



**AFCAP/MOZ/054/B**  
**USE OF ROAD WORKS TO ENHANCE COMMUNITY**  
**WATER SUPPLIES IN MOZAMBIQUE**

**INCEPTION REPORT**

*December 2012*



# AFCAP



This project was funded by the Africa Community Access Programme (AFCAP) which promotes safe and sustainable access to markets, healthcare, education, employment and social and political networks for rural communities in Africa.

Launched in June 2008 and managed by Crown Agents, the five year-long, UK government (DFID) funded project, supports research and knowledge sharing between participating countries to enhance the uptake of low cost, proven solutions for rural access that maximise the use of local resources.

The programme is currently active in Ethiopia, Kenya, Ghana, Malawi, Mozambique, Tanzania, Zambia, South Africa, Democratic Republic of Congo and South Sudan and is developing relationships with a number of other countries and regional organisations across Africa.

## THE PROJECT

Many rural communities in Mozambique have poor access to water, particularly in the dry season. The task of walking long distances to collect water is often left to women and children. Experience in Mozambique has shown that road works can be used to enhance community water supplies.

The purpose of the overall project is to undertake research on using road works to enhance community water supplies on a larger scale in Mozambique.

This phase of the project is aimed at establishing a pilot project through the identification of suitable sites for

- a) the construction of structures for research and demonstration purposes, preparation of engineering designs and tender documents,
- b) the identification of suitable borrow pit sites where water may be stored with appropriate design for harvesting the water, and;
- c) establishing participatory, representative community road pond committees at each of the sites



## TABLE OF CONTENTS

1	INTRODUCTION .....	6
2	MEETINGS.....	6
2.1	ANE Maputo .....	6
2.2	Provincial Meetings .....	7
3	FIELD RECONNAISSANCE .....	7
4	CONCEPTUAL DESIGNS .....	9
4.1	Inhambane Province .....	9
4.1.1	Site INH/1: Nhambuica: Improved Borrow Pit.....	12
4.1.2	Site INH/2: Tambajane: Road Dam .....	13
4.1.3	Site INH/3: Inhamussua: Road Dam.....	15
4.1.4	Site INH/4: Pambarra Calcrete Quarry: Improved Borrow Pit.....	17
4.2	Manica Province.....	18
4.2.1	Site MAN/1: "Gravel": Improved Borrow Pit .....	21
4.2.2	Site MAN/2: Dunda: Road Dam .....	22
4.2.3	Site MAN/3: Magoro: Improved Borrow Pit.....	24
4.2.4	Site MAN/4: Guezanhe: Proposed Road Dam.....	25
4.2.5	Site MAN/5: Tucene: Excavated Reservoir.....	27
5	PRELIMINARY SOCIOLOGICAL SURVEY .....	29
5.1	Introduction.....	29
5.2	Inhambane Province .....	29
5.3	Manica Province.....	30
6	COMMENTS REGARDING ROAD DAMS .....	31
7	WORK PLAN FOR NEXT STAGE.....	32

## LIST OF PHOTOS IN TEXT

Photo 1: Nhambuica: Improved Borrow Pit: .....	12
Photo 2: Tambajane: Proposed Road Dam: .....	14
Photo 3: Inhamussua: Proposed Road Dam.....	16
Photo 4: Pambarra Calcrete Quarry: Improved Borrow Pit.....	17
Photo 5: “Gravel”: Improved Borrow Pit .....	21
Photo 6: Dunda: Proposed Road Dam .....	23
Photo 7: Magaro (Dombe): Improved Borrow Pit.....	25
Photo 8: Guezanhe: Proposed Road Dam.....	26
Photo 9: Tucene: Proposed Off-River Storage in an Existing Borrow Pit .....	28

## LIST OF TABLES IN TEXT

Table 1: Schedule of Meetings with Steering Committee and Other Stakeholders.....	7
Table 2: Roads Reconnoitred in Inhambane Province.....	8
Table 3: Roads Reconnoitred in Manica Province .....	8
Table 4: Inhambane Province: List of Proposed Pilot Project Sites .....	10
Table 5 : Manica Province: List of Proposed Pilot Project Sites.....	19
Table 6 : Estimated Project Costs .....	33

## LIST OF FIGURES IN TEXT

Figure 1: Inhambane Province showing location of road pond pilot projects .....	11
Figure 2: Cross-section of Embankment showing Drop-inlet arrangement .....	15
Figure 3: Manica Province showing location of road pond pilot projects .....	20

## LIST OF APPENDICES

- Appendix (A): Topographical site survey of the borrow pits and dam sites  
Appendix (B): Summary of Sociological data collected for potential sites

