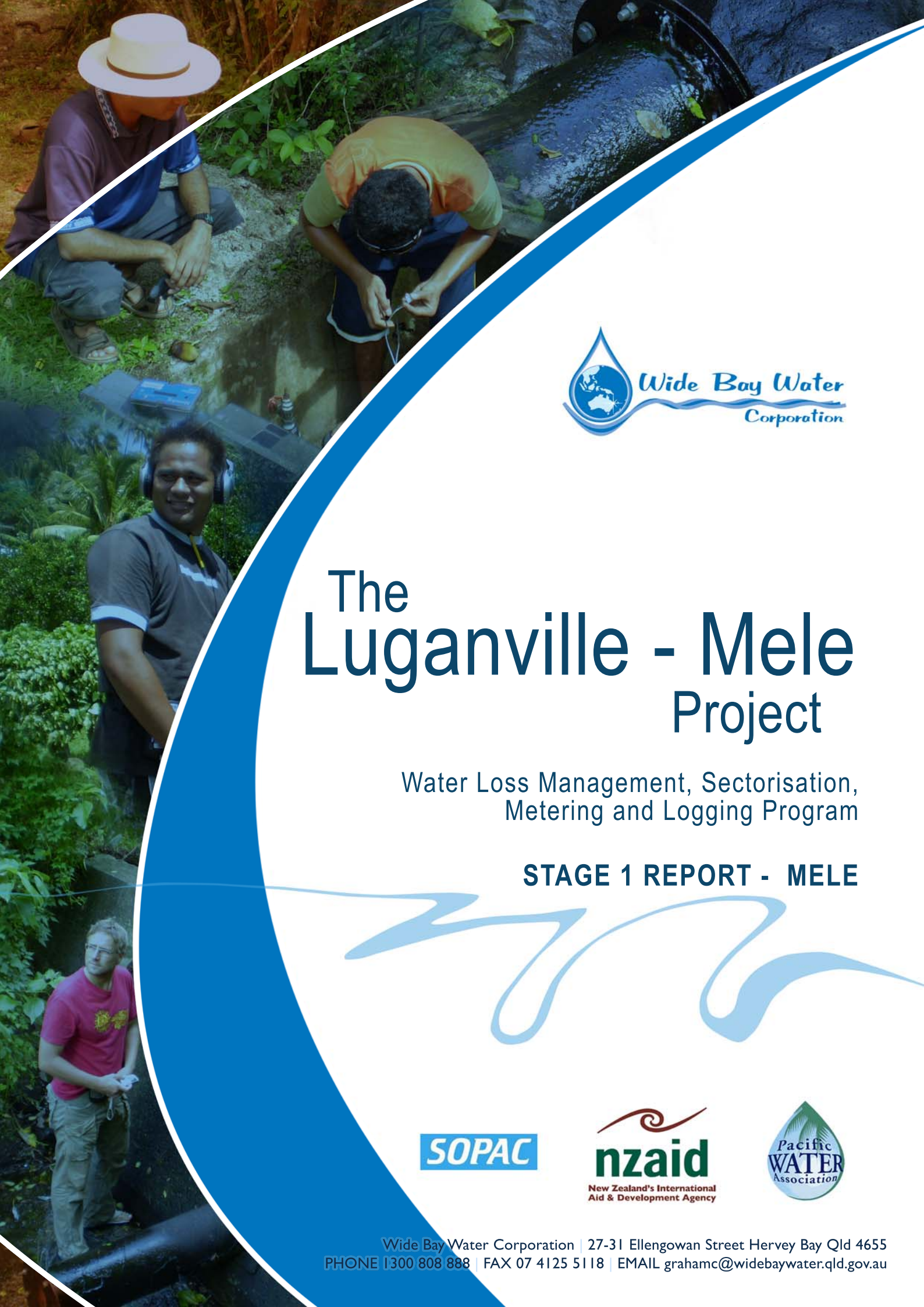

Wide Bay Water Corporation

The Luganville - Mele Project

Water Loss Management, Sectorisation, Metering and Logging Program

STAGE 1 REPORT - MELE

SOPAC

nzaid
New Zealand's International Aid & Development Agency

Pacific WATER Association

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Executive Summary

The Pacific Islands Applied Geoscience Commission (SOPAC) has received funding for a regional Water Demand Management (WDM) programme being executed as a response to the Pacific Regional Action Plan on Sustainable Water Management (2002). The programme aims for sustainable improvement in the management of water supply systems by urban water utilities in Pacific Island Countries. This is to be achieved by building capacity in the region's utilities to produce and implement workable plans for water demand management and by facilitating the exchange of knowledge and experience in this area.

