**Water Supply Infrastructure Rehabilitation**

**(SU-L1018)**

**Ex-post Socio-economic Annex**

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|  | **LIST OF ACRONYMS** |
| **CBA** | Cost-Benefit Analysis |
| **ENPV** | Economic Net Present Value |
| **ERR** | Economic Rate of Return |
| **IDB** | Inter-American Development Bank |
| **IRR** | Internal Rate of Return |
| **O&M** | Operating & Maintenance |
| **NPV** | Net Present Value |
| **SWM** | N.V. Surinaamsche Waterleiding Maatschapij |

1. **INTRODUCTION**

The general objective of the program “Water Supply Infrastructure Rehabilitation” (the “program”) was to improve efficiency and quality of the potable water services provided in Greater Paramaribo. The specific objectives were: (i) improve the operational performance of the water supply distribution system in the Greater Paramaribo area through rehabilitation works; (ii) decrease the level of Non Revenue Water (NRW) through the improvement of operational and maintenance processes and practices; (iii) strengthen N.V. Surinaamsche Waterleiding Maatschapij (SWM) performance by improving operations and maintenance, incorporating a management information system and decreasing energy consumption. To attain its objectives, the program was comprised of four components: 1) NRW program; 2) water supply system rehabilitation; 3) energy efficiency pilot project; and 4)institutional strengthening.

This Annex presents the Ex-post Cost-Benefit Analysis(CBA) for three components of the program: the rehabilitation of the water system (most of component 2) and the non-revenue water program (component 1), that were considered as a single project; the micro metering project (that includes part of component 2); and the energy efficiency pilot project (component 3). The Annex is structured as follows: Section 2.1 briefly describes the water rehabilitation project and the NRW program and its costs; Section 2.2 presents the methodology adopted to estimate the economic benefits; Section 2.3 illustrates the results of the ex-post cost-benefit analysis; Section 3 presents the information regarding the ex-post CBA for the micro metering project; and Section 4 presents the information regarding the ex-post CBA for the energy efficiency component. The Report also includes a series of Appendices, namely: Appendix 1, including a table showing the detailed cash flow of the rehabilitation project and Appendix 2, reproducing the detailed cash flow of the micro metering project.

1. **REHABILITATION OF WATER SYSTEM AND NRW PROGRAM**
   1. **The Project** 
      1. ***Background***

SWM, which was founded in 1930 and is a state-owned company, provides water supply services to the urban areas, including Paramaribo and parts of Wanica, Nieuw Nickerie, and Albina (all in the Coastal Zone). SWM has approximately 76,000 of connections. All the water production and distribution processes for the Paramaribo area come from ground water, which enters a production plant, and then is pumped to the final points of distribution for the population. SWM supplies water with 15 production stations supplied by 85 water wells, with a total capacity of about 31 million m3 per year, which is predominantly abstracted from three aquifers: the Zanderij, the Coesewijne, and the A-sand aquifer, with the Zanderij being the largest source of water.

In general, the water supply in the Coastal Zone was relatively poor and inadequate. Unaccounted-for water, or non-revenue water, was estimated to be 45%. Consumers experienced low / no water pressure and poor water quality. The main reasons for this were: the condition of the facilities was generally old and dilapidated, there was a high percentage of leakage in the system, the pumping stations and booster stations were under capacity, and there was not enough water in the system.

* + 1. ***Project Description***

The main problems detected on the network infrastructure side were:

* Pipes in the distribution system were in bad condition (breakages, sulphate deposits).
* Low water pressure due to the risk of pipes bursting or a lack of water in the system.
* Shallow trenches for existing pipes, which increased the risk of collapse.
* Water meters in bad condition.
* Low efficiency rates for electromechanical equipment in pumping stations. Network valves in poor condition.
* Deficit in service reservoir volume for district regulation.

From the operational point of view the main issues to be addressed were:

* Lack of a maintenance program oriented to the sustainability of the infrastructure;
* Lack of an integrated management and information system, including network information, customer data and operational information;
* No definition of district metering areas for network operation;
* No measuring system for energy consumption monitoring;
* High percentage of non-revenue water for the system.
* Lack of a standard system for operating the network and plans for its expansion and/or replacement.

