primary informant at Amatola Water put me in touch with a consultant who was working with the SRVM at the time (first in relation to the RRU intervention and then later independently employed by the SRVM). This consultant shared a similar concern about the institutional arrangements both within the municipality, and between the municipality and the L-WUA, but she said that she was too busy to participate in any of our planned workshops. In a later telephone call, she asked me whether I had seen the Tripartite Funding Agreement, or the MoU between AW and the municipality (saying that she had not). She was concerned about the high level of role confusion and possible overlap in consulting work, and yet she said that she had had difficulty meeting with any of the AW officials due to time and resource constraints. Ultimately she attended the October 2012 workshop that we organised, admitting that she wanted to use it for her own professional purposes (namely, as an opportunity to meet the AW officials who were due to attend). This was the first time that I became aware of our research project being actively used by different participants towards their own ends (even if these ends complimented what we were trying to achieve). It was a salutary reminder that our project more broadly (and not just my specific study) was now part of the interventionist problem dynamics that I was observing and analysing in my study.

By the last quarter of 2012, the RBIG agreement for the Kirkwood raw water dams had been signed-off, the tripartite RRU funding had been spent, and it appeared that most of the major problems between AW and SRVM were now behind them. But in the weeks leading up to our October 2012 workshop (see Box 6.5), it transpired that the municipality's main contact at AW (who was also my primary research informant in AW) was technically no longer an AW

employee, due to his contract not being renewed. In conversation with him, this official relayed his interpretation of the situation, saying that AW was under serious pressure from government to fill senior management positions in line with BEE (i.e. employment equity) requirements, and that as an older white male, he had stood little chance of having his contract renewed. In the subsequent months, he was contracted by AW on a temporary basis, and therefore continued to manage a number of projects (including those in the SRVM). Yet AW declined to renew his employment contract, and by January 2013, he left the Eastern Cape to begin work elsewhere. In the following month, Sizwe (the SRVM Technical Director introduced in sub-section 6.2.6) contacted me to report that since this AW official had left, all of the AW-overseen projects in the SRVM had 'ground to a halt'. Sizwe asked me for different contacts at AW or for recommendations of who could help the SRVM, as the technical officials felt seriously 'left in the lurch'. When I interacted with other municipal technical officials over the next week, two of them described AW as being in a 'deep financial hole'. The SRVM officials elaborated by saying that DWA had asked them, as the municipality, to begin advertising for the third phase of the Paterson bulkwater scheme project, effectively making the SRVM the implementing agent (in spite of it being an RBIG-funded project for which AW was supposed to be implementing agent). The municipal officials interpreted this request from DWA as a tacit acknowledgement of the serious financial trouble that AW was in. The context and nature of these challenges, and the implications for the SRVM case, are described in the following sub-section.

6.4.6 Amatola Water's internal challenges (2011-2013)

Over the course of the apparent impasse between AW, the SRVM, and DWA that followed the June 2012 meeting, I heard from a number of sources at AW that their organisation was facing serious challenges of its own. I interpreted the implication of these statements to be that there was little strategic reason for AW (at the organisational level) to be too concerned about the interactions with the SRVM, because of the scale of organisational challenges within AW. In late 2012, I began hearing about an organisational restructuring process within AW, which one of my informants described as a shift in the ratio of primary to secondary activities undertaken by AW. This official stated that AW was now going to focus on its primary business of providing retail and bulk water services to large municipalities in the Amatole and Buffalo City regions of the Eastern Cape. The supporting, implementation-agent type roles entailed in the organisation's interactions with smaller municipalities (such as the SRVM) were secondary business activities that AW was now downscaling. The underlying

message seemed to be that these secondary activities were costing the organisation far too much (in all forms of resources), for far too little return, and that these secondary activities were actually bankrupting AW. The facts behind these assertions began to surface in early 2013, when I learned about the financial turnaround strategy that AW had put in place in the 2011-2012 financial year.[14] Amatola began an 'initial financial turnaround' in 2011, following the listing of a R40 million deficit in the previous financial year (Amatola Water, 2012: 16). According to AW's 'Financial Performance' report, this loss could be attributed to an increase in the water board's secondary activities, which grew by 34% between 2010 and 2012.[15] The chairman of the board for AW described its turnaround strategy as including "ring-fencing the primary and secondary business activities, reducing operating costs, [and] tightening internal controls" (Amatola Water, 2012: 6). These measures were required in order to combat the rising costs associated with AW's secondary activities from impinging any further on the organisation's capacity to perform its primary activities (which had both operational and legal implications).[16] Hence, a core aim of the turnaround strategy initiated in the 2012-2013 financial year is to restructure AW to achieve a target of 70% primary business mandated activities within five years.[17] But AW is also being called on by DWA to undertake a broader array of activities: the institutional changes proposed between 2013 and 2014 that are discussed in sub-section 5.5.4 will result in AW transforming into a regional water utility with expanded functions and gazetted area, seemingly requiring the organisation to extend and expand, rather than simply being able to focus on primary activities of bulk water services.[18]

The SRVM case offers a number of insights into why the secondary activities undertaken by AW carried such significant costs: firstly, many dysfunctional aspects in the SRVM water unit were at the interface of social dynamics, infrastructural problems, and institutional arrangements (which were often lacking). These challenges had multiple interconnected dimensions and multiple participating actors. But the AW officials often underestimated the interlinked and entrenched nature of the challenges. Over the course of the project initiation meetings between the Rhodes SANPAD team and AW officials in August 2011, AW officials shared the latest draft of their organisation's implementation plan for the SRVM, which was intended to serve as background information for a '3-year support contract of the Water Service Provider function of the SRVM' (Amatola Water, 2011b). The implementation plan was formatted as a spreadsheet that contained over 150 individually-specified and budgeted tasks, where each task was aligned to particular objectives and action plans. The plan was

predominantly a list of required technical tasks, and the spreadsheet format did not facilitate any interconnections of feedback between the neatly categorised items. The action plan items pertaining to the L-WUA illustrate how the AW officials saw the challenges described in thick description 2: as Table 6.1 summarises, action plan items included a task to "resolve [the] tenuous relationship" between the L-WUA and the SRVM. In discussion between the SANPAD project team and the AW officials, one official described the nominal impasse between the water user association and the SRVM at the time as being "easily resolvable". This official (who later became my primary informant in AW) was confident that he could resolve the situation within a week, arguing that it was mainly a case of "rapping some farmers over the knuckles". Four months later – after participating in several workshops and after we had both become more familiar with the situation – this informant retracted his earlier comment, admitting the following: "when I said I thought it could be easily fixed, I wasn't aware of the history." But engaging with this 'history' requires more employees' time, more travel and subsistence costs, and more facilitation skills than technical fixes and interventions that are controllable using traditional project management approaches.

Table 6.1: Excerpt from Amatola Water's 'Implementation Plan' for Sundays River Valley Municipality (July 2011). 'WUA' and 'SRV' refer to the Lower Sundays River Water User Association. Source: Amatola Water (2011b).

Reference	Objective	Action Plan
2	Product Quality: Water Availability	Water allocation issues: resolve tenuous relationship between Water User Association and SRVM
4.1	Water Resource Adequacy: Water resources	Verify raw water source/s
		Verify Registered volume
		Verify Contractual supply arrangement between WUA and municipality
		Develop a holistic and integrated water resources management plan
10.1	Stakeholder Understanding & Support: Abstraction & discharge registration	Water allocation via the SRV Water User Association. Details of the contract and water allocation need to be verified

A second dimension of this problem is the over-extension of AW officials: the same officials who worked with the SRVM also provided services to many other municipalities in the Eastern Cape. One of the AW managers said that at least three days of his working week was spent traveling from one corner of the province to the next, entailing as much as seven hours travel time per day, in order to visit outer-lying municipalities to which AW provides some or other service.[19] Furthermore, the meeting dynamics described in sub-section 6.2.2, which

often entailed meetings being held without resolutions being taken (and therefore requiring further meetings), and/or last-minute reorganisation or cancellation of meetings, inevitably complicated the travel routines of these officials.

To use a concept from Political Science, AW's involvement in SRVM can be conceptualised as a 'progressive entanglement' (de Bruijn, Ten Heuvelhof, & In't Veld, 2010), rather than a planned or intentional strategy of increased interaction. One persistent question arising from the use of the latter concept is whether AW has the capacity to perform the multiple roles that they are now playing (and required to play) in the Eastern Cape. Some of the AW research participants indicated awareness of the pressures created by the additional roles – particularly those roles that call for diverse forms of social engagement and facilitation. After a project steering committee meeting for the Paterson bulk-water project in 2012, an AW official who had chaired the committee said to me with a sigh, "You know, in our job the engineering part is the easy part: what really gets you is the social stuff". Many of the engineering consultants who I interviewed or who became my informants over the course of this study, expressed this same sentiment. The concept of progressive entanglement can also be applied to my own involvement in the SRVM case study, which followed a similar pattern of increased interaction (as discussed in fieldwork story in Box 6.7).

In summary, it is hard to avoid the irony that one of the major organisations employed in the turnaround process of the SRVM ended up requiring a financial turnaround strategy of its own (partly as a result of becoming over-extended in providing the kind of support services that it did to the SRVM). As this sub-section has shown, the internal challenges in AW over the course of this study help explain why AW had little capacity to take into account the local complexity of situations like the SRVM's, and why AW relied on techniques like desktop studies, business plan development, and rapid appraisals, which collectively are blunt tools when dealing with the developmental issues of a dysfunctional municipality. But the above account should not be read as meaning that AW had little to do with the SRVM from 2013 onwards, as illustrated in the penultimate sub-section of this thick description.

Box 6.7: Fieldwork story 7– my own progressive entanglement in the Lower Sundays River Valley

In late-2011, I participated in a site visit to the Addo water treatment works (WTW), with officials from the Department of Water Affairs (DWA) and the municipality. One of the technical issues raised by municipal officials on this visit was that the WTW's filters were impaired, which they thought was the result of the filter sand needing to be replaced. However, the municipal officials lacked operating manuals for the WTW, and were unaware of what size sand granule was required in these particular filters. The query was referred to the engineers at Amatola Water (AW), one of whom called me to pass on the technical specifications of the required sand: he said that he had tried getting hold of municipal officials via cellphone and email, but without response, and so had resorted to contacting me because he knew I was in the field. After he passed on the information, he chuckled and said "you never thought you'd end-up learning about the rapid-sand filters at the Addo treatment works, did you?" I agreed with him, and remarked that my whole experience in the LSRV had been a steep learning curve in which I was exposed to many different aspects of water service provision, regulation and management that I previously knew very little about. In the months following this incident, I increasingly became an intermediary between different stakeholder groups, often for very pragmatic reasons: for example, when the municipal server was offline over the course of the Blue Water Services Audit, the municipal officials submitted their report to DWA using my laptop. The AW officials in East London (more than 300km away) would also copy me into emails to the SRVM for the same reason, and when the Rapid Response Unit engineers were trying to get hold of municipal officials in late-2011, I ended up helping to organise an intervention workshop that the RRU engineers ran in February 2012. Through interactions such as these, I became 'progressively entangled' in the LSRV case, and I also began to care more: I noticed that (at times), the 'participant' part of my 'participant observation' was overtaking my observational duties, and that it was becoming more difficult to maintain any form of an objective 'distance' from the research. However, my progressive entanglement in the LSRV was also what enabled the action research components of my study, as introduced in sub-section 6.6 below, and described in detail in Chapter 7.

6.4.7 The planning workshop in February 2014

In February 2014, the SRVM technical directorate invited members of the SANPAD project to participate in a planning workshop.[20] The focus of the workshop was to assess the need of a full upgrade to the Kirkwood WTW in order to meet the demand for water in the Greater Kirkwood area. The workshop was hosted by the SRVM, with officials from the L-WUA, members of the Kirkwood Ratepayers' Association, and the manager who had replaced my primary informant at AW also present. The planning workshop was facilitated by a consulting engineer, who had been sub-contracted to provide technical support to AW and the SRVM in the preparation of a new proposal for RBIG funding. The consulting engineer acted as an intermediary between AW and the SRVM, with the outcomes of the workshop being successfully presented to the RBIG funding committee the following month. This workshop demonstrated that the challenges experienced between 2011 and 2013 had been sufficiently dealt with for the municipality and AW to continuing working together. However, the February 2014 workshop occurred more than 19 months after the first RBIG allocation was

granted to the SRVM (on an emergency basis to address the Kirkwood water supply problems).[21] The fact that this workshop only occurred in early 2014 therefore also demonstrates the wider challenge of delivering large-scale infrastructural developments within an inter-organisational network, which in this case, features national government departments as funding agents, regional water boards as implementing agents, consulting engineers as technical specialists, and the municipality as the client and recipient. The mal-functioning inter-governmental system in South Africa was introduced earlier as a governance challenge affecting local water authorities in the LSRV (in sub-section 5.5.2). The intermediary roles played by Amatola Water within this mal-functioning inter-governmental system are discussed further in point (iii) of sub-section 6.5.3.

6.4.8 Conclusion to thick description 3

This third thick description has provided the context of Amatola Water's engagement in SRVM, using its involvement in the Kirkwood water supply scheme expansion project as the starting point. Describing the multiple stories around what happened in the June 2012 meeting usefully illustrates the dynamics of institutional change in the SRVM. More broadly, this thick description has explored:

- The role confusion, scope-creep, and progressive entanglement of AW;
- How one of the key agents in the turnaround of the SRVM was itself undergoing a turnaround at the same time;
- The background to AW's changing institutional status in the Eastern Cape between 2011 and 2014; and
- How AW acted as the entry point for the SANPAD project into the LSRV (including providing the initial set of contacts and means of engagement for the study reported upon in this thesis).

The following section draws from this thick description, along with the two preceding thick descriptions, in order to discuss how the overlapping themes contribute to a thicker interpretation of the September 2014 protests in Kirkwood.

Notes for Thick Description 3:

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[1] The L-WUA was not represented at the meeting because this was explicitly about municipal funding, and the meeting included representatives from two other municipalities in the Cacadu District Municipality.

[2] The Regional Bulk Infrastructure Grant (RBIG) is administered by the Department of Water Affairs, and is one of the 'Schedule 7' grants of the *Division of Revenue Act*. Schedule 7 grants are 'Allocations-in-kind to municipalities for designated special programmes', with the Division of Revenue Act describing the purpose of RBIG as follows:

> To develop regional bulk infrastructure for water supply to supplement water treatment works at resource development and link such water resource development with the local bulk and local distribution networks on a regional basis cutting across several local municipal boundaries. In the case of sanitation, to supplement regional bulk collection as well as regional waste water treatment works (RSA, 2011: 102).

[3] See sub-section 5.3.5 for the different institutional status of water boards in comparison to municipalities.

[4] Workshop A:2:15, referenced in Table A.2.

[5] I never heard anything else about this proposal, so it was possibly just a rumour or a policy proposal that never got anywhere. The idea of Amatola Water receiving an equitable share grant is nonetheless interesting, as it speaks to the developmental, government department-like role that some officials in the organization saw it playing.

[6] Workshop A:2:16, referenced in Table A.2.

[7] My informants, i.e. those who attended the meeting, included representatives from DWA, AW, technical officials in the SRVM, and representatives from the DBSA, in addition to representatives from the Financial division of the SRVM.

[8] My initial response to the logos complaint of municipal officials was dismissive: surely this was a red herring? A point made by Ostrom et al. (2011) – from the mainstream institutionalism school (see Table 2.1) – provided cause for me to re-interpret the municipal officials' complaint as follows: Ostrom et al. (2011) provide an institutional analysis of development cooperation, with a particular focus on how development aid generates different incentives with varying effects on the multiple individuals involved. One of the issues that Ostrom et al. (2011: 24) consider is the tendency for contractors to view the programme developer or donor, rather than the recipient, as the de factor project owner: they argue that "consultants often face incentives to maximize their efforts on tasks they think will please the donor. Given that consulting firms tend to seek long-term relationships, they strive hard to maintain their reputation and relationship with the donor" (*ibid*.). Seen in this light, the municipal officials' complaints about not being treated as the client, and their perception of how this was demonstrated by the relative size of organisational logos on project documentation, can be interpreted as reflecting a broader problem of relations between municipalities, national government and consultancies.

[9] The trend of consultants demanding bank-guaranteed cheques or up-front payment from municipalities seemed to be particularly prevalent with the independent consultants (i.e. those not part of a large engineering firm or organisation). One such consultant mentioned to me that he had been several months financially exposed as a result of non-payment on municipal projects, and was behind on all of his own bills as a result. As he put it, "we also have to be able to keep our lights on".

[10] The Paterson bulk water supply scheme, which has been introduced and discussed in sub-section 5.2.5 and was another project primarily funded through RBIG and the DWA.

[11] The misuse of R9 million grant funding from the DWA to cover SRVM operational expenses, instead of being spent on the intended bulk water infrastructure project between Addo and Paterson, was covered in the newspaper articles describing the financial state of the SRVM in 2009 (for e.g. Masondo, 2009a), and was introduced in sub-section 4.7.2.

[12] The Rapid Response Unit (RRU) was introduced in endnote [1] of section 6.2. The Eastern Cape RRU for 2011-2012 was overseen by a consultant based in Kwazulu-Natal (KZN), with participating consultants from the provinces of the Orange Free State and Gauteng, in addition to KZN. Some members of the RRU team worked in all provincial teams, whereas others only worked in the RRU teams in their home provinces.

[13] The 'quick wins', which were funded as part of the Rapid Response Unit (RRU) intervention in the SRVM, were earmarked for operations and management expenditure, and not for the replacement, refurbishment, or renewal of physical infrastructure. One of these 'quick wins' was the payment of the chemicals bill over the course of the incident recounted in the first thick description (see sub-section 6.2.1).

[14] I first heard about Amatola Water's financial challenges (which led to the organisation requiring a turnaround strategy of its own) from a board member.

[15] The R40 million loss in the 2010/2011 financial year (attributed partly to the "increase in Section 30 [i.e. secondary] activities"), and the statistic of the 34% increase in secondary business from the prior year, were both noted in the 'Financial Performance' section of the 2011-2012 Annual Report (Amatola Water, 2012: 15-6).

[16] As discussed in sub-section 5.3.5, a water board is only permitted to perform activities other than its primary activity if it does not limit the board's capacity to perform its primary activity, or if it does not 'financially prejudice' itself (as detailed in Section 30 of the *Water Services Act* (RSA, 1997)).

[17] The aim of restructuring AW towards achieving 70% primary business activities within five years (i.e. by the 2016/2017 financial year) was stated in the 2013 annual report (Amatola Water, 2013). In the 2011/2012 financial year, primary activities only accounted for 49% of AW's business, which changed to 55% primary and 45% secondary in 2012/2013 (Amatola Water, 2013: 6). Institutional dimensions of a water board's legally-mandated activities – including a breakdown of primary versus secondary activities – were introduced earlier (see sub-section 5.3.5).

[18] The institutional reform and realignment processes discussed in the National Water Resource Strategy 2 (June 2013 edition) is summarised in Box 5.5 and discussed in sub-section 5.5.4. As part of these reforms, AW reported in its 2013 annual report that it is "in the process of preparing... itself for [its] transformation into a regional water utility with expanded functions and gazetted area" (Amatola Water, 2013: 6).

[19] For example, the distance between Amatola Water's head office in East London (where the managers are based) and Kirkwood (where the SRVM technical officials are based) is about 315km – equating to around four hours drive time each way.

[20] Workshop A:2:20 referenced in Table A.2.

[21] The RBIG allocation to the SRVM for the Kirkwood WTW was at the centre of the June 2012 meeting that was the starting incident of this thick description; the Kirkwood water supply problems were also the starting incident for the second thick description.

6.5 Discussion

This chapter began with the aim of exploring the September 2014 protests in Kirkwood not as as an event, but as a dramatic manifestation of a systemic problem that has developed over time (see sub-section 6.1.1). The overall question asked in this section is, 'what are the Kirkwood protests a manifestation of?' An interpretive account of the Kirkwood protests is developed here, which describes the protests as emerging from three interconnected manifestations of the governance challenges that were identified and analysed in section 5.5. These manifestations are grounded in the ethnographic data collected over the course of this study, from which the three thick descriptions were written. The manifestations are described at the operational level which, following Ostrom et al. (2011: 7), is the level at which "individuals interact in repetitive settings that directly affect physical outcomes". Each operational manifestation reflects on the governance challenges discussed in section 5.5, and draws on the theory and concepts described in Chapter 2. In particular, institutional theory and systems thinking and theory, and literature from the anthropology of infrastructure are drawn from, and are used collectively to argue for a 'thicker' form of thick description. This adapted form of thick description was developed and employed in this study as part of the broader action research process (as explained in section 6.6).

6.5.1 'A sad day for Kirkwood'

The violent service delivery protests that broke-out on the 23rd September 2014 were introduced in sub-section 6.1.1. In terms of my own research, the protests occurred at a time that constrained my learning about either the protests or the background events (for the reasons described in Box 6.8). However, the protests prompted me to return to the field the following month, and also prompted the broader SANPAD project to re-initiate action research within the LSRV. The action research aspects of this re-engagement are discussed in section 7.6. This sub-section returns to the Kirkwood protests in order to further describe what happened, and how research informants in the LSRV made sense of the event at the time.

The buildings destroyed in the September 2014 protests in Kirkwood included a local ANC office, the directorates for Financial Services and for Technical Services in the SRVM, the Municipal Manager's office, and the municipal council chambers (see Figure 6.2). Despite the extensive destruction of municipal property and the violence of the protests (where rubber

bullets were fired by riot police in what one informant described to me as "a very sad for Kirkwood"), no deaths were reported and the situation did not immediately escalate.

Box 6.8: Fieldwork story 8 – Kirkwood burning

I was in the process of writing the 'final' version of my thesis when I received the news that violent protests had broken-out in Kirkwood, with water shortages seemingly one of the issues of contention. The first picture that I saw in an online news article showed the municipal council chambers on fire (Sesant, 2014): the same municipal council chambers that I sat in over the course of many meetings and workshops since 2011 (including the Blue Water Services Audit in November 2011). I saw how municipal officials with whom I was friends on Facebook posting photos of the municipal offices burning, with simple messages saying that their places of work no longer physically existed. Alongside these employee perspectives, I read about the extended water shortages and on-going service delivery issues in the Kirkwood area, and was struck by guilty feelings that I should have done more with my study – and panicked that another round of protests would break out and become even more destructive. Although fieldwork was unscheduled at this stage, the Kirkwood incidents motivated our research team, including myself, to re-engage the SRVM.

One of the Kirkwood fire-fighters described why he and his colleagues were unable to tend to the fires as follows:

> We couldn't put out the municipal office fires… we were told by the people toyi-toying [protesting] that they would burn our fire-trucks if we came near. So we sat in our offices surrounded by police.

The buildings that were burned were evidently targeted and planned, with no surrounding businesses or homes affected. One of the municipal officials involved in water services described how he did not believe the destruction of property to be random:

> [The] protesters wouldn't have burned down the water-treatment works and the waste-water treatment works [because] they know that they are reliant on those… The burnings were calculated… for example, the storage garages at the technical division were not burned [because] the protesters were warned that explosive canisters of chemicals were stored in the garages, and that setting those garages alight would be dangerous and impact on the water treatment works functioning.

Yet in the immediate aftermath of the protests, there were many different interpretations of what had led to the protests becoming so violent, and what role water shortages had played in the protests. One of the commonly-mentioned issues was the irregular expenditure amounting to R84 million (featuring in a number of the newspaper reports around the protests – as described in sub-section 6.1.1). According to Sizwe (the technical director of the SRVM), the irregular expenditure was actually accumulated over four years, and was a composite figure that included operational expenses incurred by the SRVM on a monthly basis and capital grants that had been misspent (from as far back as 2009).

Figure 6.2: Photo of the municipal offices in Kirkwood on fire as part of the protests on 23/09/2014. Source: Facebook (no citation/acknowledgement available).

Sizwe argued that the problem was mischaracterised in the media – where, for example, newspapers reported that the amount was misappropriated through tenders to companies that had "… allegedly failed to deliver services" (Sesant, 2014). R12 million of the R84 million, for example, was spent by the SRVM on the chemicals used at the municipal WTW (as described at the beginning of the first thick description – sub-section 6.2.1). Rather than the chemicals not being provided, the problem lay with the municipality's informal arrangement with the chemicals company – in which the municipality did not have a service-level agreement with the chemical supply company, and the latter failing to be officially appointed by the SRVM's Supply-chain Management division. Given that the municipality is only supplied with chemicals by one company, and given that this company has not been officially appointed, all financial interactions between the SRVM and the chemicals company are categorised as 'non-compliant' under the 'Generally Recognised Accounting Principles' (GRAP) mandated in the Municipal Financial Management Act (introduced in sub-section 5.4.4). Over four years, at an average monthly cost of R300 000, the chemical component of the irregular expenditure amounted to around R12 million. The R84 million also included the misappropriation of capital grants on operational expenses by the municipal administration between 2006 and 2009, with the largest single item being the R9 million grant awarded to the municipality by DWA for the Paterson Bulkwater Scheme (as described in endnote 11 of

the third thick description). Sizwe argued that the R84 million even included expenditure on RBIG projects that were overseen by Amatola Water, for which the latter held the role of Project Implementing Agent, but for which the SRVM is now being held responsible. In summary, Sizwe argued that the irregular expenditure and misappropriation of funds was accrued over four years and contained many balance-sheet items that were either outside of municipal officials' control, or reflected decisions made by previous municipal administrations. As noted in sub-section 5.5.3, there are significant barriers to accounting and accountability under the current municipal financial framework, where the bureaucratic lines between what counts as irregular expenditure, misappropriation of funds, and irregular tender processes "makes the [regulatory] system costly, burdensome, ineffective and prone to fraud" (NPC, 2012: 47).

The decision made by the SRVM municipal council to write-off the irregular expenditure in September 2014 was motivated by the need to write-off the expenditure in order to manage the municipal finances more cleanly going forward. The major problem was less the irregular expenditure itself – according to Sizwe – and more the lack of clarity between municipal officials and municipal residents as to the nature of the expenditure. Sizwe's interpretation was that the background explanation of the irregular expenditure, and the municipal requirement to write-off the irregular expenditure, was inadequately communicated to municipal residents – in particular, to municipal residents in Ward 1 where the majority of the protesting residents were from (as described below).

All stakeholders acknowledged that water shortages have continued to affect urban settlements in other parts of the Kirkwood region (for example, the technical director reported that the suburb of Aqua Park in the Kirkwood area had been without water between the 21st December 2013 and mid-March 2014). Yet according to a number of informants (both within with the municipality, and from different community groups in the Greater Kirkwood region), the service delivery protests began in Ward 1 for a clear reason. Since the 2011 local government elections, the councillor for Ward 1 has also been the Mayor of the SRVM. When the irregular expenditure of R84 million became public, the majority of the ward councillors in the SRVM allegedly explained the reasons behind the irregular expenditure to their constituencies using the ward committee structures (see Figure 5.7 and associated description in sub-section 5.4.3). The only exception was the Mayor, who did not meet with his ward constituency. A number of my informants, including those employed within the municipality,

stated that it was now common knowledge that the Mayor had failed to attend meetings, specifically the meetings requested by residents in his ward. The final straw was the Mayor and Municipal Manager's lack of response to the water shortages in Moses Mabida the week prior to the protests. As Sizwe described it:

> A week before the municipal offices were burned, the same group of protesters burned the door at the technical directorate's offices as a warning… saying that what people want is for the mayor to come speak to them.

In sub-section 6.2.4, the basic geographical issue of the location of the technical directorate's offices was mentioned (in that the technical directorate's offices were located separately from the other municipal offices in the Greater Kirkwood region, in the suburb of Moses Mabida – see the map in Figure 7.9). Despite the apparent warning sign of mounting resident dissatisfaction, the mayor did not attend the meeting demanded of him.

The second issue that was prominently raised by informants and stakeholders in the Greater Kirkwood region (alongside the irregular expenditure) was the water shortages themselves. Water shortages had continued to affect the region throughout 2014, and had increased in severity and frequency in the weeks preceding the September 2014 protests. Hence, another interpretation was that the absence of a clear explanation regarding the irregular expenditure served to anger communities that were already dissatisfied with water shortages, with these shortages interacting synergistically with the irregular expenditure problem to provide the final catalyst for the violent protests. However, the fact that the majority of the protestors were from Ward 1 supports the interpretation that there was something particular distinguishing this ward from others (namely, the mayor and associated political interests).

The third interacting element of the dissatisfaction around service delivery in the Kirkwood region was the lack of progress with the RBIG project to expand the Kirkwood water supply scheme (introduced in 6.4.7). Whilst only a few stakeholders were aware of the technical details of the proposal to increase the capacity of the Kirkwood WTW, the municipality had publicised that it was seeking funding from DWA to address the numerous infrastructural problems affecting the Kirkwood scheme. The local businessman who was involved in the sluice-cutting incident (see 6.3.1) and who participated in the February 2014 planning workshop, said that he had found out that DWA would not be funding the proposed project due to the extent of the water leaks in the Kirkwood system. When I met with the technical director in mid-October, he corroborated the businessman's report, and described how the

SRVM technical directorate was stuck in 'a catch-22' situation: in 2012, the municipality submitted a water conservation/water demand management (WC/WDM) proposal to DWA, which was turned-down on the basis of being too expensive. Following this, the municipality submitted the first funding proposal for the Kirkwood WTW expansion, with DWA subsequently awarding an RBIG grant for the scoping phase of this project. The awarding of the latter grant occurred at the contentious meeting that began the third thick description (sub-section 6.4.1). But now that the scoping phase had been completed (in September 2014), DWA was turning down the proposed expansion on the grounds that the SRVM could not warrant an augmented water supply scheme without *first* addressing the extensive leaks in the bulk water supply network of the Greater Kirkwood. The technical director expressed exasperation at now having to re-submit a cheaper WC/WDM proposal to DWA, arguing that if a grant had been awarded in 2012 when the first application was made, then many of the water leaks could have been fixed by 2014, and the Kirkwood crisis could have been potentially avoided as a result.

A further issue of concern over the course of the September protests was the perception (and experiences) of declining water quality in the Greater Kirkwood region. The chairperson of the Kirkwood Ratepayers' Association stated in October 2014 that recent water quality data reported to residents in ward committee meetings were 'appallingly bad', with high E.coli counts detected in the potable water provided by the municipality. Different interpretations for the poor quality of the drinking water included the following:

- That blockages and breaks in the sewerage-system were overflowing into the irrigation canal upstream of the abstraction point of the Kirkwood WTW;
- That the municipality was consistently running-out of chemicals (chlorine and aluminium flocculate) with which to treat the water; and
- That the filters at the Kirkwood WTW were not being backwashed and, as a result, were now heavily clogged and operating with decreasing efficiency.

One response from Sizwe to the above listed interpretations was to say that the challenges of supplying a sufficient *quantity* of water interacted with the challenges of supplying an adequate *quality* of water. Sizwe argued that the Kirkwood WTW could only provide about 75% of its daily design capacity on the days that the filters are backwashed, and that backwashing is therefore unfeasible given the current water shortages that require the WTW to perpetually operate above-design capacity. Sizwe acknowledged, however, that the quality of the drinking water was poor, which many of my informants spoke of in different ways:

- A local guesthouse-owner in the town of Kirkwood described to me how she warned all visitors to avoid drinking the tapwater;
- The principal of a local high-school reported that children in his school were regularly getting diarrhoea and complaining of 'upset stomachs' (which he attributed to the drinking water); and
- Several of the commercial farmers in the region warned of the economic threats that sewage-spills posed to their businesses (and therefore to the economy of the region).

Sewage-spillages into the irrigation canals that feed both the WTW with raw water, as well as the citrus packhouses in the region, were of particular concern to the businesspeople. A common theme that arose in discussions with most stakeholders in the Greater Kirkwood region was one of general frustration with a failure of 'getting the basics right'. As one of my informants put it:

> What can we do if the municipality can't even get the basics right? The roads are falling apart, the electricity is constantly going off, and water and sanitation are appalling. It's a disgrace. Someone is going to die, and then what?

At the 2014 Presidential Local Government Summit (held five days before the protests in Kirkwood), the Department of Cooperative Governance and Traditional Affairs (CoGTA) launched a new programme to monitor the performance of municipalities: the 'Back to Basics' programme acknowledged that service delivery protests frequently result from the inability of many municipalities to render services to communities, and that these protests are "a reflection of communities' frustration… particularly in economically marginalised communities" (DWS, 2014b: 1). Whilst the timing of the Back to Basics programme was prescient in relation to the SRVM, the programme joins a long list of previous national-level acknowledgements of local government failure (extending back to the 'Local Government Turnaround Strategy' of 2009: see Table 5.7). In the following sub-sections, the five governance challenges identified and analysed in section 5.5 (including the prior failures to address known issues) are discussed in relation to the operational manifestations of these governance challenges in the SRVM. Each operational manifestation draws on the ethnographic material collected in this study – discussing common themes in all three of the thick descriptions – and relates these themes to the broader literature.

6.5.2 Overview of the operational manifestations of the governance challenges

The five governance challenges affecting the functioning of local water authorities in the LSRV are summarised in Figure 5.12. As argued in section 5.5, these governance challenges

are inter-related and connected to all three spheres of government – national, provincial, and municipal. This sub-section introduces three ways that these governance challenges manifest at the operational level of water management and water service delivery in the LSRV (focussing on the bulk water supply stage of the urban water cycle).

> 'Manifestation A' discusses the negative effects arising from interventions into local water authorities in relation to government staffing capacity (sub-section 6.5.3);
> 'Manifestation B' analyses the manifestations of reinforcing cycles of crises within local government (sub-section 6.5.5); and
> 'Manifestation C' explores the patterns of behaviour around infrastructural 'asset stripping' (sub-section 6.5.4)

The three operational manifestations draw from overlapping themes that emerged out of the interpretive analysis in the thick descriptions. As with the governance challenges, these themes are inter-related rather than discrete. The following three sub-sections describe each manifestation both individually and in relation to one another – with the collective aim of providing a deeper analysis of the factors contributing to 'Kirkwood burning'.

6.5.3 Manifestation A – The iatrogenic effects of interventions in relation to government capacity

The first operational manifestation of the governance challenges affecting local water authorities uses a medical concept that interventions can, and often do, have costs that outweigh the benefits. Following Taleb (2012: 111), "the name for such net loss, the (usually hidden or delayed) damage from treatment in excess of the benefits, is *iatrogenics*, literally, "caused by the healer," *iatros* being a healer in Greek" [emphasis in original]. The risks entailed in any medical intervention increase when a patient's health is already compromised ahead of the intervention (for example, in the cases of elderly individuals or anyone with a compromised immune system). Similarly, the potential negative side-effects of interventions into local water authorities increase when the capacity to manage and take advantage of such interventions is lacking. As this sub-section will argue, many of these interventions respond to staff capacity issues at the municipal scale. This sub-section will also show how these skill shortages extend throughout the South African water sector – manifesting in district municipalities, regional water boards, and national government departments, all of which interact with local water authorities in the LSRV. In addition, these skills shortages are wider than civil engineering, which is the part of the water services sector that typically gains the most attention in national media (e.g. Berkowitz, 2012; Bisseker, 2012; PMG, 2014b; SAICE,

2013): the skills shortages extend to project management, financial management, facilitation, and a range of professions associated with planning, financing, and implementing projects within a context of socio-technical systems. The skills shortages are partly addressed through the use of professional service providers (i.e. consultancies). But the use (and over-use) of such consultancies as a form of 'skills bailout' carries its own dynamics (such as requiring internal capacity within municipalities and government departments to manage and regulate the quality of the consultancies' work). In order to build this argument, this sub-section begins with describing staff capacity within the SRVM, and then widens the analysis to the district, regional, and national levels.

(i) Staff capacity within the Sundays River Valley Municipality:

In sub-section 6.2.3, an SRVM councillor was quoted as describing the municipal staffing challenges as being primarily reputational in origin. The councillor described the various constraints that all municipal employees face, and argued that these problems discourage qualified professionals from wanting to work for the SRVM. This councillor's views – expressed in late-2011 – closely match the findings of an infrastructural report produced by the World Bank in 2009, which stated the following:

> Even with adequate funding… it is hard to entice qualified professionals, especially those with families and career ambitions, to take up residence in remote areas with inadequate housing, schooling, and networking opportunities (World Bank, 2009: 30).

Yet it is important to recognise that the new technical director started in the SRVM as a qualified engineer five months after the municipal councillor's dire prediction above. Even with the new technical director employed, staffing problems in the SRVM continued though, with other necessary technical posts remaining unfilled. A further dimension of the staffing challenges is the technical competence of the individuals currently employed: most of the (usually white) consulting engineers who interacted with the SRVM appeared adamant that a combination of under-resourced maintenance departments and a relative lack of training were to blame for the majority of the technical incompetence attributed to municipal officials. The occasional racist explanation was given to me, which can be summarised in the opinion expressed by one retired engineer when he said, "these black officials only know how to do one thing - and that's break infrastructure". Other officials and engineers – from government departments, consultancies and water boards – sought alternative explanations. One engineer provided a psychological explanation to me, saying that most of the Eastern Cape technical officials with whom he interacted lacked confidence, even when they were technically

competent. This lack of confidence was most frequently exhibited in the interactions between consulting engineers and municipal technical officials (as discussed in point (vi) below). Another (white, English-speaking) official provided what he saw as a cultural explanation for why many black, Xhosa-speaking technicians do not *appear* to have the same affinity for looking after water infrastructure as the white technicians of the apartheid era did. This official argued that the idea of infrastructural maintenance is culturally antithetical to Xhosas, saying the following: "Do you know that there's no word for 'maintenance' in Xhosa?" In point of fact, there are a number of words for maintenance in the Xhosa language, including 'ukugcinwa'; 'ukusekelwa'; 'isondlo'; and 'isixaso'. What is interesting here is the attempt by the above-mentioned engineers to broadly explain municipal staff issues in a more-nuanced way: it should hardly need stating that these explanations are, however, inadequate.

From the perspective of the municipal officials who were research participants in this study (including those officials who became some of my key informants), technical competence was a resource question: as described in the sub-section on the day-to-day working environment in the technical directorate (6.2.2), municipal officials argue that they are constantly having to address crises, attend meetings, and work overtime, leading to fatigue and demotivation (particularly when the demands on their time are high, and the supporting resources are low). In sub-section 6.2.3, one municipal official was quoted as saying that he was 'over putting in the extra effort' because he felt that he was carrying the weight of several officials, and because the only recognition from his supervisors of this extra effort was to be given additional responsibilities. These issues are further analysed in the second operational manifestation of the governance challenges (the vicious cyle described in sub-section 6.5.4 below).

The multiple issues affecting staff capacity in the SRVM are connected to equivalent capacity issues throughout the Eastern Cape province, and throughout the South African water sector more broadly. These capacity issues influence municipal management in a host of different ways, as the following sub-sections argue.

(ii) Cacadu District Municipality:

As introduced in sub-section 5.4.1, the Cacadu District Municipality (CDM) is the Category C municipality that the SRVM is situated within. In formal institutional terms, a district municipality is supposed to support the functions of the local municipalities within its area of jurisdiction, but in the case of the CDM, the district municipality has been downsized

between 2010 and 2012 (see sub-section 5.4.2). My primary research informant within the CDM described the problem as follows:

> We are supposed to help 'capacitate' local municipalities… [with local municipalities] coming in and saying "we need help with projects". But it's more like helping them to help themselves, because we don't have capacity anymore: we have had our budget consistently cut and our department reduced in size, from 1000 workers down to around 90 workers [as of the May 2011 changes in municipal demarcation].

The above-quoted official noted that as of February 2012, there was only one professional engineer within the ten municipalities of the CDM (i.e. including CDM itself and the nine local municipalities within CDM). Whilst the staffing situation subsequently improved (with both the SRVM and it's neighbouring municipality in the CDM – Makana Municipality – employing civil engineers), the employment of qualified civil engineers neither solved the water challenges in the SRVM, nor did it prevent the extensive water cuts that afflicted Makana Municipality in 2013 (Mngixtama-Diko & Roux, 2013). Following the September 2014 protests in Kirkwood, I learned from several informants that the senior management of CDM were now lobbying for the district municipality to be more actively involved in water service provision and regulation roles in the nine local municipalities within its jurisdiction. However, since the municipal demarcation changes of May 2011 (and the subsequent reduction in the district municipality's technical directorate), the CDM does not have the capacity to adequately perform *either* the water service authority role, or the water service provider role for all nine local municipalities. This raises the question of whether Amatola Water, as the regional water utility in the Eastern Cape, can perform these roles for the SRVM.

(iii) Amatola Water:

The different functions that Amatola Water has performed in relation to the SRVM's water services were discussed in the third thick description (section 6.4), in which the role confusion and progressive entanglement of the two organisations were described. The governance analysis further accounted for the fact that the SRVM is outside of Amatola Water's gazetted area of operation (see sub-section 5.3.5), and described the state of institutional flux that Amatola Water has been in over the course of the National Water Policy Review process (see point (iv) of sub-section 5.5.4). This institutional flux is one explanation for the delays in the scoping phase of the RBIG-funded expansion of the Kirkwood WSS (see sub-section 6.4.7). As this RBIG project illustrates, Amatola Water is required to work within an inter-organisational, multi-actor network: these networks are characterised by mutual

dependencies and negotiations between differing, and sometimes conflicting, interests (de Bruijn & Ten Heuvelhof, 2008). The demands on Amatola Water's resources therefore have both technical and socio-political dimensions, which require a differentiated approach to governance from the traditional, command-and-control governance models that are suitable in hierarchical contexts (*ibid.*). A reasonable interpretation of the dynamics in the third thick description (section 6.4) is that Amatola Water does not currently have the capacity to perform the numerous roles that it is being called upon to perform, particularly given the extent of the organisation's internal challenges between 2011 and 2013 (see sub-section 6.4.6). An additional factor in Amatola Water's over-extension is the intermediary role that the organisation plays between DWA and municipalities in the Eastern Cape, with DWA facing significant and similar challenges.

(iv) Department of Water Affairs:

The DWA-Regional Office (DWA-RO) provides an illustration of how extensive the skills deficits are in the Eastern Cape province, and the effects this has on service provision and regulation. Several of my key informants in the Eastern Cape RO worked in the Directorate for 'Water Regulation & Use'. As discussed in 5.3.7, the Directorate for 'Water Regulation & Use' is composed of four sub-directorates that are overseen by a Director's office. The sub-directorate of 'Water Services Technical Regulation, Compliance and Enforcement' (highlighted in red in Figure 5.5) is tasked with the aim of 'ensuring technical regulation of water services in the Eastern Cape' – and is thus the most relevant regulatory sub-directorate for the SRVM. The divisions of the sub-directorate are summarised in the organogram in Figure 6.3 below.

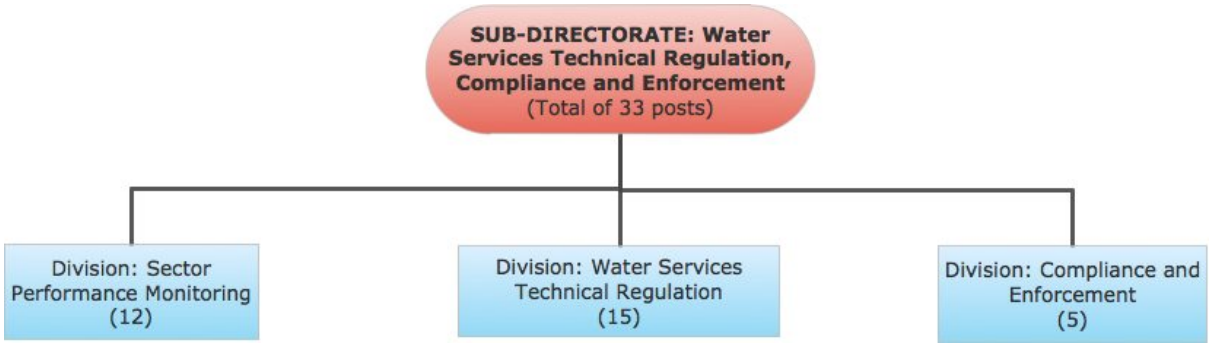


Figure 6.3: Organogram of the Sub-directorate of Water Services Technical Regulation, Compliance and Enforcement (as of July 2012). The intended number of posts per division are provided in brackets, with the total of 33 posts including the 32 posts in the divisions plus the director of the sub-directorate.

In the capacity assessment that led to the organisational structure in in Figure 6.3, 33 posts were identified as necessary to fulfil the roles and responsibilities of this sub-directorate. By July 2012, only two of these posts were filled (with one of the two employees being an

intern). This has resulted in only a few of the Key Performance Areas of water services actively being monitored and regulated by the DWA in the Eastern Cape, which is particularly problematic given the importance of regulation of this kind within a decentralised model of water supply and management (Muller, 2009). A particularly relevant case in point is the following: under the fourth 'Compulsory National Standard' for quality water services (see Box 5.2), if water services are disrupted for longer than 24 hours, the water services institution (WSI) has to undertake to deliver emergency water. The explanatory notes and guidelines for these regulations specify that a WSI

> … can use water tankers to deliver water to households or communal (shared) water points… [and that] they may buy these temporary or emergency services from other organistions or suppliers… All WSIs must have back-up plans for breakdowns in water services supply (DWAF, 2002b:16).

In mid-2012, the DWA-RO acknowledged that they were aware of these emergency supplies not being delivered according to the requirements (including in the case of the SRVM and the Greater Kirkwood scheme), but the interviewed officials said that they simply do not have the capacity in the Eastern Cape RO to regulate water provision against Norm 4. In one interview that I conducted in July 2012, a senior DWA official said the following:

> There's lots in theory that we are supposed to be doing as a regulator, that's not being put into practice because of capacity. Although we know there's lots going wrong, we just don't have the warm bodies on the ground to get out there and to regulate. We need more individuals on the ground in order to communicate with municipalities so that they know they are transgressing certain prescripts according to the legislation.

One of the regulatory tools that DWA uses to assess a municipality's performance in terms of the 'Compulsory National Standard' is through the municipality keeping an incident register to record the frequency and duration of water outages. The 16th Compulsory National Standard specifies that a WSI must have a consumer service facility to report and record non-compliance (see Box 5.2), with the guidelines stating that facility "must include what responses and actions have been taken to address the complaint" (DWAF, 2002b: 41). When DWA officials requested to see the SRVM's incident register over the course of the 2011 Blue Water Services Audit (see Box 6.1), the technical officials from the municipality said that they had only kept a hard copy of incidents in a logbook, and that the logbook was incomplete. Whether this was a strategy to avoid being held accountable to regulation, or simply a management strategy employed under resource constraints, is unknown. Either way, the senior DWA official's interpretation of such occurrences was the following:

> Municipalities get away with a lot, which under normal, theoretical circumstances they shouldn't get away with. To be quite honest – in the case of some of them – because they know the department doesn't have the capacity [to regulate], they deliberately do things.

The capacity challenges in the water services technical regulations sub-directorate of the Eastern Cape DWA-RO are illustrative of the overall skills shortages within DWA itself: as of May 2013, DWA had only 31% of its complement of civil engineers; furthermore, of that 31%, around 25% were aged between 60 and 64, meaning that they are due to retire by 2018 (a loss that represents 44% of the chief engineers at the DWA) (SAICE, 2013). More recently, DWA presented to parliament on the "serious shortage of skills in the country", arguing that the problem of brute scarcity of skills is compounded by the fact that quality engineers tend to be absorbed into the private sector, particularly given that public sector salaries are uncompetitive (PMG), 2014b). Several consulting engineers who became research informants expressed interest in working directly for municipalities, but were deterred by what they referred to as "a common perception amongst civil engineers that local government is a disastrous place to work". As one consultant admitted to me, "I'd love to work within a municipality, but I'm scared that I would just never get anything done." This individual described engineers as practical people who are trained as problem solvers. Circumstances where problems abound but "their hands are tied" – as he put it – are the most frustrating to engineers. The inability to perform one's job because of a lack of support or denial of resources is not just frustrating to consulting engineers: as discussed in the first thick description, the dynamic of efficient and hard-working municipal employees becoming frustrated with a lack of support – along with the numerous incentives to *avoid* doing good work – also affects key members of the SRVM technical directorate (sub-section 6.2.3).

The shortage of in-house engineering skills in local and district municipalities, Amatola Water, and the DWA-RO in the Eastern Cape is off-set through the use of consultancies as professional service providers (introduced in the historical analysis in sub-section 4.8.5). As the South African Local Government Association (SALGA) acknowledged, this problem is generic to South African municipalities:

> The practice in many municipalities is to retain very limited in-house technical capacity and depend on external service providers for the design and implementation of infrastructure projects – even for just repairing potholes (Bisseker, 2012: 1).

The use (and over-use) of such consultancies as a form of 'skills bailout' comes with its own set of dynamics, as the following sub-section analyses.

(v) Consultancy dynamics:

The interactions between consultancies and the SRVM were issues of concern frequently raised both within the municipality and by non-municipal officials and informants. Over the course of fieldwork in the SRVM between 2011 and 2014, I found consultancies to perform a range of water sector-related roles, which can be categorised as follows:

i. Engineering project management, design and construction;
ii. Policy and strategy-development;
iii. Capacity development and municipal support.

Roles that consultancies play in the 'engineering project management, design and construction' category include the following: supervising the development of new public works and the refurbishment or expansion of existing infrastructure; technical planning; problem analysis; feasibility studies; and preliminary and detailed design. Examples in the SRVM include the Paterson Bulkwater scheme and the upgrade of the Addo WWTW. Consultancies in this category are typically engineering specialists who then interact with the project commissioners (who are also referred to as the 'project owners') in the following way:

> Under South African law, the roles of the consulting engineer and the construction company on a project are clearly ring-fenced. Consulting engineers are never allowed to sub-contract construction companies. The owner of the project always contracts the construction company directly – the engineer provides the quality control and compliance monitoring on behalf of the project owner (Gorgens, 2015).

Examples of the work that consultancies have done in the second broad area (policy and strategy-development) include:

- An engineering consultancy being tasked to compile the Water Services Development Report (WSDP) for the SRVM; and
- An accounting firm being employed on a contract to create the municipal asset register.

Consultancies within this category are typically specialists in financial management, information systems, strategic management, and engineering firms. Speaking over the course of the November 2011 Blue Water Services Audit, a senior financial official within the municipality candidly remarked to me that "we [the SRVM] just produce the policies and bylaws for compliance purposes." This official described policies and strategies being produced as 'paper processes', where documents are created but remain unused on a day-to-day level, and hence are often lost or buried under other paperwork subsequent to their creation. When the SRVM needed to provide documentary evidence to DWA for the 2011

audit, the technical division conceded to not having a number of municipal policies on hand (including the SRVM's Free Basic Services (FBS) policy). Officials asked to be excused from the assessment in order to look for the FBS policy, amongst others, in the municipal archives. In some instances, municipal officials could not find documentary proof of policies that they were sure the municipality had created in the past, but which officials now maintained had disappeared. One of the explanations given by the municipal staff was that the municipality had only received hard copies of a particular policy or strategy from the consultancy that was employed on the contract. The municipal officials said that no replacement or electronic copies were made available, and hence, they could not submit any documentation to the DWA assessors. Many of the consultants with whom I interacted over the course of this study provided another perspective. According to these individuals, their consultancies typically provided electronic copies of project reports via email as well as hard copies, which were delivered either via post or in-person during feedback sessions.

An additional concern raised by DWA assessors and regulators on a number of occasions between 2011 and 2013, was the way in which consultancies create policies and strategies as desktop exercise. In these situations, consultancies frequently use generic spread-sheet templates, which results in documentation that is compliant with the necessary regulations, but which is insufficiently tailored to the local context or reflexive to specific municipal needs. Where consultancy-generated policy and strategy reports produce results and make particular recommendations, a number of municipal officials all questioned how the municipality is supposed to apply any of the recommendations in the reports that are generated.

The third broad category of consultants are those who provide 'capacity development and municipal support', where a central aim is to address these implementation challenges. All consultancies are supposed to have a capacity development aspect of their contract with local government. In its most narrow form, consultancies are supposed to develop capacity within the municipality through, for example, skills transfer programmes or by including municipal officials in the planning and execution where feasible: some of the officials in the technical division perceived such programmes as more of a hindrance than a help, with a senior technical official saying, "we can't afford this; we don't have time to sit with 11 different consultants in a day!" Other consulting projects have capacity development as a central rather than peripheral aim. One example in the SRVM was a contract with a financial management

firm, sponsored by National Treasury as part of a municipal support programme between 2011 and 2013. An accountant within the SRVM financial division described the project as follows:

> One consultant is based here for the next two years, working full time Monday to Friday, with other consultants being available and on-call (on a demand-basis)… The consultants have been very useful. I don't know how we'd be doing without them.

The accountant outlined how the consultancy assisted the SRVM with the new municipal software, helping the financial division to use the software to access important data and issue bills, which were some of the challenges affecting the SRVM at the time of the chemicals incident (see sub-section 6.2.1). The SRVM technical division benefited from an equivalent programme, called Siyenza Manje, as described in the following sub-section.

(vi) The Siyenza Manje programme and the goal of 'dealing with consultants on an equal basis':

The Siyenza Manje programme (introduced in sub-section 5.5.5) was initially funded by the Development Bank of Southern Africa (DBSA) but was absorbed into the Municipal Infrastructure Support Agency (MISA) under the Department of Cooperative Governance and Traditional Affairs (CoGTA) in 2012. The Siyenza Manje programme was initiated to provide technical support to municipal officials: a senior DBSA technical expert in the Eastern Cape described the key role of the programme as being

> … to back-up municipal officials with the knowledge they desperately need when dealing with consulting engineers… [so that] they can begin to deal with consultants on an equal basis.

The requirement for this technical assistance has been broadly acknowledged – with SALGA arguing that "in many cases there is no internal capacity [within municipalities] to even manage the quality of work of these external providers" (Bisseker, 2012: 1). An engineer was seconded to the SRVM in 2009 as part of this programme, where he was appointed as acting Project Manager in the technical division until a full-time employee filled this position in mid-2011. After the Siyenza Manje programme was incorporated into MISA in 2012, the afore-mentioned engineer remained seconded to the SRVM in a project-support role.

Some of the specific difficulties that Eastern Cape municipalities face in engaging consultants include lacking the capacity and skills to do the following:

- To compile a detailed request for the design and construction of either new WTW or WWTW, or for the upgrade of existing works;
- To define the scheme required and the scope of the project;
- To create an adequate terms of reference; and
- To enter into a contract with consulting engineers that will adequately protect the municipality against costs attendant to remedying possible design shortcomings.

The senior DBSA official quoted above, argued that because of these difficulties, "the letter of appointment [of consulting engineers] is often a carte blanche document as municipalities understandably rely on the assumed professionalisms of consulting engineers." Municipal officials tend to engage consultancies under a series of assumptions and beliefs, including that consulting engineers,

- Know better than the municipality itself what plant is required;
- Will follow the best interest of municipalities; and
- Have the capability and skills to design and oversee the construction of all the plants that are approved.

According to the DBSA official, most of the Eastern Cape technical officials with whom he interacted lacked confidence, even when they were technically competent. In the officials' experience in the province, lack-of-confidence in combination with one or more of the following frequently results in municipalities ending-up as victims:

- Consultancies themselves lacking the expertise to undertake jobs that they bid for;
- Consultants taking shortcuts on testing equipment prior to handing over to municipal officials; and
- Consultancies failing to provide comprehensive documentation, including operation and maintenance manuals.

A specific example of the above factors was the proposed upgrade of the Addo WTW in the SRVM, which according to the DBSA engineer, would double the capacity of the WTW but would copy all the shortcomings inherent in the design of the existing WTWs. In addition, basic requirements were excluded from the budget – even though the upgrade proposal was produced by a prominent engineering consultancy – including refurbishing the current mechanical and electrical parts, and catering for operational manuals being produced. The DBSA official is not alone in his criticism of consultancies. Government reliance on consultancies is being increasingly questioned by the South African public and by regulators, including the South African parliament's Standing Committee on Public Accounts (SAPA,

2013), and the Auditor-General of South Africa (Stone, 2014). A further example is the financial component of municipal management: although over R650m was spent on consultants preparing financial statements for municipalities (in the 2012-2013 financial year), the Auditor-General reported that it had to correct 80% of the financial statements that municipalities paid consultants to prepare, leading the Minister of CoGTA to state the following:

> You would expect the so-called private sector people to come and do the right thing and get things right… Why do these consultants get paid? What are they doing in municipalities and why are they contributing to undermining our municipal financial performance as opposed to actually assisting? (Stone, 2014)

The historical dimensions to the growing reliance on consultancies were introduced earlier (see Figure 4.1 and associated description). As broadly noted in the literature, consultancy-reliance cannot be divorced from the post-apartheid migration of skills out of the public and into the private sector (e.g. Dent, 2012; Mehta et al., 2014; van Koppen & Schreiner, 2014).

The Rapid Response Units instituted by DWA offer further insight into the consultancy dynamics discussed here. The Department of Water Affairs instituted the Rapid Response Units (RRUs) to assist troubled municipalities on an emergency basis (DWA, 2011b), sub-contracting teams of consultants to both project manage the units in each province, and to perform the actual intervention work. The RRU team that worked in the Eastern Cape between 2011-2012 RRU argued that consultancies are required for emergency interventions given the current skills shortages in the public sector. However, the design of the 2011-2012 RRUs were intended to avoid a model of "rapid-in, rapid-out, helicopter-consultancy" (as phrased by one of my informants from the DWA-RO). The RRU was instead supposed to adopt a systemic approach – tackling the reasons why the emergencies in municipalities had developed in the first place. Yet the majority of the RRU programmes in the SRVM were still run on a workshop-basis, where consultants arrived in the municipality for a few hours or days at a time, conducted a workshop, filled-in spreadsheets of technical data derived from question-answer sessions with municipal officials, and then produced reports with recommendations. Municipal officials from the technical and financial directorates complained that in many cases, the municipality could not implement the recommendations in these reports, due to a combination of the following:

- The recommendations not being context-specific;
- The municipality lacking the required resources or capacities to implement; and

- The technical and financial staff being unable to gain the required buy-in from municipal councillors and/or senior management.

The RRU therefore seemed to work in the exact 'helicopter-consultancy' mode that the Eastern Cape team had tried to avoid. The primary iatrogenic effect of these interventions is that national revenue is being spent on interventions that have little effect on the operational situation in the SRVM and because these interventions fail to build capacity within the SRVM, new problems frequently arise that further intervention. Following the argument developed in sub-section 5.5.1 on developmental local government (DLG), the SRVM is therefore intepreted here as an organisation that is stuck in a vicious, rather than a virtuous cycle. The net effect of this vicious cycle is that the basic goal of DLG – namely, to facilitate active, engaged citizens to work with, and be served by, efficient and accountable local governments – is not achieved. The following sub-section explores a further operational manifestation of these challenges, describing reinforcing cycles of crises.

6.5.4 Manifestation B – Negative reinforcing crisis cycle

In the first thick description on the internal operations of the municipality (sub-section 6.2.2), a municipal official was quoted as describing how he and his colleagues felt that they were not in control of their own time. As another official described it, "currently the status of this municipality is that we are running after the emergencies and not planning…" Several technical officials described this pattern of behaviour as one of perpetual 'fire-fighting': officials were constantly reacting to crises, which placed constraints on their capacity to manage, operate or maintain current infrastructure. The effects of this perpetual fire-fighting can be understood in terms of a cycle in which emergencies require the symptoms of problems to be addressed, but a combination of resource constraints and multiple other emergencies (often occurring simultaneously) do not allow for the deeper, structural causes of the emergencies to be similarly addressed.

Figure 6.4 below expresses the fire-fighting cycle using a causal loop diagram from the field of system dynamics (introduced methodologically in point (iii) of sub-section 3.5.3). Two interacting feedback loops are identified in this causal loop diagram (CLD). In the first loop, municipal officials respond to the immediacies of crises: the more the crises, the more the 'immediate actions required to address crises', and the more the immediate actions, the more the 'immediate causes of crises [are] addressed', which serves to then decrease the number of crises. Hence, to use the appropriate system dynamics language, the three blue arrows in

Figure 6.4 below represent a balancing (**B)** feedback loop, where the effect of the feedback is to lessen the influence of the initial variable (in this case, the variable 'crises').

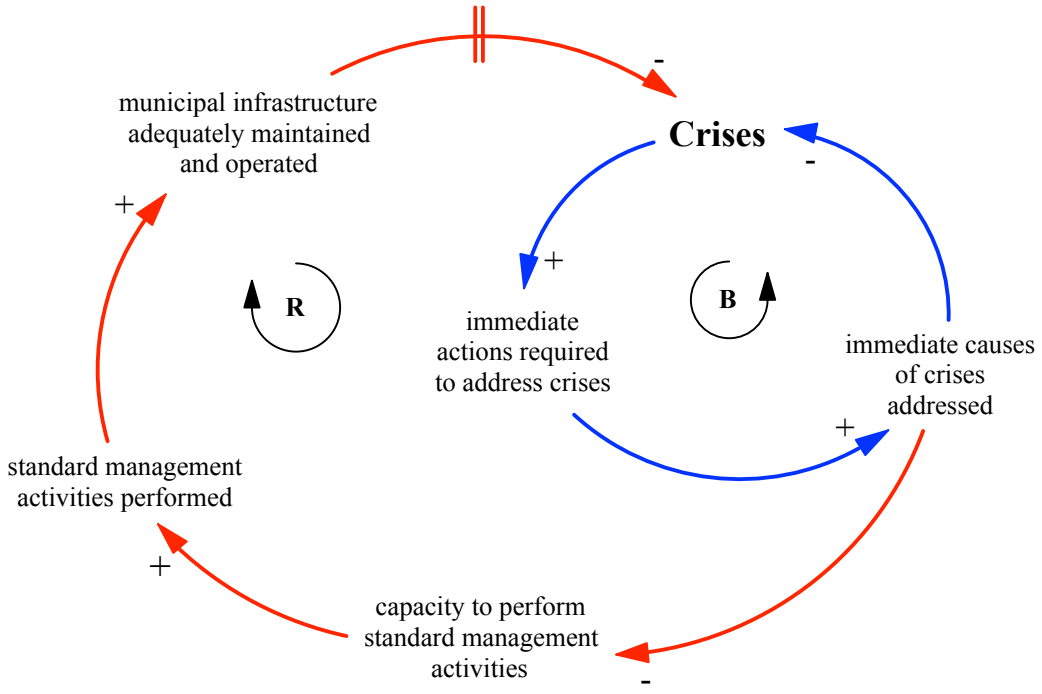


Figure 6.4: The fire-fighing (i.e. crisis) cycle, represented in a causal loop diagram (CLD) employing diagrammatic notation from the field of system dynamics. The way in which variables are causally related is demonstrated by stipulating a polarity on the arrow: a positive relation (+) between two variables (e.g. *x* and *y*) means that a change in *x* will effect a change in *y* in the same direction. A negative relation (-) means that a change in *x* will effect a change in *y* in the opposite direction. The balancing feedback loop is identified with the anti-clockwise 'B', and the reinforcing feedback loop with the clockwise 'R'. The double-line on the one arrow denotes a delay.

One of the issues identified by the municipal officials early on in my research was that immediate actions to address crises carries a short-term benefit of 'fire-fighting', but at the cost of performing standard management activities (including routine maintenance and strategic planning). This trade-off is represented in the second feedback loop CLD in Figure 6.4 below: the more that the 'immediate causes of crises [are] addressed', the less the municipal 'capacity to perform standard management activities', and the less this capacity, the less the 'standard management activities [are] performed'. By performing these standard management activities, 'municipal infrastructure [is] adequately maintained and operated': hence, the less this infrastructure is adequately maintained and operated, the more the crises. In the language of system dynamics, the net result of this pattern is a reinforcing (**R)** feedback loop, where – to use the fire-fighting metaphor – tending to burning fires results in standard management activities being performed less, which creates fertile conditions for future fires to

break out, demanding more fire-fighting of municipal officials, which leads to more fires over time, and so the pattern reinforces itself. The effect becomes additionally reinforcing when the urgency of the current crises not only demands immediate actions, but also rewards municipal officials for addressing these immediate issues, and therefore incentivises further firefighting. In the SRVM, technical officials lamented the fact that this vicious cycle left them with little capacity to systematically assess (and then address) the interlinking challenges they faced, and that they therefore had little way of breaking out of the vicious cycle except through interventions from external agents (such as national and provincial government, water boards and consultancies).

The CLD in Figure 6.4 is a simple picture of a complex system that uses six (highly-aggregated) variables, and it therefore offers a limited perspective on the dynamics of interest. The systems thinking embodied in the CLD was taken forward in this study through the development of four system dynamics models, which are described and the results of which are discussed in section 7.5. The fourth model, in particular, explores the 'modes of failure' of local government, expanding on the CLD in Figure 6.4 (see sub-section 7.5.6).

The chemicals incident that was the initial event in the first thick description (see sub-section 6.2.1) provides additional insights into the systemic challenges faced by the municipality, as introduced in the CLD in Figure 6.4. In early 2012, municipal officials argued that the chemicals incident was caused by two sets of factors: the first set of factors pertained to the increase in potable water demand in the SRVM, and the second set of factors pertained to the over-extension of the municipal technical directorate in unfavourable circumstances. The municipal officials argued that the growth in demand and a shortfall in municipal capacity were collectively driving the crises that kept the municipality in fire-fighting mode. These two sets of factors are briefly discussed here.

(i) Growth in demand:

Officials from the municipal technical directorate attribute the growth in water demand to a number of transitions in the LSRV region between 2011 and 2012. The first transition is the broad pattern of urbanisation in the LSRV: at a research workshop in the SRVM in February 2013 (referenced as 'Workshop A:2:19' in Table A.2), an experienced municipal official argued that urbanisation was the most significant change in the demography of the SRVM in the preceding decade. The official argued that urbanisation had been driven from within the LSRV, as a secondary-effect of farms transforming from commercial agriculture to eco-

tourism (see sub-section 4.6.2). Given that the municipality does not provide water services to rural residents (as described with Figure 5.2 and associated description), but is responsible for overseeing and providing water services to residents of urban settlements, the urban influx associated with the rural transformation dramatically increased the number of people in urban settlements that the municipality now needed to serve.

The second transition that municipal officials attributed to the growth in water demand was the upgrading of the levels of water services in urban households – whereby households receiving a basic supply level are upgraded to being fully-connected to the municipal reticulation network. A 'basic supply level' of water services is defined here as having access to potable water either from a nearby standpipe, a yard connection, or a household connection, but without waterborne sanitation. This second (service-level) transition was what municipal officials raised most frequently over the course of fieldwork as underlying the sharp increase in demand for potable water in the urban settlements of the SRVM, but is of course related to to urbanisation: the acting technical director over the time of the chemicals incident described the two transitions as compounding one another, because the majority of the urbanising residents moved into households which then received upgraded services.

A senior technical official in the SRVM argued over the course of the chemicals incident that the service-level transition was further exacerbated by "poor planning on behalf of the previous housing department": this official noted that standard protocol requires that the bulk water supply schemes of a municipality are assessed ahead of any new housing development being approved. In particular, the capacity of the bulk water supply system and the associated waste-water management system should be sufficient to handle the additional requirements that the new developments will place on them. If the capacity of this supporting infrastructure is deemed insufficient, then planning must be initiated for increasing the capacity in order to meet the future demands. The design standards for these developments, and the implications for water supply, are clearly outlined in the 'Guidelines for Human Settlement Planning and Design' (produced by the national Department of Housing (DoH) and informally known as 'the red book' (DoH), 2000)). However, the DoH [now the Department of Human Settlements] is not the only responsible actor in these situations: as another senior technical official from the SRVM confessed,

> Our department has been pressured by councillors to get houses up – even without the necessary infrastructural development to service these houses. Then, when we [the technical division] cannot serve the houses, we are blamed for it.

The implication of the municipal official's comment is that the SRVM technical division is forced to deal with a legacy of the above-mentioned standard protocol being ignored or overlooked – both by municipal councillors in response to pressures and obligations from the communities they represent, and by the provincial DoH responsible for implementing the housing projects – leading to housing developments being approved regardless of the capacity of the supporting infrastructure. This implication relates to the mal-functioning inter-governmental system in SA, where different functions are performed by different departments and spheres of government, frequently in a non-cooperative and conflicting manner (identified as one of the governance challenges in sub-section 5.5.2).

The above factors pertain to the increase in potable water demand in the SRVM. The various dimensions to the growth in water demand are further explored in the third system dynamics model – the 'Kirkwood water demand' model – in sub-section 7.5.5. Around the time of the chemicals incident in early 2012, the municipal technical officials also accounted for why they were unable to meet the demand requirements, as described in the following sub-section.

(ii) Over-extension of the municipal technical directorate in unfavourable circumstances:

As introduced in the historical analysis, prior to the establishment of the SRVM in 2001, the technical directorate in Kirkwood only served the Greater Kirkwood area (see section 4.6). With the changes in municipal demarcation in 2011, the areas of Glenconnor and Kleinpoort, previously managed by the CDM, were added to the SRVM (as described in sub-section 5.4.2). One municipal official commented in late-2011 that "with this larger area we now have more infrastructure to maintain, and a larger geographical area to manage, without an increase in our budget." The lack of budget increase is as a result of the rural and predominantly poor nature of the areas, meaning that the areas are both economically unproductive and relatively unpopulated, but have bulk infrastructure that nonetheless still requires maintenance. Municipal officials argue that the addition of Kleinpoort and Glenconncor is indicative of the pattern of more and more infrastructure being constantly added to the municipal asset register, and therefore requiring maintenance, without a concomitant increase in resources to perform maintenance. This is true both for new infrastructure in the main urban settlements of the municipality as well as infrastructure added as part of the larger area now managed by the SRVM. Furthermore, as one of my informants at the CDM argued:

> When the SRVM began in 2001, the district council asked the technical division of the [Kirkwood] local council if they could handle the additional infrastructure… they said they could do it, but now the municipality has increased five-fold – and now they definitely can't do it.

The above illustrates why many of the technical officials in the SRVM would complain about having to work within the legacies of previous municipal administrations. Some of the technical implications of these infrastructural legacies are analysed in the second system dynamics model on the 'Greater Kirkwood Water Supply' system (see sub-section 7.5.4).

Compounding the basic problem of the municipality now servicing a larger area was the way in which municipal officials took ownership of infrastructure in the early-2000s: municipal officials said that there was almost no hand-over process for this infrastructure, complaining that the infrastructure was just "dumped in our hands by other authorities… and then became our problem". For example, two informants at the technical directorate said that they had received no operational and maintenance (O&M) manuals for the Addo WTW, and so therefore no-one at the technical directorate knew the design capacity and specifications for key pieces of infrastructure. This was the official reason given by municipal officials in the Blue Water Services Audit in 2011 (Box 6.1) for not knowing some of the vital characteristics of municipal water supply infrastructure (including the age of particular components, required to assess depreciation rates for calculating infrastructure life-cycles (Hosking & Jacoby, 2013)). Over the course of the RRU intervention into the SRVM, several consulting engineers addressed this complaint of the SRVM technical officials: the DWA-contracted engineers argued that the absence of O&M manuals in the hand-over of the infrastructure is an inadequate answer for failing to maintain the infrastructure once in the SRVM's possession. According to the RRU engineers, the municipality would only need to hire an engineering firm, and possibly even just one engineer per day per plant, to provide a once-off audit of municipal infrastructure that would give the municipal officials all the technical specifications that it required as management criteria.

The above example aims to show that the municipality could adopt coping measures to adaptively manage some of the challenges it faces. Many government and Amatola Water officials expressed frustration to me over the course of my fieldwork that such coping measures were seldom sought and adopted by the SRVM during the turnaround period. The unwillingness to seek and adopt such coping measures was one of the reasons why intervention agents perceived the SRVM officials as being unwilling to change. The

engineering consultant appointed by DWA to run a Water Services workshop as part of the RRU intervention in the SRVM (referenced as 'Workshop A:2:3' in Table A.2) phrased this point bluntly, saying to the attending SRVM officials that "your municipality does not care about water – that much I can see. I don't know what you do care about, but all I can say is that you don't care about water." In this consultant's view, if the municipality did care about water management and the business of providing safe water to the users within its jurisdiction, then there were many simple management tweaks that could be performed – at little to no financial cost – to ensure better levels of water services than the institution was currently providing. One of the most noticeable aspects of the new technical director starting in the SRVM in July 2012 (see sub-section 6.2.6) was his personal adoption of such coping measures (and his promotion within his department, and within the municipality more broadly, of such measures).

In summary, this sub-section has introduced the systemic challenges faced by the SRVM using the 'fire-fighting' crisis cycle in Figure 6.4, and then described these systemic constraints via two sets of factors that contributed to the chemicals incident in the first thick description. These two sets of factors – the growth in demand for potable water and the over-extension of the municipal technical directorate in unfavourable circumstances – are both analysed further in the system dynamics models in Chapter 7. The following sub-section explores the third operational manifestation of governance challenges in the LSRV, in the form of infrastructural 'asset stripping', and shows how it overlaps with the reinforcing crisis cycle.

6.5.5 Manifestation C – Infrastructural asset stripping

Infrastructural asset stripping refers to the practice of over-using and/or under-maintaining infrastructure, such that it depreciates in value quicker (by decreasing the remaining usable life of the asset and increasing the eventual capital replacement costs). In addition to the long-term cost implications, the effects of asset stripping include increased risks of mechanical breakdown and process failures in current infrastructural functioning (CSIR & CIDB, 2007: 7). Despite national government policies aimed at mitigating this behaviour (as described in sub-section 5.5.3), asset stripping has continued across South African municipalities (Infrastructure Dialogues, 2013; Joubert et al., 2014) – including in the SRVM. Asset stripping contains two inter-linked dimensions: the first being the practices and

incentives to over-use infrastructure, and the second being the practices and incentives to under-maintain, each of which are discussed in relation to the SRVM here.

Several of the reasons for the over-use of water supply infrastructure in the SRVM were introduced in the discussion of the growth in demand for potable water in sub-section 6.5.4 above. One of the short-term responses used by the municipal technical officials is the purposeful over-extension of water supply infrastructure above its design capacity (i.e. operating a pump at 130% in order to compensate for a capacity shortfall, as explored in the 'Greater Kirkwood Water Supply' system dynamics model in sub-section 7.5.4, and the 'modes of failures' model in sub-section 7.5.6).

An exchange between members of the SRVM financial directorate and RRU-consulting engineers at the 2012 Water Services workshop (referenced as 'Workshop A:2:3' in Table A.2) usefully introduces maintenance budgeting: at this workshop, one of the senior accountants in the SRVM challenged the RRU engineer asking "where is the MIG [Municipal Infrastructure Grant] equivalent for maintenance?" The post-apartheid legislative framework for local government water services requires municipalities to maintain their own infrastructure, using revenue generated from the services they provide (see sub-section 5.4.4) – as such, the response from the RRU engineer running the 2012 workshop was, "run your Water Services Provider correctly and you will pay for maintenance yourselves." The RRU engineer argued that if the municipality planned strategically to meet the increase in demand, then it should not have to over-use infrastructure. Secondly, if the municipality budgeted for maintenance, then it should be able to extend the life of current infrastructure and prevent breakdowns. The low levels of infrastructural planning in the SRVM in the last five years (resulting in a lack of infrastructure replacement) has left the municipality reliant on current infrastructure, and therefore reliant on maintenance budgets. However, as shown here, these budgets are tied to the broader politics of operational expenditure.

In the budgetary planning process for the 2013-2014 financial year, the municipal budget was set against a 70% collection rate, despite the actual collection rate in the SRVM averaging around 40% the last few years (as confirmed by informants and research participants both within and external to the SRVM). According to a senior municipal official, one of the Key Performance Indicators (KPIs) of municipal managers is set against a 70% municipal collection rate, which incentivises over-estimating the collection rate in the planning

processes. Other informants who track the municipal budgetary processes argue that there is a broader incentive at play: the RPA chairman argues that the primary reason for inflating the expected collection rate is that municipal salaries for the upcoming financial year are set according to the 'expected budget'. National Treasury, empowered by the MFMA (introduced in sub-section 5.4.4) mandates municipal staff salaries to be capped at a certain percentage of the municipal budget (around 35%). Estimating a higher collection rate therefore allows for setting higher municipal salaries. When overall operational expenditure (including water infrastructure operations and maintenance) is budgeted against this inflated collection rate, it results in restricted operational funds to meet budgeted expenses, given that municipal staff salaries tend to be paid as the first operational expense on a monthly basis, and these salaries tend to remain unadjusted even when the actual collection rate is well below the expected collection rate.

In addition, municipal officials were circumspect about accessing what little maintenance budget that does exist. In one illustrative example, Sizwe (SRVM technical director) explained how he was unable to access the maintenance budget in order to purchase a R20 piece of equipment. In order to bypass the lengthy supply chain process and the seeming inability to access maintenance funds, he described driving to the nearest city of Port Elizabeth (a 120km return trip) to purchase the piece of equipment with his own money. One of the ways in which such operational funds can be reserved for exclusive use in water-related expenditure is through ring-fencing (introduced in sub-section 5.4.4). Ring-fencing remains a contentious concept: as of the 2013-2014 financial year, ring-fencing is advised rather than required in National Treasury audits. Municipal officials (including the current municipal manager) have defended the SRVM's lack of ring-fencing by arguing that no municipality in the country ring-fences water-related operational expenditure and income, so why should the SRVM? DWA engineers involved in the RRU intervention in 2012 conceded that complete ring-fencing almost never occurs, but argued that the municipality should stipulate in its operational plans what percentage of collected revenue it, as the water service provider, was putting back into water services. The key thing, according to the RRU engineers, is for the municipality "to know how much money that goes into the water business stays in the water business". As with many parts of DWA oversight of water service authorities, the situation is currently changing: institutional reforms proposed in late-2014 will mandate that a certain percentage of municipal operating budgets is ringfenced (as discussed in sub-section 5.5.3).

A final dimension to infrastructural asset stripping relates to the provision of capital grants by national government. As noted in sub-section 5.5.3, capital grants awarded to municipalities by National Treasury have historically carried no conditions requiring municipalities to budget for on-going operations and maintenance (CSIR & CIDB, 2007: 14). Mainstream institutional analysts (see Table 2.1) argue that the provision of condition-free capital grants for new infrastructure, coupled with the expectation that grant recipients maintain current infrastructure through self-financing, perversely dis-incentivises infrastructure maintenance (Ostrom et al., 2011). This perverse *dis-incentive* to maintain, which is a perverse *incentive* to asset strip, is reinforced by a political dynamic in SA, recently described by DBSA analyst as follows:

> New infrastructure development attracts vast amounts of attention and support at the highest level… plans are put in place, resources are made available and importantly the completed projects present "ribbon cutting opportunities" (Infrastructure Dialogues, 2013: 10).

In short, there is more political cachet in the provision of new infrastructure and supply augmentation than there is in the maintenance of current infrastructure and demand management. As described in sub-section 6.5.4, technical officials in the SRVM argue that they are pressured by councillors to build new housing projects and to connect these projects to the municipal reticulation system. These councillors, in turn, are responding to the needs of the communities they represent – yet as the municipal technical director has noted, bulk services typically receive less political attention (and therefore less support), because the supporting roles played by bulk water infrastructure are less visible than taps in households or large dams.

The Greater Kirkwood water supply scheme evolved as the focus of the LSRV's bulk infrastructure challenges for a number of the reasons already discussed in this chapter:

- The water supply scheme (WSS) has been the site of civil society intervention and conflict between citizen groups, the municipality, and the L-WUA (as described in section 6.3);
- The water shortages in the Greater Kirkwood area were contributing factors in the September 2014 service delivery protests (as described in sub-section 6.5.1);
- The Greater Kirkwood WSS was the locus of project funding, planning, and implementation disputes between the municipality, Amatola Water, and DWA (as described in section 6.4); and

- Over the course of interviews and engagement processes with municipal technical officials, the declining functionality of the Greater Kirkwood WSS also became a potent symbol of the broader patterns of infrastructural asset stripping (as described in sub-section 6.5.5).

