COMMUNITY ENGINEERING: WATER SUPPLY DEVELOPMENT IN RURAL SAMOA

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ABSTRACT

Between 2010 and 2012, Blue Barn Consulting Ltd undertook two major rural water supply projects in Samoa.

The Samoa Water Authority (SWA) project involved the assessment of long term water source and network options in South-east Upolu, as a result of damage from the September 2009 tsunami, where many of the population had moved uphill from the coastal network. The project included a master strategy for 15 relocated villages, comparison of lake, stream and groundwater sources, ecological investigations, consultation and detailed design of 38 km of pipeline and 7 storage reservoirs.

The Independent Water Schemes Association (IWSA) project involved the review of 5 previous upgrades and designs for 14 member villages across both islands. Many existing gravity schemes were inadequate, in poor condition with poor source quality.

Both projects provided environmental and technical challenges: network complexity, geology, terrain, climate and varying water quality from multiple sources. Also significant were unique relational challenges: disaster recovery, political, cultural, language, community governance, land ownership and institutional capacity in both the state owned and community setting.

It was our experience that project benefits were maximised by acknowledgement and active engagement with local culture, protocols and knowledge, and through comprehensive investigation of all possible options. Solutions were often developed through a relational methodology rather than a purely technical approach.

KEYWORDS

Water Supply, Community Scheme, Development, Catchment Protection, Water Quality, Disaster Recovery, Governance.

1 INTRODUCTION

The island nation of Samoa has been described as an "Oceanic Eden" – lush, wild and fertile with an abundance of sunshine and rainfall, palm trees towering above unspoiled white sand beaches, scented flowers, friendly people, great food – set to a backdrop of rugged mountains, waterfalls, crater lakes and lava flows.

The two main islands Upolu and Savaii comprise 2,820 km^2 with an extensive electricity network covering most areas – approximately 38% from hydro schemes, 62% from diesel generators.

Recent investment and improved management of the road network within Apia and many rural routes is evident, as is the result of the 2002 Telecommunications and Postal Sector Reform Project - more than 90% of Samoa's population now have access to a mobile phone.

With a population of approximately 187,820 and a corresponding sized economy (GDP around NZ$845 million), it is reliant on both foreign imports and the highest percentage of remittances in the world (approximately 20% of GDP).

Over recent decades Samoa has boasted economic growth, including significant increases in tourism, but at a community level it is also well regarded in the pacific region for its strong leadership of development priorities.

The Samoa Development Strategy: 2008-20012 (SDS 2008), boasted a number of achievements toward the Millennium Development Goals (MDGs); those without access to safe and reliable supply of potable water reduced from 63% in 2003 to 21% in 2007; the proportion without access to improved sanitation reduced from 42% in 2003 to 33% in 2007; infant mortality rate reduced from 37 per 1,000 in 1981 to 17 per 1,000 in 2001.

Although figures vary, most sources suggest that 90-95% of the population now receive piped water from either the state owned Samoa Water Authority (SWA) or from community managed alternatives.

Between 2010 and 2012, Blue Barn Consulting Ltd (Blue Barn) undertook two major rural water supply projects both the main islands of Savaii and Upolu, serving both SWA, who is claimed to supply 88% of the population, and the Independent Water Schemes Association (IWSA), collectively claimed to supply the remaining 12% in distinct community managed schemes.

Photograph 1: ***Idyllic coastal village, North East Upolu.***

2 CHALLENGES

Few would argue against access to safe water being a human right (one which we possibly take for granted in New Zealand, however) nor disagree with the United Nations stance that "The human right to water [sufficient, safe, acceptable and physically accessible and affordable water for personal and domestic uses] is indispensable for leading a life in human dignity…a prerequisite for the realization of other human rights".

However, like many Pacific countries, while Samoa has made significant progress toward achieving the MDGs (specifically Target 7C), government monitoring of water supplies indicates that there are still problems with the safety of much of the water delivered. The SDS 2008 claims that less than one-third of the population served by SWA currently receives treated water, and 15% of samples from these treated supplies fail quality tests. This clearly has the potential for public health related risks.

Photograph 2: ***Girls collecting household water from service pipe leakage.***

2.1 TECHNICAL

Both projects provided technical challenges of the type and scale that engineers typically thrive on; existing network complexity and uncertainty, unique geology, mountainous volcanic terrain, harsh tropical climate, poor source water quality, geographic isolation and a wide range of sources including bores, springs, lakes and river sources.