The interventions were chosen based on the above issues to find a program that would addresses these issues in a short-medium term impact and bring sustainability to the system in terms of operability and sustainability of their assets. Therefore, the following works were developed:

* Replacement of the most critical areas of Paramaribo’s asbestos network from which high portion of the non-revenue water was being generated. Specifically, it included:
  + replacement program of 21.8 km of asbestos pipes,
  + disposal plan of the asbestos pipes that were going to be removed for the site,
  + replacement and/or refurbishment of valves and special fittings in the area,
  + and definition of a district metered area in the intervened sectors.
* Replacement of secondary networks from Wanica and Para districts that were under dimensioned for the demand. Specifically, it included:
  + replacement program of 12.5 km of secondary PVC pipes
  + installation of 5,000 household connections in Leidingen
  + replacement program of 7 km of secondary PVC pipes
* Re-laying of some secondary distribution networks which were under permanent risk of collapse due to traffic.
* Installation of household connections in areas formerly operated by NH/DWV which were not metered and did not have a proper service (see section 3 for CBA of this specific intervention).
* Replacement of critical pumping equipment in key pumping station facilities with an energy efficiency and maintenance plan (see section 4 for CBA of this specific intervention).
* Development of a long term non-revenue water program with a pilot study. The activities included in this program were:
  + Development of a network modelling and integration with the existing information system
  + Implementation of a network simulation model NRW Action Plan completed
  + Installation of 80 flow and pressure meters in the network
  + Training of SWM staff on NRW

The defined areas of intervention were chosen in conjunction with SWM’s technical specialists and Genivar Consultants, who were carrying out a condition assessment of the infrastructure. The areas of intervention were chosen with the above criteria and were thought to give the highest positive impact to the performance of the infrastructure. Since the main impact of both interventions, the NRW program and the rehabilitation of the water system, was to reduce the amount of water loss from the system, both were evaluated as an integral, single project.

* + 1. ***Investment Costs***

Investment costs include the cost of the works and the indirect cost of investment, such as the cost of administration, design and work supervision.

The total value of the investments, at market prices reached about US$ 9.7 million.

**Table 2.1 - Investment Costs – per cost item**

|  |  |
| --- | --- |
| **Cost Item** | **US$**  **(‘000)** |
| **Non-Revenue Water Program** | **2,211** |
| NRW Program implementation | 1,304 |
| Purchase of measuring devices | 575 |
| Designs and EA | 332 |
| **Water Supply System Rehabilitation** | **6,457** |
| Replacement of asbestos pipes | 3,896 |
| Replacement of secondary pipes (Wanika and Para) | 1,105 |
| Re-laying of secondary pipes | 270 |
| Replacement of old cast-iron pipeline | 1,186 |
| **Project Administration** | **1,075** |
| **TOTAL** | **9,743** |

**Table 2.2 - Investment Costs - per year**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **2012**  **(in US$ ‘000)** | **2013**  **(in US$ ‘000)** | **2014**  **(in US$ ‘000)** | **2015**  **(in US$ ‘000)** | **2016**  **(in US$ ‘000)** | **2017**  **(in US$ ‘000)** | **Total**  **(in US$ ‘000)** |
| NRW | 0 | 0 | 293 | 356 | 954.85 | 607 | **2,211** |
| Water System Rehabilitation | 24 | 8 | 1,693 | 801 | 1,418.05 | 2,512 | **6,457** |
| Project Administration | 90.39 | 125 | 113 | 207 | 111.49 | 429 | **1,075** |
| **Total** | **115** | **133** | **2,100** | **1,364** | **2,484** | **3,548** | **9,743** |

To transform the above financial (investment) costs in economic costs, conversion factors should be applied. However, given the impossibility to obtain the information in a timely manner, the financial costs were assumed to be equal to the economic costs. This is a conservative assumption, and therefore it will be a robustness check of the project ex-post economic feasibility.

* + 1. ***Operating and Maintenance Costs***

Considering that this is mainly a rehabilitation project, the operating and maintenance costs (O&M) were the same as in the situation without project.

* 1. **The economic benefits**
     1. ***Project Beneficiaries***

The number of connections served within this component was estimated at 16,650 households, that were already connected to the service. Table 2.3 below shows the type of intervention and number of beneficiaries.

