



The Zimbabwe Water Forum provides a platform for Government and Development Partners to share international best practices in the water sector between Zimbabwe and other countries. The forum was formed through a partnership between the Ministry of Water Resources Development and Management, the Multi-Donor Trust Fund and the World Bank and is hosted by the World Bank's Zimbabwe Country Office and the Urban WSS Thematic Group.

Improving the operation of Harare's water and wastewater treatment plants

The Government of Zimbabwe requested technical assistance from the World Bank to assist the City of Harare in developing design briefs for the appointment of professional service providers to undertake the design and tender process for key urgent projects in the water and wastewater sector (WWS). The consultants from Arup Pty were requested to identify the scope of selected urgent works projects and to prepare project design briefs that would specify the work required for each project. These briefs could then be used as the basis for consultants to conduct further research, or for contractors to bid on design, construction, and supervision for the urgent refurbishment needed to bring the struggling Harare WWS sector back to the high standards of the past. The consultants were also requested to develop a schedule for the studies, surveys, tests, and reports that would be needed for each project. In addition to the scope of work and design briefs, the consultants prepared contract data for each project that included the special conditions required to comply with all necessary regulations. This policy note focusses on six of the highest priority tasks that were identified during the study.

Procurement strategies appropriate to the project

There are a number of options for executing WWS projects: a consultant can be hired to undertake the studies, surveys, and design prior to tender, with the contractor responsible only for carrying out the project; or the contractor may be made responsible for the research and design in addition to the execution of the project.

When studies and surveys are required to determine engineering details—such as plant capacity—or when the project's feasibility might be affected by ground conditions, it is preferable to have the design completed before the issue of tenders. However, when the scope of the project is already well defined—such as when old equipment is to be renewed without any significant changes in function—a design-and-build model can work well. Each project in this report was evaluated to choose the approach that was most suited to its specific design needs. The contract and design brief templates prepared by the consultants were designed to accommodate both options. The project briefs included:

- The rationale for the project and the specific objectives to be achieved
- The solution proposed for the project
- The scope of the work to be carried out
- The studies and surveys required to carry out the design and supervision of the project
- Contract data completed for a standard contract including special conditions required to comply with City of Harare Standing orders and the Urban Councils Act
- A brief project proposal or funding application

Six key tasks for renewal of the WWS system

Based on previous research by the consultants, six urgent tasks were chosen as the subject of the scope of work and design briefs. These tasks focused on upgrades and refurbishment of water treatment facilities at the Prince Edward and Morton Jaffray Works and of wastewater treatment facilities at the Firlie and Crowborough wastewater treatment works and the Budiriro sewage pumpstation. In addition, the consultants

- The background to each project

were asked to prepare a scope of works and project brief for the optimization of all the biological nutrient removal (BNR) plants, which had been struggling with poor performance because of frequent power outages and other technical issues. These tasks were chosen because they answered urgent needs for refurbishment of the system but were also carefully designed to dovetail with the ongoing work of the Urgent Water Supply and Sanitation Rehabilitation Project (UWSSRP).

Task One: Prince Edward Works

Prince Edward Works is the City of Harare's secondary potable water source, with a design capacity of 90MI/day. Prince Edward has recently undergone some refurbishment, primarily of its chemical dosing and disinfection facilities, which considerably improved the effectiveness of the plant. More improvements are now being planned by the UWSSRP, but it is critical for this upgrade to be designed as a single project to maximize efficiency.

The Prince Edward Works was originally designed to supplement potable water during peak demand periods, rather than to provide a continual supply. Given increasing demand from Greater Harare, the consultants suggested the appointment of a contractor to undertake a design check of the entire works.

The design check would include a preliminary engineering design, design development, construction procurement, inspection, and project close out. The project will require the services of a number of specialists including civil, electrical, mechanical, process control, and structural engineers. The coordination of these specialists by a single consultant will be a critical component of the selection process for the consulting firm.

Task Two: Morton Jaffray Works

The Morton Jaffray Water Treatment Works is the primary source of potable water for Greater Harare. With a design capacity of 614Mld, the works are located below Lake Chivero, outside Harare. The facility comprises three plants constructed between 1952 and 1994. While the plants once functioned efficiently, the economic crisis of the last decade has taken a heavy toll. Lacking the funds for maintenance and improvements, the works have fallen into serious

disrepair and struggle to supply the needs of the quickly increasing population of Harare.

A critical component of the works, Clarifier Three, has been out of commission for many years, and repairs are urgently needed to return the plant to full operating capacity. Retrofitting of lamella type settlers would increase the efficiency and production capacity of Clarifier Eight.

