Tractor Based Plant and Equipment Trial

Evaluation Report



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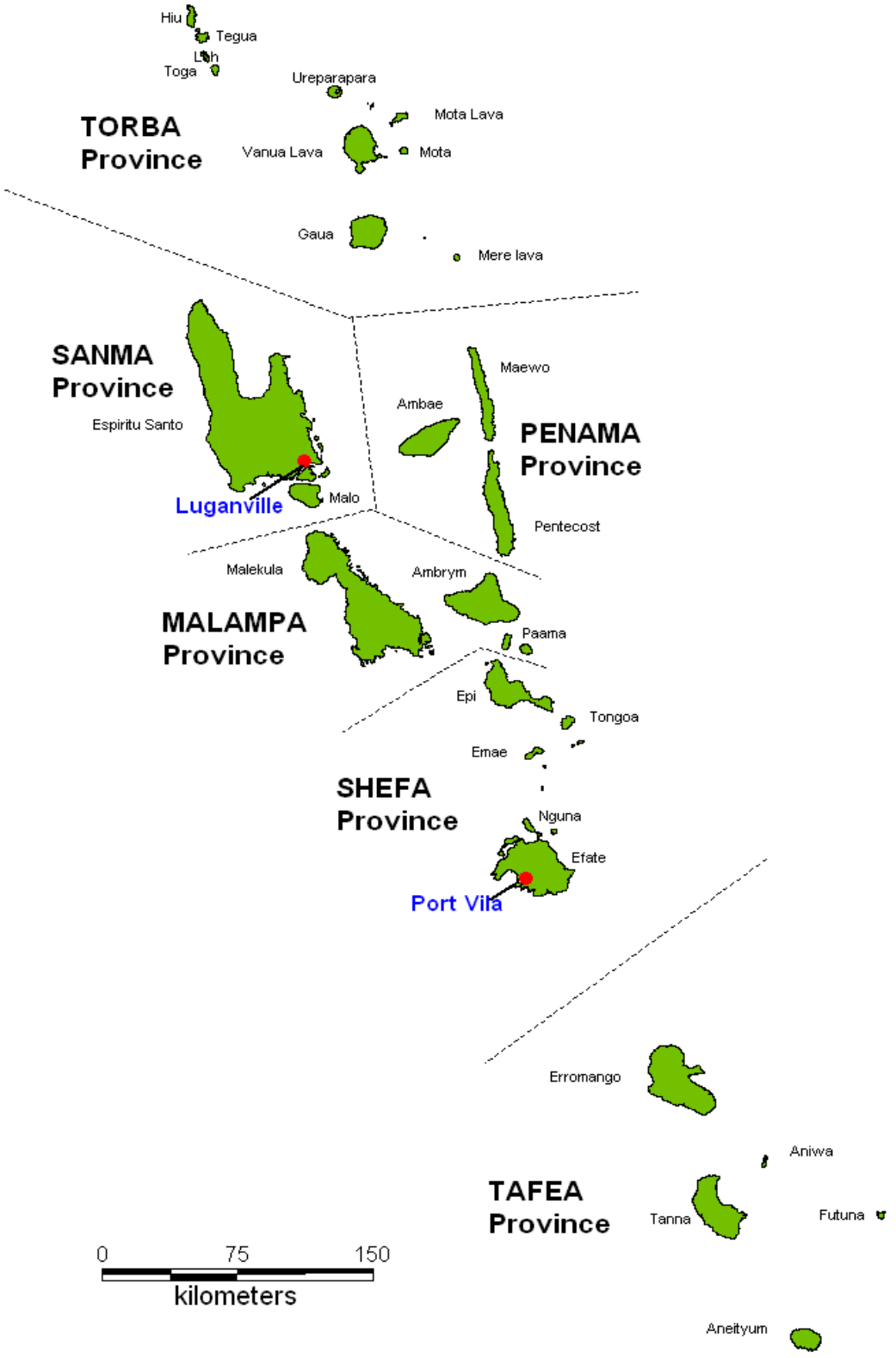
ACRONYMS AND ABBREVIATIONS

AHC	Australian High Commission
CBC	Community-Based Contractor
DFAT	Department of Foreign Affairs and Trade
EHC	Equipment Hire Contractor
FA	Force Account
GoA	Government of Australia
GoV	Government of Vanuatu
IBC	Island-Based Contractor
MIPU	Ministry of Infrastructure and Public Utilities
NC	National Contractor
PWD	Public Works Department
R4D	Roads for Development (previously Vanuatu Transport Sector Support Program)
TBPE	Tractor-Based Plant and Equipment
TBPET	Tractor-Based Plant and Equipment Trial
VTSSP	Vanuatu Transport Sector Support Program (now R4D)

MAP OF VANUATU



EXECUTIVE SUMMARY

This report was prepared by the Roads for Development program (R4D) to provide guidance to the Public Works Department on the applicability of tractor-based plant and equipment for road maintenance and construction works following a trial carried out during the period 2015-2017.

R4D hereby acknowledges the contribution of many who participated in the trial and the preparation of this report, especially PWD management and divisional staff, short-term external advisers and the AHC team for their dedicated support and useful suggestions and guidance throughout the period of the trial.

Trialling the tractor-based equipment was part of the initial Scope of Services for the Roads for Development Program.

The intention of the trial was as follows:

a) to verify the hypothesis that tractor-based equipment has significant comparative advantages over conventional equipment traditionally used for road construction and maintenance works in both Force Account and outsourced contractor contexts;

b) to establish whether such equipment could effectively supplement the capacity of the small-scale IBC contractors, and;

c) to provide guidance on whether Public Works Department and private contractors should be encouraged to invest in tractor-based equipment.

The key findings and recommendations are summarised below:

- **The comparative advantages of TBPE, over conventional construction equipment are negligible**
- **TBPE cannot adequately supplement capacity of the IBC's**
- **TBPE does not offer substantial benefits within the Force Account context, while it is unlikely that it would be competitive in the private sector context also;**
- **PWD and private contractors should generally not be encouraged to invest in this type of equipment, although some further trialling of specialist equipment may be useful to explore alternative tractor-based options for specialist works for which they are suited.**

Roads for Development (R4D)

TRACTOR BASED PLANT AND EQUIPMENT TRIAL

EVALUATION REPORT

1. Introduction

Background Information

Tractor Based Plant and Equipment (TBPE), in relation to the Roads for Development Program, is mentioned in the Project Design Document for R4D Phase II[1]. The document describes the tractor based technology to be used as a support to the Island Based Contractors (IBC's), who were established previously, during the VTSSP Phase I.

The main purpose of the Island Based Contractors was to provide an alternative to Force Account capacity in the outer islands, where the contractor market was undeveloped, and where the use of external contractors was largely unaffordable. IBC's normally rely on locally available manual labour and use of hand-tools and small equipment to provide road maintenance and improvement services.

The IBCs were, however, too small to independently undertake maintenance and improvement work at a greater scale and without the use of larger machinery[2]. Being in the early stage of evolution, they were also constrained by limited technical and business capacity and knowledge. Therefore, much of their work depended on the readiness of the Force Account teams to supplement their limited capacity. These combined efforts, using IBCs in tandem with FA support, often failed, either due to the increased complexity arising from these interdependencies or the capacity of the Force Account team. The rationale for undertaking the TBPE trial was therefore to test the potential to support or enhance the existing IBC model[3].

The rationale for the trial was further expanded to test the potential for using tractor-based equipment as an alternative to large, expensive heavy plant (commonly known as '*yellow plant*') which is currently used by PWD, either through Force Account teams or external contractors. It was suggested that using tractors may be able to reduce costs, while also providing more flexibility to achieve full utilisation by increasing the range of activities the equipment is used for, such as providing support to the agriculture sector.

Purpose of the Evaluation and Applied Methodology

The purpose of this evaluation was to assess which aspects of the trial and to what extent each aspect was successful; comment on the limitations of the trial and present the findings regarding the applicability of TBPE technology in Vanuatu.

This evaluation aims to provide answers to the following questions:

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[1] See *Vanuatu Transport Sector Support Program – Phase II; Australian Agency for International Development, September 2012*

[2] This refers to works that require extraction and processing of quarry materials, haulage, and similar

[3] : "the IBC are to be supported by small fleets of basic equipment (tractor, trailers, tractor attachments, tools, etc.)" - see *Vanuatu Transport Sector Support Program – Phase II, Annex 5, section Work Plan Methodology, p. 75; Australian Agency for International Development, September 2012*

a) What types of works is TBPE suitable for?
b) To what extent can TBPE effectively support IBCs in undertaking their works?
c) Does TBPE provide a sustainable alternative to conventional heavy plant?
d) Should PWD (Force Account) and the contracting community be encouraged to use TBPE?

Furthermore, this Evaluation Report provides some options for the future use of the TBPE after closure of the trial.

The evaluation was undertaken on the basis of the information obtained through:

a) Field observations and field reports;
b) Monthly TBPET Reports;
c) R4D Quarterly Reports;
d) PWD rural roadwork projects.

The qualitative aspects of the evaluation mostly rely on the subjective observations of PWD and R4D personnel made during the field trips and through everyday work with the equipment, while the quantitative data has been derived from TBPET related records and reports.

Limitations

This evaluation report should be read in the context of its various limitations.

The various observers often had different, and sometimes completely opposing views on TBPE performance. The evaluation tried to identify consistencies amongst the various sources of information and shape the conclusions by emphasising the predominant view amongst observers.

The quantitative data collected throughout the trial does not allow for detailed disaggregation of the output information. This stems from the initial setup of the trial and the way that the information was collected, recorded and reported. Unfortunately, the data makes it difficult to undertake a detailed assessment of the cost-effectiveness of each type of work, but it does provide sufficient data to allow a broader assessment.