## LIST OF ABBREVIATIONS

AfCap	Africa Community Access Programme
ANE	Administração Nacional de Estradas
ARA-Sul	Administração Regional de Águas do Sul
DPOPH	Direcção Provincial das Obras Públicas e Habitação
FRL	Finished Road Level
FSL	Full Supply Level
HDPE	High Density Polyethylene (sheeting)
IL	Invert Level
PI	Plasticity Index
PVC	Polyvinylchloride (pipes)
MZN	Mozambique Meticals
ToR	Terms of Reference
USD	United States Dollar

## UNITS OF MEASUREMENT

m	metre
mm	millimeter
m <sup>3</sup>	cubic metre
km	kilometer
km <sup>2</sup>	square kilometer
ha	hectare
mamsl	metres above mean sea level

## 1 INTRODUCTION

Following a competitive bidding process, Stange Consult GmbH were appointed as Consultant in a Contract dated 13<sup>th</sup> July 2012 for *Use of Road Works to Enhance Community Water Supplies and Climate Resilience in Mozambique (Phase 2a – Design of Water Pilots)*, Contract Reference AFCAP/MOZ/054.

The assignment is to take 6 months commencing 11<sup>th</sup> October 2012. A Pre-Inception Report was submitted on 10<sup>th</sup> November 2012. Other reporting is as follows:-

- Inception Report – 10th December 2012;
- Draft Design Report – 10th February 2013;
- Final Project Report – 10th April 2013.

This report is the Inception Report covering the following activities carried out by the Consultant in the period 11<sup>th</sup> November to 10<sup>th</sup> December 2012:-

- Co-ordination with the project steering committee and other stakeholders;
- Topographical surveys of the road pond (small dams) and borrow pit sites identified for pilot projects in the Pre-Inception Report;
- Initial sociological study of the communities likely to benefit from the pilot schemes;
- Preparation of conceptual designs for each of the road ponds (small dam) structures indicating its location, recommended type of structure, alignment, height of water retaining structure and approximate volume of water to be retained;
- Preparation of conceptual design for demonstration of borrow pit improvements.

## 2 MEETINGS

### 2.1 ANE MAPUTO

Date	Venue	Meeting	Participants
22-11-2012	ANE, Maputo	DIMAN	Mr. M. Coanai Director DIMAN Mr L Fernandes Head Dept.

Meeting with ANE Director DIMAN to explain project, discuss ANE requirements and present the *Pre-Inception Report*.

## 2.2 PROVINCIAL MEETINGS

During the assignment to date, meetings have been held with the project steering committee and other stakeholders as indicated in **Table 1** below.

*Table 1: Schedule of Meetings with Steering Committee and Other Stakeholders*

Date	Venue	Meeting	Participants
17-9-2012	ANE, Maxixe	Inaugural Steering Committee	Steering Committee
22-10-2012	ANE, Maxixe	Second Steering Committee	Mr. Dias Constantino (ARA-Sul) Mr. André Chongo (DPOPH-I)
29-10-2012	ANE, Chimoio	Briefing with ANE representative	Mr. Freitas Edreth
29-10-2012	ANE, Chimoio	Briefing with ANE advisor	Mr. Kuda Machibaya
29-10-2012	ANE, Chimoio	Courtesy call on Scott Wilson (maintenance engineers for Manica)	Mr. Luis Mulingawiza Mr. Taurai Mutangiro
22-11-2012	ANE, Maxixe	Briefing with ANE Delegate	Eng. Fernando Dabo
26-11-2012	ANE, Chimoio	Briefing with ANE Delegate	Eng. Adam Ali Mr. Freitas Edreth
26-11-2012	ANE, Chimoio	Briefing with ANE advisor	Mr. Kuda Machibaya
26-11-2012	ANE, Chimoio	Courtesy call on Scott Wilson	

## 3 FIELD RECONNAISSANCE

Whilst carrying out the topographical surveys of the various road pond (small dam) and borrow pit sites the opportunity was taken to reconnoitre additional roads in both Inhambane and Manica Provinces with totals of 840kms and 583kms reconnoitred respectively. The full list of roads reconnoitred is given in **Tables 2** and **3** below.

*Table 2: Roads Reconnoitred in Inhambane Province*

No.	Designation	Route	Distance [kms]
N222	Secondary	Mapinhane – Mabote – Chicaiane	143
R444	Tertiary	Sitila – Funhalauro	71
R480	Tertiary	Inharrime – Mocumbi	28
R481	Tertiary	Maxixe – Mocoduene – Mavume – Funhalauro	144
R482	Tertiary	Maxixe – Homoioe	23
R484	Tertiary	Nhachengue – Chicomo – Fornos	72
R485	Tertiary	Homoioe – Pembe	25
R900	Vicinal	Morrumbene – Sitila	60
R902	Vicinal	Morrumbene – Mocoduene	18
R908	Vicinal	Cruz. R485 – Fanha-Fanha	10
R911	Vicinal	Homoioe – Mocoduene	20
R918	Vicinal	Lindela – Homoioe	17
R921	Vicinal	Mabote – Mussengue – Cometela – Pambarra	132
	Unclassified	Cruz. R902 – Cambine	5
	Unclassified	Morrumbene – Tambajane	21
	Unclassified	Fornos – Muabsa	20
	Unclassified	Cruz. R484 – Cheline	31