WDM Programme Objectives and Goal
Overarching goal: Sustainable access to safe drinking water for communities in Pacific Island countries.
Objective: Improved capacity for water demand management in Pacific urban water utilities.

Mele
Mele is a pilot rural system under the WDM Programme. With an estimated population of 4000, Mele is situated approximately eight kilometers from Port Vila, the capital of the Republic of Vanuatu. The "Mele" system essentially comprises two separate reticulation networks, Mele and Mele Maat, that feed from the same reservoir.

Mele Village

The key statistics and performance indicators for the Mele Water Supply System are summarised in the three tables below.

Water Supply System- Current Performance

Table 1. *Physical Statistics*

Mele and Mele Maat Network Physical Statistics	
Length of water main (Km) (Estimate)	10-15
Number of connections*	800
Highest system pressure (Meters)	45
Lowest system pressure (Meters)	35

*The number of connections is estimated by dividing the total estimated population for the two villages (4000) by 5 (assuming 5 persons per residence/connection).

Table 2. *Statistics and Performance Indicators Bottom-Up Water Balance*

Mele Bottom Up Water Balance –150mm Line to Mele alone	
Calculated Water Supplied/Day (Kl)	945.73
Minimum Night Flow (Lts/Sec)	9
Minimum Night Consumption (Lts/Sec)*	0.67
Water Losses (Lts/Sec)	8.33
Daily Water Losses (Kl) **	719.71
Calculated Average Daily Consumption (Kl)	226.02
***Calculated* Water Supplied/Annum (ML)**	**345.19**
Average Annual Consumption (ML)	**82.4973**
Unavoidable Annual Real Losses (ML)	**9**
Current Annual Real Losses (ML)	**262.69**
Recoverable Real Losses (ML)	**253.69**

* Based on 3 Lts/ Connection / Hour (the current standard used in Australia).
** This figure is based on the constant water loss figure of 8.33 Lts/sec. This gives a slightly lower estimate compared to subtracting the *calculated* daily Consumption from the *calculated* daily Water Supplied figure (777.6 ML). See page 5 "*Real Loss and Consumption Estimates- Data Validation*"

Table 3. *Whole of Mele System Bottom-Up Water Balance*

Mele- Whole System Bottom Up Water Balance	
Calculated Water Supplied/Day (Kl)	1215.94
Minimum Night Flow (Lts/Sec)	11.57
Minimum Night Consumption (Lts/Sec)*	0.67
Water Losses (Lts/Sec)**	10.90
Daily Water Losses (Kl)	941.88
Calculated Average Daily Consumption (Kl)	290.60
Calculated Water Supplied/Annum (ML)	443.82
Average Annual Consumption (ML)	**106.07**
Unavoidable Annual Real Losses (ML)	**9.00**
Current Annual Real Losses (ML)	**343.79**
Recoverable Real Losses (ML)	**334.79**

*Note that the above figures are calculated on the basis of a revised MNF estimate of 11.57 Lts/sec for both pipelines.

Recommendations According to Priority

1. Install two pressure reduction valves (PRVs) at designated points to reduce system pressure, leakage and mains and service bursts (see map in Appendix One).
2. Install two additional bulk meters at designated points (see map in Appendix One).
3. Install 40mm on service line to Hideaway Resort.

Leakage Target

With a combined minimum night flow of 11.57 Lts/sec and limited resources for leak detection and repair, a realistic target for the Mele system minimum night flow should initially be 4 litres per second. This allows 2 Lts/sec for minimum night consumption and 2 Lts/sec for background and unreported leakage. This target can be reviewed once if it is achieved. Below are tables showing the savings to be gained by reducing pressure.

