



EU EDF – SOPAC Project Report 47
Reducing Vulnerability of Pacific ACP States

VANUATU

COUNTRY MISSION AND TECHNICAL ADVISORY REPORT – COASTAL MANAGEMENT AND AGGREGATES ASSESSMENT IN SELECTED PARTS OF SOUTH-WESTERN EFATE ISLAND

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Beach Profile along the Mele Bay coast, northwest of Port Vila.

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INTRODUCTION

Apart from the aggregates related activities that were identified in the first two stakeholder consultation meetings in 2003, additional tasks were identified during the April 2004 visit by the SOPAC-EU Project Aggregates Geologist to Vanuatu (Tawake, 2004). It was evident from the discussions and consultations with key-stakeholders that beach sand mining along the Mele Bay coast (Fig. 1), development of coastal management strategies and the need to identify alternative sources of aggregates in Efate were the most pressing issues.

In order to attend to most of these tasks, discussions with relevant specialists at SOPAC were carried out to determine the most effective way of delivering assistance in an integrated approach. In July 2004, the Head of the Mineral Section in the Department of Mines, Geology and Water Resources (DMGWR) in Vanuatu made a courtesy call to SOPAC in Suva to discuss the proposed October visit and subsequent work plan. Russell Maharaj (SOPAC Training Coordinator) and Andrick Lal (SOPAC Surveyor) accompanied Akuila Tawake to Vanuatu for this implementation mission.

Project Task Nos. VU 1.2.2, 1.2.3, 1.2.5 1.2.8 and 1.4.1, as outlined in the Vanuatu Work Plan, were delivered during this trip. These included coastal management training, coastal and quarry survey, preliminary aggregate source assessment in Pango and Quoin Hill (Fig. 1) and initiation of Integrated Coastal Management (ICM) in Vanuatu. The ICM approach was proposed and accepted as a positive step towards collaboration among stakeholders in the Mele Bay Area.

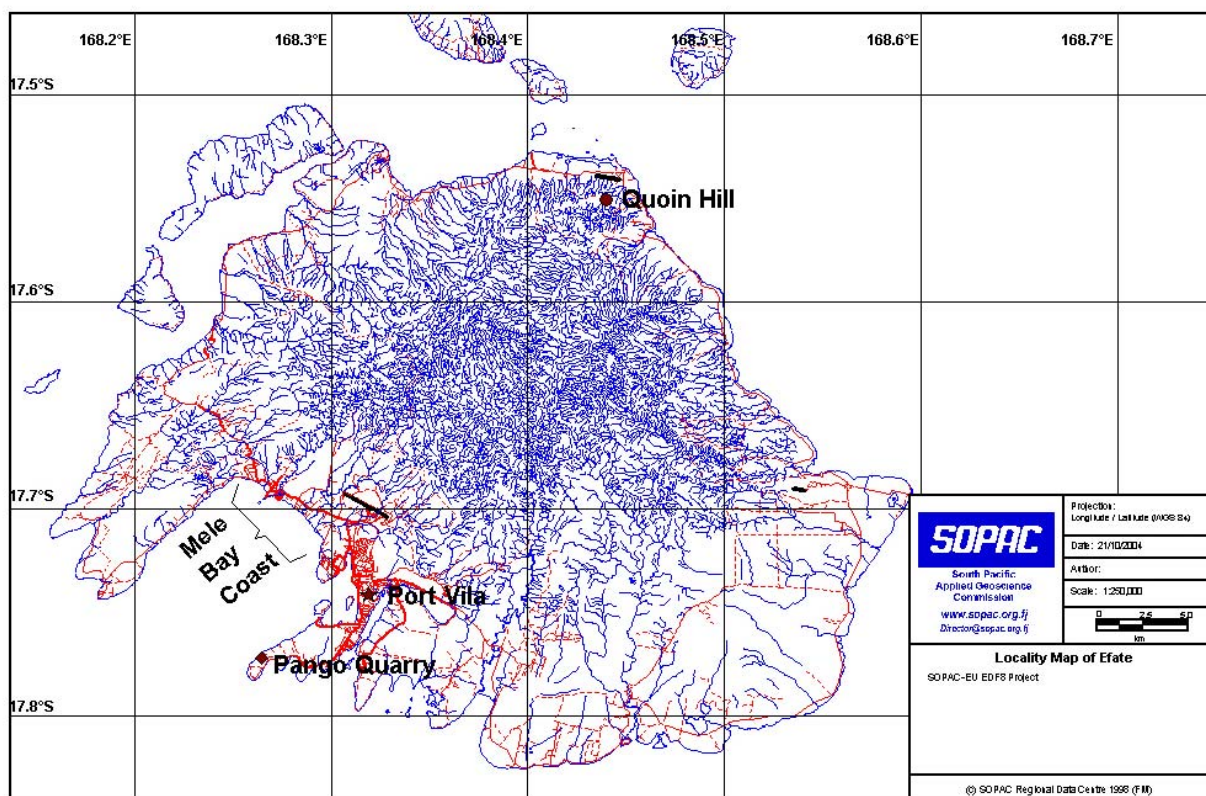


Figure 1. Locality Map showing areas of interest on Efate Island.

Objectives

The principal objectives of this mission were to:

- Conduct coastal management training for government stakeholders, resource owners, and sand mining companies.
- Initiate Integrated Coastal Management (ICM) in Efate. Present the ICM strategy to stakeholders and, if possible, establish the ICM Project in Vanuatu by electing a steering committee and a coordinator.
- Install permanent beach profiling benchmarks along the Mele Bay coast and carry out beach profiling in this area.
- Survey quarry boundaries to assist in the resource estimation.
- Geologically assess the potential of Quoin Hill volcanic rocks as an alternative aggregates source in Efate.
- Undertake other aggregates related activities as appropriately identified during field surveys and discussions with stakeholders.

List of People Met

Steven Tahi (Director General, Ministry of Lands and Natural Resources)

Chris Ioan (Director, DGMWR)

Mike Bakeoliu (Director, Department of Lands Survey (DLS))

Toney Tevi (Head of Mineral Section, DGMWR)

Brooks Rakau (Exploration Coordinator, DGMWR)

Russell Nari (Deputy Director, Environment Unit)

Moses Kalsale William (Principal Surveyor, Department of Land Survey (DLS))

Jeffrey Kaitip (Assistant Physical Planner, Department of Provincial Affairs (DPA))

Martha Yamsui Kaltal (Cultural and Sites Survey, Vanuatu Cultural Centre)

Catherine Malosu (Environment Officer, Environment Unit)

Fataui Sope (Deputy Town Clerk, Port Vila Municipality)

Uravo Nafuki (Laboratory Technician, Public Works Department (PWD))

Tony Kalorib (Mental Health, Ifira Island)

Alex Palavi (General Manager, SMET)

Sailas Vatoko (Landowner, Pango Quarry)

Kaltango Tarimiala (Landowner, Mele Village)

Edmond Kochiwola (Self-employed & sand supplier, Mele Worawia)

Tony Kanas (Senior Surveyor, Department of Land Survey)

Riyriy Magkawai (Blacksand Village)

Laisa Kaipilelu (Blacksand Village)

Charles Vatu (Governance Officer, FSP Vanuatu)

Rensly Hambu (Graduating Student, USP)

Willie Watson (Project Manager, Public Works Department (PWD))

Williams Ganileo (Vanuatu Country Intern, Lands Department)

Morris Stephen (Water Resources Section, DGMWR)

EXECUTIVE SUMMARY

The work plan for this visit was designed in such a way to deliver the required tasks in the most effective manner within the duration of the visit. Consequently the SOPAC team was divided accordingly to cater for different project tasks that were carried out concurrently.