*Table 3: Roads Reconnoitred in Manica Province*

No.	Designation	Route	Distance [kms]
N260	Secondary	Espungabera – Lucite (Dombe) – Chimoio	225
N261	Secondary	Cruz. N7 – Dunda – Macossa	85
R441	Tertiary	Inhacufera – Espungabera	36
R520	Tertiary	Cruz. N1 – Dombe	50
R521	Tertiary	Muxungue – Machaze – Inhacufera	147
	Tertiary	Cruz. R521 – Chibabava	40



## 4 CONCEPTUAL DESIGNS

### 4.1 INHAMBANE PROVINCE

Pilot project sites for two road dams and two improved borrow pits were identified at the Pre-Inception stage of the assignment, viz:-

- Road dams:-
  - Tambajane (Unclassified road from Morrumbene – Tambajane)
  - Muabsa (N222 from Mapinhane – Mabote)
- Improved borrow pits:-
  - 9kms north of Unguana on the N1
  - 11kms north of Homoine on the R485

Levels taken during the topographical survey at Muabsa indicated that on the left bank the proposed embankment had height and length limitations in relation to the existing road (i.e. only a low embankment of less than 2m height was feasible and even this would require an excessively long embankment of 400 – 500m length), which resulted in poor basin characteristics in terms of storage capacity and the depth / storage ratio. Consequently, this site was not considered further.

Although the borrow pit on the R485 Homoine – Pembe road showed some signs of retaining a small amount of water it became apparent that this was from a short length of road side drain discharging into the pit. In effect, up to 1.5km of side drain could be diverted into the pit. However, it is not practicable to run drainage for any great length alongside a gravel road without destroying the road itself through erosion. The solution could be to line the drain but this is not strictly necessary for road functionality since, as in this case, mitres at 50 – 100m spacing are an adequate means of dispersal. Consequently, this borrow pit was not considered further since it was felt that road works would have to be enhanced disproportionately in relation to the amount of water that could be stored in the pit.

Additional field reconnaissance as mentioned in **Section 3** above identified other sites, with the final selection of proposed pilot project sites in Inhambane Province as follows:-

- Road dams:-
  - Tambajane (Unclassified road from Morrumbene – Tambajane)
  - Inhamussua (R482 from Maxixe – Homoine)
- Improved borrow pits:-
  - 9kms north of Unguana on the N1
  - Pambarra calcrete quarry

The salient features of these sites are given in **Table 4** with their locations shown in **Figure 1**.



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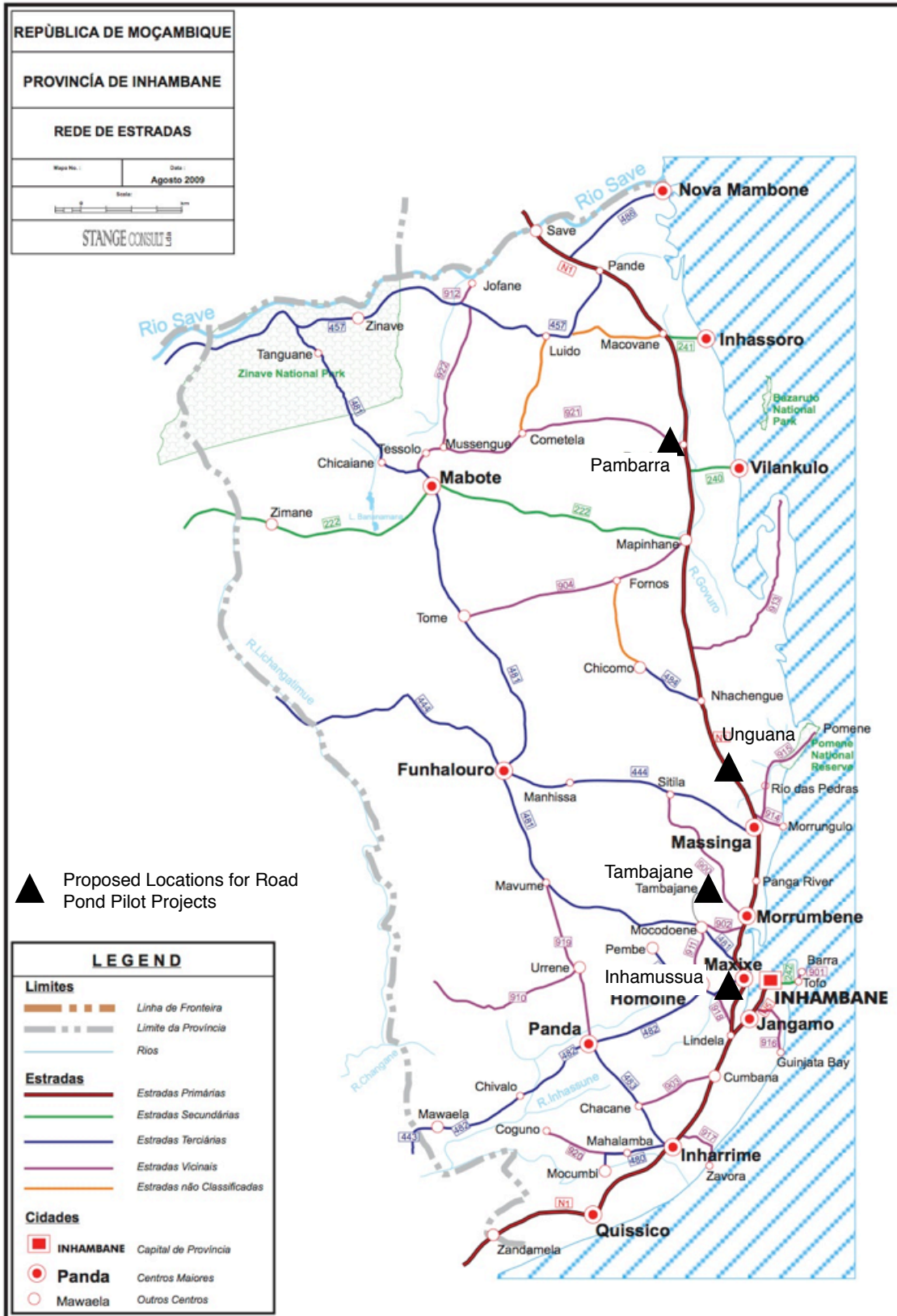
**Table 4: Inhambane Province: List of Proposed Pilot Project Sites**