There was significant deviation between the original design of the trial and the actual implementation, in particular the team structure which was reduced in size. This raises the question of whether the outcomes would have been different if the original design had been followed.

Finally, the selection of a different brand of tractor equipment may have delivered a somewhat different set of conclusions, especially as the New Holland tractors used for the trial proved to be particularly unreliable.

Structure of this Document

This document is structured to first introduce the reader to the historical information relevant to the trial, outline the original design of the trial and to describe the multiple aspects of the implementation of the trial.

The second part provides an analysis of the qualitative and quantitative information.

The third part provides recommendations on the future application of TBPE, while the finishing section outlines options for the continued use of the tractor-based equipment after this trial.

2. Design and Implementation of the Trial

Preliminary Arrangements

The program design initially allowed for the purchase and deployment of four sets of equipment, to be deployed in Ambae, Pentecost, Malekula and Tanna.

During 2013, prospective suppliers were contacted as part of the effort to assess the market for options that would be most adequate. Specifications and tender documents were developed soon afterwards.

The number of sets, however, had to be reduced from the initial four to two, due to R4D budget constraints. The obvious consequence was that the equipment was tested on only two, instead of the initial four islands. To enable testing of the TBPE model in diametrically different organisational environments and its ability to work in different soil and pavement conditions, it was decided that the trials would take place on the islands of Ambae and Tanna.

The tentative composition of teams and equipment was as outlined below[4].

Proposed Ambae TBPE Team

1 x Foreman to supervise both teams

Team 1 – Scoria pavement works		**Team 2 – Scoria pavement works**	
Equipment	**Personnel**	**Equipment**	**Personnel**
Tractor with 4-in-1 bucket	Operator No. 1	Tractor only	Operator No. 1
Pedestrian roller	Unskilled Labourer No. 1	Pedestrian roller	Unskilled Labourer No. 1
Tipping trailer	Operator No. 1	Tipping trailer	Operator No. 1
Towed grader	Operator No. 2	Tractor mounted grader blade	Operator No. 1
General support	Unskilled Labourer No. 2		**Total Team of 2**
	Total Team of 4		

Therefore, a total of 7 personnel were proposed in Ambae as follows:

- 1 x Foreman;
- 3 x Operator;
- 3 x Unskilled Labourer.

[4] Source: *R4D TBPET – Briefing Paper*

Proposed Tanna TBPE Team

1 x Foreman to supervise the three teams

Team 1 – Coronous pavement works		Team 2 – Coronous pavement works		Team 3 – Whitesands area ash roads	
Equipment	**Personnel**	**Equipment**	**Personnel**	**Equipment**	**Personnel**
Tractor with 4-in-1 bucket	Operator No. 1	Tractor only	Operator No. 1	Tractor with 4-in-1 bucket	Operator No. 1
Pedestrian roller	Unskilled Labourer No. 1	Pedestrian roller	Unskilled Labourer No. 1	Tractor mounted grader blade	Operator No. 1
Combi-roller	Operator No. 2	Combi-roller	Operator No. 2	Tipping trailer	Operator No. 1
Tipping trailer	Operator No. 1	Water tanker trailer	Operator No. 1 / Unskilled Labourer No. 1	General support	Unskilled Labourer No. 1
Water tanker trailer	Operator No. 1 / Unskilled Labourer No. 1	Low trailer	Operator No. 1		**Total team of 2**
Low trailer	Operator No. 1		**Total Team of 3**		
Towed grader	Operator No. 3				
General support	Unskilled Labourer No. 2				
	Total Team of 5				

Therefore, a total of 11 personnel were proposed in Tanna as follows:

- 1 x Foreman;
- 6 x Operator;
- 4 x Unskilled Labourer.

An in-country Specialist Adviser, Justin Leary, was appointed as the TBPET Project Manager during the whole period of the trial implementation. The key role of the Project Manager was to coordinate and oversee the usage of the plant, ensure it was maintained and repaired when necessary, assist with arrangement of operator training and keep the PWD Divisional Management informed of progress.

Purchase, Delivery and Deployment of TBPE

R4D initiated the procurement process for two sets of equipment in early 2014. This procurement, however, didn't include the initially planned purchase of two towed graders.[5]

[5] Purchase of two towed graders never eventuated. Instead, a mini-grader was purchased and delivered in 2017. Due to the late timing of the arrival and the distinct nature of the mini-grader, it has not been considered as part of this TBPE trial and therefore not included in this evaluation.

Procurement was finalised in Quarter 3 of 2015, with the equipment (including spare parts) delivered to Port Vila and stored at PWD Shefa depot.

Image 1: Tractor with attached water tanker at PWD Shefa depot

Image 2: Tractor-trailers with spare parts and rollers

The overall cost of purchase amounted to 1,085,301 AUD.

The Tractor Based Plant and Equipment was officially handed over from the Australian High Commissioner to the Minister for Infrastructure & Public Utilities on the 13th November 2015.

Image 3: Minister of MIPU (Don Ken) and Australian High Commissioner (Jeremy Bruer) during the handing over ceremony

Image 4: Representatives of MIPU, PWD, AHC and R4D at the TBPE handover ceremony

By the 25 October 2015, all equipment was assembled in Port Vila. On 20 November 2015, the Ambae set of equipment was delivered to PWD Penama Depot in Saratamata. On 21 November 2015, the Tanna set of equipment was delivered to PWD Tafea Depot in Isangel.

Image 5: TBPE being loaded onto the vessel at Port Vila harbour

Image 6: TBPE awaiting transportation to Tanna

Recruitment and Training of Operators and Foreman

The recruitment of operators and foreman was undertaken during the period from November 2015 to March 2016. The initial period for the submission of applications was extended due to the low number of applications received. In February 2016, before official employment, all foreman and operators undertook both theoretical and practical training conducted by a registered operator trainer who was contracted from Australia.

Image 7: Training of the operators on Ambae (grading)

Image 8: Training of the operators on Ambae (grading)

Image 9: Training of the operators on Ambae (gravelling)

Image 10: Training of the operators on Ambae (gravelling)

The staff recruited included two Road Foreman, five Operators and three Labourers for Ambae. The remuneration package for the staff was meant to be similar to PWD rates. The labourers on Tanna were later engaged on casual contracts as required to suit the trial works.

Image 11: Training of the operators on Tanna (filling up the water tanker)

Image 12: Training of the operators on Tanna (reshaping)

Image 13: Training of the operators on Tanna (reshaping)

Image 14: Training of the operators on Tanna (gravelling)

Period Observed

The trial period started in March 2016. The end date was not formally fixed, but cannot extend beyond the end of the current R4D program set for the end of June 2018.

For this evaluation, only the first year of the trial has been observed. This is because the additional mini-grader which was purchased later and added to the TBPE fleet, used the same source of funding and set of operators after its arrival, and therefore distorts the data. An evaluation of the mini-grader, which is not a tractor-based piece of plant, will be prepared separately.

Therefore, this evaluation report deals with the data and information for the period from March 2016 – February 2017.

Nature of the Trial

The main objective of the trial was to establish whether TBPE provides a cost-effective and sustainable alternative to heavy plant for undertaking rural road works in the varying, geotechnical, topographic and climatic conditions across Vanuatu.

During the initial design of the trial, the intention was to also establish the viability of TBPE in the private sector, implemented through a 'provide-maintain-operate PPP' arrangement. It was thought that such arrangement could work well because of the potential to use TBPE across numerous sectors such as agriculture and forestry, therefore improving utilisation rates. However, this option would only have been tested further if TBPE proved successful from a technical perspective in a force account setting, which this evaluation report shows was not achieved. Also, there were

concerns that sufficient budget could not be found across the sectors where tractors could be used so that utilisation rates could be guaranteed sufficiently to test a viable PPP arrangement[6].

Cost, Financing and Executing Arrangements

The overall cost of the equipment observed for the trial (without the later mini-grader) amounted to 80,931,964 VUV (1,085,301 AUD). The plant and equipment was purchased over the period from April 2015 to September 2015 using the funds from the R4D Grant. In March 2016, an additional mini-grader was purchased, and in June 2016, additional attachments for the tractors (4-in-1 bucket and rear tractor mounted grader blade) were purchased. A detailed list of the equipment purchased is presented in *Annex A*.

Operation and maintenance costs during the period of the trial were also funded from the R4D Grant Fund and amounted to a further 18,973,823 VUV. Equipment was normally serviced at the location of deployment in Tanna and Ambae, and in case of the more difficult repairs, in specialised workshops in Port Vila.

For the period of the trial, R4D appointed Justin Leary to manage the TBPET in the capacity of Project Manager. Regular servicing and repairs at the locations of deployment were arranged by the Project Manager.

Locations of Work

Over the period of the trial, works have been undertaken at various locations in East Ambae and Tanna.

Implementation of the trial on Ambae was undertaken in areas of soft soils and scoria pavement material, as follows:

a) Saratamata – Torgil, Torgil – Lolowai, Lolowai – Lolovenue, Lolovenue – Lolopuepue (March 2016) ;
b) Saratamata – Navonda Jct, Saratamata – Lolopuepue (April 2016) ;
c) South Rd – Navonda Jct (May and June 2016);
d) Saratamata – Torgil, Atavoa – Wawana (July 2016);
e) Saratamata – Lolovenue, Wailavo – Maloa (August 2016);
f) Loloaru – Nangire, Namoru – Waluibue, Walorgi – Vatuwite, Lolowai – Longana Airport (September 2016);
g) Sarailowatu – Namenaki, Saratamata – Wailakao, Akabij – Lovunidao, Lovunidao – Tanoimala (October 2016);
h) Saratamata Area, Saratamata – Wailakao, Saratamata – Taukera (November 2016);
i) Saratamata Area (January, February 2017).