The consultation meeting for initiating the ICM Project in Vanuatu was carried out on Monday (4/10/04) where relevant government stakeholders were invited to attend. With the existing sectoral approach to coastal management in Vanuatu, it was agreed that the integrated strategy would be more effective in bringing about consensus and better decision-making among stakeholders. The meeting concluded with the participants agreeing to adopt the ICM strategy and, as proposed, the Mele Bay Area (Fig. 2) was identified as the pilot project site.

The survey of the Mele Bay area was conducted in conjunction with the ICM meeting, where the entire coast was inspected and eight beach profile benchmarks were installed. Beach profiling continued on Tuesday (5/10/04) and was completed on Wednesday (6/10/04). Four locals were actively involved in the survey.

Coastal Management training was carried out in two days (Wednesday (6/10/04) and Thursday (7/10/04)) with the idea of increasing capacity among local stakeholders, especially those who have no or little knowledge about the environment and the processes that shape them. This was also an awareness campaign to educate a wide range of stakeholders to understand their coasts, look after them and to promote sustainability when it comes to resource development. In addition, the training was a vital link to the proposed ICM Project activities in Mele Bay. It was wrapped up on Thursday afternoon when participants were taken for a field survey in the Mele Bay Area and were also taught how to conduct a beach profile.

A survey was carried out at the Pango Quarry from Thursday (7/10/04) to Saturday (9/10/04) to determine the amount of resource available that would assist the operator in future operational plans. The inland sand deposit that overlies the limestone at Pango was also surveyed to give an inferred resource estimation.

Sand samples collected from Pango and Mele Bay were taken to the PWD Laboratory for geo-technical testing. The test entails the manufacture of concrete cylinders using the sand and then applying the compressive test to get the strength of the concrete, which would in turn determine the suitability of the sand as a construction material.

The second week was entirely devoted to the assessment of the volcanic rocks that occur at Quoin Hill in northern Efate (Fig. 1) as a potential aggregates source. This site had previously been identified as a suitable sand and gravel source (Hutchinson, 2002) but the quantification of the resource has not been done. The assessment involved geological mapping to ascertain the rock types that occurs in the area, spatial extent of fresh outcrops, pattern of weathering and the overburden thickness. It was also imperative to find out the types of land use at Quoin Hill and the nearby areas, details of the surrounding river system (e.g. flowing or dry, rock outcrops in the creeks) and the different vegetation types that occur in the area. This is of paramount importance when it comes to an Environmental Impact Assessment (EIA) and a feasibility study should a developer be interested in starting a quarry.

The source of pumice in the upper reaches of the Mele Plain was also visited in order to fully understand the amount of materials coming from these pumice mountains through the existing drainage systems and being deposited along the coast.

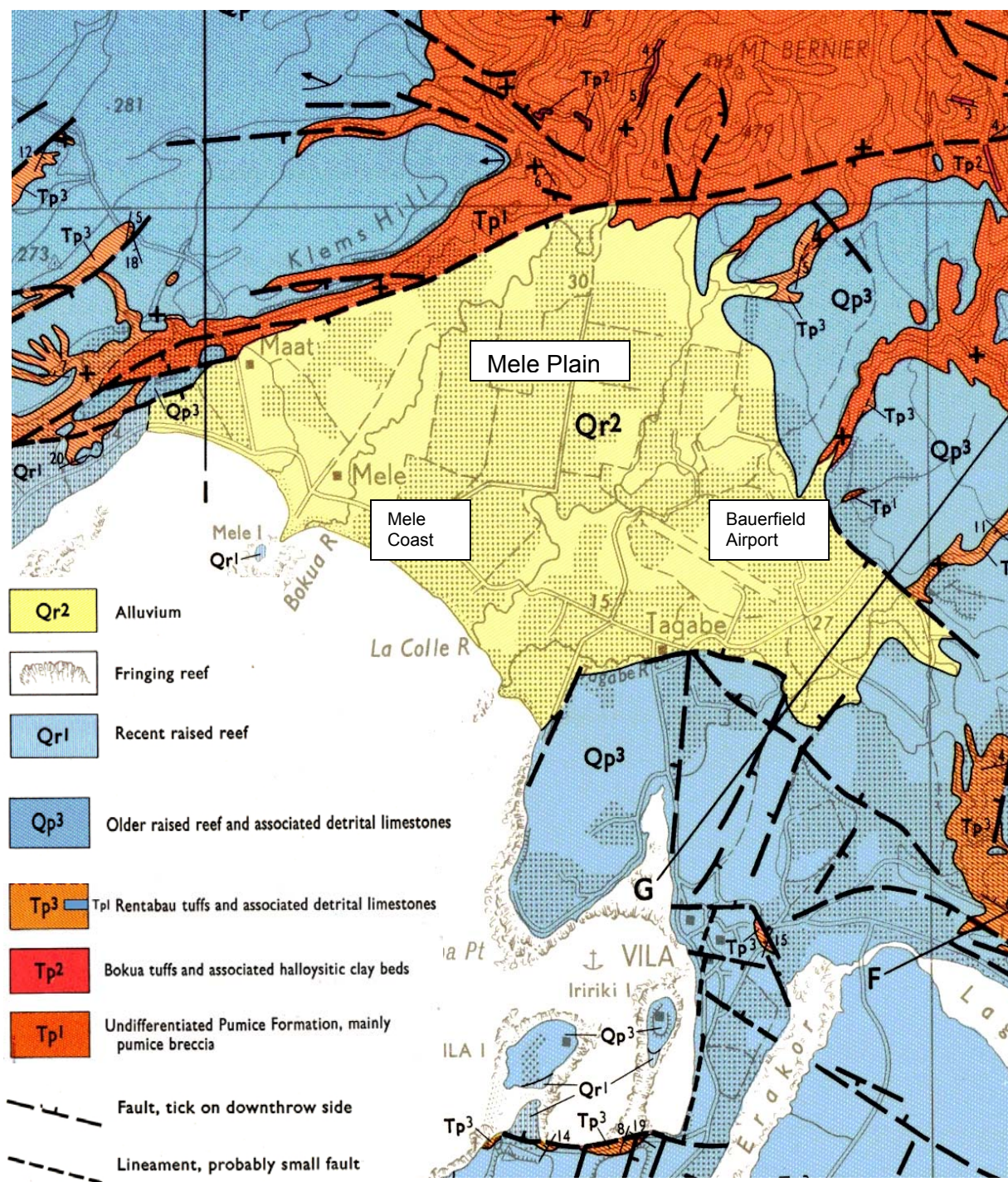


Figure 2. Geology Map of the Mele Bay Area (from Ash et al. 1973). The huge pumice formation inland is the major source of pumice sand along the Mele Bay coast.