No.	Name	District	Road	Location	1:50,000 Map No.	Proposed Pilot Project Works	Comments
INH/1	Nhambuica	Massinga	N1	9kms north of Uanguana	1061	Improved borrow pit Sealing of the base and diversion of a lined drain from the N1 into the pit.	The borrow pit has been rehabilitated.
INH/2	Tambajane	Morrumbene	U/C Morrumbene – Tambajane	Tambajane	1093	Road dam Raising of existing embankment with drop inlets into the existing culverts to act as a spillway.	
INH/3	Inhamussua	Homoine	R482 Maxixe – Homoine	11.2kms from Maxixe	1109 1110	Road dam Utilisation of the existing embankment without raising. Drop inlet into existing box culvert to act as a spillway.	
INH/4	Pambarra	Vilankulo	N1 Pambarra Calcrete Quarry	5.7kms from N1	973	Improved borrow pit	Water is retained in part of the quarry and is being used by transient villagers and livestock.

Table 5 : Manica Province: List of Proposed Pilot Project Sites

No.	Name	District	Road	Location	1:50,000 Map No.	Proposed Pilot Project Works	Comments
MAN/1	“Gravel” <sup>2</sup>	Macossa	N261 Cruz. N7 – Macossa	29kms from Cruz. N7	733	Improved borrow pit	The borrow pit retains water all year.
MAN/2	Dunda	Macossa	N261 Cruz. N7 – Macossa	1.5kms west of Dunda	733	Road dam Raising of existing embankment with a drop inlet into the existing culvert to act as a spillway.	There has been a previous, failed, attempt to store water at this site.
MAN/3	Magaro	Sussendenga	N260 Chimoio – Espungabera	4kms west of Dombe	873	Improved borrow pit	The borrow pit retains water all year.
MAN/4	Guezanhe	Machaze	R521 Muxungue – Nhacufera	3.3kms west of Guezanhe	904	Road dam Raising of existing embankment with a drop inlet into the existing culvert to act as a spillway.	There has been a previous, failed, attempt to store water at this site.
MAN/5	Tucene	Sussendenga	R520 Cruz. N1 – Dombe	20kms west of Cruz. N1	874	Excavated Reservoir An extension of the ARA-Sul concept with the feasibility of using an existing borrow pit for off-river storage under investigation.	This is an additional site that shows promise for off-river storage.

Figure 1: Inhambane Province showing location of road pond pilot projects



## 4.1.1 SITE INH/1: NHAMBUICA: IMPROVED BORROW PIT

Of the numerous borrow pits reconnoitred along the N1 in Inhambane Province, this pit was selected because:-

- There are beneficiaries (villagers with livestock) in the immediate vicinity;
- The borrow pit is no longer in use;
- The borrow pit has been rehabilitated to a reasonable standard;
- The borrow pit has a regular shape and covers a relatively large area of 1.34ha;
- The borrow pit has a uniform depth of 4 – 4.5m;
- A 400m length of lined side drain from the N1 can be diverted into the borrow pit.