**Table 2.3 – Interventions and Beneficiaries**

**

* + 1. ***Project Benefits***

The main impact of the project was to decrease the NRW level and hence improve the quality of the system. Water losses were product of a deficient infrastructure and poor O&M. As a consequence, users faced discontinuities in the service and low water pressure. With the system rehabilitation and the NRW program, approximately 8% of the water production, a significant part of which is lost (estimated at 45% before the project), was recovered and distributed to users.

The importance of the project was largely confirmed by a household survey done in 2009[[1]](#footnote-1). Because of the poor quality of the service, between 27% and 50% of the households connected to the water system owned a water pump. Moreover, 88% of the SWM customers owned a water tank.

For NRW interventions, the benefit of the reduction of physical losses is determined by the savings in production cost. Therefore, the benefit was calculated using: 1) the amount and timing of the reduction of physical losses; and 2) the economic cost of producing water.

Table 2.4 below illustrates the amount and timing of the reduction of physical losses because of the interventions. At the time this evaluation was performed, reduction data was available until 2016, since more interventions were carried out in 2017, it is expected to have more reductions in physical losses. Up to December 2016, the water losses were reduced by 3.4 million m3 per year.

**Table 2.4 – Reduction of physical losses**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **2014**  **(in ‘000 m3)** | **2015**  **(in ‘000 m3)** | **2016**  **(in ‘000 m3)** |
| Reduction in Water Losses | - | 3,116 | 3,370 |

The cost of producing water was estimated using data on administration, operation and maintenance costs provided by SWM. This cost is not including capital expenditures, therefore is underestimating the value of water. Additionally, since most of the water supply is pumped from the ground, the cost of electric energy should be adjusted to reflect economic costs. As it will be mentioned in section 4, the tariff paid by SWM for electricity is well below the economic cost of energy. The production cost calculated as explained above, is equal to US$0.4148/m3, and this is the value used to obtain the cost savings due to the project. Table 2.5 illustrates the production cost savings.

**Table 2.5 – Cost savings**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **2014**  **(in ‘000 US$)** | **2015**  **(in ‘000 US$)** | **2016**  **(in ‘000 US$)** |
| Production cost savings | - | 1,292 | 1,398 |

* 1. **The results** 
     1. ***Cost-Benefit Analysis Results***

Using an economic life of 20 years, an evaluation horizon of 20 years, and a discount rate of 12%, the present value of the costs of investment was estimated to be US$ 5.8 million which is lower than the present value of the benefits (US$ 7.02 million). As illustrated in Table 2.6 below, the project is economically viable, showing an Economic Rate of Return (ERR) of 16.8 percent and a Net Present Value (NPV) of US$ 1,240,317.

**Table 2.6 Results of the Economic Analysis**

|  |  |
| --- | --- |
| **ENPV** | **ERR** |
| US$ 1,240,317 | 16.8% |

The cash flow of the project is presented in Appendix 1.

* + 1. ***Sensitivity Analysis***

For the sensitivity analysis, the production cost of the water was analyzed.

**Table 2.7 Results of Sensitivity Analysis**

|  |  |
| --- | --- |
| **Variables** | **Critical value[[2]](#footnote-2) (%)** |
| Production cost of the water | -18% |

This analysis demonstrates the robustness of the project. The production cost should decrease 18% so the project is not economically feasible. As explained in Section 2.2.2, the production cost used underestimates the value of water, therefore it’s very unlikely that this value would decrease 18%.

1. **MICRO METERING PROJECT**

The program included US$ 605,631 for the purchase and installation of 8,000 water meters. 5,000 water meters were installed in the Leidingen area (Wanika) in 2015 and 3,000 were distributed among Ressort Domburg (Wanika), Ressort Houttuin (Wanika) and Para in 2017. The installation, maintenance, and operation of these meters provided additional revenues for SWM, which improved the entity’s financial condition. The economic benefits of water metering, however, derive from the allocative efficiencies which result from charging the customers the opportunity cost of providing water.

Since after the project was completed consumers haven’t face significant water supply problems, the opportunity cost of water is assumed to be equal to the operation and maintenance costs of providing water[[3]](#footnote-3). Therefore, the gross economic benefit results from the decrease in production costs as consumers cut back their consumption in response to being charged a price for water. This gross benefit is partially offset by the reduction in consumer surplus as consumers cut back. The loss of consumer surplus depends on the elasticity of consumer demand and the price charged. The computation necessary to calculate the decrease in consumer surplus is the integral of the demand curve between a price of zero and the tariff level.