GENERAL

Tabulated below are the Vanuatu Work Plan Tasks attended to during the visit with subsequent follow-up action:

Work Plan ID	Activities	Follow Up Action
VU 1.2.2	Eight permanent beach profile benchmarks were installed along the Mele Bay coast to monitor sediment erosion and accretion. The location of each benchmark was selected after consultation with Russell and DGMWR. Land/property owner's permission was obtained. The first set of beach profiles was carried out using these benchmarks.	DGMWR will be responsible for carrying out beach profiles at least twice a year. In addition, beach profiles should also be done soon after a seasonal event (e.g. cyclone, tidal waves, continuous heavy rain) that disrupts coastal dynamics.
VU 1.2.3	Coastal Management Training was conducted by Russell Maharaj in Vila, and was attended by government stakeholders, resource owners, Vila Municipality and individuals. The idea is to train and empower local stakeholders on how coastal processes work naturally, and how they respond and adjust to human-induced activities. The training also covers monitoring methods that should be employed in the marine, coastal and terrestrial environments in order to carry out a sand budget study in Mele Bay.	The ICM Steering Committee in collaboration with DGMWR will be responsible for the monitoring activities in Mele Bay.
VU 1.2.4	After Akuila's discussion with Robert Smith, it was decided that the Mele and Teouma Bays are too deep for any dredging operation, thus any resource assessment would be pointless. This is shown in the 2003 bathymetry survey map of Efate. This has been communicated to DGMWR. Terrestrial sand sources are not an issue in Efate but the quality of sand and compensation/royalty payments to resource owners are matters of concern.	There will be no further follow up on this project task.
VU 1.2.5	Pango Quarry resource assessment was conducted to determine the aggregates resource available. This entails setting up of survey marks, surface area measurement and depth of extraction. This task was carried out in collaboration with the DGMWR and DLS in Vanuatu.	Andrick to produce a technical report. Any future quarry survey can be carried out by the DLS in Vanuatu.
VU 1.2.8	The volcanic rocks at Quoin Hill, northern Efate were assessed in three days to quantify their potential as an aggregates source. It was also an opportunity to see the type of land use, the vegetation cover and waterways at Quoin Hill and the surrounding area. This will assist in the feasibility study if a hard-rock quarry has to be set up.	Preliminary assessment completed. Geo-technical testing of rock samples to be carried out.
VU 1.4.1	During the consultation meeting with the Government Stakeholders in Vila, it was unanimously agreed that Vanuatu shall adopt the Integrated Coastal Management Project and, as proposed, Mele Bay was identified as the pilot project site. A Government Stakeholder Core Group was tasked to be responsible for the ICM activities with the election of a Chairman / Coordinator and an assistant. It was also agreed to establish a steering committee, which will include stakeholders outside of government.	Toney Tevi and Russell Nari to call a meeting for the development of the ICM Project vision and action plan in Vanuatu.

APPENDIX 1

Order of Events

These were the order of events during the period spent in Efate:

- Sunday (3/10/04):* Arrived in Vanuatu.
- Discussed work plan with Toney Tevi.
- Monday: (4/10/04):* Presentation and consultation on initiating Integrated Coastal Management Project in Vanuatu in the Cultural Centre Conference Room.
- Establishment of the beach profile benchmark locations along the Mele Bay Coast and commencement of benchmark installation. Local participants were made aware of the importance of coastal monitoring using beach profile.
- Tuesday (5/10/04):* Public Holiday in Vanuatu (Constitution Day)
- Completed benchmark installation and started with beach profile using total station.
- Wednesday (6/10/04):* Commencement of Coastal Management Training by Russell. It was attended by 18 participants (see the list in Appendix 3).
- Completed beach profile in Mele Bay. Survey points were installed at Pango Quarry.
- Thursday (7/10/04):* Training continued in the morning and it was wrapped up in the afternoon where participants were taken for a field survey in Mele Bay. They were also shown how to carry out beach profiles using basic equipment such as a level, staff and measuring tape.
- Pango Quarry survey continued.
- Friday (8/10/04):* Pango Quarry survey continued.
- Saturday (9/10/04):* Quarry survey was completed.
- Toney Tevi, Brooks and Akuila went to North Efate to talk to the landowners about the aggregate assessment at Quoin Hill and to check out available accommodation.
- Sunday (10/10/04):* Rest day. Russell and Andrick returned to Fiji.
- The work plan for the following week was discussed with Toney Tevi and Tony Kanas in the afternoon.
- Monday: (11/10/04):* Had a meeting with Chris Ioan where he was briefed on what had been done in the previous week and what will be done this week.
- A similar meeting was also held with Mike Bakeoliu.

Beach sand sample collection at Mele Bay. Samples for geo-technical testing were taken to PWD laboratory.

Tuesday (12/10/04): Left for North Efate with Toney Tevi, Toney Kanas, Brooks Rakau and Morris Stephens.

Akuila checked in at the Beachcomber Resort near Takara Village whilst the other guys stayed at Siviri Village.

Geological investigation started at Quoin Hill.

Wednesday (13/10/04): Geological mapping continued.

Thursday (14/10/04): Geological work completed.

Friday (15/10/04): Team meeting at the Beachcomber Resort where the outcomes of the geological investigation were discussed.

The team returned to Vila.

Had a meeting with Steven Tahi where he was briefed on the progress of the SOPAC-EU Project coastal and aggregates activities in Efate.

Saturday (16/10/04): Visited the upper reaches of the Mele Plain with Toney Tevi and Brooks.

Sunday (17/10/04): Akuila returned to Fiji.