**Photo 1** illustrates the potential to divert the side drain.



*Photo 1: Nhambuica: Improved Borrow Pit:  
Lined side drain from the N1 can be diverted into the pit,  
which can be glimpsed in the background.*

The topographical site survey of the borrow pit is included in **Appendix A**.

Based on the area of the borrow pit and with diversion of the N1 side drain into the pit, provided the borrow pit can be sealed, an estimated yield of approximately 10,200m<sup>3</sup> could be feasible, which would give a maximum water depth of approximately 2.5m.

However, with the exception of calcrete borrow pits<sup>1</sup>, borrow pits in Inhambane Province do not retain water. This is primarily because they are located in deep porous sandy terrain, the sand itself having been extracted for use as road making material. The flat topography also has an effect in that generally the pits do not have a defined catchment other than the area of the pit itself.

For sand borrow pits to retain water in Inhambane Province, of necessity the pit will need some form of lining. The use of HDPE lining, as in the ARA-Sul Mucuíne (Funhalauro) and Panga excavated reservoirs, is considered to be prohibitively expensive. An alternative, currently under investigation, is to seal the pits by mixing bentonite into a top layer of compacted sand. A local bentonite producer, MIMOC at Mafuíane Quarry near Maputo, has been identified in this regard. The suitability and cost effectiveness of the product will be assessed during the detail design stage of the assignment.

#### 4.1.2 SITE INH/2: TAMBAJANE: ROAD DAM

This site is attractive because Tambajane has good agricultural potential and, to date, the unclassified road from Morrumbene has not been fully rehabilitated. In the event that the road is rehabilitated, the opportunity exists to raise the existing low embankment over the Rio Tendele drainage line that crosses the road in a series of three concrete pipe culverts (i.e. with 1 x single, 1 x double and 1 x triple 900mm dia. concrete pipes) to form a road dam. **Photo 2** illustrates the site and the topographical survey is included in **Appendix A**.

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<sup>1</sup> Calcrete borrow pits include:-

- i) Pambarra calcrete quarry – See Site INH/4
- ii) Inhassane calcrete quarry on the R483 from Inharrime – Panda. Calcrete from this quarry is currently being used on the DIMAN/600 contract. Excavations in the quarry have flooded. The quarry is in a wetland and consequently there is no immediate need to enhance community water supplies.
- iii) There is photographic evidence of water collecting in the calcrete borrow pits along the R481 Mocoduene – Mavume road (at km38). However, these pits are very shallow and do not retain water all year (during the field reconnaissance on 19-10-2012 they were dry) and since the area is sparsely populated they were not considered further.

Provisionally, the principal features of the proposed road dam are:-

- Catchment area – 25 to 30km<sup>2</sup>
- Full Supply level (FSL) – 107.0mamsl
- Storage capacity – 23,116m<sup>3</sup>
- Length of embankment to be raised – 220m
- Finish Road Level (FRL) of embankment – 108.0mamsl
- Invert Level (IL) of existing [lowest] culvert – 105.16mamsl
- Freeboard – 1.0m
- Maximum water depth – 1.8m
- Maximum height of embankment – 2.8m
- Spillway type – Drop inlet of approximately 30m length discharging into the existing pipe culverts – see **Figure 2**

Local knowledge indicates that during the rains water may rise to the top of the existing embankment and in extreme storms it may actually overtop the embankment. As water levels subside shallow ponds of variable depth form both upstream and downstream of the embankment. The proposed road dam would provide a more consistent water depth and therefore reduced evaporation losses



*Photo 2: Tambajane: Proposed Road Dam:  
Existing embankment, incorporating three culverts,  
across the Rio Tendele drainage line is to be raised*