Water supply infrastructure across Samoa is extensive. Most schemes were built in the beginning of the 1900s during colonial times or by the Public Works Department following Samoa's independence in 1962, but many have not been maintained since.

The Blue Barn team was involved in more than 31 distinct communities; each served by one or more schemes and faced many of the following challenges:

- Inadequate network capacity for the current population, resulting in poor performance and water shortage
- Sources that were inadequate during the dry season
- Networks that don't reach the entire community
- Limited or no as-builts of existing networks, leading to uncertainty of extent and connectivity

- No existing metering of (take or distribution), leading to willful wastage, little or no revenue. Revenue gaps are significant in some urban networks due to low tariff levels where average non-revenue water (NRW) can be as high as 80%.
- Poor quality network construction and/or maintenance, resulting in unsustainability high levels of leakage
- Little or no storage to meet peak hour demands
- Inadequate pressure breaks in the network profile, leading to excessive pressure (up to 270m static head). This included bypassed / decommissioned break pressure tanks and Pressure Reducing Valves
- Limited local understanding of technical management principles
- Limited understanding of hygiene, resulting in poor source catchment protection
- Numerous natural springs used as an alternative source of water during the dry season are increasingly neglected
- Competing uses of water and priority uses - public water supply and public energy supply are, in places, provided by the same river systems.

Photograph 3: ***The authors assisting to connect an additional spring source.***

2.2 CLIMATE

Samoa is an increasingly popular tourist destination due to its tropical climate and abundant natural beauty but by nature, this provides additional challenges to developing and maintaining public infrastructure. Since 1950, natural disasters in the Pacific region have directly affected more than 3.4M people and have led to more than 1,700 reported deaths (outside of Papua New Guinea).

Disasters of this magnitude are suggested by some, to be increasing in frequency. The World Bank report on Natural Hazards in the Pacific Islands Region (2006) stated that 10 of the 15 most extreme events reported in the previous half century, had occurred in the last 15 years.

In Samoa alone, the estimated economic and social impact of 12 recorded disasters during the period 1950-2004, resulted in total reported losses of USD$743.4M. The fiscal cost of the 2009 tsunami rehabilitation was estimated at between 15 and 18 per cent of GDP.

Most rivers experience dry periods and very few rivers run all year round despite high rainfall, and are prone to flash flooding during the wet season. This creates a human toll, causes infilling of intake reservoirs with sediment and places extreme pressure on infrastructure.

Approximately 65% of all water supply infrastructure in Samoa is reliant on surface water sources that are highly affected by annual rainfall and vulnerable to water shortages - as evidenced in the 2011 regional drought.

Many international donors are working in the pacific, and with natural disasters in the region becoming more intense and more frequent, it appears that many donors have a renewed focus on water: harvesting, storage and security. The New Zealand Government have likewise, prioritised improving resilience and recovery from emergencies as part of the New Zealand Aid Programme.

Photograph 4: ***Damage from the 2009 Tsunami – South East Upolu.***

2.3 RELATIONAL

Samoa features at number 6 in Lonely Planet's 10 friendliest countries, and this was certainly Blue Barn's experience, but, like any other country, Samoa presented its own unique relational challenges.

Village governance has strong traditional ties of kinship, history, land, involving a number of key stakeholders:

- matai - holders of family chief title within the chiefly system, Fa'amatai
- ministers from local churches
- member of parliament within each political district
- water committee (community schemes)

Within many community managed schemes, the role of village plumber – almost exclusively men - is assumed rather than appointed, and skills are passed down by parent or grandparent.

Land ownership in Samoa is approximately 81% customary (held by village matai and families), 15% government owned and 4% freehold. Land and road boundaries are often historically defined and based on local landmarks (including trees).

Water sources, pipelines and storage tanks are often located within customary land and can create access issues in both community and government managed schemes.

The concept of fa'asamoa - Samoan identity and values – involves an overwhelming generosity toward family, village matai, church and each family will prioritise resources in this manner. As a result of such historically embedded relational values, water tariffs have been difficult to both implement and manage in many government and community schemes.