For the above-listed reasons, the Greater Kirkwood WSS featured heavily in the action research process, which is detailed in Chapter 7, where the particularities of this WSS are explored at institutional, operational, and systemic levels. The following sub-section, on the other hand, draws on analytical insights and literature from the field of the anthropology of infrastructure (as introduced in Chapter 2), and employs these insights to the Greater Kirkwood WSS and its associated operations and interventions.

6.5.6 Perspectives from the anthropology of infrastructure

The earlier introduction to the anthropology of infrastructure referenced the ethnographic dimensions of infrastructure that were originally asserted by Star (1999) (as summarised in Box 2.2 in sub-section 2.4.3). As Larkin (2013) notes in his literature review, it has almost become obligatory for (anthropological) studies of infrastructure to repeat one of these assertions, namely, that infrastructure is "by definition invisible… [and] become[s] visible on breakdown" (Star, 1999: 380). Larkin (2013) argues that this particular assertion is only a partial truth, and shows how "the anthropological literature traces out an enormous range of ways that infrastructure is often anything but invisible" (ibid., 336). For example, a recent study of water supply in a suburb of Mumbai describes how the suburb's two supply pipes were referred to by the names of the politicians who supplied them – the Congress Party two-inch-diameter pipe and the Shiva Sena nine-inch-diameter pipe (see Anand, 2011, 2012). The political nature of water supply in South Africa strongly resonates with that of Mumbai: the reason why municipal councillors pressure technical officials to build new houses, and why large dams carry such political currency, is precisely because of how visible these infrastructural developments are, and because of the technological modernity represented and enabled by these developments. The historical analysis of this study demonstrates the many places where water supply infrastructure has played an explicitly political role in the last century of South African history. For example, when the Orange River Development Project (ORDP) was initiated in 1962 (see sub-section 4.4.2), President Verwoerd highlighted the project's "grand scale" and painted the project as "the image of a South Africa which is constantly growing" (WCD, 2000: 7); in 1965, Verwoerd further argued that the "entire scheme stood as a symbol of the determination of the white civilisation in Southern Africa to

stay… in the African continent, and was a heritage to be passed onto our children" (Turton et al., 2004: 188). The scheme was therefore driven by the needs for agricultural and industrial development, and the desire for a political symbol of Afrikaner nationalism. For infrastructural schemes such as the ORDP to be successful, "visibility was necessary to continually renew its political effect" (Larkin, 2013: 336). Whilst the development of new infrastructure offers potent symbols and "ribbon cutting opportunities" (Infrastructure Dialogues, 2013: 10), the Greater Kirkwood case also shows how the reverse holds true: the purposeful destruction of a particular piece of infrastructure is often a symbolic act, as illustrated by the burning of the front door of the technical directorate in the SRVM (see sub-section 6.5.1).

The functional focus of this study on the bulk water stage of the urban water cycle (see Figure 2.1) is interesting precisely because this stage is situated between water resource management and people's experiences of actual water service provision. In one respect, it is true that intermediary storage reservoirs, pump stations, treatment works, and other components of bulk water supply are usually 'hidden' from peoples' day-to-day experiences of access to water until the infrastructure breaks-down: however, municipal public planning tools and structures are intended to make this supporting infrastructure visible through assessing the current state of the infrastructure in relation to residents' future needs. These tools and structures include ward committees, integrated development plans and water services development plans (as described in sub-section 5.4.3). Hence, the technical director's comment in sub-section 6.5.4, that bulk services receive less attention because they are less visible than taps or dams, can also be interpreted as an acknowledgement that the public planning tools and structures are failing to perform their intended role within developmental local government. In lieu of strategic planning, stable financing, effective asset management, and productive public participation, the water shortages in the Greater Kirkwood region have resulted in a constant state of municipal fire-fighting (in the form of addressing emergencies) and a torrent of interventions involving government departments, agencies, consultancies, local businesses, civil society groups, and residents. Breakdown has become, in many respects, the norm rather than the exception. For anthropologists interested in infrastructure, these breakdowns offer "occasions for remaking forms of political claims… and [for] realigning institutional and political relations" (Simone, 2012: 1). Whether or not this holds true for the Greater Kirkwood region is discussed here.

The second thick description (section 6.3) provided an account of how civil society actors in the SRVM intervened in the functioning of the Greater Kirkwood WSS, drawing on their technical knowledge and their social networks, whilst relying on their relative socio-economic privilege as business-people, home-owners, and ratepayers. These actors demonstrated what Agnew (2011) refers to as 'conditionally cooperative' behaviour (see sub-section 2.4.1), rather than simply being adversarial and pursuing zero-sum outcomes. The chairman of the RPA, for example, chose not to employ one of the strategies at his organisation's disposal – namely, a rates boycott – despite the fact that many members of his organisation were pushing him to do so. The chairman opposed a rates boycott on the grounds that it would reduce the operational budget of the SRVM, which in the short term would only exacerbate the service delivery challenges. He sought to negotiate with municipal officials and councillors instead, and actively did so throughout the remainder of this study. The way in which other members of the RPA mediated between the L-WUA and the SRVM for the extended period of supply and for the construction of a new sluice gate (as described in sub-section 6.3.3) is a further example of this conditionally cooperative behaviour. In both of the latter examples, agents mobilised and deployed resources strategically within their networks, but it took the September 2014 protests – and the associated destruction of infrastructure – for these agents to work across different networks. As described in the action research process in Chapter 7, a rare collaboration was formed that included civil society organisations, commercial farms and agricultural industries, and urban ratepayers' and businesses, resulted in a proposal for immediate actions to address water and sanitation issues in the Greater Kirkwood region (see sub-section 7.6.4). The civil society representatives included 15 members of local branches of SANCO (the South African National Civic Organisation), which was one of the organisations that led the September protests. Whilst it is too early to say whether a realignment of institutional and political relations has taken place (as Simone (2012: 1) posits), the collaboration that led to the proposal being put forward suggests the following:

1. That the commercial agricultural interests in the LSRV are now sufficiently concerned about the state of poor service delivery in urban regions of the LSRV to propose financial support and intervention-oversight into the SRVM;
2. That organisations from different surburbs of the Greater Kirkwood region (which previously have not collaborated on any substantive service delivery projects, to the best of my knowledge) are now aligning key interests towards collaborative ends; and

3. That the perceptions of *what* counts as a water supply problem to *whom* (in relation to the different water constituencies in the LSRV) are evolving.

For Anand (2011), the practices around accessing water in Mumbai are politically mediated acts (as introduced in sub-section 2.4.3). Other anthropologists similarly argue that water supply infrastructure reveals larger issues, seen in research on prepaid water meters and citizenship in post-apartheid South Africa (von Schnitzler, 2008) and Carse's (2012) exploration of catchment management around the Panama Canal. But studying technological systems also highlights the limitations of the ethnographic approach, which Larkin (2013: 328) usefully describes as follows:

> [Anthropologists'] disciplinary bent is to examine the influence of a road in this part of Peru... rather than to analyze road building as a network. A systems analysis in this regard demands **an ethnographic retooling** [my emphasis], one in which ethnography might need to be conducted in government centers far from where the actual roads are constructed and might take into account politicians, technocrats, economists, engineers, and road builders, as well as road users themselves.

In the following section, I conclude this chapter by showing how I applied the tool of thick description in a qualitatively-different way to the classic Geertzian approach, and further argue that the thickened form of thick description contributes towards Larkin's (2013) call for an ethnographic retooling.

6.6 Towards a 'thicker' thick description

6.6.1 The benefits of thick description

In a recent study of 37 South African municipalities, Siddle and Koelble (2012: 18) argue that "the atmosphere of chaos, buffoonery and intrigue that prevails in many South African municipalities is difficult to capture on paper, and needs to be experienced in order to be fully appreciated." Whilst I undertook fieldwork in the SRVM, I experienced how even the most technically-minded engineers sought to encapsulate their understanding of this 'atmosphere of chaos' through describing their experiences narratively, and through providing examples of particular instances that they took to be indicative of the local situation 'on the ground'. These experiences and instances – however embellished and regardless of how closely they accord to facts in the world – can be seen as little pieces of informants' own analyses, which informants believe to be 'thick' in meaning. For the policy analyst, thick description is a way of drawing together these experiences and instances into the analysts' interpretation of

'what's going on in the case under examination'. What thick description does so well is to engender verisimilitude, where "the voices, feelings, actions, and meanings of interacting individuals are heard" (Denzin, 1989: 83). Thick description is not just about rich detail, but about the "multiple perspectives or interpretive frameworks, that is, multiple motivational frames that inform social events and actions" (Atkinson & Delamont, 2005: 832). Capturing on paper the complexity of the municipal working environment, from the multiple perspectives of participating, interested, and affected actors, is therefore one of the primary benefits of employing thick description as a tool in this study.

Secondly, the interpretive accounts provided across the three thick descriptions in this chapter serve to counter caricatures of the state as either being completely benevolent, malevolent, or incompetent. Following Dubbeld (2013) (who conducted ethnographic research in the village of Glendale in the KwaZulu-Natal province), the thick descriptions in this chapter show how "the state is not a unified whole with a single vision" (*ibid*., 492), and how municipal problems cannot be reduced to the typical scapegoats of political interference in technical supply systems, financial inadequacy, or corruption in, and between, elected and employed officials.

Thirdly, thick description is a valuable form of research into bureaucratic and organisational contexts because of how it "problematizes the ways that individuals and groups constitute and interpret organisations on a daily interactional basis" (Schwartzman, 1993: 4). As Webster (2014: 2) notes, literature on state bureaucracy in post-apartheid SA has typically made little room "for [the] experiences of ordinary people in their attempts to understand bureaucracy." The thick descriptions in this chapter have tried to make room for the experiences of technicians, officials, managers, consultants, politicians, and residents in local water supply situations in the LSRV. This approach is grounded in an understanding of the practical politics of water, which features "actual people who could do or who are doing things that affect other people" (Agnew, 2011: 469). However, this practical politics plays out within wider sets of rules, constraints, and influences, which brings us to the first weakness of thick description.

6.6.2 Incorporating institutional analysis

Following Guggenheim (1994), the failure to situate analyses within broader socio-political processes can be understood as one of the most serious limitations of Geertzian thick

description (see sub-section 6.1.2). Thick descriptions of policy problems need to relate micro details to macro structures: for this, the experiences and instances that constitute an informant's interpretation (and the analyst's interpretation) need to be related to the broader context. Hence, the first way in which thick description has been 'thickened' in this study is through incorporating institutional analysis. In order to understand how arrangements for managing water in the LSRV region results in negative outcomes, this study explored the rules-in-use in relation to the rules-in-form by situating local arrangements within wider frames of governance. As described in sub-section 3.5.1, the institutional analysis balanced a focus on local complexities with seeking to identify and track the larger processes that influence those local complexities. Chapter 4 provided a history of water management and local government that moves between institutional levels and biophysical scale, illustrating how "local government is a mirror of the larger political and economic forces, cleavages and problems that are shaping SA society" (Powell, 2012: 11). The governance analysis in Chapter 5 built on the historical analysis, and focused on situating the management of bulk water in the LSRV within the formal institutional domain, where this domain was conceptualised as structured between the principles, policies and frameworks for 'integrated water resource management' and the principles, policies and frameworks for 'developmental local government' in South Africa. Combining the institutional analysis in chapters 4 and 5 with the thick descriptions in this chapter has enabled insights into how agents (from municipal officials, to consultants, and businesspeople) interpret the problems they face, and find ways of working in the 'muddled middle' between formal institutional structures and informal institutional relations. The 'muddled middle' was grounded through drawing on the five governance challenges that were identified and analysed in Chapter 5 (see section 5.5): three operational manifestations of these governance challenges were discussed in this chapter, using the ethnographic material collected in the study and represented in the thick descriptions, in relation to the associated interpretation of data, and the broader literature.

The understanding of politics as a practical activity (Agnew, 2011) is underpinned by the question of "who does what to whom for whose benefit?" (Guess, 2008: 25). When dealing with the governance and management of water, however, the latter question needs to be reframed as "who gets what water, when, and how?" (Tropp, 2005: 11). This reframing highlights the technical aspects of water management that interact with social complexity to create further knotted structures with which any water policy analyst must grapple. In post-apartheid SA, all residents require, desire, and are entitled to water of a particular quantity and

quality to be delivered within stipulated time periods. Given this reality, it becomes necessary to query how qualitative studies of local government policy issues (including the thick description approach described here) can be related to the unavoidably technical and quantitative aspects that are germane to all water issues. The second way in which thick description is thickened in this study is through the integration of ethnographic analyses with systems analyses, as discussed in the following sub-section.

6.6.3 Incorporating systems thinking and systems analysis

As introduced earlier, systems thinking is based on a holistic worldview that emphasises interrelationships, change, and feedback (see sub-section 2.6.2 and Box 2.3). Systems analysis was introduced in this chapter with Figure 6.4, which used a causal loop diagram to express the crisis cycle that municipal officials described feeling stuck in. The discussions that followed the crisis cycle drew on ethnographic material to describe:

- The interrelated factors pertaining to the growth in water demand;
- The declining infrastructure capacity and the behaviour of infrastructural asset stripping; and
- The over-extension of the municipal technical directorate.

The above-mentioned examples involve many agents operating at different scales and acting in response to various incentives. Of particular interest in this study are the dynamics that emerge from the interactions of these agents with the physical water supply systems in the LSRV. The broader systems analysis that was undertaken as part of this study is described in detail in section 7.5, where the process of developing and using four system dynamics models is described and discussed. I selected system dynamics modelling because it is one of the only forms of modelling that explores stakeholders' actual practices and experiences in applied settings (Maani & Cavana, 2007). The discussion in sub-section 7.7.2 returns to the integration of systems analysis with institutional and ethnographic analysis, in order to show how the systems analysis influenced the thick descriptions, and vice versa. Chapter 7 also describes how the systems analysis was embedded in an action research process, which represents the third and final way in which the tool of thick description is 'thickened' in this study.

6.6.4 Anthropology and action research

The kind of thick description developed and employed in this chapter contributes to the overall action research agenda of the wider study. Whilst the conventional anthropological goal is to add to the ethnographic record (Blasco & Wardle, 2007), action researchers adopt an activist, change-oriented role, which resonates with the following overlapping areas of anthropology: action anthropology (Tax, 1975); public interest anthropology (Sanday, 1998); engaged anthropology (Basch et al., 1999); the anthropology of public policy (Wedel et al., 2005); activist anthropology (Hale, 2007); and public anthropology (Beck, 2009). In the latter (most recent) iteration, Beck (2009: 1) notes that "central to this work is a method that takes [anthropologists]... away from a solely enquiry-based methodology and towards one that is dialogic and change oriented". Hence, this 'thicker' form of thick description is motivated by the applied challenges of undertaking a deep problem analysis within an action research setting, where my involvement as a researcher led to my involvement in the messy, real-world complexity of water management in the LSRV, as recounted and analysed in Chapter 7.

6.6.5 Conclusion

This chapter began with the aim of exploring the September 2014 protests in Kirkwood as a dramatic manifestation of a systemic problem that has developed over time rather than as an event (see sub-section 6.1.1). An interpretive analytical tool of thick description was employed in this chapter, with three thick descriptions developed and analysed. The interpretive account described the Kirkwood protests as emerging from three interconnected manifestations of the governance challenges that were identified and analysed in Chapter 5, which were additionally explored in this chapter by drawing on insights from the anthropology of infrastructure. Lastly, this chapter argued for a 'thicker' form of thick description, showing how this adapted form of thick description was developed and employed in this study as part of the action research process.

Chapter 7 A Systemic Action Research Process

7.1 Introduction

Chapter 7 discusses the intervention process and the associated products, preliminary outcomes and insights derived from the action research components of this study. Section 7.2 posits a conceptual framework that theoretically locates action research (AR), and provides a methodological outline of the process that follows. Sections 7.3 to 7.6 explore the AR process, products and outcomes at the empirical level. Section 7.7 reflects on the systems modelling components and provides an overall discussion on the AR process. This chapter employs a technique of judicious repetition – whereby certain AR aspects are discussed in varying levels of details and cross-referenced multiple times, in order to account for the interwoven nature of the research.

7.2 Conceptualisation

Action research is defined here as:

> A participatory process [that is] concerned with developing practical knowing [which] seeks to bring together action and reflection, theory and practice, in participation with others, in the pursuit of practical solutions to issues of pressing concern to people (Reason & Bradbury, 2008: 4).

The action research (AR) process undertaken in this study aimed to (i) be recoverable; (ii) involve larger research themes than the specific context; (iii) involve iteration; and (iv), involve a clearly articulated epistemology (following Ison, 2008). Each of these aspects is briefly considered here.

Making the research process 'recoverable' (i) requires stipulating how the action research process was undertaken (in terms of the conceptual framing and the research design) in order for the research process to be recoverable to interested outsiders. The set of ideas drawn from in this study was expounded in the conceptual framing in Chapter 2. The process by which the ideas were used, and the methods that were selected as tools, was broadly described in the methodological framing in Chapter 3, and is more specifically explained in this chapter. Instead of being located only within one context, the research themes of interest (ii) in this AR process were located in a wider set of problems, puzzles and dynamics. These research themes were of a wider nature than a temporally or geographically specific issue – such as water governance in the Lower Sundays River Valley (LSRV). Many of the research themes

for the LSRV case were drawn from the larger research project in which this case was situated (funded by the South Africa Netherlands Research Programme for Alternatives in Development (or SANPAD), and discussed below).

The research process was consciously iterative (iii) in a number of important ways. Firstly, the action research process involved co-facilitators in both its design and implementation; secondly, critical peer-review was gained via presenting aspects of the research approach and preliminary findings and analyses at international conferences, national symposia, and local research seminars (see Table B.2 for details); thirdly, the principle of "cultivating reflexivity through iteration" (Pohl & Hirsh Hadorn, 2007) was sought through the research process including cycles of engaging and disengaging in the case study – allowing for periods of reflection and analysis – as well as allowing for an evolving methodology (discussed further below). Lastly, the research sought to clearly articulate its underlying epistemology (iv), in order to motivate for what counted as 'knowledge', and different kinds of knowledge, within the research. This was held to be of particular importance given that the research was undertaken within a diverse team of researchers from a range of different disciplinary backgrounds. Figure 7.1 displays a conceptual representation of how the above four prerequisites were incorporated into a cycle of action research.

The blue, inner circle of Figure 7.1 illustrates the action research cycle, in which the researcher draws on a declared framework of ideas – in the form of a project conceptualisation and conceptual framing – and a declared methodology. The researcher is connected to a broad range of collaborators, practitioners, colleagues and supervisors in the overarching SANPAD project (represented by the green circle). In Figure 7.1, the two groups of people that are directly connected to this study are collaborators (in the form of co-researchers and co-facilitators), and academic supervisors.

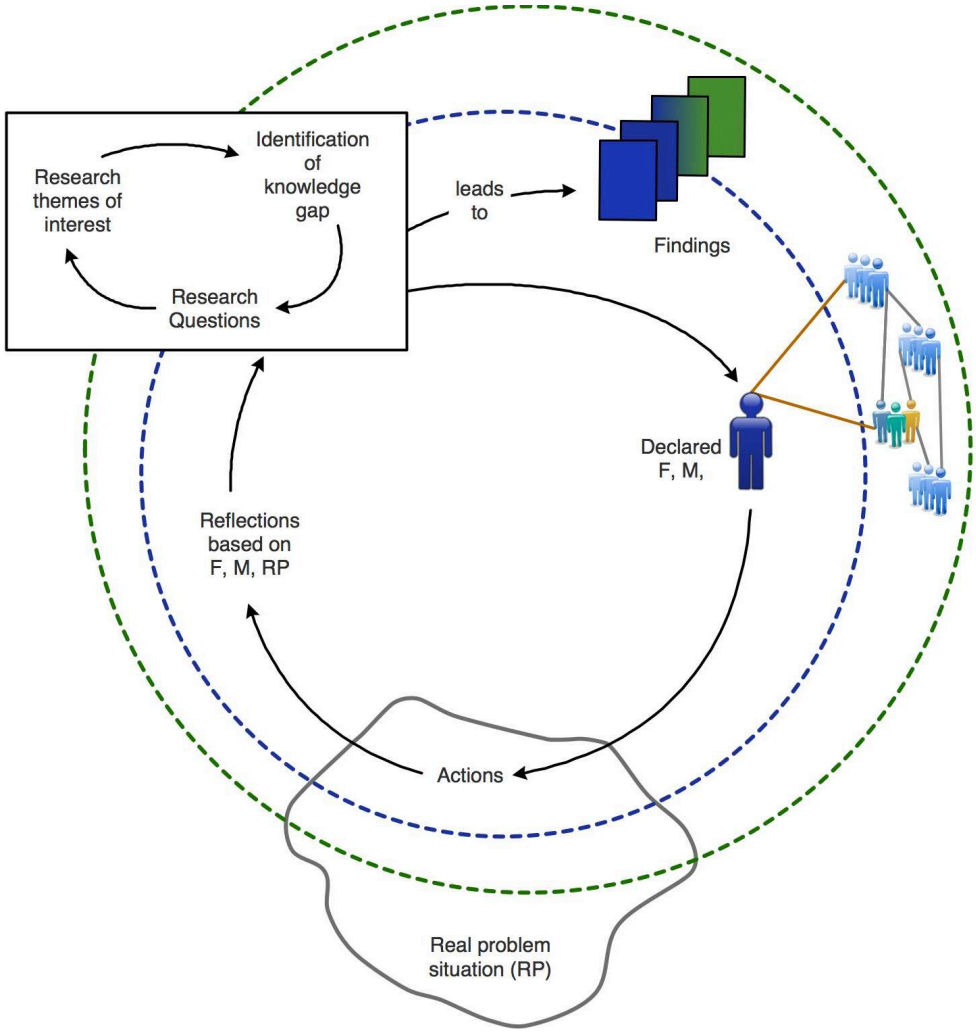


Figure 7.1: Cycle of action research. Within the blue circle is the cycle of action research (AR) undertaken within a declared framework of ideas (F) that is informed by larger research themes, applying a declared methodology (M) to a real problem situation (RP). The area within the larger, green circle denotes the SANPAD project, with connections between the core AR cycle and groups of researchers within the SANPAD project. Diagram adapted from Ison (2008).

The SANPAD project has been introduced in section 1.1 (with further details available in Appendix B), so is only briefly summarised here. The stated objective of the SANPAD project was to produce a guide to working with complex water management problems, in the form of a compendium of methods, concepts, perspectives and processes. The guide would be drawn from the experiences and training of the researchers involved, and be 'field-tested' in three case studies. The project aimed to contribute substantively in the case studies themselves, striving to do the following:

- Loosen problem spaces that have many interdependent, controversial, complex and uncertain elements;
- Co-create knowledge with stakeholders and problem-holders; and
- Enable and empower action and mobility.

The SANPAD project provided an enabling research context in a number of important ways. The project allowed for an evolving methodology, where methods could be iteratively drawn from the SANPAD 'tool box' according to problems encountered in the case studies. These problems were explored through cycles of engaging in the 'real problem situation', followed by periods of reflection (as illustrated in Figure 7.1). The use of multiple methods can be understood as a process of 'methodological hybridization' (Horlick-Jones and Rosenhead, 2007: 588), which was further enabled by the SANPAD project's transdisciplinary base and network of researchers from different disciplines. Individuals who work across different disciplines are sometimes referred to as 'boundary spanners', which is also a term that can be applied to agents who work across and between organisations (Williams, 2002). The SANPAD project was undertaken within an inter-organizational context of water resource management and water service delivery that inherently crossed sectors (including academic research departments, private consultancies, government agencies and civil society organisations and groups). The inter-organizational context was further complicated by the fact that the SANPAD project explicitly sought case studies containing seemingly intractable, highly contested problems. As such, a philosophy of experimentation underpinned the SANPAD project and was incorporated into the action research process described in this chapter. Experimentation called for any engagement process to be flexible and adaptable – adopting a trial-and-error approach that treated failures as additional data to be learned from. This adaptive philosophy contained a certain degree of opportunism, which understood the importance of timing for initiating changes in complex systems. Following Kingdon (1995), significant changes are most likely to occur when three independently operating 'streams', in the form of problems, solutions, and political events, come together at critical times (see Figure 7.2). This type of coupling provides a so-called 'window of opportunity' for change in which "... a problem is recognized, a solution is available, the political climate makes the time right for change, and the constraints do not prohibit actions" (*ibid*.).

Kingdon's model suggests that rather than these three streams becoming magically linked of their own accord, certain actors become central to the process of linking the streams. These key actors are variously referred to as policy entrepreneurs (Olsson et al., 2006), policy brokers (Hermans, 2005), and boundary spanners (Williams, 2002). The SANPAD project sought to work with these boundary spanners and, where possible, play such boundary spanning roles ourselves.

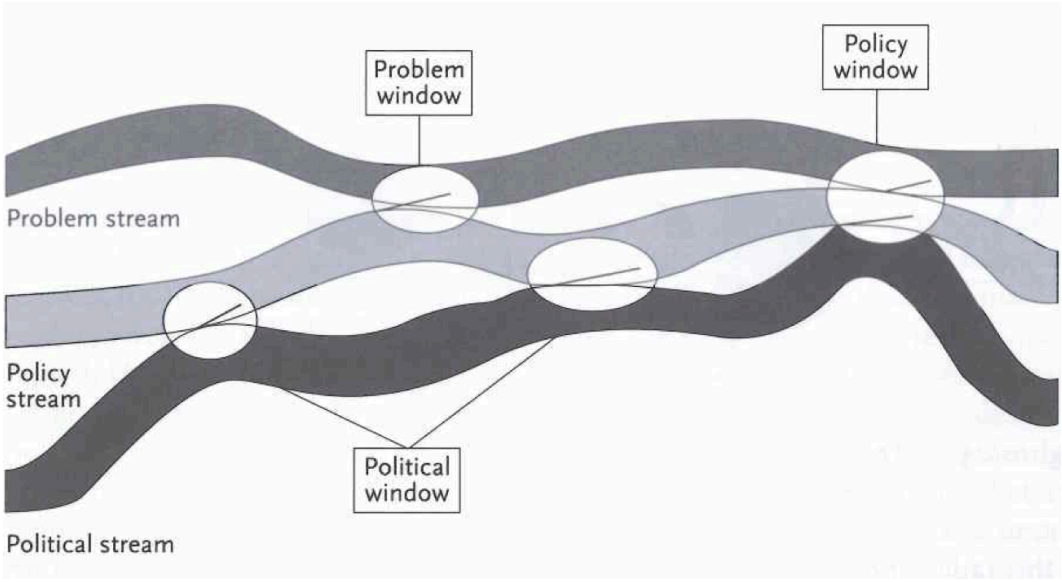


Figure 7.2: Kingdon's streams model. Source: reproduced from Enserink et al. (2010b: 40).

Highly contested environments are typically those where actors have been in conflict, and are therefore sensitive to the additional sources of disturbance created by any form of intervention (opportunistic or otherwise). Multiple ethical considerations were incorporated into the SANPAD project (and into the AR process recounted here) in order to account for these sensitivities. These ethical considerations included the following:

- Interventions should explicitly aim to increase local capability to act without destroying or damaging existing working relationships;
- Where tensions or conflict are raised through intervention processes led by the SANPAD project, the researchers should aim to sensitively address these conflicts through the action research process – rather than treating the conflicts as excuses for why further engagement should not occur; and
- Action researchers should remain perpetually vigilant to iatrogenic effects of interventions (i.e. aware that interventions can, and often do, have negative effects that outweigh potential gains – see sub-section 6.5.3). Reflexivity is therefore an ethical, as well as intellectual, prerequisite.

The initial fieldwork undertaken in the LSRV case demonstrated that numerous interventions into the water services of the Sundays River Valley Municipality (SRVM) were on-going. Many of these interventions were run by different government departments and agencies, and sometimes even by different directorates within individual departments (as discussed in the thick descriptions in Chapter 6). The recognition of the complexity created by these multiple interventions provided an additional motivation to structure the AR process, as recounted in

this chapter, within the larger intervention processes – in particular, those run by Amatola Water and the Department of Water Affairs (DWA).

The final aspect of the AR design and conceptualisation reported in this chapter relates to an emerging characteristic of the research process. The AR process and products have served to deepen the understanding of the case study, both in terms of the immediate problems of interest, and in terms of the deeper systems-level constraints and dynamics that are responsible for generating the immediate problems. The research has therefore benefited from an analytical deepening over the course of the intervention process recounted here, rather than the intervention being distinct from the scoping and problem analysis stages of the research.

7.3 Narrative description and overview of systemic action research process

This section introduces the overarching intervention process by providing a narrative description of what was done when, and why. The narrative follows the diagrammatic representation of the intervention process, as contained in Timeline 7.1 below. This timeline provides an overview of the action research (AR) stages, and displays these stages alongside the primary stages of the systems analysis process. Sub-section 7.3.1 contains a first-person narrative description of the systemic AR process, which expounds on the stages detailed in Timeline 7.1. The analytical insights drawn from the AR process are summarised in Table 7.1, which relates each insight to the relevant stages of the AR process in Timeline 7.1, and to the institutional analyses in Chapter 4 and 5 of this study, the ethnographic analyses in Chapter 6, and the systems analyses (as contained in this chapter and the detailed Appendices D, E, F, and G).

7.3.1 Narrative description

I began the fieldwork component of my research in October 2011 (the point at which the historical analysis provided in Chapter 4 ends). My initial research tasks included conducting a broad actor analysis, in order to learn about the actors involved in the provision of water services in the SRVM, and developing a contextual understanding of water management in the LSRV (see 3.5.2). The results of the initial research tasks form the core material in the governance analysis in Chapter 5, and provided initial ethnographic material for the thick descriptions in Chapter 6. I had originally conceptualized and designed this first stage of the research as a scoping exercise that would precede a yet-to-be-defined intervention process (scheduled for early 2012). Yet several developments over the course of the initial period of

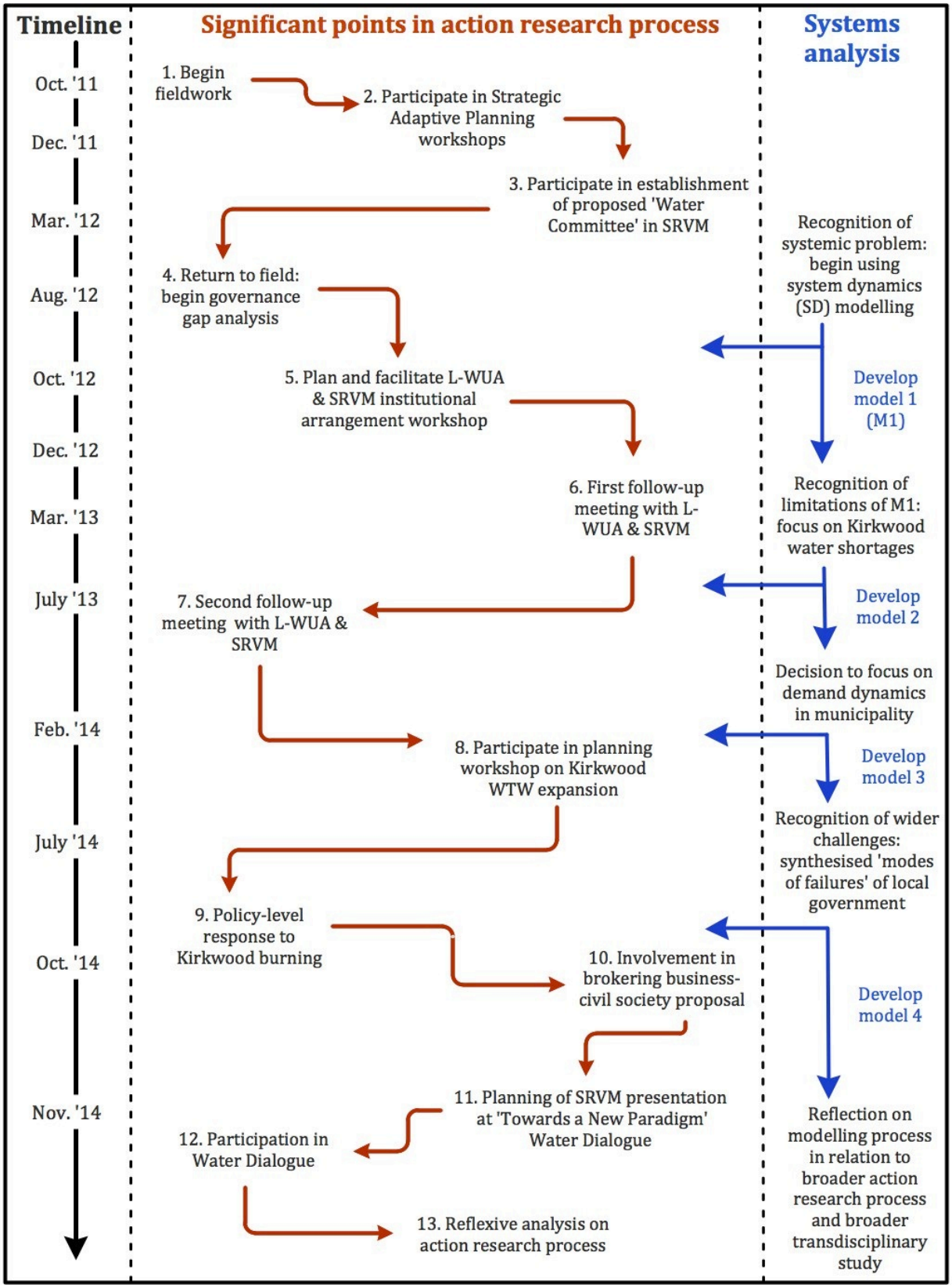
field research resulted in a shift from direct observation and interviews, to participant observation. These developments are briefly recounted below.

One of the initial research tasks of the SANPAD project was to host two multi-stakeholder workshops in the LSRV, using a Strategic Adaptive Planning process, following the practice of strategic adaptive management developed by Rogers and Luton (2011). The first workshop (held in October 2011), included representatives from two primary research partners – Amatola Water and the SRVM – in addition to SANPAD project researchers who facilitated the workshop. A wider group of stakeholders was then invited to participate in the second, follow-up workshop. In addition to serving as initial data collection, this period of research was focused on building relationships and social capital with a range of stakeholders involved in the SANPAD project.

The second development in this period was the increasingly inter-organizational role that I found myself playing (as described in Box 6.7). During the November 2011 Blue Water Services Audit, the municipal server was offline, and so one of the municipal officials used my laptop and internet connection to submit the SRVM's assessment form to the DWA. The result of these interactions was the unintended inclusion of a boundary-spanning role in addition to that of a researcher – spanning across and between organisations in the case study itself, and between those organisations and the SANPAD project. In effect, the action research process therefore began the day that I started fieldwork in the LSRV.

An important juncture in the early research process was the second SANPAD workshop (introduced above, and described in further detail in Appendix B). This workshop included representatives from community organisations, DWA, Amatola Water, and the Lower Sundays River Water User Association (L-WUA), in addition to representation from the political and management arms of the SRVM.

Timeline 7.1: Timeline of the action research process of this study, as part of the broader SANPAD transdisciplinary research project in the Lower Sundays River Valley. In this timeline, 13 points are denoted between October 2011 (Oct.'11) and November 2014 (Nov. '14), and related to the systems analysis. L-WUA = the Lower Sundays River Water User Association; SRVM = the Sundays River Valley Municipality; WTW = water treatment works.



The facilitators of the workshop elicited problem formulations from the multiple stakeholders in attendance, and then synthesised these problem formulations into a picture of water service-related issues in the LSRV. This synthetic picture contained four interrelated issues, namely,

1. Bulk water supply and storage;
2. Treatment of raw water to potable water, and related concerns about water quality;
3. Reliable and safe distribution of potable water to households;
4. Wastewater (sewage) treatment works and the associated effects on human and environmental health.

Financial management was seen as a multi-faceted issue that was part of each of the above issues. The workshop facilitators described these issues as 'knots' – i.e. interrelated and interdependent, such that attempts to unravel one knot, leads to tightening of other knots elsewhere. The only way out of such a 'knotty' problem is through time, patience, and consistent effort expended towards loosening and eventually unknotting the set of problems (see Box B.2). Out of this workshop, I identified knot 1 – bulk water supply and storage – as a key focal issue for my research (with other researchers examining aspects of knots 3 and 4). Knot 2 was not investigated as part of the SANPAD project, except in relation to bulk water storage and distribution. Two other inter-related themes were becoming increasingly prominent through fieldwork at this point. The first of these themes was the recognition of the complexity created by the multiple interventions involved in the so-called 'turnaround' of the SRVM (often with little to no coordination between them); the second theme was the lack of institutional separation between the regulatory and service provision roles of the municipality.

Immediately following the second SANPAD research workshop, I participated in the proposed establishment of a Water Committee in the SRVM. The Water Committee was an institutional intervention aimed to address the conflation of regulatory (water service authority, or WSA) and service provision (water service provider, or WSP) roles of the municipality's internal operations. Committee members for the planned institution included representatives from the technical and financial directorates of the municipality, as well as from the political arm. The conflation of the service delivery and regulation aspects of municipal water service provision was raised frequently over this initial period of fieldwork (by DWA assessors in the Blue Drop assessment and in the SANPAD workshop). During the Rapid Response Unit (RRU) intervention in the SRVM, this issue was raised again, with the DWA-employed consultants voicing their approval of the municipality's nascent water

committee. At a workshop hosted by the RRU in February 2012, which several members of the SANPAD team (myself included) helped organise and attend, a municipal councillor was elected as the committee chairperson, and several municipal officials committed to driving the Water Committee. In spite of these positive developments, the committee failed to meet regularly, and failed to achieve official recognition from the municipal council (partly due to a lack of agreed-upon 'terms of reference' being passed by the municipal council). My involvement in promoting the establishment of the committee (by working to establish the terms of reference with the project champions in the municipality) had little effect. The dynamic of overburdened officials and constant requirement to deal with pressing emergencies (as discussed in sub-section 6.5.3) led to diminishing enthusiasm for the water committee. In March 2012, I left the LSRV to undertake a two-month internship at Delft University of Technology (TU Delft), in the Netherlands. The internship provided distance from the case study, and acted as the first major disengagement from being 'in the field'. Having time to now reflect on the research, I began to examine the systemic drivers of municipal failure, with reference to my particular 'knots' of interest. In addition to drawing from the ethnographic thick descriptions, I undertook a high-level, qualitative systems analysis of these drivers (as shown in Figure 7.3).

Figure 7.3: My first systems feedback diagram, drawn in early 2012 before I had ever heard of the discipline of system dynamics and causal loop diagrams. A formal version of this diagram is presented in Figure 6.4.

My internship supervisor at TU Delft proposed the use of system dynamics (SD) (introduced in sub-section 3.5.3). SD could provide a method for displaying and analysing multiple types

of data and issues, and could model flows of water, finances, and information, whilst exploring select interdependencies, feedbacks, and unintended consequences. As such, SD was a potentially ideal problem structuring technique for the set of issues emerging in my fieldwork. The resulting collaboration between this supervisor and myself used SD in the first attempt to systematically grapple with the entangled 'mess' of water services in the LSRV. The collaboration led to an initial SD model that accounted for municipal bulk water supply, financial management, staffing and housing (the model is further described in section 7.5.3*)*. Upon returning to the SRVM, I found that the model was too broad, and at too high a level of aggregation to be of use in the action research process. In addition, the number of sub-models and levels of data uncertainty complicated my attempts at model validation. Whilst using the model for discussion with municipal officials, the specific problems of bulk water supply in the Kirkwood water scheme was consistently raised as one of the most pressing challenges that the SRVM faced.

The supply arrangement between the L-WUA and the SRVM was central to this 'knot' of bulk water supply management in Kirkwood. As introduced in the second thick description (section 6.3), this supply scheme was the subject of citizen activism and interventions and had been the focal point of a longstanding dispute between the L-WUA and the SRVM. Any attempt to focus on this 'knot' therefore required an understanding of the broader institutional issues between the SRVM and the L-WUA. The supply arrangement between these two organisations also provided the opportunity to re-examine the service provision-regulation conflation, which was central to the motivation for establishing the Water Committee. The failure to establish the Water Committee had demonstrated the requirement for clearer incentives that could motivate stronger project champions to drive the establishment of a new institution in the SRVM. My experience with the Water Committee had also demonstrated the need for a more analytical approach to institutions – including placing local institutional arrangements within a wider governance context. In the resulting institutional analysis, I differentiated between the rules-in-form and the rules-in-use in order to understand the way in which the supply arrangement between the L-WUA and the SRVM was supposed to work (according to water policy), versus the way in which the supply arrangement was actually working (the institutional analysis and the associated processes is further described in section 7.4).

The action research aspect of this institutional analysis was further enabled through a particular 'window of opportunity' open at this time. Two DWA-funded projects were running concurrently – one focused on the 'transformation of water user associations', and the other focused on developing municipal capacity for water service provision by the Rapid Response Unit (RRU). A third characteristic of this window of opportunity was the new technical director, who had just begun in the SRVM at this point, and was aware of both the pressing water supply problem in Kirkwood, and the institutional conflation of service provision and regulation in the SRVM. I presented the gap between the rules-in-form and the rules-in-use as a 'governance gap' that the two DWA-funded projects could seek to address as part of their respective project mandates (one from the L-WUA's perspective, and one from the SRVM's). Using policy compliance and the Kirkwood water outages as the incentive, and capitalizing on the window of opportunity, I worked with the broader SANPAD project team to host a workshop in the SRVM, which sought to explicitly address this governance gap.

At the workshop, representatives from both the L-WUA and the SRVM committed to improving their working relationship, citing the dysfunction of the Kirkwood system in particular as a major source of frustration to both actors. I facilitated the workshop with the assistance of two experienced facilitators from the SANPAD project, and drew heavily on my historical understanding, and my ethnographically-derived understanding of the various actors' problem formulations (and making use of the relationships and social capital developed over the course of embedded fieldwork in the LSRV). The agreed outcome of the workshop was the creation of an 'operational guide' that would enable the two systems to function more effectively – with a particular focus on the Greater Kirkwood water treatment works and bulk water supply system. What emerged from the workshop was that the municipality and the L-WUA had different understandings of the limitations of the Kirkwood supply scheme, and therefore differing views on the causes of the persistent water outages in Kirkwood. These differing views presented the opportunity to develop a more focused SD model of the Kirkwood water supply scheme, where the process of model building could be used as part of the ongoing facilitation process. I collaborated with system dynamicists at TU Delft in order to structure my understanding of the Kirkwood water supply system (derived from the above research processes) into a model. To this end, the 'Greater Kirkwood water supply model' (*GKWS* model) was developed (D'Hont, Clifford-Holmes, & Slinger, 2013) and then extended (D'Hont, 2013) – as discussed in sub-section 7.5.4.

The focus on the operations of the Kirkwood supply system meant that this second model was more refined, and of more strategic and analytical use in the case study than the first model. The *GKWS* modelling initiative highlighted the fact that the SRVM is currently locked-in to operating a water supply scheme that is an historical artefact from the apartheid era: as discussed in detail in section 4.4 of the historical analysis, municipal water supply infrastructure were designed to almost-exclusively service white settlements at the active exclusion of all other population groups during apartheid. The *GKWS* model therefore illustrated that ensuring the current system does not perpetuate apartheid-style inequalities can only occur with re-engineering the system or investing in systemically changing operational management. The modelling initiative demonstrated that individual operators at the Kirkwood WTW could not be blamed for 'mismanaging' the water supply scheme, when in fact the system was flawed by design. Furthermore, the modelling process revealed that there was little shared understanding between participating and affected actors as to the nature of these infrastructural challenges, and even less acknowledgement between actors of how the post-apartheid drive to expand water supply to a greater proportion of the population had resulted in the over-extension of the infrastructural system.

Two shortcomings placed limitations on the use of the model within the AR process. Firstly, the supply model did not include the determinants of the rising demand for potable water in Kirkwood (partly as a result of data uncertainty). Secondly, the process of using the model as a means of facilitating strategic conversations (Howick & Eden, 2010) between the municipality, the L-WUA and other organs of government soon took me to the limits of my own SD knowledge and technical skills, exacerbated by the fact that the other modellers with whom I collaborated were based in the Netherlands. These two factors motivated me to undertake training in SD, and develop a third model that could explore demand management in the Kirkwood water scheme. This third model sought to account for the systemic issues around what was driving the demand for potable water in Kirkwood (initially described in sub-section 6.5.4), with a policy focus on what the municipality could do to reduce demand on the L-WUA's canal system, including through the use of possible alternative water sources in the area. One of the uses of this model was in interacting with a range of stakeholders in a DWA-funded workshop on the expansion of the Kirkwood water treatment works (in which the L-WUA and the municipality participated) (discussed further in sections 7.4 and 7.5).

The second and third SD models returned me to the question of why it had been so difficult for the SRVM to either provide adequate quantities of potable water, or to effectively manage water demand in the Greater Kirkwood region. The fourth and final SD model explored this question in terms to of the interconnected 'modes of failures' of local government, with a particular focus on the following interrelated dynamics:

- The simultaneous underinvestment in, and over-extension of, water supply infrastructure;
- The effects of municipal staff shortages, emergencies, and over-commitment on standard technical activities; and
- The effects of crises and the implications for operations, maintenance and management of municipal water services.

This model and the associated analysis became additionally relevant in the wake of the Kirkwood protests in September 2014, which served as a catalyst for a final return to the field (as discussed in section 7.6). The final data section of this chapter (section 7.6) provides an overview of the project-level response to the protests, after which it focuses on how the protests and the subsequent events in the SRVM provided insights that enriched the governance, ethnographic, and systems analyses undertaken in this study and, in turn, discusses how these analyses fed back into the AR response to Kirkwood burning. The analytical dimensions of the systemic AR process are further summarised through the integrating insights in Table 7.1 below.

7.3.2 Conclusion

The above narrative has broadly introduced the AR process, in addition to describing how institutional and system analyses were combined with ethnographic research, with a focus on bulk water management in the LSRV more broadly, and on the Greater Kirkwood WSS more specifically. The following sections describe the two main action research thrusts in more detail: section 7.4 discusses the institutional analysis-related aspects, whilst section 7.5 discusses the system dynamics process, models, and outcomes.

Table 7.1: Summary of the integrating insights derived through the systemic action research process undertaken in this study. Each insight is related to the relevant stages of the action research process (column 2), and to the three components of institution analyses (in Chapters 4 and 5); ethnographic analyses (in chapter 6) and systems analyses (this chapter + Appendices D, E, F, and G). References to sub-sections (S.S.) in text.

Integrating insights		Relevant stages of the action research process	Institutional analyses	Ethnographic analyses	Systems analyses
1	Multiple effects of institutional gaps in the LSRV: in particular, between the SRVM and the L-WUA, and within the water unit of the SRVM.	Participation in establishment of a Water Committee in SRVM (Dec.'11); Governance gap analysis (July '12); Workshops and follow-ups between the L-WUA and the SRVM (Oct.'12 – Aug.'13).	Historical analysis exploring the socio-political context of decentralised water management and local government structures in post-apartheid SA (Chapter 4); Description of municipal governance structures (S.S. 5.4.3); Governance challenge 3 (presence of multiple institutional gaps – see S.S. 5.5.4).	Recognition of institutional gaps during fieldwork (see fieldwork stories in Box 6.3 and Box 6.5); Institutional gaps also related to the capacity challenges in the DWA-Regional Office in the Eastern Cape (in terms of inability to perform technical regulation (see S.S.)).	Institutional gaps affecting the operational management of the Greater Kirkwood water supply scheme between the L-WUA and the SRVM (as explored in the second system dynamics – SD – model: see S.S. 7.5.4); Effects of 'ring-fencing' water-related finances (fourth SD model: see S.S. 7.5.6).
2	Interconnected and mutually-enforcing vicious cycles within which the governance and management of bulk water supply are stuck.	Strategic Adaptive Planning workshops (Nov.'11) – in which the four knots were initially identified and discussed; through to Sept.'14 protests and explorations of the 'modes of failure'.	Historical context of 'developmental local government' (DLG) in SA (see section 4.5); Positing a normative model for understanding the aims of DLG (see S.S. 5.5.1), where the SRVM is currently stuck in a vicious, rather than a virtuous cycle.	Discussion of systemic challenges facing the municipality (see fire-fighting and crisis cycle in Figure 6.4 and associated description).	Wicked web of interconnected issues first explored at systemic level in system dynamics (SD) model 1 (see S.S. 7.5.3); Interconnected 'Modes of Failure' explored further in fourth SD model (see S.S. 7.5.6).
3	Recognition of bulk water supply in the LSRV as 'locked-in' as a result of socio-technical system factors and vicious cycles.	Workshops and follow-ups between the L-WUA and the SRVM (Oct.'12 – Aug.'13); Planning workshop for the Kirkwood water treatment works expansion (Feb. '14).	Historical analysis showing the infrastructural development in the LSRV around irrigation, and segregated urban settlements (Chapter 4); Infrastructural profile in relation to IBT (see section 5.2).	Differential experiences of service delivery in Greater Kirkwood region, according to what supply zone residents live in: see S.S 7.5.4.	Greater Kirkwood water supply SD model explored the infrastructural design of the Kirkwood water supply scheme (see S.S. 7.5.4).

Table 7.1 (continued): Summary of the integrating insights derived through the systemic action research process undertaken in this study. Each insight is related to the relevant stages of the action research process (column 2), and to the three components of institution analyses (in Chapters 4 and 5); ethnographic analyses (in chapter 6) and systems analyses (this chapter + Appendices D, E, F, and G). References to sub-sections (S.S.) in text.

Integrating insights		Relevant stages of the action research process	Institutional analyses	Ethnographic analyses	Systems analyses
4	Requirements for emergency water and the opportunities and constraints of this policy measure.	Action research response to Kirkwood burning through to the participation in the Water Research Commission (WRC) 'Water Dialogue' (Nov.'14).	Governance analysis on statutory requirements for provision of basic water supply in relation to the relevant Norms and Standards (see Box 5.2).	DWA-Regional Office in the Eastern Cape acknowledging its inability to regulate the provision of emergency water (see S.S 6.5.3).	Household transition from unconnected to connected households explored in Kirkwood water demand SD model (see S.S.7.5.5); Demand for emergency water in the 'Modes of Failure' model (see S.S. 7.5.6); Causal loop diagram in Figure 7.40).
5	Practical politics of interventions into local water authorities, in particular, local government water services: recognition of uncoordinated interventions.	Strategic Adaptive Planning workshops (Nov.'11) – in which the four knots were identified and discussed; through to Kirkwood burning and involvement in brokering business-civil society proposal (Oct. – Nov.'14).	Lack of coherent intervention strategy between national government departments involved in supporting, funding and regulating local government water services (see S.S. 5.3.6); Governance challenge 5 (constitutional constraints on interventions – see S.S. 5.5.6).	Experiences of overlapping interventions in the SRVM between 2011 and 2014, including national and provincial government departments, regional water boards, consultancies; Inter-actions with the Rapid Response Unit of DWA.	-

7.4 Institutional analysis focus

7.4.1 An institutional action research process

The particular knot of the Greater Kirkwood water supply scheme (WSS) was repeatedly raised as an issue, and was reiterated in the discussion of the first SD model with municipal officials. Since the issue was raised as 'knot 1' at the second SANPAD research workshop in November 2011, the situation had worsened, and by mid-2012, it was apparent that the increasing dysfunction of the Greater Kirkwood WSS was a source of frustration for many actors. Indicators of these frustrations included:

- Municipal residents who received potable water from the Kirkwood system expressing disillusionment with the capacity of the SRVM as a water service provider (following water shortages): leading to certain residents taking drastic action of unlawfully opening the sluice gate from the L-WUA canal to the Kirkwood water treatment works (destroying L-WUA property at the same time);
- The L-WUA threatening legal action against the municipality and certain Kirkwood residents for 'destruction of property' and 'theft of water' – with the L-WUA seeing the SRVM as constantly failing to adhere to the L-WUA's operational rules; and
- The SRVM Technical Division having multiple complaints with regards to the process of ordering water, the raw water tariffs charged to the municipality by the L-WUA, and the persistent water outages in Kirkwood.

The limited off-site storage at the Kirkwood water treatment works (WTW) and the expanding demand for potable water in the Kirkwood region were the two most consistently-raised issues within the stakeholder group participating in this study. When the latter two factors were combined with the particular delivery system operated by the L-WUA – namely a canal system operated on weekly releases with no storage within the L-WUA's structure – the effect was that the Greater Kirkwood region faced persistent water outages (particularly over weekends). The municipality's response had been to request for continual supply over the weekend, whilst the L-WUA countered by stating that it is the user's responsibility to build sufficient off-site storage, and that the municipality was mismanaging its current water allocation (as described in sub-section 6.3.4 of the second thick description).

The institutional arrangement between the L-WUA and the SRVM was initially construed as a legal issue centred on water licences (as described in sub-section 6.3.1). One of the RRU

team members made an additional suggestion that the RRU and the SRVM should seek to "escalate the problem to the National DWA office and [to] the Minister", in order to highlight the difficulties underpinning how the L-WUA and SRVM interacted.

The net effect of the above frustrations was an effective stalemate, with both the L-WUA and the municipality unwilling to compromise. This stalemate was particularly evident in the initial workshops facilitated by the SANPAD project in late-2011. The opportunity to engage the relevant actors in order to try and overcome this impasse first emerged out of a connection between the SANPAD research project and a consultant working on a DWA-funded project (see fieldwork story in Box 6.6) This consultant was employed as the 'professional service provider' on the DWA project that sought to hasten transformation of water user associations through the development of business plans (described in section Box 6.4). Whilst meeting this consultant to discuss potential overlaps in July 2012, the idea of using the dysfunctional arrangement between the L-WUA and the SRVM as one of the L-WUA's transformation-related projects was mooted. The first substantive step in the intervention process was to produce a governance analysis that clearly outlined the problem. The governance analysis drew on the actor analysis conducted between October 2011 and March 2012, in order to characterise the current institutional arrangements as the rules-in-use (displayed in Figure 5.13). The rules-in-use were contrasted to the rules-in-form – i.e. the way the South African water management policy framework required the two organisations to interact (summarised in Figure 5.14 in Chapter 5). The subsequent institutional analysis was summarised into a report (entitled 'Analysis of relationship between the Lower Sundays River WUA and the Sundays River Valley Municipality (SRVM)' – see Box 7.1).

The next step in the intervention process was to introduce the DWA consultant to the Technical Director of the SRVM (Sizwe). At the point of this introduction in August 2012, the director was still in his first two months of employment in the SRVM, but he was aware of the dysfunctional arrangement with the L-WUA, and the problems in the Kirkwood water supply scheme. In addition, he faced the conflation of WSA and WSP roles within the municipality on a daily basis (as discussed in sub-section 6.2.6). As such, the Technical Director approved of the intervention concept, and he introduced SANPAD researchers to the Municipal Manager in order to gain official approval.

A crucial following step in the intervention process was a meeting between the CEO of the L-WUA and Sizwe, facilitated by the SANPAD project in August 2012. Given that Sizwe was

still in his first two months of work in the SRVM, he had not met the association's CEO yet. In contrast to previous meetings between the municipality and the L-WUA, this introductory meeting was civil and professional. One of the outcomes of this meeting was the agreement of the association's CEO to participate in a process to try and resolve the institutional and operational issues between the two organisations.

Box 7.1: Replication of the 'Executive summary of key findings' from the report 'Analysis of relationship between the Lower Sundays River WUA and the Sundays River Valley Municipality (SRVM)'

1. As a result of providing bulk water services to the Sundays River Valley Municipality (SRVM), the Lower Sundays River Water User Association (WUA) is functioning as an 'unacknowledged' water service provider (WSP). Under the *Water Services Act of 1997*, any water service provider should be contracted to, and regulated by, the water service authority (WSA) to which they are providing bulk water services. The SRVM and the WUA should therefore enter into a contractual relationship.

2. As a result of (1), neither the SRVM as WSA, nor the WUA as bulk-WSP, are compliant to the *Water Services Act*. The lack of compliance on the part of the WUA is in spite of the organisation adhering to the regulations of the *National Water Act* (in terms of structure and function). Under the current institutional framework, the SRVM carries the executive authority for water services in the region in which it operates, and is therefore primarily to blame for the lack of institutional arrangements between the WUA and the SRVM. National government in general, and the Department of Water Affairs in particular, have also failed in its regulatory role, as outlined in the *Draft White Paper on Water Services* (DWAF, 2002), and the *Strategic Framework for Water Services* (DWAF, 2003).

3. There is positive scope for development of an institutional arrangement for both the WUA and the SRVM. Firstly, the SRVM is currently engaging in separating the regulatory and service provision functions that it performs as a water service provider. Secondly, the current DWA project requiring the WUA to draft a business plan (Project Number WP 10503) provides an opportunity (and potential motivation) for the WUA to be involved in the development of a contractual agreement between itself and the SRVM, which is in both parties' interest. Thirdly, the management of the SRVM's Kirkwood system provides a point of engagement.

Once the critical group of actors had agreed to participate in the intervention process, a number of additional actors were invited to participate in a scheduled workshop to address the 'governance gaps' raised in the institutional analysis report. The additional actors included representatives from DWA and Amatola Water. Through these invitations, a second consultant became involved in the process. This consultant was also funded by the DWA, but was working with the municipality as part of the RRRU intervention (rather than with the L-WUA). The RRU consultant believed that the lack of distinction between the WSA/ WSP functions of the municipality was a hindrance to the RRU's work in the SRVM: she argued that whilst this institutional distinction was *not* in her portfolio of duties, the lack of

institutional structures in the SRVM was preventing the adoption and implementation of tools developed over the course of the RRU intervention, and she was therefore willing to engage in processes to address this issue. The RRU consultant further conceded that her enthusiasm to participate in the workshop had an opportunistic element as well: she had not had the opportunity to meet with Amatola Water officials yet, and so their attendance at the workshop was a motivating factor for her attendance (see Box 6.6).

The intervention process was structured around an initial workshop, which was aimed at bringing together the key participants in order to address the governance gap. The reflexivity prerogative, as conceptualised in the action research framework in section 7.2, was built into the workshop in three different ways. Firstly, the workshop format was designed with the help of two experienced facilitators involved in the SANPAD project (accounting for process management principles of "openness, protection of core values, progress and content" (de Bruijn et al., 2010) in the design of the workshop). Secondly, the two SANPAD researchers were involved in the facilitation of the workshop, specifically to be sensitive to shifts in the workshop direction according to participant-raised issues. Thirdly, workshop participants were invited to provide feedback both during the workshop, and afterwards.

The workshop was hosted in the LSRV in October 2012, with participants from all the above-mentioned organisations in attendance. The planned phases of the workshop are summarised in Box 7.2 below. As introduced in the narrative in section 7.3, representatives from both the L-WUA and the SRVM committed to improving their working relationship at the workshop. The participants cited the dysfunction of the Kirkwood system in particular as a major source of frustration to all actors.

Box 7.2: Planned phases of the October 2012 workshop

Phase 1: Building a common understanding of what the various participants' goals and interests were for the workshop, and agreeing on the aims of the workshop.
Phase 2: Description of the governance gaps (*summary of the institutional analysis report*).
Phase 3: Description of ethnographically-derived understanding of the institutional arrangements, using an approach of 'mirroring back'(Engestrom, 2007) to workshop participants the municipality and water user association's problem formulations.
Phase 4: Workshop participants to divide into break-out groups – one with the SRVM at the centre, and the other with the L-WUA at the centre – to discuss individual and group actions.
Phase 5: Feedback from break-out groups, discussion and agreement of way forward.

The agreed-upon starting point was the creation of an 'operational guide' that would enable the two systems to function more effectively – with a particular focus on the Greater Kirkwood WSS. The first steps to creating this guide was for the technical officials from the municipality to arrange a tour of the L-WUA's canal system, in order to understand better the irrigation canal system characteristics and constraints (with the L-WUA staff reciprocating for the SRVM's water supply system). The operational guide was promoted as serving a double purpose of assisting with the Kirkwood WTW operations and bulk water management, and acting as a jointly-produced document that would precede the development of a service-level agreement between the two organisations. One of the participants from Amatola Water summed-up his thoughts on the workshop (and the associated intervention process) by simply saying "we have come a long way": several other participants agreed, with the workshop therefore broadly deemed as a success.

However, the complexities involved in moving the process forward soon became evident. A date was set with the key participants for a follow-up meeting – scheduled for February 2013 – in order to report on progress since the October 2012 meeting. The timing of this meeting was pertinent given the ongoing water outages in two townships in the Greater Kirkwood area (Moses Mabida and Aqua Park), which were reported in provincial newspapers (Ndamase, 2013). Despite six weeks of planning, the logistics of the meeting were re-arranged at the last minute after it transpired that there were three other meetings in the Eastern Cape that municipal officials were required to be present at on the same day (as discussed in Box 6.2). The technical director had delegated members of his division to each meeting so as to be represented at all the meetings – but this meant that the various decision makers required for the SANPAD-hosted follow up meeting could not all be present. The SANPAD team elected to facilitate the February 2013 meeting with a reduced number of people, rather than postpone the meeting. Representatives from the municipality, the L-WUA and from DWA were present at the meeting. Participants recorded a list of agreements from the last workshop that had been reneged upon, and resolutions that had failed to be implemented. In addition, there was evidence of a reversion to previously-held positions, with the municipal representative demanding that the L-WUA supply the municipality on weekends, and the L-WUA CEO refusing to do so. Whilst the February 2013 meeting ended with a list of tasks that were mainly recycled from the outcomes of the October 2012 workshop, the meeting appeared to reinvigorate the intervention process, and served to keep the process moving. When SANPAD researchers facilitated a third meeting in August 2013, there was still no defined

operational plan or service level agreement (SLA), and reports of on-going water shortages in the Kirkwood region continued to circulate in provincial newspapers (de Kock, 2013). In spite of these various problems, the L-WUA included a support programme for the SRVM as one of its transformation-related projects in its business plan for 2013 to 2015 (see Box 7.3).

Box 7.3: Excerpt from the Lower Sundays River Water User Association's Business Plan (2013 – 2015).

> **STRATEGY 7 - SUPPORT SUNDAYS RIVER MUNICIPALITY TO ACHIEVE MORE RELIABLE BULK WATER SUPPLY.**
>
> The actual practicalities of operation of the Municipal system is of a much simpler level of complexity than what the WUA is administering and managing for the whole of the Sundays Valley, and furthermore, the WUA engineers and technicians have an excellent understanding of the Municipality system and what exactly must be done to resolve the ongoing problems. The significant body of technical and operational knowledge within the WUA could then be used to support the SRLM technicians to better plan and operate their system.
>
> This possible support intervention by the WUA would be undertaken in the spirit of transformation and skills transfer at minimal direct cost to the WUA, but with *major positive impact* to the residents of the towns suffering from unreliable supply and with great benefit to the technicians in the Municipality to increase their skills and functionality.

Around six months later (in February 2014), SANPAD researchers participated in the planning workshop on the expansion of the Kirkwood water supply scheme (the context of this planning workshop was introduced earlier in sub-section 6.4.7). The L-WUA officials were present, and agreed with the SRVM technical officials and the consulting engineers on the basic scope of work that the Kirkwood water supply scheme (WSS) required in order provide adequate infrastructural capacity to support the growing demand for potable water in the Greater Kirkwood region. Later in 2014, the L-WUA began supplying the SRVM with raw water throughout the week (including over weekends), which the L-WUA officials had previously refused to do. The SRVM technical director (Sizwe) commented that by mid-2014, he felt that he had developed a functional working relationship with staff at the L-WUA – even if a contractual arrangement between the two organisations was still not forthcoming. Sizwe acknowledged that the working arrangement could not, however, just be inter-personal asking, "what happens when I leave?"

In summary, the action research process involving the L-WUA and the SRVM was successful in terms of the collaborative actions it facilitated, but unsuccessful in securing an institutional arrangement between the two organisations. Over the course of the study, the L-WUA did

begin supplying the municipality with water over weekends, which prior to the AR process reported here, was not perceived a viable option. Yet it is not possible to categorically state what role this AR process played in the latter change in operations. Finally, the AR process involving the institutional arrangements between the L-WUA and the SRVM played a number of important analytical roles in this study, as the following sub-section concludes.

7.4.2 Analytical dimensions of the institutional arrangements component of the action research process

The initial institutional analysis on the arrangements between the L-WUA and the SRVM was undertaken for relatively straightforward reasons. Whilst most stakeholders acknowledged that the current situation between 2011 and 2012 was dysfunctional, there was significant confusion as to what the institutional arrangement between the two organisations should look like. This confusion was exacerbated by the fact that an institutional arrangement between the two organisations was supposed to be consistent with the following pieces of legislation:

- *Municipal Structures Act* of 1998;
- *Municipal Systems Act* of 2000;
- *Municipal Finance Management Act* of 2003;
- *Water Services Act* of 1997 and
- *National Water Act* of 1998.

In addition, the arrangement fell under the regulations of DWA's Regulatory Performance Management System and the Blue Drop programme, and National Treasury audit requirements. From the perspective of this overall study, the institutional gap between the L-WUA and the SRVM became a window to a broader set of institutional issues. These issues included those internal to the SRVM (the municipality's conflation of the water service provider and water service authority roles), and external (the arrangements between the SRVM and other government agencies, departments, and organisations). The institutional gaps in the LSRV ultimately led to the entire governance analysis contained in Chapter 5 of this study, and the effects of these gaps form one of the six integrating insights summarised in Table 7.1.

The arrangements between the L-WUA and the SRVM also initiated the operational dimensions of this study: the focus on the Kirkwood water supply scheme required that technical aspects of bulk water supply become included in this study, in a way that was first excluded from the study's focus. These technical aspects were increasingly explored using

systems analysis, which then fed back into the action research process and enhanced the institutional analyses of this study. As the following section shows, bulk water supply in the SRVM is operated and maintained withth in a complex context, despite what the L-WUA argued in its business plan (see Box 7.3). The operational complexity of the SRVM is explored in the following section drawing on insights from a portfolio of four system dynamics models.

7.5 Systems analysis within a system dynamics modelling process

This section focuses on the modelling process and the select outcomes of the four system dynamics (SD) models, drawing on a conceptual framing of reflective learning in relation to the modelling cycle (Slinger, Kwakkel, & van der Niet, 2008). The model structure of each SD model is described qualitatively, with findings presented in graphs and insights discussed alongside model outputs. The structure of each model is presented in detail in Appendices D, E, F, and G, in the technical format of stock-flow diagrams and equations.

7.5.1 Introduction to the modelling approach

Slinger et al. (2008) propose the metaphor of an optician to describe the analytical aims of modelling. An optician assists her customers to see more clearly; likewise, modelling provides a lens that is intended to assist in gaining clarity on a particular situation. Slinger et al. (2008) argue that reflecting on the modelling process should not just focus on the mechanics of the modelling process itself (see sub-section 3.5.3(iv) of the methodology, where the modelling cycle is introduced). Instead, modellers should reflect *both* on the modelling process (from problem description through to final documentation), *and* on the particular choices and assumptions made during the process, reflecting on how these choices and assumptions interacted with the motivations for undertaking a modelling endeavour to begin with. These reflections should ideally include:

- Reasoned justifications for the selection of one modelling method over others;
- Assessments of the added value of the modelling approach to the 'problem holders'; and
- The modeller's role in bringing this added value to the fore.

To facilitate these reflections, Slinger et al. (2008) propose an on-going process of reflective learning that is aligned to the modelling cycle (see Figure 7.4 and associated description in caption). This reflective approach to modelling is consistent with the conceptualisation of

cycles of action research, as summarised in Figure 7.1 and the description in section 7.2. Insights from the models and modelling process are distilled in Table 7.2, with further reflective learning insights described in section 7.7 following the presentation of the models.

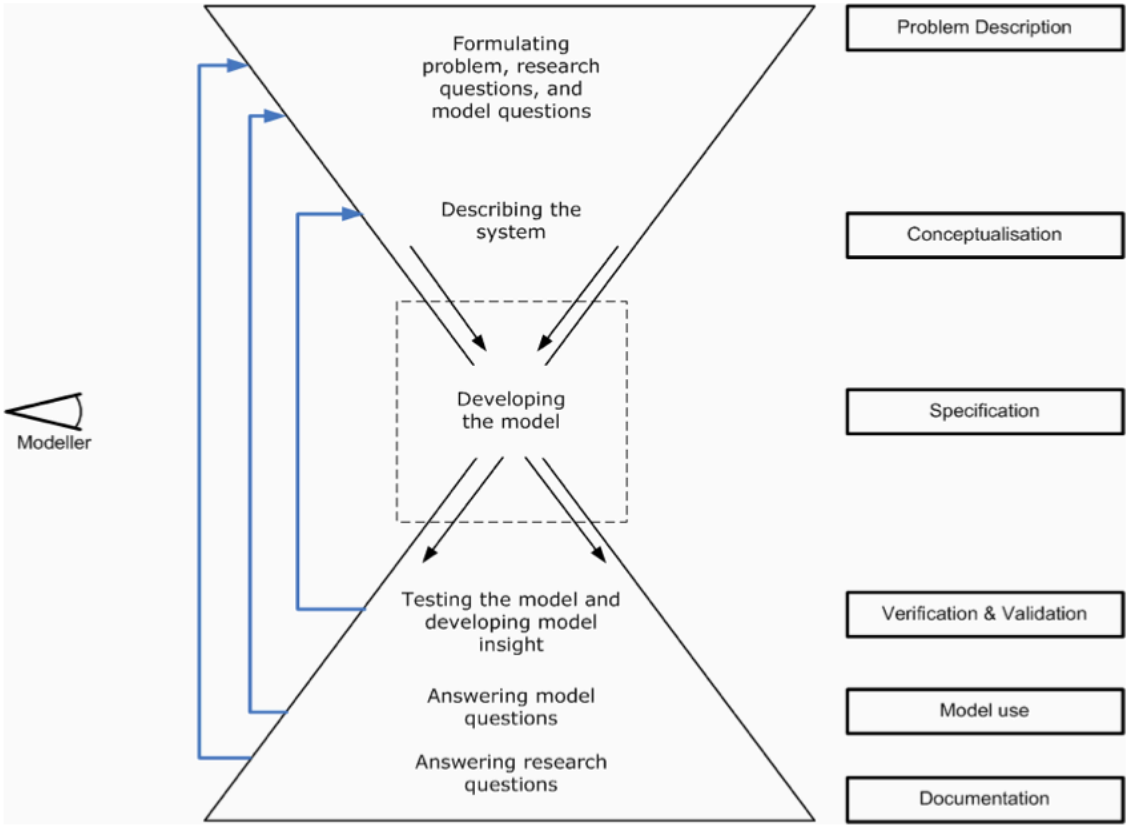


Figure 7.4: Following Slinger, Kwakkel, and van der Niet (2008), a model is understood here as embedded in a convergent and then divergent analytical process associated with the modelling cycle (the six steps in the modelling cycle are listed on the right-hand side). In order to draw conclusions on the validity of the model and its use, the analyst needs to reflect on the choices made in moving from the problem formulation through to the conceptual system description through to the model itself. Similarly, in providing analysis and insights into the problem modelled, the analyst needs to reflect on the initial assumptions that he or she made. The arrows on the left-hand side represent these reflective learning activities. Source: reproduced from Slinger, Kwakkel and van der Niet (2008: 6).

7.5.2 Summary of the four system dynamics models and the modelling process

This sub-section provides a summary of the four SD models and the associated modelling process in two parts: the first part uses a system diagram – formulated following the methodological guidelines of Enserink et al. (2010: 53) – to introduce the different dimensions of each model, whilst the second part details the model focuses, alongside model and process insights.

(i) Systems diagram of the four models:

The system diagram in Figure 7.5 shows the four SD models (M1 to M4) surrounded by the following:

- Outcomes of interest, which are the desired situations or what the problem holder and the analyst wants to get out of the analysis (in modelling terms – the performance indicators relating to the purpose of the model);
- Means, which are the policy instruments or actions by which key actors can affect the system; and
- External factors, which can be defined as variables that "cannot be influenced by the problem owner or by the factors inside the system, but that do place important limitations or constraints on the behaviour and outcome of the system" (Ensrink et al., 2010: 53).

The above three factors represent the dimensions of interest in each model. An additional factor requiring explicit attention when developing an SD model is the choice of the boundary. With SD modelling, analysts strive to produce an endogenous explanation of the problem under examination (Forrester, 2007; Sterman, 2000), which is to say that the primary driving forces of the system (and the feedbacks between these driving variables) should be included within the model. Other variables that affect the system, but are not affected *by* the system, can be included in the model as exogenous variables. Given that a model is a simplification of reality in order to gain analytical purchase on a particular problem, variables that are held to be less important for the problem(s) under examination are excluded from the analysis – but are done so consciously and explicitly. A description of which variables are treated endogenously and exogenously in relation to those that are excluded is therefore a central part of stipulating the model boundary, and relates to the purpose of the model. The boundaries were set differently in each of the four models developed (depicted by the black boxes around each of the models in Figure 7.5 below). A detailed system diagram – using the same convention as Figure 7.5 – is provided for each of the four SD models, with the third and fourth SD models additionally displaying the endogenous, exogenous, and excluded variables in 'boundary charts' (Table F.1 and Table G.1).

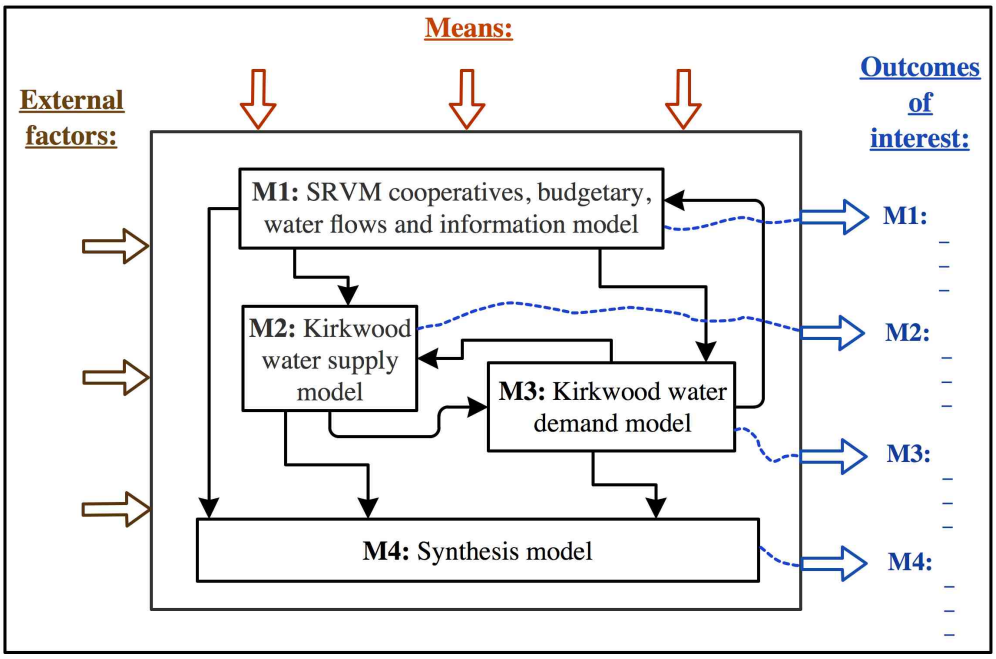


Figure 7.5: Systems diagram showing the four system dynamics (SD) models produced over the course of this study (M1 – M4). The system boundaries are conceptually represented in this diagram by the black boxes. Each model had particular outcomes of interest (represented by the blue arrows and blue dotted lines), and each model was impacted by specific external factors (brown arrows). Lastly, the problems explored in each model could be affected by particular actions of different actors, described here as the 'means' available to these actors (orange arrows). The objects of interest, means, and external factors for models M1 to M4 are contained in detailed system diagrams for each model, and are discussed in sections 7.5.3 to 7.5.6.

(ii) Stages of the modelling process:

Figure 7.5 shows that each model is influenced by different external factors, with various means available to stakeholders, and diverse outcomes of interest informing the purpose of each model. The four models were developed in this study as stages of the overall modelling process, as summarised in the first column of Table 7.2 below. The focus of each model is described in the second column, whilst the third and fourth columns display key model insights and process insights. Each model is described in this study drawing on the associated model 'artefacts' (i.e. the models themselves). The models are described and presented in increasing levels of detail, with supported documentation pertaining to each model provided in appendices.

Table 7.2: Summary of the five main stages of the system dynamics (SD) modelling process undertaken within the broader action research process of this study. The five stages are listed in column 1; the model focus in relation to the model purpose and boundary is listed in column 2, with insights derived from the models listed in column 3, and insights derived from the modelling process listed in column 4.

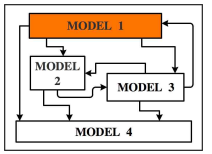
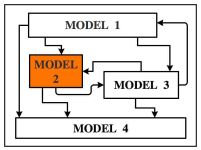
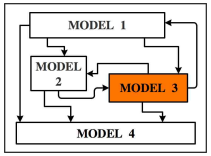
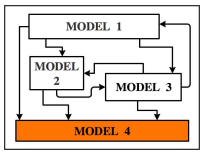
Stages of the modelling process		Model focus	Model insights	Process insights	Systems analysis artefacts
1	Recognition of a systemic problem in the SRVM: decision to employ SD for exploratory purposes: development of Model 1 (M1).	Effects of cooperatives projects on internal operations of municipality in relation to water supply, water demand, leak repairs and indigent registration.	Scale and interconnectedness of problems in the SRVM (not just raw water supply, finances, or staff, but a 'wicked web' of problems); First indication of a possible underlying infrastructural capacity problem.	Use of SD as a problem structuring tool for exploring and analysing multiple types of data and issues.	 Appendix D
2	Return to the SRVM (June 2012) to find the cooperatives project under review. Experience of M1 being at wrong scale. Kirkwood water shortages motivating for development of Model 2 (M2).	Use of system design knowledge and experience over time to model the Kirkwood municipal water supply system and water treatment works (WTW) in relation to the water user association's supply system and process.	Supply schedule interacting with infrastructural constraints (raw water dams, WTW, potable water reservoirs and pump capacities) to create water shortages, which are exacerbated by differentiated experiences in water zones.	SD modelling as means of understanding and responding to complex real-world problems, synthesising knowledge and providing tool for facilitating strategic conversations between conflicting actors.	 Appendix E
3	Recognition of M2 excluding demand dynamics and alternative water supply options: development of Model 3 (M3).	The determinants of rising potable water demand; the use of rainwater harvesting (RWH) as an alternative water source; the effect of water conservation programmes.	RWH potential is highly limited but SRVM can counter the impacts of rapid expansion in household demand (using household water conservation).	Use of model insights in contributing to planning process for Kirkwood WTW expansion; experience of limitations of M3; motivating for Model 4 (M4) as synthesis model.	 Appendix F

Table 7.2 (continued): Summary of the five main stages of the system dynamics (SD) modelling process undertaken within the broader action research process of this study. The five stages are listed in column 1; the model focus in relation to the model purpose and boundary is listed in column 2, with insights derived from the models listed in column 3, and insights derived from the modelling process listed in column 4.

Stages in the modelling process		Model focus	Model insights	Process insights	Systems analysis artefacts
4	Insights from M2 and M3 related to wider challenges faced by the SRVM in providing water supply and managing demand (in relation to citizen experiences of water services): development of M4.	Simultaneous underinvestment in, and over-extension of bulk infrastructure; staff capacity and financial constraints on proactive management and maintenance; demand for emergency water; Choice to ignore details of the water supply infrastructure in order to focus on synthesis.	Crises are generated through interconnected modes of failure of local government in water service provision and citizen-state interactions (involving four main actors).	Use of an ethnographically-embedded understanding of local dynamics (in relation to formal institutional domain) to enrich the model; Opportunities and difficulties associated with employing model insights in case study (around Kirkwood Sept. 2014 protests).	 Appendix G
5	Documentation of models and reflection on modelling process in relation to broader action research process, and broader transdisciplinary study.	▪ Reflective learning in relation to the modeling cycle, drawing on the analytical framing developed by Slinger et al. (2008); ▪ Analysis of how modelling process utilised in this study differed to conventional SD approaches to modelling with stakeholders: development of an approach called 'modelling in the muddled middle'; ▪ Reflection on insights from models and modelling process in terms of potential application in systemic analyses in the South African water sector.			Section 7.5 + sub-section 7.7 (this chapter).