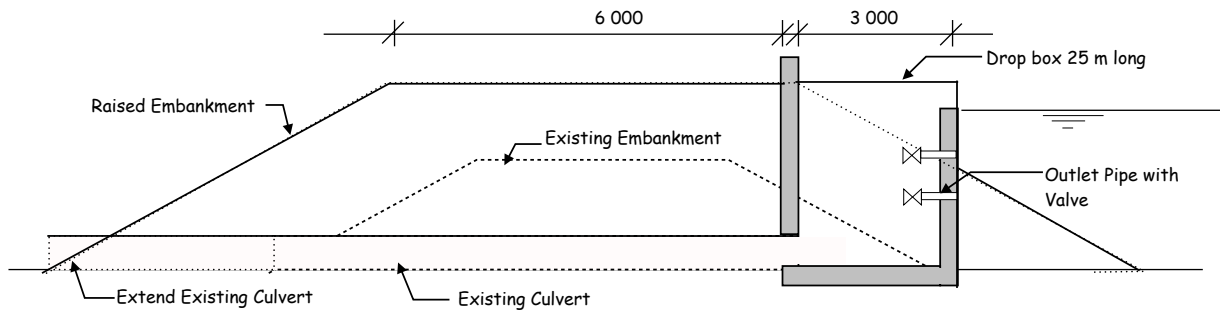


Figure 2: Cross-section of Embankment showing Drop-inlet arrangement

### 4.1.3 SITE INH/3: INHAMUSSUA: ROAD DAM

The site was not initially considered because it is along the R482 road from Maxixe to Homoine currently under reconstruction (under Contract DIMAN/600) to paved standard. There was some concern that using the embankment as a dam could lead to consolidation and, at a later date, distortion of the pavement but the embankment has been in place for over 35 years and the risk from unacceptable consolidation is considered to be minimal.

The drainage line is one of only a few that is not perennial in the dune fields south of Massinga, and the feasibility of using the existing road embankment without raising to provide water for local cultivation is attractive and can be achieved at minimal cost. The embankment incorporates a 3m wide x 2.6m deep concrete box culvert but it is apparent from the catchment that this is over sized. **Photo 3** illustrates the site and the topographical survey is included in **Appendix A**.





*Photo 3: Inhamussua: Proposed Road Dam*

*An existing embankment with box culvert can form a road dam without raising*

Provisionally, the principal features of the proposed road dam are:-

- Catchment area – 5km<sup>2</sup>
- Full Supply level (FSL) – 11.0mamsl
- Storage capacity – 20,000m<sup>3</sup>
- Length of embankment to be raised – Nil
- Finish Road Level (FRL) of embankment over the box culvert – 12.3mamsl
- Invert Level (IL) of existing box culvert – 8.39mamsl
- Freeboard – 1.3m
- Maximum water depth – 2.6m
- Maximum height of embankment – 3.9mm
- Spillway type – Drop inlet of approximately 10m length discharging into the existing box culvert

## 4.1.4 SITE INH/4: PAMBARRA CALCRETE QUARRY: IMPROVED BORROW PIT

Depressions in one corner of the Pambarra calcrete quarry retain water throughout the year, which is used by transient villagers working in the area for drinking, bathing and livestock watering. At the time of the field reconnaissance in late November 2012, two ponds, both heavily polluted from livestock, were in use with drinking water being obtained from two small natural wells on one side. The wet season high water mark indicates that the ponds have a capacity of up to 2,340m<sup>3</sup>. **Photo 4** illustrates the site and the topographical survey is included in **Appendix A**.



*Photo 4: Pambarra Calcrete Quarry: Improved Borrow Pit  
The larger pool is approximately 19m x 15m in extent*

As a source for domestic and livestock water supply, improvements to the overall water quality can be achieved at relatively low cost by the installation of draw-off arrangements that separate the current multiple uses (drinking, bathing, laundry and livestock watering). Improved draw-off arrangements would comprise installation of the following works:-

- Fencing
- Piped outlet in a filter medium to a concrete lined well fitted with a hand-pump
- Separate laundry plinth
- Separate livestock watering trough (fed from the hand-pump)

The hand-pump, laundry plinth and livestock watering trough would be positioned so as to eliminate waste water draining into the pond(s).

## 4.2 MANICA PROVINCE

Pilot project sites for two road dams and two improved borrow pits were identified at the Pre-Inception stage of the assignment, viz:-