APPENDIX 2

Initiating ICM Consultation Meeting

Date: Monday 4/10/04

Venue: Vanuatu Cultural Centre Conference Room

Name	Position	Organisation
Toney Tevi	Head of Mineral Section	DGMWR
Russell Nari	Deputy Director	Environment Unit
Moses K. William	Principal Surveyor	DLS
Jeffrey Kaitip	Assistant Physical Planner	DPA
Martha Y. Kaltal	Cultural and Sites Officer	Vanuatu Cultural Centre
Fataui Sope	Deputy Town Clerk	Port Vila Municipality
Uravo Nafuki	Laboratory Technician	PWD
Williams Ganileo	Vanuatu Country Intern	Lands Department
Catherine Malosu	Environment Officer	Environment Unit
Brooks Rakau	Exploration Coordinator	DGMWR
Akuila Tawake	Aggregates Geologist	SOPAC

The concept of initiating ICM in Vanuatu was proposed during the April 2004 in-country visit by the SOPAC-EU Project Aggregates Geologist (Tawake, 2004). After receiving positive responses from relevant stakeholders during the initial consultation, it was decided that further consultations, especially with the Fiji ICM Committee, were required prior to the establishment of the project in Vanuatu. This would also provide enough time for local stakeholders to deliberate on the matter and come up with ways of integrating coastal management strategies in their respective areas of responsibilities.

One of the prime objectives of this October 2004 mission to Vanuatu is to present to the government stakeholders what ICM is all about, what benefits it can bring about compared to the existing strategies, and a proposed way forward that will meet coastal management and development needs of the country. During the presentation, Mele Bay was proposed to be the pilot project site in an effort to try and tackle some of the ongoing problems that emerge as a result of intensive human activities in the area.

In order to understand the nature of coastal management in Vanuatu and what the various government departments are responsible for, it was agreed that each of them would also present what their area of responsibility encompasses. Presentations were conducted in Bislama by the Environment Unit, DGMWR, and DPA.

After all the presentations, it was agreed that there was a need for integration of coastal management activities in Vanuatu as it was evident that the various responsible authorities seem to operate in isolation. The involvement of resource owners is quite critical if the ICM is to be effective in guiding and assisting them on the sustainable development of their resource. Consequently it was emphasised during the discussion that they must be included in the steering committee, so they can be part of the decision-making process. This would help resolve conflicts among coastal / marine users and resource owners, and it has the tendency to avoid future recurrence of conflict of the same nature.

The participants were also cautioned that similar initiatives had been implemented in Vanuatu in the past where many came to an abrupt halt when the project term expired or the allocated funds had been exhausted. These past failures could also be attributed to the absence of relevant experts to continue the work. The government cannot afford this trend to continue and the ICM Project should be locally driven hence the SOPAC-EU Project has been requested to see that, apart from financial support, in-country capacity development should be a priority.

Therefore, to make good use of the limited resources available, government departments need to collaborate first before inviting other stakeholders to be part of the ICM Project.

One of the things that tend to stagnate the progress of activities is that so much time, effort and resources are wasted on planning and preparing coastal management plans without any implementation. Coastal management would only be effective if there are works carried out on the ground to achieve what has been documented in these plans. This includes data collection, participation in community development and sustained implementation of recommendations in the coastal management reports of the area to be managed. This would result in better decision-making based on updated datasets, increased resilience of the local community and improvement of the environment conditions.

Government stakeholders were urged to involve regional organizations like SOPAC, USP and SPREP due to the relevant technical experts they normally employ. Their assistance may be in the form of technical work, advice and/or financial assistance, which will boost the effectiveness of ICM in the Mele Bay area.

The decision to adopt the ICM Project in Vanuatu was put to the floor for deliberation and to decide whether existing coastal management strategies are the best way to go, further consultation is required or they agree to take the idea on board. At the end of their deliberation it was unanimously agreed that Vanuatu needs integration for more efficiency and better delivery when it comes to coastal management. This has resulted in the establishment of a Core Group and the election of its chairman / coordinator and his deputy.

The Core Group comprises the following departments/authorities:

Geology, Mines and Water Resources
 Environment
 Physical Planning
 PWD
 Lands / Survey
 Vanuatu Cultural Centre
 Meteorology
 Fisheries
 Port Vila Municipality
 SHEFA Province

Toney Tevi of DGMWR was elected as the Chairman / Coordinator and Russell Nari of the Environment Unit were voted as his deputy.

The following departments/authorities were identified as possible members of the ICM Steering Committee:

1. Government Departments:

- Geology and Mines
- Water Resources
- Lands/ Survey
- Environment
- Fisheries
- NDMO
- Port Vila Municipality
- Provincial Affairs
- PWD
- VIPA

2. Resource Owners:

- Mele Village
- Blacksand Village
- Mele Maat Village

3. Sand Mining Companies:

- Enterprice-Perronet
- SMET
- Melanesian Commerce Industry
- Small-scale sand supplier

4. Hideaway Hotel Management

5. Regional Organisations:

- SOPAC
- SPREP
- USP

6. NGO:

- FSP Vanuatu

7. Shefa Province

The Chairman and his deputy will be responsible for talking to these authorities and identifying who should be their representative to the committee.

The government stakeholders present in the meeting were assured of the SOPAC-EU EDF8 Project assistance and support for the ICM activities in the Mele Bay area. The Chairman and his deputy were urged to invite a USP law lecturer based at Emalus Campus, who has a legal background in coastal law and natural resources, with some familiarity of Vanuatu legislation pertaining to marine and coastal resources, to be part of the committee. This can be supplemented if the committee can also secure the technical and/or financial involvement of Aid donors such as AusAID and NZAID.

At the end of the meeting some of the participants were taken to Mele Bay to see how the installation of beach profile benchmarks was done and to actually participate in the installation process.

APPENDIX 3

Vanuatu Coastal Management Training – Phase 1

Date: Wednesday (6/10/04) and Thursday (7/10/04)

Venue: Vanuatu Cultural Centre Conference Room

Trainer: Russell Maharaj

Name	Position	Organisation / Village
Toney Tevi	Head of Mineral Section	DGMWR
Russell Nari	Deputy Director	Environment Unit
Moses K. William	Principal Surveyor	DLS
Jeffrey Kaitip	Assistant Physical Planner	DPA
Martha Y. Kaltal	Cultural and Sites Officer	Vanuatu Cultural Centre
Uravo Nafuki	Laboratory Technician	PWD
William Ganileo	Vanuatu Country Intern	Lands Department
Catherine Malosu	Environment Officer	Environment Unit
Brooks Rakau	Exploration Coordinator	DGMWR
Riyriy Magkawai	Villager	Blacksand Village
Laisa Kaipilelu	Villager	Blacksand Village
Charles Vatu	Governance Officer	FSP Vanuatu
Kaltango Tarimiala	Landowner	Mele Village
Edmond Kochiwola	Self-employed & sand supplier	Mele Worawia
Rensly Hambu	Graduating Student	USP
Leonard Tari	Journalist	Daily Post
Tony Kalorib	Mental Health	Ifira Island
Akuila Tawake	Aggregates Geologist	SOPAC

The Coastal Management Training was carried out as part of the awareness and capacity building campaign of the Project in Vanuatu. The idea was to empower the members of the committee and other stakeholders with knowledge and understanding on how an island system is affected by natural and man-induced processes. With the establishment of the ICM Project in Vanuatu, committee members would be able to effectively carry out awareness and educational programs, prepare comprehensive information brochures and guidelines, and offer sound advice to all levels of society.