2.4 COMPLIANCE AND LAND USE

The overall Water Sector policy goal is "ensuring community access to water of a suitable quality and appropriate quantities to meet all reasonable health, environmental and economic development needs." Like many Pacific countries, the availability of both surface water and groundwater resources in Samoa are controlled by geology and climate, however water quality is increasingly compromised by unsustainable waste disposal and land use practices; deforestation, sediment and nutrient run-off from agriculture and farming, nutrients from unmanaged septic tanks and pesticides.

Included here is a sample result, representative of many of the rural schemes Blue Barn were involved with: "Microbiology results … remains poor and will continue to be so as it is a surface water source or river which remains open and prone to contamination…the only barrier currently in place is a metal screen to filter large objects such as leaves and twigs. Upstream of the intake are plantations and a cattle farm." While chemical parameters tested comply with recently introduced national drinking water standards, total coliforms at this site were above the upper threshold while E. coli was as high as 960 cfu/100 mL.

Water quality monitoring is undertaken with increasing frequency by the Samoan Government, resulting in increasingly useful baseline data, however, sedimentation remains the only available treatment for many rural schemes to date (if at all).

Photograph 5: ***Typical existing river intake - makeshift coarse screen in foreground.***

3 SOUTH EAST UPOLU PROJECT - SAMOA WATER AUTHORITY

On the 29th of September 2009, a magnitude 8.1 earthquake in the Samoan Islands region generated a tsunami that caused substantial damage and loss of life in Samoa, American Samoa, and Tonga and large waves with no major damage were reported on the coasts of Fiji, New Zealand and Rarotonga.

Regions along the southern Samoan coast experienced waves up to 14 metres high and caused substantial damage to the coastal network in areas of South East Upolu and Aleipata Coast (approximately 15 villages), but two existing bores (at 33m and 38m amsl), and some inland sections of pipeline continued to operate.

The population of the region in 2006 was approximately 6000 and predominantly coastal (below 60m amsl) and with low growth, was estimated to be up to 8000 by 2030, distributed over a 75 km² region (refer to Figure 1 below).

Immediately following the tsunami, up to 65% of the population of many villages in this region chose to relocate some distance inland and up to 300m above sea level, building new houses, schools, churches - communities - away from the existing water supply network.

Within a few months, RedR Australia Engineers completed a network design and humanitarian agencies shipped new polyethylene pipelines, storage tanks, generators and submersible pumps from New Zealand to form a new supply from Lake Lanoto (Lago) at 410m amsl (refer to Figure 1 below). However, due to the emergency nature of this network, large portions of the target population were restricted to intermittent water supply.