Hence the steps for CBA are the following: 1) estimate the elasticity of demand for water; 2) obtain the average household water consumption; 3) calculate the operation and maintenance costs of the system. Steps 1) to 3) allow the estimation of the gross benefit and the consumer surplus loss. Finally, the cost of investment and operation of the water meters need to be subtracted to obtain the net benefit.

For this ex-post CBA, it is used the same elasticity of demand for water that was used for the ex-ante analysis, equal to -0.45. Regarding water consumption, according to data provided by SWM, the average consumption for users is 18 m3/month. The operation and maintenance cost are equal to US$ 0.4148/m3, and the tariff charged by SWM for a consumption of 18 m3 is US$ 0.36/m3.[[4]](#footnote-4) Additionally, the incurred incremental O&M costs could not be obtained, then it is assumed that the O&M cost of the water meters is equal to 5% of the investment cost. The Table 3.1 below summarizes the key parameters of the analysis.

**Table 3.1 CBA Parameters**

|  |  |
| --- | --- |
| **Parameter** | **Value** |
| Water demand elasticity | -0.45 |
| Household average monthly consumption | 18 m3 |
| Tariff | US$ 0.36/m3 |
| Opportunity cost | US$ 0.4148/m3 |
| Annual O&M cost (as a % of investment) | 5% |

Using an economic life of 20 years, an evaluation horizon of 20 years, and a discount rate of 12%, the present value of the costs of investment, combined with annual O&M costs, was estimated to be US$ 0.74 million which is lower than the present value of the resource savings US$ 1.28 million. Therefore, the project is viable, with an NPV of US$ 544,171 and an IRR of 29.9% (see Table 3.2 below). The cash flow of the project is presented in Appendix 2.

**Table 3.2 Results of the Economic Analysis**

|  |  |
| --- | --- |
| **NPV** | **IRR** |
| US$ 544,171 | 29.9% |

Given the uncertainty regarding the elasticity of demand value, a sensitivity analysis was conducted incorporating the assumption that the elasticity is between -0.6 and -0.3 to see if the conclusion on feasibility changes. It also calculated the value of the elasticity that would change the conclusion (the switching point). Additionally, considering that the actual incremental O&M costs could not be obtained, also a sensitivity analysis was conducted and presented in the Table 3.3 below.

**Table 3.3 Results of Sensitivity Analysis**

|  |  |  |
| --- | --- | --- |
| **Elasticity Values** | **NPV** | **IRR** |
| elasticity of demand = -0.6 | US$971,532 | 45.9% |
| elasticity of demand = -0.3 | US$116,810 | 15.8% |
| elasticity of demand = -0.259 (switching point) | US$0 | 12.0% |
| O&M = 10% of investment costs | US$325,306 | 22.4% |
| O&M = 15% of investment costs | US$106,441 | 15.4% |
| O&M = 17.4% of investment costs (switching point) | US$0 | 12.0% |

If the real elasticity of demand is included in what is considered a normal range, then the conclusion on feasibility is sustained. An elasticity value of -0.259 or lower would make the project non-feasible. However, conservative values were used for the rest of the parameters, thus the non-feasibility of the project appears very unlikely. Similarly, the project would not be feasible if the incremental O&M of the micrometers represents 17.4% or higher of the investment costs, which is very unlikely considering the nature of the intervention.

1. **ENERGY EFFICIENCY**

At the time this operation was prepared the annual cost of electricity for SWM was approximately USD $1,000,000, and the annual electricity consumption amounts to 15,010,000 kWh, which was used to produce a total of 31,000,000 m3 of fresh water to supply the population. The total specific energy consumption, also called the Energy Index, was 0.45 kWh/m3, a relatively low Index due to the predominantly flat topography of the country.

As part of the “Technical Cooperation for Energy Efficiency for Caribbean Water Companies”, supported by the IDB, comprehensive Investment Grade Energy Audits (IGEA) were conducted in SWM installations. The general objective of the study was to improve supply-side energy efficiency and reduce energy costs within the water and sanitation sector in Suriname. Specifically, the objectives were to provide SWM with an action plan to increase energy efficiency for the company, and to develop a general methodology to help SWM to self-assess their installations’ efficiency and identify the best available technologies and practices to emulate. The energy audit was conducted in eight major water pumping systems in Paramaribo.