Russell Maharaj prepared the materials and delivered the training in three major components, as summarised below:

1. Sand Budgeting and Geo-materials

Topics covered under “Sand Budgeting”:

- Definition of Sand Budget
- Origin of Sand
- Sand budget sources
- Sand Sinks and Accumulation
- Sand Storage
- Coastal Cells
- Longshore and Cross-shore Transport
- Sand Budget Model.

Topics covered under “Geo-materials”:

- Concrete Technology
- Engineering consideration with reference to the quality of sand in Mele Bay.

2. Introduction to Coastal Engineering

Topics covered under “Oceanography”:

- Wave Mechanics
- Water Levels
- Currents
- Tides
- Wave forms and types

Topics covered under “Scope of Coastal Engineering”:

- Shoreline Protection
- Structural Measures
- Seawall Design

3. Coastal Erosion and Monitoring

Topics covered under “Coastal Risks”:

- Sea Level Rise: A Central and South Pacific Perspective
- Coastal Management and Engineering
- Concept of Risk
- What are Risk Assessment and Management?
- Why Evaluate Risk?
- How to Evaluate Risk?
- Approaches to Risk Management
- Beach Profile

Topics covered under “Evaluating Coastal Erosion Risk”:

- Erosion Assessment
- Coastal Erosion Management

Discussion

During the discussion session, a few people raised their concern about the quality of sand that occurs along the Mele Bay coast. If people continue to build their houses using the poor quality sand from this site, government could be held responsible for issuing beach sand mining permits if there is any structural failure due to the use of poor quality sand.

It was revealed that the first batch of samples collected and taken to Fiji in April this year for analysis generally exhibit 90 % pumice and volcanic glass. Two of these samples are made up purely of pumice and glass. For the sake of educating people who may not be familiar with the characteristics of pumice, it was described as a porous, weak and light weight volcanic rock that often occurs in light to dark grey colour as witnessed in large quantities along the Mele Bay coast. Surprisingly, the general input from marine aggregate sources along the entire coast is minimal.

Relatively good quality sand occurs to the western corner of the Mele Bay coast and is composed mainly of obsidian, mafic minerals such as olivine and augite and basic volcanic rock fragments. However, the significant occurrence of volcanic glass and silica bearing minerals can be a matter of concern to the construction industry. Various forms of reaction can occur in concrete between certain aggregates and alkali hydroxides derived from the concrete mix (Smith and Collis, 1993). Devitrified glass is potentially reactive while certain variety of silica can trigger alkali-silica reaction if present in critical amount.

According to Toney Tevi, the quality of sand along the entire Mele Bay coast was similar to the sand that occurred on the west beach before the big earthquake in January 2002. Black-sand Village got its name from the black sand that used to be present along the beach on the eastern side of the coast where the village is located. Massive landslides occurred in the pumice hills behind the Mele Plain after the earthquake. Investigations that were carried out in the upper reaches of Bokua and La Colle Rivers soon after the earthquake found that massive landslides had partially choked the river channels at various locations. This pumice debris was carried down to the coast via the four rivers that run into Mele Bay and ended up being deposited along the coast.

Vanuatu lies in a tectonically active region of the southwest Pacific and this NNW-trending chain of islands is host to some active volcanoes. Earthquakes of variable magnitude are commonly experienced in Vanuatu. Scars of the 2002 event are still fresh in the minds of the people of Efate where buildings, bridges and roads were damaged. The reason it is very critical to use good quality aggregates for constructions is so that buildings can to some extent withstand the ground vibration.

It was revealed that Vanuatu does not have a building code for builders to adhere to during construction. There had been an attempt to develop a code some years back and the document is still in draft version with seemingly no urgency to progress and finalise it. Russell has offered to return for a bigger awareness and training campaign to make sand miners, builders, decision makers and the general public aware of the importance of using good quality materials for construction and the ramifications if people continue to use poor quality aggregates to build houses. Most people welcomed this and Toney Tevi had shown much interest in having this event some time early the following year (2005).

The training was completed with a fieldtrip to the Mele Bay area where terrestrial, coastal and marine processes interplay and shape the coast over time to become what it is today. These processes are driven by the action or cumulative effect of waves, current, tides, wind, rainfall, river system, marine and terrestrial sediment transport, reefs and tectonic activity. The impact of human activities, such as beach sand mining, in these areas and the surrounding environment were identified and explained in detail to the participants. In addition, the importance of continuous monitoring, such as beach profile, was also emphasised.

Russell Maharaj will prepare a training report on this training.

APPENDIX 4

Sources of Sand that occur along the Mele Bay Coast

Brief Geology of Efate

The geology of Efate Island is described in detail in the “Geology of Efate and Offshore Islands” including associated maps by Ash, Carney and Macfarlane (1978). The purpose of this brief description of the Efate Geology is to highlight different rock types that occur on the island, from which the major components of sand in Mele Bay derive from.

The geology of Efate comprises four major rock formations that essentially make up the island. The oldest rocks belong to the Efate Pumice Formation, a Pliocene-Pleistocene series of submarine pumice tuff and breccias that generally occur in the central part of the island. This pumice formation is overlain in North Efate by the Pleistocene Basalt Volcanic Formation, comprising submarine brecciated lava flows of olivine basalt composition. These two older volcanic formations have been overlain by an extensive series of limestone terraces, which make up the Late Pleistocene to Recent Reef Limestone Formation. Holocene deposits encompass younger reef limestone and loosely consolidated alluvium (Ash et al. 1978).

The Efate Pumice Formation has an extensive outcrop of over 300 km² in central Efate and is also exposed as small outcrops along fault scarps near the coast. The topographic expression of the formation is greatest in the outcrop to the west of the Teouma Graben, as typified by the deep valleys of the Bokua (Fig. 3) and La Colle Rivers (Ash et al. 1978). These two river systems are part of the principal drainage in the Mele Bay Plain, which also includes the Tagabe River to the east and Teae River to the west.



Figure 3. Upstream of the Bokua River is characterised by deep, narrow valleys and high, massive pumice deposits on either side of the river.

Where sands are coming from?

As shown in Figure 2, the Mele Bay coast is bounded to the northwest and southeast by the older raised reef limestone, the alluvial deposit to the northeast and the southwestern side is boarded by the ocean with infrequent patches of reef offshore. Typically with this type of island setting, it is expected that a fair amount of sand would come from both land and marine sources. Surprisingly, the preliminary analysis results of the sands collected from the Mele Bay coast revealed an average of 98 % land derived sediments, 95 % of which is pumice. Contribution from the marine sources is about 2 % or less, consisting of coral rubble and shell detritus.

