Methodology for Optimal NRW Program Design

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Abstract

During 2009-2010, RTI International developed and published a financial model which calculates the financially optimum level of Non-Revenue Water (NRW). The model computes a steady-state target for NRW reduction and control programs, based on site conditions and local costs. The model was presented at IWA Water Loss Specialist Conferences in Cape Town and Sao Paulo and other international meetings. It has been applied in over 30 countries using secondary data, and applied at a more detailed utility-level in Brazil, Jordan, Uganda, and Zambia. While the model has garnered considerable interest, it does not provide specific NRW program design guidance for utilities which are undertaking or interested to undertake the transition from a high level of losses to the lower, financially-optimal steady-state level of NRW.

This paper presents the conceptual framework for a new planning tool which guides utilities on developing an optimal NRW reduction program - one that reaches the optimal level of NRW at the lowest cost. The method, once fully developed at a given site, provides guidance on the optimal mix of actions to reduce commercial losses and the optimal mix of actions to reduce physical losses, based on site conditions and local costs. It also provides information on the schedule of cost inputs required (amount and timing) and the time line of NRW reduction that would be achieved over a multi-year period. Utilities can monitor actual results of their program and periodically update the NRW reduction program design based on empirical monitoring results and updated costs of inputs. The tool can also be used by governments, funders, and regulators to estimate costs and impacts of NRW reduction programs and conduct oversight. Utilities can also use to tool for defining terms and targets for NRW reduction contracts.

The paper outlines the concepts behind the planning tool, describes the various components of the tool, with illustrations and examples and outlines the process for using it, considering its primary audience (e.g., utilities in developing countries and associated utility stakeholders).

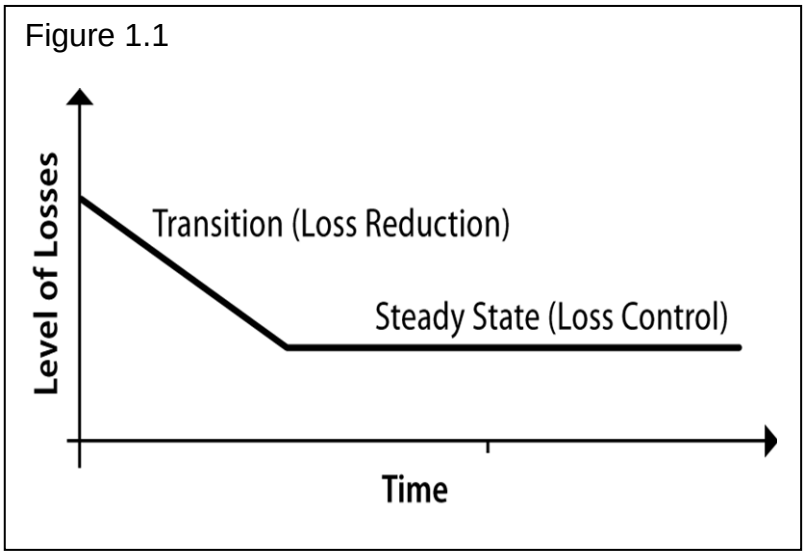
1. Background

During 2009-2010, RTI International developed and published a financial model which calculates the financially optimum level of Non-Revenue Water (NRW). The model computes a target (under future steady-state conditions) for NRW reduction and control programs, based on site conditions and local costs. The tool accounts for the financial costs and benefits of reducing and managing physical losses and commercial losses, as well as the financial aspects of near term water supply capacity expansion needs. The model was presented at IWA Water Loss Specialist Conferences in Cape Town and Sao Paulo and

international meetings in Dead Sea, Jordan, London, UK, Rabat, Morocco and Kampala, Uganda. It has been applied in over 30 countries using secondary data, and applied at a more detailed level in Brazil, Jordan, Uganda, and Zambia. The concepts and specifics of the model have been extensively reviewed with many members of the IWA Water Loss Specialist Committee, and refinements made.

While the model has garnered considerable interest, it does not provide specific NRW program design guidance for utilities which are undertaking or interested to undertake the transition from a high level of losses to the lower, financially-optimal steady-state level of NRW.

Figure 1.1



This paper outlines the conceptual framework for a new model - called Program Optimizer – which, when fully implemented in a given site, help the user define the best way to reach the optimal level of losses. It helps to:

- Develop a multi-year NRW reduction program, integrating a variety of actions
- Forecast the level of NRW year by year
- Prepare a full, multi-year, investment schedule
- Monitor and refine the plan

2. Core Approach

Determine the Cost per m^3 of water "savings" of many possible *Actions* for reducing both commercial losses and physical losses.