Summary of Predicted Savings

The following table present predicted estimates of water savings gained through reductions in system pressure.

Table 4. *Savings based on reducing pressure in Mele alone.*

Savings from Pressure Reduction in Mele	
Target pressure	**Savings Ml/year**
30.0	0
25.0	61
20.0	117
15.0	167
20.0	**115**

Savings based on reducing average pressure to 20m.

Table 5. *Savings based on reducing pressure in both Mele and Mele Maat.*

Savings from Pressure Reduction in Mele and Mele Maat Combined	
Target pressure	**Savings Ml/year**
30.0	0
25.0	80
20.0	153
15.0	218
20.0	**150**

Introduction

The Pacific Islands Applied Geoscience Commission (SOPAC) has received funding from the New Zealand Aid & Development Agency (NZAID) for a regional Water Demand Management (WDM) programme executed as a response to the Pacific Regional Action Plan on Sustainable Water Management (2002). Through the Pacific Partnership Initiative on Sustainable Water Management, the programme aims for sustainable improvement in the management of water supply systems by urban water utilities in Pacific Island Countries. This is to be achieved by building capacity in the region's utilities to produce and implement workable plans for water demand management and by facilitating the exchange of knowledge and experience in this area.

Wide Bay Water Corporation (WBWC), acknowledged as an industry leader in water loss management, has provided consultancy services to several countries under the WDM programme in the Pacific, aimed at improving water demand management strategies.

Mele
Mele is a pilot rural village system under the WDM Programme. With an estimated population of 4000, Mele is situated approximately eight kilometers from Port Vila, the capital of the Republic of Vanuatu. The "Mele" system essentially comprises two separate reticulation networks, Mele and Mele Maat that feed from the same reservoir.

There is a 150mm meter on the line that supplies Mele, however there is no meter on the 80mm line which supplies Mele Maat. This means there is no data available to calculate water supplied or minimum night flow for Mele Maat. If, however, an assumption is made that the circumstances for Mele Maat do not differ significantly from Mele then the simplest method to obtain an overall water balance is to add the proportionate flow volume for an 80mm pipe to the calculated data from the 150mm pipe at the same pressure (equal to 150mm flow volume divided by 3.5).

Water Balance
A water balance is a summary of the key statistics of a water supply system and can be constructed either from the "top-down" or the "bottom-up". The top-down model is useful where annual production and consumption figures are provided by reliable meter readings. The water loss is then calculated by subtracting the consumption total from the production total with allowance for calculated background leakage, meter under-registration, water theft, etc.

When this data is not available, or the top down model requires validating, a "bottom-up" water balance can be created by logging the flow of bulk water into the system during the early hours of the morning when there is very little water use. Where there is no meter this can still be achieved by measuring the drop in the reservoir water level during the early morning hours. Once this base flow figure is known, a water balance can be "built up" using assumptions and calculations on consumption and background leakage.

Note that there was not enough reliable data on consumption or bulk water supplied in the Mele system to create a useful top-down water balance so all figures provided are based on the bottom up model.

The methodology used for this bottom-up analysis is based on the International Water Association's best practices and standard terminology as shown below in Figure 1.