7.5.3 Model 1: The 'Cooperatives Model'

(i) Introduction:

As recounted in sub-section 7.3.1, the first application of SD modelling in this study was as a problem structuring technique – a means of intellectually and empirically grappling with the interconnected set of problems emerging in the LSRV case. Work began on the first SD model (M1) in April 2012, and used the cooperatives project in the SRVM as the point of departure. The Infrastructure and Basic Service Delivery Cooperatives (to use the project's full name) was introduced earlier in sub-section 6.2.5. At the time of working on M1, the cooperatives were a major municipal project aimed at improving service delivery whilst providing employment. The SRVM saw the cooperatives as being relevant for water services for two primary reasons: firstly, by increasing the number of indigent households on the municipal indigent register, the municipality's equitable share could increase; secondly, by monitoring bulk water leaks and undertaking minor leak detection and repair, the demand for potable water could be decreased. The functioning of the cooperatives was one of five sub-models in M1. The sub-models are represented within the box in the centre of Figure 7.6 below.

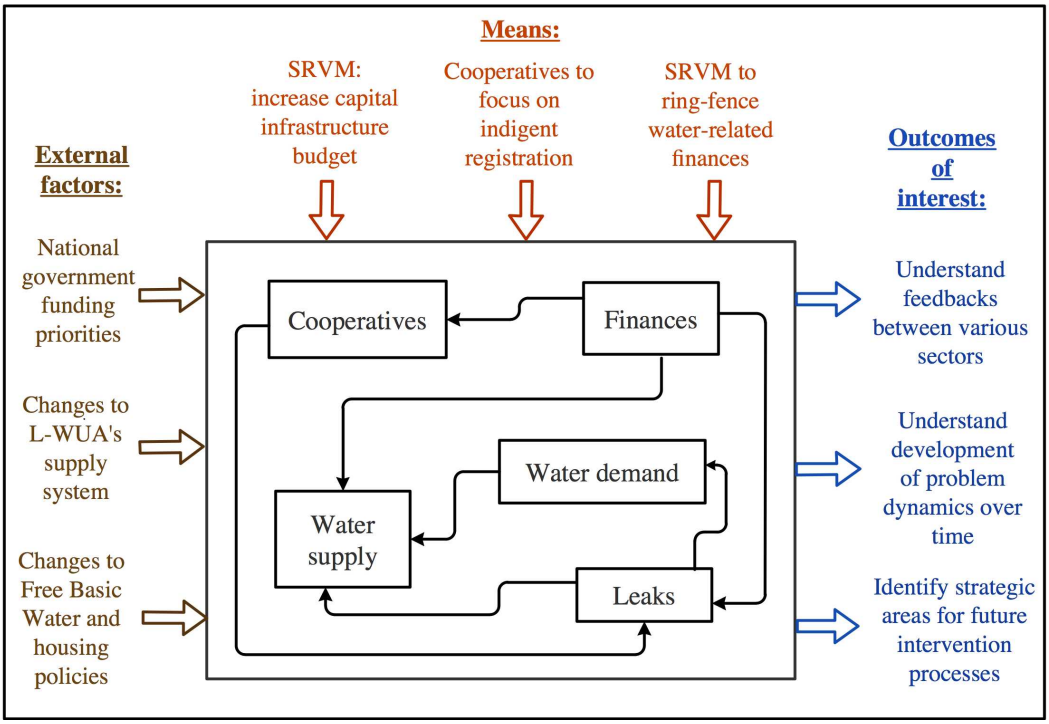


Figure 7.6: System diagram of the first system dynamics model (M1), initiated for problem structuring purposes.

Figure 7.6 also lists three of the external factors that were held to influence M1, but were outside of the model boundary (represented by the inner black box in Figure 7.6). These external factors were national government funding priorities (and the associated political processes around the setting of these priorities); changes to the supply system of the L-WUA, and changes to nationally-set policies, including those affecting the provision of Free Basic Water and housing.

The cooperatives model (M1) identified three means available to actors as including the SRVM increasing capital expenditure and ringfencing water-related finances, and a strategy available to the cooperatives to prioritise indigent registration over the other possible functions that they could perform. The following were the outcomes of interest for M1:

- To broadly understand some of the key feedbacks between various sectors (specifically, between the different municipal directorates – financial and technical directorates – and between the cooperatives, the municipality, and residents);
- To explore the development of problem dynamics over time, in order to begin to understand path dependences and lock-ins in the SRVM;
- To identify strategic areas for future intervention processes, both as part of the SANPAD project, and as policy recommendations for actors involved in the SRVM case (including the municipality itself, DWA, and Amatola Water).

The following sub-section briefly accounts for the structure of the first SD model developed in this study, referred to here as 'the cooperatives model' or 'model 1' (M1). Further details on the model structure can be found in Appendix D.

(ii) Structure of model 1:

As introduced with Figure 7.6 above, the cooperatives model is composed of the following five sub-models:

1. A sub-model representing the water-related functions of the cooperatives, in terms of indigent registration, meter reading, bill delivery, and minor leak detection and repair;
2. A sub-model representing municipal bulk water water supply, including the municipality's allocation of raw water from the L-WUA, and the supply of potable water across the three water supply schemes operated by the municipality;
3. A water demand sub-model that calculates the total household water demand in the SRVM;

4. A sub-model representing the SRVM financial division in terms of operational and capital expenditure; and
5. A sub-model for major leak repairs and the resulting 'water savings'.

We chose to place the cooperatives sub-model at the centre of model 1 (M1) because of the emphasis municipal officials gave to the service delivery roles that the cooperatives were envisioned to play in the SRVM. As introduced above, the SRVM promoted the cooperatives project between late-2011 and early-2012 as a win-win situation in which the municipality could increase its operational revenue (via indigent registration, meter reading and bill delivery), whilst creating jobs and reducing water losses. The cooperatives would assist in reducing water losses by detecting and repairing minor leaks, and by reporting major leaks as part of their service assessments. The major leaks reported by the cooperatives would then be fixed by the municipality, either directly or via sub-contractors. In M1, the five functions of the cooperatives are represented in sub-model 1 (see Figure D.4), whilst the fixing of major leaks is represented in sub-model 5 (see Figure D.8).

The second sub-model represents the municipal bulk water supply system and calculates the water delivered by the municipality to its residents (see Figure D.5). This sub-model includes stocks and flows accounting for:

- The raw water allocated to the municipality by the L-WUA; and
- The storage and treatment capacities of the three water supply schemes operated by the SRVM, which provide potable water to the communities of Kirkwood, Enon-Bersheba and Addo (as illustrated in the schematic in Figure 5.2).

The potable water available for supply to residents increases with the water saved through major leak repairs, which is how the cooperatives sub-model and the leak repairs sub-model influences the available water supply. The water supplied to communities in the SRVM is modelled on a demand basis in M1: this demand is driven by household water demand, which is formulated in the third sub-model (see Figure D.6). The percentage of these households that are metered is one of the information sources used to influence the water services billing income into the operating budget of the SRVM. The operating budget is one of two budgets in the fourth sub-model on the municipal financial division (see Figure D.7), and can be summarised as follows:

- The operating budget increases with income from billed water services, indigent grants (via the municipality's Equitable Share grant), and from income from other sources unrelated to water services;
- The operating budget decreases according to the costs of the cooperative employees, and according to the cost of municipal operations.

The second budget in the municipal financial sub-model is the capital budget, which increases with the municipality being awarded infrastructure development grants, and decreases with infrastructure development expenditure. Further details on the model structure can be found in Appendix D, with the insights from M1 and the modelling process discussed in the following sub-section.

(iii) Insights from model 1:

The cooperatives model demonstrated the scale and interconnectedness of problems in the SRVM, showing how these problems were not discrete issues pertaining to raw water supply, finances, or staff capacity, but rather a 'wicked web' of interrelated problems. The model also provided the first indication that the municipality faced serious underlying infrastructural capacity problems, which affected all aspects of the bulk water supply system that the municipality owned, operated and managed. In this regard, the cooperatives model was a useful tool for initially structuring the messy, interconnected set of issues affecting municipal water management in the LSRV, and for generating further questions about the dynamics of the real-world situation. Between May and June 2012, we sought feedback from the municipality on the cooperatives project, intending on incorporating this feedback as a validation stage in the use of M1. Whilst engaging municipal officials, it became apparent that the cooperatives project had run out of funding by May 2012, and was therefore under-review. This fact reduced the relevance of the cooperatives sub-model that was a central structure in M1 and was one of our original motivations for undertaking the modelling exercise in the first place. We also found that the municipality did not have numerical or documented data for a greater percentage of the variables than we had previously considered, and found that M1 lacked a clear focus and a defined problem boundary.

As described in section 7.3, the feedback sessions with municipal officials motivated us to focus on a particular part of the SRVM's water services, in the form of bulk water management of the Greater Kirkwood water supply scheme. The subsequent AR process primarily employed institutional and actor analyses (as described in section 7.4 above). Insights into systemic complexities in the SRVM that were derived from M1 (and the

modelling process of building M1) proved complementary to the institutional analysis. Whilst these modelling insights informed the AR process, they were not utilised in any further model development until October 2012. At the October 2012 workshop with the L-WUA and the SRVM (described in section 7.4), the L-WUA identified four issues as being critical to the management of the Kirkwood WTW and the ordering of raw water from the association (see Box 7.4).

Box 7.4: Four issues that were identified by the Lower Sundays River Water User Association in October 2012 as being 'critical' in the management of the Kirkwood water treatment works and the ordering of raw water.

- Infrastructure components need to be quantified (including capacities of raw water and potable water reservoirs, and the capacity of treatment works and pumps);
- Observe levels in raw water reservoirs, monitoring and understanding raw water flows from the L-WUA's canals into these reservoirs;
- Accurately predict or estimate potable water demand;
- Ability to make day-to-day adjustments.

What emerged from the workshop was that the municipality and the L-WUA had different understandings of the physical limitations of the Kirkwood water supply scheme, and therefore differing views on the causes of the persistent water outages in the Greater Kirkwood area. These differing views presented the opportunity to develop a more focused SD model on the Kirkwood water supply scheme, where the process of model building (and the model itself) could be used for analytical purposes and as part of the on-going process of facilitation and research. The resulting model is described in the following sub-section (7.5.4), with a greater focus on the model results and analysis.

7.5.4 Model 2: The 'Greater Kirkwood Water Supply' model

(i) Introduction:

In the 'Greater Kirkwood Water Supply' (GKWS) model, we chose to focus on the Greater Kirkwood water supply system primarily because the SRVM and the L-WUA indicated that this was the water system in which they were experiencing the most contestations and the longest-standing difficulties. One of the advantages of SD modelling in this particular situation is that detailed and accurate data on the water supply system (e.g. the evolution in water demand over time and variations in the water treatment pumping capacity) are not

prerequisites to modelling. Instead a deep knowledge of system design and experienced behaviour over time is required from the research participants. Detailed data was drawn from various sources, such as municipal technical reports, including the Water Services Development Plan (SRVM, 2010), and information pamphlets outlining how the L-WUA water supply system works and annual reports of the L-WUA (L-WUA, 2007, 2012). Where detailed numerical data was unavailable, information on system behaviour was drawn from the research workshops and meetings (described in section 7.3 and 7.4), and corroborated where possible with site visits and further interviews. The technical model-building was undertaken in collaboration with a Dutch team at Delft University of Technology, out of which the *GKWS* model was developed (D'Hont, Clifford-Holmes, & Slinger, 2013) and then extended (D'Hont, 2013). This second model (M2) is described here.

The real world problem situation of Greater Kirkwood's water supply is represented in the system diagram in Figure 7.7, which shows three elements that interact with each other and together form the Greater Kirkwood water supply scheme (WSS), as follows:

1. The L-WUA supplies the municipality with raw water, according to an order placement procedure;
2. Raw water is stored and treated to drinking-quality standards within the SRVM bulk water supply system, following which the potable water is distributed to five separate zones in the Greater Kirkwood region; and
3. The water supply system should aim to meet the water demand of the domestic population in the region: at the bare minimum, the supply system must be able to meet the requirements for basic water supply (as stipulated in the Norms and Standards summarised in Box 5.2).

The four external factors identified in M2 are:

1. Seasonal variation in climate, including summer heat, droughts, varying rainfall and winters;
2. Policy changes regarding water provision as a basic human need, for instance the Free Basic Water policy that was introduced by national government in 2001;
3. The quantity and delivery-related issues of raw water transported from the Orange River via the Orange-Fish-Sundays inter-basin transfer scheme; and
4. Aggregate lifestyle expectations (the social preferences relating to lifestyle changes).

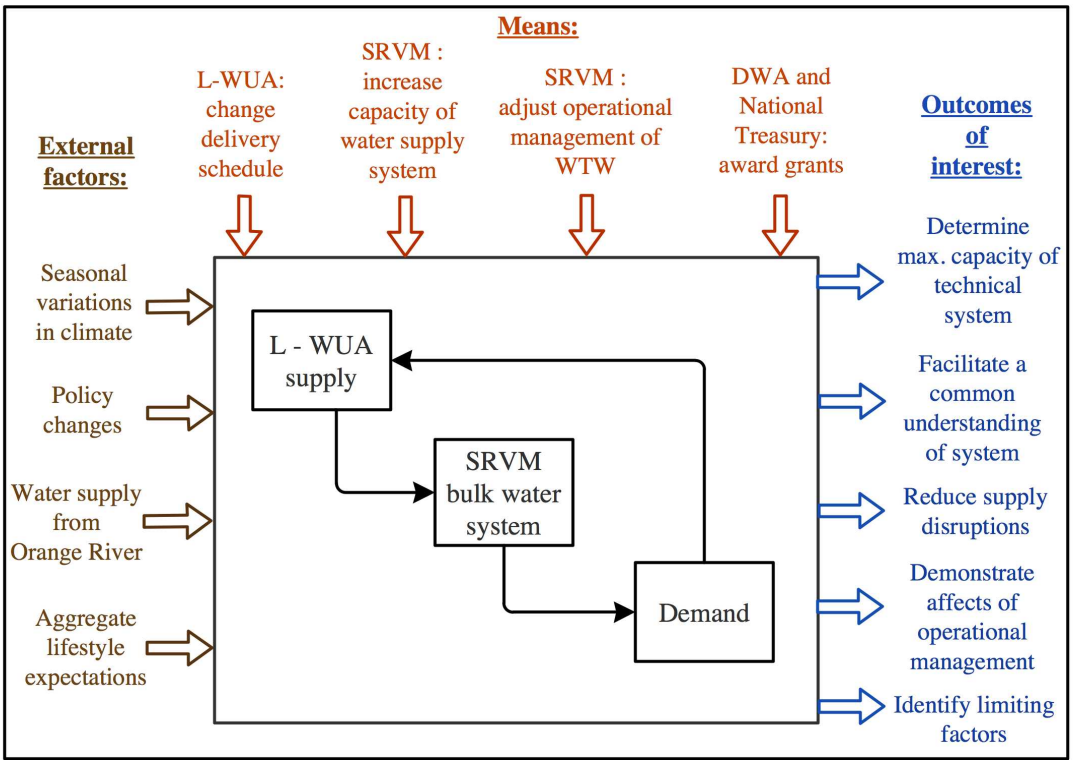


Figure 7.7: System diagram of the 'Greater Kirkwood water supply' model (M2).

The available means by which stakeholders can intervene in the system are depicted in Figure 7.7 by the orange vertical arrows. The L-WUA can adjust the water delivery schedule currently in place. The SRVM can increase the capacity of the water supply system by building extra storage or replacing water pumping systems. Additionally, the operational management of the water treatment works can be intensified by the SRVM. Finally, DWA and National Treasury can award grants to improve the system performance.

The motivations for building the model (i.e. the purpose of M2) are described here in terms of the five outcomes of interest to participating stakeholders. First, the maximum capacity of the technical water supply system of Greater Kirkwood needs to be determined (at the time of building M2, the capacity was contested and of deep interest to the SRVM). Second, a common understanding of the complex technical water supply system and its behaviour can serve as a basis for finding an operational mode that is supported by all stakeholders. The third outcome of interest is that disruptions to the potable water supply of the Greater Kirkwood area are reduced, both in frequency and duration. In addition to being of interest to all stakeholders supplied by the system, reducing such disruptions could contribute to the SRVM improving its score in the regulatory programmes and assessments run by DWA (in particular, the Regulatory Performance Management System (RPMS) assessments, and the

Blue Drop programme). An additional dimension of the water supply disruptions in the Greater Kirkwood area is that historically, these water outages affect some areas worse than others, with the reasons why this was the case being unclear.

The fourth outcome of interest is to more deeply understand how the operational management of the water supply system affects the supply system's performance. The two operational aspects included in the *GKWS* model are:

1. The effect of varying reservoir water levels on pump performance; and,
2. The effect of the SRVM lacking a full complement of operators at the Kirkwood WTW, which meant that as of late-2012 / early-2013, the WTW was only operational for limited hours throughout the week.

The fifth and final outcome of interest is to identify the weakest links in the Kirkwood water supply system: identification can assist in facilitating contingency plans to address these weak links, which would enable municipal operators to improve system performance both now and into the future. The following sub-section describes the structure of M2, in order to account for how the *GKWS* model met the five stipulated purposes that motivated undertaking the modelling exercise.

(ii) Structure of model 2:

This sub-section briefly accounts for the structure of the *GKWS* model using a schematic representation of the Kirkwood water supply scheme, with the equations and sub-models of the *GKWS* model described in detail in section E.4 of Appendix E. Figure 7.8 is a schematic representation of the Kirkwood water supply scheme (WSS) that shows the connections between the following bulk water supply components:

1. Raw water infrastructure (including the L-WUA main canal, the old storage canal and the raw water reservoirs);
2. The Kirkwood water treatment works (WTW) and associated pumping systems; and
3. The distribution of potable (i.e. treated) water to the five supply zones in the Greater Kirkwood WSS, via six potable water storage reservoirs.

In the *GKWS* model, the above-listed components are structured into a chain of interconnected stocks and flows that are influenced by three additional sub-models, namely:

1. A sub-model representing the annual operational schedule (accounting for the L-WUA's maintenance schedule and the operating regime of the Kirkwood WSS by the municipality);

2. A rainfall sub-model; and
3. A sub-model simulating the effects of pumps cutting-out on the functioning of the Kirkwood WSS.

Lastly, the *GKWS* model features a sub-model for monitoring the received water in all five zones of the Kirkwood WSS. This sub-model calculates the time that zones 1 to 5 are without potable water over the course of the simulation period, and therefore performs an informational function (rather than driving system behaviour in any way). The remainder of this sub-section describes these sub-models qualitatively, referring to Figure 7.8.

The municipality manages and operates the Kirkwood WSS, whilst the L-WUA manages and operates the irrigation canals. The municipality abstracts raw water from the L-WUA main canal, according to a set delivery schedule, via three sluices that have varying flow rates: the first sluice diverts raw-water into an 'old storage canal' in the town of Kirkwood, with the second two sluices functioning to fill four raw water reservoirs.

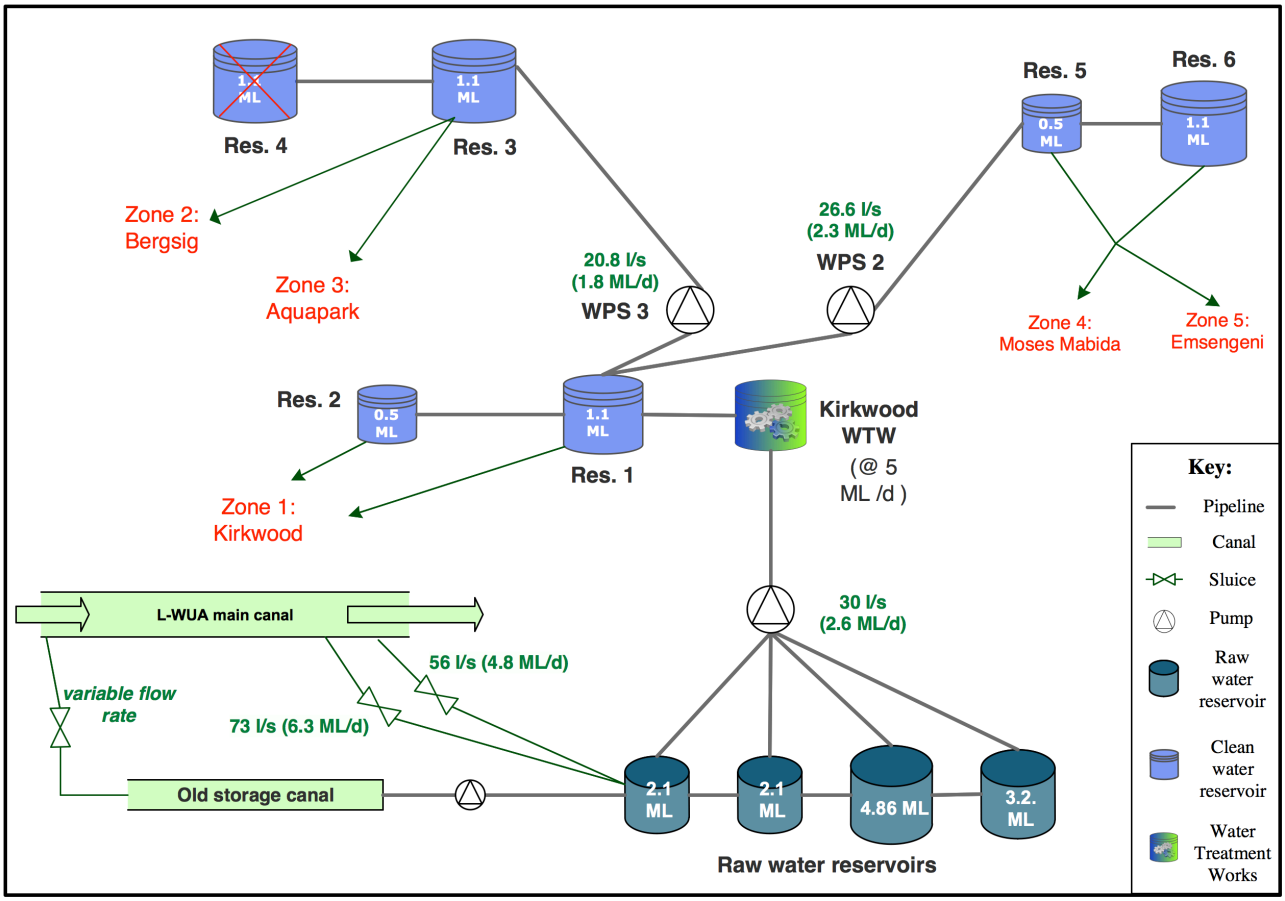


Figure 7.8: Schematic representation of the primary components of the Kirkwood water supply scheme, which supplies the Greater Kirkwood region of the Sundays River Valley Municipality. The Kirkwood scheme is supplied with raw water via the main canal of the Lower Sundays River Water User Association (L-WUA). Source: own design, using data from SRVM (2010b).

The four raw water reservoirs and the old storage canal collectively represent the full off-site storage capacity for raw water in the Kirkwood WSS. In the *GKWS* model, the raw water reservoirs and the old storage canal are combined into one stock variable called 'off-site storage' with a given maximum capacity (see Figure E.4 and associated description in Appendix E). Water is pumped from the raw water reservoirs up to the Kirkwood WTW, where the raw water is treated to a potable water-quality level, and stored in reservoir 1.

The *GKWS* model divides the Greater Kirkwood area into five zones, following how the SRVM technical directorate differentiates between the suburbs and communities in the region: zone 1 is Kirkwood town – the largest urban settlement in the area; zones 2 to 5 represent the suburbs of Bergsig, Aquapark, Moses Mabida and Emsengeni (as shown in the map in Figure 7.9). The potable water stored in reservoir 1 in the *GKWS* model is either pumped through to the water reservoirs storing the water for the urban areas of Bergsig, Aquapark, Moses Mabida or Emsengeni, or remains in reservoirs 1 and 2 to supply Kirkwood town, which is consistent with how the Kirkwood WTW operates in reality.

Due to its location beneath the WTW, potable water gravity-feeds to Kirkwood town from reservoirs 1 and 2 at the WTW. Water can only reach reservoirs 3 to 6 with the assistance of two water pumping systems (WPS). To avoid overheating and seizure, the diesel engines of the WPSs cut-out when the volume in the reservoirs falls to 20% of the reservoir capacity or below. Once the pumps have cut-out, the reservoirs need to fill to 50% capacity before the WPSs can start running again. The residents of zones 2 to 5 are without water whilst the pumping systems are inoperable, leaving the remaining 20% of the potable water in reservoirs 1 and 2 to gravity-feed to Kirkwood town. In short, because of its geographical location and the water supply system design, Kirkwood town is the first to receive water and the last to run out of water. As introduced above, one of the sub-models in the *GKWS* model represents the cutting-out of these pumps, in order to simulate the behaviour of pumps cutting-out on the functioning of the Kirkwood WSS.

The discharge rates of the pumps and the design capacity of the WTW together determine the maximum feasible performance of the modelled water supply system (schematically-represented in Figure 7.8). Available system data suggests that in an attempt to meet the water demand in the Greater Kirkwood region, the municipality has been operating the pumping systems and the WTW above the maximum discharge rate for which they have been designed.

Appendix E further describes how these aspects of operational management interact with the infrastructural system that has been introduced in this sub-section. In particular, section E.4 of Appendix E details the equations and data sources for each sub-model of the *GKWS* model. The following sub-section displays and discusses the results of M2.

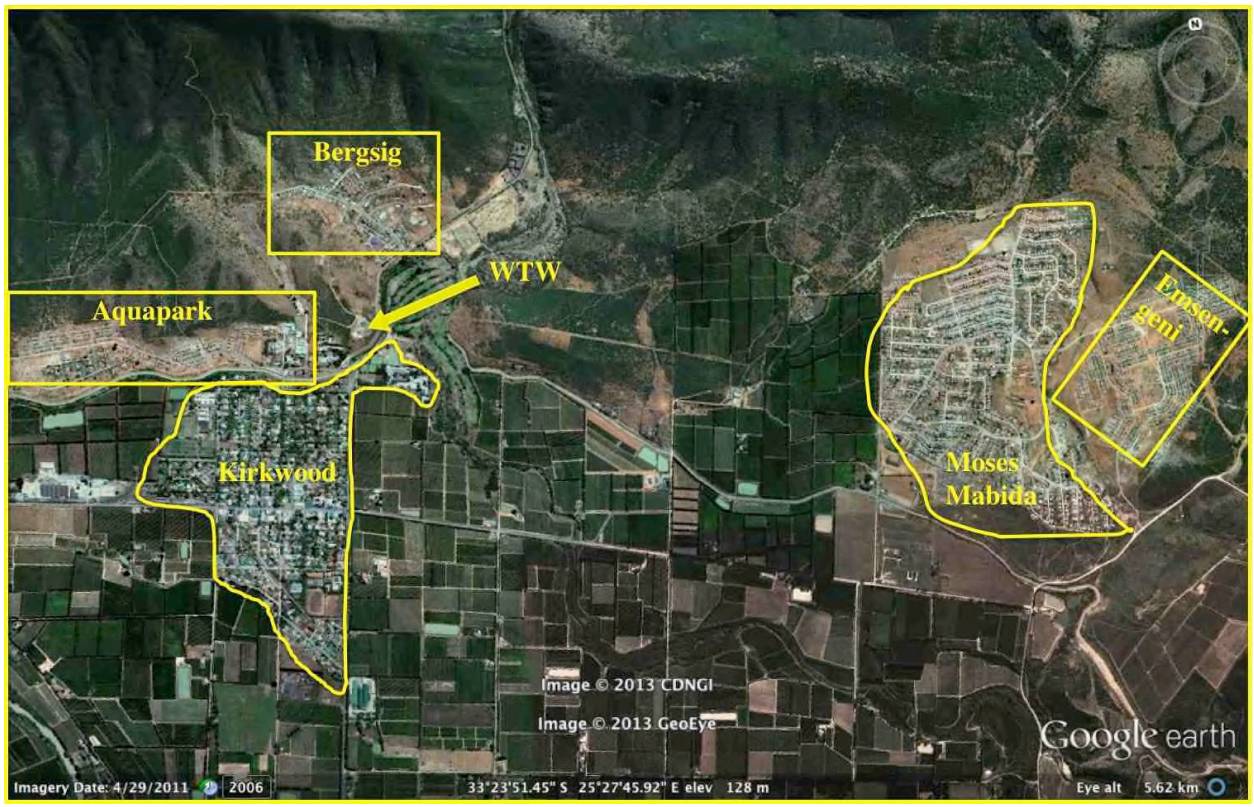


Figure 7.9:Map of the Greater Kirkwood are of the Sundays River Valley Municipality, with the five urban settlements outlined in yellow and the location of the Kirkwood water treatment works (WTW) above the town of Kirkwood noted. Source: Google Earth.

(iii) Model results and insights:

The *GKWS* model simulates a 450-day period, using the 'time unit' of days. The 'time step' for the model is set to 1/1000 of a day, equating to around 1.4 minutes (which is a frequent-enough time step to calculate the difference in reservoir water levels, and larger enough to enable a fast-running model).

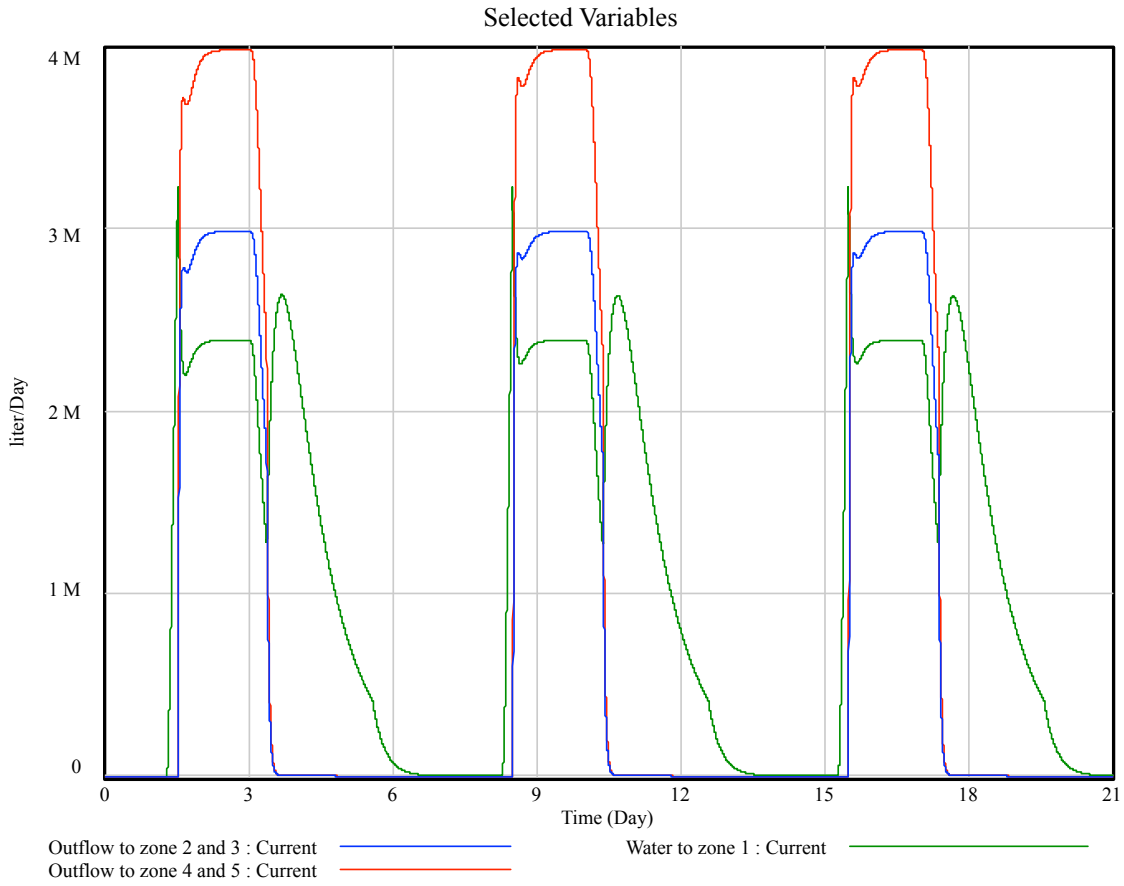


Figure 7.10: Water supply to all zones, presented as a 21-day fragment of the total simulation run in order to illustrate system behaviour.

In the results discussed here, the simulation starts at time 0 with no water in the supply system. Raw water flows into the L-WUA's main irrigation canals in the Kirkwood region approximately 24 hours after it is released from Darlington Dam on a Monday morning (depending on the flow rates). Figure 7.10 aboves shows a model output presenting the first 21 days of the 450-day simulation: as Figure 7.10 illustrates, the outflow from the WTW begins to pick-up after day 1, with water being provided to all five supply zones. However, the outflow to zone 1 (the green line in Figure 7.10) increases at the same time as the outflow to zones 2 to 5 is reduced to zero in day 3. This behaviour is representative of the water pumping systems to the other four zones (zones 2 to 5) cutting-out, which results in the remaining water gravity-feeding to zone 1 (Kirkwood town) over a 48-hour period. The implications of this pattern of behaviour is further discussed alongside Figure 7.14 below.

Figure 7.11 shows the overall water supply to all zones in the Greater Kirkwood area, over a one-year period. Figure 7.11 further demonstrates the model behaviour (initially shown in Figure 7.10) in which reservoirs drain and empty, and pumping systems turn on and off, resulting in weekly flucutations in the potable water supply to all zones. An additional

dynamic is evident between days 121 and 212 in Figure 7.11: longer outages are visible on a weekly-basis during the winter months, resulting from the operational schedule of the L-WUA adjusting to its winter maintenance schedule – meaning that the Kirkwood WTW is only supplied with three rather than five days of water per week.

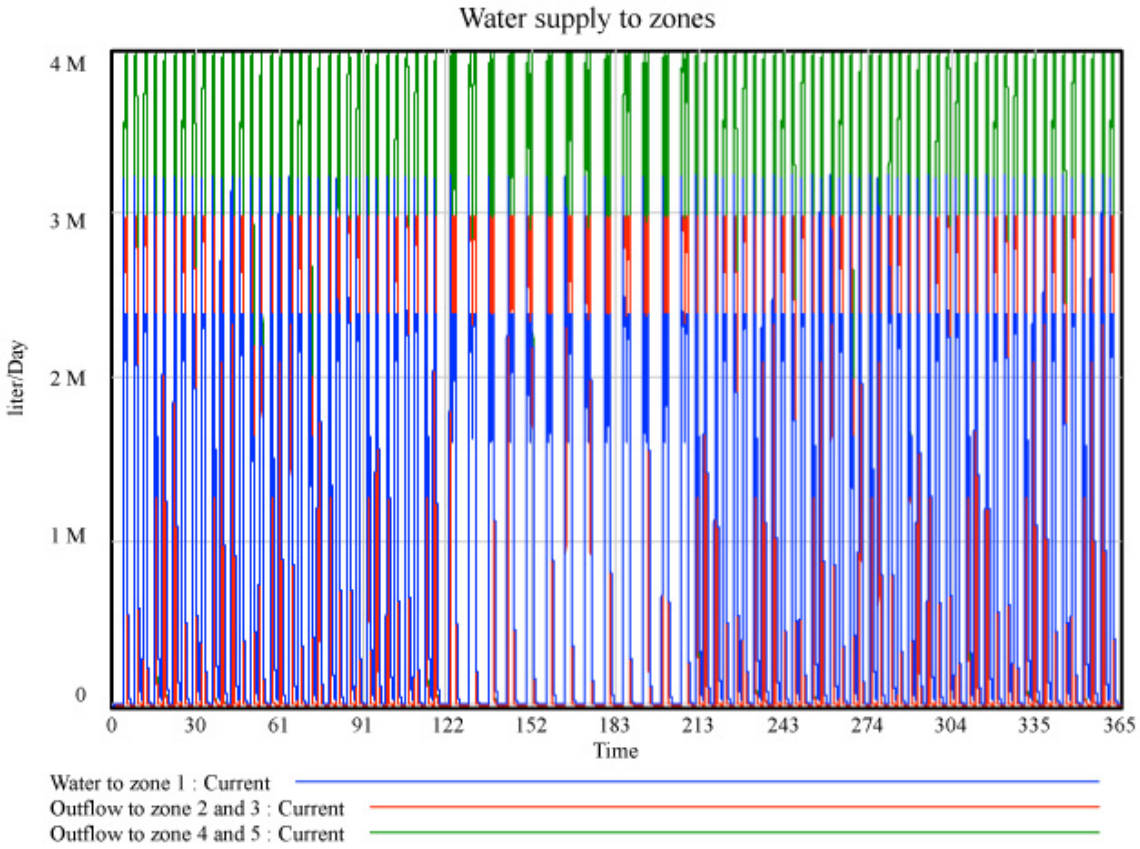


Figure 7.11: Baseline simulation displaying the water supply to all zones of the Greater Kirkwood region over a one-year (365 day) period.

The *GKWS* model also assessed the capacity of the main components in the bulk water supply scheme (WSS) that are owned, operated and managed by the SRVM. Whilst the reservoir capacities are fixed, the mechanical and electrical components of the WSS have design capacities that these components should be operated within. However, these components can be pushed over-design capacity, in response to demand exceeding potable water supply, or as a result of the operational schedule described above. In Figure 7.12 and Figure 7.13, the designed discharge rates of the water pumping systems are compared against the actual discharge rates in the *GKWS* model. The designed discharge rates were drawn from engineering data, whilst the actual discharge rates were generated in the *GKWS* model (as described in the model description in section E.4 of Appendix E). Figure 7.12 compares the

designed to the actual discharge rate of water pumping system (WPS) 2, with Figure 7.13 performing the same function for WPS 3.

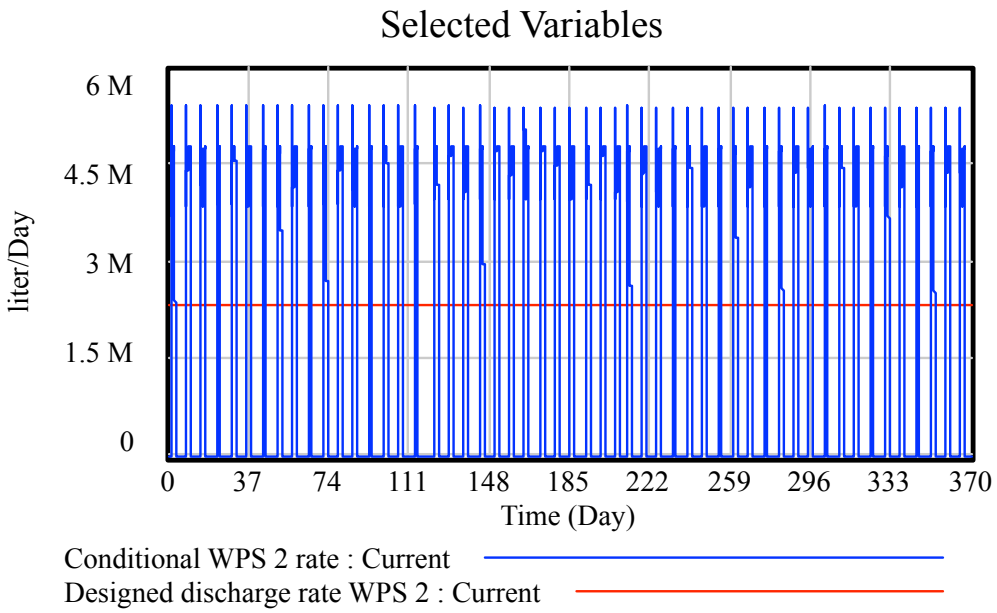


Figure 7.12: Designed discharged rate of water pumping system (WPS) 2 compared to the conditional discharge rate. The conditional discharge rate represents the actual discharge of the pumping system in the GKWS model.

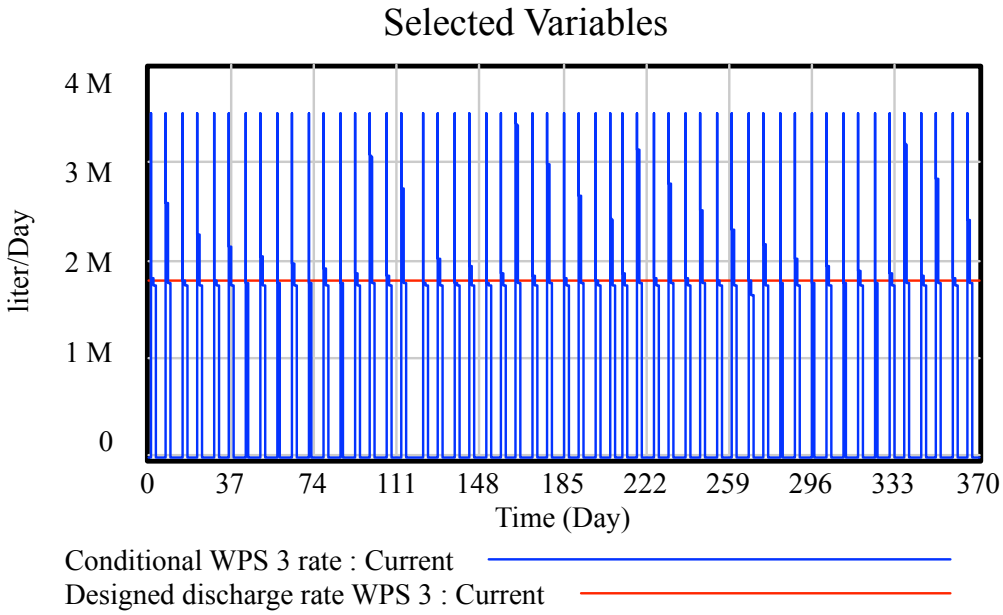


Figure 7.13: Designed discharged rate of water pumping system (WPS) 3 compared to the conditional discharge rate (following Figure 7.13).

The graphs in Figure 7.12 and Figure 7.13 show that the actual discharge rates in the *GKWS* model are frequently more than twice the designed discharge rates. In reality, these pumping systems can only operate around 130% before they burn-out, but this maximum limit was not set as a constraining factor in the *GKWS* model (but were incorporated into M4).

The final output from the *GKWS* model discussed here relates to the 'time without water' in the five supply zones. As described earlier, water outages have a differential impact across Greater Kirkwood, such that all areas do not run dry at the same time. Figure 7.14 demonstrates the relative time periods without water, over a one-year simulation period. As demonstrated in Figure 7.14, zone 1 suffers the least number of days without water in the simulation period. The reasons for this – in terms of the gravity-feed pipeline from the WTW to zone 1, and the cut-out behaviour of the WPSs – have already been described in this sub-section. What is important to note is that zone 1 is still primarily inhabited by white residents, who are comparitvely wealthier than the poorer communities who reside in zones 2 to 5. The safety mechanisms in the technical design of the pumps, together with the nature of the gravity-feed system to Kirkwood town collectively result in Kirkwood town being the last area to be cut-off, and the first area to receive water. Municipal residents living in zones 2 to 5 have understandably complained that this aspect of system behaviour is inherently unjust, with several research informants arguing that the preferential supply of potable water to zone 1 is discriminatory both on class and racial lines. In Figure 7.14, Moses Mabida and Emsengeni (zones 4 and 5) lack sufficient access to potable water more than 80% of the year, which indeed portrays an inequitable supply system. The *GKWS* model usefully demonstrates that the differentiated service delivery experience lies more in the physical characteristics of the infrastructural design than it does in the operational choices made by the municipal employees managing the infrastructure.

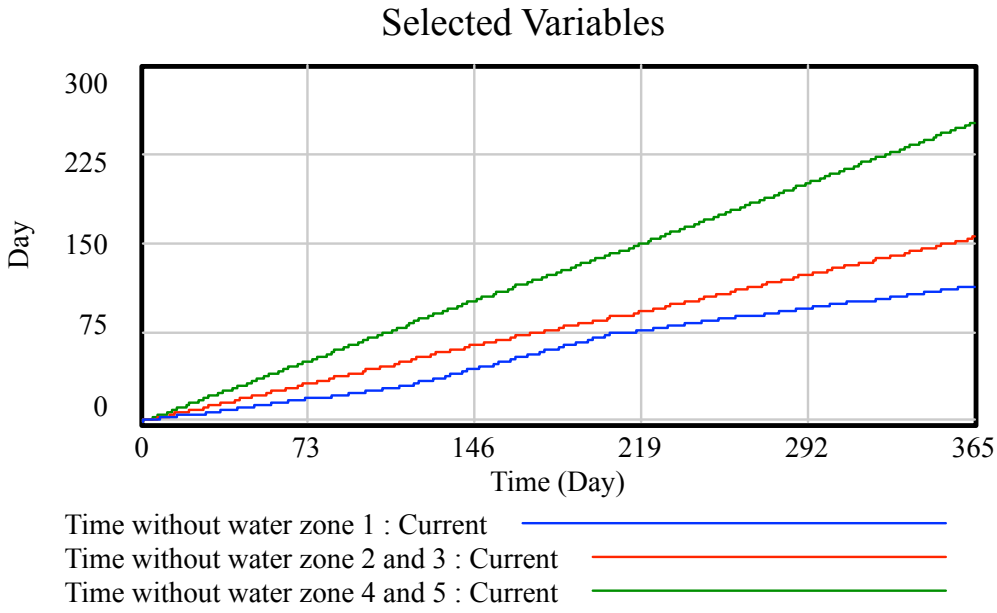


Figure 7.14: SD output from M2, illustrating the time without potable water, differentiated across supply zones 1, 2 and 3, and 4 and 5.

The GKWS modelling initiative highlighted the fact that the SRVM was locked-in to operating a water supply scheme that is an historical artefact from the apartheid era. As discussed in detail in section 4.4 of the historical analysis, municipal water supply infrastructure was designed to almost exclusively service white settlements at the active exclusion of all other population groups during apartheid. The location of the storage reservoirs above the town of Kirkwood, which allows for water to gravity feed to zone 1 but requires pumping to other zones, was an intentional design decision of apartheid engineering. The particular design of the water pumping systems in the Greater Kirkwood WSS compound the problematic (spatial) legacy of apartheid planning, by placing conditions on the operating of pumps in relation to reservoir levels. The *GKWS* model therefore illustrated that ensuring the current system does not perpetuate apartheid-style inequalities can only occur with re-engineering the system or investing in systemically changing the operational management of the entire scheme. The modelling initiative demonstrated that individual operators at the Kirkwood WTW could not be blamed for 'mismanaging' the WSS, when in fact the system was flawed by design. Furthermore, the modelling process revealed that there was little shared understanding between participating and affected actors as to the nature of these infrastructural challenges, and even less acknowledgement between actors of how the post-apartheid drive to expand water supply to a greater proportion of the population had resulted in the over-extension of the infrastructural system.

From a process perspective, the focus of the *GKWS* model was to use SD modelling to understand the supply constraints in the Greater Kirkwood area, and as a means of facilitating strategic conversations between the municipality, the L-WUA and other affected and interested stakeholders. M2 therefore emphasised the operations of the supply system. However, using M2 as an analytical and engagement tool within the broader AR process suffered from three shortcomings:

1. The primary limitation of M2 – as a tool – was the exclusion of household demand drivers from the model, due to a lack of data and unclear dynamics. The determinants of the rising demand for potable water (which were introduced in point (ii) of sub-section 6.5.4) were therefore excluded;
2. In contrast to M1, which suffered from being too broad and without a clear, structured focus, the final version of M2 had a high level of operational detail addressing a specific supply scheme. For example, the capacity of individual pumps and the diameter of certain pipes were modelled, meaning that it was easy for stakeholders

(and the modelling facilitator) to focus on (and often get lost in) the detail rather than engaging with the overall dilemmas; and

3. The above two limitations were further compounded by the personal limitations of the facilitator's own modelling knowledge.

As this sub-section has shown, the development of the *GKWS* model demonstrated the value of modelling within a transdisciplinary AR project – as a means of understanding and responding to complex real-world problems, synthesizing knowledge, and providing potential decision-support (Badham, 2010). Much of the value of M2 can be described as providing a "systematic way of developing a more comprehensive understanding of key aspects of the problem" (Lyall, Bruce, Tait, & Meagher, 2011: 42). The experienced value of SD within the LSRV case motivated for a third model to be developed. In order to address the limitations referenced above, the third model (M3) was created after the modelling facilitator undertook formal training in SD modelling, and focused on exploring the determinants of the rising demand for potable water in the Greater Kirkwood region (as described below).

7.5.5 Model 3: The 'Kirkwood Water Demand' model

(i) Introduction:

The third SD model developed in this study was called the 'Kirkwood Water Demand' model (hereafter *K-DEM*). This third model (M3) focused on exploring the determinants of the rising demand for potable water in the SRVM, using the Greater Kirkwood region as a case study. M3 had an additional policy focus on what the municipality could do to reduce its reliance on the L-WUA's canal system for raw water, including by using possible alternative water sources in the area. The system diagram in Figure 7.15 summarises the four sub-models of the *K-DEM* model in the same format used in the preceding two sub-sections to introduce M1 and M2. The determinants of household demand are central to the *K-DEM* model, with the household demand sub-model influenced by the population dynamics in the SRVM (in the second sub-model). The remaining two sub-models of *K-DEM* focus firstly on the provision of potable water via a surface-water supply source (as described in detail in the *GKWS* model), and secondly, the use of rainwater harvesting as an alternative supply source at the household-level. In addition to the system diagram in Figure 7.15, the external factors for the *K-DEM* model are described further in the 'model boundary chart' in Table F.1 and sub-section F.2 and F3 of Appendix F. The following sub-section differs to the descriptions of M1 and M2 by introducing the problem formulation of the *K-DEM* model using a causal loop diagram.

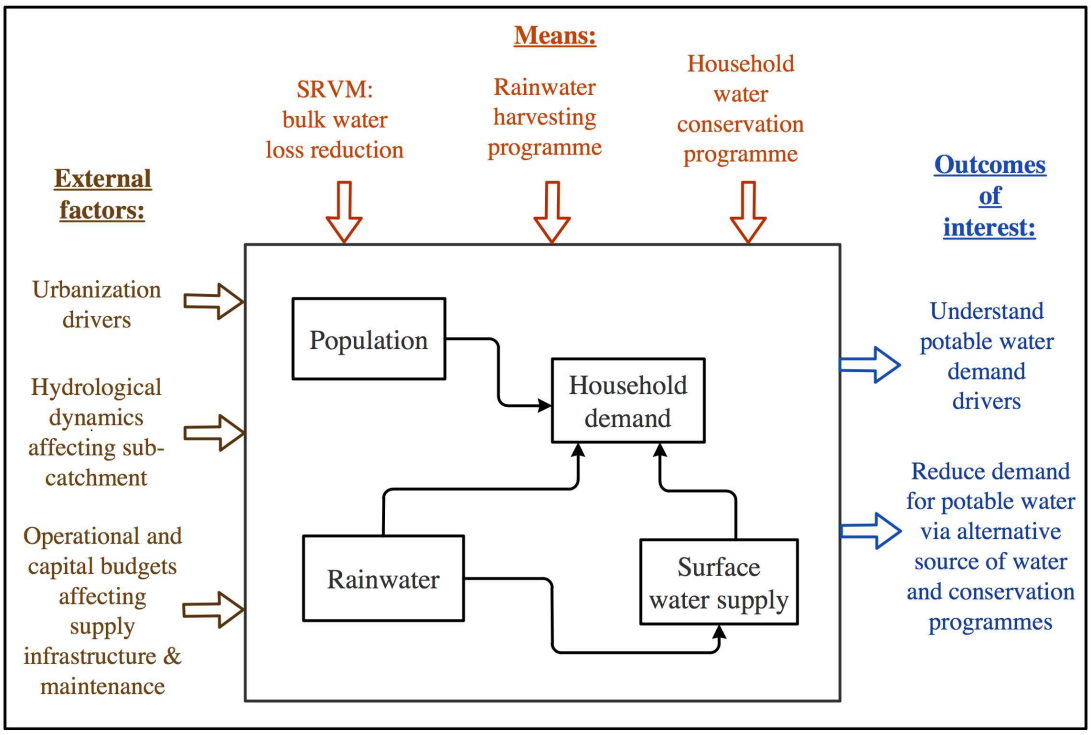


Figure 7.15: System diagram of the 'Kirkwood water demand' model (M3).

(ii) Problem formulation:

The causal loop diagram (CLD) discussed in this sub-section describes the relationship between the primary variables of interest in the *K-DEM* model (see Figure 7.16). The driver of the system is the 'gap between current and desired levels of potable water services' in Kirkwood. This gap exists between three variables: as the 'current potable water demand' and the 'desired level of potable water services' increases, so does the 'gap between the current and desired levels of potable water services'. The gap decreases with 'potable water distributed to residents', given that the larger the quantity of potable water distributed to residents, the less the gap. The greater the 'gap between the current and desired levels of potable water services', the greater the 'pressure on [the] municipality to meet demand'. This pressure can manifest in two ways: firstly, in the demand for increased levels of potable water services delivered via household water connections (including water-borne sanitation), and secondly, in the 'refurbishment and construction of new infrastructure'. With the first response, the municipality increases the 'connection rate of households', which increases the total 'no. [number] of connected households', which in turn increases the current potable water demand, and increases the gap. This response creates the first reinforcing feedback loop in the CLD (**R1: connection rate increasing water demand**). Increasing the 'connection rate of households' tends to have an associated effect of increasing the bulkwater losses in the

municipal reticultation network: as more houses are connected to the network, and as the size of the network increases, the quantity of bulkwater lost also increases. The more the 'bulkwater losses', the less the 'infrastructure capacity', and the less 'potable water distributed to residents', which increases the 'gap': this pattern creates the second reinforcing feedback loop (**R2: connection rate increasing losses**).

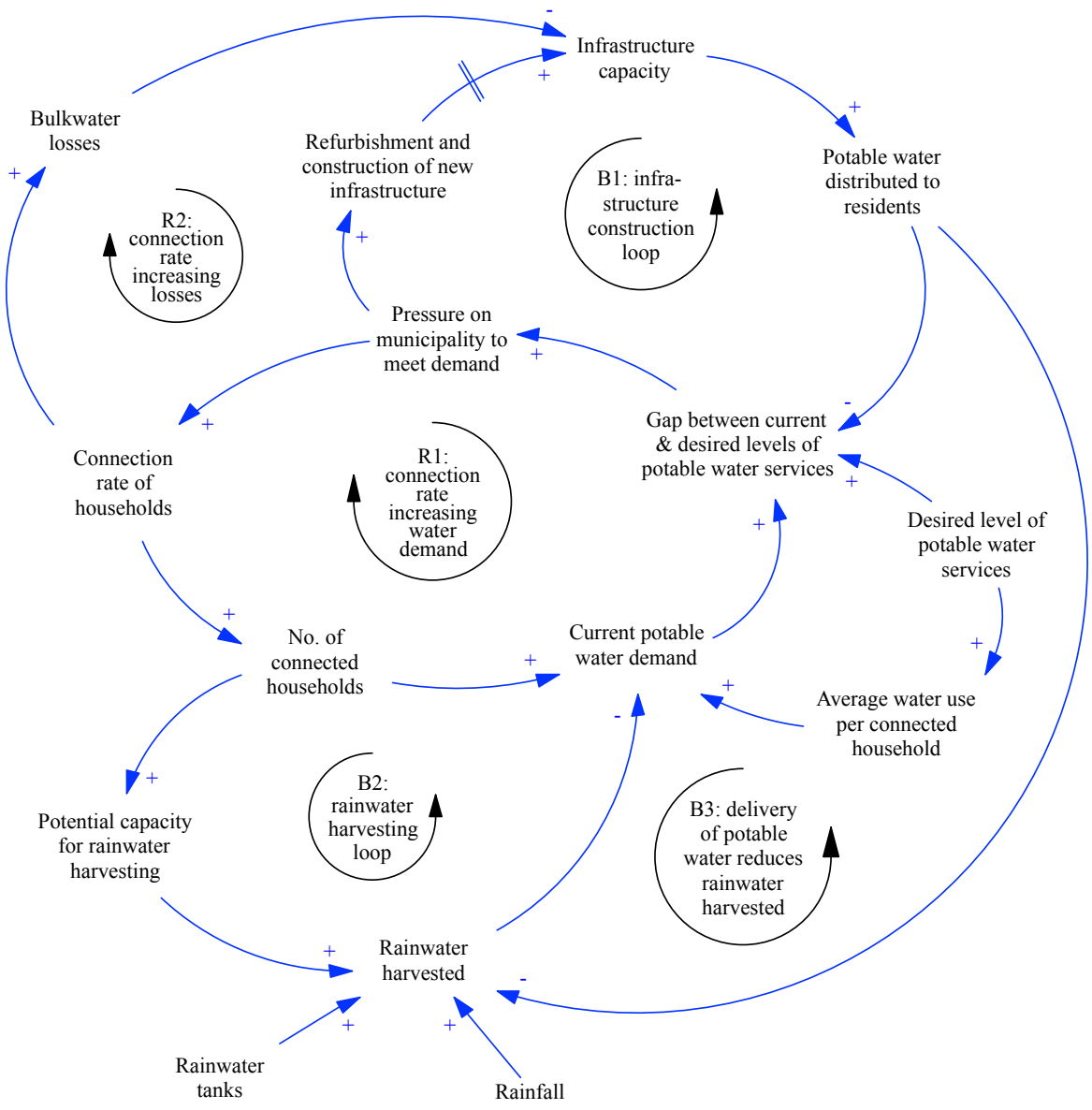


Figure 7.16: Aggregate causal loop diagram for model 3 (the 'Kirkwood water demand' model). Five feedback loops are identified in the CLD, in the form of two reinforcing loops (R1 and R2) and three balancing loops (B1, B2, and B3). The double lines on the arrow between the variables 'Refurbishment and construction of new infrastructure' and 'Infrastructure capacity' denotes a delay. See the caption for Figure 6.4 for further explanations of diagrammatic convention.

In the second response to the 'gap', the municipality refurbishes current infrastructure (through retrofitting and equivalent programmes that increases the current supply

infrastructure) and/or constructs new infrastructure. By doing so, the municipality increases its overall 'infrastructure capacity' over time, allowing a greater quantity of potable water to be distributed to residents, which therefore reduces the 'gap'. This response creates the first balancing feedback loop in the CLD (**B1: infrastructure construction loop**). This feedback loop was excluded from the *K-DEM* simulation model but is central to the fourth SD model (described in sub-section 7.5.6).

The last two feedback loops in the CLD in Figure 7.16 pertain to the use of rainwater harvesting as an alternative water source to augment the potable water services provided by the SRVM. The greater the number of connected households, the greater the 'potential capacity for rainwater harvesting' (given that households connected to the municipal reticulation network have a greater chance of being formal structures with roofs and gutters suitable for rainwater harvesting, versus households in informal settlements that are not connected to the municipal network, and less likely to have suitable household-level infrastructure for rainwater harvesting. However, the quantity of 'rainwater harvested' is dependent on the number of 'rainwater tanks' and 'rainfall': the more the rainwater tanks and the more the rainfall, the more rainwater can be harvested. The more 'rainwater harvested', the less the 'current potable water demand'. This pattern creates the second balancing feedback loop (**B2: rainwater harvesting loop**), whilst the third balancing feedback loop addresses the preference of residents for potable water over rainwater: the more 'potable water distributed to residents', the less the 'rainwater harvested', and the less 'rainwater harvested', the more the 'current potable water demand' (**B3: delivery of potable water reduces rainwater harvested**). The empirical relationships between the variables introduced in this CLD are further described in section F.3 of Appendix F, where the equations and sub-models are explained in detail. The following section summarises the structure of *K-DEM*.

(iii) Model structure:

The *K-DEM* model consists of four sub-models (as shown in the system diagram in Figure 7.15 and illustrated in the stock-flow diagram in Figure F.1). These sub-models are:

1. Population;
2. Household water demand;
3. Surface water supply system; and
4. Rainwater harvesting.

The central variable in the *K-DEM* model is 'total household demand', which is influenced by the population sub-model and is calculated as the sum of the demand for water from the variables 'informal households', 'households with basic supply', and 'connected households'. The latter two variables are modelled as stocks in an 'aging chain' model structure (Sterman, 2000), in which households progress from a stock of 'households with basic supply' to the stock of 'connected households'. The rate at which households progress from the first to the second stock is determined by the 'connection rate': the connection rate varies according to the average water use per connected household, and is therefore influenced by potential household water conservation policy.

The surface water supply system for potable water is modelled in *K-DEM* using a simple stock-flow structure (given that this system was modelled in detail in the *GKWS* model described in sub-section 7.5.4). The sub-model features a stock for raw water and a stock for potable water, where the inflows and outflows are constrained by the storage and treatment capacities of the Kirkwood water supply scheme. The stock of potable water is additionally reduced by bulk water losses according to an exogenous variable that is set as a parameter in the *K-DEM* model.

The fourth and final sub-model in M3 is the rainwater harvesting sub-model, which is composed of only one stock (called 'rainwater volume in storage tanks'). The stock increases according to the rate at which rainwater is stored in Kirkwood: this rate is influenced by the available rainfall and the 'total household storage capacity for rainwater harvesting' (where the latter increases according to the number of households, the percentage of households with rainwater tanks, and the average number of tanks per household). The stock of 'rainwater volume in storage tanks' decreases according to the rate at which rainwater is consumed in Kirkwood: this rate is influenced by the total available supply of water (including potable water). The empirical relationships between the variables in the sub-models introduced here are further described in section F.3 of Appendix F. The following sub-section discusses particular outputs from the *K-DEM* model in relation to the model insights.

(iv) Model results:

The *K-DEM* model simulates a 20-year period, equating to a time horizon of 2005-2025. The period between 2005 and 2013 was used primarily for model calibration purposes, whilst the period between 2013 and 2025 was used for projection and simulation purposes. A 'time step' of 0.0625 years (a little less than a month) was selected. The model was simulated using the

'time unit' of years. The results of *K-DEM* are predominantly summarised in this section by using the outputs from the model, with supplementary explanations supplied where necessary. The emphasis is on simulating the problem situation known to, and experienced by, the SRVM. This is referred to as the 'Base' scenario in *K-DEM* and provides the reference mode against which policies and scenarios can be assessed.

In Figure 7.17 below, the total number of households rises: connected households rise as the number of 'households with basic supply' and 'informal households' drops. The resulting rise in overall water demand is demonstrated in Figure 7.18.

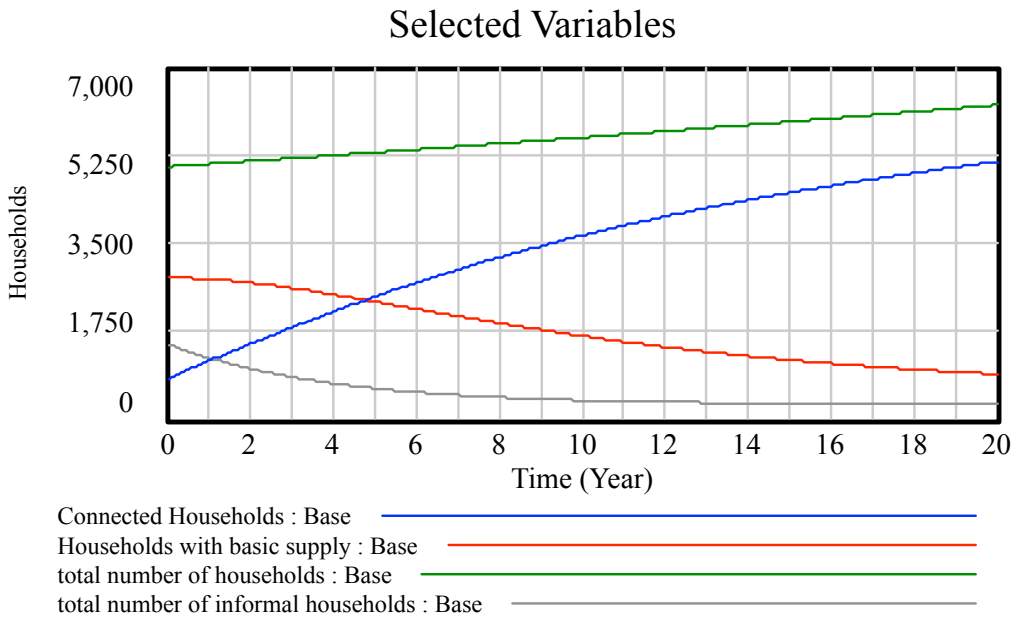


Figure 7.17: Baseline simulation showing the total number of households, broken down into the categories of connected households, households with basic supply and informal households.

Additionally in Figure 7.18 the household demand is disaggregated into the three contributors ('connected households', 'households with basic supply' and 'informal households'), illustrating how the rise in 'total water demand of connected households' (in red) mirrors the 'total household demand' (in blue) whilst the total household demand for basic and informal households declines and remain insignificant contributors to total demand.

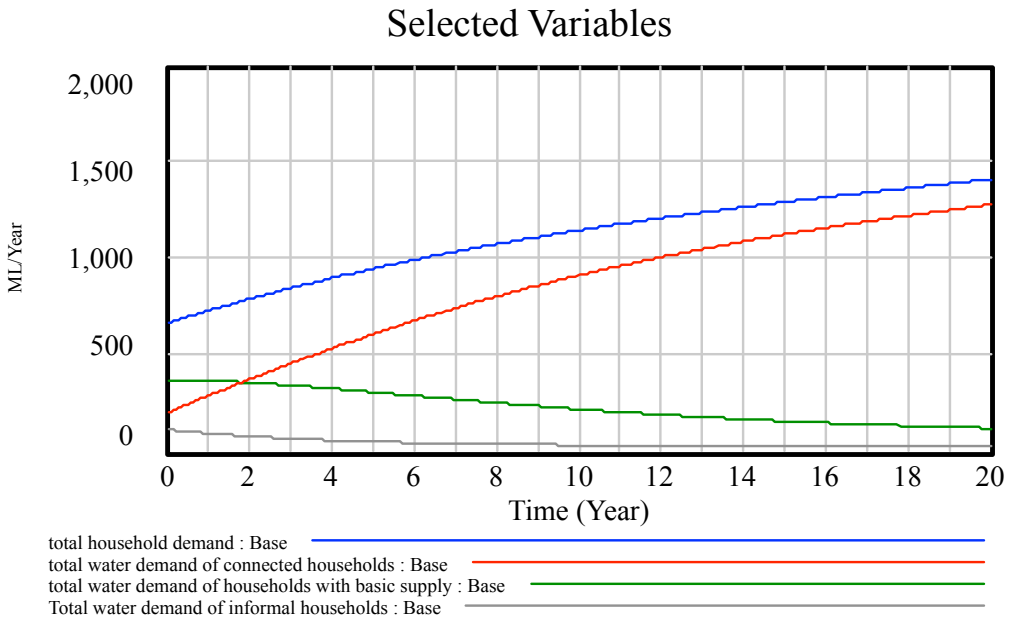


Figure 7.18: Baseline simulation for water demand

As water demand rises, the stock of potable water falls (visible in the left-hand graph in Figure 7.19). The potable water consumption rate is compared against the total household demand in the right-hand graph of Figure 7.19, which shows that total household demand exceeds the ability of the water supply system to provide water by year 9 of the baseline simulation. At this point, potable water consumption levels out – meaning that the water supply system is functioning at maximum and, as such, the supply system cannot meet the demand. The 'gap' between 'total household demand' (in red) and the 'potable water consumption rate' is the supply and demand gap that is one of the key phenomena of interest in *K-DEM*.

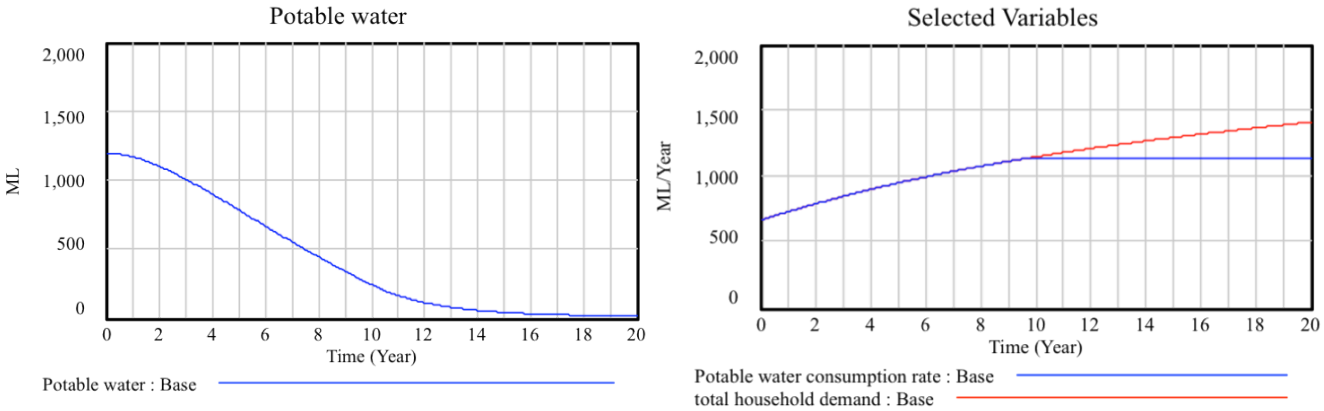


Figure 7.19: Baseline simulation outputs, with potable water shown in the left-hand graph and a comparison of the potable water consumption rate against total household demand shown in the right-hand graph.

Figure 7.19 fits with the municipal experience in Kirkwood, where residents observed that the number of water outages per year rose dramatically in the 2012-2013 period, as total household demand exceeded the maximum design capacity of the water supply system (with no concomitant restriction in supply – in the form of water restrictions – nor constriction in demand, in the form of conservation or water demand management programmes).

The next two figures pertain to rainwater harvesting. Figure 7.20 demonstrates the behaviour of the stock 'Rainwater volume in storage tanks'. The initial spike in the volume of the stock can be understood as settling behaviour: for this simulation, the initial volume in the stock appears to be set too low, so that the stock takes time to fill (in the first two years), after which the stock depletes at a rapid rate (Years 3 – 5), before stabilizing and growing at a steady rate from Year 6 onwards.

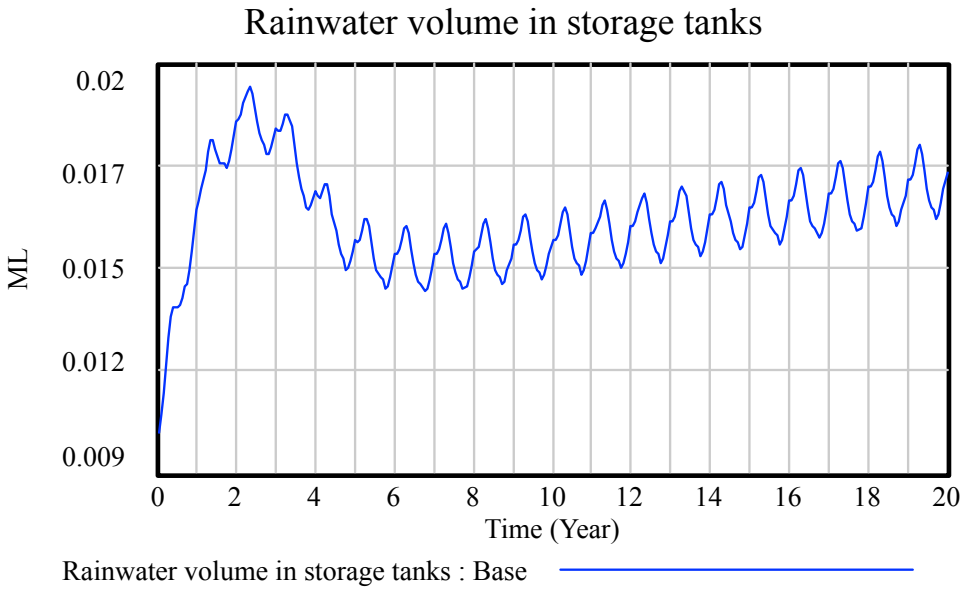


Figure 7.20: Baseline simulation: volume of rainwater in storage tanks

The behaviour in Figure 7.20 is further demonstrated in Figure 7.21, which graphs the 'Rainwater storage rate' against the 'Rainwater consumption rate'. In addition to seeing the 'Rainwater consumption rate' rise in the initial 4 years (in response to the rainwater stock), the 'Rainwater storage rate' also gradually increases (as the number of households grows, increasing the 'Total household catchment for rainwater').

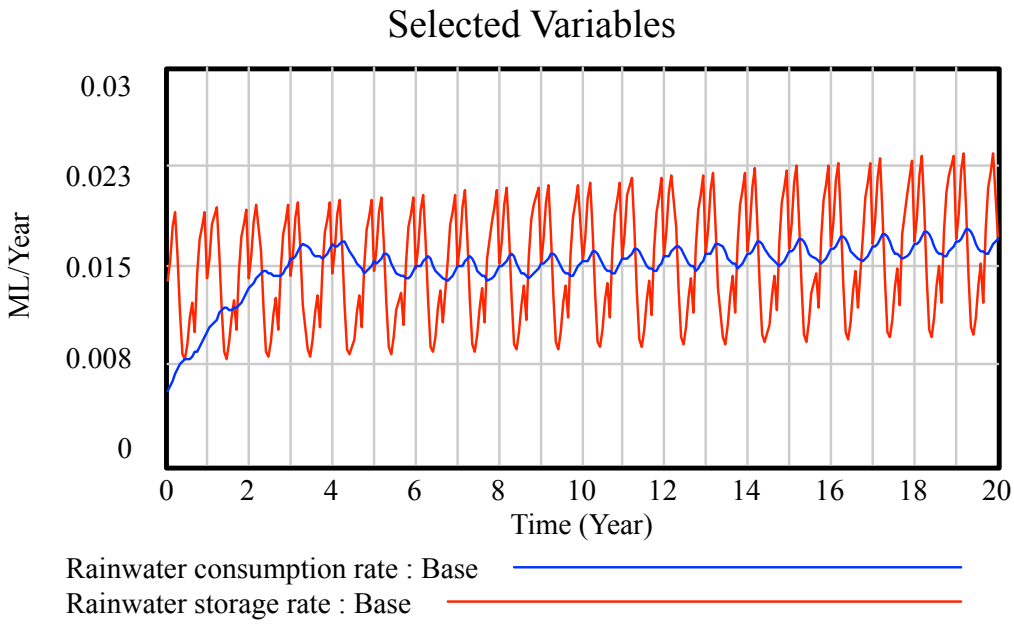


Figure 7.21: Baseline simulation comparing the rainwater storage rate against the rainwater consumption rate.

The final model output displayed here is the 'Water security index' (Figure 7.22). This index is computed as the 'Total water supply' over the 'total household demand' (as described in sub-section F.3.9 of Appendix F). The results displayed in Figure 7.22 indicate that the water security index never attains a value greater than 2, as per DWA's requirement, and indeed declines steadily over the simulation period. The simulation confirms that the growing demand for water is acting to exacerbate the problems of water service delivery of the SRVM.

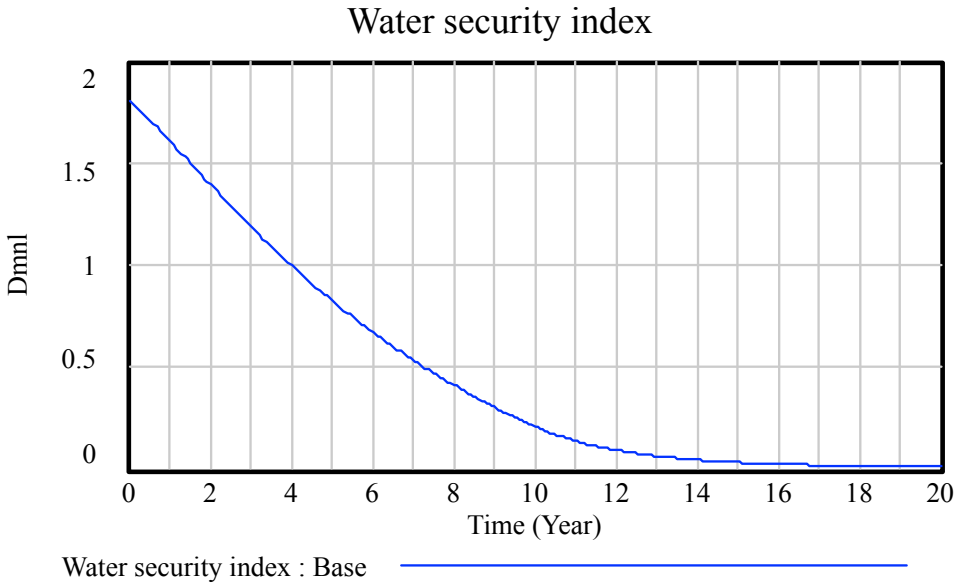


Figure 7.22: Baseline simulation showing the water security index.

(v) Discussion:

K-DEM modelled the dynamics of household demand for potable water growing as a result of an increasing number of households becoming connected to the municipal network. The model demonstrated that a combination of low rainfall with a minor percentage of households with rainwater tanks means that residents cannot rely on rainwater as an alternative water source. The *K-DEM* model was also used to explore a further policy option available to the SRVM, in the form of the municipality implementing a household water conservation programme (the results of which are briefly described in section F.4 of Appendix F). In the *K-DEM* policy scenario, a 10% reduction in the potable water demand of connected households allows the SRVM to meet water demand for two years longer than in the baseline simulation (see Figure F.5), but demand still outstrips supply after Year 12 of the simulation period. The number of houses continually being connected to the municipal reticulation system results in a growing water demand that acts to reduce the impact of any household water conservation programme, which further motivates for re-engineering the water supply scheme (as concluded with the *GKWS* model). Furthermore, connecting households to the municipal reticulation network remains one of the political imperatives of service delivery in post-apartheid South Africa: in areas like Greater Kirkwood, where water outages are a frequent occurrence, water conservation programmes are less likely to receive support either from the required political constituencies or from residents.

The February 2014 planning workshop on the expansion of the Greater Kirkwood WSS provided an opportunity to explore the *K-DEM* model insights with five stakeholder groups: the SRVM technical directorate; the L-WUA technical officials; members of the Sundays River Business Chamber; officials from Amatola Water and from DWA (the context of this planning workshop was introduced in sub-section 6.4.7). Around half of the workshop in February 2014 was spent discussing the drivers of demand for potable water in the Greater Kirkwood region, and what water conservation and water demand management (WC/WDM) measures the municipality had put in place to address this growth in demand. The consulting engineer facilitating the workshop asked many of the same questions that were raised in the process of building the *K-DEM* model, including:

- What data has the SRVM collected in terms of household connection rate and household water demand?
- Does the SRVM know where water losses are occurring within the bulk water supply system and approximately what the losses are?

- Can an expansion of the Kirkwood WSS be justified to DWA (as the funding agency) on the basis of these estimated water losses?

This planning workshop, along with the associated reports and funding proposals, provided the opportunity to validate the dynamics explored in the *K-DEM* model. However, the process of interacting with the five stakeholder groups further highlighted what both the *K-DEM* model and the *GKWS* model did not capture: namely, 'why it has been so difficult for the SRVM to either provide adequate quantities of potable water, or to effectively manage water demand in the Greater Kirkwood region?' How the fourth and final SD model of this study explored that question is described and discussed in the following sub-section.