Compile *Actions* into NRW Reduction *Programs*

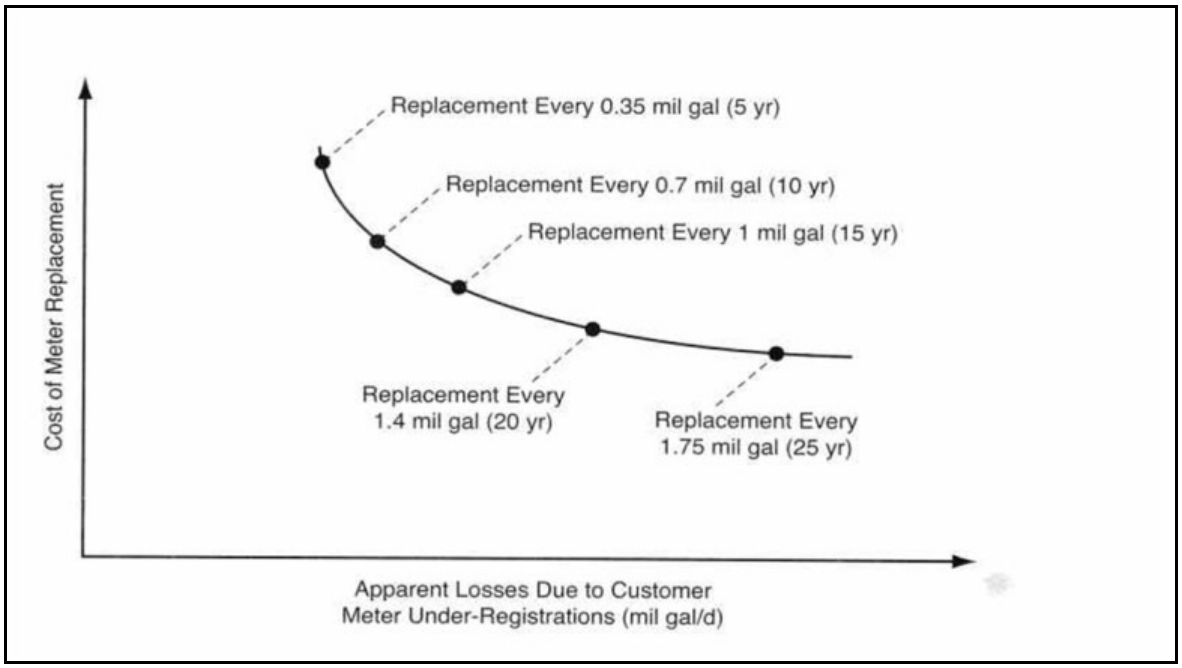
- Assemble *Actions* incrementally, starting with most cost effective, then the second most cost effective, then the third, etc.