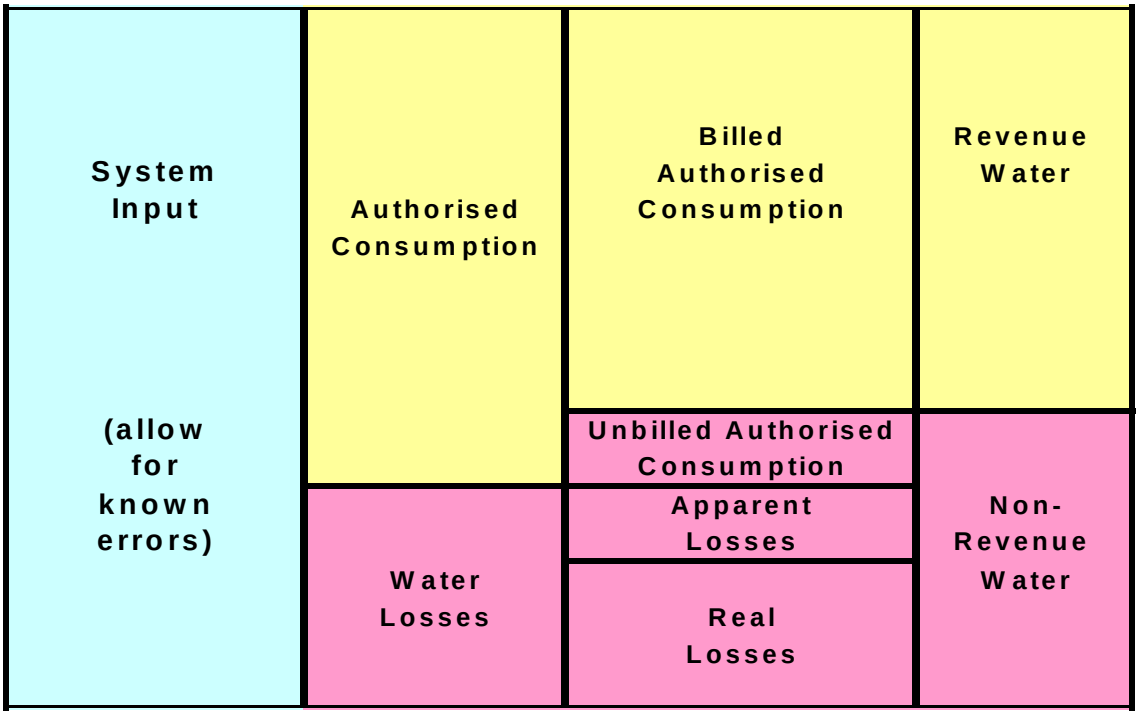


Figure 1. *IWA simplified Best Practice Water Balance*

The International Water Association recommends the following definitions for terms to describe components of water supply, water loss and water consumption.

System Input Volume is the volume of water supplied into a water supply system, usually measured on an annual basis.

Current Annual Real Losses are defined as physical water losses from the water supply system up to the point of the customer meters. The annual volume lost through all types of leaks and bursts depends on burst frequency, flow rates, and average duration of leaks

Unavoidable Annual Real losses – The section of Real Water Losses which consists of small background leakage that cannot be discovered through currently available leakage detection techniques.

Apparent Losses consist of "losses" due to inaccuracies in flow meters and customer meters, water theft, data transfer errors and data management errors.

Authorised Consumption is that proportion of the water supply, metered or unmetered, which is consumed with the knowledge and consent of the water service provider.

The Mele Water Supply System

Main Points

Bulk Supply
The Mele system consists of two villages (Mele and Mele Maat) receiving a gravity fed reticulated water supply from two connected reservoirs (the spare reservoir is fed from the first reservoir and is used for storage only). The reservoirs are situated in the hills approximately a kilometer from Mele Maat, the smaller and higher of the two villages. The meter on the reservoir inlet is fogged and cannot be read. Water is piped from an outlet on one of the two reservoirs, via two separate pipelines: an 80mm line which feeds Mele Maat village and a 150mm line which feeds the main village of Mele. The following analysis is based only upon the 150mm line feeding the main village of Mele as there was no flow data available for the smaller village of Mele Maat.


150mm meter on the line supplying Mele

Bulk Metering
The 150mm line is equipped with an inferential meter which records the flow going to Mele village. There is no bulk flow meter on the 80mm line which feeds the closest village.

Reticulation Network
According to staff at the Vanuatu Department of Geology, Mines and Water Resources the Mele reticulation network was installed during the late 1980s and consists primarily of PVC.

Real Loss and Consumption Estimates- Data Validation

No data is available on consumption as consumers are not metered. The average flow to Mele village (Figure 2) can be assumed to include leakage of approximately 8.33 litres per second. This is calculated from the logged minimum night flow (MNF) of 9 Lts/sec (Figure 3 with data detailed in Appendix 1) and allowing for 0.67 Lts/sec for consumption. The total amount of genuine consumption may be calculated as the total average flow at the reservoir outlet (10.95 Lts/sec) minus estimated leakage (8.33 Lts/sec). This calculation provides the only basis for estimating consumption and gives an average figure of 2.62 litres per second over the period covered in the graph (40 hours). When extrapolated over a year this gives an annual consumption figure for Mele village of 82.49 ML out of a total annual flow of 345.19 ML.