7.5.6 Model 4: The 'Modes of Failure of South African Local Government' Model

(i) Introduction:

The fourth and final SD model in this study drew on the previous modelling performed in M1, M2, and M3, and developed out of the numerous insights pertaining to vicious cycles (from the discussion of a vicious cycle in developmental local government (DLG) in sub-section 5.5.1, to the fire-fighting cycle in in Figure 6.4, to the over-extension of infrastructure explored in the *GKWS* model). The fourth model sought to answer the question raised in the discussion of the *K-DEM* model above (i.e. why has it been so difficult for the SRVM to either provide adequate quantities of potable water, or to effectively manage water demand in the Greater Kirkwood region?) through exploring interconnected modes of failures in local government. The 'modes of failure' model (hereafter *MoF*) explored the following inter-related dynamics:

- The simultaneous underinvestment in, and over-extension of, water supply infrastructure;
- The effects of municipal staff shortages, emergencies, and over-commitment on standard technical activities; and
- The effects of crises and the implications for operations, maintenance and management of municipal water services.

The system diagram in Figure 7.23 below shows the seven inter-related sub-models of the *MoF* model, alongside the external factors, means and outcomes of interest of the model.

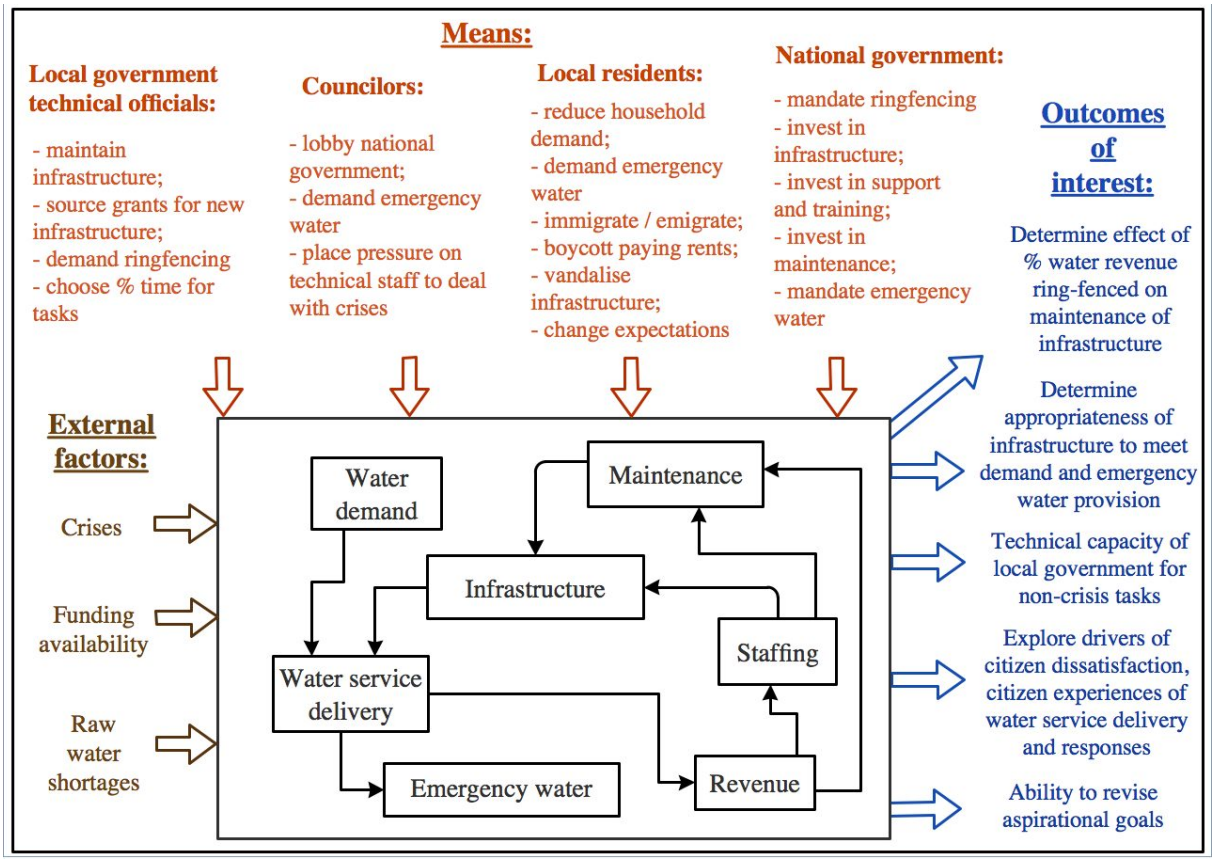


Figure 7.23: System diagram of the synthesis 'modes of failure' system dynamics model (M4).

As with the *K-DEM* model, the external factors are described further in the 'model boundary chart' (see Table G.1). The following sub-section introduces the problem formulation of the *MoF* model using a CLD to describe the relationship between the primary variables of interest.

(ii) Problem formulation:

The driver of the system presented in the CLD in Figure 7.24 below is the 'Gap between demand & supply' in the Greater Kirkwood area (in red). This gap increases with the 'Total water demand', and decreases when the 'Water delivered' to users in the region sates the current demands. The gap increases the likelihood that the municipality will need to provide emergency water services and therefore the 'Demand for emergency water'. This demand is also influenced by crises, such as water shortages or infrastructural failure, which result in a temporary cessation of water service delivery. Crises are reduced by the municipality undertaking maintenance, with maintenance influenced by two variables: 'Technical staff capacity available for standard management activities' and 'Revenue dedicated to maintenance'. In the following description, the interactions between these variables is further described in terms of the five primary feedback loops identified in the CLD in Figure 7.24.

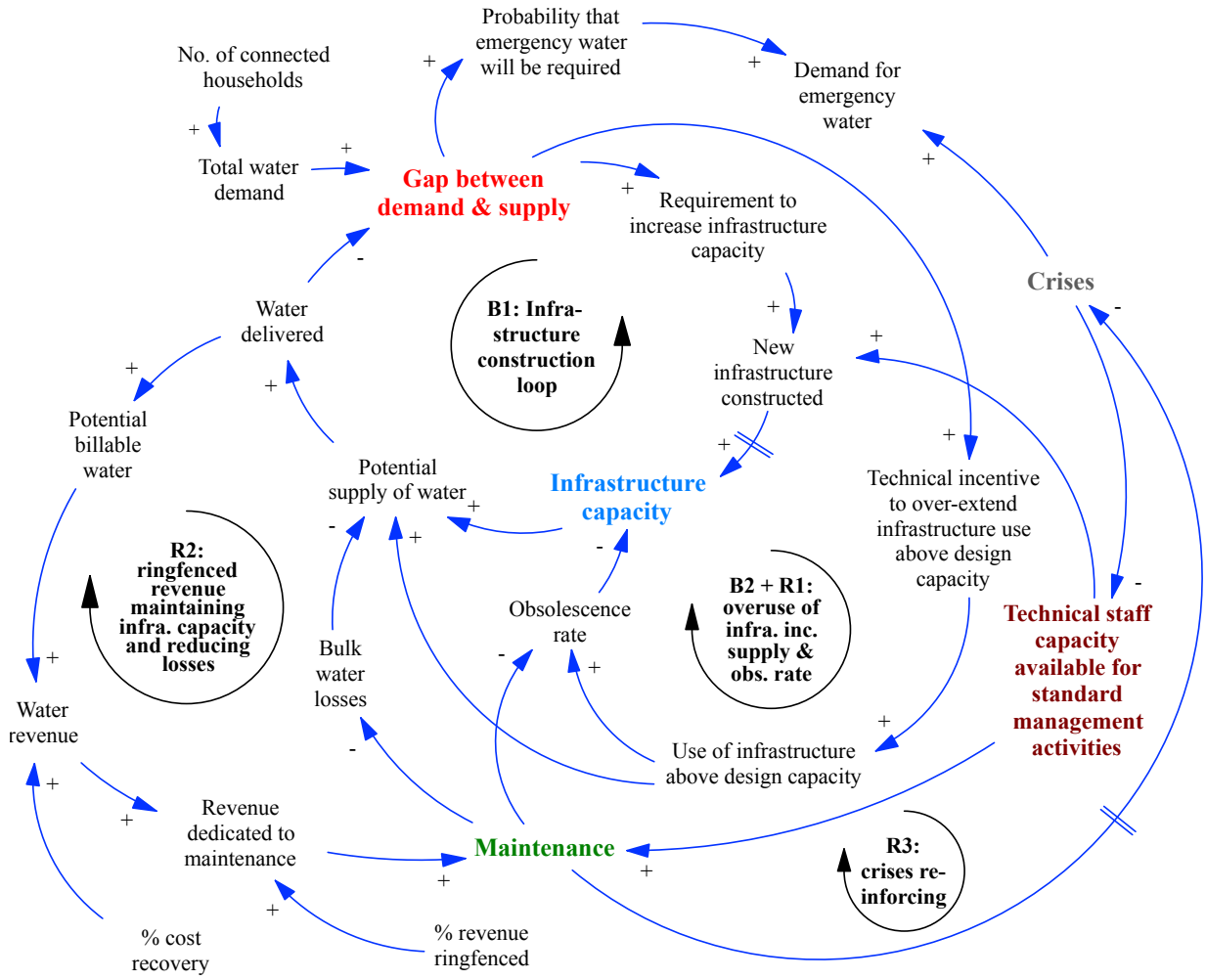


Figure 7.24: Aggregate causal loop diagram (CLD) for Model 4 ('modes of failure' model). Five feedback loops are identified in the CLD, two balancing loops (B1 and B2) and three reinforcing loops (R1, R2, and R3). See the caption for Figure 6.4 for further explanations of diagrammatic convention.

When there is a gap between demand and supply, the standard response is to adjust the infrastructure capacity, through refurbishment of current infrastructure and the construction of new infrastructure. This 'Requirement to increase infrastructure capacity' positively influences the 'New infrastructure constructed', which after a delay, will result in the total 'Infrastructure capacity' increasing, and with it, the supply of water, and the water delivered. This is the first balancing loop (**B1: Infrastructure construction loop**). The second way in which the municipality meets the gap between supply and demand is through over-extending the current infrastructure above its design capacity: the 'Use of infrastructure above design capacity' allows the municipality to increase the quantity of potable water produced, and therefore increase the supply of water, which in turn decreases the gap between supply and demand (**B2: overuse of infrastructure increasing supply**). However, the over-extension of infrastructure carries the concomitant effect of increasing how fast municipal infrastructure

decreases in value and use (the 'Obsolescence rate'): the longer water supply infrastructure operates above its design capacity, the quicker the infrastructure obsolesces, and the quicker it requires refurbishment and replacement. This is the first reinforcing feedback loop (**R1: overuse of infrastructure increasing obsolescence rate**).

The obsolescence rate is also influenced by municipal officials undertaking day-to-day maintenance as part of the operational regime of water service delivery: how much maintenance work can be accomplished is influenced both by the attention that the municipal staff can give and the revenue dedicated to maintenance, which is subject to the amount of revenue derived from providing water services. The more water delivered to users, the more the 'Potential billable water'. Actual 'Water revenue' is determined by the proportion of billable water for which the municipality receives payment ('% cost recovery'). Similarly, the 'Revenue dedicated to maintenance' is subject to the proportion of the 'Water revenue' that is reserved ('% revenue ringfenced'). By increasing the proportion of water revenue that is ringfenced, the municipality can perform more maintenance, and therefore reduce bulk water losses and the obsolescence rate, which enables more potable water to be delivered and in turn, increases the 'Potential billable water' (**R2: ringfenced revenue maintaining infrastructure capacity and reducing losses**).

The final feedback loop involves the 'Technical staff capacity available for standard management activities'. In order to address 'Crises', municipal staff divert their attention away from standard activities towards immediately addressing these crises. Doing so reduces the capacity of the municipal staff to address standard technical activities, which reduces the amount of maintenance that can be performed. Over time, the accumulated lack of maintenance creates the conditions for new infrastructural crises to occur, which serves to further reduce the municipal staff capacity for standard activities. A reduction in these activities influences both the maintenance activities and the quantity of 'New infrastructure constructed' (by affecting strategic planning, grant sourcing, and other such activities that municipal officials perform in the process of constructing new infrastructure). This feedback loop (**R3: crises reinforcing**) is the primary endogenous driver of municipal crises explored in this model. The empirical relationships between the variables described in this problem formulation are described in greater detail in the model description provided in section G.3 of Appendix G, whilst a summary of the model structure is provided below.

(iii) Model structure:

The *MoF* model consists of seven sub-models (as shown in the system diagram in Figure 7.23). The focus of these sub-models are:

1. Water demand of urban domestic and urban commercial users in Greater Kirkwood region;
2. Water service delivery;
3. Infrastructure capacity;
4. Infrastructure maintenance;
5. Revenue;
6. Staffing capacity within the SRVM; and
7. Emergency water.

The water demand sub-model uses the structure of the *K-DEM* model (as described in sub-section 7.5.5), but includes two additional dynamics: the first is the urbanisation rate into Kirkwood, and the second is the additional demand from other urban users (including urban commercial users). The *MoF* model represents the municipality's attempts to meet the water demand via the second sub-model for 'water service delivery'. This sub-model apportions the 'current supply of water' between the different user groups (unconnected households, connected households, and 'other urban users'). The difference between the demands of the different user groups, and the water delivered to the users according to the available supply, is calculated through a series of discrepancy variables. The variable 'current total discrepancy' is the sum of the following:

- The discrepancy in water delivered to unconnected households;
- The discrepancy in water delivered to connected households; and
- The discrepancy in water delivered to other urban users.

The variable current total discrepancy drives the demand for additional infrastructure capacity, which influences the infrastructure sub-model that is at the heart of the *MoF* model. The infrastructure sub-model consists of three stocks linked in an aging-chain model structure. The first stock represents the required additional infrastructural capacity, the second stock calculates the infrastructure under construction and refurbishment, whilst the third stock accounts for the total infrastructure capacity. The infrastructure capacity sub-model includes the following:

- The effects of staff capacity constraints on initiating and completing the refurbishment and construction of new infrastructure;

- A decision-rule that when there is a discrepancy between the demand for water and the supply of water (and the municipality therefore requires additional capacity), then municipal supply infrastructure is over-extended above its design capacity in order to meet the additional capacity reqruiements;
- The effects of the above-mentioned decision-rule on the rate at which infrastructure obsolesces; and
- The effects of maintenance on obsolescence.

The maintenance sub-model both influences, and is influenced by, the infrastructure sub-model (see Figure G.3). The quantity of required maintenance is calculated against the infrastructure capacity stock (using an aggregated estimate of the quantity of infrastructure capacity requiring annual maintenance in order to maintain optimum performance). The crux of the maintenance model is the variable 'potential maintenance', which is the point at which the financial constraints on maintenance and the technical staff capacity constraints on maintenance interrelate. The financial constraints on maintenance are determined in the revenue sub-model of the *MoF* model, whilst the staff capacity constraints on maintenance are calculated in the staffing sub-model (which additionally influences the infrastructure construction and completion rates). The final sub-model in the *MoF* model calculates the emergency water requirements for the Greater Kirkwood area (see Figure G.10), and presents the emergency water requirements in absolute (ML/year) and relative terms (number of tankerloads of emergency water required per year). As stated in the introduction to this sub-section, the equations and sub-models of the *MoF* model are described in detail in section G.3 of Appendix G, with this sub-section intended to provide an overview of the model structure. The following sub-section displays and discusses the model results.

(iv) Model results:

The *MoF* model simulates a 20-year period between 2001 and 2021. This period was selected to account for when the SRVM began operating, through to the development of the service delivery problems in the Kirkwood area between 2009 and the 2014. The period between 2001 and 2014 was used primarily for model calibration purposes, whilst the period between 2014 and 2021 was used for projection, scenario and policy analysis purposes. The model was simulated using the 'time unit' of years.

The results of the *MoF* model are summarised in this section drawing on model outputs with supplementary explanations provided where necessary. The emphasis is on simulating the problem situation known to, and experienced by, stakeholders in the SRVM. This is referred

to as the 'Base' run of the *MoF* model, and provides the reference mode against which policies and scenarios are assessed. The results of two scenarios are described in this section: scenario 1 simulates the effects of municipal infrastructure *not* being extended over design capacity, whilst scenario 2 simulates a financial crisis in which the annual municipal financial bailout is temporarily suspended. The results of these two scenarios are compared against the baseline simulation, and against one another.

(iv-i) Baseline simulation results:

The gap between demand and supply is represented in the *MoF* model as the 'current total discrepancy'. As Figure 7.25 shows, municipal infrastructure can adequately meet demand until 2006, after which the 'current total discrepancy' begins to grow. This discrepancy grows to around 150 ML/year, where it stabilises until mid-2010 when the discrepancy then increases exponentially as the gap between the demand and the supply of water grows. This behaviour results from the increase in the 'potential supply of water' over this period, as is visible in Figure 7.26.

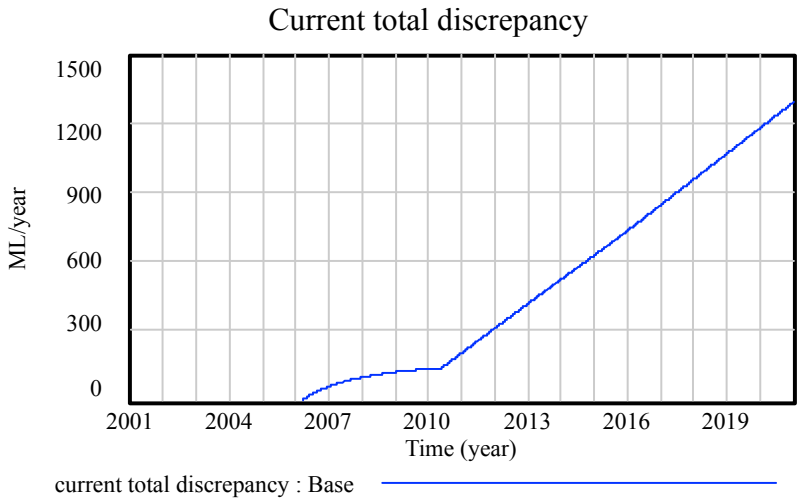


Figure 7.25: Base – Current total discrepancy

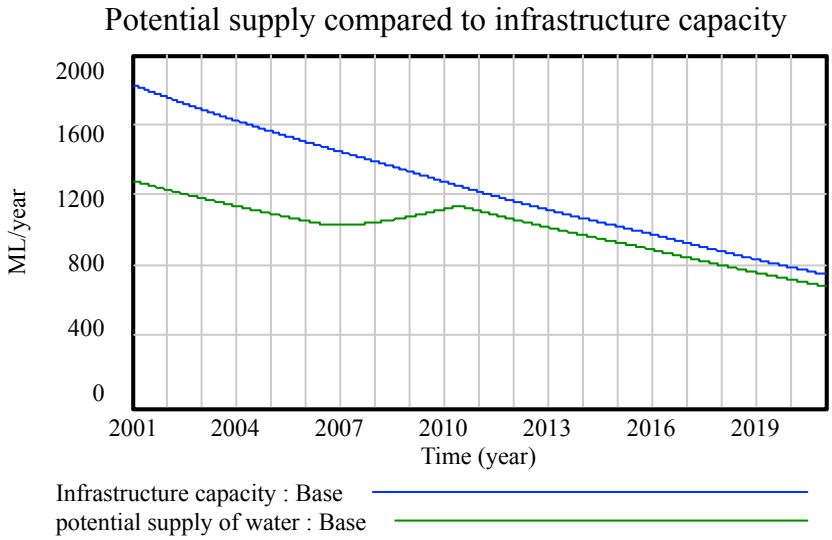


Figure 7.26: Base – Potential supply of water (in green) compared to infrastructure capacity (in blue)

The supply of water increases between 2007 and mid-2010 as a result of municipal infrastructure being operated above its design capacity: in real terms, infrastructure capacity declines in this same period (the blue line in Figure 7.26). The effect of over-extending infrastructure beyond its design capacity is visible in the obsolescence rate of municipal water supply infrastructure: particularly between 2007 and 2010 when water infrastructure obsolesces at an increasing rate of 55 ML/year to 60 ML/year (as Figure 7.27 shows). The decreasing trend in the obsolescence rate from 2001 to 2007 is determined primarily by the decrease in infrastructural capacity over this period. Little refurbishment or construction of infrastructure occurred during this period, but infrastructure continued to obsolesce. The potential maintenance that the municipality can perform fluctuates between 60 and 80 ML/year between 2001 and 2011, after which it decreases sharply (see Figure 7.28).

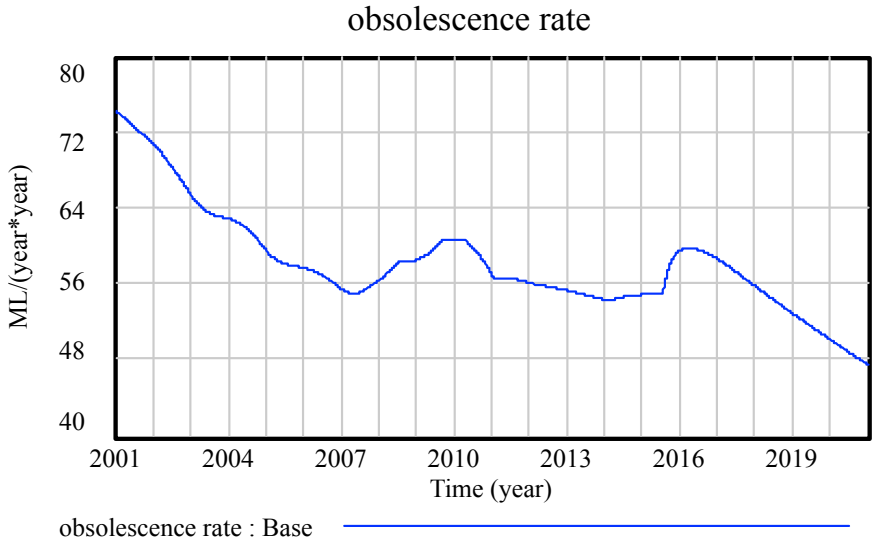


Figure 7.27: Base – obsolescence rate

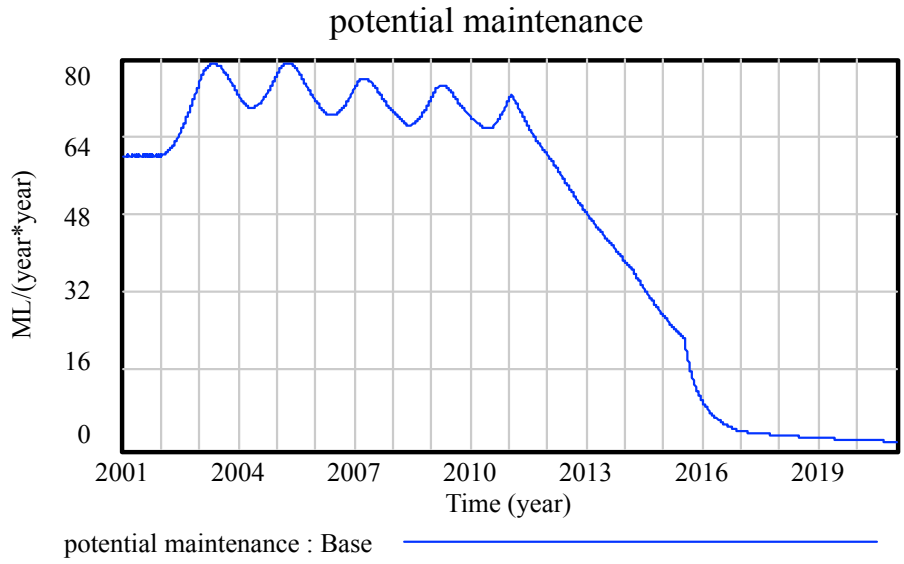


Figure 7.28: Base – potential maintenance

The financial constraints on maintenance are the primary constraints on potential maintenance in this early period (2001 – 2011): as the comparative graph in Figure 7.29 illustrates, the technical staff capacity constraints on maintenance affect the system from 2011 onwards.

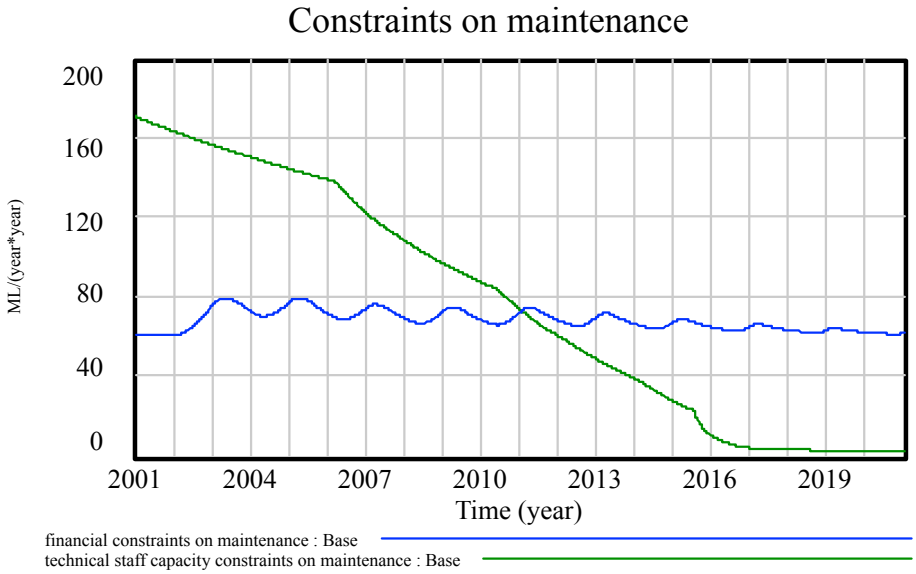


Figure 7.29: Base – comparison of the 'financial constraints on maintenance' (in blue) with the 'technical staff capacity constraints on maintenance' (in green).

(iv-ii) Scenario 1:

The first scenario, referred to as the 'no infrastructure overuse' scenario, simulates the effects of municipal water supply infrastructure operated within the constraints of its design capacity. This scenario was simulated by changing one parameter, namely adjusting the maximum over-design capacity factor (*MOCF*) downward from 1.3 to 1 (see equation 16 in Appendix G for technical details). The *MOCF* was set at 1.3 in the baseline simulation, accounting for a

maximum actual production of 130% of the infrastructural design capacity, whilst in scenario 1, the *MOCF* variable constrained actual production to 100% of infrastructural design capacity. The results are visible in the decreasing potential supply of water in (Figure 7.30), where between 2007 and mid-2010, the potential supply of water increases in the baseline simulation (as infrastructure is over-extended), and decreases in the 'no infrastructure overuse' scenario.

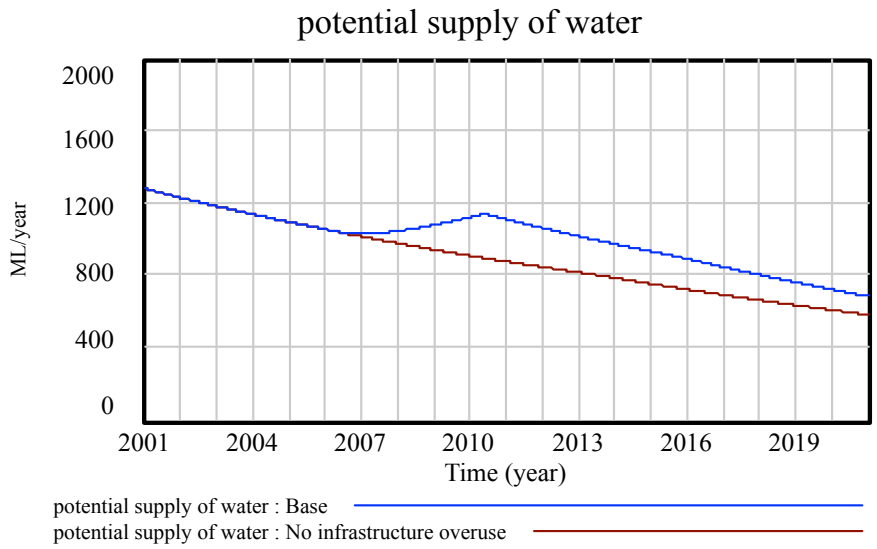


Figure 7.30: Scenario 1 (no infrastructure overuse) – potential supply of water

One of the possible motivating factors for the municipality overextending infrastructure is illustrated in Figure 7.31, which compares the 'potential billable water' across the two scenarios. In the baseline simulation, a sharp increase in the potential billable water is evident between 2007 and mid-2010, which results from the increase in the water delivered to billable users (connected households and other urban users). The greater the potential billable water, the greater the potential water revenue (depending on the efficacy of cost recovery measures): hence, Figure 7.31 illustrates one of the incentives to over-extend infrastructure use to continue being able to meet demand, and to continue producing a greater quantity of billable water.

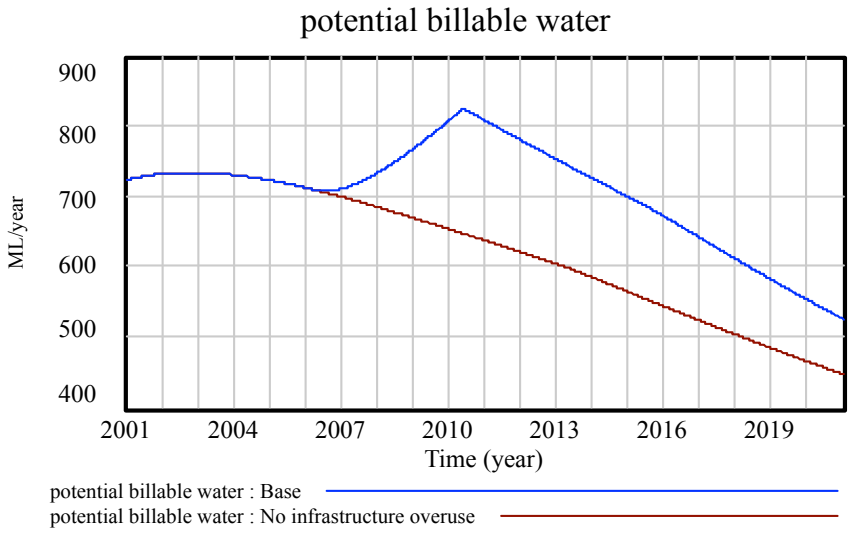


Figure 7.31: Scenario 1 (no infrastructure overuse) – potential billable water

By only producing water within the design constraints of infrastructure, the municipality can supply less potable water to meet the rising demands from 2007 onwards. In scenario 1, this results in the municipality initiating refurbishment and construction more rapidly, because of the incentive to create additional capacity in order to meet demands (see Figure 7.32). However, by 2013, the service delivery crises resulting from the supply-demand discrepancy increasingly have an increasingly negative effect on the technical activities required of municipal officials (see Figure 7.33), dramatically increasing the total required technical activities (see Figure 7.34).

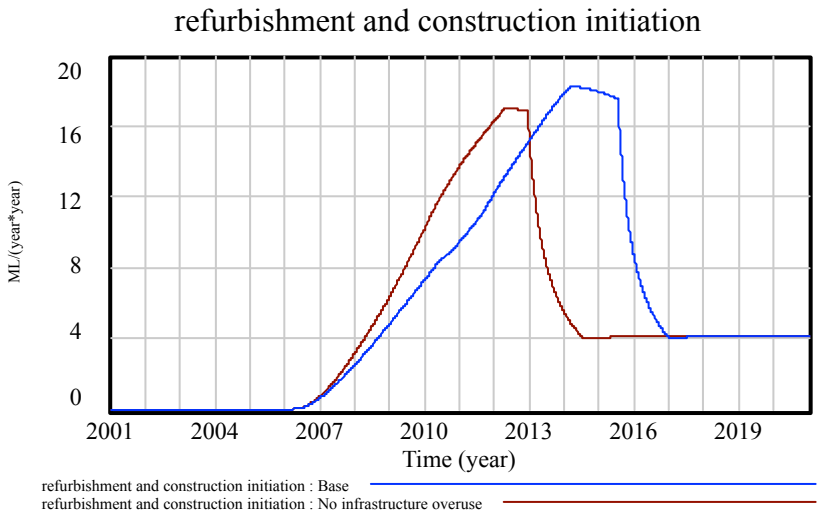


Figure 7.32: Scenario 1 (no infrastructure overuse) – refurbishment and construction initiation

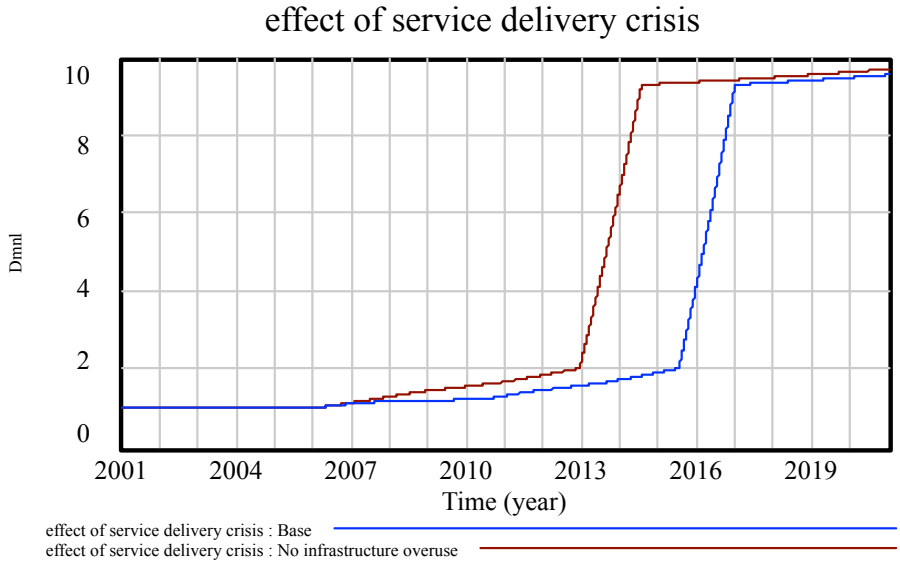


Figure 7.33: Scenario 1 (no infrastructure overuse) – effect of service delivery crises on technical activities

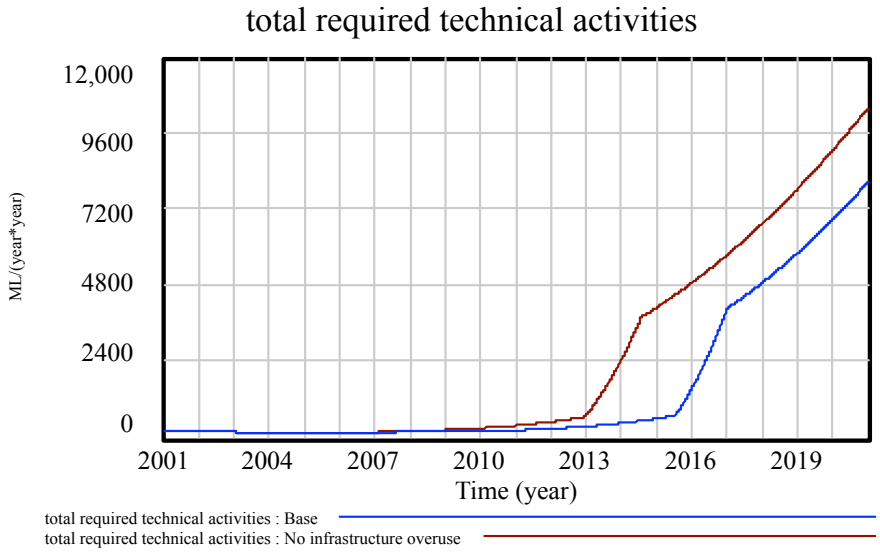


Figure 7.34: Scenario 1 (no infrastructure overuse) – total required technical activities

(iv-iii) Scenario 2:

Scenario 2 simulates a financial crisis in which the annual municipal financial bailout (see equation 23 of Appendix G) is suspended for a 2.5 year period. This scenario is motivated by actual events within the SRVM, which saw the finances that had been available on an ad-hoc, day-to-day basis cease in early 2012. The effect of this crisis is visible in Figure 7.35, which displays the financial constrains on maintenance in the baseline simulation and scenario 2.

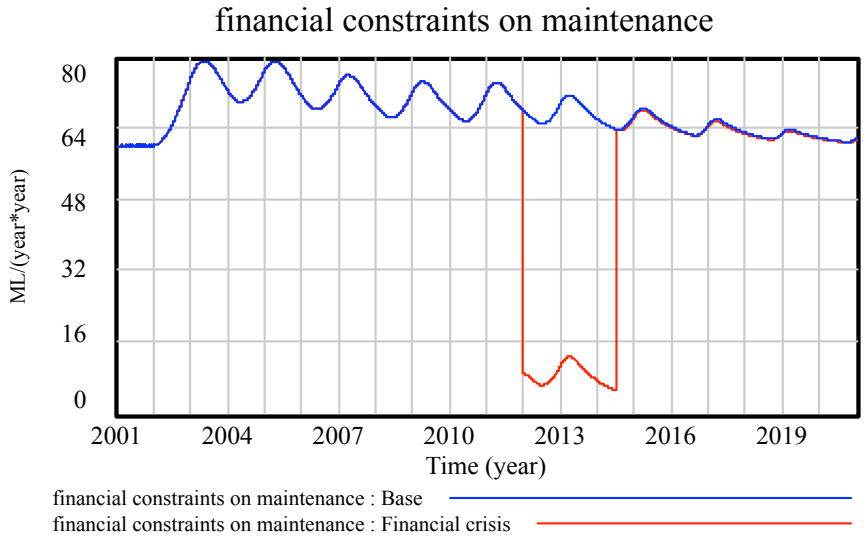


Figure 7.35: Scenario 2 (financial crisis) – financial constraints on maintenance

The effects of a financial crisis are particularly evident when comparing the obsolescence rate under scenarios 1 and 2, against the baseline simulation. As Figure 7.36 shows, the obsolescence rate sharply increases with the financial crisis (red line), which is particularly noticeable given the increase in obsolescence rate between 2007 and 2010 in the baseline simulation (for reasons described in scenario 1 simulation above). The decline in obsolescence rate is also evident in the first scenario – no infrastructure overuse – where between 2007 and 2013, the obsolescence rate stabilises around 48 ML/year/year.

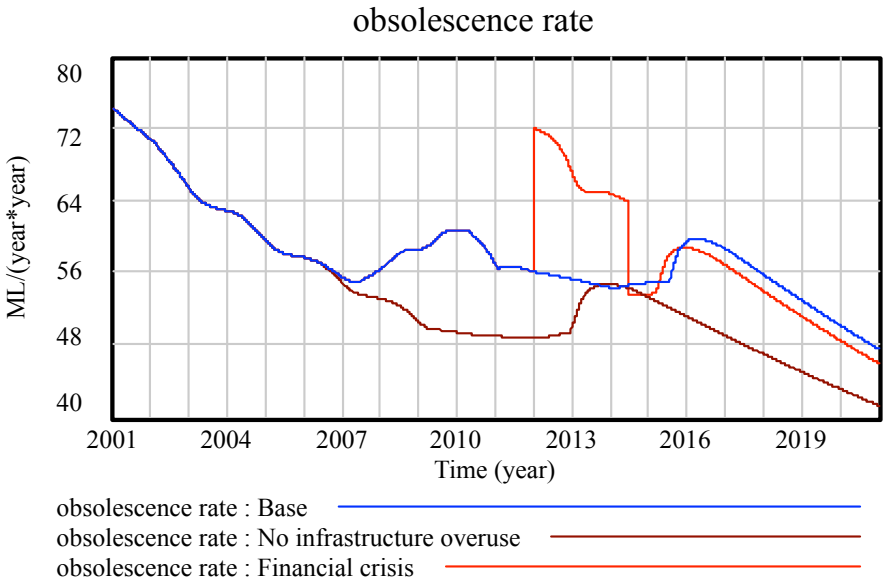


Figure 7.36: Scenario comparison of obsolescence rate. No infrastructure overuse' (brown line); 'financial crisis' (red line); 'Base' (blue line).

In Figure 7.36, all three simulation runs show a characteristic rise in obsolescence, which occurs at varying points point between 2013 and early 2016. The reasons for this rise are visible in Figure 7.37, which compares the 'potential maintenance' variable across all three simulations.

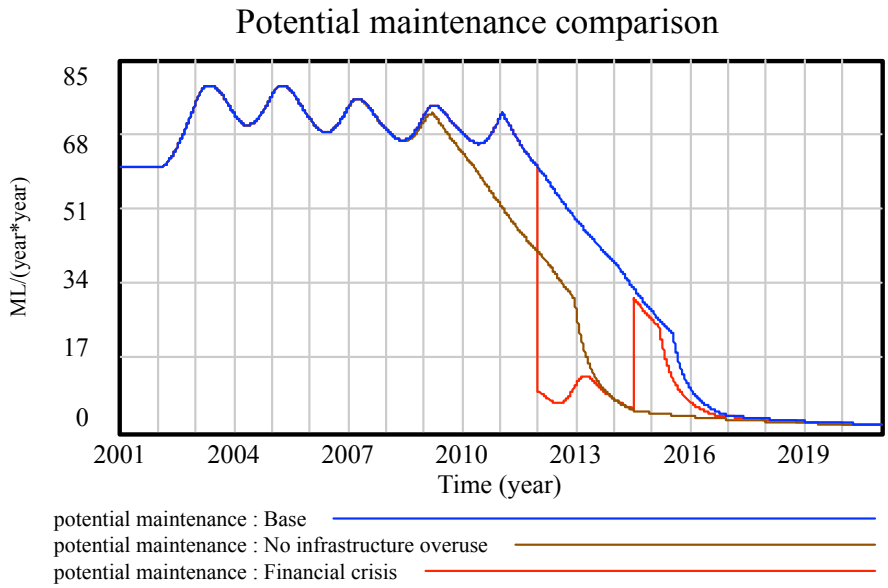


Figure 7.37: Scenario comparison of potential maintenance. No infrastructure overuse' (brown line); 'financial crisis' (red line); 'Base' (blue line).

In the no infrastructure overuse scenario, a sharp decrease in the potential maintenance is visible after 2013 in Figure 7.37, which therefore increases the obsolescence rate at the same time. The final two comparisons involve infrastructure capacity (Figure 7.38) and emergency water requirements (Figure 7.39). The infrastructure capacity comparison in Figure 7.38 shows that infrastructure capacity is best maintained in the 'no infrastructure overuse' scenario (in which refurbishment and construction is initiated earlier than in the other two simulation runs, and in which the obsolescence rate is more gradual).

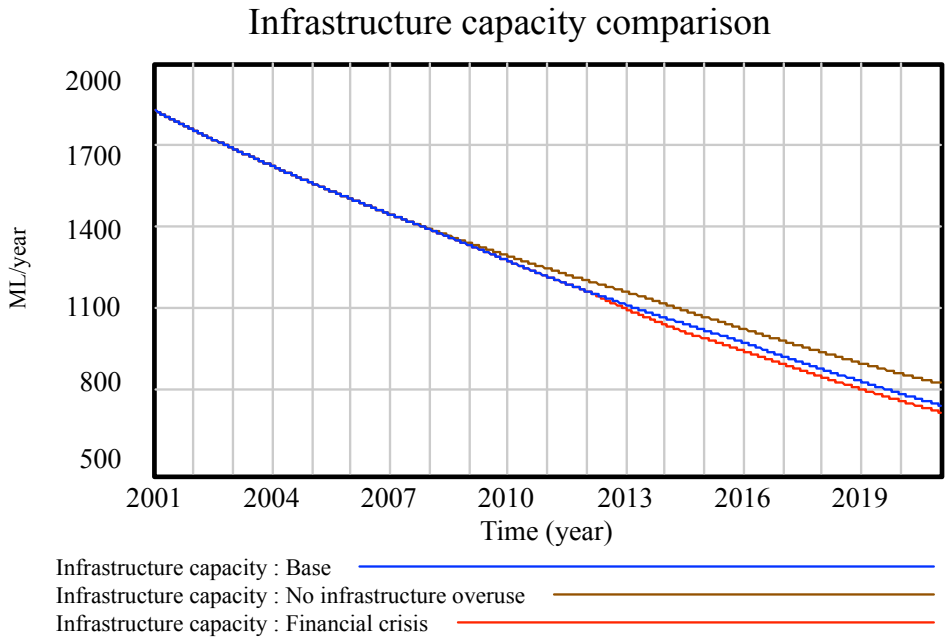


Figure 7.38: Scenario comparison of infrastructure capacity. 'No infrastructure overuse' (brown line); 'financial crisis' (red line); 'Base' (blue line).

However, the municipality only gains a relatively minor dividend in the form of extra capacity for not overusing infrastructure, and this dividend only becomes visible in the latter half of the simulation run in Figure 7.38. Similarly, the effect of a financial crisis on infrastructure capacity, as in scenario 2, is actually quite minor: in reality, a financial crisis would also impact on the percentage bulk water losses, which would lessen the potential supply of water to users (but this feedback is not incorporated into the *MoF* model as of yet). The final output considered here is the 'total number of tankerloads of emergency water required per year' (see Figure 7.39). The greatest number of tankerloads of emergency water per year is required in the first scenario (no infrastructure overuse) because the gap between supply and demand widens in this scenario ahead of the others – this requirement to provide emergency water further incentivizes the over-extending of infrastructure above design capacity.

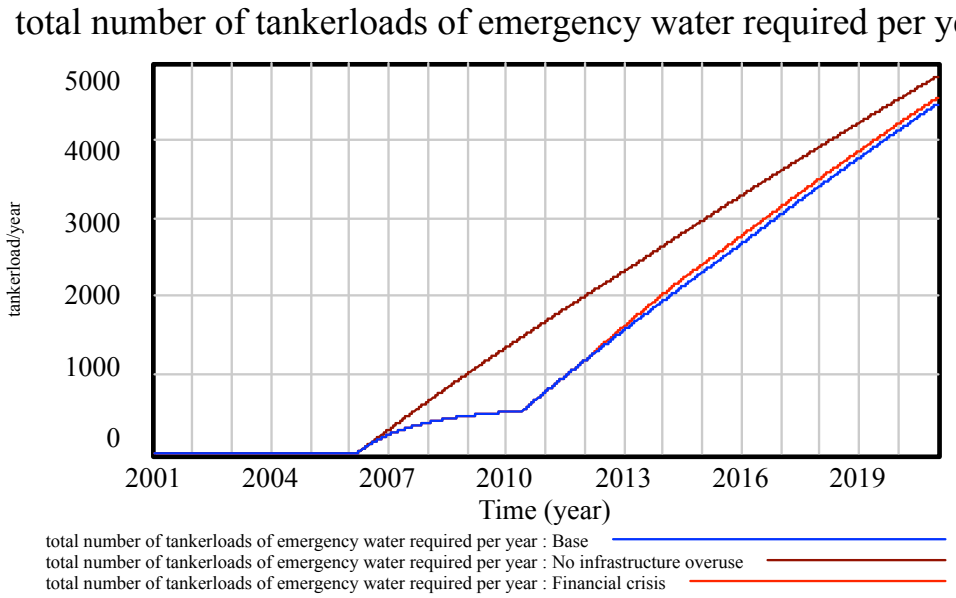


Figure 7.39: Scenario comparison of the total number of tankerloads of emergency water required per year. 'No infrastructure overuse' (brown line); 'financial crisis' (red line); 'Base' (blue line).

(v) Discussion:

The *MoF* model described in this sub-section explores a number of interlinked 'modes of failure' of local government, including the simultaneous underinvestment in, and over-extension of, water supply infrastructure, and the effects of municipal staff shortages, emergencies, and over-commitment on standard technical activities. One of the most important dynamics between the staffing capacity and infrastructural capacity aspects of the *MoF* model reflects what Repenning and Sterman (2001) call the 'capability trap'. Given that there is a substantial delay "between cutting corners and the consequential decline in capability" (*ibid*., 72), supervisors and managers reap the benefits of increased output from a particular system whilst saving on maintenance costs. However, as time goes on, and as equipment ages, managers are faced with lower yields and longer downtimes, which is a pattern of behaviour that has been identified in cases across production management and industrial engineering (*ibid*.). Importantly, system dynamicists explore the behaviour of 'cutting corners' and 'taking shortcuts' as rational responses to increased pressure in working environments (for example when crises occur).

As introduced in the model boundary discussion (sub-section G.4.1 in Appendix G), the *MoF* model excludes dynamics that are undoubtedly important, but held to be outside the scope of this model. These dynamics include staffing costs, and the municipal administrative and political exigencies pertaining to recruitment and training processes. We consciously chose to

leave these labour-hiring and training processes as exogenous and excluded variables in the *MoF* model. The following are acknowledged limitations of the model that are however, planned for inclusion in the next phase of (post-thesis) modelling:

1. Accumulating citizen dissatisfaction resulting from the rising discrepancy, service delivery crises, and emergency water not being delivered;
2. The effect of constraints on financial and technical staff capacity on bulk water losses;
3. Implementing water restrictions to ensure that basic needs are always met, therefore reducing the number of days without water that require emergency water to be delivered, and
4. The 'injection' of new infrastructure according to a 30-year planning horizon.

A further reason why the *MoF* model represents work-in-progress relates to the September 2014 service delivery protests in Kirkwood – in which municipal offices and infrastructure were set alight by protestors and burned to the ground. These protests occurred in the time period in which validation of the *MoF* model with municipal stakeholders had been scheduled. The dramatic events called for re-arranging how this model validation occurred. The subsequent engagement process between our action research project and stakeholders in the SRVM cast further light on the interconnected modes of failures in local government, in addition to drawing on the systems analysis generated through the *MoF* model as part of the engagement process. The following section (7.6) describes the action response to the Kirkwood protests, with section 7.7 discussing iscussion in returning to the specific use of SD in this study.

7.6 Action research response to 'Kirkwood burning'

7.6.1 Introduction

The September 2014 service delivery protests in Kirkwood were introduced in sub-section 6.5.1. This section outlines the AR response to 'Kirkwood burning' (as the protests became known in our research group). This response occurred at two levels, namely, within the broader transdisciplinary research project, and within the specific context of the study reported on in this thesis. This section (7.6) begins by providing an overview of the project-level response to Kirkwood burning, after which it focuses on how the protests and the subsequent events in the SRVM provided insights that enriched the governance, ethnographic, and systems analyses undertaken in this study and, in turn, discusses how these analyses fed

back into the action research response to Kirkwood burning. In terms of this study, the protests raised the following questions:

- Why were the protests so violently destructive and what was being done to prevent a second round of protests (at a political/facilitation/mediation level, and in terms of immediate technical fixes to the Kirkwood WSS)?
- If the L-WUA was now delivering water to the Kirkwood WTW on a daily basis – as was alleged by a number of participating stakeholders – why were water outages still persistently affecting the Greater Kirkwood region?
- Why had the RBIG-funding proposal for the expansion of the Kirkwood WTW not been approved?
- Why, if the water outages in Kirkwood had continued for months, were systems and processes not being instituted to provide emergency water to all areas affected by the water outages?

As the 'Towards a New Paradigm' (TNP) project, our first AR response to the Kirkwood situation was to address a letter to senior management in the Department of Water and Sanitation and the Water Research Commission (reproduced in section B.10 of Appendix B). This letter asserted that our research team had conducted extended action research in the LSRV region since 2011 – partly funded by the Water Research Commission – and had been involved in attempts to assist in the challenges faced by users and managers of the Greater Kirkwood WSS – including through the process recorded in this chapter. The letter argued that the transdisciplinary research project had developed a multifaceted view of water in the SRVM, which included accounts of the following:

- Governance and institutional arrangements;
- Actor analysis;
- Technical and systems analyses of water supply and demand;
- River health assessments; and
- A social science study of local residents who have experienced interrupted water supply and poor water quality.

Our project argued that we had "we have come to an understanding of the underlying systemic mechanisms leading to people's experiences of service delivery failure, and believe that this understanding can be significant for DWS' [Department of Water and Sanitation] interactions with local government". The Water Research Commission (WRC) was due to host a 'Water Dialogue' focused on the TNP's work, and featuring case studies that included

the SRVM (scheduled for November 2014). Senior representatives from national government departments and the WRC were expected at the event, which provided an opportunity to tell the story of how the Kirkwood situation developed, describing how the SANPAD/TNP project had been involved since 2011, and what could be learned from this case study of local water authorities in post-apartheid South Africa. The particular way in which the Water Dialogue was used in this study is further discussed below (in sub-section 7.6.5). Ahead of doing so, the following sub-section draws on the governance analysis in Chapter 5 to discuss issues pertaining to water restrictions, the delivery of emergency water, and resident dissatisfaction around water service delivery (sub-section 7.6.2).

7.6.2 Water restrictions and the provision of emergency water

From the perspective of this study in particular, the Kirkwood protests provided a forceful example of how the 'modes of failure' of local government create conditions that may lend themselves to violent civil unrest. The protests also provided motivation to reflect on dynamics that were unexplored in the *MoF* model, in particular, the dynamics of citizen-state interactions around water service delivery, and the diverse contributors to, and effects of, resident dissatisfaction with water services. This sub-section explores three issues:

- Implementing water restrictions as an interim policy measure;
- Providing emergency water according to policy requirements; and
- Addressing water services-related causes of resident dissatisfaction.

The above issues are related to one another in Figure 7.40, which expands on the aggregate-level CLD presented in Figure 7.24 of the *MoF* model. These issues are explored drawing on insights from the governance analysis in Chapter 5, with the following sub-sections outlining how these issues featured in the subsequent action research process.

(i) Water restrictions:

As introduced in sub-section 5.3.3 of the governance analysis, Section 5 of the *Water Services Act* (RSA, 1997) contains one of the most important statutory requirements for water service provision, namely that the provision of basic water supply and basic sanitation are to have preference. Hence, when facing any form of supply constraint (whether resulting from water resources or from inadequate capacity of bulk supply infrastructure to meet demand), a water services institution is required to manage its available water in order to ensure that basic levels of water supply and sanitation are always met. The operational implications of the above section of the *Water Services Act* can be applied in the Kirkwood situation as follows:

- As the water service authority (WSA), the SRVM is responsible for ensuring that potable water is provided to all five areas of the Kirkwood region (see Figure 7.9);
- In 2009, the SRVM assessed its own capacity to act as water service provider (WSP), and the municipal council voted to continue acting both as WSA and as WSP (see sub-section 5.5.4(i));
- As WSP, the SRVM is responsible for providing potable water services at the minimum standard for basic water supply services, as stipulated in the 'Compulsory National Standards' for Quality Water Services (DWAF, 2002a), and summarised in Box 5.2; and
- If the WSP is unable to meet its requirements, then the available water must be apportioned to all five supply zones in order to ensure that basic service levels in all five zones are met at the minimum standard for basic water supply services.

In the Kirkwood situation, the operational implication is that the SRVM – as WSP – is obligated to manage a reduced water supply by, for example, implementing water restrictions and/or reducing bulk water losses. The only endorsement of water restrictions in the technical documentation on the Kirkwood WSS surveyed for this study was in the RBIG design proposal for augmenting the Kirkwood WSS, which stated the following: "Water restrictions can also be imposed during the period when canal maintenance takes place. 50% water restrictions should eliminate the need to develop any infrastructure" (Amatola Water, 2014: 5). Based on the consulting engineer's assessments, about a third of the potable water produced at the Kirkwood WTW is lost in the bulk water system. If these losses are reduced, and if water restrictions are put into place, then adequate water could be made available in all supply zones without needing to construct any new infrastructure – including over the two 10 day periods a year in which the L-WUA undertakes canal maintenance (as described in the GKWS model). According to the consulting engineer, DWA is reticent to fund any new infrastructure development in Kirkwood until the municipality demonstrates that it is actively managing current infrastructure, and current water supply, adequately. Hence, the CLD in Figure 7.40 incorporates a policy of 'designing and implementing water restrictions at periods of peak demand and/or low supply' as a means of reducing the 'gap between demand & supply'. This policy measure is an interim alternative to expanding the infrastructural capacity, as discussed in detail in the *MoF* model. If water restrictions cannot be applied, and if the gap between demand and supply is allowed to grow without constraints, then the resulting water outages may extend for periods of more than 24 hours. In such situations, the SRVM is required to ensure that emergency water is provided, as described below.

(ii) Emergency water:

Section 3(b)(iii) of the 'Compulsory National Standards' (DWAF, 2002a) states that a minimum standard for basic water supply services is "a minimum quantity of potable water… with an effectiveness such than no consumer is without a supply for more than seven full days in a year" (see Box 5.2). The Compulsory National Standards cited above (DWAF, 2002a) provide guidelines for what a WSA must do in situations when the water services usually provided by the water services institution are interrupted for a period of more than 24 hours: namely, it must ensure that a consumer has access to alternative water services comprising at least 10 litres of potable water per person per day. In the *MoF* model, this basic amount is described as a 'lifeline amount' of emergency water (see Figure G.10 and associated description in Appendix G for details).

Hence, whenever water outages exceed 24 hours (as they have regularly done in suburbs of Kirkwood) the SRVM is required to provide alternative water supply – for example, using a water tanker (i.e. truck with water tank fitted to it). The cost (per litre) to the municipality of providing emergency water to municipal residents is many times more expensive than providing those same basic quantities of potable water via the conventional reticulation system. The CLD in Figure 7.40 shows how different forms of incentives might stimulate the delivery of emergency water. The 'delivery of emergency water at [the] required minimum level' is shown as a variable that is influenced by three others in Figure 7.40:

1. The 'demand for emergency water', which increases as the gap between demand and supply increases;
2. The 'technical and institutional capacity for delivering emergency water', which is positively influenced by the 'establishment of delivery mechanisms for emergency water'; and
3. The 'regulatory incentive to deliver emergency water at [the] required minimum level'.

The second and third variables listed above are positively influenced by DWA and the Department of Cooperative Governance and Traditional Affairs (CoGTA). The regulatory incentive to deliver emergency water is provided through enforcement by DWA and CoGTA, whilst the capacity for delivering emergence (in technical and institutional terms) can be stimulated through DWA and CoGTA providing financial and technical support.

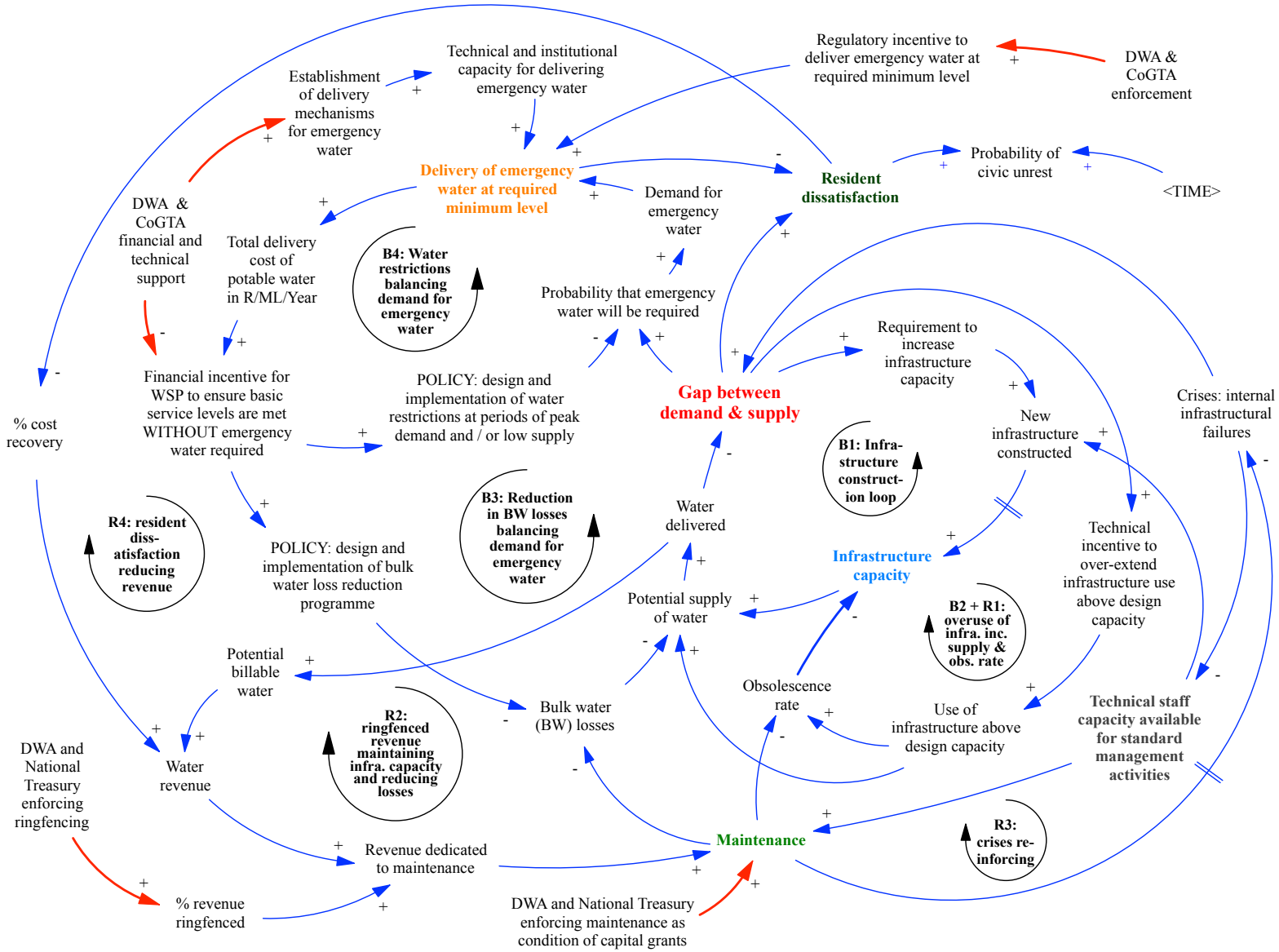


Figure 7.40: Updated causal loop diagram (CLD) with balancing (B) and reinforcing (R) feedback loops numbered and labelled.

In short, the municipality should aim to ensure that basic service levels can be met without emergency water being required: the financial incentive for the WSP to ensure that this is the case should be the 'total delivery cost of potable water in R/Ml/year'. However, this incentive can be reduced in impact if DWA and CoGTA provide financial support for the delivery of emergency water, as it removes the financial incentive on the WSP's side to manage the available water supply so that emergency water does not need to be delivered. Two of the policy measures available to the WSP are therefore:

- To design and implement a bulk water (BW) loss reduction programme (which is the third balancing loop in Figure 7.40, **B3: Reduction in BW losses balancing demand for emergency water**); and
- To design and implement water restrictions at periods of peak demand and/or low supply (which is the fourth balancing loop in Figure 7.40, **B4: Water restrictions balancing demand for emergency water**).

Although the Norms and Standards require a WSA to have in place a back-up plan for emergency water, the SRVM does not, and DWA has been neither regulating this particular norm (as discussed in 6.5.3), nor regulating the water restrictions policy measure described above. These governance insights built on the insights derived from the *MoF* model, and raised the following issues:

- What was preventing the SRVM from delivering emergency water?
- How was the delivery/non-delivery of emergency water related to resident dissatisfaction in the Kirkwood case?
- Were the connections between the demand for delivery of emergency water and the 'modes of failure' of local government (as visualised in Figure 7.40) accurate representations?

The following three sub-sections return to a first-person narrative in order to present perspectives on Kirkwood burning from the point of view of this study, exploring the above questions.

7.6.3 Responses to Kirkwood burning from the perspective of this study

As introduced in Box 6.8, the September protests occurred at a time that limited my immediate involvement. I had, however, scheduled to return to the SRVM in mid-October, with the original intention of doing one last round of follow-up interviews with field informants, and to use this opportunity to validate the *MoF* model (as described in sub-section

7.5.6 above). I therefore returned to 'the field' (as the anthropologists call it) in October 2014 with four objectives:

1. To learn about why the protests had occurred when and where they did, for what stated reasons, and to explore if water services were a primary grievance in the protests;
2. To draw on insights from the *MoF* model (sub-section 7.5.6) and the expanded CLD (Figure 7.40) in discussion with municipal technical officials and other key informants in the Greater Kirkwood region;
3. To reiterate the TNP [SANPAD] project's continued interest and willingness to engage with water problems in the SRVM; and
4. To promote municipal involvement in the up-coming 'Water Dialogue' in November 2014.

The four days that I spent in the Kirkwood region in mid-October were towards the end of the 30-day 'ceasefire' that was agreed in the provincial interventions that followed the September protests (see sub-section 6.5.1). When I arrived in Kirkwood, multiple informants expressed concern at the lack of visible progress since September, and the lack of communication between the protesting organisations, individuals, residents and the municipal officials in the intervening periods; these informants said that as a result, they believed that a second round of protests were now imminent. My own experiences validated this perception: my first two attempts at meeting municipal informants were both postponed, because the municipal offices had to be evacuated in response to threats that the next round of protests were to begin that day. Another meeting with a local businessman was disturbed by him arranging rubber bullets for his rifle and fielding calls from the Kirkwood police department about the protests. The tense and rumour-filled mood in Kirkwood was exacerbated by the fact that no-one (including the municipal officials I spoke to) seemed to know when the Eastern Cape provincial MEC for Local Government was due to return to Kirkwood, and whether his return would initiate further protests or whether it would quell the civil unrest. Similarly, the Mayor and the Municipal Manager always seemed to be in crisis-meetings outside of the municipality, and unavailable for emergency meetings within the municipality.

Over the course of my four days in the LSRV in October 2014, I met with field informants from the suburbs of Moses Mabida and Aqua Park (two of the suburbs worst-effected by the water shortages) in addition to representatives from the municipal technical division, the Kirkwood Ratepayers' Association, the Sundays River Business Chamber, and the citrus

industry (including emerging farmers). These meetings culiminated in two noteworthy initiatives: the first was a proposal for immediate intervention by a business-civil society partnership (which I was involved in brokering); the second was the use of the Water Dialogue to co-present (and discuss) the 'modes of failure' with the SRVM technical directorate. Together, these outcomes explore what could immediately be done to alleviate current water problems, what constraints prevented these immediate actions from being taken, and how these opportunities and constraints relate to the broader AR process.

7.6.4 A proposal for immediate intervention by a business-civil society partnership

The September 2014 protests were sufficiently violent to prompt the involvement of the commercial farming community in the LSRV. These farmers interacted with local Kirkwood business people and members of the Kirkwood Ratepayers' Association for the reasons discussed in the second thick description (see sub-section 6.3.3). Representatives from the citrus industry raised two threats. The first was the possibility of violent service delivery protests resulting in the destruction of farming industry infrastructure (including citrus packhouses that were located in the Kirkwood region). The second was a longer-term threat to the citrus industry, resulting from major sewage spillages into the irrigation canals in the region: according to these citrus farmers, if E-coli is detected in the water supply of packhouses and/or farms, then Sundays River citrus products are liable to be blocked from export. One businessman argued that these sewage spillages were the single greatest threat that the citrus industry in the region currently faces, and therefore constituted one of the most serious economic threats to the region on the whole. These threats to the citrus industry also threatened the majority of the businesses represented in the Sundays River Business Chamber (as their markets were either directly, or indirectly influenced by commercial farming in the region).

In the immediate aftermath of the September 2014 protests, a group of farmers and businesspeople gathered to discuss what they could do to immediately assist in the service delivery problems in the Kirkwood region, and therefore to mitigate the above-mentioned threats. They proposed a plan that could raise emergency finances, and attempted to see the SRVM Municipal Manager and the SRVM Mayor to officially present this plan to the municipality. When I arrived in Kirkwood three weeks later, I found that this group of farmers and businesspeople had been unsuccessful in securing a meeting with the Mayor or Municipal Manager. Through working with one committed local businessman, I met with a

broader group of stakeholders that included private packhouses, the Sundays River Citrus Company (SRCC), Luthando Farm, businesspeople, and ratepayers. The meeting was attended by stakeholders representing more than 5000ha of citrus under production in the LSRV (equivalent to around 40% of the citrus under production in the region – see Table C.10). The outcome of this meeting was a letter entitled, 'Proposal for immediate actions to address water and sewage problems in the Sundays River Valley Municipality': the proposal is summarised in an excerpt in Box 7.5 below (with the full proposal reproduced in section B.12 of Appendix B).

Box 7.5: First excerpt from the 'Proposal for immediate actions to address water and sewage problems in the Sundays River Valley Municipality': summary of proposal of financial and technical support. See section B.12 of Appendix B for full proposal.

> We, the undersigned, therefore propose and pledge financial and technical support for the following:
>
> - To establish an emergency water fund with immediate effect;
> - These funds will be administered by an independent organisation managed as a non-profit company, subject to the relevant South African companies legislation, and overseen by the sponsors; and,
> - To use this fund to supply enough water from the raw water reservoirs to the water treatment works by installing an additional pipeline and pump at the Market Street pump station.

The proposal drew on the technical experiences of several of the local businessmen (the same individuals involved in the sluice-cutting incident discussed in thick description 2 – see sub-section 6.3.1). These businessmen argued that there were immediate short-term fixes that could be put in place to alleviate the water shortages in the Kirkwood WSS, including the upgrading of pumps and electrical panels at the WTW, and between the raw water pump stations and the WTW. These were some of the capacity constraints that we explored in the *GKWS* model (see sub-section 7.5.4), which I used in a discussion (and then later a presentation) with these stakeholders. The stakeholder group present at the October meeting that I attended (and helped broker) continually returned to one concern: that government interventions into the municipal management of the SRVM in general, and the management of the Kirkwood WSS in particular, had resulted in little substantive improvement in service delivery between 2010 and 2014. These stakeholders argued that service delivery was far worse now than it had been even at the time of the municipality being placed under provincial administration in 2010. From the perspective of this group, the previous government

proposals to address the capacity constraints in the Greater Kirkwood WSS (such as the RBIG-funded upgrade discussed in sub-section 6.4.7) had benefited the consultancies employed to perform the scoping studies, but no-one else, because the scoping studies had resulted in unfunded proposals. Amongst these businesspeople, a core group had actively engaged the municipal administration since 2009, through participatory structures including ward committees, budget meetings, and Integrated Development Planning meetings. Hence, their involvement cannot easily be written-off as 'shouty ratepayers' and 'white people who have nothing to moan about' (which were all complaints against this group that I heard over the course of my study).

The proposal emanating from the stakeholder group who met in October was to establish an emergency water fund, via placing a minimum levy of 5 cents per carton on all export citrus from Sundays River (see Box 7.5), and came with a pledge of technical support from the farmers in the region towards immediate addressing water problems in Kirkwood. The proposal carried five conditions (see Box 7.6).

Box 7.6: Second excerpt from the 'Proposal for immediate actions to address water and sewage problems in the Sundays River Valley Municipality': conditions of proposal. See section B.12 of Appendix B for full proposal.

> Our proposal has five conditions that will achieve the buy-in of the residents, businesses and communities that we, the undersigned, represent:
>
> Condition 1: That the Municipal Mayor and Municipal Manager agree, on behalf of the municipal council, to **negotiate** the increase in rates and levies that the municipality unilaterally imposed on all ratepayers in the 2014-2015 financial year. The undersigned are willing to pay **up to** a 10% increase on the 2013-2014 rates and levies.
>
> Condition 2: That the municipality will attend to broken pumps and water leaks in all areas as a matter of utmost urgency;
>
> Condition 3: That the municipality partners the undersigned to find short-term solutions to other pressing service delivery challenges (specifically waste disposal sites and roads under municipal jurisdiction, including by fixing potholes);
>
> Condition 4: That applications and business plans are submitted to national government to gain capital grants to address the long-term decay in our infrastructure; and lastly,
>
> Condition 5: That the municipality ***must*** provide alternative water services if water supply is interrupted for a period of more than 24 hours - specifically, at least 10 litres of potable water per person per day (consistent with Section 5 of the Water Services Act (1997), and Number 4 of the Norms and Standards (DWAF, 2002)). We, the undersigned, know that the municipality is currently not meeting the above condition, and we know that this is an absolute non-negotiable statutory requirement.

At the October meeting, the stakeholder group nominated two members to interact with representatives from Moses Mabida that were involved in initiating, and supporting, the September 2014 protests. These representatives included 15 members of local branches of SANCO (the South African National Civic Organisation): the business representatives met with the SANCO representatives, with the latter supporting the proposal for immediate action in the kind of affiliation that is particularly rare in South Africa, but is also particularly required. In spite of the collaboration between civil society organisations, commercial farms and agricultural industries, and urban ratepayers and businesses, the proposal for support and intervention described in this sub-section was never discussed between the municipal manager, mayor, and the proposers. A second round of protests did occur (on 30/10/2014), but were fortunately less destructive than the September protests. The following sub-section concludes the AR process of this study through describing the municipal perspectives on Kirkwood burning, gained through co-presenting with municipal stakeholders at the Water Dialogue in November 2014.

7.6.5 Municipal perspectives gained through co-presenting at the 'Practising Integrated Water Resource Management' Water Dialogue

The WRC-hosted 'Water Dialogue' in November 2014 presented a window of opportunity both for this study and for the broader SANPAD/TNP research project (as introduced in sub-section 7.6.1). I presented a talk entitled 'Kirkwood burning: happy oranges and unhappy people in the Sundays River Valley. How can this be hopeful?' along with two research informants from the LSRV (see Table B.1 for the full programme). The first informant was the municipal technical director (Sizwe), with whom our project had been in communication since the Kirkwood protests in September. The second informant was a manager at Luthando Farm (introduced in sub-section 6.3.5), who was a long-standing resident of the LSRV region and a successful entrepreneur. This sub-section focuses on the planning and co-presenting of the talk at the Water Dialogue with Sizwe.

Sizwe and I initially planned on keeping our presentations separate, with him providing the perspective of a municipal 'insider', and with me presenting a research perspective. We agreed in advance on the basic topics that we wanted to cover, deciding that the presentation needed to speak to both the particularities of the Kirkwood case and to the general governance and management issues in the SRVM. The challenge was to keep our presentation short and appropriately pitched at the diverse audience that ranged from specialists to laymen (including

government officials, research managers, university and consultancy-based researchers, practitioners and corporates). In the end, Sizwe and I presented around an adapted version of the modes of failures causal loop diagram (CLD) in Figure 7.24. I had shown Sizwe the CLD in our planning discussions, and he knew that I had worked on a version of the model but had not been able to validate it either with himself, or with other municipal officials, due to the state of flux in the municipality following the September protests. Sizwe said that in his opinion, the feedback loops in the CLD model "perfectly described the Kirkwood situation". Given the negative connotations, I was somewhat reticent about us referring to the 'the modes of failure of local government' though. Sizwe recognised that the CLD (along with the associated simulation model) represented a generic system structure, which we could apply to the Greater Kirkwood WSS and use to describe Kirkwood burning, and he therefore endorsed the 'modes of failure' name. We co-presented the model as part of a broader presentation on water and local government, describing the feedbacks one loop at a time with Sizwe providing specific examples. Many of the examples Sizwe used feature in Chapter 6 of this this study (in particular, sub-section 6.2 on the internal operations of the municipality, and sub-section 6.5.5 on the operational budgets).

Sizwe and I disagreed on some points though, including the provision of emergency water to residents using water-tankers (as in Figure 7.40 of expanded CLD). Sizwe argued that providing emergency was a choice between bad options in the SRVM. He said that the municipal-owned vehicle used to deliver emergency water was a small delivery van belonging to another directorate. Secondly, the municipality has had poor experiences with contracting private water-tankers to deliver emergency water, finding that these contractors unscrupulously ran monopolies, and both over-charged the municipality and failed to deliver emergency water effectively. Lastly, given the municipal financial constraints and lack of ringfencing, the technical directorate has had to trade-off financing the delivery of emergency water using water-tankers, against using that same funding to address immediate infrastructural issues. The combination of the above factors led Sizwe to say, "I don't want anything to do with those tanks."

One of the discussion points at the dialogue was whether the term 'emergency water' is appropriate given that some South African municipalities are failing to provide basic access to water as the norm. As such, several discussants proposed rebranding the basic lifeline quantity of water not as 'emergency water', but as 'priority water'. The latter proposal is

consistent with the second policy measure proposed in the expanded CLD (Figure 7.40), namely, to design and implement water restrictions at periods of peak demand and/or low supply, such that Section 5 of the *Water Services Act* is met (see point (i) in sub-section 7.6.2). Sizwe noted that these water restrictions have made a big difference in the Greater Kirkwood WSS over the short periods in which he had been able to implement such restrictions. However, because the SRVM technical directorate still lacks a full complement of operators for the Kirkwood WTW, Sizwe argued that he has too few operators to manage the water restrictions by, for example, restricting the water supply to different reservoirs at scheduled points in the day and night. Furthermore, the municipality has no operational budget available to pay for the operators working over-time in the manner required for the water restrictions to be effective.

In summary, for Sizwe, the broader 'modes of failure' constrained the two policy means of water restrictions and emergency water. But Sizwe could share few alternative policy means other than a full system redesign (in the form of the WSS upgrade). Similarly, his scepticism of providing emergency water via water tanks did not account for how the municipality would ensure that the basic 'lifeline' quantity of water could be provided over periods of constrained supply.

This section has outlined the AR response to 'Kirkwood burning', focussing on the AR response within the specific context of the study reported on in this thesis. The following section (7.7) reflects on the use of SD modelling in this study in relation to the overall AR process. The general discussion in Chapter 8 returns to the AR response to Kirkwood burning, in terms of policy recommendations and final conclusions.

7.7 Discussion

This section discusses the overall action research (AR) process, beginning with the particular approach to modelling used in this study, and then moves to a discussion of the systemic AR process.

7.7.1 Reflecting on the modelling initiatives of this study

The necessity of on-going reflection on the modelling process was introduced in sub-section 7.5.1. This sub-section employs the reflective learning process developed by Slinger et al. (2008) in order to:

1. Justify the use of system dynamics (SD) modelling in this study;
2. Assess the value of the modelling approach to the research participants; and
3. Analyse the role played by the modeller in terms of bringing the value of the approach to the fore.

(i) The use of system dynamics modelling:

The value of modelling within transdisciplinary research is broadly acknowledged, for example, as a means of understanding and responding to complex real-world problems, synthesizing knowledge, and providing potential decision-support (Badham, 2010). Furthermore, as Voinov and Bousquet (2010) demonstrate in their authoritative review of modelling with stakeholders, a plethora of approaches exist for interacting with stakeholders at different points of the modelling process, and employing different techniques and tools. The motivations for using SD modelling in this study were introduced in sub-sections 2.6.4 and 3.5.3. In summary, SD was selected because it is one of the few modelling approaches that allows for exploring actual practices and experiences of stakeholders in applied settings (Maani & Cavana, 2007). The diagrammatic representations of SD models (including causal loop diagrams and stock-flow diagrams) allow for stakeholders to locate themselves and their actions within the system under examination (Stave, 2003). Lastly, SD encourages operational thinking, which is one of the dominant characteristics of systems thinking (Richmond, 1997). As introduced in Box 2.3, operational thinking encourages consideration of how a particular system functions in practice, which in this study included the operations of particular water supply systems in the LSRV.

(ii) The value of the modelling approach to research participants:

The value of the modelling approach to research participants follows the above justifications for using SD in this study. Water shortages in the Greater Kirkwood area, the attempted 'turnaround' of the SRVM, and conflict between the municipality and the L-WUA provided the applied setting for the modelling inititatives of this study. The different ways in which SD allows for exploring the actual practices and experiences of stakeholders, using both qualititative and quantitative tools, were appreciated in the applied setting. The diagrammatic representations of models were helpful for research participants who were not technically-minded, whilst the engineers, in particular, could ably discuss problem dynamics as stocks and flows, given their occupational involvement with water reservoirs and flow rates. Lastly, many of the research participants were comfortable with operational thinking, which allowed for using the *GKWS* model as a means of understanding the supply constraints in the Greater Kirkwood area, and as a means of facilitating what Howick and Eden (2010) refer to as 'strategic conversations' between actors. At times, this focus on operational details led to the modelling initiative becoming stuck in the particularities (including such measurements as pump and reservoir capacities and flow rates). This was the case when interacting with technicians on the *GKWS* model for whom the day-to-day operational details were particularly important. In addition to operational thinking, SD encourages focusing on higher-level dynamics and 'seeing the forest for the trees' (Sherwood, 2002), which was part of the argument for exploring the larger 'modes of failure of local government' in the fourth SD model. In this model, we therefore chose to ignore the details of the water supply infrastructure in order to focus on the broader modes and dynamics (pertaining to supply-demand gaps, asset stripping, and crisis management).

