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Water and Wastewater Improvements in India – the Last 20 Years

For more than 20 years, R.V. Anderson Associates Limited (RVA) has been involved in developing and implementing new water and wastewater strategies to meet India's rapidly growing needs for infrastructure and services in both large and small municipalities. This iwork ncludes advances in technology, operations and maintenance, training and development, and construction. This paper provides a unique perspective on the lessons learned from more than 20 years of direct involvement with water projects in Mumbai and other Indian municipalities. New technologies and procurement strategies are being tried, projects have been implemented to maximize potential benefits for slum sanitation, and significant capacity-building efforts have been incorporated to utilize local Indian engineering skills and expertise. The authors have been continuously involved in the firm's work in India and based on this experience this paper endeavours to highlight some of the key observations and lessons learned, along with some of the changes that have taken place in civil engineering in India over the last 20 years.

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Background and introduction

In the early 1990s, India was in the process of transforming itself into a modern business economy. Nevertheless, telecommunication service was sporadic and unreliable, computer technology was just entering mainstream business, and on the streets traffic was heavy and chaotic (as it still is).

Even with the relatively short distances involved (12 to 15 km), two meetings a day in different locations was about all that could be achieved. Municipal bureaucracies – being extremely large, cumbersome and union controlled – remained one of the last segments of the Indian economy to be modernized; it was difficult to manage the implementation of municipal engineering projects under these conditions.

Core areas of Mumbai (Bombay) were served by conventional water distribution and sewerage networks. However, the bulk of the rapidly growing suburbs, like many other cities in India, were only partially served with piped systems. The slums were poorly served with tap-stands to meet their water needs, communal privies, and storm drain channels or nallahs serving as open sewers running through the neighbourhoods.

Local engineering capacity was available. Many senior municipal engineers had graduated from well respected Indian universities and many had received foreign training as well. The problems being experienced were a result of the need to keep up with the exceptional growth in demands for both sewer and water in these growth areas and the need to service the existing and also rapidly expanding slums.

R.V. Anderson Associates (RVA) became involved in Mumbai in 1994 in a World Bank-funded Operations and Maintenance Study of the sewerage pumping system, in association with a local firm PHE Consultants of Mumbai, based upon complementary skill sets and similar experience in the water sector. From this base, over the last 20 years, the firm has covered several projects in the States of Maharashtra, Gujarat, Delhi, Punjab and Karnataka, which have included not only the traditional water sector planning, design and project management work, but also operations and maintenance audits and optimizations, solid waste assessments, asset management strategies and contract operation of water and wastewater plants.

The state of infrastructure

Engineering assignments in India, especially in the mega cities such as Mumbai, are, by virtue of the large population, of a scale that is magnitudes larger than anything experienced by engineers in Canada – for example, sewage pumping stations handling 10,000 litres per second and larger are common. The smaller water pressure zones and service areas contain as many as 2 million inhabitants, the size of an entire large city in Canada. Figure 1 shows the population density of regions in India based on information from the 2001 census.

Populations and flows

Design population and flow estimates represented a critical stumbling block to effective planning. In 2001 Mumbai had an official population of some 12 million, with projected estimates of an urban population at around 16.5 million persons during the life of the Master Plan. This represented about half the entire population of Canada at the time. About one-half of that population was concentrated in the slums and unserviced areas, both in the downtown core as well as in the rapidly expanding suburbs.

There were few reliable flow records available to undertake planning for the facilities and future flows, nor for planning the need for expansion and upgrading of infrastructure to meet huge future growth targets. The lack of basic data for planning required provision for extensive data collection efforts, including identifying any complementary data sources before any meaningful planning or design exercises could be carried out.

