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### PEOPLE-CENTRED APPROACHES TO WATER AND ENVIRONMENTAL SANITATION

## Risk management in water supply

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*It has been acknowledged that the decision-making process involved in water supply project appraisals have not been free of risks. In order to optimise project investments and resources in the context of objectives and targets, all financial, managerial and technical resources need to be systematically controlled through risk management procedures. It is essential to identify the most significant risks and apply the most effective mitigation measures. The CASPAR (Computer Aided Simulation for Project Appraisal and Review) Risk Management software package is applied to a case study project to evaluate the role that risk management can play in improving the commercial viability of water supply projects over extended project horizons (typically 25 years). Key risks are identified and the financial implications of risk mitigation measures for such risks are evaluated.*

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### Introduction

This paper describes the roles of risk management in the modelling of the investment requirement and revenue generated from a typical water supply investment in a South East Asian country. The particular concern of this paper is to demonstrate the implementation of risk management techniques in decision-making process which could in turn improve the commercial viability of a water supply project.

The project has the objectives of increasing service coverage from 403,000 people (in 2001) to 646,000 people (at the end of 2010) and from 16 to 20 hours water service per day. Water quantity targets were on increase in supply from 100 lcd to 150 lcd in 2001 to 2010 respectively, and water quality should comply with WHO health standards. The project is financed through 65% grants from the Government, 23% loans, and 12% of equity, with a total investment of US\$ 32,180,000.

The project duration is 25 years (January 2001 to December 2025). The planned construction period was divided into 2 phases. Phase 1 of 3 years and 9 months duration to be commissioned in September 2004. Phase 2 taking 1 year 1 month to be commissioned in October 2006. The plant would be operated for 21 years 2 months, from October 2004. Plant operation will have 4 phases, related to the increase of production capacity and water demand with time. The major activities during the project operation phase are identified as: project operation, loan payment, and revenue generation. Activities commenced during the project's construction and operation phases are distinguished into 26 activities.

### The CASPAR software package

Project appraisal was carried out using CASPAR (Computer Aided Simulation for Project Appraisal and Review), devel-

oped at The University of Manchester Institute of Science and Technology (UMIST). This software can generate various schemes to undertake likely investment requirement and revenue generated for various types of project based on the identified risks inherent in the project. The software simulates the interaction between time, resources, costs and revenue over the project's horizon. The results of the analysis are in the form financial parameters, including: Internal Rate of Return (IRR), Net Present Value (NPV), Payback period (the time that is required for the project to pay back the initial investment), and maximum cash lock-up (amount of investment expended in the project construction phase).

There are 3 (three) major steps in the application of risk management techniques; (i) Development of basic model for financial calculation; (ii) Risk Analysis; and (iii) Risk Mitigation.

### Development of a Basic Model for financial calculation

Based on the basic model for the financial calculation, the NPV of the project is calculated as US \$73,943,000 (at base date of 2001), with the IRR of 10.18 %. The cash pay back time is 13.78 years, with the maximum cash lock-up being US\$ 32,180,000, and the Maximum Investment being US\$ 232,412,000.

The Cumulative Cash Flow (Figure 2) shows that the project is commercially viable as the, the NPV of the project is relatively high, and Cash Pay Back Time is relatively short (compared to 25 year of the project horizon).

### Risk Analysis

Risk analysis quantifies the effects of identified risks on

economic parameters. After risk analysis has been applied projects may appear more risky. This is because the identified negative risks have not been mitigated. Thus, the negative risks often outweigh the positive risks (Merna and Storch, 2000).

The result of the risk analysis is shown in the Cumulative Frequency Distribution Diagram (figure 1). There is a 20% probability that the project NPV will be less than US\$ 25,769,930 and a probability of 80% the NPV will not exceed US\$ 49,769,930.

Compared to the initial prediction of a NPV of US\$ 73,943,000, the results of the probability analysis for the project NPV show that a mean value of the NPV is US\$ 38,769,900 (this amount is much lower than the initial prediction above). This indicates that there is an opportunity to improve financial performance of the project by mitigating the significant risks.

### Risk mitigation

If systematic risk mitigation and control is applied throughout a project's life cycle, it is anticipated that the cost-benefit will be close to the optimum. The mitigation measures for 9 significant risks are briefly outlined below:

**Change in quality of water resources (B00)** - The impacts of water pollution can be fully mitigated through stringent monitoring and control by an appropriate "Environmental Agency". In the model project these actions are assumed to be attainable by the end of year 2010. The effects of the fluctuation of raw water quality within the rainy season are reduced by installing equipment for automatically monitoring turbidity and optimisation of alum use. (The installation cost of such equipment is estimated at US\$ 100,000).

