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PESHAWAR, PAKISTAN

July 2013

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Table of Contents

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List of Figures

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List of Tables

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List of Acronyms

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GCV	Gross Calorific Value
NCV	Net Calorific Value

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CHAPTER 1 INTRODUCTION

1.1 Background

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Supply of clean drinking water and efficient disposal of wastewater are essential to maintaining a high quality of life and promoting economic activity in a modern city. Reliable provision of these services requires installation, operation and maintenance of expensive infrastructure including water abstraction and treatment facilities, storage reservoirs, watermain distribution networks, pumping stations, wastewater collection networks and treatment plants. The value of these infrastructure assets in Ontario is estimated to be $72 billion (1). The earliest water and wastewater systems in Ontario were constructed around the middle of nineteenth century. However, extension of these services across the province really picked up in pace in the period following the World War II, and by 1983, 98% of Ontario's urban population had received coverage (2). This rapid expansion was made possible by the grants that municipalities received from the federal and provincial governments. However, the generous grants also encouraged municipal governments to install infrastructure systems with unnecessarily large capacity (3). Furthermore, user fees for water and wastewater services were designed so as to recover only the operating expenditures incurred on these services (4). In general, no proactive measures were undertaken to recover capital costs so that adequate resources would be available to finance the impending replacement/rehabilitation of the ageing infrastructure. This approach was to some extent motivated by the expectation of continuing flow of grants from the senior levels of government (5).

1.2 Modelling the Complexity of Water and Wastewater Network Management

In this chapter, first the complex interconnections and feedback loops between the physical infrastructure, financial and consumer sectors, are demonstrated. Then the use and application of system dynamics modeling for integrated water and wastewater network pipeline asset management is described. This is the first known application of system dynamics to self-sustaining water and wastewater asset management. This is then followed by the development of a basic aggregated water and wastewater system dynamics demonstration model that is used to model the significance of complex interconnections and feedback loops on management decisions. A fully integrated water and wastewater model can be developed that includes water and wastewater pipe network, access chambers (manholes), laterals, valves, hydrants, and treatment plants, using the proposed system dynamics approach.

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1.2.1 Feedback loop in infrastructure deterioration (R1)

Reinforcing loop R1 (Figure 1.1) represents the typical deterioration process for physical infrastructure. It shows that the rate of deterioration of infrastructure is a function of its existing condition, which in turn, determines the condition of the infrastructure. If the condition of an infrastructure component increases (e.g., on a scale of 1-5, where 5 is a poor state and 1 is the best state), an increase in the deterioration rate occurs

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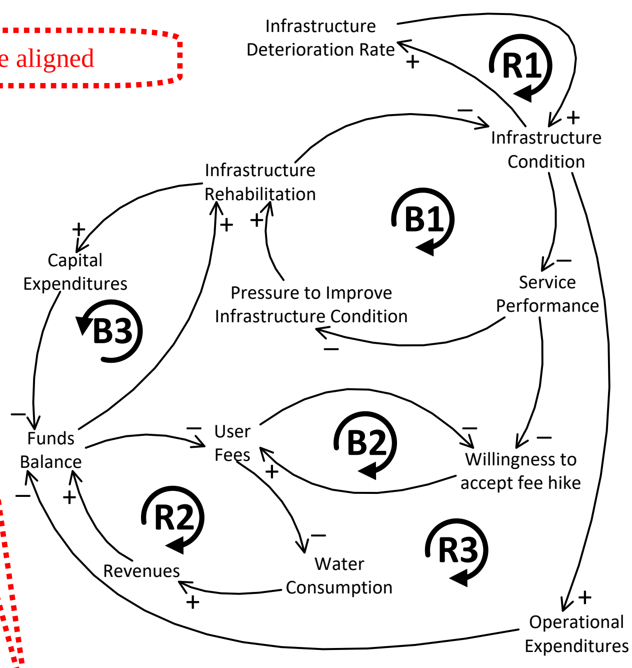

Figure 1.1: Feedback loops in water and wastewater network management.

1.2.2 Demonstration Model Simulations

Table 2.1 provides the initial distribution of pipes in each condition group stock. All pipes are assumed to have an average service life of 100 years. The initial and minimum water demand are set at 300 and 200 litres per capita per day (lpcd) respectively. Capital and operational expenditure unit prices are set at $1,000 and $50 per metre. These unit prices are assumed constant during the simulations.

Table 1.1: Initial distribution of pipes in various Condition Groups.

	Pipe Groups				
	Condition 20	**Condition 40**	**Condition 60**	**Condition 80**	**Condition 100**
Length (kilometers)	140	280	140	105	34
Fraction of Network (%)	20	40	20	15	5

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Appendix A
Sample Appendix

This is a sample Appendix.

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