The implementation of the trial on Tanna took place in areas of sandy soils (such as the ash plain roads surrounding the Yasur volcano), soft soils (such as the in-situ clay soils in North Tanna) and coronous gravel roads (such as the Imanaka – Lowiaru road). The trial covered the following areas:

a) Imanaka – Lowiaru (March 2016);
b) Imanaka – Lowiaru, Isangel Loop, Kings Cross – Ash Plain (April 2016);
c) Enima – Friendly Jct, Friendly Jct – Point Toti, Point Toti – Lowiapeng Rd, Lowiapeng – Post Letter Jct (May 2016);

[6] Source: *R4D TBPET – Briefing Paper, p. 2* (in relation to the PWD and R4D budget): *"now is not considered a prudent time to launch partnerships with the private sector when volume of works is not assured"*

d) Whitesands area, Tafea College Rd, Manuapen – Port Resolution (June 2016);
e) Manuapen – Whitesands (July 2016);
f) Korman Stadium – Port Resolution, Kito – Waisisi (August 2016);
g) Whitegrass Airport – Whitegrass Bungalow, Launalang Area (September 2016);
h) Launalang Area (October, November, December 2016);
i) Whitesands area (January, February 2017).

Types of Work Undertaken

The various types of work undertaken included:

- Gravelling, defined as spreading, watering and compaction of gravel (scoria or coronous) pavement layers;
- Reshaping, defined as loosening surface layer by ripping, formation of camber, watering and subsequent re-compaction;
- Grading, defined as formation of camber without prior loosening, followed by watering and compaction;
- Clearing of drains, defined as removal of debris/vegetation and/or reinstatement of side drains;
- Transportation of materials, defined as loading, movement to another location and unloading.

The above types of work were recorded and reported in the TBPET Monthly Reports. Together with the associated costs, they form the basis for this evaluation.

Team Structure

It is important to note at this point, that there was a difference between the number of planned operators[7] and the numbers actually employed. After taking into account the two towed graders that were never purchased, the remaining shortage of operators (at the start of the trial) was 2 (both on Tanna). However, by the end of the trial, this shortage was more pronounced as both the Ambae and Tanna teams worked with just 1 Foreman and 2 Operators each.

The reduction in numbers of personnel resulted from:

- a decision not to employ unskilled workers to train as operators;
- difficulties in attracting and recruiting reasonably skilled operators during repeated rounds of recruitment;
- the departure of some personnel during the trial due to lack of work caused by tractor breakdowns, and
- the departure of some personnel due to sickness
- the departure of some personnel because they chose to break their employment contracts.

The figures below describe the team composition at the end of the trial period.

[7] See "*Preliminary Arrangements"* section

Ambae TBPE team at End of Trial

1 x Foreman

Team 1 – Scoria pavement works		Team 2 – Scoria pavement works	
Equipment	**Personnel**	**Equipment**	**Personnel**
Tractor with 4-in-1 bucket	Operator No. 1	Tractor with 4-in-1 bucket	No operator
Combi roller	Operator No. 2	Pedestrian roller	No operator
Pedestrian roller	Unskilled Labourer No. 1	Water` tanker	No operator
Tipping trailer	Unskilled Labourer No. 2	Tipping trailer	-
Tractor mounted grader blade	-	Tractor mounted grader blade	-
Low trailer	-		
	Team Size of 4		**No team members**

Tanna TBPE Team at End of Trial

1 x Foreman

Team 1 – Coronous pavement works		Team 2 – Coronous pavement works		Team 3 – Whitesands area ash roads	
Equipment	**Personnel**	**Equipment**	**Personnel**	**Equipment**	**Personnel**
Tractor with 4-in-1 bucket	Operator No. 1	Tractor only	No operator	Tractor with 4-in-1 bucket	Operator No. 1
Pedestrian roller	No Operator	Pedestrian roller	No operator	`Tractor mounted grader blade	Operator No. 1
Combi-roller	Operator No.1			Tipping trailer	Operator No. 1
Tipping trailer	Operator No. 1				
Water tanker	Operator No. 1				
Low trailer	Operator No. 1				
	Team Size of 1		**No team members**		**Team Size of 1**

Image 15: Tanna team, March 2016

Image 16: Ambae team, March 2016

Information Used for Evaluation

The information used for this evaluation was obtained from the TBPET Monthly Reports and other sources.

The TBPET Monthly Reports for the trial period include information on the actual works outputs achieved and the expenditure associated with the trial.

Actual works outputs are expressed in the units of measurement relative to the type and nature of work, as follows:

- Gravelling – kilometres
- Reshaping – kilometres
- Grading – kilometres
- Transportation of materials – cubic metres per kilometre
- Loading of materials – cubic metres.

Indirect and other expenses, such as the depreciation and TBPET management-related expenses, have been obtained from other R4D financial records and analysis.

3. Evaluation of TBPE Trial

Technical Assessment of Adequacy of TBPE for Various Types of Works

This section describes the different types of works undertaken by the TBPE and provides an evaluation of the quality of works achieved, the suitability of the equipment to undertake these works and any other observations.

Gravelling

Description of Works

Gravelling works include spreading of either scoria (on Ambae) or coronous (on Tanna) gravel material, in uniform width and thickness over a specified length to form a pavement layer. This was undertaken by use of the attached grader blade, either in front or rear of the tractor as an attachment. The process also includes watering of the layer material to achieve the optimum moisture content prior to compaction until there is no visible movement of material beneath the compactor.

Image 17: Unloading gravel

Image 18: Spreading the gravel

Image 19: Watering

Image 20: Compaction

Observations

Tractors proved to be capable of spreading processed gravel material and forming the pavement layer, once it had been delivered to the construction site. However, during the trial, watering of the material often proved to be logistically challenging due to the distance of the works from water sources, the time necessary for transport and the high number of trips required because of the small tank capacity of 3,000 litres which ran out quickly compared to traditional water bowsers which

have a capacity of 10,000 to 30,000 litres. As a result, the degree of compaction usually achieved was unsatisfactory.

It is also important to note the capabilities of TBPE in transporting materials, such as gravel, from the quarry site to the construction site. Due to the slow travel speed of a tractor-trailer combination and the small capacity of the trailer, the time necessary for transportation of gravel is excessive, compared to the use of conventional equipment. Depending on the actual distances involved, experience with TBPE suggests that it is usually much more effective to use conventional tipper trucks to transport gravel material and then use TBPE to spread it.

The frequent breakdowns and failures of TBPE during transportation and gravel-spreading operations suggests that TBPE is not suitable for this type of work. Some of the failures were caused, for instance, by breakage of parts during transporting caused by a lack of suspension.

In Tanna tractors have been observed trying to spread gravel which contains oversize pieces. This is an unsatisfactory practice as it generally leads to poor compaction and segregation. However, the same problem would occur if spreading of oversized particles was undertaken by conventional plant. It should be noted though, that during the trial none of the TBPET teams had access to properly graded processed gravel. If improved material was made available the outcomes and quality of works would likely have been different.

Conclusions

Use of a full-set of TBPE equipment, including towed water tanker and trailer for gravel transportation is not a viable solution for gravelling works. However, if gravel and water can be made available, tractors are able to spread processed gravel material using a grader blade attachment.

Recommendations

The following recommendations are given with regards to delivery of gravelling works:

a) Use TBPE only for spreading processed gravel;
b) Spreading operations by tractor should be supported by conventional plant and equipment such as a water bowser, dump trucks and rollers.

Reshaping

Description of Works

Reshaping works normally include the formation of a cambered road surface on existing gravel roads by the use of the attached grader blade, either in the front or rear of the tractor as an attachment. It also usually includes watering of the surface material to achieve the optimum moisture content and compaction until there is no visible movement of material beneath the compactor. Materials which are soft or loose soils are suitable for reshaping by tractor, but if the existing surface material is hard, well compacted or contains large pieces, ripping is required before attempting reshaping with the grader blade.

Image 21: Shaping the camber

Image 22: Compaction with combi-roller

Observations

TBPE does not seem to be an adequate solution when the existing surface that needs to be formed is so hard that it requires ripping with the grader blade prior to reshaping. The tractors used for the trial did not have sufficient strength to rip well-compacted materials, especially hardened coronous surfaces, but tractors were not fitted with rippers, which would have worked better than a blade. Tractors often failed and required repair if they were used to re-shape hardened surfaces.

However, tractors seem to be well-suited to this type of work when working on soils which do not compact easily, such as volcanic ash and scoria, and softer wet clays. Tractors also have an advantage over conventional graders as they can work on very steep sections.

Watering of the surface layer remains logistically challenging, as is the case with gravelling works, while compaction is not normally required for this type of work.

Conclusions

Use of a full set of TBPE for reshaping is not a viable solution due to the logistical challenges of watering to achieve optimum moisture content, the general inability to rip existing compacted material and frequent breakdowns caused when working in harder materials.

Recommendations

TBPE should not be used for reshaping when it requires prior loosening of the surface layer or later watering and compaction.[8]

[8] Note the difference between *Reshaping* and *Grading* is described in the next section

Grading

Description of Works

Grading works are normally undertaken on in-situ soils (earth roads) with poor compaction properties, such as sandy soils, volcanic ash and scoria. Watering of such soils normally does not result in improved compaction properties, and therefore only light grading to restore the shape of original camber and to improve ride quality by removing surface irregularities is required.[9]

Image 23: Grading by TBPE (1)

Image 24: Grading by TBPE (2)

Observations

Tractors seem to be well-suited to this form of maintenance, especially in areas of loose soils with poor compaction properties. This activity has to be frequently repeated, usually after each heavy rainfall, and therefore requires the tractor with the grader to be stationed in the vicinity of the road to be maintained. It can be considered only as an interim measure to ensure that the road is passable, but in the long-term an engineered road may be necessary. One particular example of regular grading undertaken by one tractor/blade combination is on the Ash Plain Road leading to Yasur Volcano on Tanna, where the frequent grading operations have resulted in the level of the road surface being well below the surrounding ground level (see Image 24 above). There is an engineering limit to how much further the road can be lowered without causing side slopes to collapse, and it becomes increasingly difficult to provide access to adjoining parcels of land as the road is lowered further.