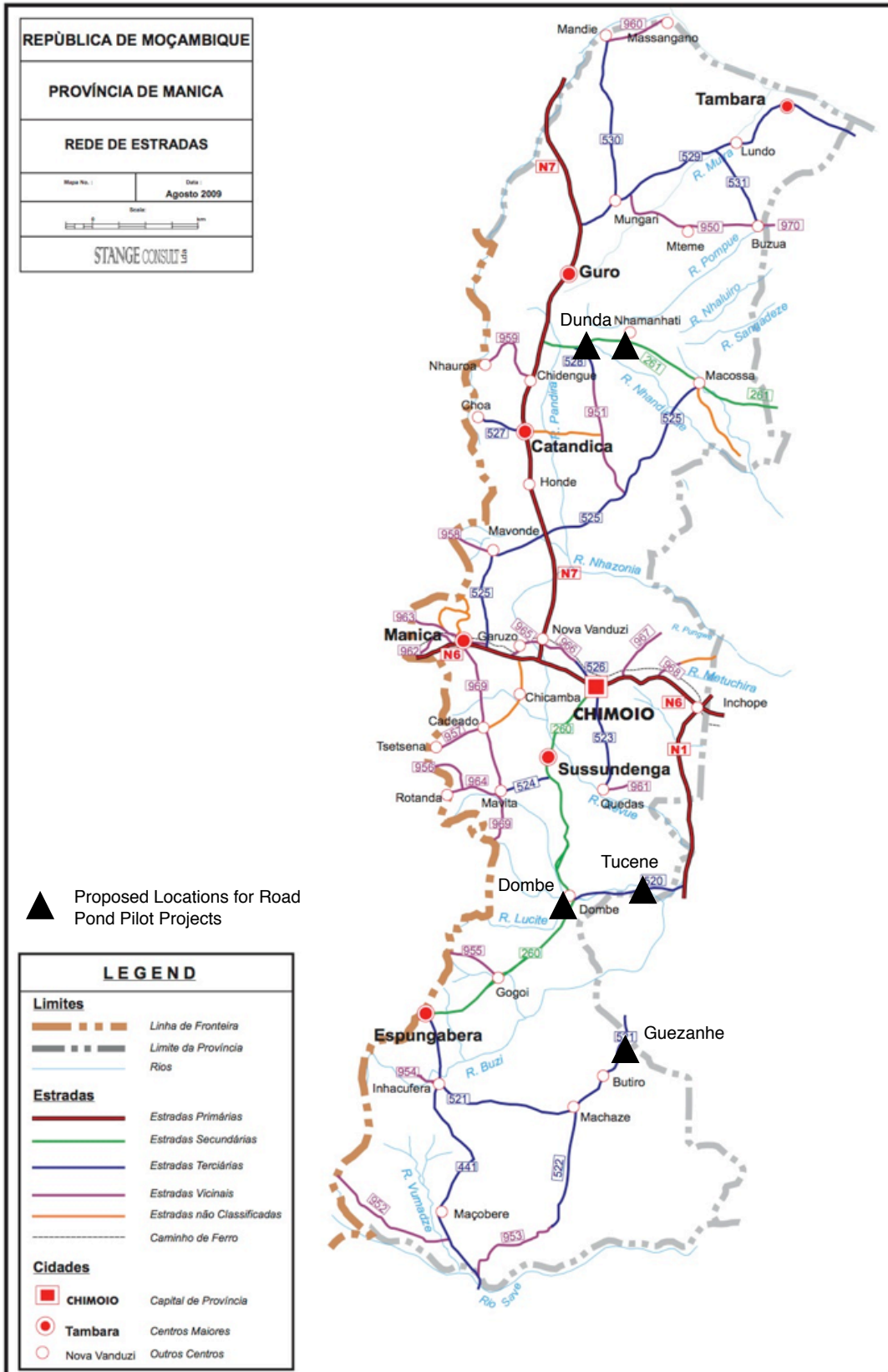
- Road dams:-
  - Dunda (N261 from Cruz. N7 – Macossa)
  - Guezanhe (R521 from Muxungue – Machaze)
- Improved borrow pits:-
  - “Gravel” (N261 from Cruz. N7 – Macossa)
  - Magaro (N260 from Chimoio – Lucite)

The Magaro borrow pit, 4kms west of Dombe, is one of two pits identified at pre-inception stage in the vicinity of Dombe. The other pit, 11kms to the north of Dombe, was discarded because, although it has been rehabilitated to a reasonable standard, after recent rains it failed to retain water and there was only a short length of road drain that could be diverted into the pit.

Additional field reconnaissance, as mentioned in **Section 3** above, identified an existing borrow pit at Tucene, 20kms from the N1 on the R520 Cruz N1 to Dombe road, which has the potential to be developed into an excavated reservoir, similar to the ARA-Sul scheme at Mavanza. What makes the site interesting is the potential for off-river storage from an adjacent tributary of the Rio Lucite.

The salient features of these sites, including the Tucene borrow pit, are given in **Table 5** with their locations shown in **Figure 3**.

Figure 3: Manica Province showing location of road pond pilot projects



## 4.2.1 SITE MAN/1: "GRAVEL": IMPROVED BORROW PIT

The borrow pit is in an arid area 29kms from Cruz. N7 on the N261 Macossa road. Although the pit is rather shallow it nevertheless retains water throughout the year. At the time of the October field reconnaissance it was being used for laundry and livestock watering purposes. At the time of the November topographical survey, plant growth obscured the low water level but livestock continued to drink at the pit. **Photo 5** illustrates the site and the topographical survey is included in **Appendix A**.



*Photo 5: "Gravel": Improved Borrow Pit*

*Water retained into November is used for livestock watering. On the far side is the N261.*

Local knowledge suggests the borrow pit fills during the rainy season. Short lengths of road side drain are also diverted into the pit. In the event, at 1.5m depth the capacity of the pit is 5,610m<sup>3</sup>.

A nearby borehole is under increasing pressure from multiple uses. Water retained in the pit complements the borehole supply especially for laundry, cultivation and livestock watering. Improvements to the pit with draw-off arrangements that separate uses would result in less pollution. These improvements would be similar to those at Pambarra, viz:-

- Fencing
- Piped outlet in a filter medium to a concrete lined well fitted with a hand-pump
- Separate laundry plinth
- Separate livestock watering trough (fed from the hand-pump)

The handpump, laundry plinth and livestock watering trough would be positioned so as to eliminate waste water draining into the pit.