Currently, there is little mechanical control of the flow of water at the mixing chamber. Flow from Lake Chivero can only be cut off by manually closing butterfly valves in the intake tower, and control of Lake Manyame flows requires switching off the Darwendale pumps. The inflows are subject to irregular, powerful surges that are not totally contained within the chamber and that repeatedly drench the surrounding area. This has led to accelerated corrosion of equipment, and workers are at risk of serious injury as they access the chamber.

Cavitation of the medium-capacity pumps has seriously damaged the pump sets and the connecting pipework, which causes frequent down time. The filters and filter galley buildings are structurally sound, but the mechanical, electrical, and control plant equipment have exceeded their design life and must be replaced. It is absolutely necessary to address the restricted suction head that is the primary cause of the cavitation. The building itself also requires refurbishment.

Planned projects for refurbishment of the Morton Jaffray Works include:

- designing, fabricating, installing, and testing the mechanical and electrical components of the Accentrifloc Clarifier (Clarifier Three);
- designing, fabricating, constructing, installing, and testing the filtration system, equipment, controls and power supply needed to completely refurbish the existing filtration system;
- designing, constructing, and commissioning a new pump sump to reduce cavitation of the medium-capacity pumps;
- designing, constructing, testing, and commissioning an additional filter bank to match the increase in Clarifier Eight's production;

- delineating the scope of work for the appointment of a specialist to undertake a geotechnical investigation into subsidence of plant three clarifiers and to propose mitigation; and
- delineating the scope of work for the replacement of inlet control valves from Lake Chivero and Lake Manyame.

Task Three: Little Marimba Outfall Sewer

The Little Marimba Outfall Sewer is in a poor state of repair, and sewage spills into the catchment in many places. Some resources have been made available under the UWSSRP to carry out refurbishments, but, while these will address some immediate problems, a more strategic view is needed to implement a longer-term solution. The capacity of the existing sewers has already been exceeded, and the system cannot meet the challenge of the extensive urban growth in this catchment.

The tasks required include:

- carrying out a survey to determine the current and future number of connections in the Little Marimba catchment;
- preparing estimates for credible scenarios of existing and future sewage generation in the catchment and flow regimes;
- undertaking a detailed survey of the existing sewerage system to calculate its capacity, determine its condition, and determine the extent and feasibility of in-situ repair;
- determining the most appropriate location for additional treatment capacity and the required combination of repair, replacement, or duplication of existing facilities
- designing the rehabilitation and new facilities; and
- preparing a phased investment plan for implementation of the works including the repair or replacement of existing sewer pipes and the repair of structures and manholes.

Task Four: Firle Existing Effluent Pump Station and rising mains and Mufakose pumpstation at Crowborough WWTW

Harare Water is presently installing new pumps in the effluent pump station at Firle Wastewater Treatment Works, but a number of serious problems remain including: pumping capacity, corrosion, and excessive leakage of the pump station discharge manifold and from the two rising mains. New pumps will prevent sewage from discharging into the Mukuvisi River by lifting treated effluent to council-owned farms for irrigation and fertilizer. Under the UWSSRP, additional pumps will be installed, repairs will be made to the pumpstation pipework, and parts of the rising mains will be replaced. This report proposes hiring a consultant engineer to check the suitability of the pumps being procured—and recommend any changes if necessary—and to design and procure permanent repairs or replacement of the rising mains, control systems, pipework, and valves.

The trickling filters and humus tanks of Crowborough Units 1 and 2 are to be refurbished under the UWSSRP, but there will be no way to dispose of the sludge from the repaired tanks. Formerly, the sludge was mixed with the raw sewage from the Mufakose outfall sewer and pumped to the inlet works, but this pumpstation is no longer functional, and raw sewage from the Mufakose Outfall Sewer is discharging directly into the Marimba River. Without pumps and without raw sewage to dilute the sludge, the trickling filters cannot be used, rendering the investment completely ineffective. This report outlines the scope for a consultant project that includes:

- surveying the condition of the Mufakose Outfall Sewer, inlet works, raw sewage pumpstation and rising main;
- determining the feasibility of repair, relining, or replacement of pipelines;
- designing the necessary repair and rehabilitation works for the sewer, rising main and inlet works;
- selecting pump type and duty;
- procuring, installing, testing and commissioning pumps and associated electrical and control equipment; and
- procuring, constructing, testing and commissioning pipelines and civil works.