Conclusions

TBPE, in this instance a single tractor with an attached grader blade, seems to be a perfect choice for working on non-engineered earth roads that need quick repairs after each heavy rain. This equipment can work alone without supporting plant and equipment, and has the ability to work on steep sections of road. However, there is a much wider unresolved question of whether repetitive grading of earth roads is a sustainable long-term maintenance solution.

[9] Repeatedly undertaking grading is not sustainable in the long term as road surfaces are lowered with each intervention. However, it is acceptable as an interim form of maintenance in some locations. The sustainability of grading earth roads is not the subject of this evaluation report.

Recommendations

It is recommended to continue to use TBPE as an interim approach to grading of scoria, volcanic ash and any other suitable earth roads.

Clearing of Drains

Description of Works

Clearing of drains refers to the removal of any debris and vegetation from the longitudinal ditches running alongside and parallel to a road and restoration to the original ditch shape by using the attached grader blade.

Observations

Tractors are able to undertake this activity in areas of soft and loose soils. They are also capable of forming V-drains at the road edge by using the same approach. However, using the grader blade to re-shape a ditch often results in enlargement of the ditch and resulting reduction in the width of the carriageway.

Tractors are unable to undertake this work in hard soils.

Conclusions

A tractor with grader blade attachment should not be used for clearing debris or vegetation from side-drains, as over a period of time this will result in enlarged drains and a reduced road width. However, tractors with grader blades are able to form new drains, and this would often be a useful thing to do alongside grading.

Although not part of this trial, TBPE can be used effectively used for vegetation control if a sidearm slasher is purchased and installed as an attachment. This practice had been proven in numerous countries and by PWD's contractors in Santo. On some roads, using a tractor/slasher combination would be less expensive and much safer than cutting vegetation using manual labour.

Recommendations

It is not recommended to use TBPE for clearing the side drains with a grader blade. However, it is suggested that tractors with sidearm slashers could be used for vegetation control on major roads with more traffic where the use of manual labour is not appropriatesuch as on Efate Ring Road or Santo's East and South roads.

Loading and Transportation of Materials

Description of Works

Works include loading of bulk materials into a tractor-drawn trailer (or a truck) by using the tractor's 4-in-1 bucket, usually as part of quarry or stockpile extraction, and the later transport of materials to the construction site using a tractor-drawn trailer. The tractor-drawn trailer was never intended to transport heavy gravel materials over long distances, but relied upon other force account teams to prepare stockpiles of gravel in proximity to the planned works.

Image 25: Loading of materials

Image 26: Transportation of materials

Observations

Using tractor-drawn trailers for transportation of materials resulted in frequent breakdowns during the trial, mostly due to the lack of suspension, and the stress put on the tractor/trailer joint when travelling across uneven ground. On one occasion they were used for transporting material over long distances and suffered damage as a result.

Furthermore, due to slow travel speeds and the low capacity of the trailer, the time necessary for transportation using the tractor equipment is excessive, even over short distances – therefore making it inefficient when other works (such as gravelling) are undertaken simultaneously. As a result, all materials necessary to undertake such dependent works should be delivered to the construction site before undertaking the actual works, and this is not possible in many cases. Alternatively, the transportation fleet should be large enough to ensure that the equipment used for gravelling is not kept waiting, but this is not always economical, depending on how far from the site the gravel stockpile is located. The conclusion is that using a combination of tractors with 4-in-1 buckets for loading and tractor-drawn trailers for transportation is not suitable for transporting gravel from quarries to works sites. It is also concluded that using tractors and trailers to transport material from local stockpiles is possible, but also problematic if distances become too long.

One observed advantage of TBPE is that it can transport materials up very steep gradients, unlike larger tipper trucks, but it is not usual to have a situation where it is necessary to transport gravel for road improvements through an impassable, hilly section of road.

Conclusions

TBPE is generally unsuitable for undertaking major transportation of gravel mainly because of its susceptibility to breakdowns during such operations and its slow delivery rates. However, on a smaller scale, TBPE could be used effectively for transportation of smaller quantities of materials, along with labour and equipment, for undertaking pothole patching on gravel roads by transporting from local stockpiles

Tractors are capable of loading gravel using the four-in-one bucket especially if loading properly processed gravel.

Recommendations

Usage of TBPE for loading and transportation of gravel materials should be limited to supporting pothole patching activities only from local stockpiles to work sites.

Cost-Effectiveness

Introduction

When the trial was designed, it was not expected that the tractors would suffer with so many breakdowns. The expectation was that they would be almost fully utilised, and therefore an analysis based upon monthly records of outputs achieved per team was expected to provide a reasonable assessment of productivity. However, in reality the number of tractor breakdowns and resulting lost time has been excessive, and this has resulted in monthly aggregated data which includes both productive and non-productive time. In hindsight, greater disaggregation of data into daily or weekly records for each type of plant would have been more useful to be able to look at productivity on those days when plant was actually in use. The resulting lack of detailed information on utilisation rates and operating expenditure related to each piece of equipment has somewhat limited the thorough analysis of the cost-effectiveness of TBPE. However, by analysis of those months when breakdowns did not occur we have managed to develop an assessment of productivity for TBPE when in operation.

The frequent breakdowns, experienced in the first year of use, and resulting low recorded outputs has led us to the definite conclusion that this particular tractor set is not cost effective when compared to conventional sets of larger plant and equipment. However, it is possible that the selection of a different brand of tractor, instead of New Holland, may have resulted in fewer breakdowns, resulting higher utilisation rates and higher overall productivity.

The analysis undertaken was based upon the following:

a) Real costs of purchase and operation of the TBPET machinery and assumed depreciation rates;
b) Average market costs of purchase and operation of conventional machinery and reasonable depreciation rates;
c) TBPE output rates when machinery is working (with idle times due to breakdowns ignored);
d) Output rates of conventional sets of machinery under similar conditions;
e) Differences between the quality of works achieved, as experienced in the field.

The structure of the following analysis follows the above outline.

Comparison of Plant and Equipment Purchase Costs

The initial cost of the purchasing a set of conventional plant is compared with and the costs of the alternative TBPE solution in the table below.

Note that the roller is excluded from the analysis, as the same type of equipment can be used in both cases.

Table 1: Comparison of Purchase Costs for the Conventional and Tractor-Based Equipment

Type of works equipment is used for	Type of conventional equipment	Can be replaced by	Cost of conventional equipment (VUV)	Cost of TBPET (VUV)
Ripping, grading, spreading	Grader	Tractor with grader blade	25,000,000	7,541,800
Transport of materials	Tipper truck	Tractor with trailer	10,000,000	8,818,275
Watering	Water Bowser	Tractor with water tank	20,000,000	9,962,638
Loading bulk materials	Loader	Tractor with 4-in-1 bucket	6,000,000	7,918,250
			61,000,000	34,240,963

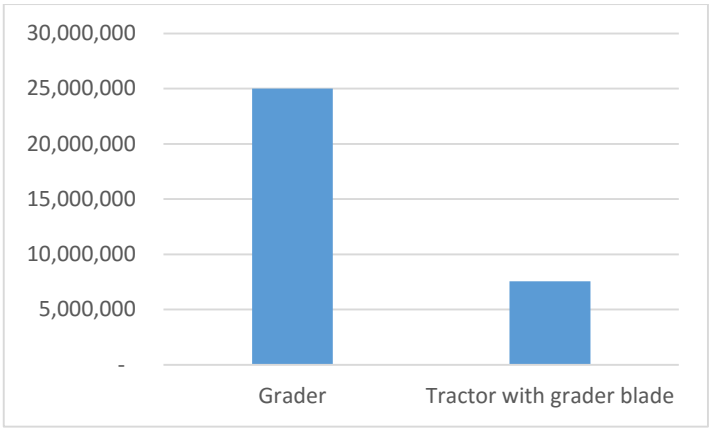

Figure 1: Comparison of purchase costs between commonly used heavy grader and tractor with grader blade

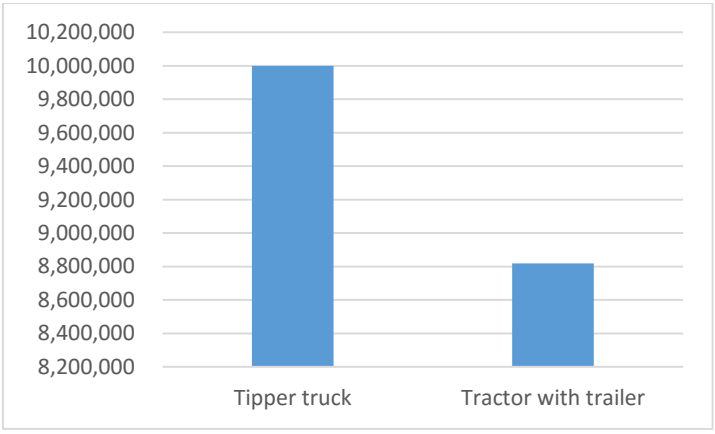

Figure 2: Comparison of purchase costs between commonly used 10 m3 tipper truck and tractor with 2.5 m3 trailer