Whilst the traditional SD practice is to build one large model at the end of a modelling initiative, this study opted for an alternative approach of developing what Ford (2009: 305) refers to as "a portfolio of models", which arguably offers the opportunity to learn more "than a single, all-encompassing model". This approach recognises the argument of Stirzaker et al. (2010: 602) that it is better "to have a simpler model which we understand, and understand the limitations of, than a complex one that we do not understand". This study also demonstrated the axiom that modelling in controversial contexts often becomes a learning exercise that raises more questions than it necessarily provides answers. As Voinov and Bousquet (2010: 1272) argue in their review of modelling with stakeholders, participatory modelling is more often about "the process rather than the product". As introduced above, the

modelling process frequently served as a way of initiating stakeholder conversations in this study. For example, when asked for the physical measurements of the old storage canal in Kirkwood (for use in the *GKWS* model, see sub-section 7.5.4), stakeholders responded both with different measurements and with differing opinions on the perceived relevance (or irrelevance) of this canal as an additional raw water storage facility. Asking for the measurements of the canal (in terms of data with which to populate the *GKWS* model) created an opportunity to discuss policy options without personalising or blaming the operational issues on any one actor. However, many of the variables employed in the four SD models relied on perceptions and estimations that are – by definition – subjective and uncertain. Senstivity analyses offer a way of exploring which of the uncertain parameters lead to major changes in the model results. As Ford (2009: 341) notes:

> Analysis of system dynamics models has often revealed that the uncertainties in many parameters do not make much difference in the results. On the other hand, some parameter values may be crucial – small changes in their estimates can lead to major changes in the results.

A primary limitation of the modelling initiatives undertaken in this study was that a detailed sensitivity analysis was only performed on one of the four SD models (the *GKWS* model, as reported in D'Hont (2013)). We therefore missed an opportunity to learn more about which of these uncertain parameters led to major changes, and to use this sensitivity analysis as a further point of engagement between modellers and stakeholders. Conducting a careful and thorough sensitivity analysis of the uncertain parameters in the *MoF* model is one of the next steps planned in the continuation of this research in early 2015 (see sub-section 8.7.1).

Table 7.3 summarises the interactions between the four modelling initiatives and the various research participants of this study, which were described in section 7.5 in detail. As Table 7.3 shows, the most interactions between any of the modelling initiatives and stakeholders occurred with the fourth and final model. Following the co-presenting of the *MoF* model at a national forum in November 2014 (discussed in sub-section 7.6.5), the municipal technical director co-authored a paper with SANPAD researchers that used the modelling initiative to further explore the 'modes of failure' of local government. This co-authorship has provided the opportunity for further model use with municipal stakeholders in the SRVM going forward. As described earlier (point (iv) of sub-section 3.5.3), the second, third and fourth models developed in this study were documented using the System Dynamics Model Documentation and Assessment Tool (SDM-Doc) (Martinez-Moyano, 2012). The

documented outputs are contained in an online repository along with the models themselves, in order to enable future analysis and use by interested stakeholders and other researchers.

Table 7.3 also highlights several of the limitations of the modelling-related aspects of this study, including that no model specific workshops were hosted by researchers over the course of this study and that the most active model use occurred in participation with the municipal technical directorate. These limitations reflect the specific way in which modelling was used in this study, which is discussed in the following two sub-sections and is further analysed in a forthcoming publication (Clifford-Holmes, Slinger, de Wet, & Palmer, n.d.).

Table 7.3: Summary of the interactions between the four modelling initiatives and the various research participants (i.e. stakeholders) involved in this study. Workshops and meetings referenced against Table A.2 in Appendix A, which lists the workshops participated in.

Model	Form of model use with stakeholders	Participating stakeholders
M1 (the Cooperatives Model)	Initial use of M1 as problem structuring method; Use of model diagrams and model-related issues to pose questions and engage municipal technical staff in conversation (June – September 2012); Facilitators drew on model insights in the planning and execution of the October 2012 workshop (Ref. A:2:18).	DWA officials; AW; L-WUA; SRVM technical officials; RRU consultants; DWA consultants; SANPAD colleagues (as facilitators).
M2 (*GKWS*)	Systemic constraints of the Greater Kirkwood water supply scheme discussed at the February 2013 meeting (Ref. A:2:21), informing the problem formulation of the *GKWS* model and providing further insights into the problem dynamics; Model insights pertaining to pump capacities and cut-off points drawn from the *GKWS* model and used in discussion with stakeholders in the February 2014 planning workshop (Ref. A:2:20).	2013 meeting: L-WUA; SRVM technical officials; RRU consultants; 2014 workshop: AW; L-WUA; SRVM Technical Directorate; DWA-appointed consultant; Kirkwood Ratepayers' Association; Sundays River Business Council.
M3 (*K-DEM)*	Model insights contributed to planning process for Kirkwood water treatment works expansion at the February 2014 planning workshop (Ref. A:2:20); In particular, the factors pertaining to household water demand are discussed and model outputs from the K-DEM model compared with engineering assessments.	*Same stakeholders as '2014 workshop' listed above*.
M4 (*MoF*)	The M4 causal loop diagram is co-presented by researchers and municipal stakeholders at the 'Water Dialogue' in November 2014 (Ref. A:2:27); Out of the above, the municipal technical director co-authors a modelling paper on the *MoF* model with SANPAD researchers in early 2015 – using this opportunity to review the quantitative simulation model.	SRVM Technical Directorate; DWA officials; Sundays River Business Council; SANPAD researchers.

(iii) The role of the modeller:

The final aspect of the reflective framing proposed by Slinger et al. (2008) (namely the modeller's role(s) in bring the value of a given modelling initiative to the fore) motivates for exploring the stakeholder participation in the modelling activities. The primary approach to stakeholder-engaged modelling in SD is 'group model building' (Rouwette & Vennix, 2006), which aims to build or come to a group understanding of a complex problem. As the founders of the technique describe it, group model building has evolved as a "distinct approach to client involvement, which specify guidelines for the complete modelling process from initial client contact, through modelling construction and handover of results" (*ibid*., 453). These guidelines have evolved to the point that group model builders can draw from an encyclopaedia of 'scripts' to assist in the planning and facilitation of each stage of the modelling processs (Hovmand et al., 2013). Historically, however, SD has had "little theory for generating and representing diverse issues [and] no theory for facilitating sensitivity to socio-political elements" (Lane & Oliva, 1998: 214). Approaches to address this shortcoming within the SD field – including group model building and mediated modelling (van den Belt, 2004) – typically rely on consensus-building exercises run within workshops or meetings.

An alternative approach is to use SD in combination with other 'problem structuring methods' (Mingers & Rosenhead, 2004: 532). Problem structuring methods (PSMs) are useful in engaging wicked problems that are characterised by multiple actors and perspectives, with incommensurable or conflicting interests, and key uncertainties (*ibid*.). As such, PSMs should "operate iteratively… [and] enable several alternative perspectives to be brought into conjunction with each other" (Mingers & Rosenhead, 2004: 531). The modelling approach that was iteratively developed and used in this study resonates most closely with the argument made by Horlick-Jones and Rosenhead (2007) for using ethnographic tools in combination with PSMs (as discussed below).

7.7.2 Methodological hybridisation and 'modelling in the muddled midde'

Horlick-Jones and Rosenhead (2007) report on research and consulting practice that combined ethnographic tools with various PSMs, referring to these combinations as forms of 'methodological hybridisation' (*ibid*., 588). The PSMs that the authors used in combination with ethnographic tools included Soft Systems Methodology (Checkland, 2000) and the Strategic Choice Approach (Friend & Hickling, 2005), but excluded SD. In contrast, the

modelling approach developed and employed in this study combined SD with institutional analysis and ethnographic tools in a form of methodological hybridisation, which nonetheless builds on Horlick-Jones and Rosenhead's (2007) argument. Some of the key benefits of combining ethnographic tools with SD in this study are summarised in Horlick-Jones and Rosenhead's (2007) analysis of the 'added value' of a combined approach, which include:

- Developing perspectives on wicked problems that "transcended the subjective understanding of any one actor" (*ibid*., 595);
- Promoting "conversations between groups whose perspectives [are] informed by sometimes disparate understandings and value commitments" (*ibid*.);
- Enabling researchers to hold well-informed positions that allowed them to 'think on their feet' whilst facilitating workshops (*ibid*.); and
- Providing "insights into the practical worlds inhabited by the participants and the nature of the problems they faced" (*ibid*., 599).

The primary ethnographic tool employed in this study was a 'thickened' form of thick description (see section 6.6). The ethnographic data that were collected, interpreted, and analysed over the course of extensive fieldwork in the LSRV between 2011 and 2014 interacted with the use of SD and within the broader AR process. The modelling approach did not rely on consensus-building in workshop environments in order to develop and use SD models. At certain points of the AR process, such workshops were untenable due to extant conflicts between actors in the LSRV. This is not to negate the importance and usefulness of workshops, which were undertaken with research participants in the LSRV and which formed an important part of this study (as described in this chapter, and as summarised in Table A.2). Rather, the AR process did not rely on workshops and meetings as the only means of interaction between researchers and stakeholders, and drew on ethnographic data throughout.

The modelling approach also drew from the institutional analysis, which focussed on developing an understanding of the rules-in-form in order to explore how actors are constrained and enabled by their institutional settings. As Meadows (2011: 158) notes, "rules are high leverage points… If you want to understand the deepest malfunctions of systems, pay attention to the rules and to who has power over them." Hence, the modelling approach employed in this study is a form of 'modelling in the muddled middle', which conceptualises agents as living and working between the rules-in-form and the rules-in-use, between the clean, theoretical lines of policy design and the messy operational reality of implementation.

In order to reflect further on this modelling approach, the following sub-sections discuss the overall systemic AR process that the modelling approach was nested within.

7.7.3 Reflecting on the systemic action research process

According to Ison (2010) – whose practice of systemic AR informed this study – a shift in a researcher's 'epistemological awareness' is one of the differentiators of traditional AR from systemic AR. Ison (2010: 278) recounts how he underwent a "crisis of relevance" in which he "rejected the high ground of technical rationality for the swamp of real-life issues". The experiences recounted in the Preface, in the fieldwork stories in the textboxes in Chapter 6, and in this AR chapter, have provided insights into how (and why) I entered the "swamp of real-life issues" in the LSRV as an action researcher. The AR process reported here formed part of the SANPAD project (which evolved into the TNP project, as described in sub-section 7.6.1). As described in this chapter, the SANPAD project facilitated workshops, promoted interaction between different factions, and engaged in joint problem solving with stakeholders. The benefits of this AR process being nested within a broader project context are further discussed below. First, this sub-section discusses a dominant characteristic of the AR process, namely the way in which windows of opportunity were utilised in this study.

Windows of opportunity were conceptualised earlier in section 7.2 (see Figure 7.2). The two kinds of occurrences that were used as windows of opportunity were the following:

- Occasions where multiple government interventions were occurring with overlapping goals, but were failing to interact with one another; and
- Crisis points.

In the first set of occasions, our aim as action researchers was to attempt to harness the multiple interventions to support one another productively. In the second set of occasions, our aim was to utilise our developed understanding of local problem dynamics to assist – where possible – in the immediate crises. This raises a number of important ethical considerations. Firstly, in a complex system, "what might be good from one perspective might be bad [from] another" (Ison, 2010: 192). By moving from being observers of phenomena to participants in a wicked problem, action researchers become part of the situation that they are observing (Horlick-Jones & Rosenhead, 2007), and hence, "responsibility replaces objectivity" (Ison, 2010: 192). Some of the most difficult research decisions that I had to make over the course of this study were in the realm of my own evaluations of what constituted ethical (and therefore responsible) research practice. These ethical evaluations required a contextualised

understanding of particular situations. Whilst this research was extended and multifaceted, and engaged many different stakeholders, my developed understanding was, of course, provisional and limited. This reflects a characteristic of systemic issues (namely, that "individuals hold partial perspectives of the whole situation; when combined, these provide multiple partial perspectives" (Ison, 2010: 192)). Adopting a principle-based approach to research engagement is one way one of accommodating provisional understandings, as reflected in the literature (Cilliers et al., 2013) and following the adoption of principles of engagement in the SANPAD project (see Box B.1).

Limited understandings are also in the nature of the fractured governance context in which this research was undertaken. As noted elsewhere, research attempts to build adaptive capacity in fractured governance contexts – such as the one in the LSRV – face significant challenges, including in the resource-intensive requirements for sustaining research engagements (Fabricius & Cundill, 2010). The resource-intensive nature is also related to the time it takes to build networks for transdisciplinary research within particular contexts (Roux et al., 2010) both academically – as an intellectual endeavour – and practically, with case study participants and stakeholders. Undertaking this AR process as part of a doctoral study placed additional constraints, in terms of making evaluations and trade-offs between academic requriements and continual engagement in the case study (see Box 6.8). The AR process was supported by virtue of it being nested within the broader SANPAD/TNP project. This context enabled overlaps and synergies between different components of the research project to develop (as introduced in the research design in section 3.4). The collaborative research project also helped to mitigate the resource-constraints of this doctoral study, including through co-facilitation of workshops (as in the case of the October 2012 workshop described in sub-section 7.4.1) and through team members taking aspects of the AR process forward over periods when I was unable to participate.

7.7.4 Conclusion

The way in which different analytical approaches were selected and employed as part of an evolving transdisciplinary methodology was demonstrated in this chapter through recounting and analysing the systemic AR process at the centre of this study. The AR process was underpinned by the aims of engaged, change-oriented research, which sought to be involved in loosening problematic 'knots' in the LSRV. But the process was also an analytical exercise through which the integrating insights of this study were derived. These insights are related

both to the stages of the AR process and to the methodological hybridisation of institutional analyses, ethnographic analyses, and systems analyses (as summarised in Table 7.1). The particular approach of 'modelling in the muddled middle' evolved out of the combined use of ethnographic tools with systems and institutional analysis. As part of this modelling approach, a portfolio of small system dynamics models was developed and employed to explore the systemic factors that generate the immediate problem dynamics of interest. The final results of this modelling approach are discussed in relation to the overall study aims in the following chapter.

Chapter 8 General Discussion and Conclusion

The general discussion and concluding chapter of this study synthesises the line of argument developed through the earlier chapters, and draws on the following:

- The discussion in the historical analysis (section 4.8);
- The governance analysis discussion (section 5.5);
- The two discussions in the ethnographic analysis (section 6.5 and section 6.6); and
- The discussion about the systemic action research process (section 7.7).

The chapter begins with a final anecdote from the action research process that reiterates the applied aims of this study (along with the investigatory approach), after which the line of argument is provided.

8.1 Introduction

At the November 2014 'Water Dialogue', I presented alongside of the technical director of the Sundays River Valley Municipality on what we called 'the modes of failure of local government in South Africa', using the recent service delivery protests in the town of Kirkwood as an illustrative case (as detailed in sub-section 7.6.5). After the municipal technical director and I had finished presenting, another participant in the dialogue responded to say that "engineering was required in this situation, not academics". The individual who said this turned out to be a senior engineer from the Municipal Infrastructure Support Agency (MISA), who had previously been with the 'Siyenza Manye' programme in the Eastern Cape (see sub-section 6.5.3). I went and spoke to him after our presentation, and asked if he really thought the Kirkwood case was 'just a simple engineering problem'. He responding by saying that the technical facts were the following:

- That the Kirkwood water-treatment works (WTW) had insufficient raw water storage capacity;
- That the pump capacities throughout the WTW were inadequate;
- That the raw water supply arrangement between the the Lower Sundays River Water User Association (L-WUA) and the municipality was biased towards the L-WUA's operations, and therefore needed re-arranging; and
- That the municipality was employing incorrect treatment processes at the Kirkwood WTW.

The MISA engineer stated that these were simple engineering issues to address. I responded by saying that whilst I was not an engineer by training, I was aware of the issues he raised, and had been involved in both technical and processual interventions, including supply system modelling (see section 7.5) and the operational schedule between the L-WUA and the Sundays River Valley Municipality (SRVM) (see section 7.4). The engineer said his agency (MISA) had done a report on the Kirkwood problems in 2011, but nothing had been done. He complained that the SRVM Technical Director had subsequently failed to contact him (or his agency) to request assistance, and that none of the recommendations of the 2011 MISA report were implemented. Over lunch, I introduced the MISA engineer to the SRVM technical director. As we sat together we spoke about numerous issues including:

- National government's restructuring that led to the Siyenza Manje programme being moved from the Development Bank of Southern Africa (DBSA), to MISA;
- The skills shortages at Amatola Water – the regional water utility that had been involved in the attempted 'turnaround' of the SRVM since 2010 – in relation to Amatola Water's own organisational restructuring and financial turnaround process;
- The dysfunctional interface between the technical and financial directorates in 'Category B' municipalities, which leads to the water services units of many local municipalities being inherently financially-unviable;
- The fact that municipal managers and mayors need to approve funding and support proposals – and that their unwillingness to do so (for numerous political and administrative reasons) frequently inhibits local municipalities gaining the technical support that they need; and
- The fact that engineering consultants often take advantage of small (predominantly-rural) local municipalities, exacerbating rather than than improving situations.

Having discussed the above issues, I asked the MISA engineer if he still thought that the Kirkwood water outages resulted from a number of simple engineering problems. He responded that the basic infrastructural issues affecting bulk water supply in Kirkwood were relatively simple, but conceded that the context in which municipal water services operate – and the intervention processes into these services – are fraught and deeply-politicised, and therefore anything but simple to address.

This study uses a series of intervention processes into municipal water service delivery as part of a case study exploring the context, constraints, and real-world messiness in which many local water authorities in post-apartheid South Africa operate. These are situations

characterised by uncertainty, complexity, interdependence, and controversy (Ison, 2010). The study is located within an emerging research tradition of transdisciplinarity, which argues that the nature of complexity requires a different response from the applied research community. It requires stepping outside of the academy and working beyond the realm of a single discipline; it requires interacting with a range of agents, over extended periods of time; in short, it requires grappling with messiness.

In this chapter, I argue that my study contributes to knowledge and to research-as-practice, and that practical policy recommendations and promising areas of future research have emerged out of these contributions. The chapter begins with a summary of the line of argument developed across the preceding three parts of this study. This summarised line of argument reminds the reader of the research journey, and provides the basis for introducing the final discussion and conclusion of this study.

8.2 Thesis summary

8.2.1 Summary of research goals and research design

This study began with the recognition that the successful implementation of water policy and the integrated management of water face multiple challenges in SA, despite post-apartheid government successes in which some significant equity, sustainability and efficiency milestones have been met. In order to explore these challenges, this study examines the operations, management, and governance of bulk water supply in the Lower Sundays River Valley (LSRV) region of the Eastern Cape province. Bulk water supply is a strategic point of overlapping jurisdiction between processes and institutions for water resource management, regional water utilities, raw water suppliers, and water service authorities providing potable water services. The local water authorities in the LSRV region comprise of the Lower Sundays River Water User Association (L-WUA) and the Sundays River Valley Municipality (SRVM). The attempted 'turnaround' of the SRVM from 2010 onwards provided the empirical focus for this research into local water authorities in post-apartheid SA, with one of the three water supply schemes operated by the SRVM selected as a particular focal point.

This study adopted an action research approach within an evolving transdisciplinary methodology, drawing on institutional, systems, and ethnographic modes of analysis. The study was concerned with situating the challenges faced by local water authorities and water users in the LSRV within an understanding of the formal institutional domain that governs

water resources and the provision of water services in post-apartheid SA. The institutional analysis therefore incorporated historical and governance lenses. In order to explore the operational challenges faced by local water authorities and users within the LSRV, a grounded ethnographic approach to fieldwork was adopted and an understanding of institutional change as occurring in the 'muddled middle' between the formal and informal institutional domains was developed. An embedded case study design was employed (which is defined and described in sub-section 3.3.4), with the following four units of analysis selected:

1. The intervention of the regional water board in the Eastern Cape (Amatola Water) into the SRVM;
2. The institutional and operational arrangements between the SRVM and L-WUA;
3. The broader intervention dynamics of state actors in relation to local water authorities in the LSRV; and
4. Bulk water management in the Greater Kirkwood water supply scheme.

The way in which these four units of analysis were explored and analysed in this research is outlined in the summary of the line of argument in Part II and Part III of this study.

8.2.2 Summary of argument in Parts II and III

Part II of this study sought to characterise and contextualise water governance in the LSRV using historical and governance analyses. The historical analysis in Chapter 4 presents the development of water issues in the LSRV over time, in a narrative manner, with the objective of coming to a grounded and processual understanding of the context and background of the contemporary challenges. Local water authorities in the LSRV are situated within broader frames of governance, focusing on changing citizen-state relationships, land ownership, and water resource management and development from 1814 to 2011. In particular, the historical narrative contextualises the reworking of municipalities into 'developmental local government', and the establishment of world-class water management policy and legislation in post-apartheid South Africa.

Chapter 5 builds on the historical analysis, by detailing and analysing the formal institutional domain that governs water resources and the provision of water services in post-apartheid SA. The chapter develops an understanding of the processes and institutions by which bulk water is governed in the LSRV by the interacting authorities. Five governance challenges are identified as affecting local water authorities in the LSRV: these governance challenges are

inter-related and connected to all three spheres of government in South Africa – national, provincial, and municipal – and are summarised in Figure 5.12.

The empirical and analytical heart of this study is contained in **Part III**, which draws on ethnographic, systems and institutional analyses. Chapter 6 adopts an ethnographic approach to the presentation and analysis of fieldwork-derived data. The chapter employs a particular ethnographic tool, namely, thick description, which emphasises the interpretive nature of ethnographic data. Following Thompson (2001), thick description is used to analyse the multiplicity of knotted structures, concepts and lived realities of policy-affected stakeholders – in this case, users, managers, technicians, residents, consultants, and other individuals in the LSRV. The way in which thick description is employed in this study is qualitatively different to how the tool is conventionally applied in anthropology: this chapter argues for a 'thicker' form of thick description that can contribute to a deeper problem analysis of complex policy dynamics (with the methodological contribution that this study makes in this regard discussed in section 8.5).

Empirically, chapter 6 begins with the September 2014 service delivery protests in Kirkwood, arguing that this dramatic event emerged from long-standing issues. In order to intepretively explore these issues, three thick descriptions are detailed in the chapter, drawing on fieldwork data collected between 2011 and 2014. In addition to playing an important analytical role, the three thick descriptions provide a rich contextual background for the action research process that is at the centre of this study, and which is first introduced through the accounts of fieldwork experiences interwoven into the thick descriptions.

Chapter 7 locates the above-mentioned fieldwork experiences within the systemic action research process undertaken between 2011 and 2014. The action research process is conceptually and then practically outlined in this chapter. Integrating insights are shown to have iteratively developed between the action research process and the analytical process, with the stages of the action research process linked to the preceding chapters in Part II and III via these integrating insights (see Table 7.1). The 'systemic' part of the action research process draws deeply on the four system dynamics models developed over the course of this study, each of which is explicated and analysed in Chapter 7. The models demonstrate the scale and interconnectedness of the financial, infrastructural, and skills issues in the SRVM,

with insights from the models feeding back into the action research process – as shown in the final stages involving 'Kirkwood burning'.

8.2.3 Structure of the general discussion and conclusions

The remainder of this chapter is structured as an argument beginning with empirical conclusions drawn from the case study and discussing these conclusions in relation to the conceptual framing. Three policy recommendations that have emerged from the study are then identified and discussed, following which the methodological contributions of this study to the emerging field of transdisciplinary research are summarised. Finally, the limitations and ethical considerations of the study are reflexively critiqued, and areas for future research posited ahead of the conclusion.

8.3 Empirical conclusions

8.3.1 The socio-political history behind 'Kirkwood burning'

This study has surfaced the socio-political history behind the civil unrest in Kirkwood in 2014. Water outages were reported as lasting for days at a time in the Greater Kirkwood region prior to the provincial turnaround being initiated in 2010 (Ndoni, 2009a). Indicators of violent civil unrest were also evident throughout 2009, when a councillor's office was set alight in protest (Ndoni, 2009b). Water outages in the Greater Kirkwood area persisted in the period following the provincial administration of the SRVM ending (in early 2012): in early 2013, two townships of the Greater Kirkwood area (Moses Mabida and Aqua Park) were reportedly without water for days at a time, with residents accussing the municipality of "ignoring the problem" (Ndamase, 2013: 4) and arguing that "maybe someone has to die before they [the municipality] make sure we always have water" (*ibid*.). The historical analysis of this study further showed how residents of townships in the Greater Kirkwood region have extended histories of dislocation and dispossession – including some residents being forcefully relocated under the *Group Areas Act* of 1950 to parts of Kirkwood with "no water… and no road" (see sub-section 4.4.2), and others moving to Kirkwood townships as farmworkers displaced by the expansion of the Addo Elephant National Park (see sub-section 4.6.2). These historical antecedents do not deterministically lead to violent service delivery protests, however. As the recent research into the trend of increasingly-violent civil unrest in SA illustrates, the term 'service delivery protest' often acts as a placeholder for a multitude of grievances (Grant, 2014; Netswera & Kgalane, 2014; van Vuuren, 2013). Service delivery

protests are often political, with protestors carrying demands for both better service delivery and the firing of particular political officials (usually a mayor or municipal manager), with the Kirkwood protests being no exception in this regard. It is also noteworthy that the Kirkwood protests were led by local affiliates of the South African National Civic Organisation (SANCO). Historically, SANCO was part of the 'Mass Democratic Movement' piloted by the African National Congress (ANC) and has therefore been a member of the broad ANC alliance since the 1990s. The ANC-SANCO alliance is increasingly fractured (Ngcukana, 2014), with calls for SANCO to leave the ANC-led alliance (under the argument that the ANC no longer represents the interests of civil society (Azania, 2013)). The fracturing of the ANC-SANCO alliance is one aspect of what some South African political analysts refer to as the 'fall of the ANC' (Mashele & Qobo, 2014). The numerous struggles for mayoral candidature, the conflicts around employing municipal managers, and the burning of the ANC offices in Kirkwood alongside the municipal offices in the September 2014 protests, are all local symptoms of political factionalism within the ANC, which has increasingly characterised the ANC since 2007 (Mashele & Qobo, 2014; Reddy, 2010).

Water service provision in the SRVM is therefore an exemplary case study of the argument that "local government is a mirror of the larger political and economic forces, cleavages and problems that are shaping South African society" (Powell, 2012: 11) (as introduced in sub-section 4.8.1). In addition to the political governance dynamics of the ANC, this study identified and described five governance challenges, arguing that local water authorities in the LSRV are affected by these governance challenges in multiple reinforcing ways (see section 5.5). The local-level events contained in the thick descriptions provided detailed accounts of how actors interpreted and reinterpreted their institutional context, with Chapter 6 further distilling three operational manifestations of the governance challenges (see section 6.5). These manifestations are concluded upon in the following sub-section.

8.3.2 Manifestations of reinforcing modes of failure

A dominant theme of this study is the characterisation of government actors as 'firefighters' who reactively respond to crises and who are not in control of their own time (see sub-section 6.5.4). As Haslett (2007: 1) notes, however, "stamping out spot fires does not stop a major bushfire." The SRVM is one of many local authorities in SA where dealing with immediate and practical realities of spot fires consistently reduces the organisation's capacity to plan and

manage its way out of the firefighting pattern. By perpetually 'firefighting', the municipal capacity for organisational learning (Senge, 1990) is significantly reduced.

The context of these crises is one in which the demand for potable water has expanded along with the number of other government responsibilities, at the same time as the capacity to perform the water services-related aspects of those responsibilities has diminished. Asset stripping (as described in sub-section 6.5.5) can be understood as a rational response of municipal officials to the water shortages that emerge in this context. Over-using and under-maintaining infrastructure in the short-term is a reasonable way of mitigating current water shortages when funds are unavailable for maintenance, refurbishment or the construction of new infrastructure. Many of the detrimental effects of asset stripping only become visible over time, as infrastructure breakdowns occur and as the dysfunctional state of the infrastructure becomes increasingly evident (by which point, much of the damage has already been done). The reinforcing effects of these dynamics are conceptualised in this study as the 'modes of failure of local government', with these modes of failure explored in the system dynamics model described in sub-section 7.5.6.

This study additionally explored the water shortages in the Greater Kirkwood area as a manifestation of mal-functioning inter-governmental relations. Over the course of the attempted 'turnaround' of the SRVM, multiple departments and government agencies intervened in the water services of the SRVM in an uncoordinated, and often ad-hoc, fashion, unproductively overlapping whilst scarcely communicating with one another (as described in the thick descriptions in Chapter 6). The uncoordinated interventions into the water services of the SRVM demonstrate why a clear and coherent strategy is required for interventions into municipalities. As discussed in sub-sections 5.3.6 and 5.5.6 (and returned to in the policy recommendation in sub-section 8.4.2), the national Department of Water Affairs (DWA) still lacks an intervention strategy that acts as "a systematic protocol to determine when to intervene and when to leave systems alone" (Taleb, 2012: 121).

In 2009, the national Department of Cooperative Governance and Traditional Affairs (CoGTA) acknowledged that interventions into municipal systems by government agencies carried multiple unintended side-effects, for many of the reasons experienced in the SRVM case between 2011 and 2014. The solution advocated by CoGTA was for it to become the "single window for coordination… for any government programme, policy directive, or other

initiative for support that moves into a municipal area" (CoGTA, 2009b: 24). This proposal formed part of the same Local Government Turnaround Strategy that sought to address what CoGTA termed the "root causes of municipal failure" (summarised in Box C.1), where CoGTA characterised these root causes as "systemic factors, i.e. linked to [the] model of local government" (CoGTA, 2009a: 3). But the attempted 'turnaround' of the SRVM between 2010 and 2012 did not tackle the modes of failure, as manifesting in the water shortages in the Greater Kirkwood area and the associated interventions by multiple government agencies and departments. The Local Government Turnaround Strategy was broadly critiqued at a national level for failing to address systemic factors that endogenously led to local government failure (Siddle & Koelble, 2012). In September 2014, CoGTA released a 'Back-to-Basics' programme (as introduced in 6.5.1), tacitly acknowledging the ongoing challenges in local government and the failure of previous 'turnaround' attempts. One of the conclusions of this study is that a belief in 'turnarounds' is deeply rooted in South African political society and public management, as briefly summarised in the following sub-section.

8.3.3 A belief in 'turnarounds'

The attempt to reengineer or rework the functioning of entire institutions is evident throughout government. When the Minister of Water and Environmental Affairs appointed her highest-level advisory committee in 2011, it was under the title of the 'Business Process Reengineering Committee' (DWA, 2012b). The methodology of 'Business Process Reengineering' (BPR) was founded in the early 1990s; as defined by two of its founders, BPR aims to rid organisations from their legacies of bureaucracy and inflexibility and is concerned with "forgetting the past in order to start all over" (Hammer & Champy, 1993). Similarly, the post-apartheid transformation of irrigation boards into water user associations was arguably underpinned by the "assumption of the transformatory potential of institutional reform" (Brown, 2011: 171). The persistent popularity of such ideas of institutional transformation, reengineering, and organisational turnarounds suggests that many policy makers, politicians and managers in SA believe that whole institutions can be 'turned around'. This belief relies on a top-down managerialist-functionalist conception of institutions (defined in sub-section 2.3.2). This study critiqued top-down conceptions of institutions and drew on processual-dynamic conceptions, as concluded below.

8.3.4 Institutional bricolage in the Lower Sundays River Valley

Bricolage refers to the "piecing together… of institutional arrangements from existing norms, practices, and relationships" (Cleaver, 2007: 229) (see sub-section 2.5.4). Cleaver's (2007, 2012) conception of institutional bricolage provides a useful conceptual device for exploring the water-related arrangements between actors in the LSRV. By 2014, the supply arrangement between the L-WUA and the SRVM for the Greater Kirkwood water supply scheme was underpinned by several personal relationships. These included:

- The relationship between the municipal technical director and a technical official at the L-WUA; and
- The relationships between members of the Kirkwood Ratepayers' Association, the Sundays River Business Chambers, and the L-WUA (as described in section 6.3).

Individuals in these organisations drew on different kinds of resources in their roles as *bricoleurs* (Cleaver, 2007: 229), which are detailed in sub-section 6.3.3 and discussed in sub-section 6.5.6. The concept of institutional bricolage also informed the institutional component of the action research process of this study (see section 7.4 and 7.6.4), where action researchers featured as additional *bricoleurs*. Despite the action research-facilitation, by the end of this study, the institutional arrangements between the L-WUA and the municipality remained unofficially-sanctioned; furthermore, an extended supply arrangement between the L-WUA and the SRVM had limited impact on water security in the Greater Kirkwood water supply scheme, due to the infrastructural capacity issues described in sub-section 7.5.4.

The limitations of the effectiveness of the *bricoleur* role is evident in the third thick description in section 6.4, which showed how the funding for the Greater Kirkwood water supply scheme (WSS) upgrade was applied for, awarded, and disbursed within a network of actors that included the SRVM, engineering consultancies, Amatola Water, National Treasury, and DWA. Despite the urgency of the WSS upgrade, the application became caught within an extensive bureaucratic process between 2012 and 2014. The length of the process was likely extended as a result of Amatola Water undergoing a 'financial turnaround' at the same point that its officials were employed to assist the SRVM (as discussed in sub-section 6.4.6 and point (iii) of 6.5.3). But the nature of the bureaucratic process also decreased the ability of local *bricoleurs* from effectively participating in (and monitoring) the progress of the upgrade application, demonstrating that it is not just poor and marginalised communities who struggle to effectively engage municipal structures. Many of the research participants

and key informants in this study interacted with their ward councillors and ward committees on a regular basis (according to the structures summarised in Figure 5.7), but these interactions resulted in little change to the on-going water problems. Similar results have been found locally and nationally, including through interviews conducted by Molony (2014) with residents in Aqua Park in the Greater Kirkwood region, and in hearings held in all nine provinces by the South African Human Rights Commission (SAHRC) on access to water and sanitation (SAHRC), 2014b). Further research into the conditions that lead to social protests notes that "often when people start hitting the streets they should have a banner saying 'all protocol observed'" (Grant, 2014). In other words, people become dissatisfied after having participated in democratic channels. In addition to the historical antecedents and the modes of failure described in sub-sections 8.3.1 and 8.3.2, this study attributes the accumulating dissatisfaction to a combination of over-complicated policy and 'complexity capture'. These factors affect the enabling environment that is required to support the development of effective water governance (see Table 2.2), particularly in terms of accountability, and transparency, as discussed below.

8.3.5 Over-complicated policy and 'complexity capture'

Accountability relies on regulation, which in the LSRV case is performed by the regulatory sub-directorate of the DWA regional office (DWA-RO) in the Eastern Cape. The significant staff capacity shortfalls in this sub-directorate were discussed earlier in terms of their constraining effects on how municipalities are regulated in the Eastern Cape (point (iv) of sub-section 6.5.3). But the regulatory capacity of the DWA-RO is further constrained by a generic institutional problem of "regulatory bodies [being] captured by their reliance on the entities they regulate for the data they need to do their work" (Ferguson, 2012: 69). This problem can be understood as one of 'complexity capture' (Weber 2012: 661), which differs to the 'traditional capture' resulting from the "public's inability to monitor regulatory action". The conflation of the regulatory and service delivery functions of the SRVM adds another dimension to this 'complexity capture' (and is discussed in terms of the third policy recommendation in sub-section 8.4.3).

A further conclusion of this study is that the bureaucratic requirements and responsibilities placed on the SRVM and other Category B3 municipalities are onerous and overly-technocratic. This conclusion supports the argument of Siddle and Koelble (2012) that decentralisation in SA has resulted in a framework of *governance* being placed upon a sphere

of *government* that is incapable of fulfilling its duties. The dimensions of this problem pertain to institutional design (including the regulatory issues described above) and the constitutionally-enshrined independence of local government (which is discussed in sub-section 5.5.6 as a further governance challenge that constrains interventions). As such, SA's model of developmental local government can be located at position 3 on the simplicity cycle in Figure 2.2 (which is where Stirzaker et al. (2010: 602) characterise an idea as becoming over-complicated and when utility stagnates as a result). In order to increase utility, a model needs to be simplified in such a way that acknowledges the complexity of a given problem and then makes "the best simplifications we can" (*ibid*.). The aim is to find 'requisite simplicities', which avoid over-simplifying and escape becoming the 'panaceas' that Ostrom (2007, 2010) warns against. The three policy recommendations of this study (described in the following section) aim to be requisite simplicities of this kind.

8.4 Policy recommendations

The policy recommendations of this study are framed within the current institutional reform process that began with the National Water Policy Review in 2013 and extends to the 'General Water Laws Amendment Bill' (scheduled for promulgation in 2015, as introduced earlier in point (iv) of sub-section 5.5.4). The first two policy recommendations are aimed at national government, whilst the third recommendation specifically addresses challenges within the LSRV (which nonetheless are nationally-relevant).

8.4.1 Recommendation 1: Implement a clear emergency water heuristic

When faced with a limited supply of potable water, a water services institution (WSI) is required under the *Water Services Act* (RSA, 1997) to manage its available resources in order to ensure that basic levels of water supply and sanitation are always met. The operational implications of this requirement – as applied in the Kirkwood situation – are detailed in sub-section 7.6.2. In summary, a WSI should restrict water to all its supply zones to equitably provide these zones with adequate basic levels of services (according to Norm 3 of the Compulsory National Standards outlined in Box 5.2). These same standards also specify how a WSI must respond when the services it usually provides are interrupted for a period of more than 24 hours: namely, it must ensure that all consumers have access to alternative water services comprising at least 10 litres of potable water per person per day (as per Norm 4 in Box 5.2). This alternative quantity of water is referred to here as 'emergency water' (but could equally be called 'priority water' for the reasons discussed in sub-section 7.6.5).

Although the estimated demand for emergency water in the Greater Kirkwood area has exponentially increased between 2007 and 2014 (see Figure 7.39), the SRVM has only delivered limited emergency water and has implemented few water restrictions within the Greater Kirkwood WSS. The Compulsory National Standards (DWAF, 2002a) regarding the provision of emergency water and the implementation of water restrictions have not been translated into a clear diagnostic tool that supports decision-making at a municipal level and which enables accountability. Hence, the first recommendation of this study is to craft a diagnostic tool for this purpose. A summarised version of the proposed decision-making process for determining whether water restrictions should be implemented, and whether emergency water is required, is provided in Figure 8.1. The stepwise design is structured as a decision tree, drawing on heuristic-based decision-support theory (Gigerenzer et al., 1999), which offers complexity-based 'rules-of-thumb', rather than laws. By making explicit when water restrictions should be applied, the decision-making process outlined in Figure 8.1 could provide both the WSI and the communities it serves with the outline of a clear emergency response: namely, first to apportion available water to all zones via water restrictions, and secondly, to provide emergency water if water restrictions still fail to provide sufficient water to meet Norm 3. Lastly, the process could assist with providing indicators of what level of national government intervention is required into the functioning of a particular WSI, with the inability of a WSI to provide emergency water leading to an agreed-upon national government intervention.

8.4.2 Recommendation 2: Create a complexity-based national intervention strategy

The emergency water heuristic described in sub-section 8.4.1 should be part of a broader intervention strategy, as recommended here. The necessity for a national intervention strategy was referenced in sub-section 8.3.2, with the lack of a guiding intervention strategy evident throughout the attempted 'turnaround' of the SRVM from 2010 onwards. Any intervention strategy will need to address the constraints placed on national government interventions into local government by the *Constitution of the Republic of South Africa* (RSA, 1996a) – as discussed in sub-section 5.5.6. These constraints currently favour the autonomy of local government and mandate provincial government to oversee interventions.

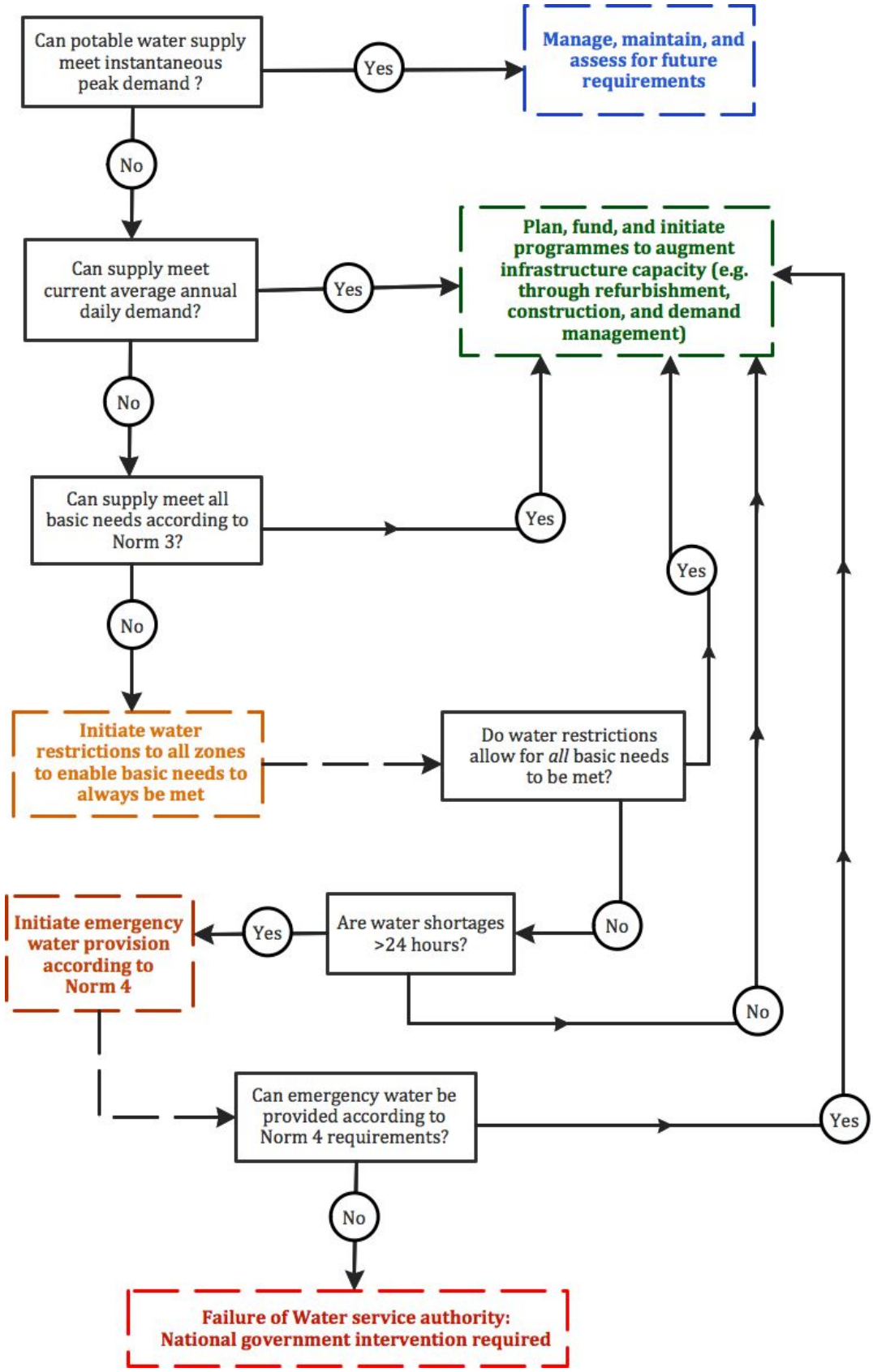


Figure 8.1: Draft flow diagram representing a proposed decision making process for determining whether water restrictions should be implemented and whether emergency water is required. Questions are contained in black boxes, whilst actions and responses are represented with dashed lines. The 'average annual daily demand' is the averaged demand (i.e. without accounting for a summer peak factor, typically set at 1.5, which is factored into the instantaneous peak demand). Norm 3 and 4 refer to the 'Compulsory National Standards' for Quality Water Services, as set by Department of Water Affairs (DWAF, 2002).

In order to create a coherent intervention strategy, the following is recommended:

- That an intervention strategy be produced for how national government will oversee interventions into local municipalities in South Africa;
- The Department of Water and Sanitation (previously called 'DWA') should lead the strategy development with the participation of the National Treasury and CoGTA;
- The strategy should be based on a 'requisite simplicities' approach, identifying clear intervention triggers (such as the proposed intervention trigger in sub-section 8.4.1); and
- The draft strategy should be crafted, made available for public comment, gazetted and piloted using a complexity-based form of evaluation (e.g. Patton, 2011), before being adapted and iteratively re-applied.

The intervention strategy should be conceptually underpinned by the acknowledgement that "*the act of trying to govern/manage/control generates system dynamics of its own*" (Richardson, 2011: 239 - emphasis in original). Because of the characteristics of complex systems (see sub-section 2.6.1), interventions lead to

> … multiplicative chains of unanticipated effects… [where] an intervention leads to unforeseen consequences, followed by apologies about the "unforeseen" aspect of the consequences, then to another intervention to correct the secondary effects (Taleb, 2012: 11).

A complexity-based intervention strategy would need to start with the above acknowledgements.

8.4.3 Recommendation 3: Address existing (and acknowledged) institutional gaps

A key insight of this study was the recognition of institutional gaps between the L-WUA and the SRVM, and within the water unit of the SRVM. These institutional gaps have manifested in problematic working arrangements between the L-WUA (as the bulk raw water supplier in the LSRV) and the SRVM (as the water service authority and the water service provider), and within the SRVM. The nature of the institutional gaps are analysed in this study as follows:

- In terms of a governance challenge affecting local water authorities in the LSRV (in sub-section 5.5.4);
- Drawing on ethnographic data in sub-section 6.3.4 and Box 6.3; and
- In section 7.4, where exploring the institutional gaps is recounted and analysed as part of the action research process.

The first institutional gap – the lack of institutional separation between the service provision and regulatory functions in the water services of the SRVM – is vital to addressing whether or not the municipal water unit is financially viable, or whether the SRVM municipal council needs to re-assess if the municipality has the capacity to perform the water service provider function (as described in sub-section 5.5.4(i)). The fourth system dynamics model demonstrated the contribution of financial mismanagement to the 'modes of failures of local government' (see sub-section 7.5.6).

The second institutional gap – the lack of operational and institutional agreement between the L-WUA and the SRVM – is also vital for bulk water supply in the LSRV. The L-WUA performs a particular function for the SRVM, namely, acting as the agency supplying raw water to the municipality. In terms of institutional design, the L-WUA is therefore a bulk water service provider (WSP) for the municipality (as described in sub-section 5.5.4). Over the course of the October 2012 research workshop facilitated in this study (see section 7.4), the participating actors agreed to focus on the concrete, operational issues affecting the Kirkwood water supply, and to work towards developing a contract between the actors. The proposal was to collaboratively draft an operational plan for the management of this system, drawing on the technical knowledge of the L-WUA staff and SRVM officials.

The L-WUA business plan stated the organisation's intentions to drive an operational support programme that would assist the SRVM (see Box 7.3). Collaborating is in both organisations' interest given the current National Water Policy Review (NWPR) (DWA, 2013b), which calls for the dissolution of water user associations with their powers and functions assumed by either catchment management agencies (CMAs) or regional water utilities. However, given that there is no established CMA in the Eastern Cape yet (as discussed in sub-section 5.5.4(iii)), and given that Amatola Water's operational area does not extend to the SRVM yet (sub-section 5.3.5), the L-WUA will most likely continue acting as bulk raw water supplier in the LSRV for the foreseeable future. It would be further in the L-WUA's interest to collaborate with the SRVM on the proposed operational agreement, given that one of the critiques of transformed irrigation boards in the NWPR is that they "have also failed in achieving the adequate participation of other users such as municipalities" (DWA, 2013b: 19).

8.4.4 Policy recommendations conclusions

One of the critiques levelled against the SA water sector is the tendency of managers, politicians, and policy makers to focus on "improving organisational arrangements and even institutional setups and legislation instead of giving implementation a chance" (Garduno, 2011: v). A dose of healthy scepticism is therefore required as to the sufficiency of "redesigning organisational architecture" (National Planning Commission, 2011: 7). Following the initiation of the NWPR process and the subsequent publication of the policy positions (DWA, 2013b), national government is now due to present the 'General Water Laws Amendment Bill' in the 2015 Parliamentary session (PMG), 2014a: 1). A sector-wide water act will still require translating into implementation plans, strategies, and norms and standards, and the requirement for capacity to regulate and support implementation will exist as it currently does. If the redesigned organisational architecture results in local government continuing 'up the complicated curve', then undersirable outcomes (such as the interconnecting modes of failure identified in this study) are likely to increase. If, on the other hand, the changes to the rules-in-form aim for requisite simplicities and adjust for the current design issues, then the current undesirable outcomes might possibly decrease. New undesirable outcomes will probably emerge, but such is the nature of policy and complex systems: the point is how the emerging outcomes are adjusted to, and used.

The SANPAD/TNP project advocates a learning-by-doing approach to integrated water resource management (IWRM), acknowledging that IWRM takes time (van der Zaag, 2005); is difficult and requires practice (Dent, 2012); and involves many issues outside of the water sector (Lenton & Muller, 2009). The tensions within the concept and practice of IWRM – as noted by Biswas (2008) and discussed in sub-section 2.2.2 – reflect the multiplicity of the demands on water resources along with the many perspectives on how water should be managed and governed. IWRM offers the best 'holding space' for the systemic thinking and practices that water management requires; hence, replacing IWRM with concepts of 'developmental water management' (as advocated by van Koppen and Schreiner (2014) for SA water management) seems unlikely to accomplish more than a rhetorical shift at the policy level. A learning-by-doing approach, in contrast, understands mistakes and challenges at the implementation level as useful feedback that provides opportunities for learning (Cilliers et al., 2013). System dynamics practitioners argue that we should use this feedback to "revise, improve, rescind, or better explain the rules" (Meadows, 2011: 137). This is where

case studies into strategic points of contention and difficulty are required, and where the study reported on in this thesis has aimed to make empirical and methodological contributions.

8.5 Transdisciplinary contributions of this study

The contributions of this study to the development of transdisciplinary, practice-based research are:

- Providing a substantively-contextualised case study that illustrates the value of systemic, engaged, extended, and embedded transdisciplinary research;
- The development and use of a 'thicker' form of thick description; and
- The initial development and proposal of a system dynamics modelling approach termed 'modelling in the muddled middle'.

This study has practiced transdisciplinary research in a particular way, namely, by undertaking a substantively-contextualised case study that is, systemic, engaged, and embedded. Each of these terms is defined here in relation to this study.

Contextualisation is a basic requirement of the case study research approach (Yin, 2009) and is a "non-negotiable" part of anthropological research practice (de Wet, 1998: 9). In addition to standard contextualisation practices, this study sought contextualisation as follows:

- Historically, via conducting an extended 'narrative of change' of the LSRV from the 19th century to the present, situating local-level developments within national and regional scales;
- Through conducting a governance analysis that assessed the processes and institutions by which decisions that affect water are made, therefore enabling the local-level dynamics to be contextualised within broader governance framings;
- By drawing on a breadth of primary and secondary data sources, collected from diverse sources; and
- By being located within a research project that assembled a transdisciplinary team and facilitated that team meeting regularly, enabling team members to discuss their work in relation to one another, and therefore to contextualise their reseach within the broader research themes.

The engaged, extended and embedded components of this research are interdependent and can be characterised as follows:

- ‘Engaged’ refers to the co-creation of knowledge with societal stakeholders and practitioners towards addressing ‘wicked’ problems;
- ‘Extended’ refers to the requirement to observe institutions-in-motion (i.e. institutional change over time, in response to developments at different levels including the state-initiated formal institutions and the operational situation on-the-ground) – and by doing so, avoiding snapshot analyses; and
- ‘Embedded’ refers to the practice of situating the research in a particular problematic context (rather than being embedded only in a geographic sense), and remaining in this context.

This research was ‘systemic’ in several ways. The research sought to explore events over time as indicators of system behaviour – rather than as discrete events – with the understanding that system behaviour emerges from a particular system structure (Meadows, 2011). Given that this underlying system structure can only ever be partially understood (Ison, 2010), all knowledge about complex systems is provisional. System dynamics modelling was employed to iteratively develop four models to explore the system structure of bulk water supply in the LSRV, with the model artefacts and modelling process forming part of a broader programme of systemic research (described further below).

The value of the overall methodology was demonstrated with the September 2014 protests in Kirkwood, where it was used as a meaning-making approach for reflexively exploring the context and reactions of stakeholders to the events at the time. This meaning-making approach had analytical and applied aspects that are consistent with how Bammer (2013: 18) distinguishes ‘synthesis’ from ‘integration’ in interdisciplinary research:

> ‘Synthesis’ is used for the bringing together of disciplinary and stakeholder knowledge… ‘Integration’ (and related terms) refers to the combination of the synthesised knowledge with a considered response to… the problem.

This study drew from disciplines across the humanities and the social, natural and technical sciences in order to synthesise disciplinary knowledge with the critical evaluation of stakeholders’ knowledge. Two particular methodological tools were developed and used in this study for synthesis purposes, namely, a ‘thicker’ form of thick description (discussed in section 6.6), and an adapted modelling approach (discussed in section 7.7). This section draws together the two earlier discussions of these approaches in order to emphasise their value as part of this transdisciplinary study.

The psychologist Steven Pinker (2014: 24-5) recently noted that in this era of 'social science', we have "become accustomed to understanding the social world in terms of "forces", "pressures", "processes," and "developments." It is easy to forget that those "forces" are statistical summaries of the deeds of millions of men and women who act on their beliefs in pursuit of their desires." The ethnographic tool of thick description provides an antidote to statistical aggregation, in that it brings to the fore the "voices, feelings, actions, and meanings of interacting individuals" (Denzin, 1989: 83). The tool fits with Agnew's (2011: 469) emphasis that water management is about "actual people who could do or who are doing things that affect other people." Likewise, ethnographic thick description enables a "focus on practical activity and practical knowledge in everyday situations" (Flyvbjerg, 2004: 296). Yet thick description has a particular interpretative angle, which extends back to its anthropological roots. Thick description was developed as a tool for cultural analysis, with the understanding that "the culture of a people is an ensemble of texts, themselves ensembles, which the anthropologist strains to read over the shoulders of those to whom they properly belong" (Geertz, 1994: 123-4). Every anthropological account – according to proponents of Geertzian thick description – is therefore an interpretation of interpretation (as discussed in sub-section 6.1.2). The interplay between research participants' and analysts' interpretations is suited to complexity analyses and policy issues. However, traditional Geertzian thick description excludes many socio-political and other contextual aspects in order to focus on the aesthetic (i.e. the cultural). In order to adjust for this weakness, this study incorporated institutional analysis into its thick descriptions (as described in sub-section 6.6.2). The second way in which this study 'thickened' thick description was the synthesised use of ethnographic analyses with systems analyses (see sub-section 6.6.3).

Secondly, this study developed a deeper understanding of site-specific modelling that drew on the ethnographic, embedded approach to fieldwork, and which did not rely on consensus-building or workshop facilitation. Following Horlick-Jones and Rosenhead (2007: 588), the modelling approach developed in this study adopted a process of 'methodological hybridisation' to use institutional, ethnographic, and systems approaches, showing how these approaches were selected and located within an evolving transdisciplinary methodology. The initial name for this approach – 'modelling in the muddled middle' – recognises where the modelling approach is aimed (i.e. in the muddled middle between policy design and the messy operational reality of implementation). Given that this modelling approach developed iteratively over the course of this study, it is posited here as a novel contribution to

transdisciplinary research that requires further analysis and exploration to be formalised (and is an 'area for future research' listed in section 8.7).

In summary, the combination of embedded fieldwork, thick description, institutional analysis, and systems analysis therefore offers an appropriate lens through which complex policy dynamics (such as the local government turnarounds and governance challenges affecting local water authorities) can be explored. Following Bammer (2013: 18), the integrative activities of this study can be understood as the combination of synthesised knowledge with considered responses to the problem dynamics of interest. These responses were 'structured' within a systemic action research process, which began in October 2011 and continued until November 2014 (see Timeline 7.1). The above-mentioned methodological innovations were iteratively developed over the course of the action research process and in response to the emerging dynamics in the case study. The iterative research approach aimed to strike a balance between the operational and the theoretical realms, and sought to ground the many threads, concepts and transdisciplinary discourses within a deeply-contextualised case study. By doing so, this study provides a substantive example of a complexity framing being used to explore intractability on-the-ground, in a way that has enabled engaged research and resulted in methodological development.

8.6 Reflexive critique of ethical considerations and study limitations

8.6.1 Ethical reflections

Ethical considerations at the level of research design were introduced in section 3.6, and were discussed in relation to the systemic action research process in sub-section 7.7.3. In this sub-section, a number of ethical considerations pertaining to the whole study are discussed as 'research tensions.' These tensions are unresolvable in their entirety, and are part of the nature of action research that engages wicked problems. This sub-section returns to a first-person narrative in order to discuss three ethical tensions.

(i) Dealing with privileged information:

Over the course of conducting participant observation in the LSRV between 2011 and 2014, I participated in (or attended) meetings and workshops where privileged information was shared, often between research participants in 'backstage exchanges' (Boden, 1994). These informal interactions were important parts of my data collection, but they also carried ethical implications in terms of how such interactions were represented in this thesis and what I could

(and could not) share with other research participants. Because of stakeholders' positions within their respective organisations and the relatively small network of people, anonymising sources of this information (in order to protect someone's identity) was inadequate. I accommodated for this tension by using the dynamics and issues that I was exposed to through these 'backstage exchanges' as sources of provisional insights: where possible, I sought documentation to support the insights, or found other research participants who were willing to speak openly about the issues. In situations where this was not possible, I chose to either record a perspective or interpretation anonymously (if it could not be traced), or to exclude it from my written analysis.

(ii) Personal involvement and action research:

An additional research tension developed out of my own 'progressive entanglement' in the LSRV case. As I became increasingly involved in the LSRV case, I found myself moving from the analytical role of 'observer' to the engaged role of 'participant' (as discussed in Box 6.7). This was partly relational, facilitated by my becoming acquainted at the personal level with research participants with whom I interacted less as subjects (sources of data) and more as agents (with their own histories, interests and drives). In doing so, I experienced the relevance of Principle 9 of the SANPAD project's 'Principles of Engagement' (see Box B.1), which emphasised respecting the agency of all participants. The primary tension came in negotiating how I interacted with participants in their personal and in their professional capacities when, for example, it *appeared* as if an informant was actively choosing to avoid (or not fulfil) a role that he or she was required to perform. Even more challenging was how to accommodate for accusations of corruption between and within organisations involved in this study (where corruption is understood as the "misuse of the office for private gain" (Iza & Stein, 2009: 97) (see Table 2.2)). I accommodated for these ethical tensions in the following ways:

1. By aiming to avoid prejudicial and reactive responses, especially to claims of corruption that I had no way of substantiating;
2. By contextualising research participants' actions and seeking alternative interpretations; and
3. By questioning the values and judgements that were colouring my own interpretations.

In addition, I tried to use the systems thinking principle of viewing contentious issues along continua, rather than in binary terms of 'right' and 'wrong' (Ison, 2010; Richmond, 1993,

1997). As Blasco and Wardle (2007: 119) note, there are obvious limits to self-reflexivity though, because "even authors who are explicit about the agenda they bring to their field research and to their writing are unavoidably selective in their reflexivity. They discuss some determining elements and not others". The SANPAD project team played an important role here. I often had my interpretations of field research challenged and problematised through participating in regular team meetings (described in sub-section 3.4.4) and through the active participation of all three of my supervisors, both academically and in the field (see section 3.6). Lastly, I found it useful to differentiate the roles of an action researcher from those of an investigative journalist: unlike an investigative journalist, my role as an action researcher was not to expose the 'truth' (whatever that may be) at any cost; rather, my role was to become embedded in a context and bring to bear a range of conceptual and methodological tools to the situations I encountered.

(iii) Ethical engagement and 'skin in the game':

When the Kirkwood protests occurred in September 2014, our research teams' first question was whether our (re)engagement in the SRVM could lead to harm – either to members of the research team (which includes masters and honours students) or to research participants. We initially chose not to get involved in the protests and subsequent interventions (for the reasons outlined in sub-section 7.6.1 and section B.10 of Appendix B). My reasons to remain uninvolved additionally included that I was in my final write-up for my thesis (see Box 6.8). But I experienced significant discomfort over these decisions: the municipality that was at the centre of my doctoral study was quite literally on fire – with a central grievance of protestors being water service delivery – and I sat 126km away, working on a systemic analysis of local government failure that used the Greater Kirkwood WSS as a case study. I was discomforted by the following question: was prioritising my academic requirements over trying to positively contribute to the situation in Kirkwood not unethical? I felt that I had benefited immensely from the participation of stakeholders in the LSRV in my research, and yet had contributed little except through facilitation and a few reports. Surely this was problematic? For Taleb (2012: 377), ethical questions hinge on "skin in the game", which provides a useful heuristic for assessing whether action researchers share some of the costs of extreme events, or whether they only benefit. If action researchers only benefit from writing about, or analysing case study occurrences in which they are involved, and in which research participants are harmed, then these researchers are perpetuating 'extractive research' (which is precisely what engaged research militates against). On the other hand, if action researchers are invested in a case study – and not just instrumentally – then they should bear some of the

costs of extreme events, if these events pertain to the research that they have undertaken in participation with stakeholders. These considerations are discussed here as a guiding heuristic, which formed part of the ethical evaluations of my own research, rather than as a law applicable in all situations. The ethical evaluations underpinned my decision to return to the field in October 2014, leading to the action research described in section 7.6. The evaluations similarly underpinned the SANPAD/TNP project teams' decision to synthesise current research and undertake to discuss research results with stakeholders in the LSRV in early 2015. My decision to undertake the first six months of my post-doctoral fellowship at Rhodes was also influenced by these evaluations. After the SRVM technical director and I presented together in November 2011 on the 'modes of failure' (MoF), we additionally arranged to present the *MoF* model and the associated analysis to municipal officials and stakeholders in early 2015 (discussed further in section 8.7 on 'areas for future research').

8.6.2 Study limitations

(i) Single case study in a Category B3 municipality:

The single-case design was selected for the reasons outlined in sub-section 3.3.3, which motivates for the focus and detail that a single case-design allows. The insights from this study will be applicable to other Category B3 and B2 municipalities in South Africa (see Table C.9 and sub-section 5.4.1 on municipal categorisations), particularly in the Eastern Cape. The study is limited in so far as it does not examine all categories of local government, and all aspects of local government service delivery.

(ii) Fieldwork focus on the municipality:

Whilst conducting fieldwork in the LSRV between 2011 and 2012, a focus developed in this study on the SRVM, with the primary interest in local water authorities in the LSRV examining the interaction between the L-WUA (L-WUA) and the municipality. As such, fieldwork was not conducted within the L-WUA offices in the same way it was in the municipal offices. Similarly, the analysis of water user associations focused on those associations that are converted irrigation boards, and not on all associations throughout SA. Lastly, fieldwork was not conducted within Amatola Water's offices.

(iii) Lack of comparative ethnographic cases from 'inside local government':

One of the challenges facing ethnographic studies of local government (as undertaken in this study) is the paucity of comparative cases. The vast majority of South African anthropologists have focused on relations between various communities and local government institutions (as

cited in Dubbeld, 2013), with far fewer ethnographies focusing on the internal functioning of local government. A possible factor influencing this discrepancy is the relative difficulty in securing access to professional organisations and municipal management (as discussed in the literature on ethnographies of elites (e.g. Adebanwi, 2014; Shore, 2002)). To compensate, comparative literature was used from the fields of anthropology of development (e.g. Crewe & Axelby, 2013); social anthropology (e.g. Bailey, 2001); the anthropology of infrastructure (e.g., Elyachar & Mains, 2012; Larkin, 2013; Merrit & Anand, 2011); and the anthropology of public policy (e.g. Wedel et al., 2005).

(iv) Limited ecological component of this study:

This study was located within a broader transdisciplinary project that was grounded in social-ecological systems approaches (see Appendix B). There is, however, a limited ecological component in this study, which is a result of the study being bound at the sub-catchment of the Lower Sundays River (see section 5.2). The LSRV is a profoundly-altered biophysical system, where the majority of the water that is utilised in the region is transported into the area via the Orange-Fish-Sundays inter-basin transfer scheme. The study is limited in so far as it focuses on users connected to the bulk water supply system, and does not address broader ecological issues or water resource users who abstract from the Lower Sundays River directly.

8.7 Areas for future research

8.7.1 Expand on, validate, and further use the 'Modes of Failure' model

Key limitations of the *MoF* system dynamics model have been identified (as listed in sub-section 7.5.6(v)). These limitations could be addressed through further validation with municipal officials and other research participants. Furthermore, insights from the *MoF* model could be synthesised and explored in relation to other theses and work-in-progress studies in the SANPAD/TNP team (e.g. Molony, 2014; Muller, 2013).

8.7.2 Evaluate the 'modelling in the muddled middle' approach

The modelling approach developed iteratively developed over the course of this study was analysed in sub-section 7.7.2 and posited as a novel contribution to transdisciplinary research that requires further analysis and exploration to be formalised (section 8.5). The approach could be evaluated in comparison to published accounts of combined soft-systems methodology and system dynamics, such as 'holon dynamics' (Lane & Oliva, 1998) and 'soft system dynamics methodology' (Rodriguez-Ulloa & Paucar-Caceres, 2005). The use of the

combined ethnographic approach and system dynamics modelling could also be evaluated in terms of a problem structuring method (Mingers & Rosenhead, 2004).

8.7.3 Exploring links between the anthropology of infrastructure and overlapping fields

Whilst a burgeoning sub-discipline known as the 'anthropology of infrastructure' has recently developed (e.g., Elyachar & Mains, 2012; Larkin, 2013; Merrit & Anand, 2011), little South African work on the subject has been completed as of yet, barring von Schnitzler (2008). Furthermore, a fertile overlap exists between this sub-discipline and socio-technical systems thinking (e.g., Bruijn & Herder, 2009; Koopenjan & Groenewegen, 2005), and social-ecological systems thinking and research (e.g., Gunderson & Holling, 2002). Exploring the overlaps and tensions between these fields could provide productive insights.

8.8 Conclusion

> We can't surge forward with certainty into a world of no surprises, but we can expect surprises and learn from them and even profit from them. We can't impose our will on a system. We can listen to what the system tells us and discover how its properties and our values can work together to bring forth something much better than could ever be produced by our will alone. We can't control systems or figure them out. But we can dance with them! (Meadows, 2011: 169-170)

This study has sought to explore and understand the use of transdisciplinary research in engaging local water authorities in a process of institutional change and, in so doing, to increase the likelihood of equitable water supply in the LSRV region of South Africa. The findings and insights from this study have sharpened our understanding of how we (as a country and as a water sector) appear to be heading in the wrong direction. South Africa's turbulent history plays a part, of course. But the aspiration of systems thinking and practice is to locate responsibility within systems in order to explore and learn from the endogenous drivers, rather than blaming external or historical influences outside of one's control. As Meadows (2011: 169) notes in the above quotation, uncertainty and undesirable outcomes do not have to lead to pessimism, because, if we are prepared, we can learn from surprises and failures, and "even profit from them."

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(Note: all references cited in the appendices are included in the reference list in VOLUME 1).

Appendix A Data sources

Table A.1: Case study individuals interacted with over the course of this research. (Form of contact: I = interview; E = email discussion; D = documents provided; R = regular discussions / interactions; P.I. = phone interview; Key 'research informants' are shaded gray)

	Organisation and position	Form of contact	Date(s):
A:1:1	Department of Water Affairs, Eastern Cape Regional office (DWA-RO)	I	07 / 2012
A:1:2	DWA-RO – Technical Regulations sub-directorate	I; P.I.; D	11 / 2011 07 / 2012
A:1:3	Cacadu District Municipality, Technical Manager water services	I	02 / 2012
A:1:4	Amatola Water (2011-2012); Consultant (2012-2013)	R; D	2011 – 2013
A:1:5	Amatola Water senior manager	I	08 / 2011; 01 / 2012
A:1:6	Amatola Water manager	R	2011 – 2012
A:1:7	SRVM: Technical services staff	R; D	2011 - 2014
A:1:8	Development Bank of Southern Africa (now Municipal Infrastructure Support Agency) engineer	R; D	2011 - 2014
A:1:9	SRVM, Water and Sanitation Supervisor	R	2011-2013
A:1:10	SRVM, Acting Technical Director (2011-2012)	R	2011 - 2012
A:1:11	Engineering Consultancy 1	R	2012
A:1:12	DWA, Hydrologist specialist	P.I.	07 / 2012
A:1:13	Emerging Farmer's Association	P.I.	10 – 2011
A:1:14	SRVM – Counsellor 1	I	12 / 2011
A:1:15	Nyembezana Cooperative	I	02 / 2012
A:1:16	Chairman of the Kirkwood Ratepayers' Association (RPA)	I; R; D	2011-2014
A:1:17	Farmer's Association	P.I.; I	11 / 2011
A:1:18	Sundays River Citrus Company (SRCC)	I	02 / 2012
A:1:19	Citrus farmer; Board member of the SRCC	R	2011-2013
A:1:20	Lower Sundays River Water User Association (L-WUA), C.E.O.	I; D; R	10 / 2011 2011 – 2013
A:1:21	SRVM, Financial Division	I	11 / 2011; 02 / 2012
A:1:22	SRVM: Counselor 2 and 3	R	2012 – 2013
A:1:23	RRU (DWA) – Head coordinator	P.I.; R	11 – 2011; 01 – 2012
A:1:24	Consultant – Rapid Response Unit (DWA)	E; D; R	2012 - 2013
A:1:25	Members of the Sundays River Business Chamber	R; D	2013 - 2014
A:1:26	Manager – Luthado Farm (Sundays River Farming Trust)	I	2014

Table A.2: Other important empirical data collected

	Source	Specification of data type	Organisation(s) involved	Primary data collection method	Date (month and year)
A:2:1	Assessment	Blue Drop assessment for drinking water quality	Assessment by DWA of SRVM	Direct observation	11 / 2011
A:2:2	Assessment	Regulatory Performance Management System assessment	Assessment by DWA of SRVM	Direct observation	11 / 2011
A:2:3	Workshop	Rapid Response Unit (RRU) hosted workshop on blue and Green drop programmes	RRU; Amatola Water; SRVM Technical, Financial, and Community health officials	Direct and participant observation	02 / 2012
A:2:4	Meeting	SANPAD-project facilitated meeting regarding the RRU engagement in SRVM	Amatola Water; RRU representatives (for DWA); SRVM	Participant observation	02 / 2012
A:2:5	Focus group discussion	Interview of 3 cooperative members	Onojawolo Cooperative	Group interview	11 / 2011
A:2:6	Focus group discussion	Interview of 5 cooperative members (5 pax)	Oyisa Cooperative	Group interview	11 / 2011
A:2:7	Focus group discussion	Interview of 5 cooperative members	Vusumuzi Cooperative	Group interview	11 / 2011
A:2:8	Focus group discussion	Interview of 5 cooperative members	Nyembezana Cooperative	Group interview	11 / 2011
A:2:9	Focus group discussion	Interview of 6 cooperative members	Gananga Cooperative	Group interview	11 / 2011
A:2:10	Meeting	3-monthly review of cooperatives	SRVM Technical and Financial divisions; Cooperatives	Direct observation	02 / 2012
A:2:11	Meeting	Introductory meeting between new SRVM municipal manager and SANPAD project	SRVM Municipal Manager & SRVM Technical Director	Participant observation	08 / 2012
A:2:13	Meeting	Project initiation meeting for the Basic Infrastructure	SRVM Municipal Manager; representatives from all cooperatives	Direct observation	11 / 2011
A:2:14	Project steering committee meetings (x3)	Paterson Bulk Water scheme	DWA; Amatola Water; SRVM; Engineering consultancy	Direct observation	11 / 2011; 02 / 2012 06 / 2012
A:2:15	Workshop	SANPAD-hosted Strategic Adaptive planning (SAP) workshop 1	AW; SRVM	Direct observation	10 / 2011

Table A.2 (continued): Other important empirical data collected

	Source	Specification of data type	Organisation(s) involved	Primary data collection method	Date (month and year)
A:2:16	Workshop	SANPAD-hosted SAP workshop 2	DWA; AW; L-WUA; SRVM; RRU; Cooperatives	Direct observation	12 / 2011
A:2:17	Workshop	Use of Geographical Information Systems (GIS) in LSRV	DWA; L-WUA; SRVM	Participant observation	05 / 2012
A:2:18	Workshop	On the WUA-SRVM 'governance gaps'	DWA; AW; L-WUA; SRVM; RRU; DWA consultant	Facilitating; Participant observation	10 / 2012
A:2:19	Workshop	SANPAD research workshop	SRVM Technical Directorate	Facilitating; Direct observation	02 / 2013
A:2:20	Workshop	Planning workshop on expansion of Kirkwood water treatment works	AW; L-WUA; SRVM Technical Directorate; DWA-appointed consultant; Kirkwood Ratepayers' Association; Sundays River Business Council	Participant observation	02 / 2014
A:2:21	Meeting	Follow up to WUA-SRVM governance gap workshop	RRU; SRVM and L-WUA	Participant observation	02 / 2013
A:2:22	Research interview	Interview for Economics masters project	L-WUA	Facilitating; Direct observation	05 / 2014
A:2:23	Meeting	RRU planning meeting	RRU; COGTA	Participant observation	01 / 2012
A:2:24	Meeting	SRVM – Makana municipality meeting regarding the engagement of the SANPAD project	SRVM Counselor (P. Blou); consultant for SRVM; officials from the Makana municipality	Participant observation	02 / 2013
A:2:25	Meeting	Weekly meeting of the L-WUA	L-WUA – Technical officers and staff members	Participant observation	11 / 2011
A:2:26	Meeting	Emergency meeting of farmers and businesspeople following Kirkwood burning	Sundays River Citrus Company, 4 packhouse owners; Kirkwood Ratepayer's Association; Sundays River Business Council	Facilitating; participant observation	10 / 2014
A:2:27	'Water dialogue'	Workshop with conference-style presentations	Water Research Commission, DWA, SRVM, DBSA and SANPAD researchers	Participant observation	11 / 2014

A.3: Summary of primary sources drawn from to ascertain the rules-in-form

Table A.3: Summary of most important legislation discussed in this study (excluding amendments)

Name	Number and Year	Description
National Water Act (NWA)	Act No. 36 of 1998	Outlining how water resources must be 'protected, used, developed, managed and controlled for the benefit of all persons'
Water Services Act (WSA)	Act No. 108 of 1997	Division of roles and responsibilities for water services between local and national government and regional utilities (i.e. water boards)
National Environmental Management Act	Act 107 of 1998	-
National Environmental Management: Biodiversity Act	Act 10 of 2004	-
Local Government: Municipal Demarcation Act	Act No. 27 of 1998	
Local Government: Municipal Structures Act	Act No. 117 of 1998	-
Local Government: Municipal Systems Act	Act No. 32 of 2000	-
Local Government: Municipal Finance Management Act	Act No. 56 of 2003	-
National Environmental Management Act	Act No. 107 of 1998	Overarching legal framework for the environmental protection in South Africa (relevant for IWRM)
Division of Revenue Act	Annual	Financial (informing amount of Equitable Share that SRVM receives)
Development Facilitation Act	Act No. 67 of 1995	Requires Integrated Development Plans (IDPs) of municipalities
Constitution of the Republic of South Africa	Act No. 108 of 1996	Water related rights contained in the 'Bill of Rights' (Chapter 2) and local government enshrined as 3rd sphere of government.

Table A.4: Summary of national and local policies discussed in this study

Name	Year	Description
White Paper on Water Supply and Sanitation	1994	-
White Paper on a National Water Policy for South Africa	1997	-
White Paper on Local Government	1998	Asserted 'developmental local government' and provided the outline of the roles and responsibilities of the newly-established third sphere of government.
Strategic Framework for Water Services	2003	DWA implementation framework (*recognised as both policy and strategy by DWA*)
Sundays River Valley Municipality (SRVM) Indigent Policy	2009	Policy outlining how the SRVM identifies municipal residents as 'indigents' - i.e. qualifying for Free Basic Services.
National Water Policy Review	2013	Release of DWA Policy Positions, aiming to bridge NWA and WSA implementation divides.

Table A.5: Strategies, implementation plans, and 'norms and standards' discussed in this study

Name	Year	Description
South African National Standards 241 (SANS 241)	2012	National standards for drinking water quality
Strategic Framework for Water Services	2003	DWA implementation framework (*recognised as both policy and strategy by DWA*)
National Water Resource Strategy 1	2004	Implementation strategy for the NWA of 1998 (water resource protection and management)
National Water Resource Strategy 2	2012	Draft revised strategy (first edition) released in August 2012
National Water Resource Strategy: Water for an Equitable and Sustainable Future	2013	National Water Resource Strategy 2 (second edition): released in June 2013
Compulsory National Standards; Norms and Standards for Water Services Tariffs; Water Services Provider Contract Regulations	2002	Guidelines provided by DWA for regulatory purposes
Compulsory National Standards and Measures to Conserve Water	2001	DWA regulations
Constitution of the Lower Sundays River Water User Association	2003	Institutional arrangement and rules of the association and its members
Local Government Turnaround Strategy	2009	Department of Cooperative Governance and Traditional Affairs strategy to address dysfunctional aspects of local government

A.6. List of additional data sources used in the System Dynamics modelling:

Hydrological data on water resources in the Lower Sundays River Valley River Valley:

Department of Water Affairs and Forestry, South Africa. (2005). *Fish to Tsitsikamma Water Management Area: Fish to Sundays Internal Strategic Perspective*. Prepared by Ninham Shand in association with Umvoto Africa, on behalf of the Directorate National Water Resource Planning. DWAF Report no. P WMA 15/000/00/0405.

Reports on the Greater Kirkwood water supply infrastructure by Sundays River Valley Municipality:

Sundays River Valley Municipality. (2010a). 'Chapter 5: Water Services Infrastructure Profile', *Water Services Development Plan: January 2010 Review*. Kirkwood, South Africa

Demand information:

Statistics South Africa. (2012). *Census 2011 Municipal fact sheet* (p. 51). Pretoria.

Sundays River Valley Municipality. (2010b). 'Chapter 2: Service Level Profile', *Water Services Development Plan: January 2010 Review*. Kirkwood, South Africa

Sundays River Valley Municipality. (2011). *Integrated Development Plan (IDP): 2011-2016 (5 Year Plan)*. Available at: http://www.dwa.gov.za/Dir_WS/WSDP/WSDP/UserControls/WSDPDownloadAttachment.aspx?id=1041 [Accessed: 01/12/2012].

Reports by the Rapid Response Unit of the Department of Water Affairs (Eastern Cape province):

Slabbert, D. (2012). *Sundays River Valley Municipality – Kirkwood – Additional Raw Water Storage Pond: Report*. Rapid Response Unit, Department of Water Affairs.

Wegelin, W.A., Siqalaba, Z., and Zondo, N. (2012) *Development of a First Order Water Conservation and Water Demand Management Strategy and Business Plan for Sundays River Valley Local Municipality*. WRP Consulting Engineers, consulted under the Department of Water Affairs, Rapid Response Unit (March 2012).

Documents and other information from the WUA:

Annual report – 2010-2011: (Lower Sundays River Water User Association (L-WUA), 2011)

Annual report – 2011-2012: (Amatola Water, 2012)

Information pamphlet: (Lower Sundays River Water User Association (L-WUA), 2007)

Constitution: Lower Sundays River Water User Association (2003). *Constitution*. Sunland

Lower Sundays River Water User Association. (2012). *Lag Times for Supply to Sundays River Municipality*. Personal correspondence with the Chief Executive Officer of the Lower Sundays River Water User Association.

Appendix B Summary of the wider transdisciplinary research context

B.1. Overview

The broader context of this study lies between two interrelated, transdisciplinary research initiatives. The first is a research project entitled 'From policy to practice: enhancing implementation of water policies for sustainable development', that was primarily funded by the South Africa Netherlands Research Programme for Alternatives in Development (SANPAD) and which technically ended in April 2013; the second initiative is a research project entitled 'Towards a New Paradigm for Integrated Water Resource Management in South Africa', primarily funded by the Water Research Commission (WRC), which built off the SANPAD project and is funded till 2017. Important dates pertaining to the development of these projects, and the transition from the first into the second project, are contained in Timeline B.1.