Task Five: Budiriro pumping station

The Budiriro catchment lies on the south-western fringe of the City of Harare. Its sewage used to be pumped into an outfall sewer that discharged to the Firle WWTW. Unfortunately, this pump station no longer functions, and all sewage is discharged into surface water that drains untreated into Lake Chivero, the main source for the city's drinking water. The UWSSRP includes plans to refurbish the pump station, but additional pump stations will be needed to service the substantial areas of housing planned for the catchment downstream of the pump station site.

This report provides the design brief for a strategic plan, and subsequent engineering, for the Budiriro catchment to determine whether all effluent from the catchment should be pumped to the Firle treatment works, or whether some or all the sewage should be treated within the catchment. Solutions may include full or partial treatment of sewage before pumping or discharge, the construction of storm overflows with storage or treatment before pumping or disposal, or other strategies to reduce the impact of sewage pumping from this area on the treatment works at least cost. A comprehensive survey of the sewage reticulation of the entire catchment is urgently needed to calculate its capacity, determine the current and future number of connections, and to identify points where stormwater and grit enter the system. All stakeholders should be consulted in preparing the strategic plan including residents, planning departments, housing co-operatives, and other developers. Once the strategic plan is in place, the design, installation, and commissioning of the chosen system can be undertaken.

Task Six: Optimization of Sewage Treatment Plants

Harare Water is in the process of rehabilitating the sewage treatment plants serving the city. This includes a number of Biological Nutrient Removal (BNR) activated sludge sewage treatment processes at the Firle and Crowborough treatment works. These plants are intended to produce treated sewage effluent that complies with the Environmental Management Regulations of 2007. Since re-commissioning the first of the rehabilitated plants, Harare Water has experienced difficulty in managing the process,

particularly in the light of frequent, extended power cuts.

This report presents a project brief for hiring a consulting firm and contractor for two years to optimize the operation of the rehabilitated BNR plants. The tasks required include:

- characterizing and monitoring raw sewage and partially treated effluent throughout the plants;
- carrying out a check on the process design for all BNR plants;
- optimizing operation of each plant including mitigation of the effects of interruptions to power supply; and
- producing an operations and maintenance manual specific for each design of BNR plant.

A coordinated and long-term approach is critical for success

The authors of this report stressed the need to undertake a thorough design review for each project and recommended that specialist water and wastewater treatment consultants be hired to undertake the design and to supervise the post-design construction. It is recommended that the design for all water treatment packages be carried out by a single consultant to avoid numerous interfaces between design teams. This integrated design approach was not considered as critical for the wastewater treatment works, but careful planning and co-ordination will be essential for all projects to avoid duplication and conflict with existing plans.

The authors also identified short- to medium-term measures to mitigate the pollution caused by the failure of the wastewater treatment systems and the overall lack of capacity. These include the repair of existing waste stabilization ponds and the construction of new ponds. While the effluent would not meet the current regulations, they would significantly reduce the pollution load on Lake Chivero and should be considered as part of the overall strategy.

Although the work outlined is urgent and must form the basis for planning and investment in the short term, it is important to take a longer-term strategic view to ensure that the residents of Greater Harare are provided with clean water and safe sewage disposal in a cost-effective and sustainable manner.

The Zimbabwe Water Forum Policy Notes Series

Between 2011 and 2013, at the request of the Government of Zimbabwe, through the Ministry of Water Resources Development and Management, and with support from the Zimbabwe Analytical Multi-Donor Trust Fund, the World Bank has undertaken a series of analytical studies and technical assistance in the water and sanitation sector. These studies are captured in the Zimbabwe Water Forum Policy Note Series. The task team leader for the studies is Michael Webster, Sr. Water and Sanitation Specialist in Harare (mwebster@worldbank.org) with support from Priscilla Mutikani (pmutikani@worldbank.org). All notes have been edited by Rolfe Eberhard and Hilary Gopnik.

- *Policy Note 1: A 24/7 water supply is possible for Harare and other cities: Lessons on what it takes from water manager Neil Macleod*
- *Policy Note 2: Modeling the water sector in South Africa and Zambia*
- *Policy Note 3: Zimbabwe's new National Water Policy: Responding to Challenges to Create a Foundation for Sustainable Growth*
- *Policy Note 4: The Future of Sanitation in Harare and Other Cities: Perspectives on Possible Pathways to Recovery*
- *Policy Note 5: The Beitbridge Emergency Water Supply and Sanitation Project: Lessons Learnt*
- *Policy Note 6: Zimbabwe Urban Water Tariff Study*
- *Policy Note 7: Improving the operation of Harare's water and wastewater treatment plants*
- *Policy note 8: Zimbabwe Dam Safety Study*