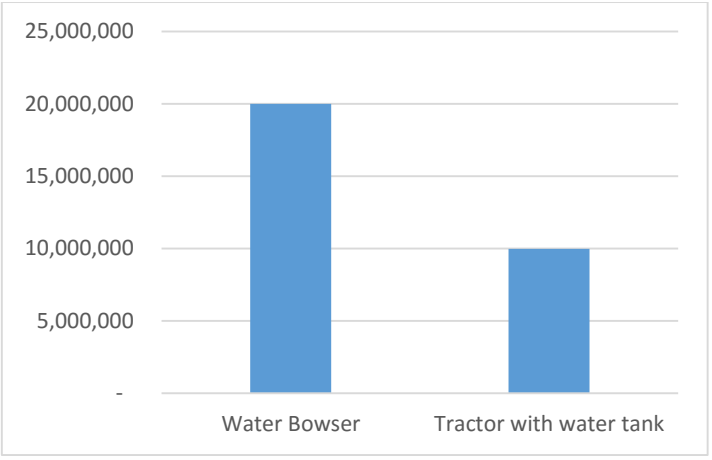

Figure 3: Comparison of purchase costs between commonly used 5000 lit water bowser and tractor with 3000 lit water tank

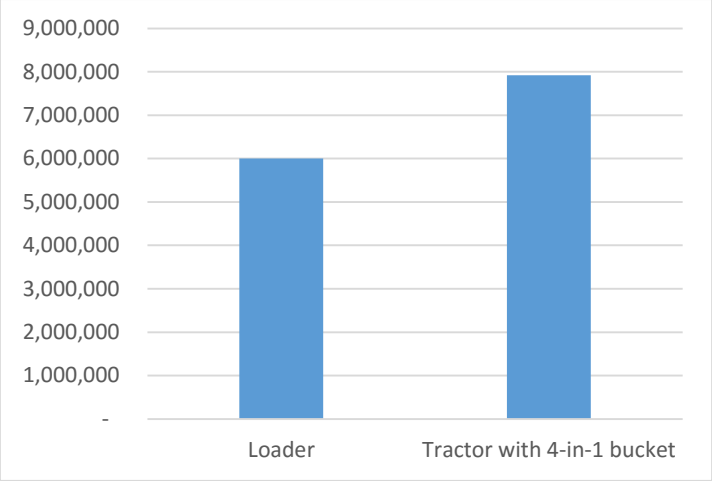

Figure 4: Comparison of purchase costs between commonly used loader with 1.3 m3 bucket and tractor with 0.75 m3 bucket

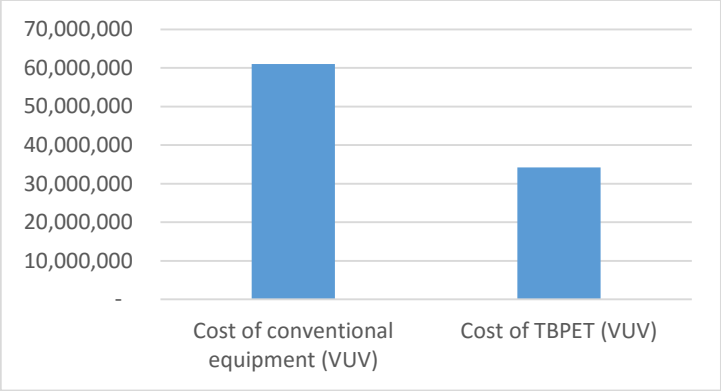

Figure 5: Comparison of purchase costs for a single set of equipment

The cost of initial investment in a single set of TBPE is lower than purchasing a set of conventional equipment with similar functionality.

As different machinery is required for different types of works, an analysis has been made to compare the purchase costs of sets of equipment necessary for undertaking gravelling, reshaping, grading, transportation and loading. The results of this analysis are presented in *Figure 6* below.

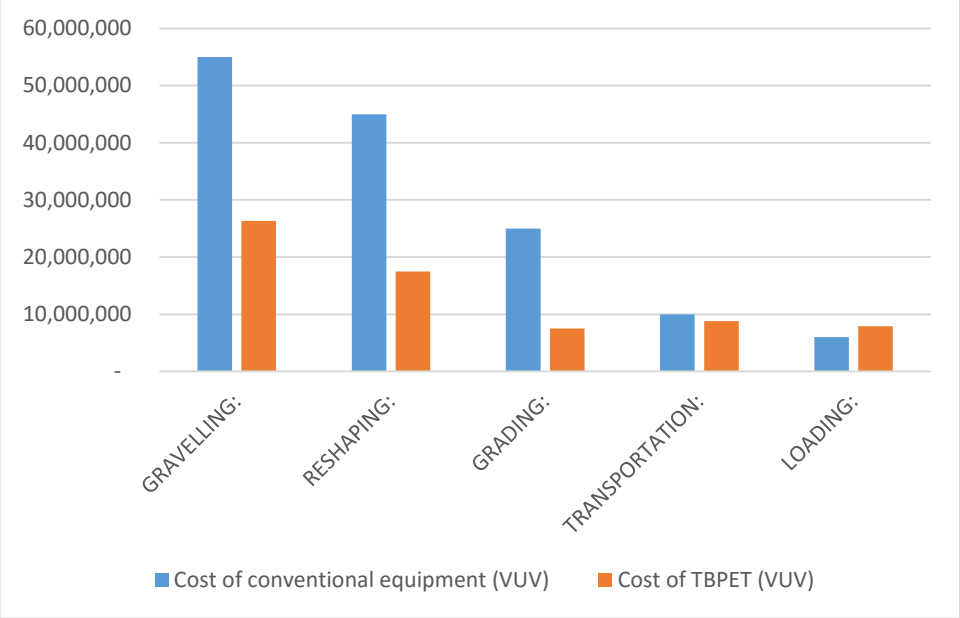

Figure 6: Comparison of purchase costs for equipment relevant to specific types of work

One of the strongest arguments within available literature[10] for using TBPE for road construction and maintenance works is that the purchase costs and ongoing operation and maintenance costs are comparatively lower than those for conventional equipment. However, it is interesting to note that this is not the case with a loader, which is more expensive in a tractor form. The cost of the grader, which is the major expenditure item in a roadworks set of equipment, used for the purpose of this analysis, refers to the use of a typical grader used by PWD. However, the use of a smaller type of the grader (such as a mini-grader now under trial) would significantly reduce the purchase price, without necessarily compromising the quality.

Figure 7 below provides the comparison of the purchase costs for the conventional type of grader, mini grader and tractor with a grader blade. It is interesting to note that the purchase cost of a mini-grader is even lower than the purchase cost of the equivalent TBPE.

[10] See *K. Gongera, R. Petts: Agricultural Tractor Based Solutions for Rural Access and Development, 2014*

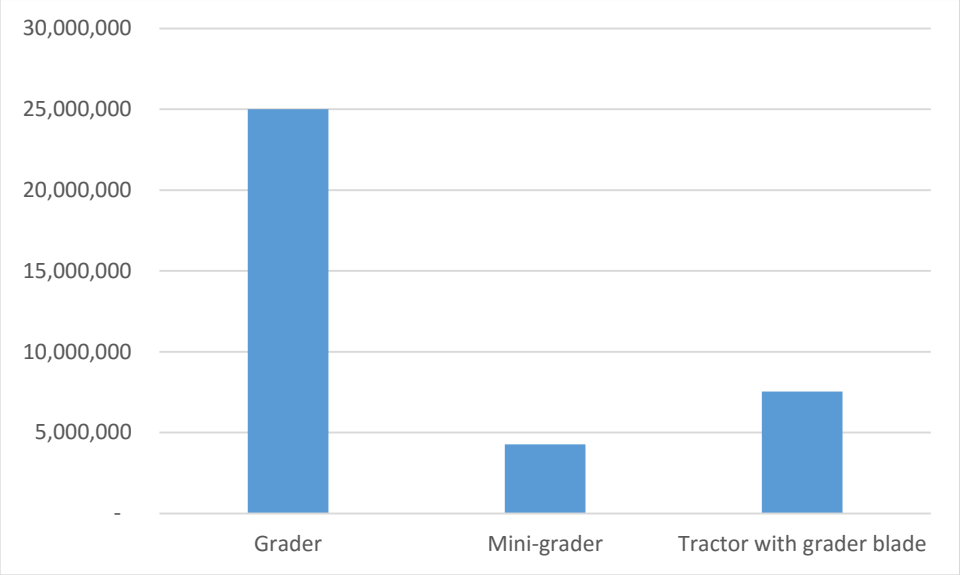

Figure 7: Comparison of purchase costs for conventional, mini-grader and tractor with grader blade suggest that mini-grader would be the favourable option

Comparison of Costs per Unit of Output

The analysis below attempts to identify and describe the comparative costs of each type of work undertaken, such as the cost per length of gravelling, reshaping and grading.

For the analysis, cost per the unit of output was derived from the following available information:

a) Management costs – considered to be the same in both cases;
b) Operator and labour costs - considered to be the same in both cases;
c) Fuel costs – dependent on the type of machinery used;
d) Depreciation costs – dependent on the type of machinery used;
e) Maintenance costs;
f) Observed daily outputs (TBPE);
g) Typical daily outputs for heavy equipment.

Listed below are the TBPE and conventional equipment necessary for the implementation of different types of works and their comparative costing per unit of output based upon the above. A 4m carriageway width was assumed for the calculation purposes.

Plant considered for the analysis within the conventional set is of the type, make and capacity commonly used under PWD's Force Account.

Table 2: TBPE unit costs for different types of works

TBPET - daily outputs and costs			
Type of work	Equipment used for complete set	Unit rate (VUV)	Unit
Gravelling	Tractor with grader blade	5,635,468	km
	Tractor with water tank		
	Tractor with trailer		
	Roller		
Reshaping	Tractor with grader blade	396,990	km
	Tractor with water tank		
	Roller		
Grading	Tractor with grader blade	49,626	km
Transporation of materials	Tractor with trailer	84.10	m3/km
Loading	Tractor with 4-in-1 bucket	782.64	m3

Table 3: Unit costs for different types of works when undertaken by heavy plant

Conventional machinery - daily outputs and costs			
Type of work	Equipment used for complete set	Unit rate (VUV)	Unit
Gravelling	Grader	708,848	km
	Tipper truck		
	Water Bowser		
	Roller		
Reshaping	Grader	248,634	km
	Water Bowser		
	Roller		
Grading	Grader	99,319	km
Transporation of materials	Tipper truck	19.29	m3/km
Loading	Loader 1.3 m3	454.02	m3

The tables above reflect the raw costs per unit of output, but makes no allowance for the difference in quality achieved between using TBPE and traditional heavy plant. Generally the quality of gravelling and reshaping works are much better using heavy equipment, and therefore to reflect this, correctional factors have been applied to these outputs as listed in the table below.