The energy audit identified areas of opportunity for energy savings associated with:

* Replacement of pumps operating with low efficiencies
* Replacement of motors operating with low efficiencies
* Installing variable speed drives on distribution pumps
* Institutional Strengthening

Based on the diagnosis, IGEA proposed several pilot projects that were implemented as part of this program. The list of interventions and the investment costs can be seen in Table 4.1 below.

**Table 4.1 List of Interventions**

|  |  |
| --- | --- |
| **Measure description** | **Investment (US$)** |
| **Strengthening measures** |  |
| 1. Energy Management Committee | 58,280 |
| 1. Improve the maintenance program | 42,030 |
| 1. Improve the operation program | 43,383 |
| **Measures to improve efficiency** |  |
| 1. WK-Plein | 4,381 |
| 1. Republiek | 35,622 |
| 1. Livorno Oversie | 140,181 |
| 1. Blauwgrond | 7,513 |
| 1. Helena Christina | 86,879 |
| 1. Tourtonne | 4,429 |
| 1. Lelydorp | 34,862 |
| 1. Van Hattemweg | 28,584 |
| **Total** | **486,145** |

The ex-post economic analysis requires: 1) the savings in energy consumption because of the project, 2) the valuation of the savings at the economic cost of energy, and 3) the calculation of the internal rate of return (IRR) and net present value (NPV).

Table 4.2 below shows the energy savings per year in both, kWh and US$, for each of the proposed projects.

**Table 4.2 Energy Savings per Project**

|  |  |  |
| --- | --- | --- |
| **Project** | **Savings** | |
| **kWh/year** | **US$/year** |
| 1. WK-Plein | 41,541 | 3,132 |
| 1. Republiek | 214,143 | 16,146 |
| 1. Livorno Oversie | 351,994 | 26,540 |
| 1. Blauwgrond | 9,211 | 694 |
| 1. Helena Christina | 39,767 | 2,998 |
| 1. Tourtonne | 0 | 0 |
| 1. Lelydorp | 157,834 | 11,901 |
| 1. Van Hattemweg | 52,441 | 3,954 |
| **Total** | **866,929** | **65,366** |

The unit savings (savings per kWh of energy) have been calculated using the average energy bill at each facility divided by the kWh consumed, giving the unit financial savings. These savings come to about US$0.0754 per kWh. This is an appropriate financial concept, but it is likely to understate the economic savings. In the coastal area of Suriname, electricity is provided by the Electricity Utility Company of Suriname, N.V. (EBS), of which the Government is the only shareholder. The tariff that EBS charges does not cover EBS’s financial costs. According to an IDB financed study, EBS’s return on assets is -11.6%, operational loss margin -23.6%, and a debt to total assets ratio of 125.4% (data for end of year 2006). To cover operating cost alone, the tariff would have to increase by 31%. To cover capital costs, the tariff would have to increase more. Considering this information, the electric tariffs appear to be well below the economic cost of energy. In that case, projects that were financially feasible were also economically feasible.

This energy efficiency program consists of several activities not specifically related to any individual project (activities 1 to 3 in Table 4.1) that can be referred as “common costs”, and 8 independent projects, each one with a “separable cost”. To conduct the ex-post economic evaluation and given the impossibility to separate the “common costs” and assign them to the individual projects, the following methodology was used: 1) assign to each project its “separable” cost; 2) use that cost to perform the cost-benefit analysis described above; 3) calculate an aggregated CBA for the component.

Using an economic life of 8 years and a discount rate of 12%, the NPV and IRR were calculated. As illustrated in Table 4.3, the cost-benefit analysis shows that the interventions in 5 of the 8 pump stations were not economically feasible. This is directly related to the extent of energy consumption savings achieved with the interventions implemented by SWM. Several factors play a role in the achievement of lower savings than expected: (i) SWM did not implement fully the consultant’s recommendations, in at least 3 stations this was due to future plans for the increase of the production capacity (i.e. Tourtonne, Van Hattemweg, Helena Christina). The production capacity of the stations is key to adjust the energy and hydraulic models which will then allow SWM to determine the technical specifications for the pumps required; (ii) The energy efficiency of some of  the submersible pumps installed was not as expected (e.g. Blauwgrond), this may point out the need to ensure the energy and hydraulic models are fully updated in order to determine the technical specifications of the required pumps. On the other hand, the savings achieved in the three stations (Livorno, LeLydorp, and Republiek) where the recommendations were fully implemented, were as expected or even higher. These results show that SWM can obtain further energy savings in the other stations by fully implementing the recommendations and by using the energy and hydraulic models to ensure the equipment specifications respond to the needs of the network configuration.