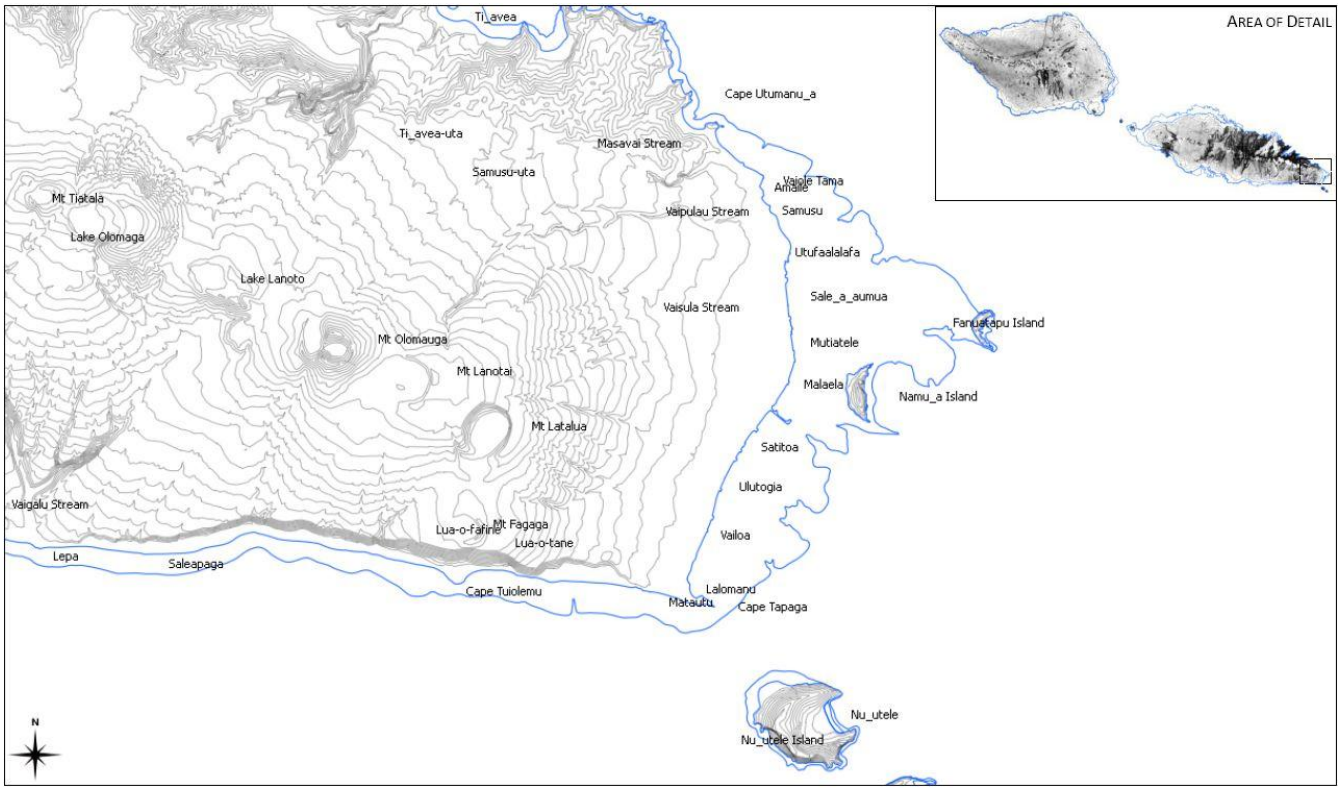

Figure 1: ***South East Upolu - Tsunami affected region.***

3.1 PROJECT SCOPE

Between 2010 and 2012, Blue Barn was contracted by the SWA to:

- review multiple environmental and design reports by international consultants
- investigate and review the emergency network
- undertake extensive site visits and consult with affected villages
- assess water needs of populations within the general areas of South-eastern Upolu and the Aleipata Coast;
- assess multiple existing springs, bores, a crater lake and alternate water sources;
- assess the capacity of existing systems;
- undertake future water demand modelling
- complete formal environmental and ecological studies
- hydraulic modelling of the network
- water supply options analysis including whole of life costing
- hydrogeological assessments of existing and proposed bore sites
- outline a long-term strategy of network development - improvements to sustainably and reliably meet the long-term water requirements of the community

Photograph 6: ***Depth measurement at Lake Lago.***

3.2 FINDINGS

Our investigations concluded that a long-term network development strategy could be implemented, based on the following.

1. Despite a modest catchment, Lake Lago appeared to have adequate capacity under the current and proposed pumping regimes but further and on-going monitoring of the ecology and water quality was necessary to manage its long-term sustainability.

2. Draw-down testing of the existing bores determined a sustainable yield, suitable for the future demand of the local network.

3. The existing spring sources at Tiavea Uta and Tiavea Tai, despite being remote, provided adequate dry season flow for the northern areas of the network and it was recommended that pumps and storage be upgraded.

4. In Lepa, the existing spring sources supplying the new filter plant ran dry during the annual dry season and it was recommended that an existing partially drilled bore be completed to provide a supplementary water source or a suitable new bore location be investigated.

5. Installation of gravity chlorinators for surface water supplies was recommended in the medium-term.

6. A series of further recommendations were made on operations and maintenance improvements that would improve the long-term reliability of the system.

3.3 DESIGN

These findings led to civil, structural and network design, tender documentation and environmental assessments for the following new works:

- rehabilitation of an existing, previously decommissioned 180 m^3 concrete storage reservoir
- civil design including access roads and siting for pre-fabricated steel storage tanks
- trenching and installation of approximately 38 km of polyethylene and PVC pipeline, air valves, washouts, pressure reducing valves, anchors and associated fittings
- construction of access tracks along proposed pipeline installation routes
- integration of new pipelines with existing networks and storage tanks, testing and commissioning of sections of emergency network not completed
- replacement of approximately 300 household connections along new pipelines
- installation of 7 prefabricated storage and break pressure tanks
- replacement of existing pumps at Tiavea Uta and Tiavea Tai spring sources
- preliminary and detailed design, costing, specifications and scheduling

The upgrade works underpinned a strategy to supply reliable, high quality water to all customers covering a network involving approximately 68 km of pipelines, five pump stations, one water treatment plant and 14 storage reservoir sites distributed over a 75 km^2 region.