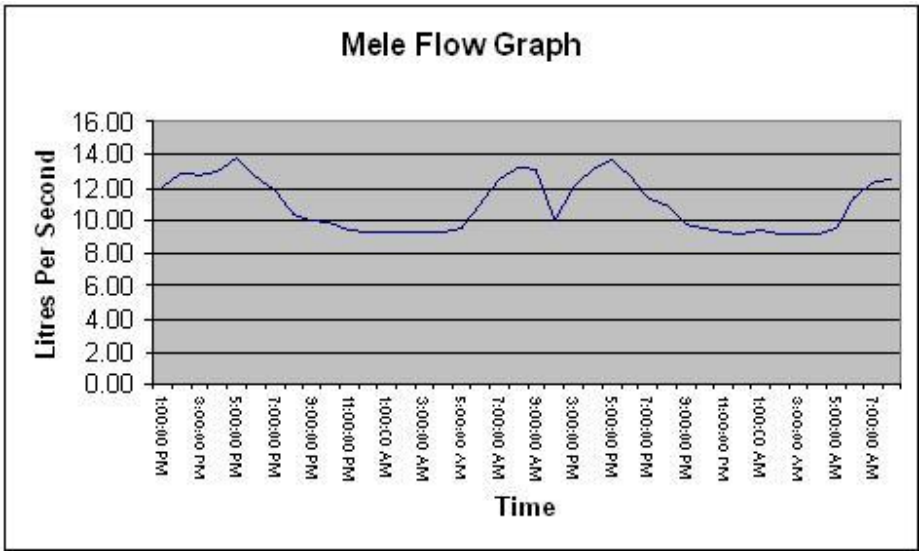


Figure 2. *Flow log taken from the 150mm meter on the Mele Village line. Note: taken over a 40 hour period with a small amount of data missing.*

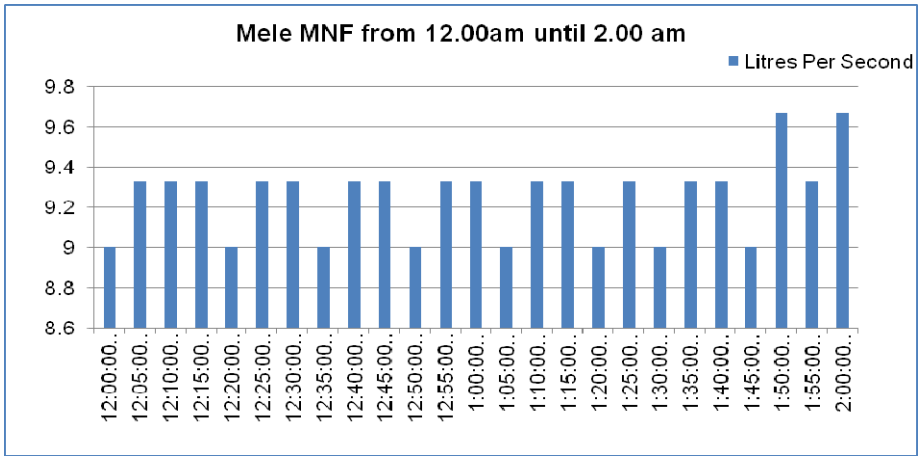


Figure 3. *Graph of MNF logged between 12.00am and 2.00 am*.

Table 6 below shows a bottom up water balance for the village of Mele. Table 7 shows statistics for the entire combined Mele and Mele Maat system based on these figures.