Table 4: Comparison of costs per unit of works (note that correctional factors are applied to TBPE)

	TBPET	Conventional equipment	Unit	Correctional quality factor applied
Gravelling	6,762,561	708,848	km	1.2
Reshaping	416,840	248,634	km	1.05
Grading	49,626	99,319	km	1
Transp. of materials	84	19	m3/km	1
Loading	783	454	m3	1

The colours in the charts below are indicative of the preference of the type of machinery in terms of the cost per unit of output, with red indicating where TBPE is not the preferred option and green indicating where it is.

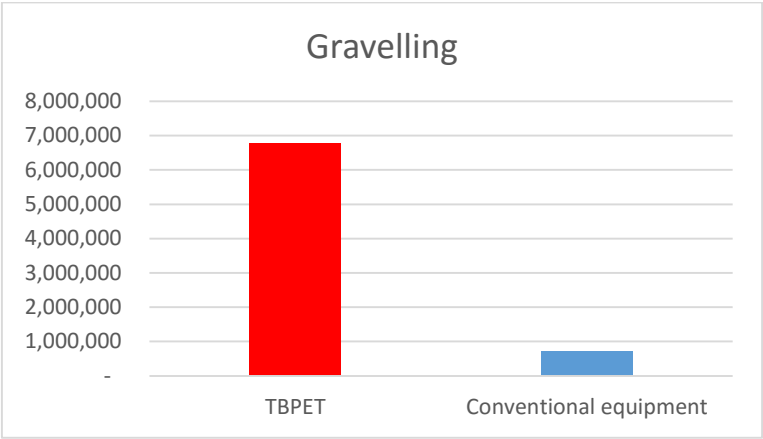

Figure 8: Comparison of unit costs for gravelling works

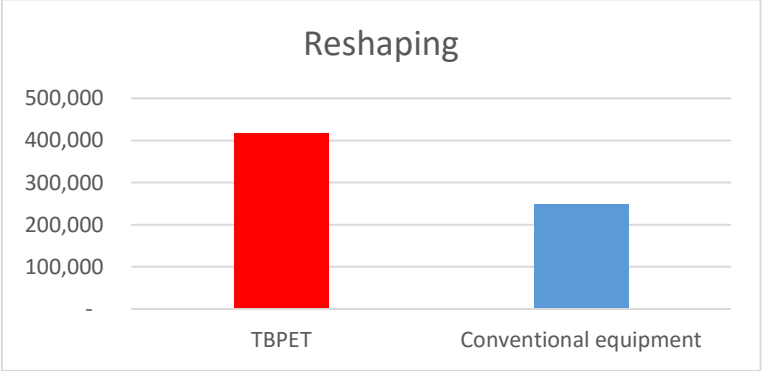

Figure 9: Comparison of unit costs for reshaping works

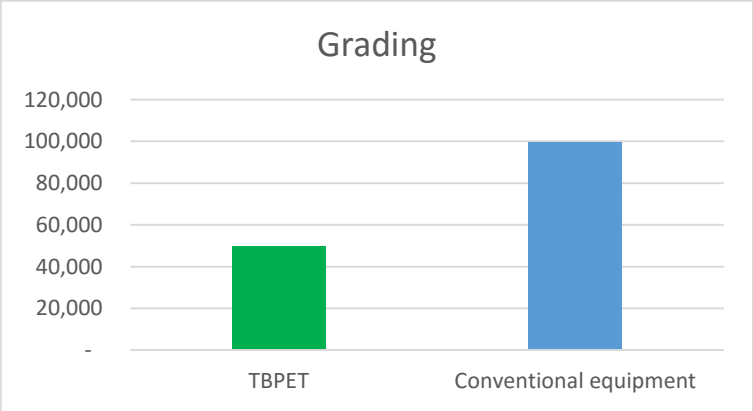

Figure 10: Comparison of unit costs for grading works (note that these are the only works where TBPE is favourable option, but use of a mini-grader provides an even more cost-effective solution)

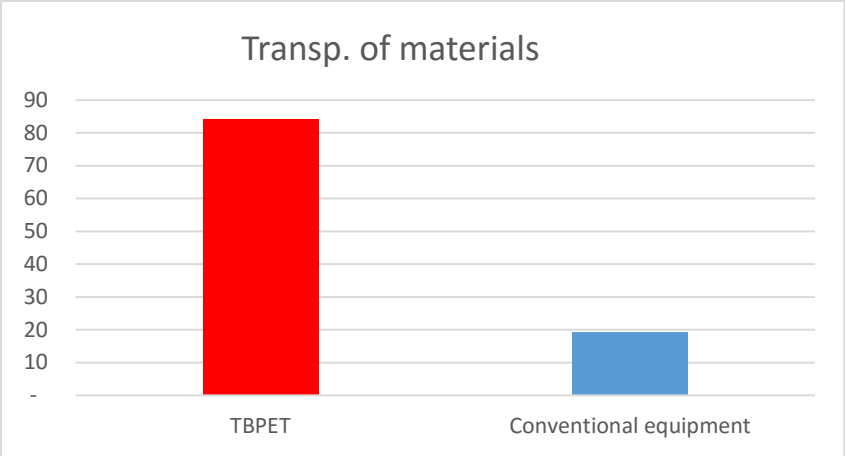

Figure 11: Comparison of unit costs for transportation of materials

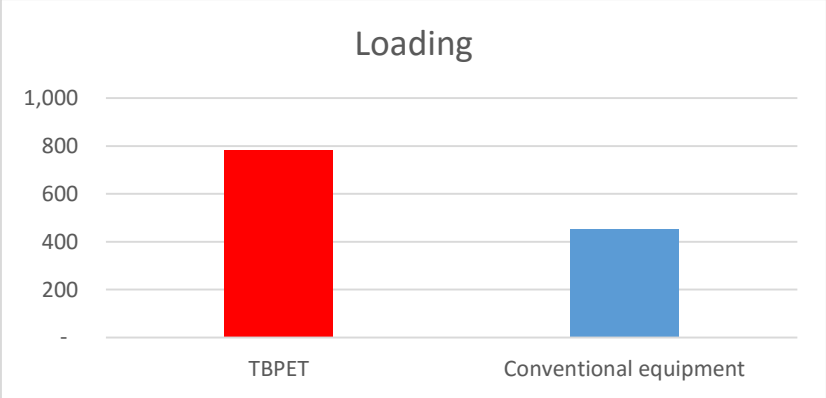

Figure 12: Comparison of unit costs for loading works

Conclusions

TBPE does not provide a cost-effective solution when compared to traditional heavy plant, except in the case of grading, which was proven to be more cost-effective using TBPE. However, our early experience with the mini-grader, which is still under trial, suggests that this will provide a more cost-effective solution than a tractor fitted with a grader blade.

This conclusion is supported by the very low output rates that have been achieved by TBPE, especially in cases when the works require transport of materials, such as gravel and water, where both the slow speed of the tractors and the limited quantities of materials that can be transported contribute to poor productivity.[11]

The cost-effectiveness of TBPE is further devalued by the relatively poorer quality of works achieved by TBPE compared to the quality achieved with a conventional set of equipment.

[11] For example, a tractor trailer can transport 2.5 m3 of bulk material at an average speed of 10 km/h, while a medium-size tipper truck can carry 10 m3 at an average speed of 30 km/h. A medium size truck therefore has 12 times the carrying capacity of a tractor-trailer combination when compared over a similar time period.

Sustainability

Sustainability of the TBPE concept is of major interest for this evaluation.

For the period of the trial, the TBPE was effectively managed like any other Force Account plant and equipment, as it was all handed over to PWD at the start of the trial and assigned to the divisional teams in Tafea (Tanna) and Penama (Ambae). R4D provided an additional layer of management through a dedicated expatriate plant specialist, who assisted with direction and training of the tractor teams, but more importantly managing servicing and repairs of all tractor-based plant and equipment, which was invaluable given the unreliability of the New Holland tractors. Despite this additional layer of management, many of the issues which traditionally hamper force account efficiency were observed:

a) Frequent breakdowns;
b) Lengthy process for procurement of parts resulting in significant downtime, and;
c) Issues associated with unreliability of personnel.

Our conclusion is that based upon the results of this trial, the use of TBPE is not a sustainable model under force account for undertaking roadworks in Vanuatu because of the frequent breakdowns, resulting downtime, and poor cost-effectiveness as described in earlier sections. It can also be concluded that no commercial private organisation would consider using TBPE for undertaking roadworks based upon the results of this trial.

The trial, of course, does not determine whether the selection and use of different a brand of TBPE would result in fewer breakdowns[12]. Perhaps a different brand of TBPE and improved supply & service arrangements could address some of the issues, but this remains unexplored and unproven under this trial.

Image 27: Bucket wear on Ambae, April 2016

Image 28: Broken steering hose, Ambae, April 2016

Conclusions

There is no evidence that would suggest that the sustainability of using TBPE for gravel roadworks could be ensured under either commercial or direct management arrangements, mainly due to frequent breakdowns, and lack of supporting repair and maintenance facilities and services across Vanuatu to minimise downtime. The lack of support network similarly applies to other brands of tractor.

[12] Some available literature advocates use of such equipment for roadworks, but in most cases it was used with the sandy gravels and soils in Africa, which are of significantly different properties than the coronous gravels which prevail as the main pavement construction material in Vanuatu.