B.2. Description of overall SANPAD project

The SANPAD project grew out of a collaboration between South African and Dutch universities. The goal of the SANPAD project was "to provide both a process and a product that will move transdisciplinary and complexity thinking into Integrated Water Resource Management practice" (Palmer, 2011: 1). The primary objective was to produce a guide to working with complex water management problems, in the form of a compendium of methods, concepts, perspectives and processes. The guide would be drawn from the experiences and training of the researchers involved, and be 'field-tested' in three case studies. Each case study involved multiple researchers from different academic backgrounds, with primary specialisations in the following disciplines: freshwater ecology; policy analysis; engineering; environmental science; environmental education; economics; management; information systems; geography; hydrology; and anthropology (Palmer et al., n.d.). The project was designed to facilitate interaction between researchers both within, and between, the case studies.

Timeline B.1: Important dates in the wider transdisciplinary research context, with emphasis on the Eastern Cape case studies.

Year	Month	Description
2010	November	The transnational funding agency, the South Africa Netherlands Research Programme for Alternatives in Development (SANPAD), hosts a project proposal workshop in Den Haag, the Netherlands (proposes 'water and sustainability' theme).
2011	April	Initiation of the SANPAD water project, entitled 'From policy to practice: enhancing implementation of water policies for sustainable development' under the international leadership of Prof. Tally Palmer
	June-July	Project initiation and planning workshop for the SANPAD water project (Delft University of Technology, the Netherlands), attended by representatives from nine universities from South Africa, Ireland, and the Netherlands.
	October – December	First research workshops hosted in the Lower Sundays River Valley: facilitated using the Strategic Adaptive Planning process of Rogers and Luton (2010.
2012	October	Second overall SANPAD project workshop, with all three case studies contributing (Grahamstown)
2013	April	SANPAD project finishes and 'Towards a New Paradigm' (TNP) project, funded by the Water Research Commission (WRC), begins.
		Makana Municipality case study initiated, following-on from research with the Sundays River Valley Municipality in the Lower Sundays River Valley.
2014	August	'Methods Mirroring Workshop' hosted by the TNP project with participants from
	November	WRC hosts 'Water Dialogue' on the TNP project, featuring case studies including the SRVM: SRVM case study focuses on Kirkwood burning.

The SANPAD project aimed to contribute substantively in the case studies themselves, striving to do the following:

1. Loosen problem spaces that have many interdependent, controversial, complex and uncertain elements
2. Co-create knowledge with stakeholders and problem-holders
3. Enable and empower action and mobility.

The team members of the SANPAD research project committed to following nine 'principles of engagement', which were drawn from a previous transdisciplinary project led by Professor

Palmer in Australia. These nine principles are summarised in Box B.1, ahead of a conceptual model of the project structure being presented in the following section.

Box B.1: Principles to which members of the broader transdisciplinary research project committed. Source: Rhodes University (2013: 88)**.**

Principle 1: Tolerate discomfort and unresolved tensions as they are often a gateway to a new level of knowledge, understanding, and trust.
Principle 2: Be sensitive to "aha" moments (insights), they emerge out of irritation as often as from consonance.
Principle 3: Engage with balanced generosity: enquiring, listening and sharing. Managing contribution and constraint is closely linked to listening.
Principle 4: Practice tolerance and trust – exploring the nature of conflict before making judgements.
Principle 5: Be sensitive to "arrivals" – physical and meta-physical – ideas, opportunities and people "arrive".
Principle 6: Create and use reflective opportunities.
Principle 7: Manage discontinuities (e.g. time intervals, purpose, discipline focus, team composition).
Principle 8: Sustain enquiry – engage in the concrete question, sustain reading, discourse and attention.
Principle 9: Remember that everyone involved in the research is a multi-faceted person, with the potential to engage with their whole self and many ways of knowing.

B.3. Conceptual model of project structure

In 2011, the SANPAD project team developed an agreed conceptual model for the project (summarised in the diagram in Figure B.1). The left-hand column presents the integrative concepts that acted as the 'intellectual scaffolding' for the project: these concepts all carried associated methods – with the exception of Critical Realism, all of these concepts were presented and discussed in Delft. The top horizontal block of the diagram draws from an understanding of path dependency and the importance of history in complex systems, and provides some of the basic questions that were explored in each of the three case studies that were selected. The hierarchy of disciplines as conceptualised by Max-Neef (2005) was used within each case study, beginning with empirical knowledge (what is?), towards pragmatic and selective knowledge ('what are we capable of?), through to normative knowledge ('what do we want to do?'), and at the highest level, exploring values-based and ethical knowledge ('how do we do what we want to do?').

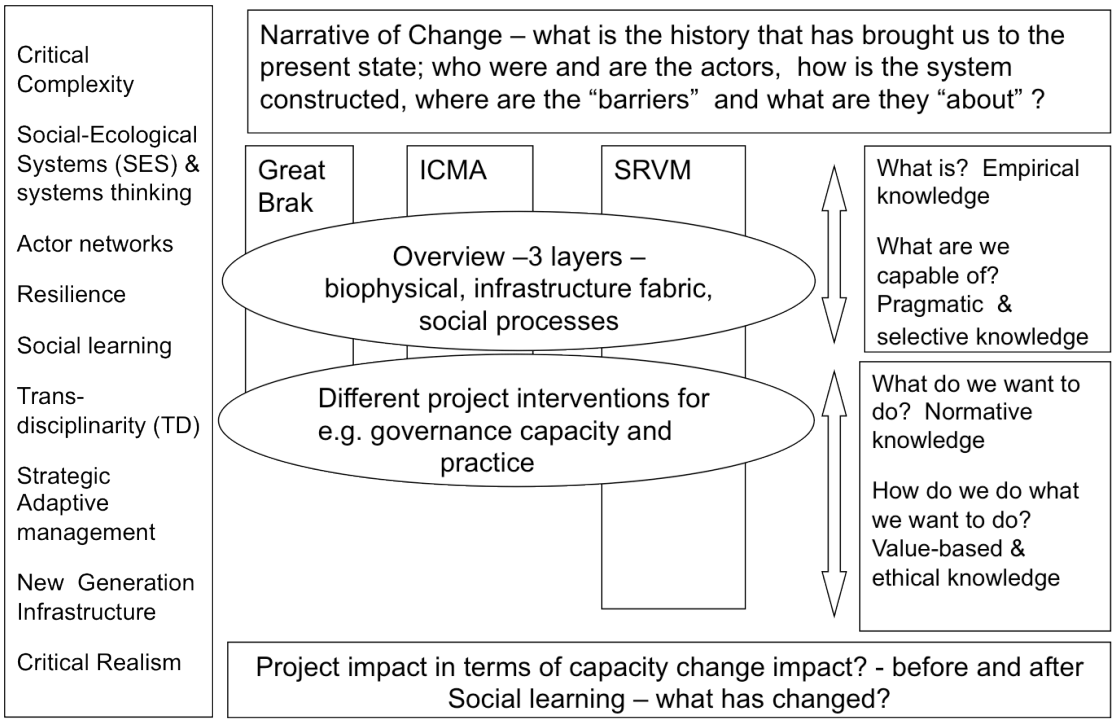

Figure B.1: Conceptual model of project structure. Source: Rhodes University (2013: 88).

B.4. Overview of the three case studies in the SANPAD project

The three case studies selected in the SANPAD project operated at different scales of water management and governance in South Africa. The Great Brak case study operated at the smallest scale, focusing on the management of an estuary at the biophysical scale of a river reach, where the IWRM challenge pertained to releases made from an upstream dam. The Inkomati Catchment Management Agency (ICMA) was the broadest, transboundary scale, whilst the SRVM was at the sub-catchment scale.

B.5. Selection of Sundays River Valley Municipality as the Eastern Cape case study

The SANPAD project first pitched the concept of an Eastern Cape case study to Amatola Water in May 2011 (further described in sub-section 3.4.2). A core aim of the SANPAD research project was to co-research with problem holders on a real-world problem, engaging 'problem holders' as partners in the research process. The Amatola Water officials selected their organisation's involvement in the 'turnaround' of the SRVM as a sufficiently complex problem for the SANPAD project to engage in, thus beginning the intervention process.

B.6. Description of the early research workshops in the Sundays River Valley Municipality in 2011

One of the initial research tasks of the SANPAD project was to host two multi-stakeholder workshops in the LSRV, using a Strategic Adaptive Planning process, following the practice of strategic adaptive management developed by Rogers and Luton (2011). The first workshop (held in October 2011), included representatives from two primary research partners – Amatola Water and the SRVM – in addition to SANPAD project researchers who facilitated the workshop. A wider group of stakeholders was then invited to participate in the second, follow-up workshop. At this workshop, four 'knots' were identified and discussed (see Figure B.2).

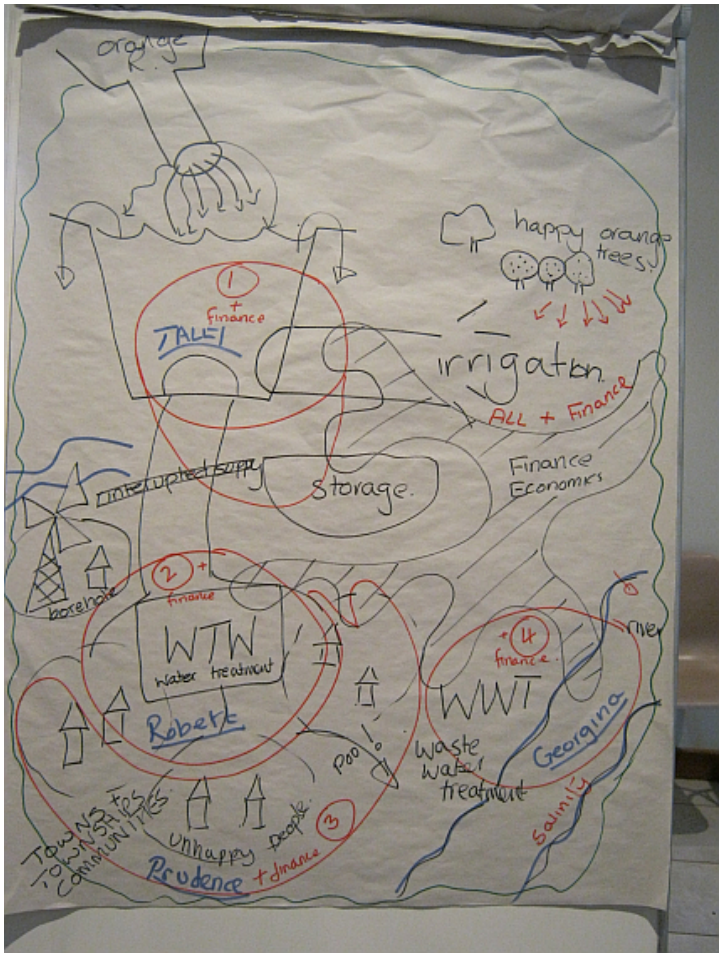

Figure B.2: Overall image of problem manifestations (water management knots) as drawn on a flipboard at the second Strategic Adaptive Planning workshop in the Lower Sundays River Valley (Palmer and Rogers, 2011)

B.7. Explanation of the 'knot' metaphor:

Box B.2: Explanation of the knot metaphor (as first described at SANPAD research workshop, referenced in Table A.2 – A:2:16).

> "Have you ever walked along a beach and picked up a piece of tangled fishing line? Perhaps with some seaweed and a fish hook mixed in? Have you started to pick at it – seeking to untangle it? As you pull on a piece of line – the line tightens elsewhere and it is hard to see where to start, and what is connected where. The first step is to loosen – to pull at the knotted pieces until a place to unravel becomes apparent. We liken difficult water problems to the knotted fishing line, and our research process to the loosening process. Loosening is followed by some unravelling, which we see as the opening of opportunities to reduce tangles and engage with problem areas. This loosening and unknotting takes time, patience, attention and nimble fingers."

Critique of the use of metaphors:

As Jeffrey (2003: 549) notes, "there is a long-standing and detailed literature concerning [the use of metaphor] as an aid to understanding and thought." Metaphors are useful in transdisciplinary research both as a tool for explanation and query, and as a means of providing common themes for participants to return to, and build onto, over the course of a research process. The knot metaphor evolved into what Jeffrey (2003: 449) refers to as a 'dominant metaphor' both in the SANPAD project and in this study reported on in this thesis: it was used on numerous occasions to illustrate different points, with several stakeholders involved in the case study also employing it in conversations and collaborations. The second metaphor that features throughout this thesis is that of fire-fighting (drawing from a description by municipal technical officials of how they perceived their roles – see Figure 6.4 and the associated description). As with diagramming, metaphors are inherently limited representations of complex phenomena, which can be misunderstood and become harmful to the research process, or detrimental to the presentation of the research when inadequately explained and qualified.

B.8. Evolution of the SANPAD project into the 'Towards a New Paradigm' project

Palmer summarised the vision of the TNP project as follows:

> The vision of this project is that engaged research – undertaken within an understanding that people in catchments comprise complex social ecological systems – which uses appropriate complexity- and systems-based approaches and methods, could result in a deeper embedding of these approaches and practices in

Integrated Water Resource Management (IWRM) in South Africa (Rhodes University, 2013: 77).

The themes of the TNP project are:

- Water resource protection
- Eutrophication
- Microbial pollution in relation to human health

These themes are investigated through three core case studies that, following the SANPAD project, operate at different scales and in diverse contexts (case study details are available from Rhodes University (2013)).

Table B.1: Programme for the Water Dialogue hosted by the Water Research Commission, in Johannesburg, South Africa on 13/11/2014.

PROGRAMME		
10:00 – 11:00	**Registration** and coffee	
11:00 – 11:15	**Welcome** and introductions	Mr Dhesigen Naidoo, CEO, WRC
11:15 - 11:35	**Opening Address**	Representative: DWS
11:35 – 11:55	**Ministry Perspective**	Deputy Minister Pamela Tshwete
11:55 – 12:55	**Narratives of hope**: What is this journey "towards a new paradigm" of IWRM practice? Kirkwood burning: happy oranges and unhappy people in the Sundays River Valley. How can this be hopeful? The Makana Municipality: from provincial administration to empowerment.	 Professor Tally Palmer Jai Clifford Holmes and partners from the Sundays River Valley Nick Hamer and Partners from the Khulumani Support Group: Water for Dignity & Unilever SA
12:55 – 13:45	**Lunch** **Conversations: The Crocodile River Catchment, with Dr Victor Munnik & stakeholders**	
13:45 – 14:05 14:05 – 14:25 14:25 – 14:35 14:35 – 14:55	**Narratives of hope**: The Inkomati-Usuthu Catchment Management Agency – Strategic Adaptive Management The Berg River co-operative process Resilience to stress in the Olifants River Citizen science: Mini-SASS and the Duzi-Umgeni Conservation Trust (DUCT)	 Professor Kevin Rogers and Dr Thomas Geydu-Ababio -IUCMA A stakeholder view Dr Sharon Pollard and partners from the Olifants Dr Mark Graham and partners from the Umgeni River catchment
14:55 – 15:45	**DISCUSSION** **Emerging principles from this practice and a way forward**	Prof Tally Palmer and an invited discussant to lead discussion
15:45 – 16:00	**Closure**	**Dr Jennifer Molwantwa, WRC Research Manager**

B.9. Presentations made:

Table B.2: Summary of academic presentations over the course of this study

	Title and date (month/year)	Event name	Event type	Co-presenter(s)
1.	A transdisciplinary investigation of an implementation barrier to sustainable water resource management by Amatola Water (05/2011)	Department of Anthropology 'Scope & Methods' seminar	Thesis proposal presentation	-
2.	Case 1 – Sundays River Valley Municipality (SRVM) (06/2011)	SANPAD project initiation workshop, Delft, the Netherlands	Presentation	-
3.	Masters study with the Sundays River Valley Municipality (01/2012)	Institute for Water Research 2012 Open Day	Presentation	-
4.	A transdisciplinary approach to working with the complexity of implementation in the Sundays River Valley Municipality (04/2012)	Policy Analysis division, Faculty of Technology, Policy and Management, TU Delft	Seminar presentation	-
5.	Water in the Sundays River Valley Municipality (05/2012)	Lecture to Environmental Science 201 class	Lecture	-
6.	What a Tangled Web We Weave – Unravelling the strands of a South African water problem (06/2012)	2012 Benelux System Dynamics conference, Delft, the Netherlands	Peer-reviewed conference: Plenary presentation	J.H. Slinger (first author)
7.	Institutional and system complexity in the Turnaround of the SRVM water services (10/2012)	Complexity Forum, Stellenbosch University	Symposium: 'Speed talk'	
8.	Governance Gaps and Opportunities in Engaging Local Government (04/2013)	South African Programme for Ecosystem Change and Society (SAPECS) Symposium:	Symposium: 'Speed talk'	
9.	Institutional complexity and the provision of water services in the Lower Sundays River Valley (05/2013)	Lecture to Environmental Science 201 class	Lecture	
10.	Water and land in 20th century South Africa (05/2013)	History Honours Agrarian Studies seminar	Seminar presentation	

Table B.2 (continued): Summary of academic presentations over course of this doctoral study

	Title and date (month/year)	Event name	Event type	Co-presenter(s)
11.	Governance Gaps and Operational Opportunities: Water User Associations and the Challenges of Municipal Bulk Water Supply (07/2013)	3rd Southern African Young Water Professional's Conference, Stellenbosch, SA.	Peer-reviewed conference	C. de Wet, J.H. Slinger, & C.G. Palmer
12.	Addressing Stakeholder Conflicts in Rural South Africa Using a Water Supply Model (07/2013)	31st International Conference of the System Dynamics Society, Cambridge, USA.	Peer-reviewed conference: poster presentation	F. D'Hont (first author) & J.H. Slinger
13.	'Water everywhere, but not a drop to drink': the supply-demand gap in Kirkwood water services (08/2013)	Short Course in System Dynamics Modeling, Stellenbosch University, SA.	Short course	A. Guyot-Staal & M. Davies
14.	Mediated modelling in the Sundays River Valley Municipality	Institute for Water Research 2014 Open Day	Presentation	-
15.	Water Services in a Small South African Municipality: An Ethnography of Interventions as part of a Transdisciplinary Research Project (07/2014)	2014 Anthropology Southern Africa Conference, Grahamstown, SA	Peer-reviewed conference	-
16.	Using System Dynamics to Explore the Water Supply and Demand Dilemmas of a Small South African Municipality (07/2014)	32nd International Conference of the System Dynamics Society, Delft, the Netherlands	Peer-reviewed conference	J.H. Slinger, J. Musango, A. Brent & C.G. Palmer
17.	System Dynamics and Ethnographic Analysis (08/2014)	'Mirroring Workshop', Grahamstown, SA	Research workshop	-
18.	Engaging the challenges of municipal water service delivery using system dynamics (11/2014)	2nd Annual Eskom System Dynamics Conference, Johannesburg, SA	Peer-reviewed conference	J.H. Slinger & C.G. Palmer
19.	Kirkwood Burning: happy oranges and unhappy people in the Sundays River Valley. How can this be hopeful? (11/2014)	Water Research Commission 'Water Dialogue', Johannesburg, SA	Presentation	SRVM technical director & Farmer / businessperson

B.10. Initial response of the TNP project to Kirkwood service delivery protests in September 2014:

UNILEVER CENTRE FOR ENVIRONMENTAL WATER QUALITY
amanzi amyoli

INSTITUTE FOR WATER RESEARCH
Rhodes University
PO Box 94
GRAHAMSTOWN
6140 SOUTH AFRICA
IWR

25th September 2014

To senior management in the Water Research Commission and the Department of Water and Sanitation:

You will know the Kirkwood municipal offices were burned on Tuesday and that further actions are anticipated today (Thursday) in a volatile situation in which the failure of water service provision plays a part.

Between 2011-2012, we conducted focussed, transdisciplinary, systemic research on water in the Sundays River Valley Municipality (SRVM) – of which Kirkwood is the administrative centre. This began within the context of Amatola Water's 'turnaround strategy' as part of the Section 139 (provincial administration) intervention in the SRVM. Since then, we have maintained contact and continued with on-going (but less intensive) research, as we have moved to working primarily in Makana Municipality – another local municipality within the Cacadu District Municipality.

We, as a research team, have made the conscious decision not to get involved in the current situation in Kirkwood, as it has a very immediate and particular dynamic of its own. Our researchers going into that highly fluid context might add to the tensions, and might well place themselves (and others) at risk. We will therefore be encouraging our colleagues not to participate in research or related activities in the area in the next while.

However, we have insights from three interlinked theses which we can offer you. These provide a multifaceted view of water in the SRVM, and include accounts of governance, institutional arrangements, actor analysis, technical and systems analyses of water supply and demand, Green Drop and river health assessments, and a social science study of local residents who have experienced interrupted water supply and poor water quality. More specifically, we have come to an understanding of the underlying systemic mechanisms leading to people's experiences of service delivery failure, and believe that this understanding can be significant for DWS' interactions with local government.

This research formed the motivation for the broader "Towards a New Paradigm for IWRM" research project. Our conviction is that water management requires a systemic engaged

Physical Address: Old Geology Building, Rhodes University Campus, Artillery Road, Grahamstown, 6139
Tel: +27 (0)46 6224014 or +27 (0)46 6222428 Fax: +27 (0)46 6229427
http://www.rhodes.ac.za/iwr email: ucewq@ru.ac.za

approach. We believe that accelerating the integration of our results will provide an opportunity to evaluate the particularities of the SRVM case with the purpose of more generally identifying combinations of risk that have, in this case, flared into serious civic unrest.

We believe it will be possible to identify thresholds, and recommend interventions for municipalities at risk that extend beyond the current, common government interventions. We suggest an approach that evaluates municipalities country-wide, and recommends a prioritized and integrated set of interventions to systemically address and promote good governance, thereby pre-empting destructive civic unrest.

Research of this kind is, by its nature, slow. Our work has not yet been formally published, nor has it moved into practice quickly enough to influence the Kirkwood crisis. We think that with support, we can fast-track integration and systemic use of the results to produce a timely, country-wide assessment and intervention process.

We believe that the insights we have, and the contributions we can make, may be of immediate interest to the Minister of Water and Sanitation and to the Minister of CoGTA, and request your advice on how to take this forward.

Regards

Prof Tally Palmer (international project leader)
Prof Chris de Wet (SRVM case study project leader)
Dr Jill Slinger (Dutch project leader)
Mr Jai Clifford Holmes (doctoral student)
Mr Nick Hamer (Makana case study project leader)

(with additional researchers: Prof. Kevin Rogers (SRVM workshop facilitator), Dr Tony Palmer, Ms Andiswa Finca, and Masters students Ms Lara Molony, Mr Matthew Muller and Ms Karabo Chadzingwa).

Physical Address: Old Geology Building, Rhodes University Campus, Artillery Road, Grahamstown, 6139
Tel: +27 (0)46 6224014 or +27 (0)46 6222428 Fax: +27 (0)46 6229427
http://www.rhodes.ac.za/iwr email: ucewq@ru.ac.za

B.11. Copy of the proposal presented to the Municipal Manager and Mayor of Sundays River Valley Municipality by stakeholder group on 23rd October 2014

To the Mayor of Sundays River Valley Municipality, the Municipal Manager of Sundays River Valley Municipality, and the Municipal Council:

Proposal for immediate actions to address water and sewage problems in the Sundays River Valley Municipality

The proposal in this letter is supported by civil society organisations (including the Kirkwood Ratepayers Association and local SANCO branches), the broader citrus industry in the Sundays River (including emerging farmers), and the Sundays River Business Chamber. These organisations and their individual members are deeply concerned with the current service delivery challenges in the Sundays River Valley Municipality, and have therefore come together to pledge immediate assistance and their commitment to address the following.

As you know, the water shortages in the Sundays River Valley Municipality (SRVM) are a violation of the basic dignity of our municipal residents. The shortages particularly affect the economically-marginalised communities that are unable to afford alternative water supplies and are unable to install additional household storage facilities. These shortages reduce the available drinking water, inhibit hygiene, and constrain food preparation. The same water shortages cripple the sanitation infrastructure by blocking main sewage lines, resulting in major sewage spillages into the irrigation canals. E-coli is both a primary health threat to all residents and a serious economic threat to our citrus industry, which will be blocked from export if E-coli is detected in the water supply of packhouses and/or farms. As farmers, we believe this is a greater threat to our citrus industry - and therefore the economy of this region - than blackspot.

Our whole intention here is to help our residents out of the current state of misery, and to assist in bringing stability to our communities. We firmly believe that this is of the utmost importance and of interest to everyone in the municipality. The business chamber has met with Minister Gordhan of the Department of Co-operative Governance and Traditional Affairs (CoGTA) - under which local government resides - and action plans are being put in place to assist the SRVM. The September protests have affected us all, and we believe that it is in everyone's interest to ensure that a second round of protests do not occur.

We acknowledge the following:

- The longstanding nature of these problems;
- The fact that water and sanitation is only one of the many technical challenges, including roads, electricity, and storm-water management, in our area;
- The financial challenges faced by the municipality in terms of cost recovery and prior financial mismanagement;
- The past inequitable distribution of resources within our own communities and within South Africa on the whole; and lastly,
- That these problems affect, to a lesser or greater degree, all the other urban settlements receiving services from the SRVM.

However: we also **know** that there are immediate technical fixes and operational adjustments that can be made to the Kirkwood water supply scheme, which can reduce the severity and frequency of the current water outages. These water outages are central

to both the drinking water shortages and the sanitation issues that are the core concerns of our municipal residents.

We, the undersigned, therefore propose and pledge financial and technical support for the following:

- To establish an emergency water fund with immediate effect;
- These funds will be administered by an independent organisation managed as a non-profit company, subject to the relevant South African companies legislation, and overseen by the sponsors; and,
- To use this fund to supply enough water from the raw water reservoirs to the water treatment works by installing an additional pipeline and pump at the Market Street pump station.

The business chamber has interacted with private packhouses, the Sundays River Citrus Company (SRCC), Luthando Farm, businesspeople, and ratepayers to try and find short-term solutions to address the immediate issues that led to the September 2014 protests, as well as the longer-term challenges. A meeting was held on 21st October 2014, with attendance from all of the above-mentioned organisations (collectively representing more than 5000ha (40%) under citrus production in the valley). The proposal resulting from this meeting was to immediately raise money through placing a minimum levy of 5 cents per carton on all export citrus from Sundays River. Some of the packhouses present at this meeting have already approved a 10cents per carton levy with their producers. However, this proposal will now be taken to all the growers and packhouses in the valley, with alternative proposals being sought from the broader business community in Sundays River.

Our proposal has five conditions that will achieve the buy-in of the residents, businesses and communities that we, the undersigned, represent:

Condition 1: That the Municipal Mayor and Municipal Manager agree, on behalf of the municipal council, to **negotiate** the increase in rates and levies that the municipality unilaterally imposed on all ratepayers in the 2014-2015 financial year. The undersigned are willing to pay **up to** a 10% increase on the 2013-2014 rates and levies.

Condition 2: That the municipality will attend to broken pumps and water leaks in all areas as a matter of utmost urgency;

Condition 3: That the municipality partners the undersigned to find short-term solutions to other pressing service delivery challenges (specifically waste disposal sites and roads under municipal jurisdiction, including by fixing potholes);

Condition 4: That applications and business plans are submitted to national government to gain capital grants to address the long-term decay in our infrastructure; and lastly,

Condition 5: That the municipality ***must*** provide alternative water services if water supply is interrupted for a period of more than 24 hours - specifically, at least 10 litres of potable water per person per day (consistent with Section 5 of the Water Services Act (1997), and Number 4 of the Norms and Standards (DWAF, 2002)). We, the undersigned, know that the municipality is currently not meeting the above condition, and we know that this is an absolute non-negotiable statutory requirement.

We believe that all of these conditions are consistent with the principles that underpin the local government legislative framework, the Strategic Framework for Water Services (2003) and the National Water Policy (1997): we are asking for nothing more than a municipality that returns back-to-basics and is accountable to us - the residents, businesses, and communities whose lives and livelihoods are based here in the SRVM.

Unfortunately, timing is now of the essence. We know that the MEC Local Government and Traditional Affairs (MEC Fikile Xasa) promised to return to Sundays River within a 30-day period with an action plan for addressing the service delivery problems: the 30-day period expires tomorrow (23/10), and to date, no such action plans or immediate solutions from either the municipality or the MEC have been forthcoming. Hence, we are all now threatened by a second round of violent protests.

It is our firm belief that all residents in the SRVM are dissatisfied with the current level of service delivery. We, the undersigned, therefore appeal to the responsible persons - specifically, the Municipal Council, the Mayor and the Municipal Manger - to embrace CoGTA's back-to-basics programme. The proposal contained in this letter is a sign-of-goodwill and commitment from the undersigned, to support a back-to-basics approach whilst immediately addressing current water challenges.

Due to the above-mentioned time constraints, we request that by the close of business (16h00) on Friday 24th October, we have a written confirmation of support for this proposal from the Mayor and / or the Municipal Manager, on behalf of the Municipal Council and administration. We are prepared to meet with the Mayor and Municipal Manager on short-notice to discuss the proposal between now and the deadline (if required). Please note, if we have *not* received written confirmation by this time, this proposal will be sent directly to Minister Gordhan (CoGTA), Minister Mokonyane (Department of Water and Sanitation), MEC Xasa, and Cllr. Kekana (Executive Mayor Cacadu District Municipality).

We, the undersigned, are not prepared to sit back and watch the destruction of property and a breakdown of public order reoccur. We fear growing instability in our communities that is increasingly affecting our schools, our businesses, and our safety. We fear that criminal elements will use this growing instability to their own benefits.
We appeal for your support.

Yours sincerely,

[*signatures excluded from this copy of proposal*]

Appendix C Supporting data for Part II

Table C.1: Selected references used as primary sources for the historical analysis in Chapter 4, differentiated by subject category and accompanied by a brief description. This table is illustrative of the range of texts drawn upon: the historical analysis draws from, and references, over 75 texts.

	Subject	Description	Reference
1.	Shaping of South African society (1702 – 1900)	Account of European domination in the Cape colony	(Hermann Giliomee & Elphick, 1979)
		Anthropological and historical accounts of the expansion of colony towards eastern 'frontier'	(Hermann Giliomee, 1979; Wilson, 1969)
2.	Water management histories	Hydropolitical history of Southern Africa	(Turton et al., 2004)
		History of South African water law and policy from 1652 to 1998	(Rowlston, 2011)
		Cultural history of water in South Africa	(Nel, van Damme, & Braune, 2007)
		Paper on historical inequities in water resource management in South Africa	(van Koppen, 2008)
		Context of changing water policy in SA	(van Koppen, Schreiner, & Fakir, 2011)
3.	Local histories	History of Sundays River Valley (up to 1950s, with commercial irrigation bias)	(Meiring, 1959)
		Unpublished manuscript by Addo resident	(Miller, n.d.)
		Information pamphlet produced by the Lower Sundays River Water User Association	(L-WUA, 2007)
		Newspaper articles about the SRVM published in provincial newspapers (2006 – 2011)	(Matavire, 2006; Ndoni, 2009b; de Kock, 2011)
4.	Irrigation development	Report on the Orange River Development Project (including the Orange-Fish-Sundays inter-basin transfer scheme)	(World Commission on Dams, 2000)
		Irrigation development in the Sundays River region (1890-1930)	(Lavin, 2005)
5.	Land-use / conservation / environmental management	History of conservation and its relation to settlement and economic development in SA	(Beinart, 2003)
		Doctoral study on human displacement and evictions in the Sundays River Valley	(Connor, 2007, 2014)
		Guidebook and background information on the Addo Elephant National Park (AENP)	(Urquhart & Klages, 1997)
6.	Local government	Analysis of local government (1800s to 1970s)	(Vosloo, 1974)
		Analysis of National Party-led reform processes in the 1980s of local government	(du Toit, 1988; Poto, 1988)
		Analysis of post-apartheid concept and practice of 'Developmental local government' in SA	(de Visser, 2005; van Donk et al., 2008)
7.	Provincial and local statistics	Assessment of the state of housing and infrastructural services in Eastern Cape (1995)	(Horn, Lloyd, & Levin, 1996)
		Statistics (2001-2014)	(Statistics South Africa, 2012, 2014)
		Statistics for Kirkwood magisterial district (1980)	(Central Statistical Services, 1986)
8.	General histories	A history of inequality in South Africa (1652 - 2002)	(Terreblanche, 2002)

Timeline C.1: Select events in period 1 (1814 – 1913)

Local scale		National and regional scale	
The first LSRV farms are awarded to leaders of the settler commandos (involved in 1811 and 1812 battles)	**1814**		
		1815	Treaty of Vienna (in which Cape Colony is official ceded to Britain)
		1875	Hydraulic division established under the Commissioner of Public Works in the Cape Colony
J.S Kirkwood formed Sundays River Land & Irrigation Company	**1883**		
		1886	Passing of the *Gold Act* following discovery of gold in the Witwatersrand region
'Forest reserves' proclaimed (including the Strathmore/Mentone reserve)	**1890**		
		1894	*Glen Grey Act* gazetted
		1896	Rinderpest epidemic sweeps through South Africa
Land adjoining Enon granted to Xhosa converts (became Bersheba)	**1898**		
		1899 - 1902	Anglo-Boer War (now referred to as 'The South African War')
Strathsommers Company founded	**1903**		
Census of the 'African population' by Strathsommers Company	**1906**		
		1910	Union of South Africa formed
		1911	*Mines and Works Act*; *Native Regulation Act*
Town of Kirkwood founded	**1912**	**1912**	Union Department of Irrigation is formed as part of the *Irrigation and Conservation of Water Act*
		1913	The *Natives Land Act* is passed

Timeline C.2: Select events in period 2 (1914 – 1947)

Local scale		National and regional scale	
LSRV farming group lobbies the Cape government for funding for a dam on the lower Sundays River	**1916**		
Fitzpatrick forms Cape Sundays River Settlement Association (CSRS)	**1917**	**1917**	Act 18 of 1917 Sanctions the Sundays River Storage Project, and the formation of the Sundays River Irrigation board
Major Pretorius begins 'complete eradication' of Addo elephants	**1918**		
		1921	International Socialist League transforms into the Communist Party of South Africa
Lake Mentz completed	**1922**		

Sundays River Citrus Co-operative (pack-house and export agency) formed	**1924**		
Cape government takes over CSRS	**1925**	**1925**	South African Native National Congress (SANNC) changes name to African National Congress (ANC)
		1926	SA Prime Minister introduces four bills in Parliament to find solution to the so-called 'native problem'
Addo Elephant National Park formally proclaimed	**1931**		
		1936	*Native Trust and Land Act*
Peri-urban settlements in LSRV transferred from Strathsommer's Estate to the Kirkwood Municipality.	**1937**		

Timeline C.3: Select events in period 3 (1948 – 1989)

Local scale		National scale	
		1948	National Party elected
Kirkwood attains municipal status	**1950**	**1950**	Key apartheid legislation passed (including *Population Registration Act* and the *Group Areas Act*)
ANC declares consumer boycott of citrus products in Port Elizabeth	**1952**	**1952**	*Native Laws Amendment Act; Prevention of Illegal Squatting Act*
'Elephant proof' fence completed (enclosing around 4000ha of the Addo Elephant National Park)	**1954**		
		1955	*Group Areas Development Act*; South African Congress of Trade Unions (SACTU) founded
		1956	*The Water Act* passed
Forced removals of black people from the 'black spot' communities surrounding Kirkwood begin	**1959**		
		1960	'Du Toit Commission of Inquiry into European Occupancy of Rural Areas' report Sharpeville massacre and banning of antiapartheid organisations
		1961	South Africa becomes a republic (withdraws from Commonwealth) ANC commits to armed struggle
Severe droughts (at a national level) bankrupt many landowners in the LSRV	**1966 - 1967**	**1966**	Construction begins on the ORDP
Tourism in the AENP begins to increase	**1970**	**1970**	'Commission of Enquiry into Water Matters' reports
Amalgamations and purchasing of farms to expand AENP begins	**1976**	**1976**	Soweto Uprising
Lake Mentz and the Sundays River connected to the Orange-Fish IBT	**1978**		

Census conducted in Kirkwood magisterial district	**1980**	**1980 - 1982**	Constitutional amendments – including the Tri-cameral parliament
		1982	'Black Local Authorities' are initiated
		1983	Inauguration of the Tri-cameral Parliament and the formation of the United Democratic Front
		1984 - 1986	State of Emergency
Algoa Regional Services Council begins	**1987**		
First houses built and water infrastructure developed in Bontrug township	**1989**	**1989**	F.W. De Klerk replaces P.W. Botha as President

Timeline C.4: Select events in period 4 (1990 – 2000)

Local scale		National scale	
		1990	Mandela release, unbanning of ANC and SACP
		1992	Convention for a Democratic South Africa
			The South African National Civic Organisation (SANCO) forms
		1993	*Local Government Transition Act*
Incorporation of Kirkwood magisterial district into Eastern Cape province	**1994**	**1994**	First democratic election and reunification of all territories within South Africa as one country;
			Reconstruction and Development Programme (RDP) initiated
Employment Research Unit produces overview of infrastructural services in Kirkwood magisterial district	**1996**	**1996**	Publication of *Fundamental Principles and Objectives for a New Water Law in South Africa*
			Constitution of the Republic of South Africa
Sundays River Irrigation Board begins writing letters to the Kirkwood Municipality warning about future water shortages in Kirkwood	**1997**	**1997**	The *Water Services Act* is passed
		1998	The *National Water Act* and the *Municipal Structures Act*
		2000	The *Municipal Systems Act* passed
First democratic local government elections held in Kirkwood district	**Dec. 2000**		

Timeline C.5: Select events in period 5 (2001 – 2008)

Local scale		National scale	
Sundays River Valley Municipality (SRVM) begins functioning as local government in the LSRV	**2001**	**2001**	'Free Basic Water' policy given legal status
		2002	*The Division of Revenue Act* legislates funding for municipal water services
Sundays River Irrigation Board converts to the Lower Sundays River Water User Association	**2003**	**2003**	Strategic Framework for Water Services (policy)
		2004	First edition of the National Water Resource Strategy is released
		2005	End of DWAF's direct role in water service delivery;
Protests and infighting involving ANC-elected mayor in the SRVM	**2006**	**2006**	Second local government elections
Technical Director retires (last engineer to work in the SRVM until July 2012)	**2007**	**2007**	ANC national elective conference, in which Zuma replaces Mbeki
		2008	SAICE skill audit of SA municipalities demonstrates endemic skills shortages

Timeline C.6: Select events in period 6 (2009 – 2011)

Local scale		National scale	
		2009	First Blue Drop results released
SRVM Municipal Manager first suspended	**Mar. 2009**		
An engineer from the Development Bank of Southern Africa starts in SRVM Review of municipal capacity as 'water service provider' held			
SRVM approves financial recovery plan	**June 2009**		
Municipal offices closed and provincial ANC attempts to 'recall' SRVM Mayor	**Oct. 2009**		
Forensic audit report of SRVM released			
		Dec. 2009	Department of Cooperative Governance and Traditional Affairs (COGTA) publishes 'Local Government Turnaround Strategy'
Municipality placed under provincial administration	**Feb. 2010**		
Acting Municipal Manager appointed by provincial authorities	**Mar. 2010**		
Amatola Water support proposal for turnaround strategy	**Dec. 2010**		

		Mar. 2011	DA Shadow Deputy Minister (COGTA) addresses parliament on ANC policy of cadre deployment using SRVM as example
New municipal council elected in the SRVM, and new municipal boundaries proclaimed	**May 2011**	**May 2011**	Local Government Elections
		July 2011	*Municipal Systems Amendment Act*
DWA's Rapid Response Unit begins working with the SRVM; Reports of SRVM 'on the mend'	**Sept. 2011**	**Sept. 2011**	DWA project regarding transformation of WUAs across South Africa commences.

Table C.2: Levels of education of residents of Kirkwood district, by population group. Source: Central Statistical Services (1986: 112, 121, 138).

	Total population in district (by population group)	**Number of individuals with Std. 9 education or higher**	**% of population group**
Black	23582	207	0.9
Coloured	5428	91	1.7
White	2878	982	34.2

Table C.3: Income for the Kirkwood magisterial district in 1980, differentiated by racial groups in urban and non-urban (NU) areas, accounting for annual income less than R1200 (source details in footnote [1])

		Total Population	**No income**	**2 - 299**	**300 - 599**	**600 - 1199**	**Total earning <1200**
Urban	**Black - U**	4001	2885	221	545	144	910
	Coloured - U	1145	845	39	35	158	232
	White - U	922	381	108			108
Non-urban	**Black - NU**	19851	13540	1490	3059	1148	5697
	Coloured - NU	4283	2803	233	471	494	1198
	White - NU	1956	947	109			109

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[1] Data compiled from Central Statistical Services (1986): 'white' population group income data: pp.183-184; 'coloured' population income group data: p.192; and 'black' population group income data: pp.207-208.

Table C.4: Income for the Kirkwood magisterial district in 1980, differentiated by racial groups in urban and non-urban (NU) areas, accounting for annual income greater than R1200 (source details in footnote [1])

		1200 - 2399	2400 - 3599	3600 - 5999	6000 - 8399	8400 - 11999	12000 - 17999	Total earning between 1200 - 17999	18000 - 29999	30000 - 41999	42000 +	Total earning 18000+
Urban	Black - U	106	35	14	0	1	2	158	2			2
	Coloured - U	38	19	4	4	0	0	65	0			0
	White - U	105	76	100	66	41	21	409	9	4	0	13
Non-urban	Black - NU	411	91	21	5	0	0	528	1			1
	Coloured - NU	184	44	23	3	2	1	257	1			1
	White - NU	122	78	220	144	88	67	719	68	41	51	160

Table C.5: Data on population, households, and access to water in the Kirkwood district in 1995, differentiated by 5 urban areas, and the non-urban area (Horn et al., 1996)

Area	Population	Households	Household size	Water in house	Water on site	Common water tap	Other water source	Squatters & migrants	Estimate backlog in housing
Addo	441	92	4.79	90	2	0	0	48	10
Bontrug	7780	1216	6.4	1201	15	0	0	3098	484
Enon	1886	408	4.57	327	81	0	0	406	89
Kirkwood	4628	1012	4.57	811	201	0	0	690	151
Nomathamsanqa	8584	1353	6.34	589	127	581	53	3416	538
Non-urban	18820	4425	4.25	100	941	1648	1721		
Total	42139	8506						7658	1272

Table C.6: Amounts received by local bodies within the Kirkwood magisterial district from the Algoa Regional Services Council, in the period from 1987 to 1991. Source: Auditor-General of South Africa (1991)**).**

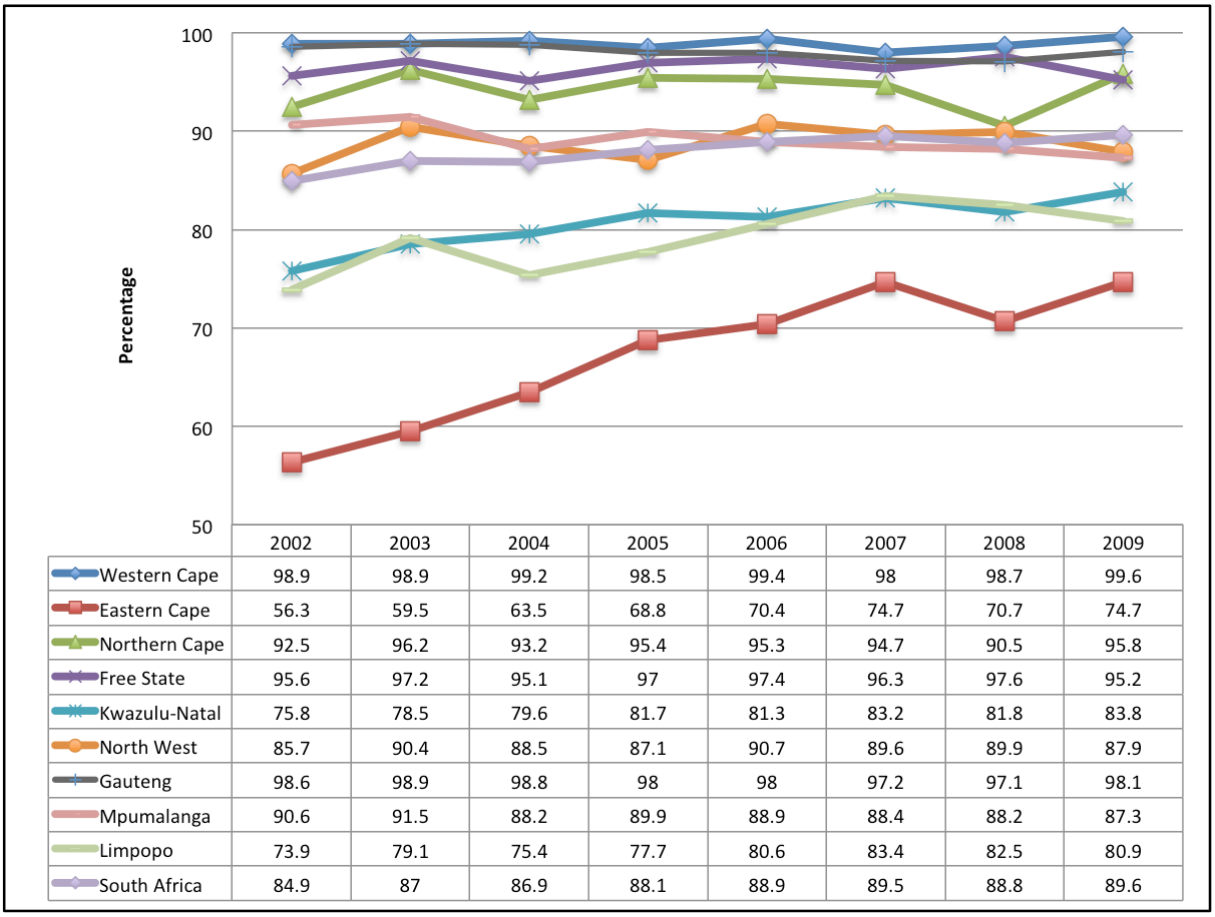
	1987 - '88	1988 – '89	1989 – '90	1990 – '91	Total
Addo local area		300337	25000		325337
Bergsig Management Committee		33000	109000	645000	787000
Bersheba				35000	35000
Bontrug town committee	100195	209720	110000	645000	1064915
Enon Management Board				231000	231000
Enon Rural Management Council			55534		55534
Kirkwood municipality			120000	12000	132000
Kirkwood region				145000	145000
Nomathamsanqa				460000	460000
Sundays River Valley				150000	150000
				Grand total awarded to Kirkwood district between 1987 - 1991	3385786

Table C.7: Comparison of selected variables from 2001 and 2011 censuses for the Sundays River Valley Municipality. Source (Statistics South Africa, 2014).

	2001	**2011**
Total population	43914	54504
Growth rate		2.16%
Number of households	10761	14749
Average household size	3.9	3.5
Unemployment rate	34.1%	15%
Piped water (inside dwelling)	13.2%	32.3%
Flush toilet connected to sewerage	22.7%	53.5%

Table C.8: South Africa's Gini index, between 1993 and 2009, indicating South Africa's ranking in comparison to other countries with high levels of inequality. Source: World Bank (2014a).

	Gini index – South Africa	Position of South Africa in ranking of most unequal countries
1993	59.3	4
2000	57.8	5
2006	67.4	1
2009	63.1	1



	2002	2003	2004	2005	2006	2007	2008	2009
Western Cape	98.9	98.9	99.2	98.5	99.4	98	98.7	99.6
Eastern Cape	56.3	59.5	63.5	68.8	70.4	74.7	70.7	74.7
Northern Cape	92.5	96.2	93.2	95.4	95.3	94.7	90.5	95.8
Free State	95.6	97.2	95.1	97	97.4	96.3	97.6	95.2
Kwazulu-Natal	75.8	78.5	79.6	81.7	81.3	83.2	81.8	83.8
North West	85.7	90.4	88.5	87.1	90.7	89.6	89.9	87.9
Gauteng	98.6	98.9	98.8	98	98	97.2	97.1	98.1
Mpumalanga	90.6	91.5	88.2	89.9	88.9	88.4	88.2	87.3
Limpopo	73.9	79.1	75.4	77.7	80.6	83.4	82.5	80.9
South Africa	84.9	87	86.9	88.1	88.9	89.5	88.8	89.6

Figure C.1: Percentage of households with access to water – piped or tap water in household, off-site, or standpipe on property, by province in the period 2002-2009. Source: amended from StatsSA (2012: 28).

Table C.9: Municipal classification developed as part of the Municipal Infrastructure Investment Framework (World Bank, 2009). The Sundays River Valley Municipality is a 'Category B3' municipality. 'Descriptions' and 'Characteristics' drawn from World Bank (2009: 10-11) and Department of Cooperative Governance and Traditional Affairs (2009a: 62), with data pertaining to 'Number (No.) of municipalities' updated from Municipal Demarcation Board (2013).

Category	Description	Characteristics	No. of municipalities (as of 2011)
A	Largest cities	Metropolitan municipalities	8
B1	Secondary cities	Aspirant metropolitans; local municipalities with the largest budgets	19
B2	Large towns	Local municipalities with a large town as the core urban settlement	27
B3	Small towns	Local municipalities with relatively small and primarily-urban population; no single large town as core urban settlement; rural areas are characterised by commercial farms	110
B4	Mostly rural	Local municipalities that are predominantly rural, with at most one or two small towns; rural areas characterised by communal land tenure, villages, and / or scattered groups of dwellings	70
C1	District municipalities that are not water service authorities	District municipalities with few service delivery obligations; typically aligned with relatively strong local municipalities	23
C2	District municipalities that are water service authorities	District municipalities with more service delivery responsibility; typically aligned with weaker (and more rural) local municipalities	21
		Total number of municipalities:	278

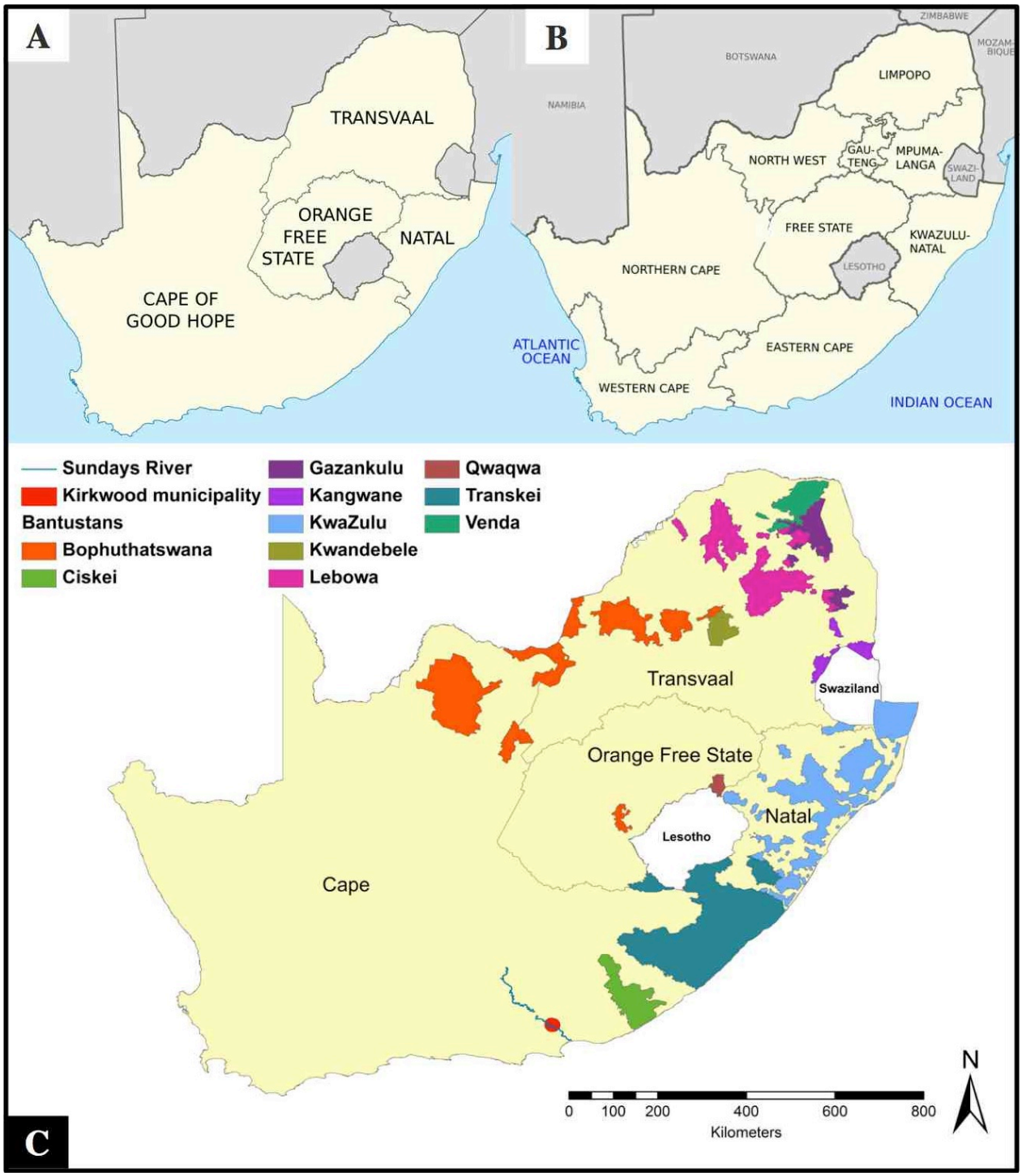


Figure C.2: Composite image of three maps. Map A illustrates the provinces of South Africa in effect from 1910 (when the 'Union of South Africa' was declared) through to 1976. Map C illustrates the ten homelands/bantustans that were self-governing territories between 1977 and 1991. The four 'independent' territories were Transkei, Bophuthatswana, Venda, and Ciskei (which were collectively referred to as the 'TBVC states', indicating the order in which the homelands gained independence). Map B illustrates the post-apartheid provinces in South Africa.

Timeline C.7: Changes in the government departments and ministries responsible for water matters, from 1875 to 2014. Note that for consistency, in this study the department managing water is referred to as the 'Department of Water Affairs' (DWA) from 1965 onwards.

	Department name	Responsible authority	Specific changes
1875	Hydraulic division	Commissioner of Public Works in the Cape Colony	—
1912	Department of Irrigation	Ministry of Land and Irrigation	First water matters department for whole country (Union of South Africa): emphasis is on irrigation development to support commercial agriculture
1956	Department of Water Affairs (DWA)	Ministry for Water Affairs	Restructuring of entire department: water management for industrial, urban and agricultural purposes legislated; water resources classified into 'public' and 'private categories'
1994	Department of Water Affairs and Forestry (DWAF)	Ministry of Water Affairs and Forestry	Forestry added to ministry – first Minister announced SA Water Law Review in May 1994
2009	Department of Water Affairs (DWA)	Ministry of Water and Environmental Affairs	Forestry moved to Department of Agriculture, Forestry and Fisheries (DAFF); Environmental Affairs remains a separate department, but grouped under same ministry as water
2014	Department of Water and Sanitation (DWS)	Ministry of Water Affairs and Sanitation	Environmental Affairs becomes separate ministry again; Sanitation added to Ministry (previously with Department of Human Settlements)

Table C.10: Land-use in the Sundays River Irrigation Scheme, grouped into land under production (crops) and all other land uses (other). Source: data drawn from L-WUA (2014: 32).

CROPS	**2013/2014 (ha)**	**% sum total**
Cash crop	881	4.5
Citrus	12356	64
Lucerne	2911	15
Pastures	504	2.5
Total crops	16652	86
OTHER	**2013/2014 (ha)**	**% sum total**
Management	460	2
Dams	319	2
Windrows	1042	5
Fallow land	880	5
Total other	2701	14
Sum total (total crops + total other)	**19353**	**100**

Table C.11: Types of irrigation systems used in the Sundays River Irrigation Scheme. Source: data drawn from L-WUA (2014: 32).

Irrigation type	**2013/2014 (ha)**	**% total**
Drip	8705	45
Micro	3826	20
Centre pivot	603	3.1
Sprinkler permanent	2712	13.9
Sprinkler moveable	445	2.3
Flood-channel supply	340	1.7
Raised micro	25	0.1
No irrigation	2697	13.9
Total	**19353**	**100**

Table C.12: Capacity assessment of the Sundays River Valley Municipality, completed by the Municipal Demarcation Board (MDB) for the 2010/2011 municipal financial year. The table compares the functions performed by the municipality (staff and operating expenditure) against the averages for Category B3 municipalities (shaded in grey). The yellow highlights are discussed in 5.4.2. Source: MDB (2013: 5).

	Function Performed	Percent of Staff	Average for Category B3	Percent of Operating Expenditure	Average for Category B3
Governance and Administration	Yes	55.40%	29.30%	37.90%	36.30%
Water Services	Yes	1.20%	14.10%	18.90%	13.40%
Electricity and Gas Reticulation	Yes	1.20%	5.30%	18.70%	25.90%
Municipal Transport	No	N/A	0.30%	1.10%	1.10%
Waste Management	Yes	1.20%	14.60%	3.90%	4.70%
Roads and Stormwater Systems	Yes	0.60%	11.20%	1.50%	5.60%
Community and Social Services	Yes	2.40%	11.50%	3.30%	4.90%
Planning and Development	Yes	0.60%	1.50%	2.40%	0.50%
Emergency Services	Yes	6.00%	2.50%	2.40%	0.80%
Municipal Health	Yes	1.20%	0.80%	0.00%	0.10%
Primary Health Care	No	N/A	0.50%	1.50%	0.40%
Environmental Management	No	N/A	0.90%	1.00%	0.30%
Economic Development	Yes	1.20%	1.80%	1.90%	2.40%
Housing	Yes	2.40%	1.20%	0.20%	1.50%
Traffic and Policing	Yes	26.50%	4.60%	5.20%	2.00%
		100%	100%	100%	100%

Box C.1: The seven 'root causes of municipal failure', identified in the Local Government Turnaround Strategy produced by the Department of Cooperative Governance and Traditional Affairs (CoGTA). Source: CoGTA (2009a: 18-9).

a. Inappropriate national and provincial government policies, practices and onerous requirements;
b. Socio-economic conditions prevailing in many municipalities that are not been [sic] adequately addressed through macro, micro-economic and industrial policies and plans of the State;
c. Political parties that are undermining the integrity and functioning of municipal councils through intra and inter-party conflicts and inappropriate interference in councils and administration;
d. A breakdown of values at a societal level that is breeding unethical behaviour, corruption, culture of non-payment, and lack of accountability;
e. Communities that are engaging in destructive forms of protest including withholding of payment for local taxes and services;
f. Those municipalities that are not geared for delivering basic services and are not responsive and accountable enough to residents; including… failure to involve communities in their own development;
g. Absence of communications resources (people, technology, equipment processes) and no accountability for how and when municipalities communicate to communities.

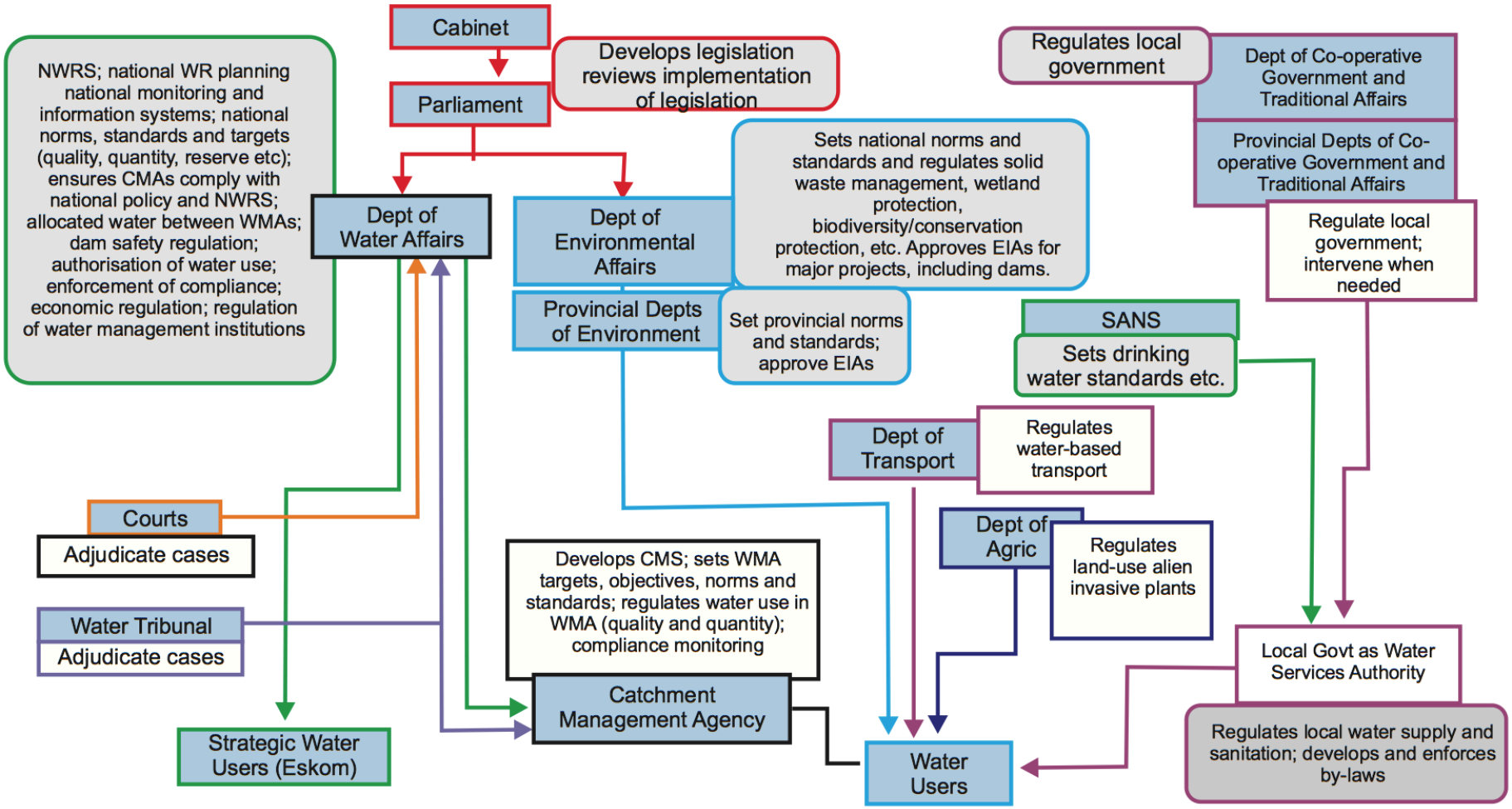


Figure C.3: Regulatory roles and functions of the different organs of state. Department of Water Affairs is responsible for the National Water Resource Strategy (NWRS) and national water resources (WR) planning, in addition to ensuring the catchment management strategies (CMSs) of all catchment management agencies (CMAs) operating in all water management areas (WMAs) comply with the NWRS. The Department of Environmental Affairs approves all Environmental Impact Assessments (EIAs) for major projects, whilst the South African National Standards (SANS) sets drinking water standards. Source: reproduced from DWA (2013b: 71).

Appendix D System dynamics model 1 (the 'cooperatives model')

The system dynamics model detailed in Appendix D was developed in collaboration with Dr Jill Slinger of Delft University of Technology (TU Delft), the Netherlands, and with further assistance from Juan Gonzalez (a masters student at TU Delft). The model was initially developed as a 'problem structuring' tool for analytical use in my doctoral study, but was then expanded and presented as follows:

Slinger, J. & Clifford-Holmes, J. (2012). What a Tangled Web We Weave – unravelling the strands of a South African water problem. Plenary presentation at *The Benelux System Dynamics Chapter Conference on Safety, Security and Public Health in a Dynamically Complex World*. 29 June 2012, Delft University of Technology, the Netherlands.

D.1. Introduction

This appendix provides supporting documentation for the 'Cooperatives' model described in sub-section 7.5.3. Unlike Appendices E, F and G, a full write-up of the cooperative model structure is not provided here. Instead, each sub-model is described using a stock-flow diagram of the model structure accompanied by a table that details the individual variables. The appendix further introduces system dynamics at the methodological level (supplementing sub-section 3.5.3).

D.2. Methodology

The two primary tools of system dynamics – causal loop diagrams and simulation modelling – were introduced in sub-section 3.5.3. This section provides supplementary details, intended for readers unfamiliar with the field of system dynamics.

The basic elements of causal loop diagrams (CLDs) are variables and arrows – which can be understood as factors and the links between these factors respectively (Maani & Cavana, 2007: 28). In a CLD, the way in which variables are causally related is demonstrated by stipulating a polarity on the arrow. A positive relation (+) between x and y means that a change in x will effect a change in y in the same direction. A negative relation (-) means that a change in x will effect a change in y in the opposite direction. Hence, the CLD provided in

Figure D.1 below can be described as consisting of two feedback loops that affect the variable 'population'.

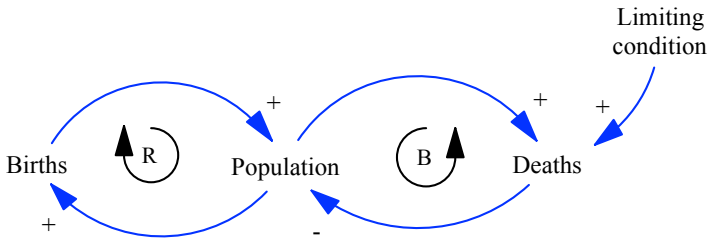


Figure D.1: Basic causal loop diagram of factors affecting an arbitrary population.

Figure D.1 can be read as follows: the more the births, the more the population; and the more the population, the more the births. This is a reinforcing (R) feedback loop. However, the more the population, the more the deaths; and the more the deaths, the smaller the size of the population. This is a balancing (B) feedback loop. In the example in Figure D.1 there is an additional variable that positively influences the variable 'Deaths', in the form of a limiting condition (for example carrying capacity of a piece of land or the outbreak of a disease).

Whereas CLDs only illustrate causal relationships between variables, stock-flow diagrams (SFDs) require distinguishing between types of variables. The basic elements of SFDs are stocks, flows, auxiliaries, constants and connectors (in the example provided below in Figure D.2, the blue arrows are the connectors).

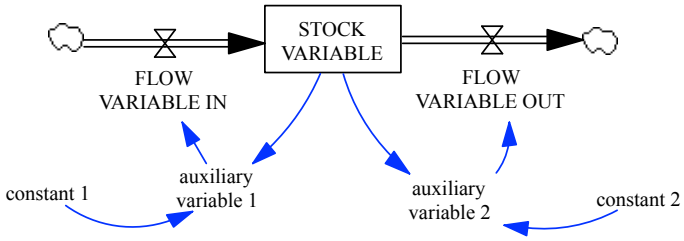


Figure D.2: Basic stock/flow diagram with a stock, input flow, output flow, auxiliary variables and constants. Source: adapted from Pruyt (2013: 86).

Stocks are accumulated quantities within the system being modelled – these stocks can be material (people, resources etc.) or informational (for example, levels of knowledge). Stocks can also be averaged statistical data, such as average birth rate (Maani & Cavana, 2007: 64). *Flows* are the changes that occur to a stock over time, in the form of the flows into a stock, and the flows out of a stock. Metaphorically speaking, if a stock variable can be seen as a

bathtub, then inflow variables correspond to taps, and outflowing variables to drains (Pruyt, 2013: 39). Flow variables are referred to as 'rates' in this study, in recognition that flows are mathematically modelled as the rates of change with which stocks increase or decrease.

System dynamics simulation models use the same symbols as SFDs, which are then mathematically related to one another using computer software. These quantitative models allow for further exploration of non-linear dynamics. In order to describe how the qualitative Stock variables are described here as a means of how this process works.

Stock variables are defined by their inflows, outflows and initial values. As Pruyt (2013: 86) says, a stock variable is "the accumulation of its inflows minus its outflows over time, starting from its initial value." Mathematically, stocks are therefore integral equations: the stock variable x is equal to the amount in the stock (x_0) at the time of starting the simulation (t_0) plus the integral over the difference of the inflow ax and outflow bx, over the time interval dt.

$$x = x_0 + \int_{t_0}^{t} (+ax - bx)dt$$

The above equation is graphically represented in system dynamics using stock-flow diagrams (such as the one represented in Figure D.3):

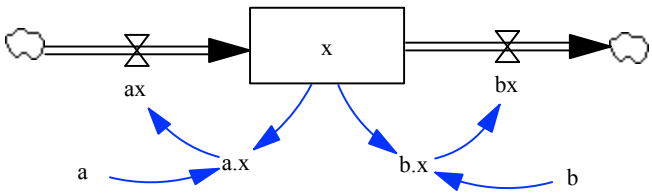


Figure D.3: Basic stock/flow diagram – as in Figure D.2 – with algebraic notation in the place of labelling stocks, flows, auxiliaries and constants. Source: adapted from Pruyt (2013: 86).

D.3. Model description

In this section, each sub-model is described using a stock-flow diagram of the model structure accompanied by a table that details the individual variables according to type (stocks, rates, constants and auxiliaries), units of measurement and finally, a definition of the variable by formulae and, where applicable, its initial value.

D.3.1 The cooperatives sub-model

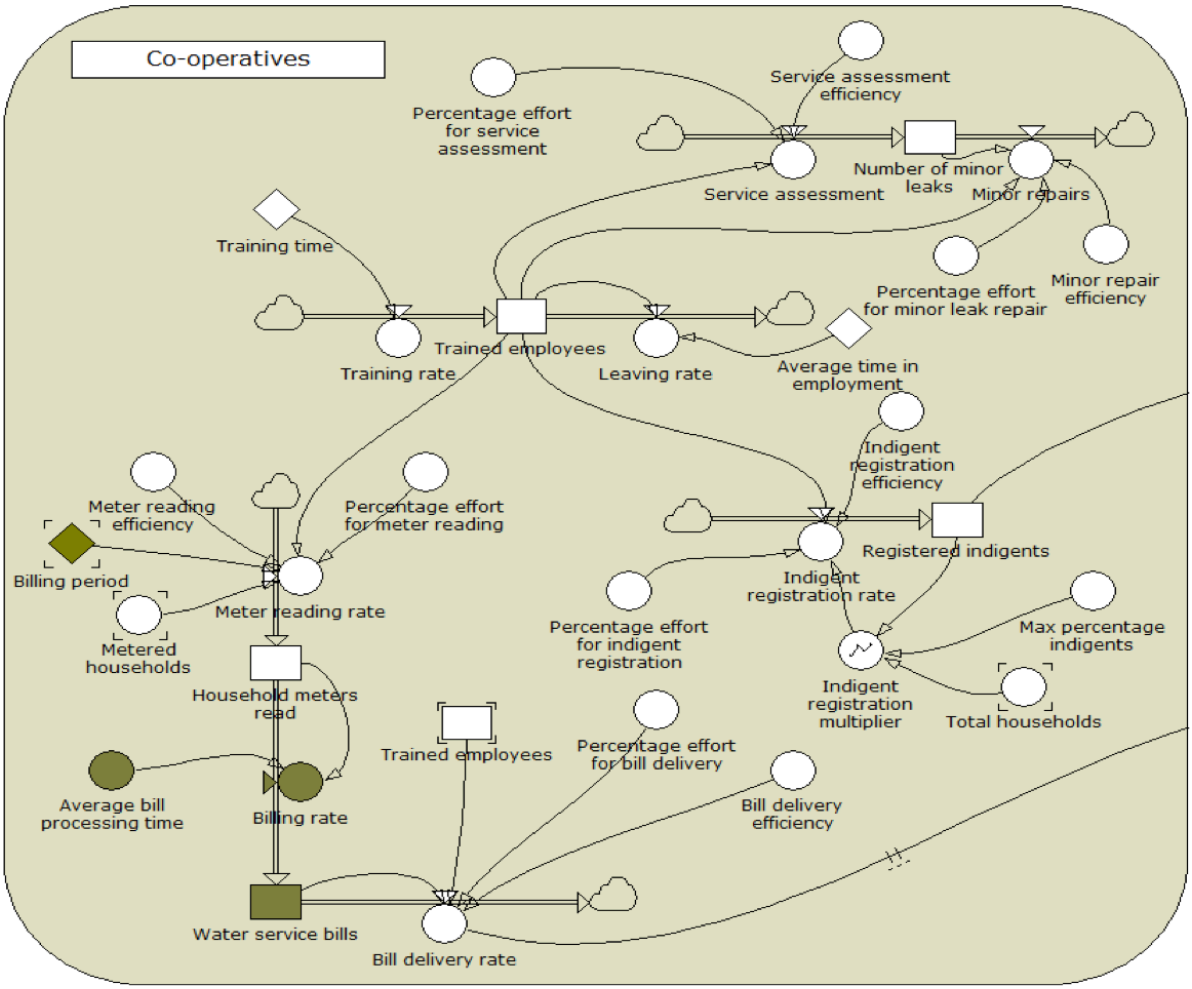


Figure D.4: Cooperatives sub-model

Table D.1: Variable description of the cooperatives sub-model

	Name	Type	Unit	Definition
1.	Number of minor leaks	stock	leaks	Initial value: 10
2.	Service assessment	rate	leaks/wk	MAX(0,('Trained employees'*'Percentage effort for minor leak repair'*' Service assessment efficiency'* 'Minor-major leak proportion'))
3.	Minor repairs	rate	leaks/wk	MIN('Trained employees'*'Percentage effort for minor leak repair'*'Minor repair efficiency'; 'Number of minor leaks'/TIMESTEP)
4.	Percentage effort for service assessment	constant	%	5
5.	Percentage effort for minor leak repair	constant	%	1
6.	Service assessment efficiency	constant	leaks/ people/wk	3
7.	Minor repair efficiency	constant	leaks/ people/wk	0.001
8.	Trained employees	stock	people	Initial value: 1
9.	Training rate	rate	people/yr	5<<people>>/'Training time'
10.	Leaving rate	rate	people/yr	'Trained employees'/'Average time in employment'
11.	Training time	constant	wk	12
12.	Average time in employment	constant	yr	2
13.	Registered indigents	stock	households	Initial value: 100
14.	Indigent registration rate	rate	household/ wk	'Trained employees'*'Percentage effort for indigent registration'* 'Indigent registration efficiency'* 'Indigent registration multiplier'
15.	Indigent registration efficiency	constant	households/ people/wk	2
16.	Percentage effort for indigent registration	constant	%	30
17.	Indigent registration multiplier	auxiliary	dimension-less	GRAPH(('Registered indigents'/('Total households'*'Max percentage indigents'));0;0,2;{0,8;1;1,25;1,25;1;0,5})
18.	Max percentage indigents	constant	%	60
19.	Total households	See variable no. 47		

Table D.1 (continued): Variable description of the cooperatives sub-model

	Name	Type	Unit	Definition
20.	Meter reading rate	rate	household/ wk	MIN('Trained employees'*'Percentage effort for meter reading'*'Meter reading efficiency';'Metered households'/'Billing period')
21.	Household meters read	stock	households	Initial value: 20
22.	Meter reading efficiency	contant	households/ people/wk	30
23.	Percentage effort for meter reading	constant	%	40
24.	Metered households	See variable no. 68		
25.	Billing period	See variable no. 77		
26.	Billing rate	rate	household/ wk	(MIN('Average bill processing time';'Household meters read'/TIMESTEP))
27.	Average bill processing time	constant	households/ wk	20
28.	Water service bills	stock	households	20
29.	Percentage effort for bill delivery	constant	%	25
30.	Bill delivery rate	rate	household/ wk	MIN('Trained employees'*'Percentage effort for bill delivery'*'Bill delivery efficiency';'Water service bills'/TIMESTEP)

D.3.2 The water supply sub-model

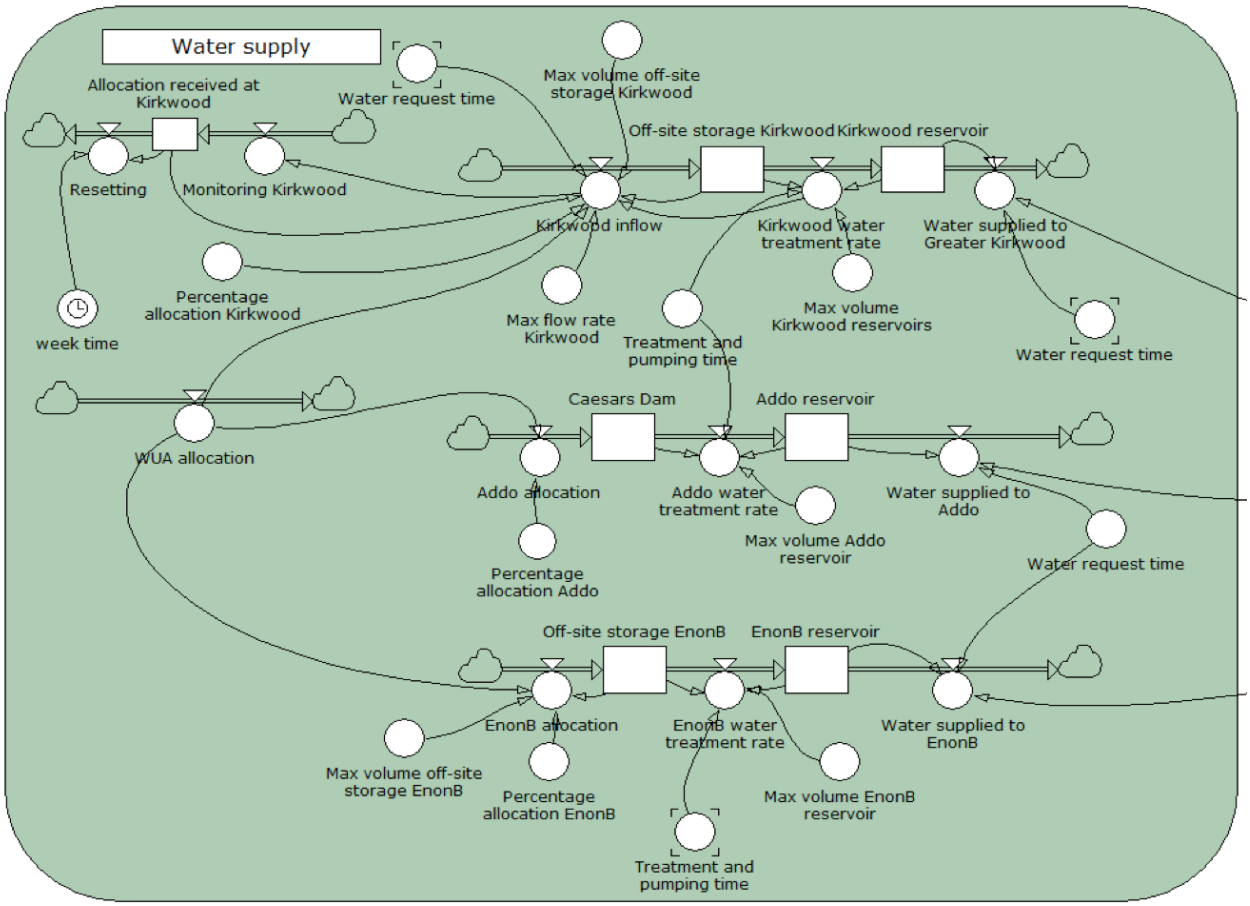


Figure D.5: Water supply sub-model

Table D.2: Variable description of the Kirkwood water supply scheme of the water supply sub-model. Note that the two other supply schemes (EnonBersheba and Addo) mirror the Kirkwood structure.