The bathymetry survey of Mele Bay revealed that the water depth drops off quickly at 50 m from the coast to 100 m. It keeps getting deeper further offshore. This means that most of the sediments that have been deposited and/or transported offshore are most likely to be lost permanently. It needs high-energy waves to stir sediments on this relatively deep lagoon floor and to subsequently transport and deposit them along the coast. This scenario may only happen during extreme events such as high magnitude tsunamis and cyclones, which may occur once every 10 years.

According to the DGMWR, earthquakes, of variable magnitudes, have been experienced from time to time on Efate. These are major causes of landslides around the island, particularly in the hilly central part where the pumice formation is concentrated. As experienced during the 2002 earthquake, massive landslides were observed upstream in two of the major rivers that discharge into Mele Bay. At some locations the landslide caused damming effects on the river channel where the water built up, leading to flash floods in some parts of the Mele Plain. In one instance, the people of Mele had to spend a day draining out water from a dam up in one of the Bokua River tributaries (*pers. com. Rakau 2004*). The village is situated beside the river near the coast and, as one could imagine, it would be a disaster waiting to happen if the dam was ignored and the water built up beyond the dam's capacity.

Due to time constraints, selected parts of two creeks in the Mele Bay Plain were investigated in a half-day fieldtrip; the upper reaches of the Bokua River and the mid-section of the La Colle River. Both rivers exhibit massive deposition of pumice. The area visited in the Bokua River is just north of the Mele Plain Alluvial Deposit-Pumice Formation contact (Fig. 2) while the inspected portion of the La Colle River was to the northwest of the airport (Fig. 2).

Massive and partly brecciated pumice deposits occur along the Bokua River. This pumice deposit is continuous along the riverbanks and on the steep walls of the valley (Fig. 3). From the river channel, pumice can be as high as 100 m or more in vertical distance. Boulders on the riverbank are largely made up of argillaceous tuffs with minor components of limestone and volcanic rocks. Pumice sand bars, a duplicate of what occurs along the Mele Bay coast, are also common along this river.

In the La Colle River, the alluvial deposit is absent and has been replaced by unsorted, massive pumice deposit (Fig. 4a). Sweet potato, cassava and corn farms are prevalent on either side of the river in the Mele Plain (Fig. 4b). Pumice and pumice fragments cover about 90 % of the farmed areas. This is indicative of the large quantities of pumice in the Mele Plain that have been carried downstream through the river system and eventually deposited along the coast and in the marine environment.



Figure 4. *Pumice deposit along the La Colle River. a) Pumice river bank on the north-western end of the airport; b) The grey-white sandy soil is made up of about 90 % pumice. The mountains in the background are composed predominantly of the Pumice Formation.*

Conclusion

The presence of pumice in sands along the Mele Bay coast is an inevitable reality that has been part of all the coastal sand deposits around Efate for a long time. The recent occurrence of pumice in large quantities in Mele Bay could be attributed to the 2002 earthquake, which caused massive landslides in the pumice formation in the central part of the island that were transported to the coast by the four river systems on the Mele Plain.

Significant quantities of pumice are expected to be part of the Mele Bay coast sand for a long time. The only viable option is to identify alternative sources of sand and educate people on the ramifications of using poor quality sand from Mele Bay.

The insignificant input from marine aggregate sources is mainly due to the limited sources available (no long fringing reef, only patch reefs in the bay) and the huge drop off in water depth inside the bay. Whatever is deposited in the bay is lost permanently. So any small amount of sand produced from corals and marine organisms would most likely be deposited on the seafloor in the bay.

APPENDIX 5

Beach Profile and Quarry Survey

1. Mele Bay Beach Profile

The establishment of the beach profile benchmarks along the Mele Bay coast was part of the coastal management plan for this area under this Project (Vanuatu Work Plan, Task No. VU 1.2.2). The purpose of this exercise is to put in place a monitoring system that would assist in assessing the effect of continuous beach sand mining in Mele Bay.

A detailed report on the beach profile will be compiled by Andrick Lal.

2. Pango Quarry Survey

2.1 Pango Limestone Quarry

The request for the survey of the Pango Quarry was made by the operator to the Project Aggregates Geologist in April this year (2004). After consultation with DGMWR, it was agreed to incorporate this task in the Vanuatu Work Plan and also include it in this implementation phase on the aggregates component of the Project.

The Pango Quarry is located on the northern side of the Pango Peninsula and is about 6 km southwest of Port Vila (Fig. 5). The quarried materials are composed of Holocene raised limestone (Fig. 5), which are essentially embedded coral fragments. Visual inspection has revealed that vuggy, powdery and moderately strong aggregates are produced from this material at Pango.

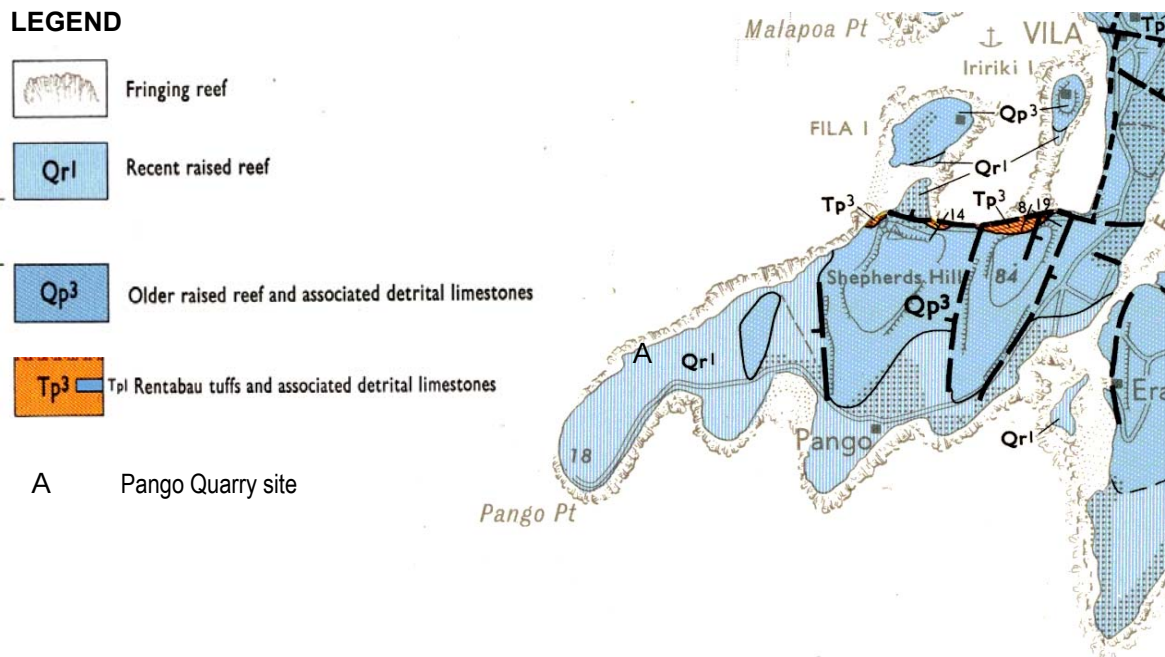


Figure 5. Geology Map of the Pango Peninsula (from Ash et al. 1978) showing the location of the Pango Quarry.