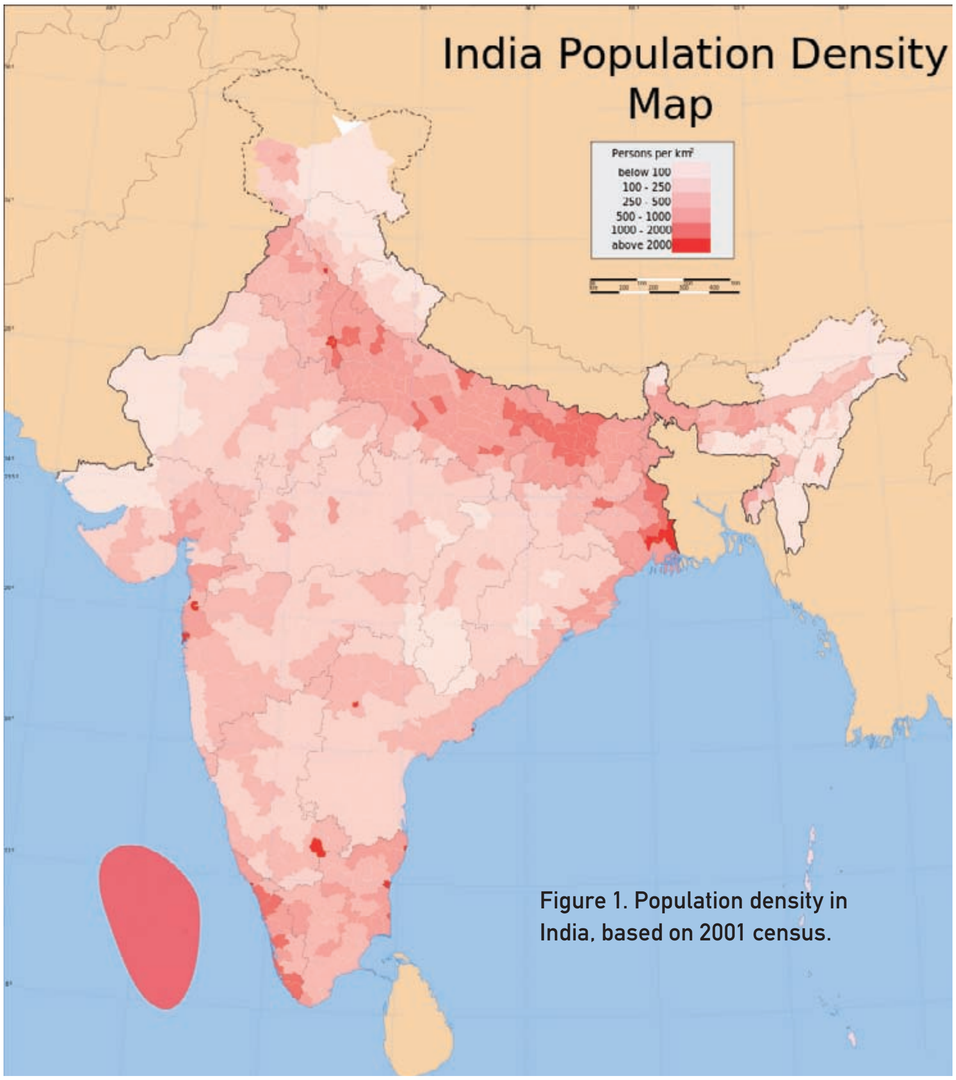

Figure 1. Population density in India, based on 2001 census.

Photo: Wikimedia Commons, author Planemad

Assets and condition

Mumbai, like most cities in India (and Canada as a matter of fact), had not generated revenues adequate to operate and maintain, let alone expand, its basic sewerage and water operations. The underground infrastructure suffered from a chronic lack of attention to the maintenance of core water mains, sewers and pumping stations, which were in extremely poor condition.

Water and sewer revenues were generated through a flat rate surcharge on the issuance of Mumbai's tax bills. Water users soon realized that there was little that the municipal agencies would do if these bills were not paid. After a number of years, the utilities have no options but to write off these significant outstanding water charges. While there should, in theory, be sufficient funds to meet current and future needs, as a result of the low rate of collection, the municipal agencies continue to depend on international financial institutions (IFI) and other internal and external borrowings to maintain their systems.

Leakage and infiltration

Systems that were poorly constructed and lacked of basic maintenance were subject to increasing demands for service. Furthermore, the amount of leakage, infiltration and flows from illegal connections was also huge.

Illegal water and power service connections were observed in many locations, known locally as "spaghetti junctions." There were substantial water losses experienced by many municipal corporations and, without serious attention and expenditure,

Table 1. Proposed treatment plants, 2002 Mumbai Sewerage Master Plan

Service Zone	Treatment Works	Average Dry Weather Flow (mld)	Pass Forward Flow (mld)	Effluent Quality BOD/SS (mg/l)	Process
1	Colaba WwTW	31	85	20/30	ASP
2	Lovegrove WwTW	399	981	100/100	ASP
3	Bandra WwTW	241	591	100/100	CEPT
3	Dharavi WwTW	337	752	100/100	ASP
4	Versova WwTW	278	750	100/100	2SL
5	Malad WwTW	644	1726	100/100	2SL
5	Gorai WwTW	39	132	20/30	3SL
6	Bhandup WwTW	253	691	20/30	3SL
7	Ghatkopar WwTW	400	1048	20/30	3SL
	Total	**2622**	**6756**		

these losses would be very hard to eliminate. The poorly maintained systems coupled with an intermittent water supply result in a high level of contamination.

Sewage treatment

The level of sewage treatment provided in the urban areas was generally not meeting the discharge requirements and was of poor quality when compared to international standards. In cities such as Mumbai, the level of treatment was limited to primary screening and grit removal with disposal of the screened effluent through outfalls into the ocean. There was one small exception, where secondary treatment through a three-stage lagoon plant was being provided to less than 1% of the total flows.

Originally, the marine outfalls from the Mumbai system were established at a distance of 500 metres offshore. With this geometry, the beaches, which are heavily used by the population, were fouled with sewage during every incoming tide. Some outfalls have now been extended to 3 km offshore, with a resultant visible improvement of beaches and shorelines along the Arabian Sea.