	Name	Type	Unit	Definition
31.	Off-site storage Kirkwood	stock	l	Initial value: 12260000
32.	Kirkwood inflow	rate	l/da	IF('Allocation received at Kirkwood'>='WUA allocation'* 'Percentage allocation Kirkwood'* 'Water request time';0<<l/da>>; MIN(('Max volume off-site storage Kirkwood'-'Off-site storage Kirkwood')/'Water request time'+ 'Kirkwood water treatment rate';'Max flow rate Kirkwood'))
33.	Kirkwood water treatment rate	rate	l/da	MIN(('Max volume Kirkwood reservoirs'-'Kirkwood reservoir')/ 'Treatment and pumping time';'Off-site storage Kirkwood'/'Treatment and pumping time')
34.	Kirkwood reservoir	stock	l	Initial value: 4600000
35.	Water supplied to Greater Kirkwood	rate	l/mo	MIN('Apparent Greater Kirkwood water demand';'Kirkwood reservoir'/ 'Water request time')
36.	Allocation received at Kirkwood	stock	l	Initial value: 0
37.	Monitoring Kirkwood	rate	l/da	'Kirkwood inflow'
38.	Resetting	rate	l/da	IF('week time'=0<<da>>;'Allocation received at Kirkwood'/TIMESTEP)
39.	WUA allocation	stock	l/wk	41000000
40.	Max volume off-site storage Kirkwood	constant	l	12260000
41.	Max flow rate Kirkwood	constant	l/wk	27290880
42.	Water request time	constant	wk	1
43.	Percentage allocation Kirkwood	constant	%	57
44.	week time	constant	da	(TIME-STARTTIME) MOD 7<<da>>
45.	Treatment and pumping time	constant	da	2
46.	Max volume Kirkwood reservoirs	constant	l	4600000

D.3.3 The water demand sub-model

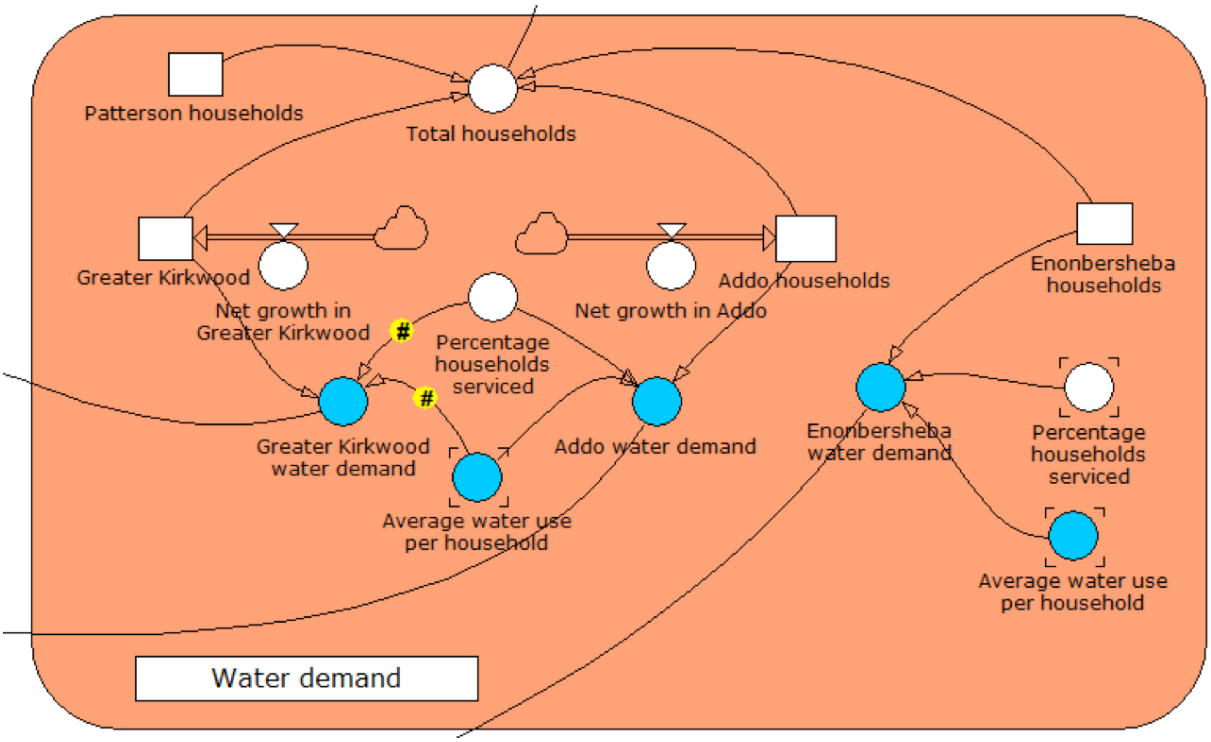


Figure D.6: Water demand sub-model

Table D.3: Variable description for the water demand sub-model.

	Name	Type	Unit	Definition
47.	Total households	auxiliary	household	'Greater Kirkwood'+'Addo households'+'Enonbersheba households'+'Patterson households'
48.	Patterson households	stock	households	Initial value: 1880
49.	Addo households	stock	households	Initial value: 3925
50.	Net growth in Addo	rate	households/ yr	0
51.	Greater Kirkwood	stock	households	Initial value: 4642
52.	Net growth in Greater Kirkwood	rate	households/ yr	0
53.	Enonbersheba households	stock	households	Initial value: 1107
54.	Greater Kirkwood water demand	auxiliary	l/mo	'Greater Kirkwood'*'Percentage households serviced'*'Average water use per household'
55.	'Percentage households serviced	constant	%	80

56.	Average water use per household	See variable no. 75		
57.	Addo water demand	auxiliary	l/mo	'Addo households'*'Average water use per household'*'Percentage households serviced'
58.	Enonbersheba water demand	auxiliary	l/mo	'Enonbersheba households'*'Percentage households serviced'*'Average water use per household'

D.3.4 The financial division sub-model

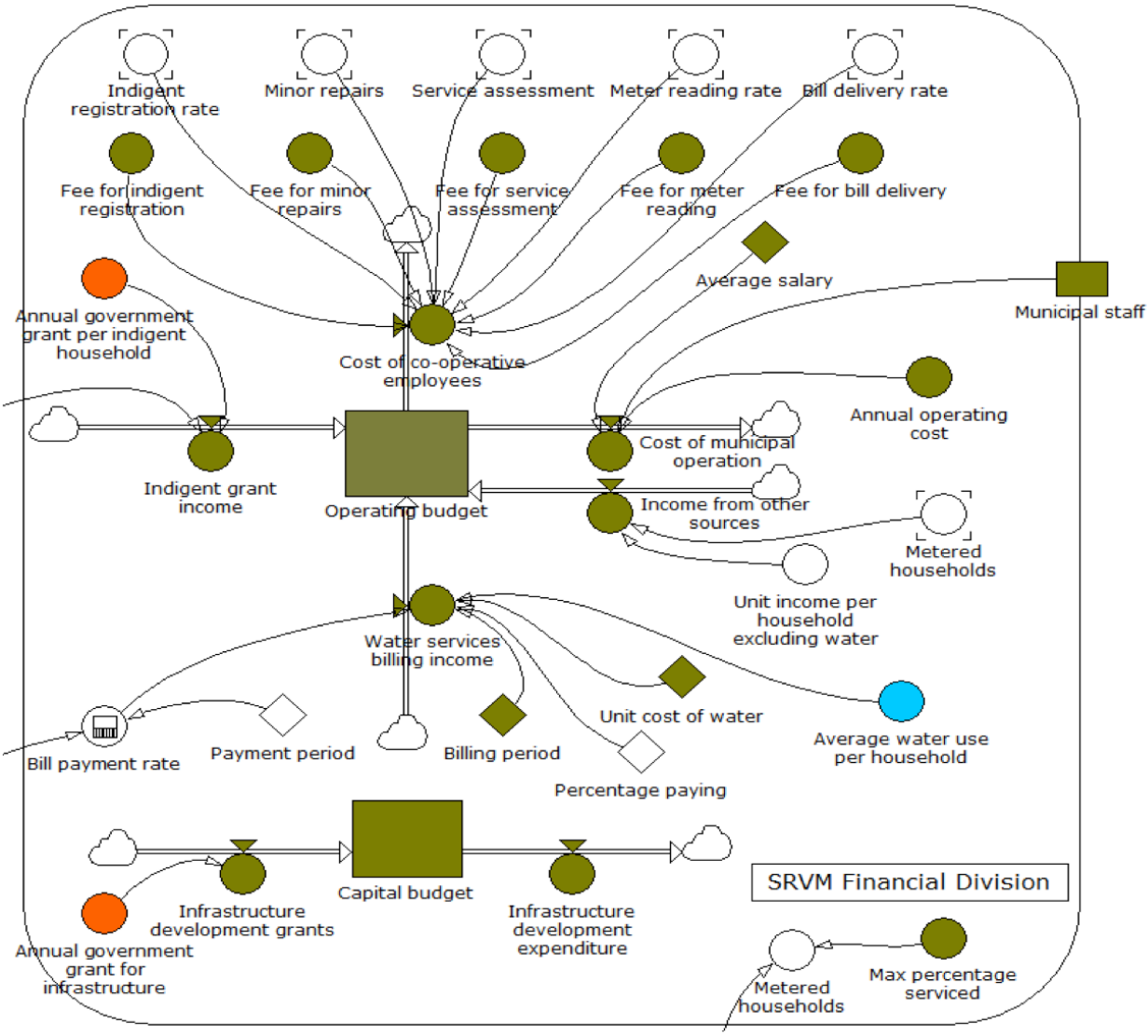


Figure D.7: Sub-model of the financial division of the Sundays River Valley Municipality (SRVM).

Table D.4: Variable description for the financial division sub-model

	Name	Type	Unit	Definition
59.	Operating budget	stock	ZAR	Initial value: 100000
60.	Indigent grant income	rate	ZAR/yr	'Registered indigents'*'Annual government grant per indigent household'
61.	Registered indigents	See variable no. 13		
62.	Annual government grant per indigent household	constant	ZAR/ household/yr	3372
63.	Cost of municipal operation	rate	ZAR/mo	'Municipal staff'*'Average salary'+'Annual operating cost'
64.	Municipal staff	constant	people	175
65.	Average salary	constant	ZAR/ people/mo	15035.11
66.	Annual operating cost	constant	ZAR/yr	74472961
67.	Income from other sources	rate	ZAR/yr	'Metered households'*'Unit income per household excluding water'
68.	Metered households	auxiliary	households	'Total households'*'Max percentage serviced'
69.	Max percentage serviced	constant	%	90
70.	Unit income per household excluding water	constant	ZAR/ household/yr	500
71.	Water services billing income	rate	ZAR/mo	'Bill payment rate'*'Percentage paying'*'Average water use per household'*'Unit cost of water'*'Billing period'
72.	Bill payment rate	auxiliary	household/ wk	DELAYMTR('Bill delivery rate';'Payment period';1)
73.	Payment period	constant	wk	6
74.	Percentage paying	constant	%	35
75.	Average water use per household	constant	l/household/ mo	16800
76.	Unit cost of water	constant	ZAR/l	0.001
77.	Billing period	constant	mo	1

Table D.4 (continued): Variable description for the financial division sub-model

	Name	Type	Unit	Definition
78.	Cost of co-operative employees	rate	ZAR/wk	'Indigent registration rate'*'Fee for indigent registration'+'Minor repairs'* 'Fee for minor repairs'+'Minor leak service assessment'*'Fee for service assessment'+'Meter reading rate'*'Fee for meter reading'+'Bill delivery rate'*'Fee for bill delivery'
79.	Indigent registration rate	See variable no. 14		
80.	Fee for indigent registration	constant	ZAR/ household	1
81.	Minor repairs	See variable no. 3		
82.	Fee for minor repairs	constant	ZAR/ leak	20
83.	Minor leak service assessment	See variable no. 2 (*named* 'Service assessment')		
84.	Fee for service assessment	constant	ZAR/ leak	5
85.	Meter reading rate	See variable no. 20		
86.	Fee for meter reading	constant	ZAR/ household	2
87.	Bill delivery rate	See variable no. 30		
88.	Fee for bill delivery	constant	ZAR/ household	1
89.	Capital budget	stock	ZAR	Initial value: 42186059
90.	Infrastructure development grants	rate	ZAR/yr	'Annual government grant for infrastructure'
91.	Annual government grant for infrastructure	constant	ZAR/yr	18000000
92.	Infrastructure development expenditure	rate	ZAR/yr	12000

D.3.5 The leaks sub-model

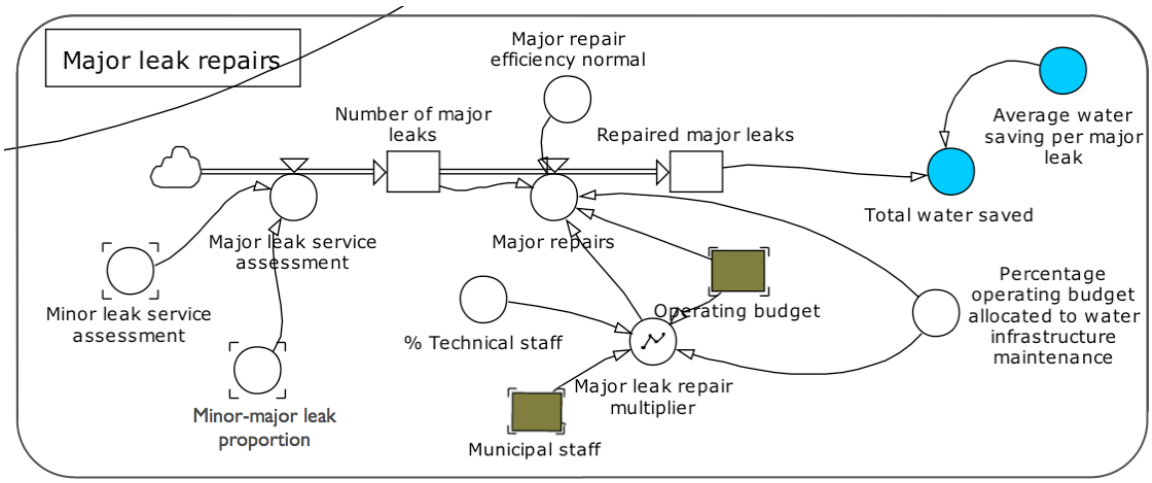


Figure D.8: Leak sub-model.

Table D.5: Variable description for the leaks sub-model

	Name	Type	Unit	Definition
93.	Number of minor leaks	stock	leaks	Initial value: 10
94.	Major leak service assessment	rate	leaks/wk	((100<<%>>-'Minor-major leak proportion')/ 'Minor-major leak proportion')* 'Minor leak service assessment'
95.	Major repairs	rate	leaks/wk	MIN('Operating budget'*'Percentage operating budget allocated to water infrastructure maintenance'*'Major repair efficiency normal'* 'Major leak repair multiplier';'Number of major leaks'/TIMESTEP)
96.	Major repair efficiency normal	constant	leaks/ZAR /wk	0.00001
97.	Major leak repair multiplier	auxiliary	dimension-less	GRAPH((('% Technical staff'*'Municipal staff')/ ('Percentage operating budget allocated to water infrastructure maintenance'*'Operating budget') *1000000<<ZAR/people>>);0;0,25; {0;0,125;0,4;0,6;1;1,375;2,0;2,5;3;3,3;3,5//Min:-1;Max:11//})
98.	% Technical staff	constant	%	18
99.	Municipal staff	See variable no. 64		

Table D.5 (continued): Variable description for the leaks sub-model

	Name	Type	Unit	Definition
100.	Percentage operating budget allocated to water infrastructure maintenance	constant	%	0.6
101.	Repaired major leaks	stock	leaks	Initial value: 0
102.	Total water saved	auxiliary	l	'Repaired major leaks'*'Average water saving per major leak'
103.	Average water saving per major leak	constant	l/leak	100

D.5 General discussion and conclusion

(see sub-section 7.5.3(iii) of Chapter 7)

Appendix E System dynamics model 2 (the 'Greater Kirkwood water supply model')

The system dynamics model presented in Appendix E was developed in collaboration with Floortje d'Hont and Dr Jill Slinger of Delft University of Technology, the Netherlands. The model was first described and published in the following peer-reviewed conference proceedings:

D'Hont, F., Clifford-Holmes, J., & Slinger, J. (2013). Addressing Stakeholder Conflicts in Rural South Africa Using a Water Supply Model. Conference proceedings - *31st International Conference of the System Dynamics Society*, 21-25 July 2013, Cambridge, Massachusetts, USA. ISBN: 978-1-935056-11-9.
(Available at: http://www.systemdynamics.org/conferences/2013/proceed/index.html).

The model was described in greater detail in Floortje d'Hont's Bachelor of Science report (d'Hont, 2013). This appendix draws on the conference paper and d'Hont's report in order to describe the Greater Kirkwood Water Supply model.

For the full model documentation, please see:
http://iwr.ru.ac.za/iwr/sanpadlink/index.php?p=CaseStudyDocs/SRVM/CliffordHolmesPhD

E.1. Introduction

This appendix reports on the development of the second system dynamics model used in this study, called the Greater Kirkwood Water Supply Model (hereafter 'GKWS model'). This modelling initiative was aimed at understanding the effects of operational management on the performance of the Greater Kirkwood water supply system in the Sundays River Valley Municipality (SRVM). Currently, the interrupted operation of the system has led to perceptions of systemic social injustice on the part of citizens and contention between the municipality responsible for supplying water to the citizens and the Lower Sundays River Water User Association (L-WUA) responsible for delivering raw (i.e. untreated) water to the SRVM. The GKWS model is used as a means of exploring the technical constraints of the water supply system, towards supporting discussions between stakeholders about contentious issues, and the ways they can address these issues.

E.2. Methodology

The recognition of the variety and conflicting interests of the stakeholders involved and the lack of clarity about the effect of operational procedures on the security of the water supply, led to the decision to adopt a system dynamics modelling approach to the seemingly

intractable water supply problems of Greater Kirkwood. The system dynamics method was designed for application in socio-technical systems (Lane 2000), with the aim of clarifying and quantifying the interactions between elements of a physical system and the humans intervening in, or operating the system. Stakeholders are able to locate themselves and their actions within the "stocks" and "flows" used to characterize the system, and so experience the method as enhancing communication (Stave 2003). An added advantage of system dynamics for this particular situation is that detailed and accurate data on the water supply system (e.g. the evolution in water demand over time, variations in the water treatment pumping capacity and the storage reservoirs fluctuations over time) are not prerequisite to modelling. Instead a deep knowledge of the design capacity of the system, and experienced behaviour over time is required. Whereas detailed data were not always available, information on system behaviour was readily obtained from the following sources:

- Technical reports of the Sundays River Valley Municipality, including the Water Services Development Plans (Sundays River valley Municipality 2010a, 2010b, 2011);
- Information pamphlets outlining how the supply system of the Lower Sundays River Water User Association (L-WUA) works, in addition to the annual reports of the L-WUA (L-WUA 2007, 2011, 2012); and
- Three workshops on the 'turnaround of the SRVM water services' (31 November to 1 December 2011, 10 October 2012 and 28 February 2013), attended by representatives from the national Department of Water Affairs, the SRVM and the L-WUA.

Accordingly, after first characterizing the situation of the SRVM and its water supply at catchment scale, we chose to focus on the complex, real world problem situation of the Greater Kirkwood water supply system and represent this as a system diagram (see Figure 7.7). Next, the system diagram was specified as a system dynamics model in Vensim PRO Version 6.0a-1. To corroborate the physical system understanding, six site visits to the Greater Kirkwood area were undertaken by one of the authors in the period January to November 2012.

E.3. Problem formulation

Problem formulation described in sub-section 7.5.4(i) and (ii).

E.4. Model description

This section describes the GKWS system dynamics model, from the model settings through to the model (explaining the mathematical formulations employed in each sub-model and accounting for the data informing each variable).

E.4.1. Model settings

The time step of the GKWS model is set to 1/1000 Day, which equals about 1.4 minutes. This seems often enough to calculate the difference in water levels, and large enough to have a fast running model. To evaluate the differential equations, the Euler method was chosen for its speed advantage. An additional reason to use the Euler method (over RK4 and other integration technqiues) is that the model employs certain functions that only properly work with the Euler method – including the SAMPLE IF TRUE function in Vensim.

The year 2013 is simulated in the GKWS model. Whilst model data are drawn from different information sources and different years, the year 2013 was selected for the ease of communication of model results. The run time is 450 days, which enables observing the results of 1.5 years (i.e. to see what happens after the first year ends).

E.4.2. Allocation sub-model

The SRVM orders water each week from the L-WUA. The L-WUA's structure of weekly ordering is designed to cope with demand fluctuations on the part of the WUA clients, (primarily agricultural users) who are required to estimate the water they will require in the coming week. Currently, the SRVM's strategy is to always request the maximum possible allocation, in an attempt to prevent failure in the supply of water to communities in Greater Kirkwood. This often causes wastage of water when more raw water is supplied by the WUA than can be stored by the SRVM. The municipality is entitled to a certain quantity of allocated water and, in principle, cannot exceed this quantity in its orders. However, different allocation figures exist, as Table E.1 illustrates.

Table E.1: Different allocation figures for the Kirkwood water supply scheme operated by the Sundays River Valley Municipality.

Allocation	Allocation (Ml/day)	Reference
159.6 ha per annum at a quota of 9000 m3 per ha	3.92	Lower Sundays River Water User Association interview
0.94 million cubic metres per annum	2.52	(Department of Water Affairs (DWA), 2010)
Actual abstraction: 2.025 million cubic metres per annum	5.55	(Department of Water Affairs (DWA), 2010)

We decided to eliminate water allocation from the GKWS model due to the ambiguous data, and instead, modelled the allocations under the assumption that the water supply system should be able to meet the water demand of the inhabitants of the Kirkwood area. As described in sub-section 5.2.4, the Greater Kirkwood area relies on raw water transferred into the Lower Sundays region from the Orange-Fish-Sundays inter-basin transfer scheme, which is stored in Darlington Dam. Raw water is released from Darlington Dam, into the lower reaches of the Sundays River, and is then delivered to the Greater Kirkwood water supply scheme via the L-WUA's irrigation canals. The time it takes for the water to flow from the opening of the sluices at Darlington Dam to Greater Kirkwood is dependent on water lag times (see Figure 5.3). This is modelled in the GKWS model using the switch "High flow on". The low flow rate and high flow rate are 27 hours and 21 hours respectively. The part of the GKWS model that calculates the quantity and time of arrival of the raw water is depicted in Figure E.1 below

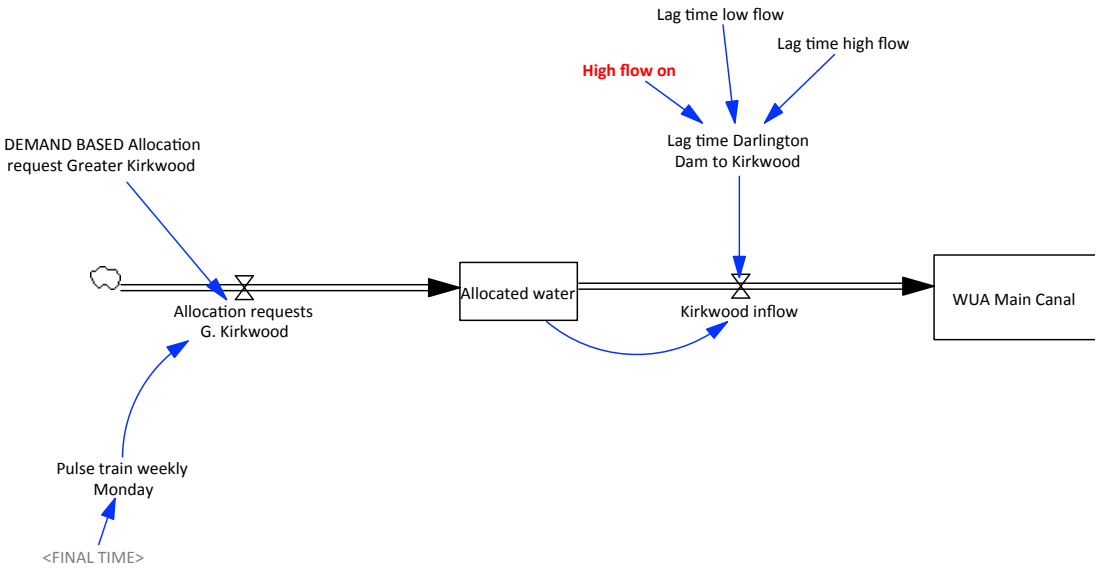


Figure E.1: Water allocation sub-model

The municipality orders raw water in terms of a 'number of hours' of water supply, and must place this order before Thursday 16h00 each week. The sluices are opened each Monday at 09h00 by the L-WUA. This is modeled as follows:

```
Allocation requests G. Kirkwood =
DEMAND BASED Allocation request Greater Kirkwood * Pulse train weekly
Monday
~ liter / Day
```

in which "DEMAND BASED Allocation request Greater Kirkwood" takes on a value that should reflect the water demand in the Kirkwood community. As discussed in sub-section 7.5.4, the development process of the GKWS model demonstrated the depth of uncertainty around the water demand of the Greater Kirkwood region. In the GKWS model we therefore chose not to include the determinants of water demand as a sub-model, instead choosing to run the model using scenarios with varying water demand, in order to test how much water the water supply system could deliver. The demand-based allocation request is multiplied by the following PULSE TRAIN function:

```
Pulse train weekly Monday =
PULSE TRAIN( INITIAL TIME, 1 , 7 , FINAL TIME )
~ liter / Day
```

This function in Vensim takes the form PULSE TRAIN(start, width, *t*between, end), in which:

- "start" is the start time, which is in this case the same as the start time of the simulation;
- "width" is the interval for which the pulse lasts, in this case 1 day;
- "*t*between" is the time for which the function is repeated, in this case, 7 days; and
- "end" is the time for which the function should stop, which in this case equals the final time of the simulation.

E.4.3. Off-site storage of raw water and the Kirkwood water treatment works

Once the allocated water flows into the L-WUA's main canal at Kirkwood, water is available to enter the Greater Kirkwood water supply scheme via a manually-operated sluice gate (see Figure E.4). Raw water flows into off-site storage reservoirs according to the rate "Raw water dams inflow". The "Raw water dam inflow" is dependent on both the water level in the raw water dams ("Off-site storage") and the water available in the WUA Main Canal, which is modelled as follows:

```
Raw water dam inflow =
Annual operational schedule * (MIN (WUA Main Canal/Water lag time to
off site storage , Sluice capacity))
```

In which:

- "Annual operational schedule" is a dimensionless function and represents the operational hours, as is elaborated in sub-section E.4.5 of this appendix;
- "WUA Main Canal" is the available water in the main canal, and
- "Water lag time to off site storage" is the time it takes for the water to flow from the canal through the sluice to the raw water dams.

The final variable influencing the 'Raw water dam inflow' rate is 'Sluice capacity'. Sluice capacity is modelled using a LOOKUP function, which represents the pattern of sluices being opened to 'over-capacity' at times in which the raw water storage dams are empty, and require filling immediately. Hence, when the off-site storage reservoirs are full, the sluices are used less-intensively. The relation between the level of water in the raw water dams and the effect of filling-up is shown in Figure E.2 below.

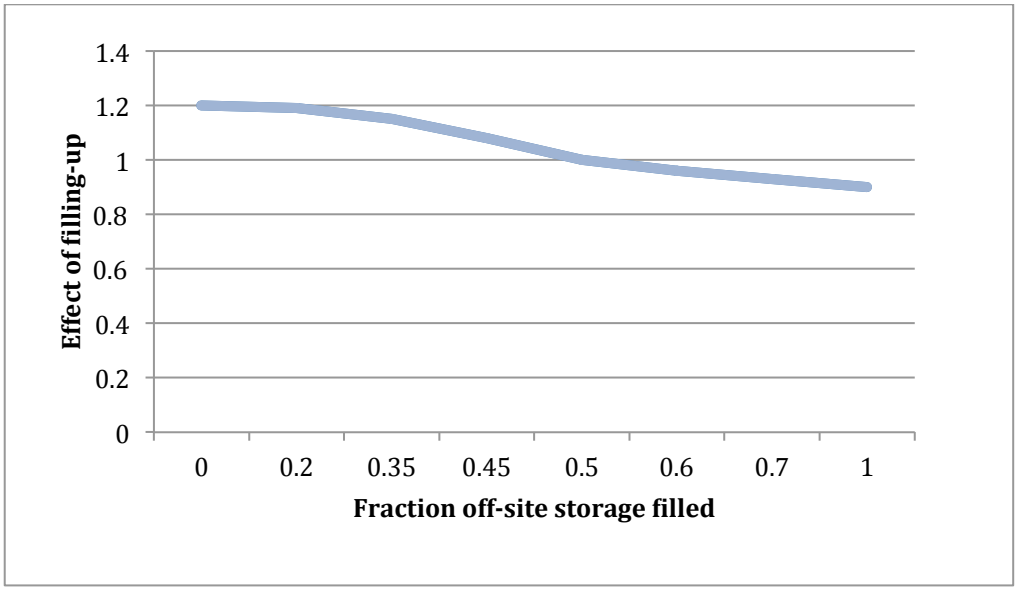


Figure E.2: Effect of filling-up multiplier LOOKUP function.

The stock variable "Off-site storage" is additionally influenced by rainfall and evaporation. The system loses water due to evaporation and gains water when it rains. In the GKWS model, the evaporation rate is kept constant throughout the year, whilst rainfall is added to the system by multiplying the monthly average rainfall by the surface of the raw water dams (using rainfall data from the L-WUA). The rainfall sub-model is represented in Figure E.3.

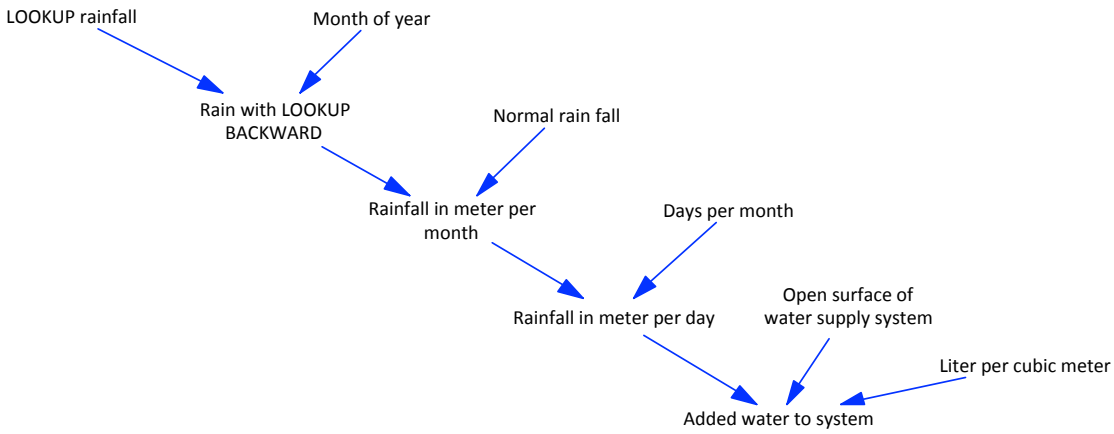


Figure E.3: Rainfall sub-model

Once the raw water is stored in the Kirkwood system, it is available for treatment. The primary treatment phases used at the Kirkwood water treatment works (WTW) are:

1. Floculation and sedimentation;
2. Filtration; and
3. Chlorination.

These three phases are grouped in the GKWS model as the "WPS 1 water treatment rate", where "WPS" refers to one of the water pumping systems in the Kirkwood water supply scheme (see Figure E.4 below).

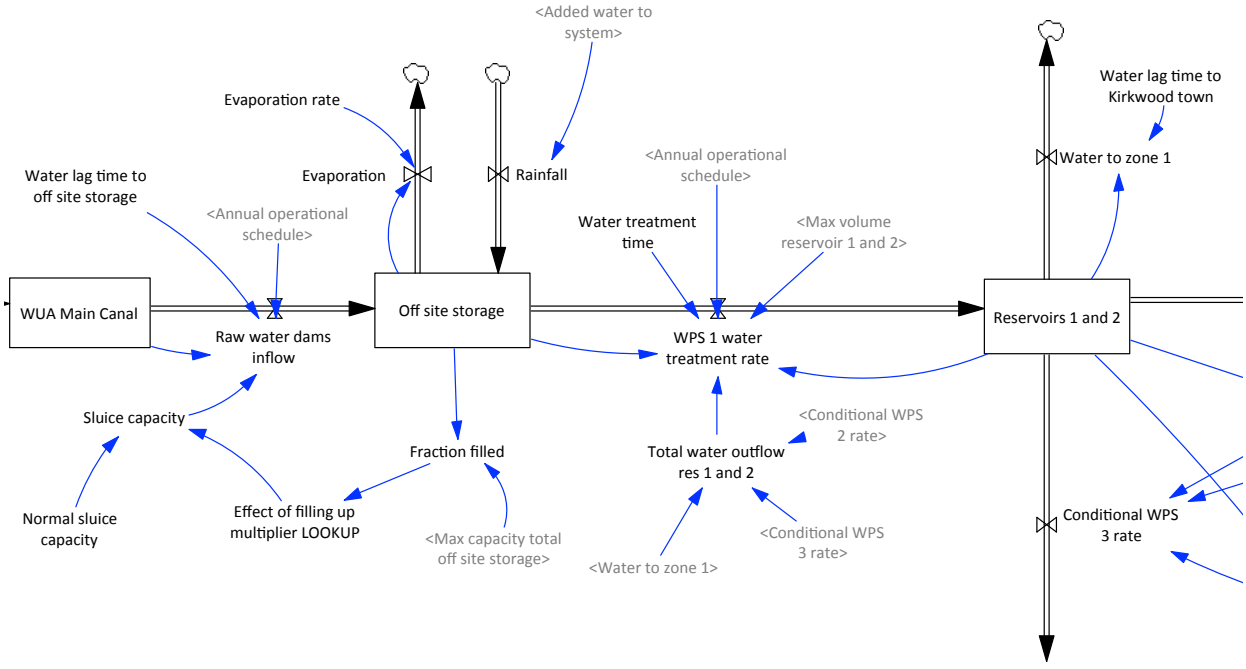


Figure E.4: Off-site storage of raw water and water treatment works stock-flow diagram

The WTW has a design capacity of 5 Ml/day, but is known to operate over-capacity. For this reason (and given the lack of numerical data), the water treatment rate of the GKWS model is affected by the water volume in reservoirs 1 and 2 or the water available in the raw water dams, according to the following formulation:

```
WPS 1 water treatment rate =
Annual operational schedule * ( MIN((( Max volume reservoir 1 and 2 -
Reservoirs 1 and 2 ) / Water treatment time ) + Total water outflow
res 1 and 2 , Off site storage / Water treatment time))
```

In which:

- "Annual operational schedule" is a dimensionless function and represents the operational hours, as elaborated in sub-section E.4.5;
- "Max volume reservoir 1 and 2" corresponds with the size of both these reservoirs, being 1,6 Ml, as is shown in Figure E.5;
- "Reservoirs 1 and 2" is the stock variable that represents the current water volume in these reservoirs;
- "Water treatment time" is the time it takes to treat the water before it is safe for use;
- "Total water outflow res 1 and 2" is the sum of all outflow rates from the stock variable "Reservoirs 1 and 2". These outflow rates are included in this function to represent the water that is in the pipes flowing to the other reservoirs. By modelling it as such, the capacity of the pipes is taken into the calculations; and
- "Off site storage" is the stock variable that represents the current water volume in the raw water dams.

E.4.4. Potable water reservoirs

As shown in the schematic representation of the Kirkwood water supply scheme (see Figure 7.8), treated (i.e. potable) water is stored in a system of reservoirs that act as intermediary points between the WTW and the five supply zones. Figure E.5 provides a more detailed schematic representation of the potable water reservoirs, in terms of how this system of reservoirs is represented in the GKWS model. The formal structure of the potable water sub-model is provided in Figure E.6.

All treated water flows from the WTW into reservoir 1. From this point, water is allocated to three areas: firstly, it can be pumped by water pumping system 3 (WPS 3) to reservoir 3 or 4 for distribution to the communities of Bergsig and Aquapark; secondly, it can be pumped by

water pumping system 2 (WPS 2) to reservoir 5 and 6 to be distributed to the communities of Moses Mabida and Emsengeni; and thirdly, it can gravity feed to Kirkwood town.

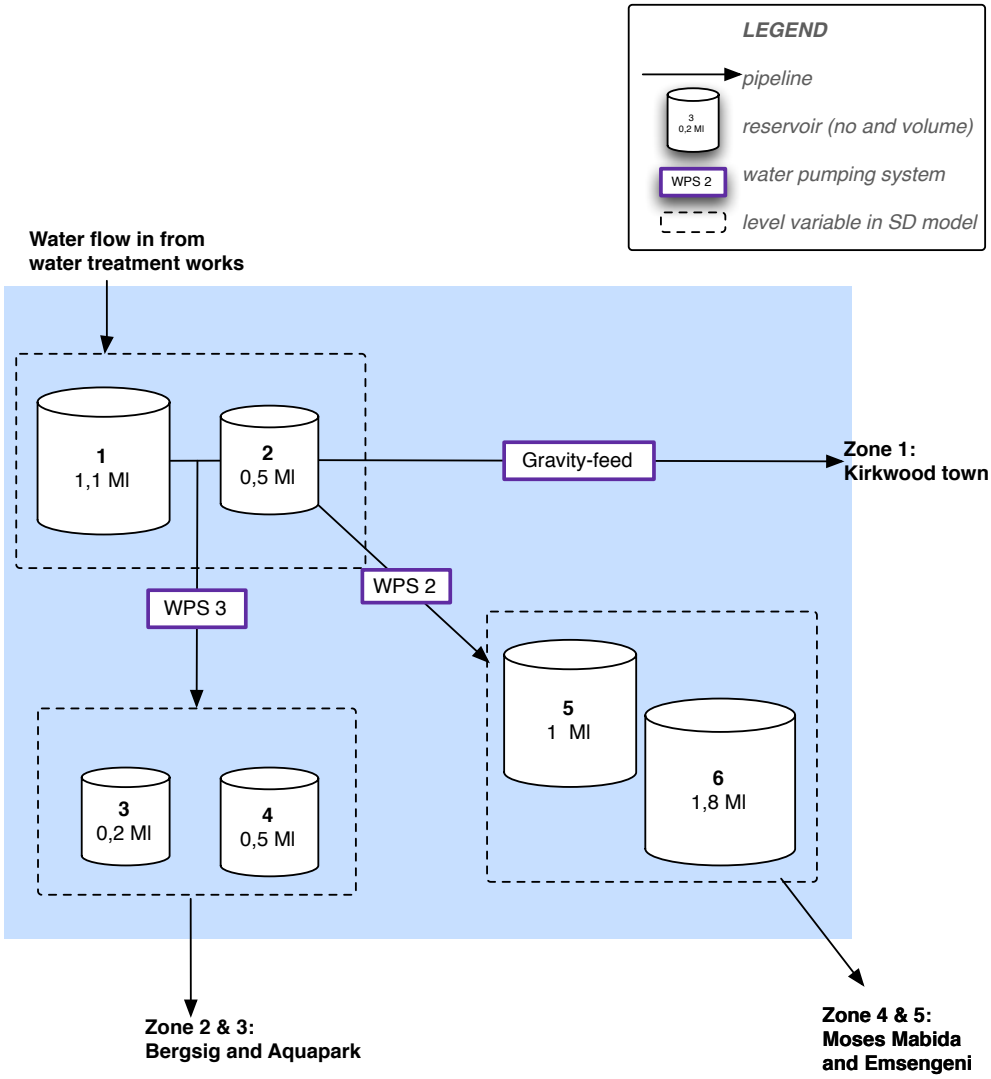


Figure E.5: Schematic representation of the potable water reservoirs in the Greater Kirkwood water supply scheme, in relation to the level (AKA stock) variables in this SD (system dynamics) model. Source: reproduced from D'Hont (D'Hont, 2013)**.**

As a result of the infrastructural design, the first supply zone to receive water and the last place to run-out of water is Kirkwood town, which has been a cause for dispute between different communities in the region: Kirkwood Town is the wealthier, formerly-white suburb, and its advantage in receiving a more stable water supply has been perceived as unfair discrimination based on social status, class and race. There is, however, a technical reason for the different level of service between the communities. The water pumping systems at the Kirkwood WTW are powered by fuel-based engines, and function as 'routers' that divide the incoming water between the outgoing channels to the reservoirs. Whilst the capacity of the water pumping systems differs – WPS 2 has a design capacity of 2.3 Ml/day and WPS 3 has a

design capacity of 1,8 ML/day – both pumping systems often perform beyond their capacity, and therefore these design capacities do not restrain the model as limiting factors. The constraint on the operating of the pumping systems is related to the capacity of the reservoirs: when the water level in reservoirs 1 and 2 drops to below 20%, the water pumping systems (WPS 2 and WPS 3) cut-out, because below this water level the pumps start drawing air. This cut-out function can be overridden, but at the cost of the water pumping systems possibly burning-out (which would prevent reservoirs 3, 4, 5 and 6 from receiving any treated water at all). When the pumps cut-out, the remaining 20% of the water volume in reservoirs 1 and 2 flows to Kirkwood town (zone 1), because the gravity feed functions independently from the water pumping systems.

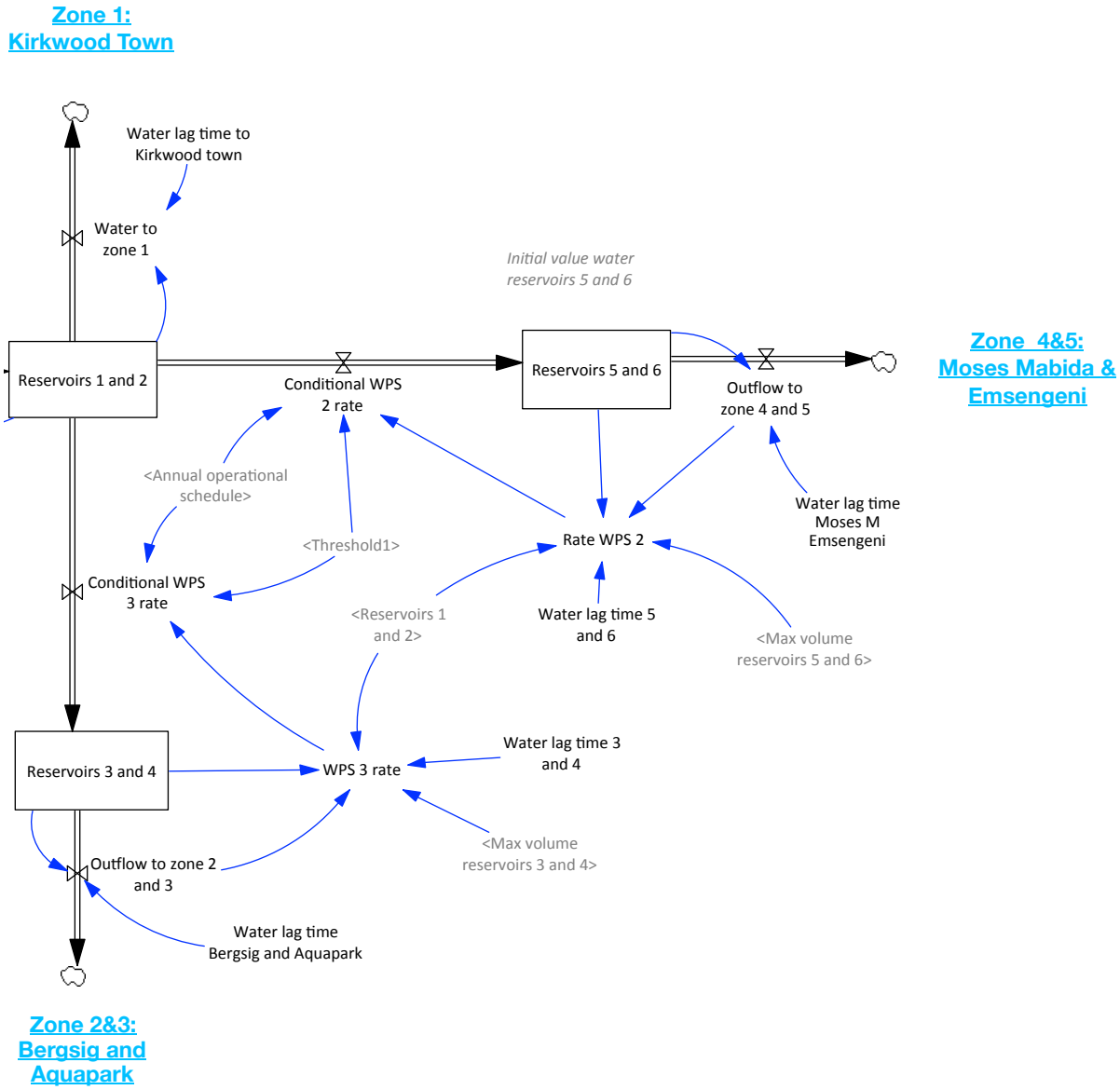


Figure E.6: Potable water reservoir sub-model.

According to the SRVM Technical officials, the water pumping systems will not work until the water level in reservoirs 1 and 2 rise to over 50%. This strange fact results in misunderstandings among the communities: there appears to be water in the reservoirs, the people in Kirkwood Town still receive water, but their own taps are delivering no water. The technical explanation for this system behaviour appears to be misunderstood by stakeholders both within the broader SRVM community and within the municipality (particularly the elected officials and the senior administrative officials). In the GKWS model, the water pumping systems stops functioning stop when the water level in reservoir 1 and 2 drops below 20% of the total volume, and only starts again when the water level rises above 50%. The sub-model governing this cut-off is detailed in Appendix A of D'Hont (D'Hont, 2013) and is excluded here for reasons of length.

The outflows from the stock variable "Reservoir 1 and 2" determine the water supply to the communities in Kirwood Town, Moses Mabida, Emsengeni, Bergsig and Aquapark. These functions are elaborated here. The first outflow rate from the stock "Reservoirs 1 and 2" is the "Water to zone 1", which is mathematically formulated as follows:

```
Water to zone 1 =
MAX(0,Reservoirs 1 and 2 / Water lag time to Kirkwood town)
~ liter/Day
```

In which:

- "Reservoirs 1 and 2" is the stock variable that represents the current water volume in these reservoirs; and,
- "Water lag time to Kirkwood Town" is the time it takes for the water to flow from the canal through the pipes to taps in Kirkwood Town.

The two other outflow rates leaving the stock variable 'Reservoirs 1 and 2" are called "Conditional WPS 2 rate" and "Conditional WPS 3 rate". These two rates are structured in the same way, with the example of "Conditional WPS 2 rate" described here:

```
Conditional WPS 2 rate =
Annual operational schedule *(IF THEN ELSE ( Threshold1 >= 1, 0, Rate
WPS 2 ))
~ liter/Day
```

Where:

```
Rate WPS 2 =
MIN ((( Max volume reservoirs 5 and 6 - Reservoirs 5 and 6) / Water
lag time 5 and 6 ) + Outflow to zone 4 and 5 ,
Reservoirs 1 and 2 / Water lag time 5 and 6 )
~ liter/Day
```

In which:

- "Annual operational schedule" is a dimensionless function and represents the operational hours, as elaborated in sub-section E.4.5;
- "Threshold1" is the output variable of the submodel that models whether the water pumping systems can be used, based on the water level in reservoirs 1 and 2. "Threshold1" is a dimensionless variable that can be either 1 or 0 (see Appendix A of D'Hont (D'Hont, 2013) for a detailed description);
- "Rate WPS 2" is the rate that is assumed when the water pumping systems are still running;
- "Max volume reservoirs 5 and 6" corresponds with the size of both these reservoirs, being 2,8 Ml, as shown in Figure E.5;
- "Reservoirs 5 and 6" is the stock variable that represents the current water volume in these reservoirs;
- "Water lag time 5 and 6" is the time it takes for the water to flow from the canal through the pipes to reservoirs 5 and 6;
- "Outflow to zone 4 and 5" is the rate in which the reservoirs 5 and 6 are emptied. This variable is included in this function because it represents the water that is in the pipes flowing. By modeling it as such, the capacity of the pipes is taken into the calculations; and
- "Reservoirs 1 and 2" is the stock variable that represents the current water volume in these reservoirs.

As discussed in this sub-section, the GKWS model uses a single stock variable to represent reservoirs 1 and 2: the model therefore simplifies how the WPS works in reality, where the WPS at the Kirkwood WTW still functions when one of the two reservoirs is above the 20% threshold. If the WPS continues to function when the water level in one of the two reservoirs is above 20%, then the Kirkwood water supply scheme would perform more effectively in reality than it does in the GKWS model. At the time of undertaking this modelling initiative (March to May 2013), there was little available information on this aspect of system behavior and therefore the reservoirs were modelled as a combined stock, as described here.

E.4.5. Operational schedule

Greater Kirkwood's water supply system is operated and maintained throughout the year. The [dry] winter period is the maintenance period. Maintenance is performed by draining the

irrigation canals, which results in a cessation of raw water supply over the maintenance periods. In these periods, the sluices and water pumping systems are operational a total of 56 hours, from Wednesday 6.00 AM to Friday 2.00 PM. The operational activities in the normal period start at Monday 7.00 AM to Friday 2.00 PM, which adds up to a total of 103 hours (as recounted in Table E.2).

Table E.2: Hypothetical operational schedule for the Lower Sundays River Water User Association (L-WUA), as used in the GKWS model. Note that the exact maintenance period was not published on the L-WUA website at the time of creating this model – as such, winter and summar dates were used as proxy dates (as described in D'Hont (D'Hont, 2013)**.**

	Maintenance period	**Normal period**
Start time	Wednesday, 6.00 AM	Monday, 7.00 AM
End time	Friday, 2.00 PM	Friday, 2.00 PM
From	1 May	1 August
Until	31 June	30 April

This operational schedule is modelled by using the hour of the week to determine the weekly working hours, and the day of the year to determine whether the maintenance or the normal schedule is applicable (as shown in Figure E.7).

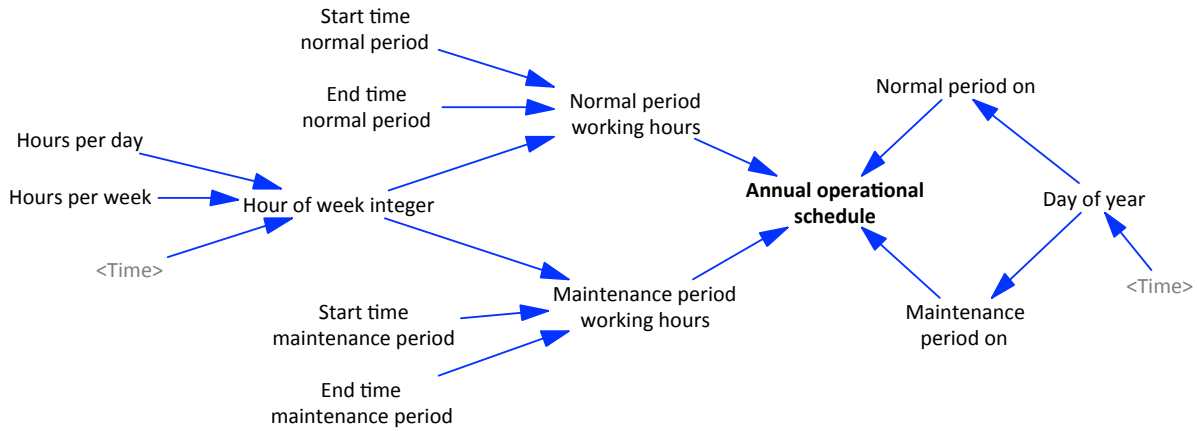


Figure E.7: Annual operational schedule sub-model

In the model, the annual operational schedule is determined as follows:

```
Annual operational schedule =
Normal period on * Normal period working hours + Maintenance period
on * Maintenance period working hours
~     1
```

In which

- Normal period on" and "Maintenance period on" are dimensionless variables that indicate which operational schedule is active, based on the time of year. The variables can assume the values 0 and 1; and,
- "Normal period working hours" and "Maintenance period working hours" are the dimensionless variables that indicate whether the system is operative or idle. The variables can assume the values 0 and 1.

Therefore, the variable "Annual operational schedule" is either 0 or 1, depending on the simulation time. If it equals 1, the water supply system is operative and if it equals 0, it is idle. By multiplying the sluice rates and water pumping system rates with this variable, the system will start and stop accordingly. The 'uses tree' diagram in Figure E.8 traces how the variable "Annual operational schedule" is used throughout the GKWS model: the variables that are enclosed in parentheses indicate the variables that are used multiple times in the diagram (and therefore in the model itself). As illustrated in the diagram, the variable "Annual operational schedule" is used to constrain the rates for the water pumping systems and the inflow to the raw water dams.

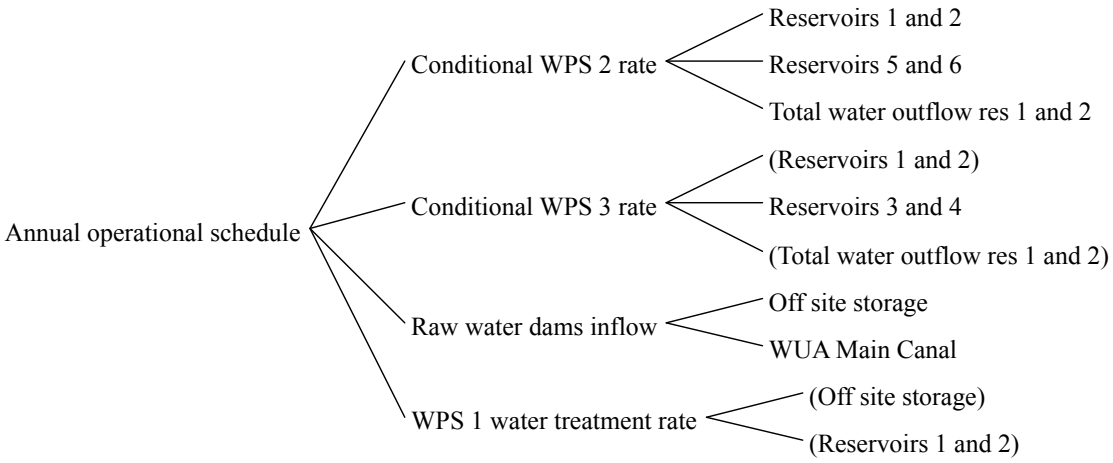


Figure E.8: Uses tree for the variable "Annual operational schedule".

E.4.6. Monitoring potable water sub-model

The main objective of Greater Kirkwood's water distribution system is to supply safe, potable water to the inhabitants of the Greater Kirkwood region in zones 1 to 5 (in accordance with the municipality's constitutional mandate to ensure that residents within its jurisdiction have

access to basic water supply). The time that zones 1 to 5 are without potable water is calculated in the submodel presented in Figure E.9.

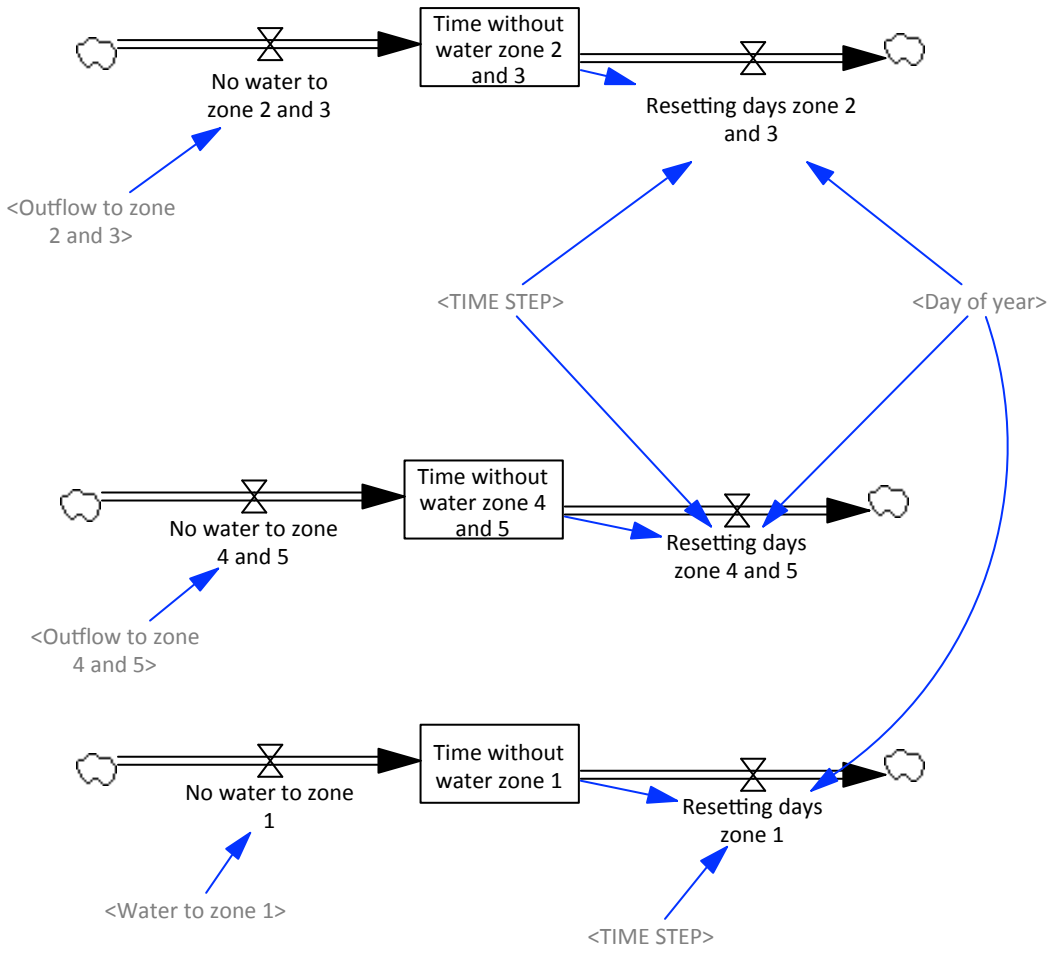


Figure E.9: Monitoring potable water sub-model

The time that a given zone (e.g. "x") is without a potable water supply is determined by the variable "no water to zone x", which is mathematically represented as follows:

```
No water to zone x =
IF THEN ELSE( Water to zone x <= 10000 , 1, 0)
```

In which:

- The function returns a dimensionless value of 1 or 0;
- "Water to zone x" is the last rate variable in the simulation model. It models the discharge rate from the reservoirs to the communities via the pipelines. If the value for

this variable is below 10 000 liter/Day, the stock variable "Time without water zone x" will increase;

- These stock variables represent the number of days that the communities of zones 1 to 5 are without water each year: hence, each January 1st, the stock variables are emptied.

E.4.7. Model validation

To verify the GKWS model, all units were checked using the Vensim software. A list of the units and variables used in the final GKWS model is presented in Appendix B of D'Hont (D'Hont, 2013). The feedback loops in the model were also checked for consistency with the systems diagram in Figure 7.7.

E.5. Results

Results of the GKWS model are presented and discussed in sub-section 7.5.4(iii) of Chapter 7.

E.6. General discussion and conclusion

The GKWS system dynamics model outlined in this appendix was developed in 2013 as an analytical tool to assist in an action research process involving members of the SRVM, the L-WUA and other interested and affected stakeholders in the Lower Sundays River Valley region of South Africa.

Presently, the municipality is running the pumps above their maximum discharge rate. This is not sustainable in the long term, but is an indication that the technical capacity of the system may in itself be insufficient to meet the demands placed upon it. Whereas the stakeholders have been blaming each other in the past, there is a growing realisation that the supply system may not be adequate. The L-WUA has long held the opinion that the municipality neither orders water appropriately (evidence of which is demonstrated by water wastage occurring through raw water dams overflowing), nor is the municipality perceived by the L-WUA to be operating the system effectively (the frequent failure to supply water is presented as the demonstration of that). Some residents and officials at the SRVM have long held the opinion

that the L-WUA is to blame for not supplying on weekends, but have themselves not grasped where the systemic issues lie.

Through the system dynamics model, we have been able to establish that the off-site storage capacity of the municipality is insufficient to meet the demand for water over a weekend of peak summer demand. So even if the SRVM runs the water supply system extremely efficiently, the supply of water will fail. This fact had not previously been understood by the municipality, despite attempts by the L-WUA to communicate this from 1997 onwards.

It is not clear, however, whether the capacity of the water supply system would still be insufficient were the L-WUA to continuously supply water i.e. through weekends as well. This is related to the uncertainty about the volume that can be stored in the old storage canal. Clearly, then the off-site storage capacity is a limiting factor in the supply system. Similarly, we have been able to identify the pump capacity as a further limiting factor should the off-site storage capacity be increased.

An additional insight is that the safety mechanisms in the technical design of the pumps, together with the nature of the gravity feed system to Kirkwood town, combine to ensure that the town of Kirkwood is the last to be cut-off and the first to receive water. Hence, the situation is such that all areas of the municipality do not run dry at the same time. Instead some areas run dry more quickly than others, notably the lower income areas. The zone with the highest socio-economic status is Zone 1 (Kirkwood town), which runs out of water last, and receives water first after outages; whilst the opposite applies to the zones with the lowest socio-economic status. Some municipal residents perceive this as systemic injustice, given that Zone 1 is still primarily inhabited by white residents, unlike the populations of the poorer zones 2 to 5.

The demand for water has grown rapidly in the last decade with more houses being added to the reticulation network. As more and more houses are added to the network, there is greater expectation on the municipality to supply water to these houses. Whilst there is political pressure to supply running water and sanitation to households, there is less pressure to maintain and develop the water supply infrastructure required to continuously services to the households. The anticipation of a strong growth in the demand for water means that the SRVM now understands that the capacity of the technical system has to be improved if they

are to meet the demand, and that they will have to plan for and acquire funding for such infrastructural improvement.

Furthermore, the SRVM is now confident that their system performance can be enhanced if they were to receive a continuous supply of water. They will continue to argue for a change in the L-WUA operating procedures, especially given the national priority placed on basic human needs for water. It is worth noting that the L-WUA's delivery system was first and foremost designed for commercial agriculture, which has different water demands to those of domestic users. For example, the open design of the canal system and the hot climatic conditions result in high-levels of algal growth in the irrigation canals: the L-WUA's chosen method for clearing algae is to drain and therefore dry-out the canals. Such system maintenance is scheduled during the winter period, when the farmers' demands for water are lowest. This means that the canal system operates for fewer days per week during the winter, despite the fact that the SRVM – as a supplier of water for domestic use – requires a similar quantity of raw water all year round. However, the SRVM cannot only demand changes of the L-WUA. They are also obliged to rethink their policy of only running the treatment works during the week (Monday-Friday), as this is a potential further constraint on water supply that lies directly under their control.

References:

(*included in overall reference list for thesis*)

Appendix F System dynamics model 3 (the 'Kirkwood Water Demand Model')

The system dynamics model presented in Appendix F was developed in collaboration with Dr Jill Slinger of Delft University of Technology, the Netherlands, Professor Alan Brent and Dr Josephine Musango of the University of Stellenbosch) and Professor Tally Palmer of Rhodes University. The model was first described in the following peer-reviewed conference proceedings:

Clifford-Holmes, J, Slinger, J., Musango, J. Brent, A., & Palmer, C.G. 2014. Using System Dynamics to Explore the Water Supply and Demand Dilemmas of a Small South African Municipality. Conference proceedings - *32nd International Conference of the System Dynamics Society*, 20-24th July 2014, Delft, the Netherlands. (http://www.systemdynamics.org/conferences/2014/proceed/index.html).

This appendix draws on the conference paper in order to describe the 'Kirkwood water demand' model.

For the full model documentation, please see:
http://iwr.ru.ac.za/iwr/sanpadlink/index.php?p=CaseStudyDocs/SRVM/CliffordHolmesPhD

Abstract:

This paper explores the challenges faced by small municipalities in providing water services in a developing-world context of increasing urban demand. The paper uses a case study of the Sundays River Valley Municipality (SRVM) in South Africa. The municipality faces multiple dilemmas in reconciling its available water supply with growing demand for potable water in the primary urban settlement in the area, in a struggle that is typical of the broad category of South African municipalities to which the SRVM belongs. These dilemmas are explored using a system dynamics model, referred to as the 'Kirkwood water demand system dynamics model' (*K-DEM*). This paper specifically introduces the *K-DEM* structure, which is aimed at investigating the impacts of households progressively receiving full water and sanitation services; the use of rainwater harvesting as an alternative form of water supply; and the possible effect of a household-level water conservation / water demand management programme. Baseline results are discussed, and areas for future research identified.

F.1. Introduction

Whilst many of the urban areas in the SRVM face significant water challenges, *K-DEM* focuses on one of the three primary schemes operated by the SRVM, which supplies communities and suburbs of the Greater Kirkwood area. The first research efforts to explore problems affecting the Kirkwood supply scheme – using the Strategic Adaptive Planning process of Rogers and Luton (2011) – identified the bulk water supply system as a key focus. To this end, the 'Greater Kirkwood water supply model' was developed (D'Hont et al., 2013) and then extended (D'Hont, 2013). The initial focus of these endeavours was to use system dynamics modelling as a means of facilitating strategic conversations (Howick & Eden, 2010)

between the municipality, the bulk water supplier in the region and other organs of government, with the emphasis on the operations of the supply system. These early modelling endeavours surfaced numerous issues that were not addressed within the purpose, nor in the design of the 'Greater Kirkwood water supply model'. The most critical of these issues were the determinants of the rising demand for potable water in Kirkwood and the possible alternative sources of water supply. This problem can be articulated from the perspective of different stakeholders in the following way:

- Municipal communities who currently receive full water services (in-house water connection and waterborne sanitation) want a stable water supply, with a reduction in the number and severity of current shortages and outages.
- Municipal communities who receive a 'basic supply level' of water services (i.e. residents who access potable water either from a nearby standpipe or yard connection, but do not have waterborne sanitation or household water connections) desire the latter services as soon as possible.
- Municipal officials want to be able to supply water now, and into the future as the municipality grows – that is, providing both to current communities, and progressively meeting the water demands of future communities.
- Funding agencies and national government departments (including the national Department of Water Affairs) want the SRVM to demonstrate active water demand management, showing how the municipality is conserving and using current water resources effectively, prior to applying for funding for further water supply infrastructure.

Following the above, the problem explored using the *K-DEM* model in this study can be summarized as:

> *How can the Sundays River Valley Municipality reconcile the available water supply with the growing demand for potable water in Kirkwood, whilst minimising the gap that currently exists between the current and desired levels of potable water services?*

The motivation for selecting system dynamics and the attendant methods for exploring the above problem are provided in section F.2. below.

F.2. Methodology

There are several reasons why system dynamics is an ideal method for exploring the supply-demand dilemmas in Kirkwood. Firstly, on-going disputes between different water users and stakeholders in the case study were compounded by uncertainty in the basic information. This uncertainty included the size of the population of Kirkwood, the quantity of unaccounted-for water, household demand requirements for potable water, and the mechanisms of access. Where appropriate numerical data were available, technical reports were consulted in order to provide data for the model parameters and initial states (references are provided in: D'Hont et al., 2013). To address the many areas where numerical data were lacking, researchers facilitated three workshops (31 November to 1 December 2011; 10 October 2012; and 28 February 2013), which were attended by representatives from the Department of Water Affairs and the SRVM, in addition to impacted and affected stakeholders.

F.3. Model description

This section outlines the structure of the *K-DEM* model in four sub-sections. Firstly, the model boundary is described by means of a 'boundary chart'. Secondly, the relationships between the primary variables are discussed using an aggregate causal loop diagram. The model settings are then summarised, after which the *K-DEM* stock-flow diagrams are explained.

F.3.1. Model boundary

A system dynamics model strives to produce an endogenous explanation of the problem under examination (Forrester, 2007; Sterman, 2000). This is to say that the primary driving forces of the system, and the feedbacks between these driving variables, should be included within the model. Other variables that affect the system, but are not affected *by* the system, can be included in the model as 'exogenous' variables. Given that a model is a simplification of reality in order to gain analytical purchase on a particular problem, variables that are held to be less important for the system under examination are excluded from the analysis. A description of which variables are treated endogenously and exogenously in relation to those that are excluded is therefore a central part of stipulating the model boundary. This is presented in the 'model boundary chart' in Table F.1.

Table F.1: Model boundary chart for the Kirkwood water demand model (*K-DEM*)

Endogenous	Exogenous	Excluded
Potable water supply	Raw water sources	Raw water allocations from the Orange-Fish Sundays inter-basin transfer scheme.
Urban domestic potable water demand drivers (households)	Population fluctuations	Possible population drivers + commercial demand + water quality + wastewater
Treatment from raw to potable water	Bulk water losses	Operational and capital budgets affecting supply infrastructure and maintenance
Rainwater harvesting infrastructure	Hydrological dynamics affecting the sub-catchment	Global and regional climatic variations
Transitions from informal households, to households with basic supply to fully-connected households	Aggregate increase in lifestyle expectations in the Greater Kirkwood area, with regards to water and sanitation	National prerogatives and directions regarding 'free basic water' and 'free basic sanitation'

F.3.2. Causal loop diagram

(See sub-section 7.5.4 (ii) for aggregate causal loop diagram for the *K-DEM* model)

F.3.3. Model settings

K-DEM simulates a 20-year period, equating to a time horizon of 2005-2025. The period between 2005 and 2013 was used primarily for model calibration purposes, whilst the period between 2013 and 2025 was used for projection and simulation purposes. A time step of 0.0625 years (a little less than a month) was selected. The model was simulated using the time unit of years. The Euler method was selected for numerical integration purposes. The level of data uncertainty, and the inclusion of the decision rule used in the water treatment process within the model (an if-then-else construction) are the primary reasons for selecting Euler over Runge-Kutta4. The model was constructed and simulated using Vensim PLE (Personal Learning Edition) system dynamics software for Macintosh, Version 6.1c (Ventana Systems, 2013).

F.3.4. Overview of sub-models

This section describes the simulation model by introducing the *K-DEM* sub-models that were developed. The model consists of four sub-models: a simple population sub-model (top-left of Figure F.1), which is linked to a rainwater-harvesting sub-model (bottom left) and to a household sub-model (top-right). All three of these are linked with the fourth sub-model (which is the potable water supply system: bottom-right). The link between these sub-models is the sum of the demand for water from 'informal households', 'households with basic supply' and 'connected households'. This 'total household demand' is represented by the variable enclosed in a circle in the middle of Figure F.1.

Each sub-model is described in detail in the following section. These descriptions provide an overview of the functions utilised in each sub-model whilst surfacing the assumptions (and some of the limitations) associated with each part the model.

F.3.5. Population sub-model

This sub-model represents the population of the Greater Kirkwood region of the Sundays River Valley Municipality. It is a simplified one consisting of one stock 'population' (*P*), which is increased by births (r_b) and decreased by deaths (r_d) (refer to Figure F.1). The population at time *t* is mathematically represented as:

$$P(t) = P(0) + \int \left[r_b - r_d \right] dt \quad (1)$$

F.3.6. Households sub-model

The households sub-model consists of two stocks, namely, households with basic supply (*HBS*) and connected households (*CH*) (refer). These two stocks are connected using an 'aging chain' model structure (Sterman, 2000: 485-490). The first stock (*HBS*) is influenced by the net growth of households with basic supply (r_{gbs}) and the household connection rate (r_c):

$$HBS(t) = HBS(0) + \int \left[r_{gbs} - r_c \right] dt \quad (2)$$

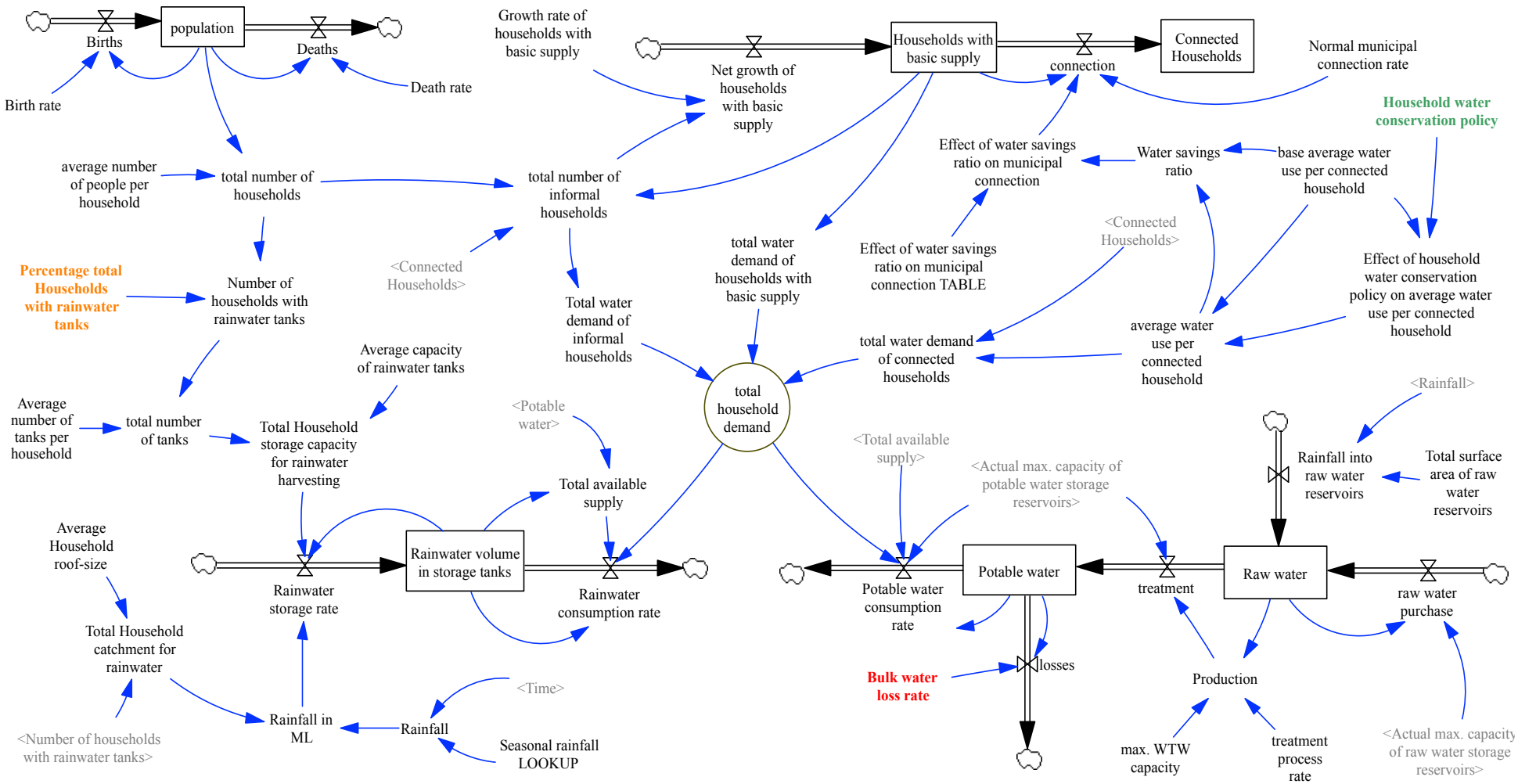


Figure F.1: Overall stock-flow diagram of the main sub-models in the Kirkwood water demand (*K-DEM*) model.

In 2005 (the start of the time horizon used in this model), the majority of the households in the Greater Kirkwood area received a 'basic supply level' of water services. The inflow into this stock – the net growth of households with basic supply (r_{gbs}) – is influenced by the total number of informal households (*TIH*) and the growth rate of households with basic supply (*GRBS*). The total number of informal households is given as the total number of households (*TH*) minus the sum of households with basic supply (*HBS*) and connected households (*CH*). This is mathematically represented as follows:

$$TIH = TH - (HBS + CH) \tag{3}$$

The key driver of demand in *K-DEM* is the water demand from connected households, which are the households that are connected to the municipal bulk water supply and waterborne sanitation network. The stock of connected households (*CH*) is influenced by the connection rate (r_c), represented as:

$$CH(t) = CH(0) + \int [\, r_c \,] dt \tag{4}$$

The rate that households move from the *HBS* stock to the *CH* stock (i.e. the connection rate) is the single most important driver of behaviour in *K-DEM* and is represented as:

$$r_c = HBS * NMC * EWSR \tag{5}$$

Where, *HBS* is households with basic supply stock; *NMC* is the normal municipal connection rate; and *EWSR* is the effect of water savings ratio on municipal connections. *NMC* is equal to the average time that it takes the municipality to connect households under normal conditions. The connection rate deviates from the norm given the effect of water savings on municipal connections (*EWSR*). *EWSR* is based on two interrelated assumptions: the first is that the *less* the water use per connected household per year, the *more* potable water will be made available for use by new connected households. The second assumption is that the municipality will use the resulting 'water savings' on connecting additional households to the bulk water supply and sanitation network. The water savings are estimated through a 'water savings ratio' (*WSR*), which is calculated as the 'average water use per connected household' (*AWCH*) divided by 'base average water use per connected household' (*BAWCH*):

$$WSR = \frac{AWCH}{BAWCH} \tag{6}$$

In order to account for the non-linear nature of the interactions between water savings ratio (*WSR)* and the municipal connection rate (r_c), *K-DEM* employs a LOOKUP function, demonstrated in Figure F.2.

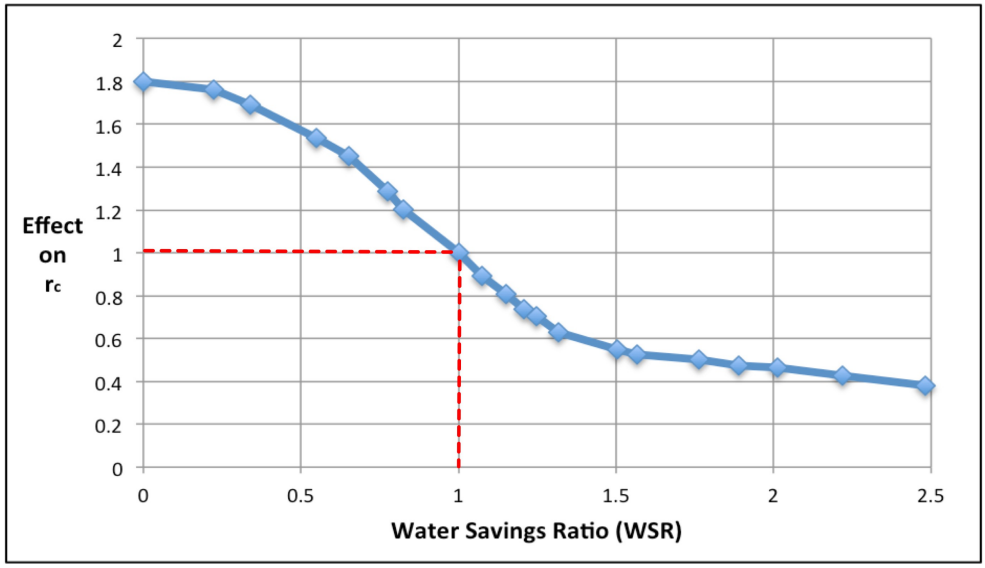


Figure F.2: LOOKUP function for effect of water savings ratio (WSR) on municipal connection rate (r_c).

The water savings ratio (*WSR*) would be within the bounds of the box created by the dotted red lines in Figure F.2 with a household water conservation policy. The ratio would only be greater than 1 if the type of domestic water uses changes. As the water savings ratio (*WSR*) exceeds 1, the number of houses that can be connected decreases sharply (as demonstrated by the sharp decline between 1 and 1.5 on the x-axis). On the y-axis, 1 denotes the standard municipal connection rate (*MCR*). At the upper bound of 2 on the y-axis, the standard municipal connection rate (*MCR*) would double (hence twice as many houses per year could be connected than the 'normal' connection rate would allow). The variability of the municipal connection rate (*MCR*) is controlled by the presence of a 'Household water conservation policy' (in green in the top right of the stock-flow diagram in Figure F.1). The latter is one of three policies that are planned for testing in the model in the future development of the work.