This quarry has been in operation for more than 30 years. The landowner has immensely benefited from the development of his resource as he receives 350 vatu for every cubic-metre

of aggregates sold. This was quite evident from his huge concrete house and shop at Pango and also his brand new four-wheel drive vehicle.

The quarry has an average depth of 4 m and the current extraction is focused on inland lateral development. An excavator is used to break the embedded coral, which is then transported to the crusher by dump trucks. Different aggregate sizes, including sand, are produced and stockpiled onsite before being transported to the point of sale.

The area to be surveyed was defined by the operator in their endeavour to know what volume of the resource is left to mine. This, under the current rate of extraction, would indicate how many more years they have left to quarry.

A detailed report on the quarry survey will be compiled by Andrick Lal.

Mining of inland sand deposits occurs at a relatively small scale in Pango. The sand deposit is best interpreted as a Holocene shoreline prior to the tectonic event that was responsible for the uplift of primary limestone on Efate Island. This unit overlies the primary limestone with an average thickness of about 1.6 m. In the absence of hand auger, excavation using a shovel was carried out in the immediate vicinity of the sand mining site to determine the surface and depth extent of the sand deposit. An average 30 cm topsoil occurs on top of the sand and it needs to be removed, together with vegetation, prior to the excavation of the sand.

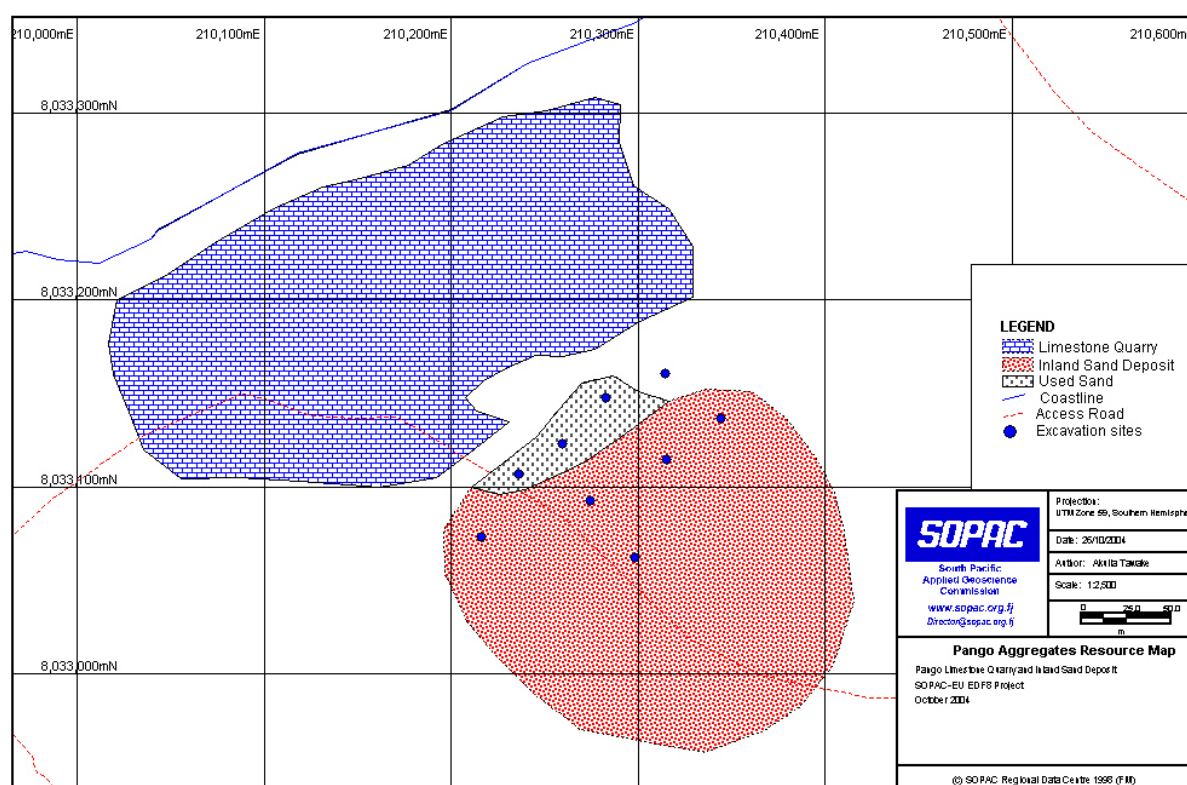


Figure 6. Pango Aggregates Resource map, showing the limestone quarry pit and the inland sand deposit..

The inferred boundary of sand deposit shown in Figure 6 above is based on the hand-dug exploration holes and the surface survey carried out around the area. Nine holes were dug to ascertain the thickness of the topsoil and the underlying sand. This sand deposit covers an area of 32,600 m² and based on the current extraction site, the average sand thickness is about 1.6 m. Assuming that the sand thickness is consistent throughout the area covered with sand, the inferred resource volume can be calculated.

Pango Inland Sand Resource: $32,600 \text{ m}^2 \times 1.6 \text{ m}$
 $52,160 \text{ m}^3$

This inland sand deposit has been identified as an alternative source of sand in southern Efate. Analysis carried out on the sand samples from this area revealed that it is mainly composed of coral rubbles and shell detritus. The Pango sand is not the best fine aggregates that can be used for construction but certainly of a better quality than the majority of the Mele Bay beach sand.

The resource estimation yields just over $50,000 \text{ m}^3$ of sand, a figure which cannot sustain the long-term demand of the building industry in Port Vila and the nearby settlements / villages. In an endeavour to identify relatively good quality sand, the Project, in close collaboration with the DGMWR, is currently engaging in the collection and analysis of sand samples, and testing of concretes made from natural sand sources closer to Port Vila. Apart from Pango, Teouma Bay beach sand samples were also collected for analysis.

Another option is to encourage quarry operators to increase their crushed sand production to substitute for the Mele Bay pumice sand. The existing four major limestone quarries in Port Vila, namely Devil's Point, Erakor, Eratap and Pango, are capable of supplying sand to consumers. The use of crushed limestone sand for construction should be encouraged at this stage, while the assessment of good quality igneous hard-rock sources in Efate and the nearby islands is ongoing.