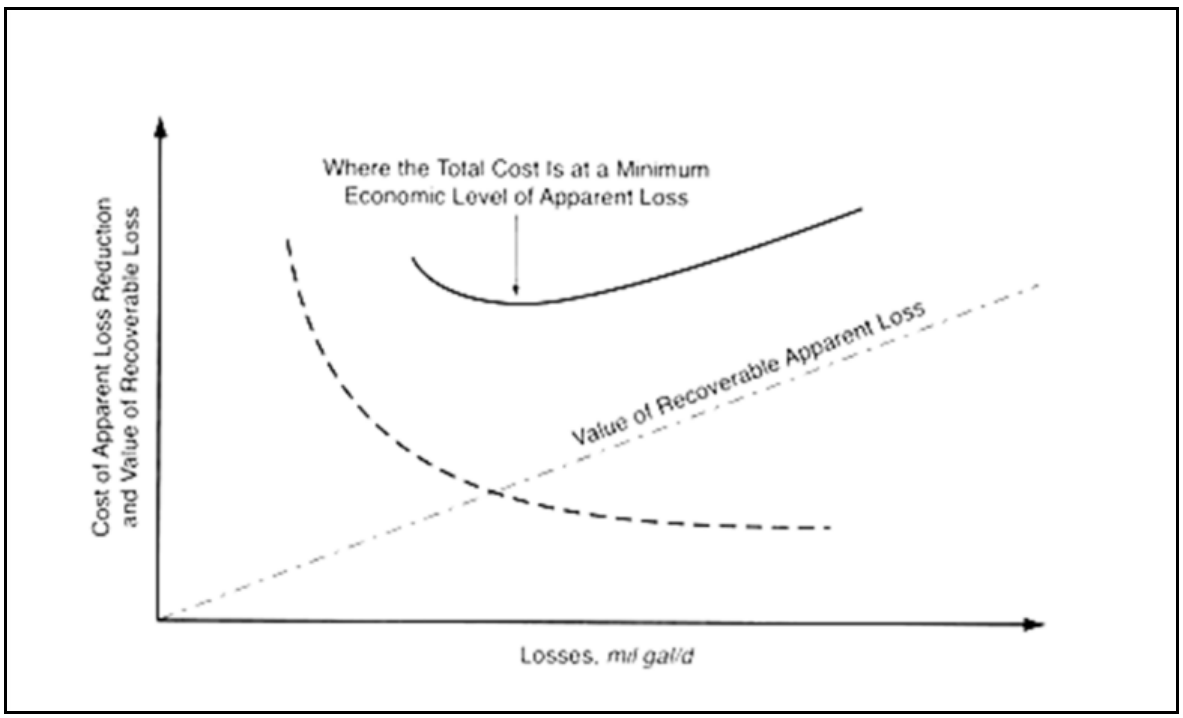
- For Commercial Losses, keep adding in *Actions* whose cost per m^3 "savings" are lower than the potential revenue per m^3 "savings".

- For Physical Losses, keep adding in *Actions* whose cost per m^3 "savings" are lower than the variable costs of water production, UNLESS recovered water can be sold to new or existing customers – in which case use the potential revenue per m^3 "savings" as the cut-off.

NRW Literature refers to the Approach

Figure 2.1





Source: AWWA Manual of Water Supply Practices M36 – Water Audits and Loss Control Programs

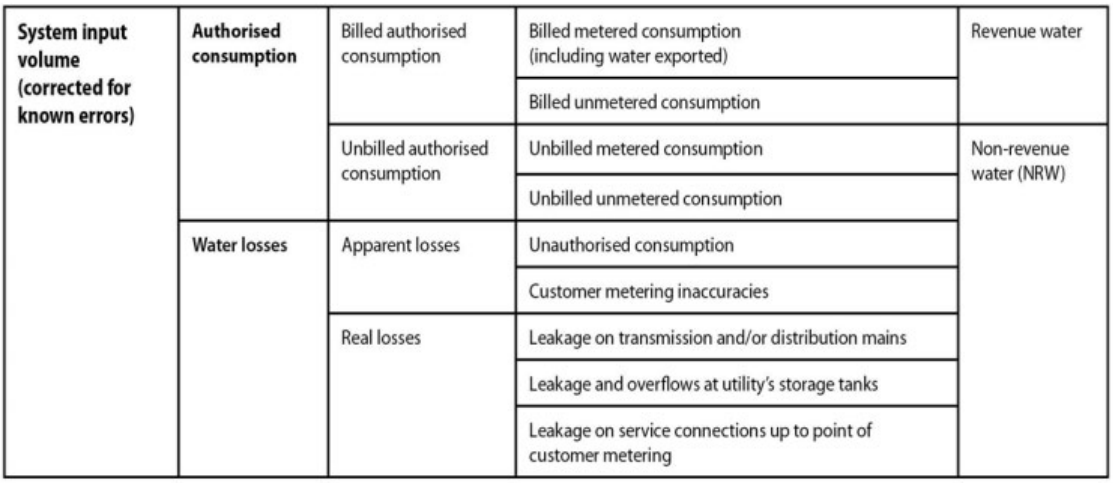
3. Program Optimizer Steps

The major steps involved in implementing the model include the following

- Prepare Water Balance
- Define Possible NRW Reduction *Actions*
- Evaluate *Actions* by Cost per m^3 of savings
- Plan Commercial Loss Reduction *Program*
- Plan Physical Loss Reduction *Program*
- Compile Multi-Year *Program*
- Implement Program
- Monitor and Refine *Program*