**Table 4.3 Results of Economic Analysis for Individual Projects**

|  |  |  |
| --- | --- | --- |
| **Project** | **Indicator** | |
| **NPV**  **US$** | **IRR**  **%** |
| 1. WK-Plein | 11,178 | 70.5% |
| 1. Republiek | 44,587 | 42.7% |
| 1. Livorno Oversie | -8,338 | 10.3% |
| 1. Blauwgrond | -4,063 | -6.3% |
| 1. Helena Christina | -71,984 | -22.2% |
| 1. Tourtonne | N/A | N/A |
| 1. Lelydorp | 24,256 | 29.9% |
| 1. Van Hattemweg | -8,942 | 2.3% |
| Aggregated CBA for the Energy Efficiency Componente | **-161,427** | **1.7%** |

1. **AGGREGATED CBA OF THE PROGRAM**

To analyze the economic feasibility of the whole Program, all the estimated benefits mentioned above were aggregated. Additionally, the costs of the four components were included ((i)Water Supply System Rehabilitation; (ii) Non-Revenue Water Program; (iii) Energy Efficiency Pilot Project;and(iv)Institutional Strengthening). Using a discount rate of 12%, the NPV and IRR were calculated. As illustrated in Table 4.4, the cost-benefit analysis shows that the Program as whole was economically feasible, with an NPV of US$ 435,932 and an ERR of 13%. The details of the cashflow are presented below.

**Table 4.4. Results of Economic Analysis for the whole Program**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Year** | **Benefits Micrometers** | **Benefits EE** | **Benefits NRW** | **Total Benefits** | **Micrometers Costs** | **EE Costs** | **NRW Costs** | **Inst. Streng. Costs** | **Total Costs** | **Net Benefits** |
| 0 | 115,657 |  |  | 115,657 | 510,114 | 486,145 | 114,502 | 10,000 | 1,120,761 | (1,005,103) |
| 1 | 115,657 | 65,366 |  | 181,023 | 24,291 |  | 133,296 |  | 157,587 | 23,437 |
| 2 | 185,052 | 65,366 |  | 250,418 | 150,090 |  | 2,099,692 | 49,793 | 2,299,575 | (2,049,157) |
| 3 | 185,052 | 65,366 |  | 250,418 | 30,282 |  | 1,364,334 | 20,491 | 1,415,107 | (1,164,689) |
| 4 | 185,052 | 65,366 | 1,292,341 | 1,542,759 | 30,282 |  | 2,484,385 | 778,686 | 3,293,353 | (1,750,594) |
| 5 | 185,052 | 65,366 | 1,398,057 | 1,648,475 | 30,282 |  | 3,548,000 |  | 3,578,282 | (1,929,807) |
| 6 | 185,052 | 65,366 | 1,398,057 | 1,648,475 | 30,282 |  |  |  | 30,282 | 1,618,193 |
| 7 | 185,052 | 65,366 | 1,398,057 | 1,648,475 | 30,282 |  |  |  | 30,282 | 1,618,193 |
| 8 | 185,052 | 65,366 | 1,398,057 | 1,648,475 | 30,282 |  |  |  | 30,282 | 1,618,193 |
| 9 | 185,052 |  | 1,398,057 | 1,583,109 | 30,282 |  |  |  | 30,282 | 1,552,827 |
| 10 | 185,052 | - | 1,398,057 | 1,583,109 | 30,282 |  |  |  | 30,282 | 1,552,827 |
| 11 | 185,052 | - | 1,398,057 | 1,583,109 | 30,282 |  |  |  | 30,282 | 1,552,827 |
| 12 | 185,052 | - | 1,398,057 | 1,583,109 | 30,282 |  |  |  | 30,282 | 1,552,827 |
| 13 | 185,052 | - | 1,398,057 | 1,583,109 | 30,282 |  |  |  | 30,282 | 1,552,827 |
| 14 | 185,052 | - | 1,398,057 | 1,583,109 | 30,282 |  |  |  | 30,282 | 1,552,827 |
| 15 | 185,052 | - | 1,398,057 | 1,583,109 | 30,282 |  |  |  | 30,282 | 1,552,827 |
| 16 | 185,052 | - | 1,398,057 | 1,583,109 | 30,282 |  |  |  | 30,282 | 1,552,827 |
| 17 | 185,052 | - | 1,398,057 | 1,583,109 | 30,282 |  |  |  | 30,282 | 1,552,827 |
| 18 | 185,052 | - | 1,398,057 | 1,583,109 | 30,282 |  |  |  | 30,282 | 1,552,827 |
| 19 | 185,052 | - | 1,398,057 | 1,583,109 | 30,282 |  |  |  | 30,282 | 1,552,827 |
| 20 | 185,052 | - | 1,398,057 | 1,583,109 | 30,282 |  |  |  | 30,282 | 1,552,827 |
|  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  | NPV | $435,932.52 |
|  |  |  |  |  |  |  |  |  | IRR | 13.0% |