Many inland lakes and rivers have been seriously degraded by the effluent from the population of upstream cities. Examples include the Yamuna River at Agra downstream from New Delhi, and Thane Creek and Ulhas River bordering Mumbai.

Operations and maintenance (O&M)

RVA's initial involvement in Mumbai concerned wastewater operations and maintenance, a World Bank-financed assessment of current operations, with recommendations designed to support the investments anticipated by the bank in the 1990s to refurbish the dilapidated infrastructure. Poorly implemented maintenance procedures in major pumping facilities, for example, resulted in large reductions in efficiency, up to 48% in some cases. This was not a surprise, as there was no consistent O&M philosophy being followed.

The O&M investigation focused on health and safety concerns, performance-limiting factors and housekeeping issues within the Sewerage Department, with its very large number of staff workers. Recommendations from this study included facility upgrades, the establishment of a new Utility Management Centre, organizational de-layering, implementation of standard operating procedures and new customer service standards. The main recommendations of this six-year project were related to the need for upgrading the design standards, establishing O&M systems and improving staff skills through focused training.

The O&M experience also provided an opportunity for R.V. Anderson to undertake similar services in related assignments in smaller cities: contract operation of industrial waste treatment and potable water treatment facilities. Similar poor operating conditions were found to exist in these plants. The waste treatment was an even greater problem in remote and rural areas, often resulting in serious degradation of the local receiving water quality.

Planning and management

Having established recommended actions for improvements for Mumbai, the next phase of the RVA involvement was the preparation of a Wastewater Master Plan. The original 1979 Master Plan required updating, not only to establish a strategy for the management of current and future sewage flows, but to recognize the updating of national and international effluent standards.

The resulting 25-year Mumbai Master Plan, developed by RVA as part of an international consortium, included a review of the need for sewerage system upgrades, major new pumping stations and transfer schemes (tunnels and cross town trunks), and the establishment and upgrading of sewage treatment works and ocean outfalls. The recommended scheme was valued at approximately CAD$1.1 billion at 2002 prices. A major component of the recommended program for implementation was a slum sanitation program. This program was to build on the work already undertaken by the municipal corporation, and recommended close coordination with local community-based organizations for successful implementation. The treatment plants proposed in the seven sewerage zones in Mumbai under the 2002 Mumbai Sewerage Master Plan are shown in Table 1.

Based on this experience, similar planning work was subsequently carried out at smaller scales for Delhi and Sangli, for industrial waste management in Punjab, and for an asset management plan for Bangalore. The main objective for RVA in these exercises was to present cost-effective, sustainable infrastructure solutions.

Currently, RVA, as part of an international consortium, is involved in the design and implementation of the "Stage II Priority Works" indentified in the 2002 Master Plan. The Design-Build-Operate approach is being experimented with for the treatment elements as an alternative to traditional design and construction using bank or International Monetary Fund (IMF) financing.

Conclusion

Based upon the experience gained, a number of observations and "lessons learned" can be made, reflecting changes in engineering in India over the last 20 years.

▶ **Scale and complexity** – Due to the size and complexity of the working environment in Indian cities such as Mumbai, the economies of scale and relative cost structures are therefore quite different than Canada's. Working closely with local Indian engineering professionals was, and remains, very important.

▶ **Operations and maintenance** – Efficient O&M of existing infrastructure remains the cornerstone of sustainable development. The benefit-cost ratio of O&M improvements is very high, as much as 3:1. Streamlined O&M and preventative maintenance programs are now being implemented in Mumbai and other Indian cities.

▶ **Slum sanitation** – This continues to be a difficult issue to integrate with larger infrastructure upgrade projects, in part because of the difficulty of engaging communities and incorporating acceptable decentralized facilities, such as communal toilets, that will be used and maintained properly.

▶ **Municipal efficiency** – Efficiency has been increasing, in part due to the pressures of a rapidly growing economy and also because of the extensive adoption of information technology and significant improvement in communication systems.

▶ **Client approvals** – Decision making in the local municipal environment continues to occur collectively through a review committee. Providing regular presentations to the committee and documenting agreements during the various stages of the planning process proved to be an expedient approach to receiving timely client approvals and minimizing the otherwise usual project delays.

▶ **Data availability** – : Lack of available data makes planning a significantly more complex process requiring extensive consultation with all stakeholders, and places importance on the ability to make decisions under considerable uncertainty, as little detail about existing physical assets, performance data, accurate maps or plans may be available.

▶ **Local Indian engineering expertise** – Indian engineering expertise is capable and easily available. Foreign expertise is generally required for planning and design support, as well as to bring an international perspective that was difficult for local municipal agencies to obtain. The ratio of foreign "expats" to local staff has fallen from 1:4 to 1:15 over the years, as a result of the growing skills and experience of local Indian engineers.

▶ **Complementary project assistance** – Canadian government support through Canadian International Development Agency (CIDA) and the Department of Foreign Affairs and International Trade (DFAIT) programs for planning and operations in India has been beneficial to the municipal agencies involved as a resource to provide additional training and guidance to their operations staff. ■