3.1 Prepare Water Balance

Figure 3.1



System input volume (corrected for known errors)	**Authorised consumption**	Billed authorised consumption	Billed metered consumption (including water exported)	Revenue water
			Billed unmetered consumption	
		Unbilled authorised consumption	Unbilled metered consumption	Non-revenue water (NRW)
			Unbilled unmetered consumption	
	Water losses	Apparent losses	Unauthorised consumption	
			Customer metering inaccuracies	
		Real losses	Leakage on transmission and/or distribution mains	
			Leakage and overflows at utility's storage tanks	
			Leakage on service connections up to point of customer metering	

3.2 Define Possible NRW Reduction *Actions*

Candidate Actions for Reducing Commercial Losses:

C1: Replacement/Calibration Program: Large Meters
C2: Replacement/Calibration Program: Residential Meters
C3: Update Customer Database
C4: Basic Theft Control Program
C5: Aggressive Theft Control Program
C6: Low-flow controllers

Candidate Actions for Reducing Physical Losses:

P1: Improve Burst Response System
P2: Systematic Leak Detection Program

P3: Pressure Control Program
P4: Network Sectorization
P5: Sector Metering
P6: Rehabilitation of Older Network sections
P7: Planned Mains Replacement Program

For Each Action, Compile Information on:

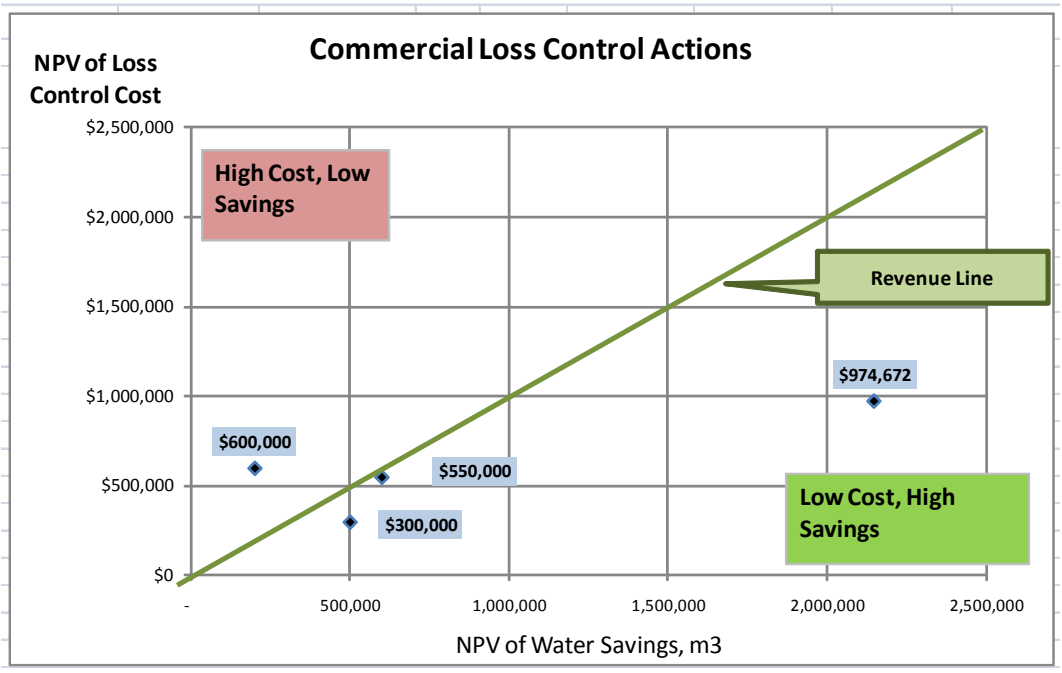
1. Implementation Process – labor, materials, etc
2. Table of Costs – year by year
3. Table of Water Savings – year by year
4. Compute Net Present Value of Costs
5. Compute Net Present Value of Savings
6. Compute Cost / m^3 savings for each Action

3.3 Evaluate *Actions* by Cost per m^3 of savings

Evaluate the possible Actions by ranking them by cost per m^3 of savings, from lowest cost to highest cost. Prepare one ranking for commercial losses and one ranking for physical losses. A hypothetical example for commercial losses is shown below