**APPENDIX 1 – CASH FLOW –REHABILITATION OF WATER SYSTEM AND NRW PROGRAM**





**APPENDIX 2 – CASH FLOW – MICRO METERING PROJECT**



|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Year** | **Investment** | **Annual Costs** | **Total Expenditures** | **Net Benefits** | **Balance** |
| 2015 | 485,823 | 24,291 | 510,114 | 115,657 | (394,457) |
| 2016 |  | 24,291 | 24,291 | 115,657 | 91,366 |
| 2017 | 119,808 | 30,282 | 150,090 | 185,052 | 34,962 |
| 2018 |  | 30,282 | 30,282 | 185,052 | 154,770 |
| 2019 |  | 30,282 | 30,282 | 185,052 | 154,770 |
| 2020 |  | 30,282 | 30,282 | 185,052 | 154,770 |
| 2021 |  | 30,282 | 30,282 | 185,052 | 154,770 |
| 2022 |  | 30,282 | 30,282 | 185,052 | 154,770 |
| 2023 |  | 30,282 | 30,282 | 185,052 | 154,770 |
| 2024 |  | 30,282 | 30,282 | 185,052 | 154,770 |
| 2025 |  | 30,282 | 30,282 | 185,052 | 154,770 |
| 2026 |  | 30,282 | 30,282 | 185,052 | 154,770 |
| 2027 |  | 30,282 | 30,282 | 185,052 | 154,770 |
| 2028 |  | 30,282 | 30,282 | 185,052 | 154,770 |
| 2029 |  | 30,282 | 30,282 | 185,052 | 154,770 |
| 2030 |  | 30,282 | 30,282 | 185,052 | 154,770 |
| 2031 |  | 30,282 | 30,282 | 185,052 | 154,770 |
| 2032 |  | 30,282 | 30,282 | 185,052 | 154,770 |
| 2033 |  | 30,282 | 30,282 | 185,052 | 154,770 |
| 2034 |  | 30,282 | 30,282 | 185,052 | 154,770 |
| 2035 |  | 30,282 | 30,282 | 185,052 | 154,770 |
| Present Value | |  | $737,913 | $1,282,084 | $544,171 |
| Benefit/Cost Ratio | |  |  |  | 1.74 |
| IRR |  |  |  |  | 29.9% |

1. Feasibility Stady of the Wanika Water System, Islamic Development Bank, June 2009 [↑](#footnote-ref-1)
2. Change in variable that reduces the NPV to 0 or the ERR to12%. [↑](#footnote-ref-2)
3. This approach underestimates the economic benefits if the users are actually facing a water shortage. [↑](#footnote-ref-3)
4. The first 8 m3 are covered by a fixed charge, the additional consumption is charged as follows: between 9 m3 and 15 m3 cost US$0.27/m3, between 16 m3 and 22 m3 cost US$0.36/m3, between 23 m3 and 50 m3 cost US$0.72/m3, and above 50 m3 cost US$0.76/m3. [↑](#footnote-ref-4)