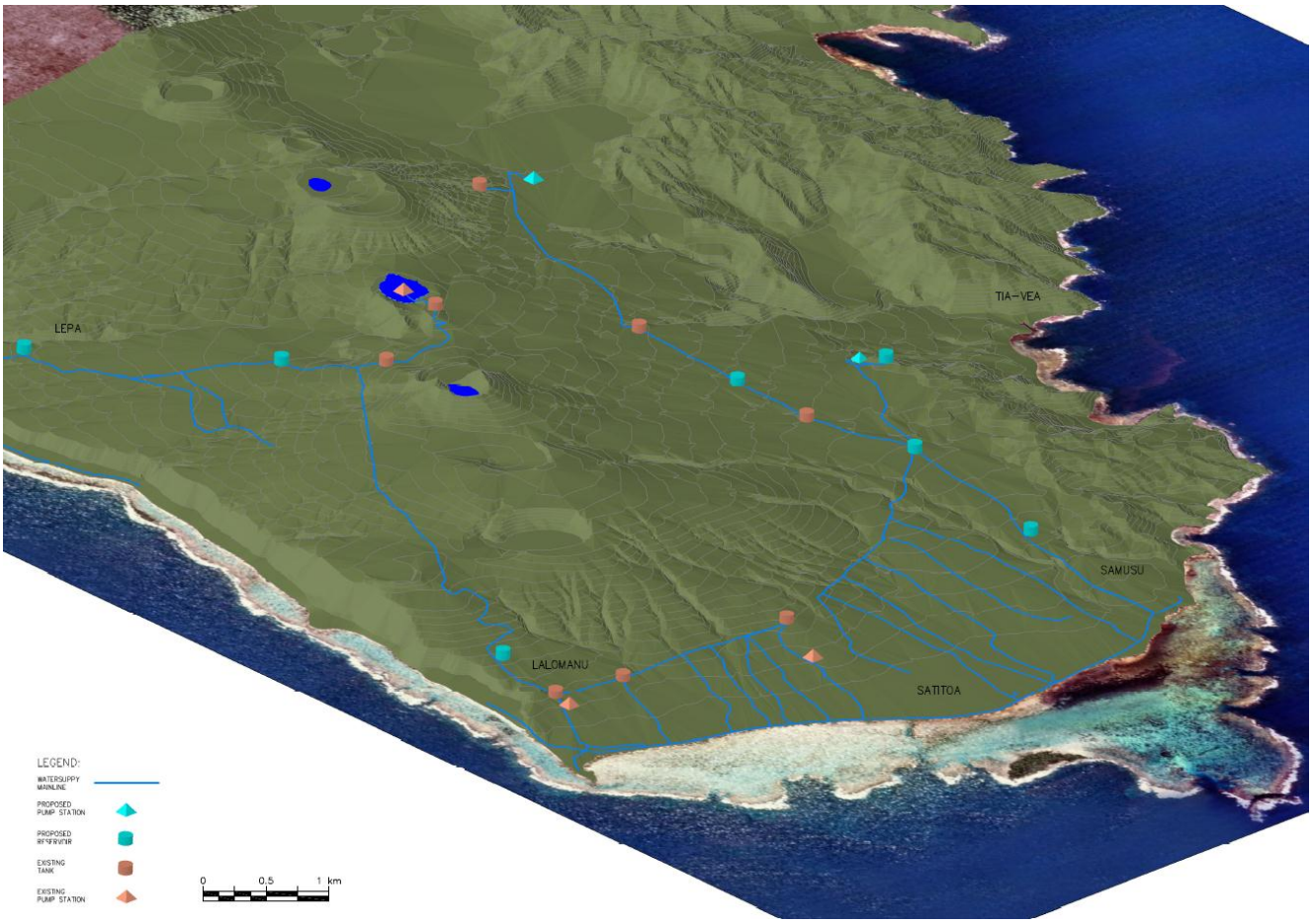

Figure 2: ***South East Upolu – proposed network.***

4 INDEPENDENT COMMUNITY SCHEME UPGRADES

The independent water schemes association (IWSA) as formed by 35 member communities to ensure *"community access to water of a suitable quality and appropriate quantities to meet all reasonable health, environmental and economic development needs"* and are managed by the local community through water committees.