F.3.7. Potable water supply sub-model

Given that potable water supply system in Kirkwood has been the subject of previous modelling endeavours (D'Hont et al., 2013; D'Hont, 2013), the water supply sub-model in *K-DEM* is relatively simple. The water supply system was modelled in *K-DEM* using two stocks: raw water and potable water. The raw water stock (*RW*) is influenced by three flows,

raw water purchases (r_{rwp}), rainfall into raw water reservoirs (r_{rf}) and water treatment rate (r_{tm}). The mathematical representation of this is:

$$RW(t) = RW(0) + \int \left[(r_{rwp} + r_{rf}) - r_{tm} \right] dt \quad (7)$$

The potable water (*PW*) stock is influenced by water treatment rate (r_{tm}), potable water losses (r_{lo}) and potable water consumption (r_{pwc}), represented as:

$$PW(t) = PW(0) + \int \left[r_{tm} - r_{lo} - r_{pwc}) \right] dt \quad (8)$$

Portable water losses (r_{lo}) are determined by bulk water loss rate (*BWL*), which is set exogenously as a constant (and is adjusted for policy analysis purposes). The rate of potable water consumption (r_{pwc}) is influenced by the total household demand (*THD*), the amount of potable water (*PW),* maximum capacity of the potable water reservoirs (*MPW*), and total available supply of water (*TAS*) – which is the sum of available rainwater and potable water. This is mathematically represented as:

$$r_{pwc} = \min (MPW, (THD * \frac{PW}{TAS})) \quad (9)$$

This model structure reflects the real-world problem that the amount of potable water available is subject to the amount of raw water available and the treatment capacity. As described above, raw water availability increases with raw water purchases (r_{rwp}) and rainfall into raw water reservoirs (r_{rf}). The latter is described in detail in the rainwater harvesting sub-model in 4.8. The primary determinant of raw water availability is raw water purchases (r_{rwp}). Raw water purchases (r_{rwp}) are calculated as the difference between the maximum capacity of the raw water reservoirs (*MRW*), corresponding to the situation in the town of Kirkwood, and the amount of raw water (*RW*) at a particular point in time. This is given as:

$$r_{rwp} = MRW - (RW / t_{rw}) \quad (10)$$

where, t_{rw} is time to adjust raw water stock.

Maximum capacity of raw water reservoirs (*MRW*) is calculated as a sum of the capacity of raw water reservoirs, as demonstrated in Figure F.3 below. This sub-model calculates the sum of the four raw water reservoirs and includes an additional storage facility – the old storage canal. As illustrated in Figure F.3, *MRW* caters for the entire possible storage infrastructure in

the model (*phrased as* 'theoretical max. capacity of raw water storage reservoirs'), with the dysfunctional reservoirs then subtracted from it.

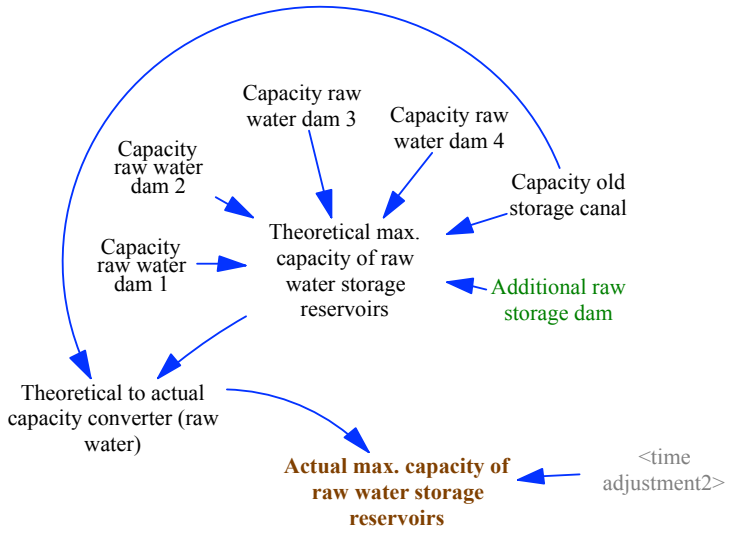


Figure F.3: Maximum capacity of raw water storage reservoirs (MRW) sub-model

Given increasing water demand in the Greater Kirkwood area, the municipality has been operating its water treatment works at its maximum capacity (*WTC*). To reflect this reality, production (*PR*) is represented as a decision rule influenced by the maximum capacity of the water treatment works (*WTC*), the treatment process rate (*TPR*) and the available raw water (*RW*). The model simulates the current operating rule of the municipality. Producing potable water is, however, still reliant on there being sufficient raw water available to support this function, so in situations when there is insufficient raw water to support maximum capacity, then the water treatment works will process everything available. As such, this is mathematically presented as:

$$PR = IF\ THEN\ ELSE\ (RW < (WTC * TPR), RW, (WTC * TPR)) \tag{11}$$

The amount of potable water available for use by Greater Kirkwood residents is constrained by the storage capacity of the potable water reservoirs (i.e. for practical purposes, more water cannot be treated than can be stored in these reservoirs). The maximum capacity of the potable water reservoirs (*MPW*) is calculated using an equivalent model structure for potable water storage to the one outlined for raw water storage in Figure F.3. The water treatment rate (r_{tm}) is therefore determined by production (*PR*) and the maximum capacity of the potable water reservoirs (*MPW*). A minimum function is utilised for the treatment rate (r_{tm}) calculation, where:

$$r_{tm} = \min (MPW, PR) \tag{12}$$

F.3.8. Rainwater-harvesting sub-model

This sub-model consists of one stock, namely rainwater volume in storage tanks (*RWT*), which is increased by rainwater storage (r_{rs}) and reduced by rain water consumption (r_{rwc}). This is mathematically represented as:

$$RWT(t) = RWT(0) + \int [\, r_{rs} - r_{rwc} \,] dt \tag{13}$$

The rainwater storage rate (r_{rs}) is determined by the amount of rainfall in ML (*RFA*) available for rainwater harvesting, total household storage capacity for rainwater (*THStR*), and the rainfall volume in storage tanks (*RWT*). This was represented as a minimum function as follows:

$$r_{rs} = \min ((THStR - RWT), RFA) \tag{13}$$

The rainwater consumption rate (r_{rwc}) is determined by the total household demand (*THD*), the rainwater volume in storage tanks (*RWT*) and the total available supply of water (*TAS*), and is expressed as minimum function as follows:

$$r_{rwc} = \min (RWT, (THD * \frac{RWT}{TAS})) \tag{14}$$

The total household storage capacity for rainwater harvesting (*THStR*) is given as the total number of tanks (*TNT*) multiplied by the average capacity of rainwater tanks (*ACR)*:

$$THStR = TNT * ACR \tag{15}$$

Similarly, the available rainfall in ML (*RFA*) is given as the product of rainfall (*RF*) and the total household catchment for rainwater (*THCR)*:

$$RFA = RF * THCR \tag{16}$$

Rainfall (RF) is influenced by the seasonality of rainfall in the Greater Kirkwood area, which was represented as a LOOKUP. In representing the seasonality, the months of the year were translated into values between 0 and 1 via dividing the value of the midpoint of each month (in days) by the total number of days in the year (i.e. a value for January was created by dividing 15 by 365, resulting in a value of 0.041). These values were used as the inputs for the LOOKUP table. Secondly, rainfall data was disaggregated into monthly rainfall (using data collected on a monthly basis, at the local level in the SRVM, between 1969 and 2012). The

average rainfall per month (i.e. January to December, from 1969-2012); and average monthly rainfall (calculated as the sum of all the monthly averages, divided by the number of months (i.e. 12)) were then calculated. The rainfall outputs for the LOOKUP table were then calculated by dividing average rainfall per month with average monthly rainfall. For example, the average rainfall for the month of January in the Greater Kirkwood area is 38.41mm. The annual average monthly rainfall is 36.96mm. Hence, the effect of seasonality on rainfall is given as 38.41 mm divided by 36.96 mm, which is equal to 1.039. The resulting LOOKUP function from this table of inputs and outputs is graphically represented in Figure F.4.

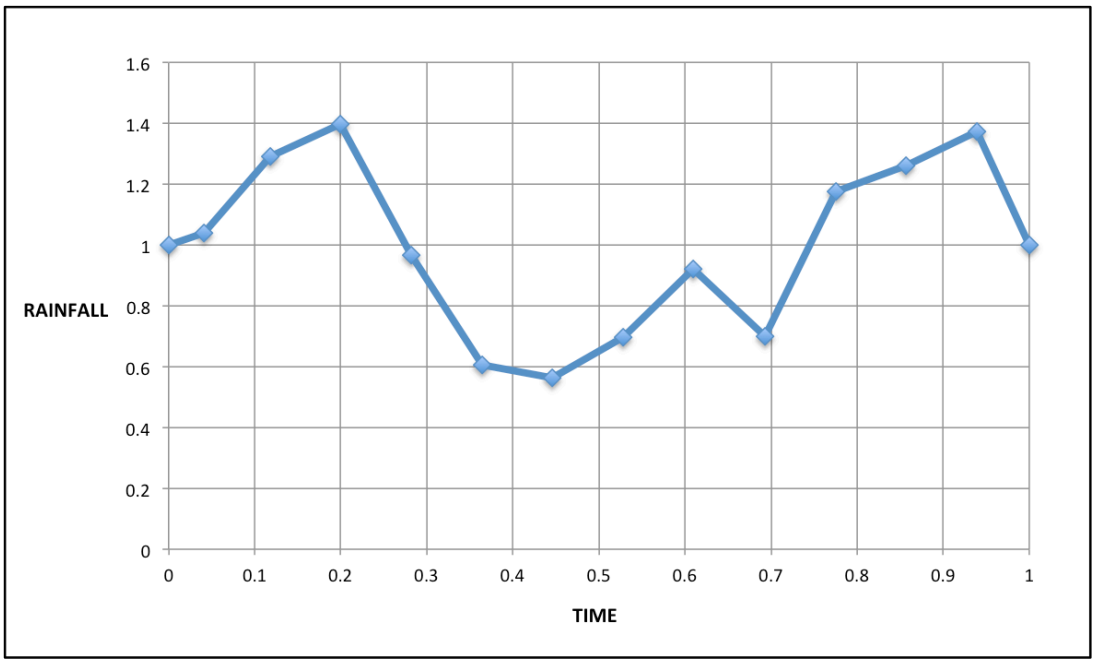


Figure F.4: Graph of LOOKUP function for rainfall

F.3.9. Supplementary variables used in model

K-DEM employs one 'supplementary' variable that has no causal effect on any other variable, and so is itself redundant within the model other than as a source from which information can be derived. This variable is the 'Water security index', the equation for which is as follows:

$$\text{Water security index} = \frac{\text{total available supply}}{\text{total household demand}}$$

The formulation of this index follows an 'Adequacy of water' index employed in an system dynamics model on water supply in Singapore (Xi & Poh, 2013; Xi, 2012). The goal of the

Kirkwood system is to have sufficient water supply to meet the demand in any particular year, and at any point throughout the year. Hence, the supply-demand ratio should be larger than, or equal to, 1. However, whilst a value of 1 on the index might suffice as an annual indicator, having demand=supply (i.e. 1) fails to provide any buffer in the event of a system failure affecting water supply *or* a sudden (and unexpected) spike in demand. On a short-term basis, the index needs to exceed 1. The Department of Water Affairs specifies that a municipal water service provider must ensure a minimum of two days' potable water supply (i.e. two days worth of storage in its potable water storage reservoirs), and a minimum of 14 days storage in the raw water storage reservoirs. This requirement is interpreted in the model as requiring that the water security index should ideally lie between 2 and 6.

F.3.10. Model verification and validation

Prior to use in policy analysis, the *K-DEM* model was tested through processes of 'model debugging', 'model verification' and 'model validation'. The first stage, 'model debugging', sought to trace and correct errors preventing the model from simulating properly (or at all). Once the obvious bugs such as floating point overflows were eradicated from the model, other verification processes were undertaken to further test whether the model was coded correctly and whether it simulated correctly. Following Pruyt (2013), verification can be distinguished from debugging in that the former looks for errors without knowing whether they are present (whilst the latter addresses errors that are obviously present). Particular attention in model verification was paid to achieving consistency between the conceptualisation of the model and its specification. Unit consistency and the numerical accuracy of the simulation were checked. By performing simulation runs throughout the model-building process, structural errors were identified and addressed iteratively.

The aim of model validation is broadly understood as striving to increase confidence in the model under development, thereby increasing confidence in the robustness of the simulated results and the policy analysis arising out of the modelling process (Sterman, 2000). Validation processes used in this study included direct structural tests and extreme condition tests, which are briefly introduced below.

Direct structural tests assess the "validity of the model structure by directly comparing the simulated reference mode with knowledge about the real system" (Barlas, 1996). These tests were particularly useful given that the modeller had in-depth experience of the real-world

problem environment (as a participant in a multi-year action research case study using the SRVM (Palmer et al., n.d.)). Rather than relying on one data set, the model was tested against historical data from a range of sources, collected by national, provincial and local authorities. The results presented below reflect the model outcomes that accord with these different data sets.

The second validation test – extreme condition testing – examined the degree to which the model "responded plausibly when subjected to extreme policies, shocks, and parameters" (Sterman, 2000: 860). The model was tested by drastically increasing the key stocks driving demand in the model (like population), and decreasing the key stocks driving water supply in the model. The outcome of these tests resulted in water demand greatly exceeding available supply, with system behaviour that agreed with the dynamic hypothesis, thereby confirming the validity of K-DEM.

F.4. Results

F.4.1. Baseline simulation results:

All baseline simulation results for the *K-DEM* model are displayed and discussed in sub-section 7.5.5(iv) in Chapter 7.

F.4.2. Scenario simulation results:

One of the options available to the municipality is to implement a programme of reducing the consumption of potable water by connected households. The assumption behind such a 'household water conservation policy' is that the municipality could implement a programme to detect and repair household-level wastage of potable water. Preliminary results from this policy are displayed in figures F.5 and F.6 below. Figure F.5 compares the baseline simulation with a 10% reduction in average water use per connected household (AWCH), using the potable water consumption rate (r_{pwc}) and the total household demand (*THD*).

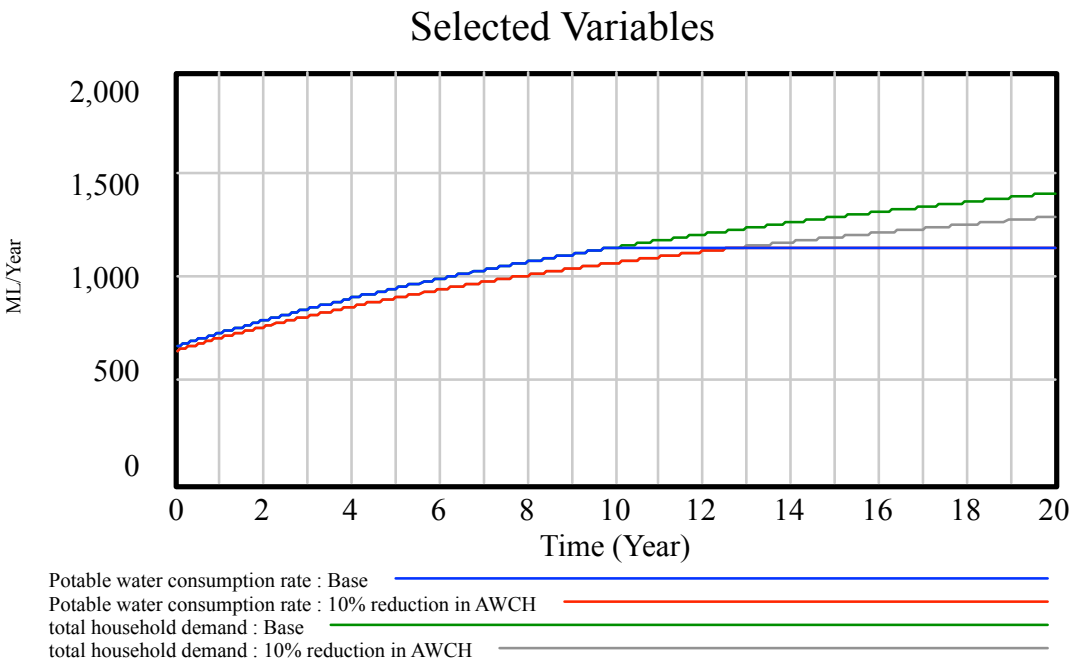


Figure F.5: Potable water consumption rate + total household demand – comparison of base and 10% reduction simulation runs.

The results demonstrate that a 10% reduction allows the municipality to meet household water demand for a full two years longer than in the baseline run (with demand only exceeding available supply after Year 12 of the simulation period). However, the 10% reduction only marginally increases the overall water security of the municipality, as it fails to provide an adequate buffer in the event of a system failure or unexpected spike in demand (see Figure F.6 below).

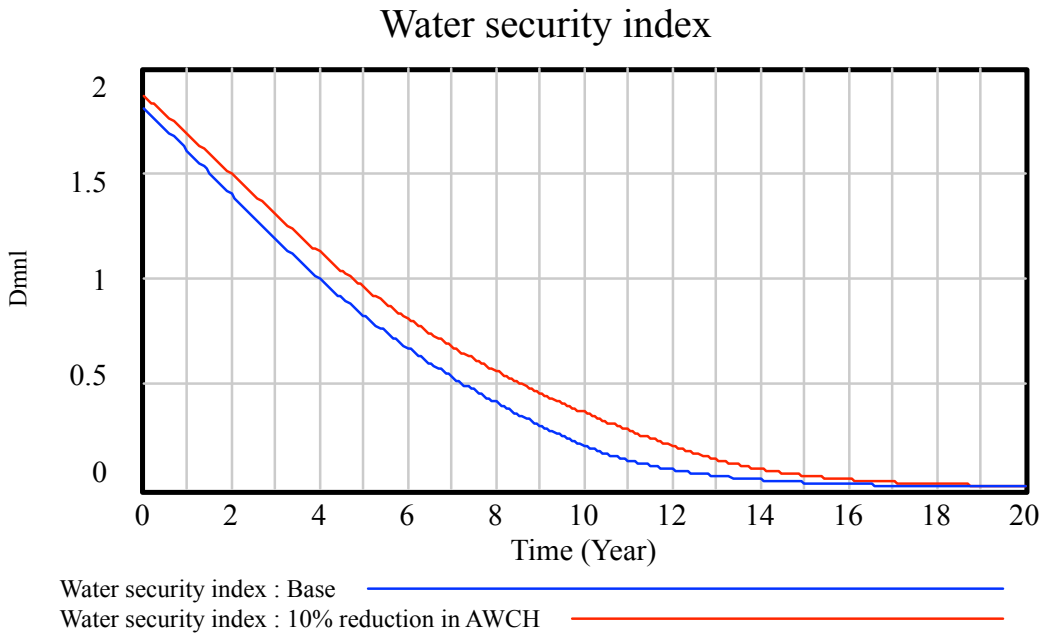


Figure F.6: Water security index – comparison of base and 10% reduction simulation run

F.5. Conclusion

In this paper, the development of the 'Kirkwood water demand system dynamics model' (*K-DEM*) was outlined, in order to assess how the Sundays River Valley Municipality (SRVM) can reconcile its available water supply with the growing demand for potable water in Kirkwood. The key dynamics that were modelled included the impacts of households progressively receiving full water and sanitation services; the use of rainwater harvesting as an alternative form of water supply; and the possible effect of a household-level water conservation / water demand management (WC/WDM) programme. A key insight derived from the modeling approach is that whilst the municipality is perhaps unable to constrain the rate of connection, the municipality can effectively counter the impacts of rapid expansion by investing in WC/WDM measures, with possible policies including programmes to address bulk water losses and household-level water conservation. The next step in the application of the *K-DEM* model to the water management issues facing the municipality is an extensive scenario and policy analysis.

References:

(*included in overall reference list for thesis*)

Appendix G System dynamics model 4 (the 'Modes of Failure' model)

The system dynamics model presented in Appendix G was developed in collaboration with Dr Jill Slinger of Delft University of Technology, the Netherlands and Professor Tally Palmer of Rhodes University. The model was first described in the following peer-reviewed conference proceedings:

Clifford-Holmes, J, Slinger, J. & Palmer, C.G. 2014. Engaging the challenges of municipal water service delivery using system dynamics. *2nd Annual Eskom System Dynamics Conference*, 12 November 2014, Johannesburg, South Africa.

This appendix draws on the above-referenced conference paper in order to describe the 'Modes of Failure' model.

For the full model documentation, please see:
http://iwr.ru.ac.za/iwr/sanpadlink/index.php?p=CaseStudyDocs/SRVM/CliffordHolmesPhD

Abstract:

This paper reports on a system dynamics modelling endeavour that builds on earlier research into the challenges faced by a small municipality in the Eastern Cape province of South Africa, as the municipality attempts to provide water services in the face of growing demand and increasing crises. The paper explores a number of interlinked 'modes of failure', including the simultaneous underinvestment in, and over-extension of, water supply infrastructure, and the effects of municipal staff shortages, emergencies, and over-commitment on standard technical activities. The paper posits a causal loop diagram, which is then explored in a simulation model, the structure of which is described, with baseline simulation results provided. The paper also discusses the findings of two scenario runs, the first of which simulates the effects of municipal infrastructure being operated within its design capacity constraints, and the second simulating the effects of a financial crisis on municipal water service provision.

G.1. Introduction

[see sub-section 7.5.6]

G.2. Methodology

System dynamics is an ideal method for exploring the supply-demand dilemmas in Kirkwood and the associated modes of failure of local government: firstly, there is extensive uncertainty with basic quantitative data around water service delivery (including the size of the population of Kirkwood, the quantity of unaccounted-for water, household demand requirements for potable water, financial data and economic trend analyses). Where appropriate numerical data were available, technical reports were consulted in order to provide data for the model parameters and initial states. To address the many areas where numerical data were lacking, researchers facilitated a series of workshops (31 November to 1 December 2011; 10 October 2012; and 28 February 2013), which were attended by representatives from the Department of Water Affairs and the SRVM, in addition to impacted and affected stakeholders. These workshops were augmented by fieldwork conducted in the ethnographic tradition (developed in anthropology), which allowed for a rich picture of water services challenges in the SRVM to be developed.

G.3. Model description

This section outlines the structure of the *MoF* model in four parts: sub-section G.3.1 describes the model boundary using a 'boundary chart'; sub-section G.3.2 then posits a dynamic hypothesis of how for the primary variables in *MoF* interrelate, using an aggregate causal loop diagram; and sub-section G.3.3 summarises the model settings. In sub-sections 3.4 through to G.3.11, the individual sub-models of the *MoF* model are explained, using the stock-flow diagrams showing model structure and describing the empirical relationships between variables as equations. The final sub-section (G.3.12) describes the model validation processes.

G.3.1. Model boundary

A description of which variables are treated endogenously and exogenously in relation to those that are excluded is a central part of stipulating the boundary of a system dynamics model. The model boundary for the *MoF* model is is presented in the 'model boundary chart' in Table G.1.

Table G.1: Model boundary chart

Endogenous	Exogenous	Excluded
Infrastructure capacity and associated maintenance, refurbishment, and construction of new infrastructure	Hiring and leaving rates of municipal staff	Municipal administrative and political exigencies pertaining to recruitment and training processes
Urban potable water demand drivers (households + other urban users)	Transitions from informal households, to households with basic supply to fully-connected households	Constraints on the municipal connection rate (i.e. the rate at which households receive in-house water services)
Effects of service delivery crises on technical staff capacity	Bulk water losses	Effects of burnout / overwork / lack of motivation on and between municipal staff
Over-extension of infrastructure above design capacity and its effects	Average lifetime of infrastructure	Effects of state-initiated arrangements and regulations on infrastructure management and maintenance
Revenue generation and ringfencing of finances for maintenance of water supply infrastructure	Cost recovery and billing processes	Costs of water service provision (including costs of providing emergency water)
Demand for emergency water		

G.3.2. Aggregate causal loop diagram

[*see* Figure 7.24 *and associated description in* sub-section 7.5.6 **(ii)**].

G.3.3. Model settings

This model simulates a 20-year period between 2001 and 2021. This period was selected to account for when the SRVM began operating, through to the development of the service delivery problems in the Kirkwood area between 2009 and the 2014. The period between 2001 and 2014 was used primarily for model calibration purposes, whilst the period between 2014 and 2021 was used for projection, scenario and policy analysis purposes. A time step of 0.007815 years (less than a week) was selected. The model was simulated using the time unit of years, with the Euler method selected for numerical integration purposes. The model was constructed and simulated using Vensim DSS system dynamics software for Macintosh, Version 6.3 (Ventana Systems Inc, 2013).

G.3.4 Overview of model structure

This section describes the seven sub-models of the *MoF* model using the stock-flow diagrams for each sub-model, with an associated description of the main functions employed in each sub-model. The model description in this paper begins with the demand sub-model, accounting for the determinants of rising potable water demand in the Kirkwood region, following which the water service delivery sub-model is described. The discrepancy between the demand and supply is calculated in the water service delivery sub-model, which influences the requirement for new capacity and /or the refurbishment of current infrastructure (all of which is outlined in the infrastructure sub-model). The next two sub-models account for financial management (focusing on revenue available for maintenance), and staff capacity (focusing on key technical activities in water service provision), which influence the infrastructure capacity sub-model at three crucial points. The final two sub-models that are described are the maintenance sub-model, and the emergency water sub-model. The latter is driven by different parts of the model, but does not in turn feed back into the model (the motivations for its use are described in the final sub-section (G.3.11), ahead of discussing model validation processes employed in the *MoF* model.

G.3.5. Demand sub-model

The demand sub-model has four stocks that accumulate the population in the overall municipality, the urbanised population in Kirkwood, and stocks of 'unconnected' and 'connected' households (see Figure G.1).

The population of the SRVM is modelled in *MoF* using a simple, one stock structure where population (*P*) is influenced by population growth (r_{pgr}), which is mathematically represented as:

$$P(t) = P(0) + \int [r_{pgr}]dt \quad (1)$$

(where r_{pgr} is influenced by an 'annual incremental change in population').

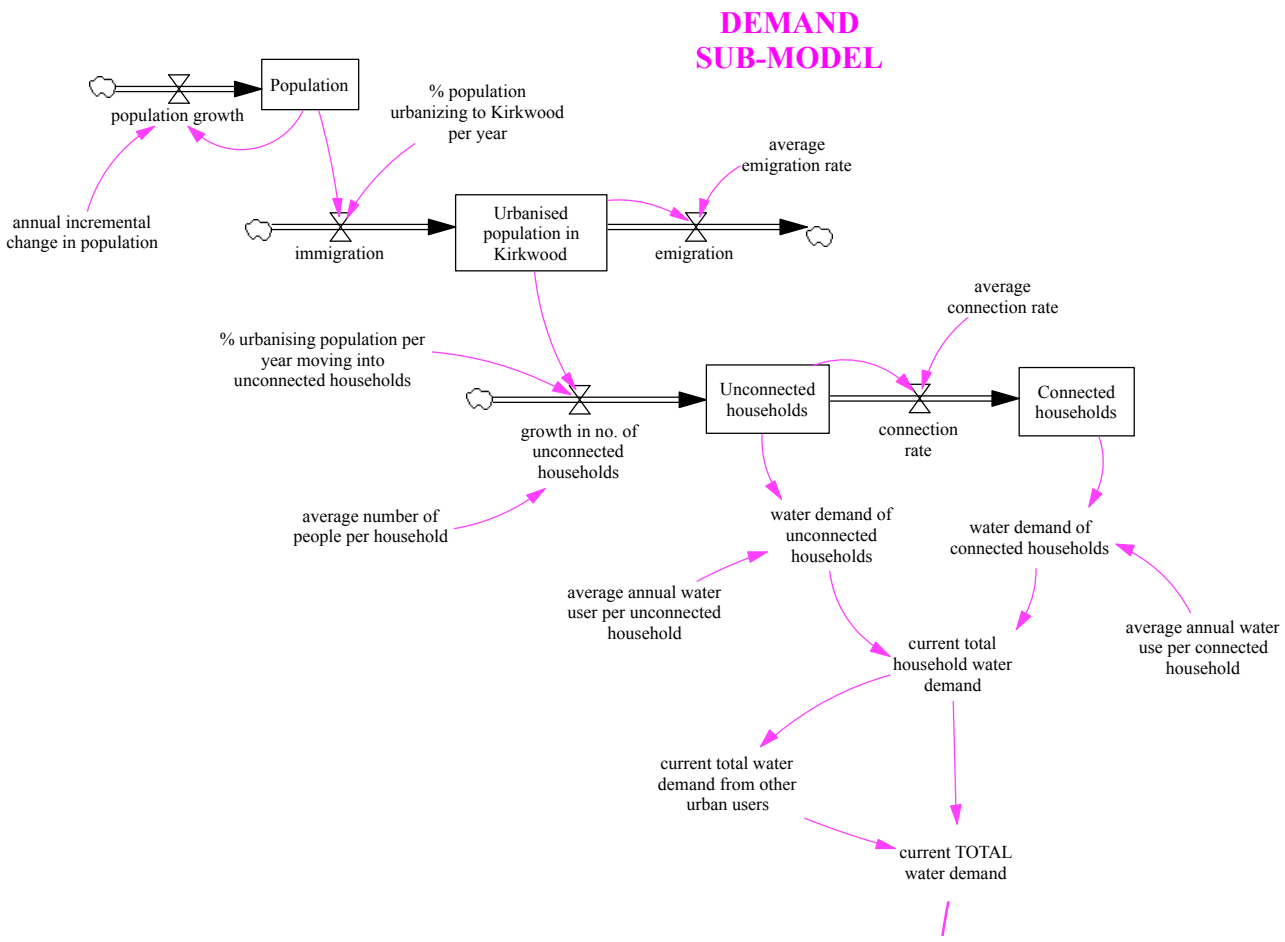


Figure G.1: Stock-flow structure of the Demand sub-model

The population in the Greater Kirkwood area is modelled in terms of the urbanised population in Kirkwood (*UPOP*), which is increased with immigration (r_{imm}), and decreased with emigration (r_{em}):

$$UPOP(t) = UPOP(0) + \int [r_{imm} - r_{em}]dt \quad (2)$$

Immigration (r_{imm}) is calculated as the product of population (*P*) and the '% population urbanizing to Kirkwood per year', as follows:

$$r_{imm} = P * UKY \quad (3)$$

The households structure consists of two stocks, namely, unconnected households (*UCH*) and connected households (*CH*), which are linked using an 'aging chain' model structure (Sterman, 2000). *UCH* groups all households that receive a basic supply level of water services (RDP level of service and below), whilst *CH* groups all the households that are connected to the municipal bulk water supply and waterborne sanitation network. The first

stock (*UCH*) is influenced by the growth in the number of unconnected households (r_{gbs}) and the household connection rate (r_c), as follows:

$$UCH(t) = UCH(0) + \int [r_{ghs} - r_c] dt \quad (4)$$

The growth in the number of connected households is calculated as the urbanised population in Kirkwood (*UPOP*), over the average number of people per household (*AvPH*), multiplied by '% urbanising population per year that moves into unconnected households' (*UKUC*):

$$r_{ghs} = \left(\frac{UPOP}{AvPH}\right) * UKUC \quad (5)$$

Information is individually drawn from the stock of unconnected households (*UCH*) and connected households (*CH*) to calculate the water demand of each household type, using 'average annual water use' statistics drawn from municipal planning reports. The variable 'current TOTAL water demand' (*CTWD*) is calculated as the sum of the 'current total household water demand' (*CTHD)* and the 'current total water demand from other urban users' (*CTO*), where *CTO* is calculated as follows:

$$CTO = CTHD * 0.5 \quad (6)$$

Whilst simplistic, the formulation for *CTO* is an appropriate approximation of the water demand of other urban users in the Greater Kirkwood area.

G.3.6. Water service delivery sub-model

The *MoF* model represents the municipality's attempt to meet the water demand outlined above via a 'water service delivery' sub-model. This water service delivery sub-model apportions the 'current supply of water' between the different user groups (unconnected households, connected households, and 'other urban users'). The overall structure of this sub-model is provided in the stock-flow diagram in Figure G.2, with a description of the equation forms following.

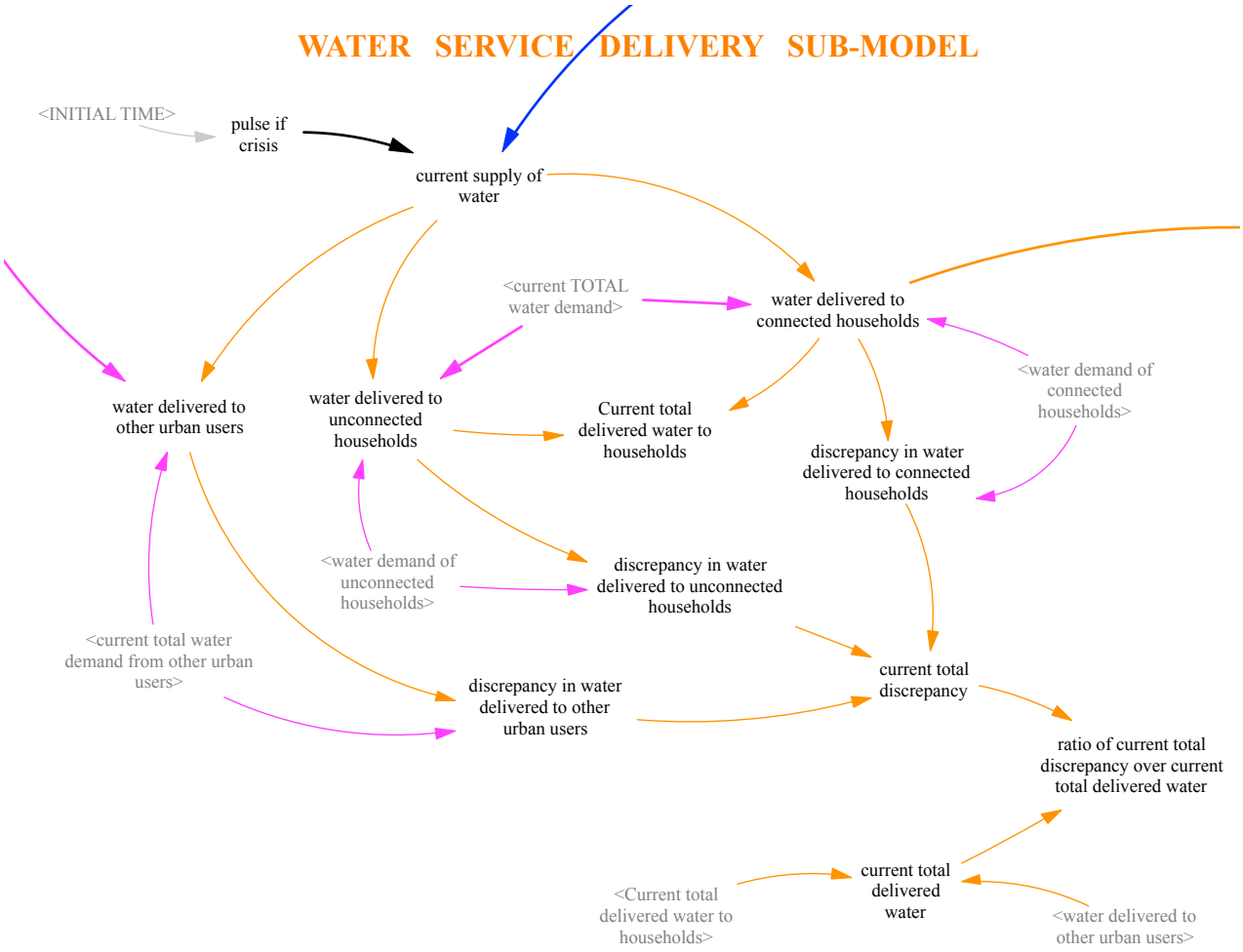


Figure G.2: : Stock-flow structure of the water service delivery sub-model

The water delivered to unconnected households (*WdlUC*) is calculated as the water demand of unconnected households (*WDUC*) over the current total water demand (*CTWD*), multiplied by the current supply of water (*CSoW*), represented as:

$$WdlUC = \left(\frac{WDUC}{CTWD}\right) * CSoW \tag{7}$$

This same structure is used for the variables 'water delivered to other urban users' and for 'water delivered to connected households'. In this way, the current supply of water (*CSoW*) is equally apportioned according to the water demand of the individual groups in relation to the current total water demand. The gap between a groups demand for water, and the quantity of the water actually delivered, is calculated as a 'discrepancy'. Hence, to use the unconnected household example, the discrepancy in water delivered to unconnected households (*DWdlUC*) is simply the water demand of unconnected households (*WDUC*) less the water delivered to unconnected households (*WdlUC*):

$$DWdlUC = WDUC - WdlUC \quad (8)$$

The current total discrepancy (*CTD*) is the sum of this discrepancy (discrepancy in water delivered to unconnected households) and the discrepancies of water delivered to connected households and water delivered to other urban users. The variable current total discrepancy (*CTD*) drives the demand for additional infrastructure capacity, which is explained in the infrastructure sub-model below.

G.3.7 Infrastructure sub-model

The infrastructure sub-model is at the heart of the *MoF* model. The sub-model consists of three stocks, linked using an aging chain model structure (see Figure G.3). The description of the infrastructure sub-model (in this sub-section) follows the aging chain from the first stock onwards.

As mentioned above, the current total discrepancy (*CTD*) drives the demand for additional infrastructure capacity. This demand is modelled in *MoF* as the first stock in the aging chain of the infrastructure sub-model: this stock, required additional capacity (*RAC*), increases with the recognition of discrepancy (r_{rds}) and decreases with refurbishment and construction initiation (r_{rfc}):

$$RAC(t) = RAC(0) + \int [r_{rds} - r_{rfc}]dt \quad (9)$$

The recognition of discrepancy (r_{rds}) is calculated as the current total discrepancy (*CTD*) over the time to identify discrepancy *(TtID)*, using the following structure:

$$r_{rds} = \text{IF THEN ELSE}\left(\left(\frac{CTD}{TtID}\right), > 0, \left(\frac{CTD}{TtID}\right), 0\right) \quad (10)$$

Municipal staff capacity is required in order to initiate the refurbishment of current infrastructure, or the construction of new infrastructure. This staff capacity is referred to as 'secondary activities' in the *MoF* model (in comparison to 'primary activities', which include the operation and maintenance of current water supply infrastructure as one part of the technical directorate's responsibilities for municipal service delivery). The variable 'technical staff capacity constraints on secondary activities' (*TSc2A)* is explained in the staffing sub-

model (see sub-section 3.9). Here the variable is described in terms of its influence on the refurbishment and construction initiation rate (r_{rfc}), which is modelled as:

$$r_{rfc} = \text{MIN}\ (RAC * PoU, 0.25 * TSc2A) \tag{11}$$

where the rate (r_{rfc}) returns the minimum of two formulations: the product of the required additional capacity (*RAC*) and the perception of urgency (*PoU*), or the technical staff capacity constraints on secondary activities (*TSc2A)* multiplied by 0.25. The second formulation acts as the constraint on refurbishment and construction initiation, saying that when the available technical capacity to perform work is reduced (for example when municipal officials are dealing with crises), then only 25% of technical staff attention is given to refurbishing and constructing infrastructure. The remaining 75% of attention is given to completing the infrastructure that is currently under construction and in the process of refurbishment, which is the second stock in the aging chain, and described here.

The stock 'infrastructure under construction and refurbishment' (*IuCR*) increases according to the refurbishment and construction initiation rate (r_{rfc}) and decreases with the outflow of the 'infrastructure completions' rate (r_{ico}), which is mathematically represented as:

$$IuCR(t) = IuCR(0) + \int [r_{rfc} - r_{ico}]dt \tag{12}$$

Where the infrastructure completions rate (r_{ico}) is modelled as follows:

$$r_{ico} = \text{MIN}\ \left(\left(\frac{IuCR}{aCRt}\right), 0.75 * TSc2A\right) \tag{13}$$

The infrastructure completions rate (r_{rfc}) copies the refurbishment and construction initiation rate (r_{rfc}) (refer equation 11) by returning the minimum of two formulations: either the infrastructure under construction and refurbishment (*IuCR*) over the average refurbishment and construction time (*aCRt*), or technical staff capacity constraints on secondary activities (*TSc2A)* multiplied by 0.75 (for the reasons outlined in the description following equation 11).

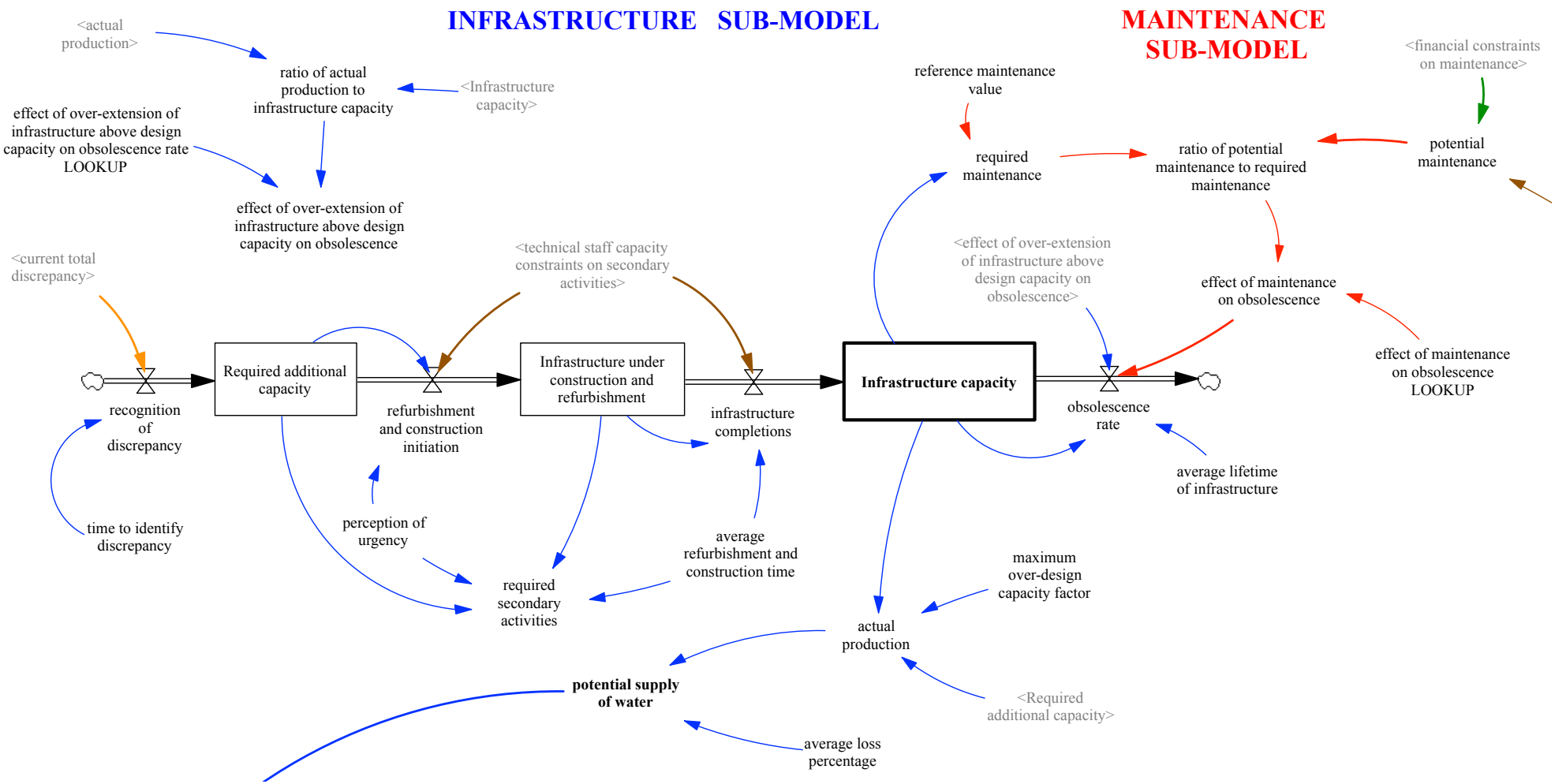


Figure G.3: Stock-flow diagram of the Infrastructure sub-model (in blue) and the Maintenance sub-model (in red).

The last stock in the aging infrastructural chain is infrastructure capacity (*IC*): the *MoF* model uses this stock to aggregate the infrastructure capacity of the Greater Kirkwood water supply scheme operated by the SRVM. This aggregate stock of infrastructure capacity (*IC*) increases with the inflow of infrastructure completions (r_{ico}) and decreases according to the outflow 'obsolescence rate' (r_{obs}), and is mathematically represented as:

$$IC(t) = IC(0) + \int [r_{ico} - r_{obs}]dt \tag{14}$$

The infrastructure completions rate (r_{ico}) has already been described (refer equation 13). The obsolescence rate (r_{obs}) is one of the key points of the *MoF* model at which the different points of the model directly interact with one another, and is given as:

$$r_{obs} = \left(\frac{IC}{ALI}\right) * EMO * EOIO \tag{15}$$

A standard, or average, obsolescence rate is derived as infrastructure capacity (*IC*) over the average lifetime of infrastructure (*AFI*), which is multiplied by the effect of maintenance on obsolescence (*EMO*), and then multiplied again by the effect of overextension of infrastructure above design capacity on obsolescence (*EOIO*). The former effect (*EMO*) is described in relation to the maintenance sub-model in sub-section 3.10, with the latter effect (*EOIO*) described here.

In order to derive the effect of overextension of infrastructure above design capacity on obsolescence (*EOIO*), the *MoF* model distinguishes between the infrastructure capacity of the Kirkwood water supply scheme against the quantity of potable water actually produced at the Kirkwood water treatment works (termed 'actual production'). In order to cater for the over-extension of infrastructure above design capacity, a maximum over-design capacity factor (*MOCF*) is stipulated, and set as a parameter. Actual production (*AP*) is therefore mathematically represented as:

$$AP = \text{MIN}\left(IC + RAC, (IC * MOCF)\right) \tag{16}$$

where the variable actual production (*AP*) returns the minimum of infrastructure capacity (*IC*) plus the required additional capacity (*RAC*), using the product of infrastructure capacity (*IC*) and the maximum over-design capacity factor (*MOCF*) to act as the maximum quantity of

water that can be produced at any time. A decision-rule is stipulated that when there is a discrepancy between the demand for water and the supply of water (and the municipality therefore requires additional capacity) that municipal supply infrastructure is then over-extended above its design capacity in order to meet the additional capacity requirements.

As described with the aggregate causal loop diagram (see sub-section 7.5.6), the over-extension of infrastructure provides an additional amount of water in the short-term, but it carries the concomitant effect of increasing how fast municipal infrastructure decreases in value and use. This is the effect of overextension of infrastructure above design capacity on obsolescence (*EOIO*), which is driven by the ratio of actual production (*AP*) over infrastructure capacity (*IC*) that passes through a LOOKUP function ahead of influencing the obsolescence rate (r_{obs}).

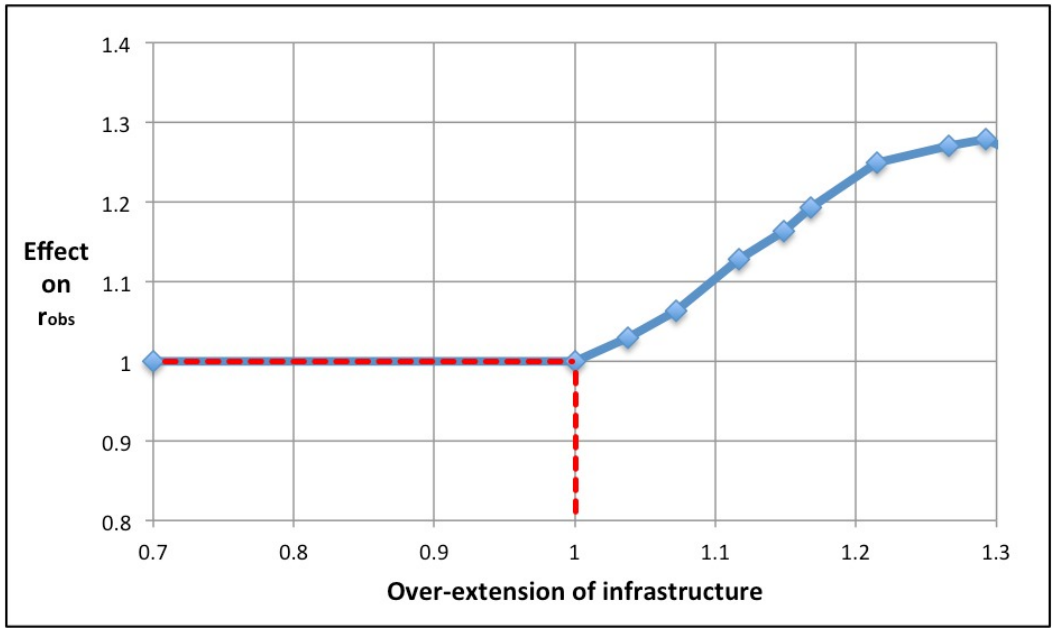


Figure G.4: Effect of overextension of infrastructure on obsolescence rate LOOKUP graph.

The final infrastructural aspect in the *MoF* is the inclusion of bulk water losses, which reduces the actual production (*AP*) by an average loss percentage in order to derive the potential supply of water (*PSW*) at any point in time. The latter variable accounts for the water that is potentially available for water service delivery, as described in sub-section 4.6 above. Further influences on the infrastructure sub-model are described in relation to the staffing capacity, revenue, and maintenance sub-models in following three sub-sections, beginning with the revenue sub-model.

G.3.8 Revenue sub-model

The revenue sub-model (refer to Figure G.5) has one stock, 'Revenue from water service delivery' (*RWSD*) which increases with revenue inflow (r_{revIN}), and decreases according to the rate at which revenue is dedicated to maintenance (r_{main}) and the rate of revenue outflow (r_{revOUT}):

$$RWSD(t) = RWSD(0) + \int [r_{revIN} - r_{main} - r_{revOUT}]dt \quad (17)$$

Revenue inflow (r_{revIN}) is calculated according to the following empirical relationship:

$$r_{revIN} = \big((PBW * UNCG) * PCR\big) * PTrI \quad (18)$$

Where *PBW* is potential billable water, *UNCG* is the unit charge for water, and *PCR* is the '% cost recovery'. The rate formulation for revenue inflow (r_{revIN}) multiplies the product of the latter three variables by a fourth variable – 'pulse train annual income' (*PTrI*) – which is one of the discrete functions employed in the *MoF* model. In the revenue sub-model, these discrete functions serve to simulate the annual filling and emptying of the budget for operational and maintenance expenditure in the SRVM. The first of these discrete functions, the pulse train annual income (*PTrI*) is formulated as:

$$PTrI = \text{PULSE TRAIN (INITIAL TIME} + 1, 1, 2, \text{FINAL TIME)} \quad (19)$$

Where the initial time and final time are in-built model variables relative to the time horizon stipulated in the model settings (i.e. 2001 and 2021 respectively), and where the quantity of revenue inflow (r_{revIN}) is pulsed into the stock of Revenue from water service delivery (*RWSD*) on an annual basis, starting in 2002.

REVENUE SUB-MODEL

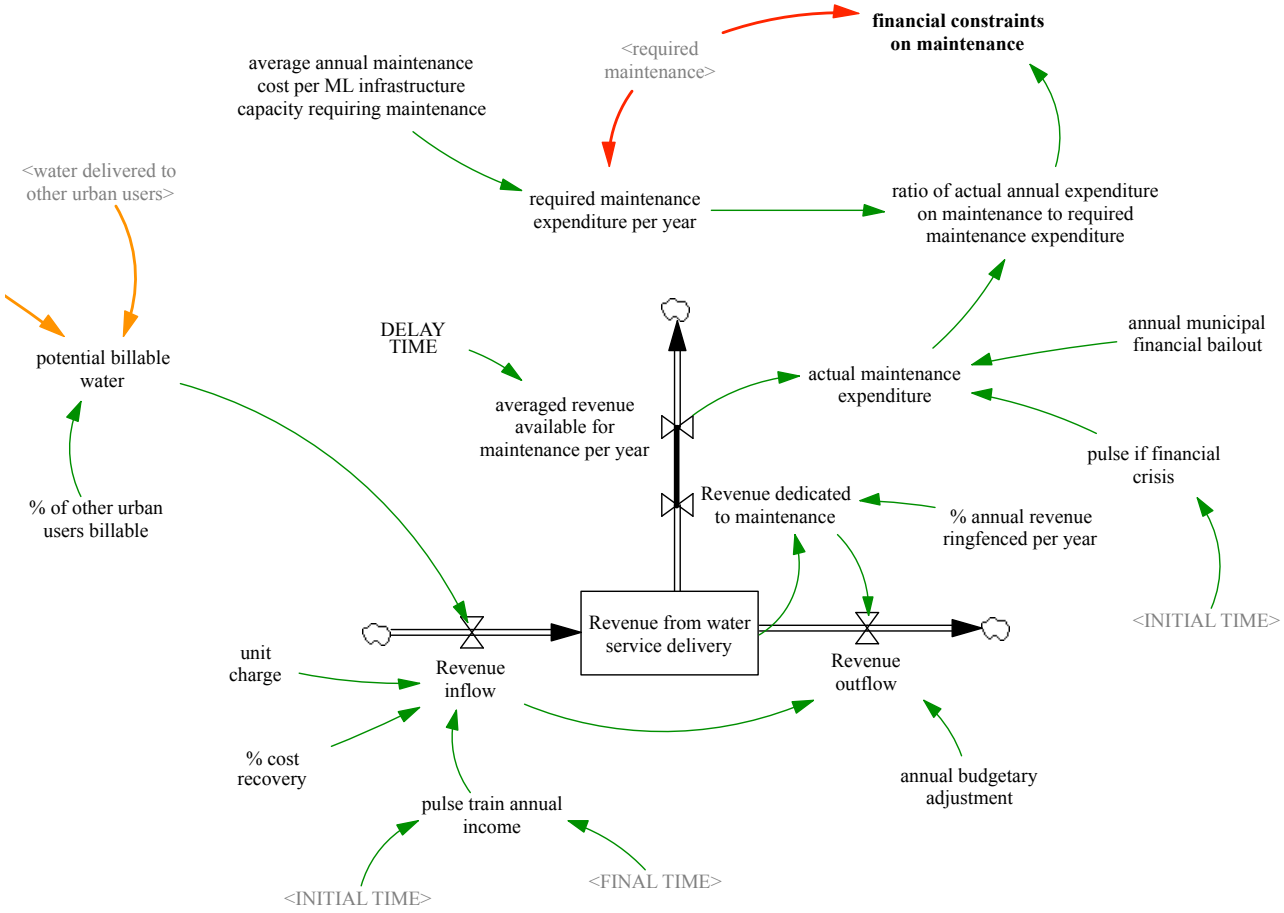


Figure G.5: Stock-flow diagram illustrating the structure of the financial revenue sub-model.

The pulse train function in equation (19) affects both the revenue inflow (r_{revIN}) and the revenue outflow (r_{revOUT}) in order to simulate the annual budgetary adjustment (*ABA*) made by the municipality: every year, the budget is used-up, and the stock of revenue from water service delivery (*RWSD*) empties. Hence, the revenue outflow (r_{revOUT}) rate is constructed as:

$$r_{revOUT} = \text{MAX}\big((r_{revIN} - r_{main})0, ABA, 0\big) \tag{20}$$

The revenue dedicated to maintenance (r_{main}) is calculated as the maximum of the revenue from water service delivery (*RWSD*) multiplied by the percentage of the annual revenue ringfenced per year (*pARR*), represented as:

$$r_{main} = \text{MAX}\,(RWSD * pARR, 0) \tag{21}$$

However, the ringfenced revenue is made available for maintenance throughout any given year on an averaged (or 'smoothed' basis), rather than as a discrete financial injection pulsed into a maintenance budget. In the *MoF* model, this behaviour is simulated using the rate 'averaged revenue available for maintenance per year' (r_{mainAV}), which is smoothed using an average delay time *(DTI)* of one year:

$$r_{mainAV} = \text{SMOOTH}\ (r_{main}, DTI) \tag{22}$$

Given that this revenue dedicated to maintenance is often inadequate for the municipality's maintenance needs, additional money is required, often on an ad-hoc, day-to-day basis: this ad-hoc money is simulated in the *MoF* model as an 'annual financial bailout' (*AFB*), which is the 'bailout' finances provided by the municipality, for when the water service delivery unit in the SRVM lacks immediate funds with which to cover maintenance requirements. This bailout fund is, however, subject to broader financial crises in the SRVM: if the municipality faces bankruptcy, as it has on a number of occasions between 2010 and 2014, then the financial crisis reduces the bailout. A variable called 'pulse if financial crisis' (*PiFC*) is employed in the *MoF* model to simulate financial crises of this kind. When switched on, this this variable reduces the annual municipal financial bailout to 2%. The actual maintenance expenditure *(AME)* is therefore calculated as follows:

$$AME = r_{mainAV} + \big(AFB * (1 - 0.98 * PiFC)\big) \tag{23}$$

In order to dynamically (and endogenously) assess the financial constraints on maintenance (*FCM*), the actual maintenance expenditure *(AME)* needs to be compared against the required maintenance expenditure per year (*RME*), where *RME* is calculated as the product of the required maintenance (*ReqM*) and the 'average annual maintenance costs per ML infrastructure capacity requiring maintenance'. The financial constraints on maintenance (*FCM*) is then calculated as the 'ratio of actual annual expenditure on maintenance to required maintenance expenditure', multiplied by the required maintenance (*ReqM*). The required maintenance (*ReqM*) variable is explained in the maintenance sub-model (see sub-section 3.10), which is the sub-model in which the financial constraints on maintenance (*FCM*) variable influences the rest of the model. Before outlining the structure of the maintenance sub-model, the second primary constraint on maintenance, namely staffing, will be described in the following sub-section.

G.3.9 Staffing sub-model

The staffing sub-model (refer to Figure G.6) operates using a similar structure to the water service delivery sub-model (see sub-section G.3.6): in the same way that the current supply of water is distributed according to different user groups in the water service delivery sub-model (according to the different needs of each group), the staffing sub-model distributes staffing capacity between different technical activities, according to the requirements of these activities. In the *MoF* model, these technical activities are simplified into two categories: 'maintenance' and 'secondary activities'. The secondary activities include the strategic planning, grant sourcing, and other such activities that are required of municipal officials, both in the process of refurbishing current infrastructure and in the process of constructing new infrastructure. These secondary activities affect the associated stocks and flows in the infrastructure sub-model (see equation 11 and equation 13) whilst the maintenance activities affect the obsolescence rate (see equation 15).

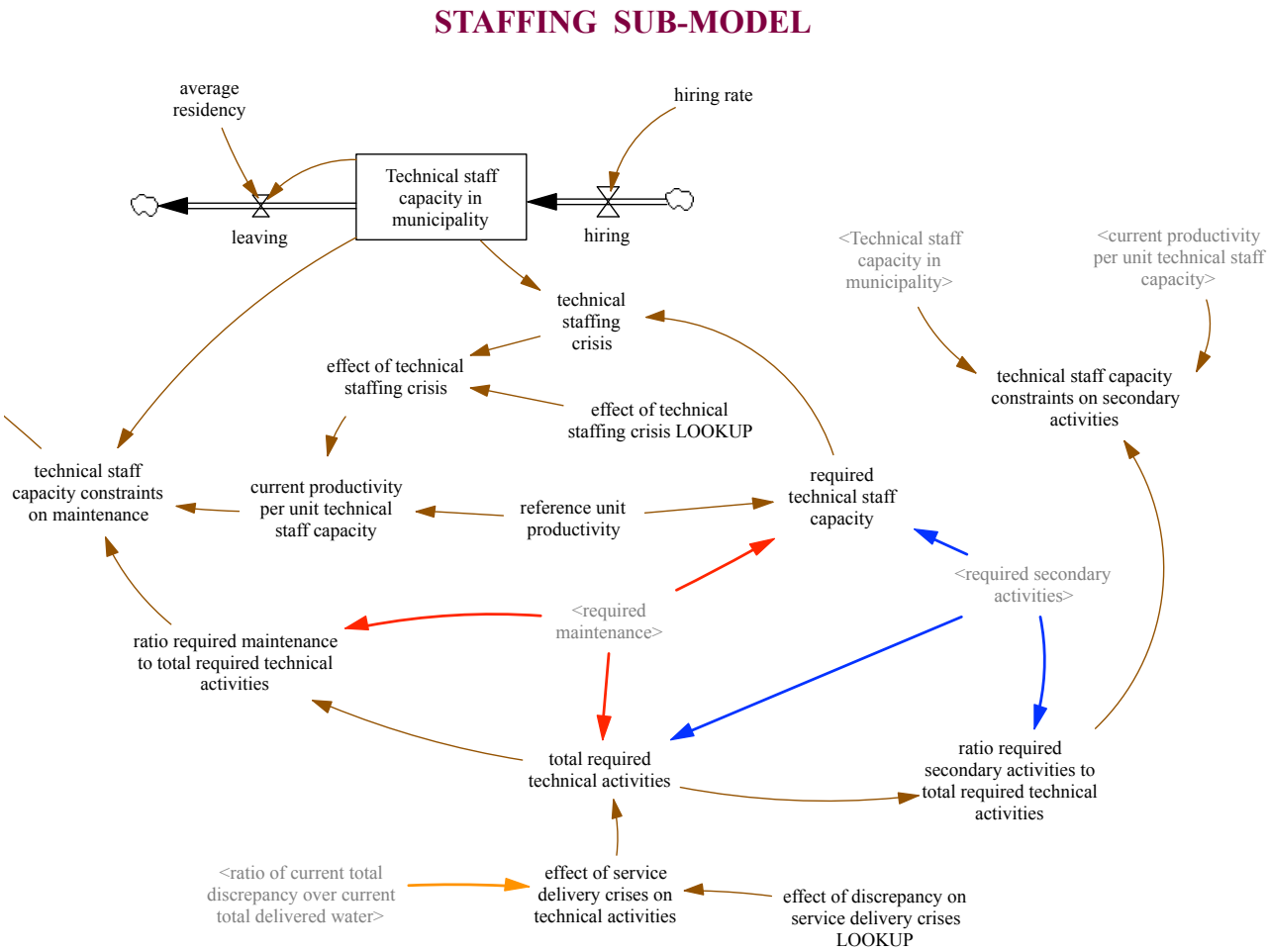


Figure G.6: Stock-flow diagram illustrating the structure of the staffing sub-model

The staffing sub-model is also subject to two crisis effects: the first effect influences the productivity of staff members in the SRVM, accounting for the behaviour of working overtime to offset staff capacity shortages in the SRVM. The second crisis effect influences the total required technical activities, accounting for what happens when crises demand the immediate attention of municipal technical officials, which results in less attention available for maintenance and secondary activities. This sub-section describes the way in which these crisis effects influence the staffing sub-model.

The staffing sub-model has one stock, 'Technical staff capacity in municipality' (*TSC*), which increases as technical officials are hired (r_{hir}) and decreases at the average rate at which technical officials leave municipal employ (r_{lv}), mathematically represented as:

$$TSC(t) = TSC(0) + \int [r_{hir} - r_{lv}]dt \quad (24)$$

The technical staff capacity in municipality (*TSC*) is not, however, treated as a variable that is influenced solely by the number of employees: the variable 'technical staffing crisis' (*TSCR)* takes the ratio of the 'required technical staff capacity' (*RTSC*) over the actual technical staff capacity (*TSC*), and uses this ratio to drive an 'effect of technical staffing crisis' on the 'current productivity per unit technical staff capacity' (*CPTS*), using the LOOKUP function displayed in Figure G.7.

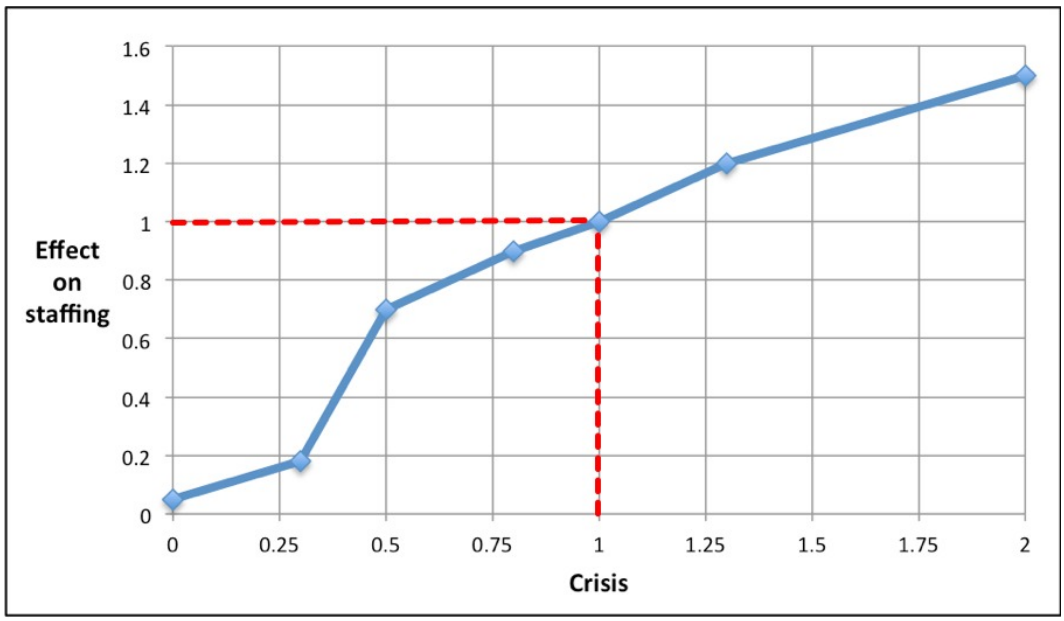


Figure G.7: Effect of crises on technical staff capacity LOOKUP graph.

The required technical staff capacity (*RTSC*) is calculated as the sum of the required maintenance (*ReqM*) and the required secondary activities (*Req2A*), over a given reference unit productivity (*REFP*):

$$RTSC = \frac{ReqM+Req2A}{REFP} \quad (25)$$

(where the 'required maintenance' and 'required secondary activities' are respectively calculated in the maintenance and infrastructure sub-models). The 'total required technical activities' (*TRTA*) is the sum of the required maintenance (*ReqM*) and the required secondary activities (*Req2A*), multiplied by the effect of service delivery crises on technical activities (*ESDC*) as follows:

$$TRTA = (ReqM + Req2A) * ESDC \quad (26)$$

The effect of service delivery crises on technical activities (*ESDC*) is driven by the 'ratio of the current total discrepancy over current total delivered water' (which is calculated in the water service delivery sub-model (see sub-section G.3.6)). This effect (*ESDC*) functions as an argument that says that the greater the discrepancy, the greater the effect of the discrepancy on crises (i.e. the more the discrepancy, the more the service delivery failures require technical staff attention). The LOOKUP function in Figure G.8 shows how this effect works.

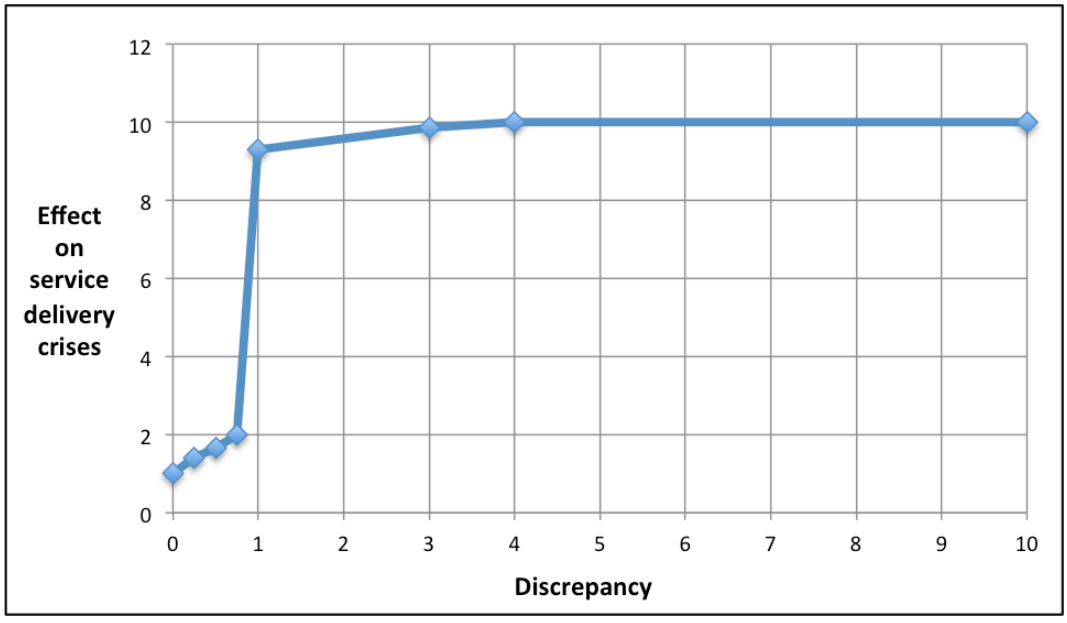


Figure G.8: Effect of service delivery discrepancy on crises LOOKUP graph.

The variable total required technical activities (*TRTA*) indirectly drives the two constraints that technical staff capacity places on the system – namely, 'technical staff capacity constraints on maintenance' (*TSCM*) and 'technical staff capacity constraints on secondary activities' (*TSC2A*). The technical staff capacity constraints on maintenance (*TSCM*) is mathematically represented as:

$$TSCM = \frac{ReqM}{TRTA} * TSC * CPTS \quad (27)$$

where the required maintenance (*ReqM*) over the total required technical activities (*TRTA*) gives a 'ratio of required maintenance to total technical activities'. This ratio is multiplied by the technical staff in municipality (*TSC*) and the current productivity per unit technical staff capacity (*CPTS*), to give the technical staff capacity constraints on maintenance (*TSCM*). Exactly the same formulation is used for the 'technical staff capacity constraints on secondary activities' (*TSC2A*). The latter staff capacity constraint has already been outlined, in terms of how it affects the rates at which refurbishment and construction is initiated (see equation 11) and the rate at which infrastructure work is completed (see equation 13). The following sub-section accounts for how constraints on technical staff capacity affect maintenance.

G.3.10 Maintenance sub-model

The maintenance sub-model directly influences, and is influenced by, the infrastructure sub-model (see the stock-flow diagram in Figure G.3). The variable required maintenance (*ReqM*) is calculated as the product of infrastructure capacity (*IC*) and a reference maintenance value (*RMV*), where *RMV* is an aggregated estimate of the quantity of infrastructure capacity requiring annual maintenance in order to maintain optimum performance.

The variable 'potential maintenance' (*PotM*) is the crux of the *MoF* model, in that this is the point at which the financial constraints on maintenance (*FCM*) and the technical staff capacity constraints on maintenance (*TSCM*) interrelate. Potential maintenance (*PotM*) is formulated as follows:

$$PotM = \text{MIN}(TSCM, FCM) \quad (28)$$

This formulation returns the smallest of the two values, using the argument that the most constraining effect limits the maintenance that can be performed: i.e. if there is adequate staff capacity, but inadequate finances for maintenance, then finances constrain the maintenance that can be performed (with the converse holding true). A ratio of potential maintenance

(*PotM*) to required maintenance (*ReqM*) is used to drive the effect of maintenance on obsolescence by passing through a LOOKUP function. This LOOKUP function caters for a two-way effect, whereby maintenance levels in excess of required maintenance serves to lessen the obsolescence rate (as infrastructure is better maintained and can function optimally for longer), whilst maintenance levels below requirements serve to quicken the obsolescence rate (see Figure G.9).

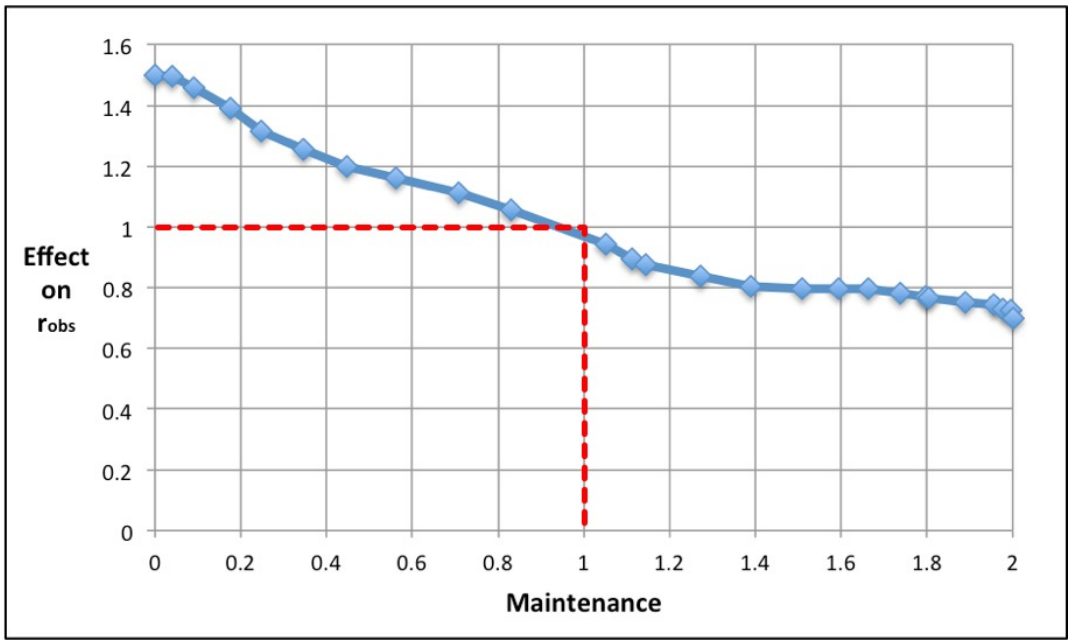


Figure G.9: Effect of maintenance on obsolescence rate LOOKUP graph.

G.3.11 Emergency water sub-model

The final sub-model in the *MoF* model calculates the emergency water requirements for the Greater Kirkwood area (see Figure G.10). This sub-model draws on the discrepancies in water delivered to households in order to approximate a total number of days without water per year. The number of days without water per year is assessed against a lifeline quantity of emergency water per person, per day, that the municipality is obligated to supply to residents whenever a water shortage exceeds 24 hours in duration (according to the nationally-set Norms and Standards summarised in Box 5.2). The emergency water sub-model also converts the total emergency water required per year (*TEWR*) into the total number of tankerloads of emergency water required per year (*TTLEW)*. These two variables (*TEWR* and *TTLEW*) are used as indicator variables in the *MoF* model, and, as the model is currently structured, do not feed back into the system at any point.

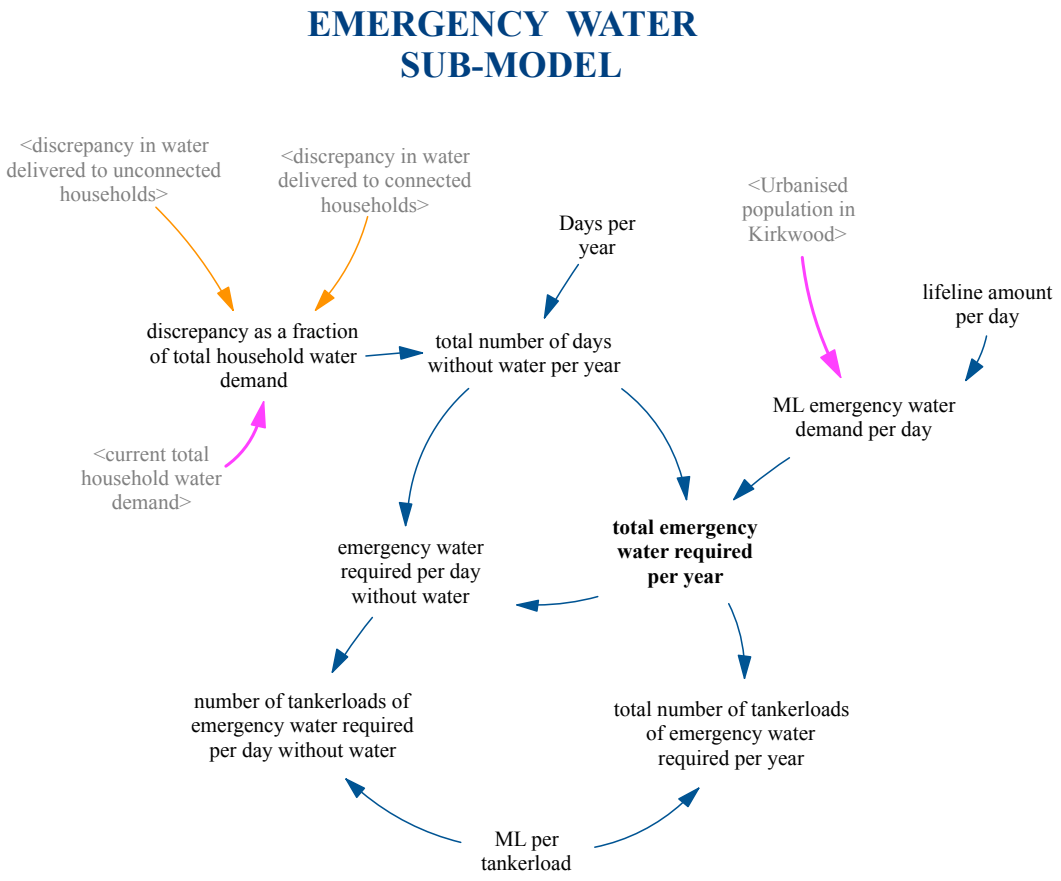


Figure G.10: Stock-flow diagram illustrating the structure of the emergency water sub-model.

G.3.12. Model verification and validation

The *MoF* model has been tested through processes of 'model debugging', 'model verification' and 'model validation'. The first stage, 'model debugging', sought to trace and correct errors preventing the model from simulating properly (or at all). Following Pruyt (2013), verification can be distinguished from debugging in that the former looks for errors without knowing whether they are present (whilst the latter addresses errors that are obviously present). Particular attention in model verification was paid to achieving consistency between the conceptualisation of the model and its specification. Unit consistency and the numerical accuracy of the simulation were checked. By performing simulation runs throughout the model-building process, structural errors were identified and addressed iteratively.

The aim of model validation is broadly understood here as striving to increase confidence in the model under development, thereby increasing confidence in the robustness of the simulated results and the policy analysis arising out of the modelling process (Sterman, 2000).

Validation processes used in this study included direct structural tests and extreme condition tests: direct structural tests assessed the "validity of the model structure by directly comparing the simulated reference mode with knowledge about the real system" (Barlas, 1996). These tests were particularly useful given that the researchers (modellers) had in-depth experience of the real-world problem environment (as participants in a multi-year action research project in the Eastern Cape, which partnered the SRVM and worked with municipal technical officials (Palmer et al., n.d.)). Rather than relying on one data set, the model was tested against historical data from a range of sources, collected by national, provincial and local authorities. The results presented below reflect the model outcomes that accord with these different data sets. The second validation test – extreme condition testing – examined the models responses to extreme shocks and parameters: The *MoF* model was tested by drastically increasing the key stocks driving demand in the model, and decreasing the key stocks driving water supply in the model. The outcome of these tests resulted in water demand greatly exceeding available supply, with system behaviour that agreed with the dynamic hypothesis, thereby confirming the validity of the *MoF* model.

In addition to the above tests, face validation was also used for the *MoF* model. This face validation was with problem holders in the municipality, and with stakeholders in the Kirkwood region who have extended experience of the dynamics explored in the model. This stage of model use is still underway, with the use of the *MoF* model occurring within an on-going research process involving the SRVM. Further validation will be required ahead of using the model for policy analysis.

G.4. Model results

(model results displayed and discussed in sub-section 7.5.6 (iv) of Chapter 7)

G.5. General discussion and conclusion

(see sub-section 7.5.6 (v) of Chapter 7)

References:

(*included in overall reference list for thesis*)