APPENDIX 6

Quoin Hill Aggregates Assessment

The assessment of volcanic rocks in Quoin Hill as a potential source of aggregates in Efate was raised during the stakeholder consultation in April 2004. The need to find good quality aggregates for construction, sealing of roads and airport runways were some of the reasons cited by the DGMWR to warrant a request for the Project's assistance. In addition, the government has suspended the importation of aggregates from neighbouring countries in order to stimulate the sourcing and ultimately the quarrying of good quality aggregates within Vanuatu (*pers. com. Tevi 2004*).

Quoin Hill is located about 2 km southwest of Takara Village and just south of the decommissioned 2nd World War US Army Airfield (Fig. 7). On the geology map of Efate, the highest point on the hill is 224 m above sea level. The landform consists largely of gently sloping and occasionally steep hillsides with many dry creek tributaries running down the sides of the hill. The entire hill is thickly vegetated except for some patches on the eastern and northern sides where subsistence farming was witnessed. Apart from this, other land uses in the area include coconut, cocoa and cattle farming.

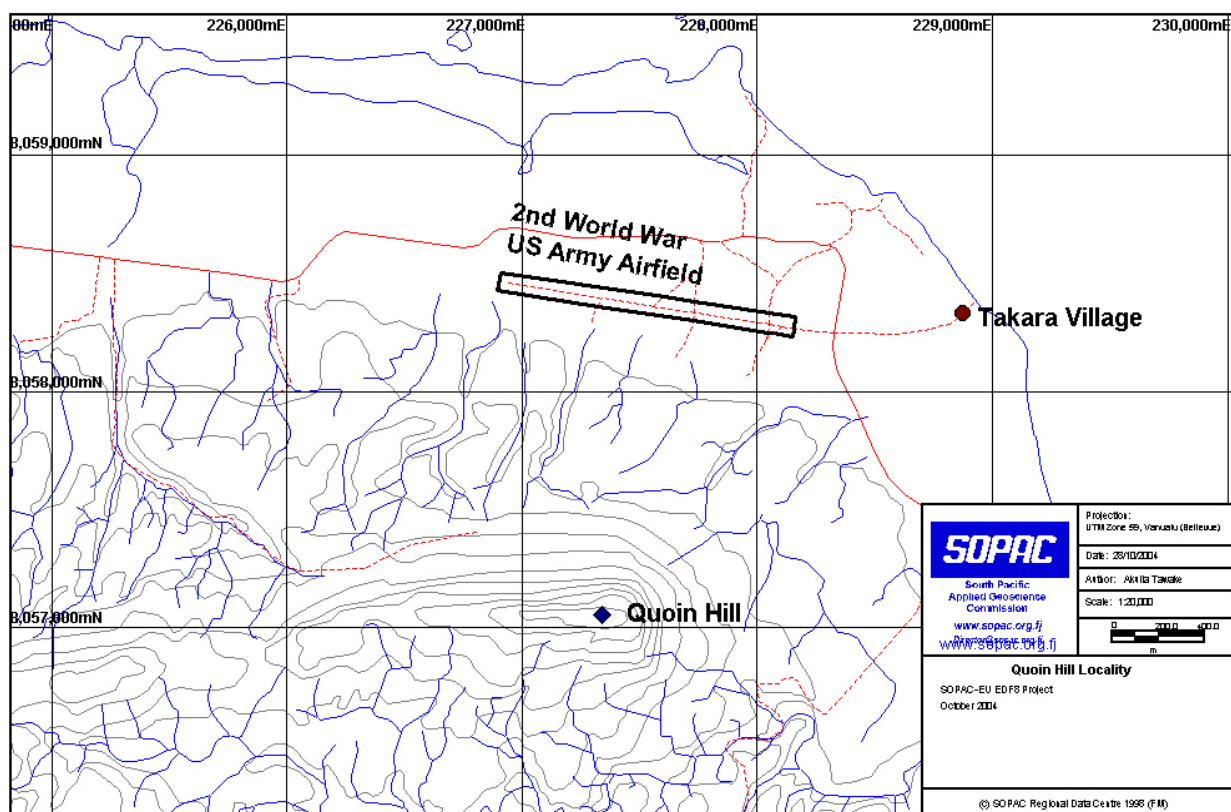


Figure 7. Locality Map of Quoin Hill.

Earlier reports revealed that the eastern and northern sides of the hill have the potential for aggregates extraction (Hutchinson, 2002) hence the geological mapping was concentrated in these areas. Geological assessment was focused on the:

- Volcanic rock types that occur in the area;
- Extent of the outcrops in the survey area;
- Stratigraphic sequence;

Level of weathering; and
Amount of overburden.

Other factors also noted during the expedition, which could impact the outcome of the assessment are given below:

Type of land use;
Accessibility of the source rock;
The drainage pattern that occurs in the area; and
Land Tenure.

Four days of the expedition were spent trying to quantify the in-situ basalt lava flows on and around the eastern part of Quoin Hill; three of which were devoted to the actual fieldwork and the last day was spent at Beachcomber Lodge collating and analysing geological data.

The survey team was briefed on the purpose of the mission and what to look for in the field. In the afternoon of the first day, the team was divided into two exploration groups with the mission to search for and map any outcrop they may come across. This would facilitate ground coverage and to ensure that the fieldwork is completed in three days. Two field guides were hired from Takara Village to assist in identifying the localities of the outcrops. At the end of the third day, an approximate area of 1.0 x 0.7 km was surveyed.

Two in-situ hard-rock samples were collected at different sites in Quoin Hill. The samples were taken to Fiji for geo-technical testing purposes.

A detailed report on this assessment will be compiled later.

APPENDIX 7

Other Activities

- A visit was made to the PWD Laboratory where all geo-technical tests are carried out. The possibility of doing some testing in their lab was suggested. This was further discussed with Willie who asked for a formal request to come from SOPAC.
- Alex and Sailas have expressed their appreciation to SOPAC and the Project for the work carried out at Pango Quarry.
- A total of 20 sand samples were collected across the beach profile at 4 different locations from the Mele Bay coast. Five samples were collected at each location, one each from the upper beach, middle beach, lower beach, in the water and one where there is visible changes in composition at a certain depth in the middle beach.
- Separate meetings with Chris Ioan and Mike Bakeoliu took place on Monday (11/10/04) in their respective offices. They were briefed on the progress of work and what would be done at Quoin Hill during the week.
- A meeting with Steven Tahi was arranged for Friday (15/10/04) afternoon. He was briefed on the Aggregates Project activities in Vanuatu and what has been achieved to date. Steven was thanked for all the manpower and logistical support received during the two weeks of fieldwork. He expressed his gratitude on behalf of the Vanuatu Government for the Project initiative in carrying out work in Vanuatu as requested.
- On in-country capacity development, it has been suggested that Brooks Rakau should travel to SOPAC office in Fiji on a short-term fellowship to undergo in-house training on how sand and gravel samples are analysed and tested.

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