Table 6. *Mele Village Water Balance – Bottom Up approach*

Mele Bottom Up Water Balance –150mm Line to Mele alone	
Calculated Water Supplied/Day (Kl)	945.73
Minimum Night Flow (Lts/Sec)	9
Minimum Night Consumption (Lts/Sec)*	0.67
Water Losses (Lts/Sec)**	8.33
Daily Water Losses (Kl)	719.71
Calculated Average Daily Consumption (Kl)	226.02
***Calculated* Annual Water Supplied (ML)**	**345.19**
Average Annual Consumption (ML)	**82.4973**
Unavoidable Annual Real Losses (ML)	**9**
Current Annual Real Losses (ML)	**262.69**
Recoverable Real Losses (ML)	**253.69**

Table 7. *Whole of Mele System Bottom-Up Water Balance*

Mele- Mele Maat Combined System Bottom Up Water Balance	
Calculated Water Supplied/Day (Kl)	1215.94
Minimum Night Flow (Lts/Sec)	11.57
Minimum Night Consumption (Lts/Sec)*	0.67
Water Losses (Lts/Sec)**	10.90
Daily Water Losses (Kl)	941.88
Calculated Average Daily Consumption (Kl)	290.60
Calculated Water Supplied/Annum (ML)	443.82
Average Annual Consumption (ML)	**106.07**
Unavoidable Annual Real Losses (ML)	**9.00**
Current Annual Real Losses (ML)	**343.79**
Recoverable Real Losses (ML)	**334.79**

*Note that the above figures are calculated on the basis of a revised MNF estimate of 11.57 Lts/sec for both pipelines.

Resourcing, Funding and Constraints

The entire Mele water supply system is operated and maintained by a "Community Water Committee" whose members are elected by the community after self-nomination. There are no charges for water usage or connection. Operation and maintenance of the entire water supply system is carried out by volunteer members of the council who receive limited training in "bush" plumbing from the Republic of Vanuatu Department of Geology, Mines and Water Resources. The short duration of tenure and limited training restrict the effectiveness of maintenance operations.

Logging the 150mm meter on the line supplying Mele Village.

System Loss Management Plan

There is an immediate need is to decrease water losses by reducing pressure throughout the system. This may be achieved by the installation of pressure reducing valves (PRVs) on both transmission pipes feeding from the supply reservoir. The estimated water savings to be gained by pressure reduction are outlined below in Table 8 and 9. These savings are based on the leakage estimate calculated in Mele village and on the leakage estimate calculated for both Mele and Mele Maat.

These calculations are based on standard current IWA methodologies for predicting water savings by reducing system pressure.

Table 8. *Savings based on reducing pressure in Mele alone.*

Savings from Pressure Reduction in Mele	
Target pressure	**Savings Ml/year**
30.0	0
25.0	61
20.0	117
15.0	167
20.0	**115**

Table 9. *Savings based on reducing pressure in both Mele and Mele Maat.*

Savings from Pressure Reduction in Mele and Mele Maat Combined	
Target pressure	**Savings Ml/year**
30.0	0
25.0	80
20.0	153
15.0	218
20.0	**150**

Based on a reduction in average system pressure to 20 meters, an estimated saving of between 115 ML/year and 150 ML/year can be achieved.

System Loss Management Plan Recommended Actions

Priority One
Pressure Reduction
Significant water savings can be achieved by reducing system pressure with the installation of two pressure reducing valves at the locations outlined on the maps in Appendix Two.

Priority Two
Bulk Metering
To achieve adequate bulk metering the Mele system requires a new meter on the 80mm line that supplies Mele Maat.

Without adequate bulk metering, the meter readings essential to monitoring the entire system minimum night flows (MNFs) will not be available. The reservoir drop test should only be used as a substitute for bulk meters when there is *no* alternative.

Mele is already a separate District Metered Area (DMA). The installation of a meter on the 80mm line to Mele Maat will complete the sectorisation process. This will provide minimum night flow data for both villages with the following benefits:

- A planning tool to assist with identifying areas of highest leakage thus allowing leak detection resources to be deployed most effectively.
- The facility to monitor DMAs to estimate the savings produced by leak detection activities and associated repair programs.
- The facility to monitor future leakage levels (left alone leakage will always increase - the "Natural Rate of Rise").

Priority Three

Meter for Hideaway Resort

Install a 40mm meter on the service connection to Hideaway Island Resort. This recommendation is based on the twin premises of monitoring the amount of water the resort uses, as well as giving the Community Water Committee the option of charging for water by volume.

This could create a revenue stream for the Community Water Committee which can be invested back into the system for maintenance, upgrades and repairing of leaks.