COMMERCIAL LOSS CONTROL PROGRAM

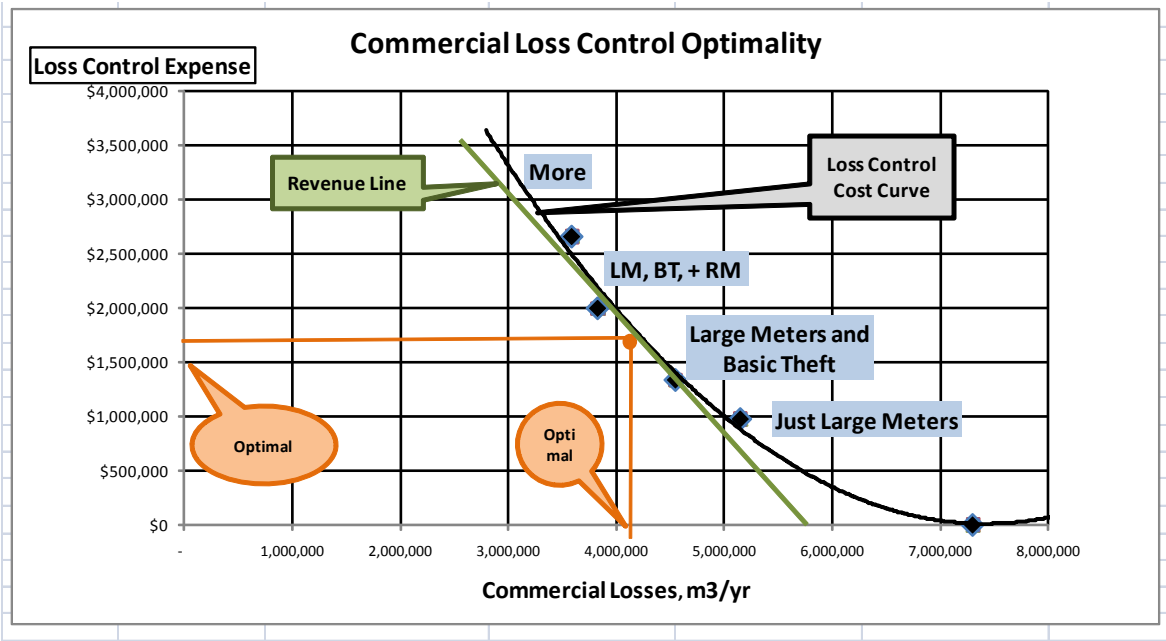
Action Code	Action Description	NPV of Water Loss Reduction, m3	NPV of Costs, $	Cost / m3 of Savings,
C1	Replacement of Large Meters	2,149,098	$974,672	$0.454
C3	Basic Theft Control Program	500,000	$300,000	$0.600
C2	Replacement of Residential Meters	600,000	$550,000	$0.917
C4	Aggressive Theft Control Program	200,000	$600,000	$3.000