**Fluctuation of water quantity from water resources (B02)** - Abundant surface water resources within the town results in relatively low fluctuation in water quantity even in the dry season. In order to reduce this small change, it is proposed to reactivate 2 small lakes as reservoirs. The cost is estimated at US\$ 300,000. In the rainy season, risk mitigation measures in the reduction of flooding impacts on water treatment plants and water intakes include the appropriate location of facilities.

**Water tariffs (B03)** - Governments (as a water regulators) have frequently failed to identify and apply appropriate water tariffs. Strong commitment is necessary from the local Government to regularly monitor and adjust water tariffs. An understanding of the willingness to pay (WTP) of water users may reduce this risk.

**Delay in the construction of plants (B04)** - Global risk related to delays in the construction of plants is partially mitigated through risk sharing between the company and the government. The local government (or departmental agencies) is committed to conducting the project's EIA, and to the issue of planning permission within the time and budget set up in the plans. In the model project it is assumed that development will proceed under the existing regulations (2001).

**Change in the engineering costs (B05)** - Engineering costs often increase as a result of technical uncertainties such as: changes in plans and designs; redundant work; human error; uncertainties in ground conditions; and increased rates of inflation (See also global risk at Risk B04). Adequate site investigations may reduce risks associated with ground conditions; staff training may reduce human error; and buying equipment and materials from robust suppliers or distributors is also required to obtain discounts. It is essential to select appropriate contract strategies (for example Design Build Operation (DBF), Build Operation and Transfer (BOT), and combination of conventional B&Q and Ls contracts).

**Uncounted for water (B06)** - Two main factors that effect to UFW in a city in the SE Asia Countries are: (i) physical factors (66.4%), and (ii) administrative factors (33.6%) (PERPAMSI, 1991). In order to reduce physical risk related to leakage, there is a need to apply leakage control. The water enterprise provides

US\$ 300,000 for reduction of leakage rate from 35% to 30% within a 3-year project operation period (started from 2003 to 2006). To reduce the impact of administration risk, the company should employ trained staff or professionals for meter reading, data entry, and data analysis. The reduction of UFW by 5% may increase revenue generation by up to 5% (after 2006). This action also reduces maintenance costs on the mains by up to 3%.

**Poor quality of treated water (B07)** - Poor quality of treated water may result in an increase in the number of customer complaints and compensation payments, which increase the company's administration expenditure. The improvement of water treatment plant facilities and distribution systems, and of control and monitoring procedures, human resources, risk management, and proper planning may reduce this risk.

**Direct costs of water production (B08)** - This may be caused by the increase of the following O&M elements: (i) chemical materials; (ii) electric power; (iii) equipment and spare parts; (iv) staff costs; (v) administration costs; and (vi) increase of raw water fees and taxes. This risk can be reduced by purchasing chemical materials, equipment, and spare parts from reliable suppliers; contracting power on a flat rate basis; reducing the number of staff and improving administration procedures by introducing IT. In order to be effective in the management of risks associated with direct costs of water production the following elements were adjusted in the model project:

- Employment of professionals to improve the company's efficiency and productivity and reduce staff numbers (from the existing 12.5 staff per 1,000 connections to 6 staff per 1,000 connections, this programme would cost US\$400,000 and is expected to finish after 2008). These actions may reduce expenditure on staff by up to 40%.
- Improvement of treatment plant efficiency from 70% to 80% within a 10 year period.
- Improvement of billing and revenue collection from 70% up to 85%.

Various types of contract could be applied for the improvement of O&M within the water supply facilities. For example, a management contract may be applied within the water treatment plants and distribution systems, and this contract may also include staff training programmes. Billing and revenue collection, and leakage control also could be contracted to the private sector (i.e. professionals) in the form of a service contract.

Currency exchange rate (B10) - Fluctuation of the host currency rate against hard currencies significantly increase loan payments. This risk is influenced by political factors and as such is almost uncontrollable (global risk). It is suggested that financial instruments such as bonds (debentures); venture capital (made in the form of equity capital), and flat currency rate agreements for loan payment may reduce such risk.

### Reappraisal after risk mitigation

Based on the application of risk mitigation procedure above, the most significant risks in the project are identified, the negative risks are reduced, and the positive risks are enhanced. Using CASPAR it is revealed that the more likely project profitability is improved. For the model project the new results after risk mitigation shows that there is an 80% probability that the NPV will not exceed US\$87,474,710, and the mean value of the NPV is US\$77,400.000. The value of NPV after risk mitigation is greater than both the initial prediction of NPV of US\$ 73,943,000 and a mean value of NPV before risk mitigation of US\$ 38,769,900 (Table 1).

### Summary

The application of risk management procedures using the CASPAR software package enhances predicted economic performance, as the identified risks have been partially or fully mitigated and controlled. The cost of risk mitigation and control measures should be included in project accounts, and

should assist in the generation of best value for money. The results given after risk mitigation procedures applied could provide beneficial information for the project proponents, project sponsors, and project managers in the modelling of more likely the investment requirement and revenue generated from a typical water supply project.

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