Water service connection to Hideaway Resort

Leakage Target Beyond Pressure Management

With a combined minimum night flow of 11.57 Lts/sec and limited resources for leak detection and repair, a realistic target for the Mele system minimum night flow should initially be 4 Lts/sec. This allows 2 Lts/sec for minimum night consumption and 2 Lts/sec for background and unreported leakage. Given the current and probable future constraints on resources and expertise devoted to leakage control, this is a reasonable target. This target can be reviewed if achieved.

Equipment Required

Table 10 provides a list of equipment and costs according to recommended installation priority. This data is presented in such a way as to reflect the cost of each priority category, providing flexibility in the event funding is insufficient for the full program down to priority three.

Table 10. *Equipment List and Costs in $AUD*

Equipment List for Mele Water Supply system					
Item	**Number**	**Unit Cost**	**Total**	**Total Accumulated Cost**	
Pressure Reduction Valves (80mm and 100mm)	2	$2500	$5,000	Priority One	$5000
80mm Flow Meters	1	$700	$700	Priority Two	$5700
40mm Flow Meters	1	$150	$150	Priority Two	$5850

The optional extras outlined in Table 11 below are included because they provide the most convenient way to collect comprehensive pressure and flow data. They are, however, complex and costly technology that require trained operators to operate both the equipment and software. In the event of equipment failure it is not likely that the equipment would be quickly or easily replaced.

As the Mele system is maintained by a Community Water Committee with transient membership it would be better if personnel from the Department of Geology, Mines and Water Resources (DGMWR) assume responsibility for monitoring the overall water supply into the Mele system. In this case there would be some benefit in purchasing and installing flow and pressure loggers as this would provide the DGMWR with a quick and convenient way to collect data. Capacity and expertise currently exists within the DGMWR to fulfill this role.

If the DGMWR does not assume responsibility for monitoring the Mele water supply system, there is no expertise in the Community Water Committee to monitor and maintain pressure and flow loggers and the necessary software.

Table 11. *Optional Extras: Logging Equipment and Costs in $AUD*

	Number	**Unit Cost**	**Total**
Flow Loggers	2	$1,200	$2,400
Pressure Loggers	1	$1,500	$1,500
Total Logger Costs			$3,900

The Maintenance Issue

The Mele system mains reticulation system theoretically *should* be in reasonably good condition: system pressures are not excessive and the water mains are not yet half way through their expected lifetime. The excessive water losses in the Mele system is a classic example of the consequences of inadequate maintenance and the “Natural Rate of Rise” (if leakage is not repaired it will continue to get worse), particularly on service connections and household taps.

Given the limited knowledge and resources available to the local Community Water Committee who are responsible for maintenance and management of the system, it would be more effective if the Department of Geology, Mines and Water Resources were to take responsibility for monitoring the overall performance of the Mele system by recording monthly minimum nights flows once the necessary meters are installed. They would thus be in a position to advise the Community Water Committee on required actions (limited leak detections surveys and repairs) to reduce leakage levels. The Department would also need to take responsibility for maintaining any pressure reducing valves that may be installed.

A simple solution for the day-to-day maintenance of the Mele system may be for the Community Water Committee to engage a local plumber from Port Vila area to visit the two villages on a weekly basis to carry out necessary repairs. Revenue to fund this initiative could come from the charging of Hideaway Resort for water by volume, given that installation of the bulk meter on this connection goes ahead.

This initiative should be combined with an education program for the local population encouraging them to report leaks to members of the Community Water Committee. The Committee would thus be in a position to present a list of leaks for repair to the visiting plumber each week. The contracted plumber could also be engaged to conduct periodic leak detection sweeps in the two villages using simple sounding methods.

The lack of active maintenance and repair will continue to result in massive water losses in the Mele system, despite the savings which could be gained by installing pressure reducing valves. An estimated 115 Ml/year in Mele village alone can be saved by reducing system pressure to an average of 20 meters; however the system will continue to lose an estimated 148 Ml/year from leakage; this is almost 1.8 times the annual estimated consumption.

Although ongoing maintenance is outside the scope of this initial assessment it is recommended that SOPAC work with the Vanuatu Department of Geology, Mines and Water Resources to find a solution to this issue.