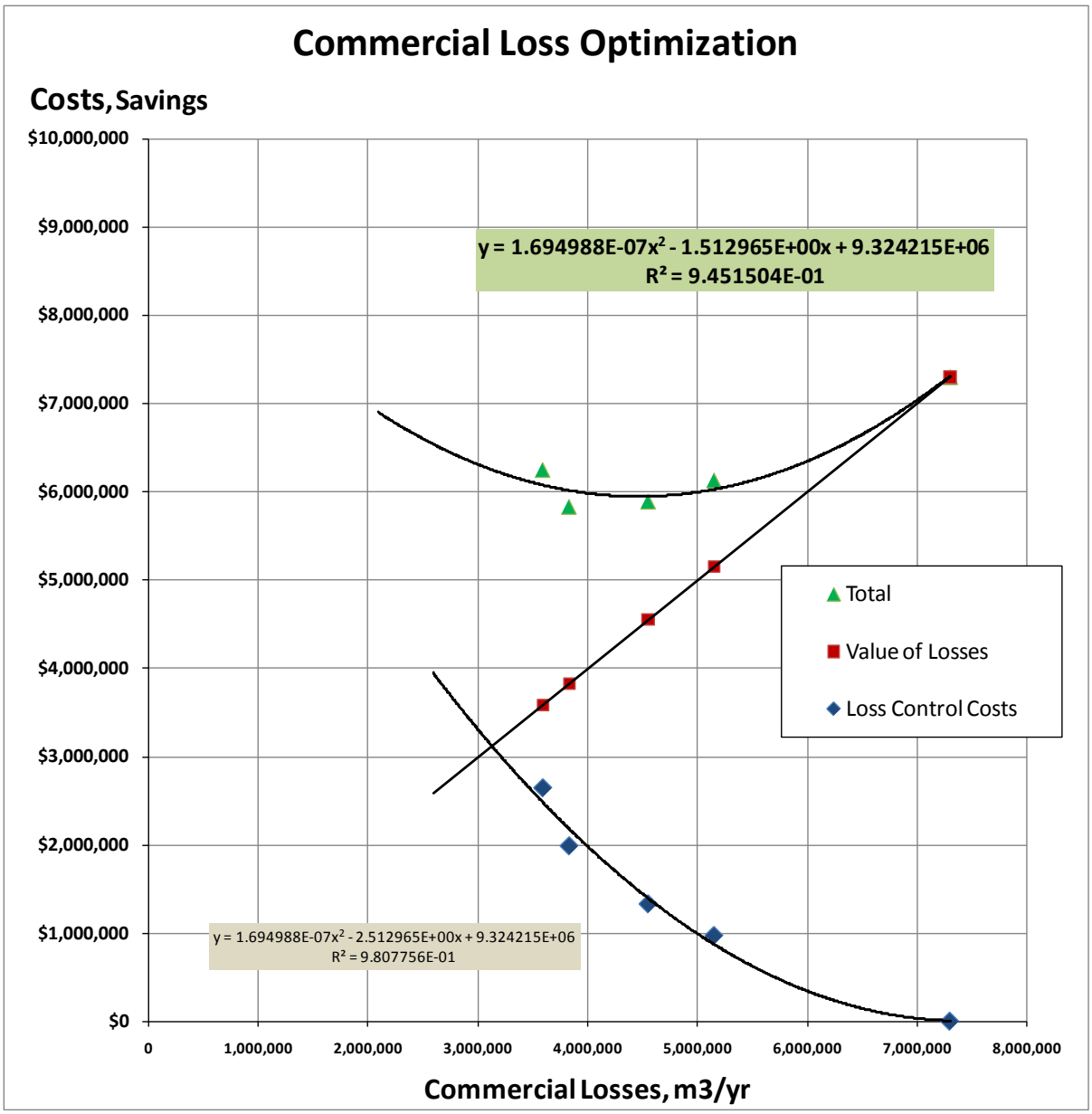


3.4 Plan Commercial Loss Reduction *Program*

- Compile *Actions* into *Program* Options
- Begin with most cost efficient *Action* and add *Actions* incrementally, to increase savings, up to the point where last *Action* is last one with a cost lower than the benefit

Program	Actions Included	Initial NRW, m3/yr	Reduction, m3/yr	NRW w /Program	CL Control Costs
		7,300,000	0	7,300,000	0
A	C1	7,300,000	2,149,098	5,150,902	$974,672
B	C1+C3	7,300,000	2,749,098	4,550,902	$1,334,672
C	C1+C3+C2	7,300,000	3,469,098	3,830,902	$1,994,672
D	C1+C3+C2+C4	7,300,000	3,709,098	3,590,902	$2,654,672





3.5 Plan Physical Loss Reduction *Program*

- Same process as process for Commercial Losses above, except
- Optimality is found using the variable cost of water production, not the revenue, unless customers are not getting enough water. If not, and recovered water can be sold, use the marginal revenue
- Account for rate of rise – whether measured on site or estimated from empirical results in other locations

3.6 Compile Multi-Year *Program*

- Combine Commercial Loss Program and Physical Loss Program into one integrated Program.
- Account for interactions between physical loss reduction programs and commercial loss reduction programs
- Account for increasing demand for water and water production capacity expansion
- Specify amount and timing of all cost inputs
- If necessary, define inputs as a capital program so that future costs are funded.
- Make projections of Program impact

3.7 Implement Program

- Follow schedule in Optimal Program design

- Can be conducted “in-house” or using contractors, or a mix

- Contract terms can be defined from the cost benefit parameters, and monitored in terms of impact

3.8 Monitor and Refine *Program*

Conduct Bi-Annual Updates, accounting for:

- Progress Achieved => New Water Balance
- Changes in Tariff, Variable Production Costs
- Changes in Costs of inputs for Actions
- New, Empirical data on Results of each Action

Outline updated Program Options and Optimality Conditions

Formulate updated NRW Reduction Plan

4. Tool development

The water loss scientific community needs a major Research Program to compile and synthesize better data on cost of, and the specific results from a full array of NRW reduction and control actions and programs. The research program needs to build a worldwide database for program costs and impacts. It is very important that a standard data collection and assessment process be developed to make the results meaningful.

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