Management Arrangements

Observations

For the period of the trial, TBPE operations were being managed by the TBPET Project Manager. All activities were planned and agreed with the respective Divisional Managers of Penama and Tafea provinces, and were undertaken in support of the annual workplan.

Despite this additional management layer, from a management perspective, the TBPE trial was susceptible to similar issues as frequently experienced by force account teams, as follows:

a) Frequent breakdowns and low utilisation rates resulting from the lengthy procurement of spare parts (despite being new pieces of equipment[13]);
b) External interference and numerous exceptional requests;
c) Performance and other personnel-related issues.

Conclusions

No evidence suggests that TBPE can be managed under a divisional force account team more effectively than a team operating a conventional set of equipment. All the same issues apply in both scenarios.

Building on this conclusion, we can also assume that, given the complexities arising from procurement, frequent breakdowns and resulting idle time, TBPE could not be effectively managed by small-scale contractors, such as IBCs.

[13] In comparison, no mechanical problems have been observed with regards to the new set of heavy equipment donated by JICA and which is being operated on Maewo works for almost one year at the moment of writing of this report.

4. Summary of Recommendations

A summary of the key recommendations from this Evaluation Report are summarised below:

To what extent can TBPE effectively support IBCs in undertaking their works?

TBPE should not be considered to supplement existing small-scale contractors, regardless of the management arrangements for such equipment.

What types of works is TBPE suitable for?

TBPE should only be considered for works where the adequacy has been proven from the aspects of quality, cost-effectiveness and sustainability. As such, use of TBPE should be limited to works as indicated in *Annex B* of this report. Such works include:

a) Gravelling (limited application only, conditions apply);
b) Grading (limited application only, conditions apply);
c) Pothole patching;
d) Vegetation control.

Does TBPE provide a sustainable alternative to conventional heavy plant?

The cost comparisons per unit of output suggest that generally tractor based plant and equipment should not be considered as a replacement for conventional heavy plant.

Should PWD (Force Account) and the contracting community be encouraged to use TBPE?

The purchase of new tractor based equipment by either PWD or private contractors is not generally recommended for Vanuatu rural roadworks due to the lack of comparative advantages over conventional equipment. However, PWD could consider purchasing tractors in the future for specialist areas of work where they are proven to be effective, such as the grading of the Ash Plain Road on Tanna.

5. Options for TBPE after Completion of Trial

Although all TBPE was handed over to PWD formally in February 2016, the TBPE Trial in all other respects (project manager, fuel, servicing, repairs, storage and operators) are all currently financed through the R4D grant.

Now that clear conclusions and recommendations have been derived from the trial, it may be drawn to a close in the coming months, with options for use of the TBPE beyond the trial to be presented and discussed with PWD for agreement and implementation.

Since all current TBPE operator employment contracts end on 28 February 2018, this is chosen as the most suitable end-date for formal closure of the TBPE trial. All R4D funding for TBPE will cease at this point.

Period up to End of Trial on 28 February 2018

Plant and Equipment: The focus of the TBPET Project Manager, the Divisional Teams and operators during the remaining three months of the trial must be to repair and maintain all TBPE so that it is in an operational condition for smooth transfer to other activities beyond 28 February 2018. This is a difficult challenge, as at the time of writing this Evaluation Report, all tractors are broken down, some with serious faults such as a cracked gearbox housing, which is under order, but not yet delivered after three months. It is likely that the ongoing maintenance and repairs will require continued inputs by the TBPET Project Manager up to 28 February 2018. At the end of the trial, R4D's TBPET Project Manager will hand over all TBPE-related documentation, including maintenance records, supplier details, spare parts inventory, and status report on each piece of equipment to PWD's Fleet Manager. All TBPE and spare parts will be transferred to the control of the PWD Fleet Manager at this point. From that point onwards, PWD should be responsible for all TBPE as part of their fleet.

Operators: During this close-down period of the trial, HR must hold discussions with all TBPE Operators to explain contract end-dates and opportunities to apply for vacancies within PWD. The R4D HR Specialist will assist the MIPU HR Manager in this task.

Continued Works: It is recommended that only light works which are unlikely to result in further breakdowns and failures of TBPE are undertaken during the final months of the trial. This is necessary to avoid ending the trial period with plant which is not transferable to other activities. This will inevitably mean a scaling back of ongoing and proposed work operations.

Options for TBPE beyond 28 February 2018

The following six options are presented for PWD consideration for use of TBPE beyond 28 February 2018:

1. Transfer TBPE into various Force Account Teams for undertaking limited roadworks operations. A suggested strategy for practical redeployment of TBPE onto the islands of Ambae, Tanna, Santo and Malekula is presented in Annex C.

2. Transfer into force account teams but used for grass-cutting duties only (requires fitting with side-slasher attachments);

3. Transfer to airstrip grass cutting duties within PWD Buildings and Airstrip Division (requires grass-cutting attachments);

4. Transfer to another Government Ministry such as Ministry of Agriculture for use in the agriculture sector;

5. Transfer to an alternative aid program or NGO who could make good use of the equipment;

6. Sell all TBPE to the private sector highest bidder (probably within the agriculture sector).

An initial review of the advantages and disadvantages of these options is presented in the table below.

Table 5: Comparison of Uses of TBPE after Completion of Trial

	1. Transfer to FA for limited roadworks	2. Transfer to FA for roadside grass-cutting only	3. Transfer to PWD Airstrip grass-cutting team	4. Transfer to other GoV Ministry (Agriculture)	5. Transfer to Aid Program or NGO	6. Sell TBPE
Provides services to people of Vanuatu	✓	✓	✓	✓	✓	✓
Provides services to transport sector	✓	✓	✓	×	×	✓
Suitable works for TBPE	×	✓	✓	?	?	?
Long-term sustainability (funds for O+M etc.)	✓	✓	✓	?	?	?
Ease of transfer	✓	✓	✓	x	x	?
Risks/Issues	Additional fleet mgmt burden	Conflicts with established CBC role, needs grass-cutting attachments	Needs grass-cutting attachments	Likely downstream issues due to poor reliability	Likely downstream issues due to poor reliability	-
RANK	3	2	1	5=	5=	4

From this initial high-level analysis, it is concluded that the most appropriate solution is to find a use within Public Works Department for the TBPE which better matches its capability. One ideal solution is to re-purpose the tractors as grass-cutting plant to be used at airstrips throughout Vanuatu. This is a much-needed service within PWD and provides the TBPE with suitable work which is likely to place little strain on the tractors resulting in less frequent breakdowns.

It is recommended that the next step is to hold a joint AHC/R4D/PWD meeting/workshop to explore the options described above further, and to reach agreement on a way forward before putting together a detailed implementation plan to be put into effect on 28 February 2018[14].

[14] Post-Evaluation Report Note: The recommended workshop/meeting was held on 7 Dec and involved AHC/PWD/R4D. The notes of the meeting are included in Annex D.

Annex A: TBPE Purchase Details

Asset No.	Purchase Details							
	Supplier	Description	Asset Category	PO date	Qty	Currency	Unit Cost	Total Amount (Purchase Price)
1	Earthquip Limited	New Holland Tractor with 4-in-1 bucket (AUD95,000@	Plant and Equipment	1/08/2015	1	VUV	7,918,250	7,918,250
2	Earthquip Limited	New Holland Tractor with 4-in-1 bucket (AUD95,000@	Plant and Equipment	Sept 2015	1	VUV	7,744,875	7,744,875
3	Earthquip Limited	New Holland Tractor with 4-in-1 bucket (AUD95,000@	Plant and Equipment	Sept 2015	1	VUV	7,744,875	7,744,875
4	Earthquip Limited	New Holland Tractor Only (AUD76,000@83.30)	Plant and Equipment	Aug 2015	1	VUV	6,330,800	6,330,800
5	Earthquip Limited	New Holland Tractor Only (AUD76,000@81.775)	Plant and Equipment	Sept 2015	1	VUV	6,214,900	6,214,900
6	Earthquip Limited	Tractor Mounted Grader Blade (AUD14,000 @ 86.50)	Plant and Equipment	April 2015	1	VUV	1,211,000	1,211,000
7	Earthquip Limited	Tractor Mounted Grader Blade (AUD14,000 @ 86.50)	Plant and Equipment	April 2015	1	VUV	1,211,000	1,211,000
8	Earthquip Limited	Pedestrian Roller (AUD17,000 @ 86.50)	Plant and Equipment	April 2015	1	VUV	1,470,500	1,470,500
9	Earthquip Limited	Pedestrian Roller (AUD17,000 @ 86.50)	Plant and Equipment	April 2015	1	VUV	1,470,500	1,470,500
10	Earthquip Limited	Pedestrian Roller (AUD17,000 @ 86.50)	Plant and Equipment	April 2015	1	VUV	1,470,500	1,470,500
11	Earthquip Limited	Pedestrian Roller (AUD17,000 @ 86.50)	Plant and Equipment	April 2015	1	VUV	1,470,500	1,470,500
12	Earthquip Limited	Bomag 138-AC5 Combi Roller (AUD69,800@85.70)	Plant and Equipment	25.6.15	1	VUV	5,981,860	5,981,860
13	Earthquip Limited	Bomag 138-AC5 Combi Roller (AUD69,800@84.55)	Plant and Equipment	25.6.15	1	VUV	5,901,590	5,901,590
14	Earthquip Limited	Giltrap Trailer (8 Tonne) - T23-06 (AUD29,000@85.77	Plant and Equipment	20.5.15	1	VUV	2,487,475	2,487,475
15	Earthquip Limited	Giltrap Trailer (8 Tonne) - T23-06 (AUD29,000@85.77	Plant and Equipment	20.5.15	1	VUV	2,487,475	2,487,475
16	Earthquip Limited	Giltrap Trailer (8 Tonne) - T23-06 (AUD29,000@85.77	Plant and Equipment	20.5.15	1	VUV	2,487,475	2,487,475
17	Earthquip Limited	Giltrap Trailer (8 Tonne) - T23-06 (AUD29,000@85.77	Plant and Equipment	20.5.15	1	VUV	2,487,475	2,487,475
18	Earthquip Limited	Water Tanker (AUD42,500@85.455)	Plant and Equipment	25.6.16	1	VUV	3,631,838	3,631,838
19	Earthquip Limited	Water Tanker (AUD42,500@85.455)	Plant and Equipment	25.6.17	1	VUV	3,631,838	3,631,838
20	Earthquip Limited	Giltrap Low Trailer - for C/Roller (AUD27,900@85.775	Plant and Equipment	20.5.15	1	VUV	2,393,123	2,393,123
21	Earthquip Limited	Giltrap Low Trailer - for C/Roller (AUD27,900@85.775	Plant and Equipment	20.5.15	1	VUV	2,393,123	2,393,123
22	Challenge Implements	Rear End Grader 2400 G24 (AUD 13,073.13 @ 85.73)	Plant and Equipment	09-Jun-16	1	VUV	1,120,759	1,120,759
23	Challenge Implements	Tractor Arms, Bucket & Ancillaries (AUD19,482.50 @ 85.73)	Plant and Equipment	09-Jun-16	1	VUV	1,670,235	1,670,235
24	Hebei (China)	Motorised Grader (100hp) with ripper inc freight (USD40,750 @ 0.75)	Plant and Equipment	01-Mar-17	1	VUV	4,278,750	4,278,750
		TOTAL						**85,210,714**