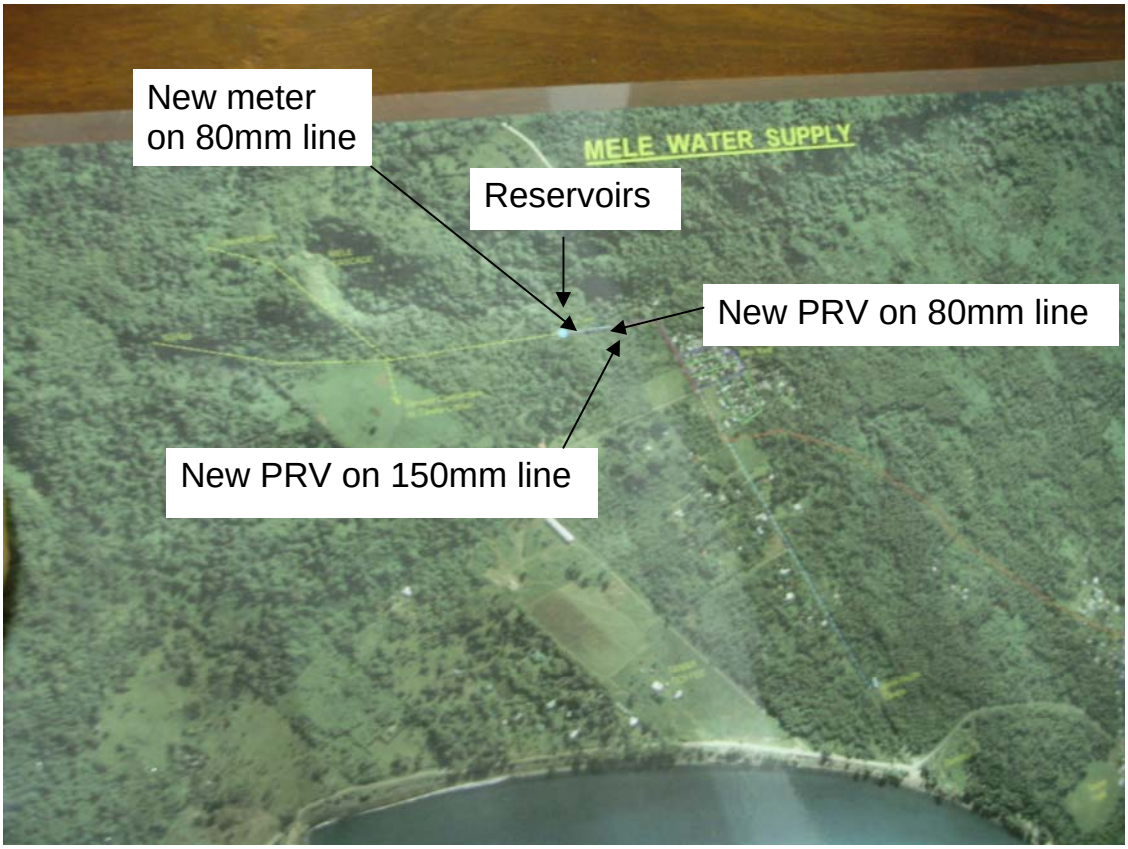
Appendix One

Mele minimum night flow as logged on the 150 mm meter.

Time	Litres Per Second
12:00:00 AM	9
12:05:00 AM	9.33
12:10:00 AM	9.33
12:15:00 AM	9.33
12:20:00 AM	9
12:25:00 AM	9.33
12:30:00 AM	9.33
12:35:00 AM	9
12:40:00 AM	9.33
12:45:00 AM	9.33
12:50:00 AM	9
12:55:00 AM	9.33
1:00:00 AM	9.33
1:05:00 AM	9
1:10:00 AM	9.33
1:15:00 AM	9.33
1:20:00 AM	9
1:25:00 AM	9.33
1:30:00 AM	9
1:35:00 AM	9.33
1:40:00 AM	9.33
1:45:00 AM	9
1:50:00 AM	9.67
1:55:00 AM	9.33
2:00:00 AM	9.67

Appendix Two

The following photos show the proposed locations of new meter and pressure reducing valve installations for the Mele system.




Hideaway Island Resort
New 40mm meter