IWS schemes vary in size, from a small village of 100 people, to district-wide schemes providing water to multiple villages with several thousand people (10 - 300 household connections).

All schemes are gravity-fed, utilising water from streams and springs on the hillside with networks to households running down to coastal settlements. Historically, users have not generally been required to pay tariffs and basic repairs were only undertaken when absolutely necessary.

Despite low tariffs, Blue Barn observed that embedded community values can facilitate the rapid raising of funds when absolutely necessary and, combined with local ingenuity, communities have been able to keep schemes operating, even if at extremely low service levels.

Between 2011 and 2012, Blue Barn was contracted by the IWSA to:

- review design, implementation and subsequent impacts on water quality and quantity following the construction of 5 IWS community upgrade projects
- complete conceptual and detailed design for 14 further scheme upgrades, serving a population of approximately 11,000

- provide governance training for water committees and maintenance training for plumbers

Prior to inspection of scheme components, consultation was undertaken with members of each respective IWS committee, acknowledging cultural and village protocols. This assisted in gaining a true appreciation of the community requirements and participation in water supply scheme management and upgrades.

Photograph 7: ***Inspection of a community river intake.***

4.1 REVIEW CONSTRUCTION OF 5 SCHEME UPGRADES

Particular areas of focus included: construction approaches, local community involvement and scheme management, materials, and the design of intakes and other components in relation to 5 schemes across both Upolu and Savaii; Matautu, Saoluafata, Patamea, Aufaga and Satupaitea (refer Figure 3 below).

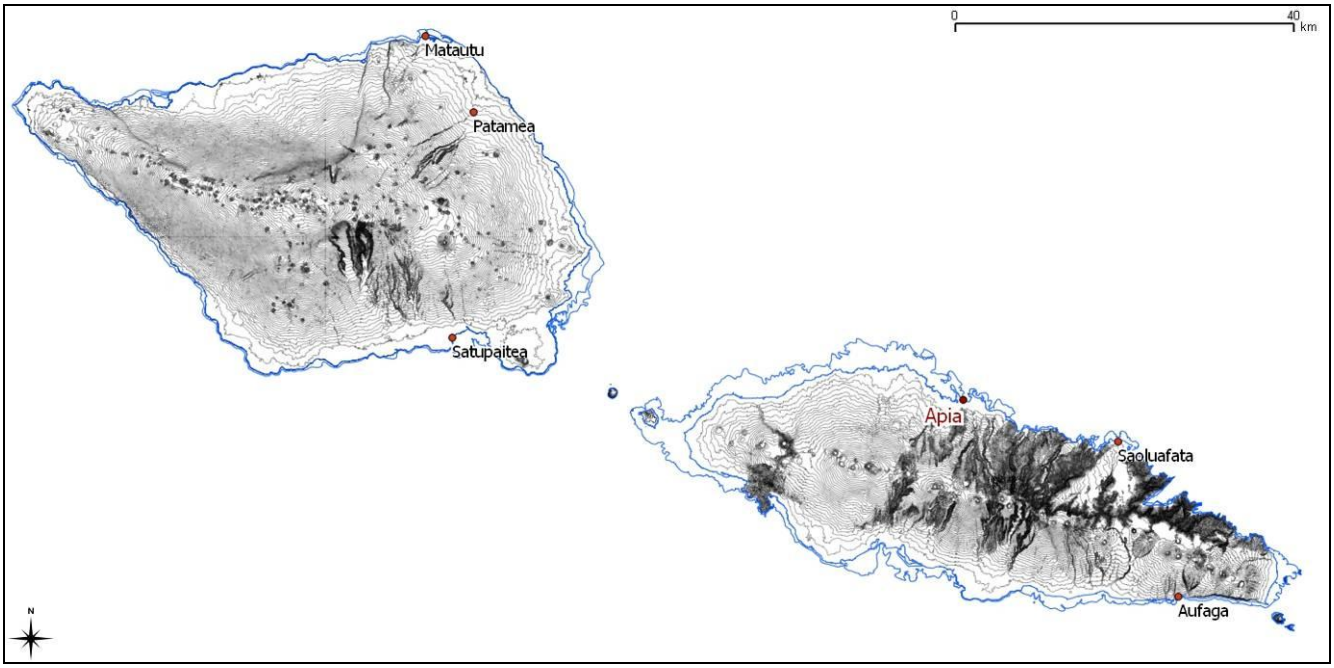

Figure 3: ***Review of (5) previous scheme upgrades.***

Overall, our investigations identified improvements to all schemes as a result of the upgrades, and a number of recommendations were presented as opportunities to further enhance the performance of future networks.