Annex B: TBPE Works Matrix

Legend

	TBPE is suitable for this type of work.
	TBPE is suitable for this type of work only under certain conditions.
	TBPE should not be used for this type of work.

Type of Works	Suitability	Equipment required	Use only under conditions below
Gravelling		1) Tractor with attached grader blade	• Tractor equipment to be used exclusively for spreading the gravel • Tractor equipment to be always used in combination with the conventional equipment for transportation of materials, watering and compaction
Reshaping			
Grading		1) Tractor with attached grader blade	• Apply only on sandy and soft soils
Clearing of drains			

Pothole patching (gravel roads only)		1) Tractor with 4-in-1 bucket and trailer 2) Tractor with attached water bowser or water tank carried on a trailer 3) Pedestrian roller or plate compactor	
Loading			
Transportation of materials			
Vegetation control		1) Tractor with side arm attachment for grass cutting	

Annex C: TBPE – Suggested Force Account Relocation Matrix

Relocation Strategy

Equipment	Current Location	To be relocated to	Types of works to undertake	Proposed work locations
Tractor with 4-in-1 bucket	Ambae	-	• Gravelling • Grading	• Scoria roads
Tractor with 4-in-1 bucket	Ambae	-	• Gravelling • Grading	• Scoria roads
Tractor mounted grader blade	Ambae	-	• Gravelling • Grading	• Scoria roads
Tractor mounted grader blade	Ambae	-	• Gravelling • Grading	• Scoria roads
Combi roller	Ambae	-	• Compaction	• At location of gravelling works
Pedestrian roller	Ambae	Santo	• Compaction	• Anywhere in the province
Pedestrian roller	Ambae	-	• Compaction	• Anywhere in the province
Tipping trailer	Ambae	-	• Pothole patching	• All scoria roads
Tipping trailer	Ambae	Malakula	• Pothole patching	• All gravel roads
Low trailer	Ambae	-	• Transportation of combi roller	• At location of gravelling works
Water tanker	Ambae	Malakula	• Pothole patching	• All gravel roads
Mini - grader	Tanna	-	• Gravelling • Reshaping • Grading	• All gravel roads
Tractor with 4-in-1 bucket	Tanna	Malakula	• Pothole patching • Vegetation control	• All gravel roads • Norsup-Lekan, Norsup-Pankumu River
Tractor with 4-in-1 bucket	Tanna	Santo	• Vegetation control	• East and South Road, central Santo gravel roads
Tractor only	Tanna	-	• Grading	• Ash roads

Tractor mounted grader blade	Tanna	-	• Grading	• Ash roads
Combi roller	Tanna	-	• Compaction	• At location of gravelling works
Pedestrian roller	Tanna	-	• Compaction	• Anywhere in the province
Pedestrian roller	Tanna	Malakula	• Pothole patching	• All gravel roads
Tipping trailer	Tanna	Santo	• Pothole patching	• All gravel roads
Tipping trailer	Tanna	-	• Pothole patching	• All gravel roads
Low trailer	Tanna	-	• Transportation of combi roller	• At location of gravelling works
Water tanker	Tanna	-	• Gravelling • Pothole patching	• At location of gravelling works • All gravel roads

Final TBPE Locations following Relocation

Ambae	Malakula	Santo	Tanna
Tractor with 4-in-1 bucket	Tractor with 4-in-1 bucket	Tractor with 4-in-1 bucket	Mini - grader
Tractor with 4-in-1 bucket	Tipping trailer	Tipping trailer	Tractor only
Tractor mounted grader blade	Water tanker	Pedestrian roller	Tractor mounted grader blade
Tractor mounted grader blade	Pedestrian roller		Combi roller
Combi roller			Pedestrian roller
Pedestrian roller			Tipping trailer
Tipping trailer			Low trailer
Low trailer			Water tanker

Annex D: Record of Follow-Up Meeting 7 December

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AHC/PWD/R4D Meeting

7 December 2017

Use of Tractor-based Plant and Equipment after Completion of Trial.

NOTES OF MEETING

Attendees:

Acting PWD Director	Junior Shim George
AHC First Secretary (Health and Infrastructure)	Megan Kybert
AHC Senior Program Manager	Pamela Carlo
Infrastructure Advisor to AHC	Charles Andrews
R4D Team Leader	Rob Hardy (RH)
R4D HR Specialist	Katrina Doherty

Action by

1.0 Presentation of TBPET Evaluation Report Findings

1.1 RH provided a summary presentation of the evaluation report findings. The slides are attached. The key findings in response to the evaluation questions were:

To what extent can TBPE effectively support IBCs in undertaking their works?

TBPE should not be considered to supplement existing small-scale contractors, regardless of the management arrangements for such equipment.

What types of works is TBPE suitable for?

TBPE should only be considered for works where the adequacy has been proven from the aspects of quality, cost-effectiveness and sustainability. As such, use of TBPE should be limited to works as indicated in Annex B of this report. Such works include:

- Gravelling (limited application only, conditions apply)
- Grading (limited application only, conditions apply)
- Pothole patching
- Vegetation control

Does TBPE provide a sustainable alternative to conventional heavy plant?

The cost comparisons per unit of output suggest that generally tractor based plant and equipment should not be considered as a replacement for conventional heavy plant.

Should PWD (Force Account) and the contracting community be encouraged to use TBPE?

The purchase of new tractor based equipment by either PWD or private contractors is not generally recommended for Vanuatu rural roadworks due to the lack of comparative advantages over conventional equipment. However, PWD could consider purchasing

1

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tractors in the future for specialist areas of work where they are proven to be effective, such as the grading of the Ash Plain Road on Tanna.

2.0 Agreement of End-Date for TBPET

2.1 All parties agreed that since the trial was now complete, and current operator employment contracts expire on 28 February, the trial would be formally closed on 28 February.

2.2 All parties agreed that R4D funding for the trial (operators, fuel, repairs, etc.) would cease on 28 February.

3.0 Agreement on use of TBPE up to 28 Feb 2018

3.1 All parties agreed that tractor-based plant and equipment should be used as little as possible through to 28 February, and the focus should be on the servicing and repair of all tractors so that they are handed over to another function in reasonable working condition. R4D

3.2 TBPE should not be used for heavy works during the period up to 28 Feb 2018. PWD

4.0 Consideration of Options for use of tractors beyond 28 Feb

4.1 It is unclear from the wording of the DFA whether tractors are already under the ownership of PWD, as it is silent on this specific issue. However, formal 'handover' ceremonies from DFAT to PWD were held at the commencement of the trial. All agreed that beyond 28 Feb all TBPE would be under the control and ownership of PWD.

4.2 R4D presented six potential options for use of tractors beyond 28 Feb:

1. **Transfer TBPE into various Force Account Teams for undertaking limited roadworks operations**. A suggested strategy for practical redeployment of TBPE onto the islands of Ambae, Tannam Santo and Malekula is presented in Annex C of the Evaluation Report.
2. **Transfer into force account teams but used for grass-cutting duties only** (requires fitting with side, rear or side-shift adjustable flail mowers)
3. **Transfer to airstrip grass cutting duties** within PWD Buildings and Airstrip Division (requires grass-cutting attachments, probably a simple rear-mounted flail mower)
4. **Transfer to another Government Ministry** such as Ministry of Agriculture for use in the agriculture sector
5. **Transfer to an alternative aid program or NGO** who could make good use of the equipment
6. **Sell all TBPE** to the private sector highest bidder (probably within the agriculture sector).

4.3 All parties contributed to the discussion which concluded with an agreement to use tractors as follows:

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	Option 2: Transfer into FA teams for roadside grass cutting only *Option 3:* Transfer to PWD airstrip grass-cutting duties *Option 6:* Sell TBPE not required for options 2 and 3 through tender, using the funds raised to trial other plant and equipment such as crushers, mini-graders, etc.	
4.4	It was accepted that some tractors could be used for a combination of roadside grass cutting and airstrip grass cutting in some provinces, if that was appropriate.	PWD
4.5	PWD will assess how many of the trial tractors are required to cover Option 2 and 3 duties and report back to R4D/AHC. PWD, with R4D assistance, will assess options for flail mowers, and provide necessary budget for the chosen option.	PWD
4.6	PWD will sell any remaining tractors through tender.	PWD

RPH
07/Dec/2017