Recommended improvements included:

- Incorporating sedimentation tanks for river intakes
- Developing low maintenance intake screens
- Adding washouts at river intakes and pipeline low points
- Revising spring intakes to improve source capture and protect water quality
- Undertake leak detection and repairs to reduce system losses
- Complete thorough source flow assessment during the dry season
- Replace ‘Samoa style’ air valves with reliable models
- Ensure sufficient intake pipeline grade, surveying during pipeline laying
- Adding pipe restraints in flood prone areas
- Increase storage to balance daily peaks and revise existing tank configuration
- Revise valve chambers to aid future maintenance
- Revise Break Pressure Tank design to eliminate spilling
- Ensure effective commissioning and practical completion
- Establishing clearer community responsibility

Photograph 8: ***Existing storage tanks in poor condition.***

4.2 DESIGN 14 SCHEME UPGRADES

This work involved site visits and community meetings in 14 distinct communities (refer to Figure 4 below), to present and discuss conceptual designs and conduct specialist training workshops to up-skill water committees and local plumbers.

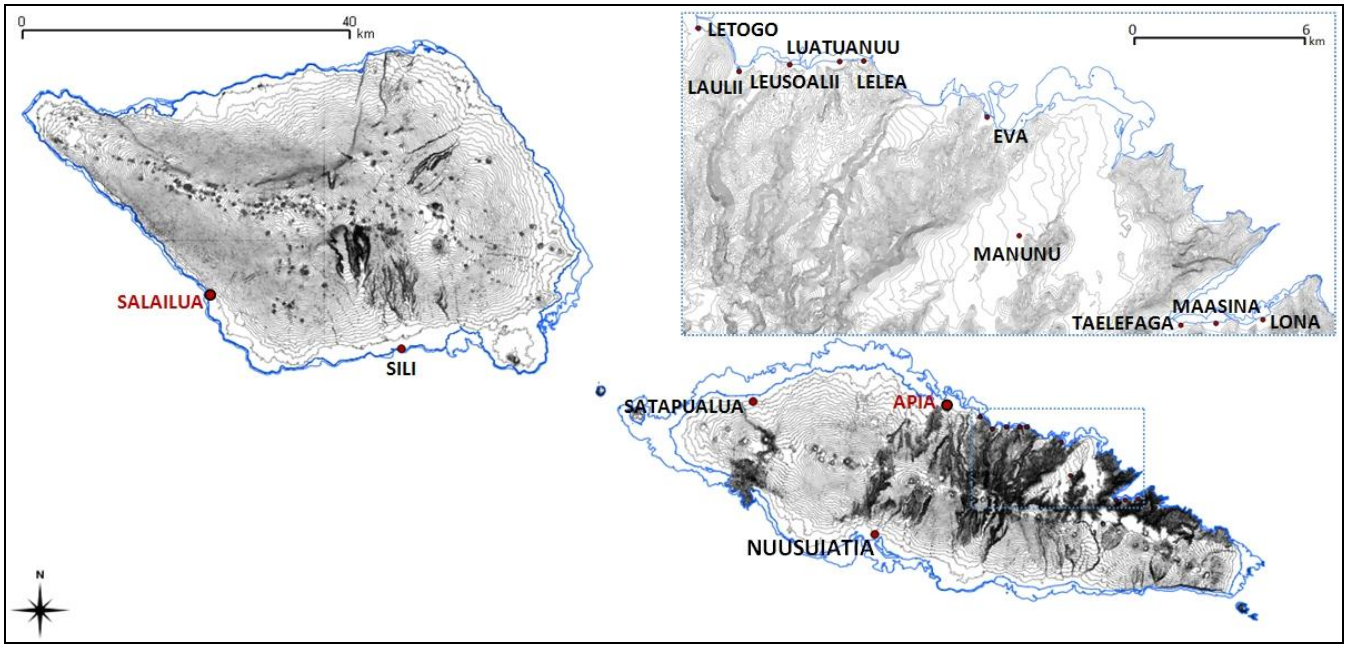

Figure 4: ***Locations of 14 IWS scheme designs.***

Specific tasks included:

- the review and assimilation of multiple previous reports by international consultants
- extensive site visits and community consultation
- assessment of existing networks and structures
- future water demand, catchment and water quality analysis
- hydraulic network modelling
- specialist training workshops to up-skill water committees and local plumbers

These investigations led to civil, structural and network design, tender documentation, environmental assessments and advice on the process for physical works tenders for the following new works:

- rehabilitation of existing concrete storage reservoirs and break pressure tanks
- trenching and installation of approximately 40 km of polyethylene and PVC pipeline, air valves, washouts, pressure reducing valves, anchors and associated fittings
- design of 17 river and spring intakes with consideration to suitable future treatment plant locations
- construction of access tracks to upgraded intakes
- design of 24 break pressure, sedimentation and storage tanks
- civil design including access roads and siting for pre-fabricated steel storage tanks
- integration of new pipelines with existing networks, tanks and intakes
- preliminary and detailed design, costing, specifications and scheduling

Photograph 9: ***Air valve – Samoa style.***

5 CONCLUSIONS

There are advantages and opportunities for success with both the public utility and community managed models.

As a result of our experience serving both the public utility (SWA) and community managed schemes (IWSA) in Samoa, we were able to make the following recommendations:

1. Government support for independent schemes could be further improved, in recognition of their important role at a community level.
2. Collaboration, regulation and interaction between the public utility and community managed schemes could be improved, and would optimise the use and protection of limited natural resources and further develop management capacity.
3. Improved contractual processes and support would produce improved project outcomes – specifically site supervision, surveying of pipelines, network commissioning and practical completion.
4. Designer, construction supervisor, water committee representatives and the contractor must be present at commissioning to ensure that unexpected issues are addressed and the scheme is operating as intended.
5. Promote and provide support to achieve household rainwater harvesting where connecting to the network is too costly.
6. Increase water quality monitoring and implement treatment solutions for communities at risk.
7. Eliminate poor quality pipelaying (PVC pipes on surface, leaks, cut pipes, poor valves and chambers) as this practice leads to unsustainably high maintenance costs and can lead to parts of the network being severed as a result of land disputes.
8. Continue with community participation in disaster recovery and environmental workshops to reduce exposure to environmental effects & disasters.
9. Involving local members of parliament and government representatives in community committees may increase access to funding and support.
10. Providing community training opportunities in areas such as water safety, leak detection and demand management will improve scheme management.
11. Enhancing the support role of IWSA to include maintenance and emergency funds, on-call technical advice and contractor assistance will improve scheme service levels.
12. Encourage gender, hierarchy and demographic diversity within community committees.

Photograph 10: ***Training community plumbers in scheme maintenance.***

A wide range of institutional, economic and technical capacity was observed across the communities encountered during these projects, and this is clearly a challenge to the effective management of community schemes.

But, in our experience, rural communities in Samoa are knowledgeable, ingenious, and resilient, demonstrate skill and experience and display strong, historic coping mechanisms in the face of significant and life-threatening challenges. Following damaging floods, intakes are cleared and pipelines rebuilt; in drought or low supply conditions, households conserve water; where water quality is poor, it is routinely boiled.

Further still, we observed that each community wants the best for its people and our place as "experts' was to offer empowerment and education in the benefits to the health of the community.

We would highly recommend the following keys to achieving successful solutions:

1. Acknowledge and seek to understand culture, local protocols and local knowledge.
2. Listen in order to engage.
    - Walk every pipeline with locals and allow time to be led to the backblocks.
    - Pursue local knowledge. This involves asking and listening until you get accurate information.
    - Sight every water source, preferably at the end of the dry season.
    - Encourage resolution of potential land disputes.
3. Assume solutions are relational, and technical solutions often follow.
4. Maximise the benefit to recipient communities. Both public and community models exist to serve the community, nothing more or less.
    - Engage in long term relationships with communities.
    - Pursue the desire to enhance human dignity in every initiative.

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