#### 4.2.2 SITE MAN/2: DUNDA: ROAD DAM

In the same arid area as Site MAN/1 above, there are a number of locations along the N261 with good potential for the construction of road dams. A site with good approach gradients was selected 1.5kms west of Dunda where a watercourse crosses the road in a twin 800mm dia. culvert. **Photo 6** illustrates the site and the topographical survey is included in **Appendix A**.

It is apparent that there has been a previous attempt to store water at this site with an earth embankment or “barrage”, as shown on the topographical survey, constructed downstream of the road by Caritas in 2008. Inexplicably the barrage is not located on the watercourse and consequently it has never filled.

Of interest also, and shown on the topographical survey, is an isolated twin 1.0m arch culvert approximately 80m downstream of the road. It is apparent this was constructed many years ago as a prelude to upgrading the road. At 16m, the length of the culvert indicates that an embankment of at least 3m height was anticipated at this location.



*Photo 6: Dunda: Proposed Road Dam*

*The site with an existing culvert is in the sag. Note Dunda Mountain to the right.*

Provisionally, the principal features of the proposed road dam are:-

- Catchment area – 1.5km<sup>2</sup>
- Full Supply level (FSL) – 729.0mamsl
- Storage capacity – 30,172m<sup>3</sup>
- Length of embankment to be raised – 310m
- Finish Road Level (FRL) of embankment – 730.0mamsl
- Invert Level (IL) of existing twin 800mm dia. culvert – 724.0mamsl
- Freeboard – 1.0m
- Maximum water depth – 5.0m
- Maximum height of embankment – 6.0m
- Spillway type – Drop inlet of approximately 10m length discharging into the existing twin pipe culvert

Although the catchment area is relatively small, good run-off is anticipated because of the proximity of Dunda Mountain, which rises to 860mamsl immediately northwest of the site.

A nearby borehole is under increasing pressure from multiple uses. Availability of water from the road dam would relieve pressure from livestock watering and also provide water for cultivation.

### 4.2.3 SITE MAN/3: MAGORO: IMPROVED BORROW PIT

The N260 road from Chimoio to Espungabera via Lucite (Dombe) is under reconstruction to paved standard. As a consequence, there are numerous borrow pits alongside the road, many still in use. A borrow pit 4kms to the west of Dombe, in the commune of Magaro on the right bank of the Rio Mussapa, is one such pit from which material was extracted for the abutments to the Lucite and Mussapa high level bridges. **Photo 7** illustrates the site and the topographical survey is included in **Appendix A**.

The borrow pit is reported to retain water all year and during the topographical survey in November, at the end of the dry season, the estimated water depth was 1.5m, which equates to a stored volume of approximately 1,679m<sup>3</sup> covering an area of approximately 0.36ha. The water is used for bathing, laundry, recreation and livestock watering in preference to the nearby perennial Rio Lucite where there is an ever present danger from crocodiles. Rio Mussapa is seasonal. During cyclonic events (in 2000 and 2007) the Rio Lucite backed-up the Rio Mussapa which then overflowed into the borrow pit.

The borrow pit, which has been rehabilitated with relatively gentle side slopes, covers an area of 3.2ha and, as such, has its own relatively large catchment with a potential yield of approximately 11,000m<sup>3</sup>, assuming 50% run-off. Storage of this volume would see the water level rise slightly above the 153.0mamsl contour and cover an area of approximately 1.0ha.

A number of households surround the pit. However, towards the end of the dry season, they refrain from using the water in the pit because of pollution and a bad smell. Much of the pollution results from multiple uses, especially bathing and laundry activities, which progressively increase the pollution load in the diminishing water volume, and from livestock watering.





*Photo 7: Magaro (Dombe): Improved Borrow Pit  
A relatively large, reportedly perennial body of water used for laundry,  
recreation and livestock watering*

Improvements to the pit with draw-off arrangements that separate uses would result in less pollution. These improvements would be similar to those at Pambarra and “Gravel”, viz:-

- Fencing
- Piped outlet in a filter medium to a concrete lined well fitted with a hand-pump
- Separate laundry plinth
- Separate livestock watering trough (fed from the hand-pump)

The hand-pump, laundry plinth and livestock watering trough would be positioned so as to eliminate waste water draining into the pit.

#### **4.2.4 SITE MAN/4: GUEZANHE: PROPOSED ROAD DAM**

There are a number of locations along the R521 from Muxungue to Machaze, which traverses an arid area, with good potential for the construction of road dams. A site with very good approach

gradients was selected 3.3kms west of Guezanhe where the headwaters of Rio Tomere cross the road in a triple 800mm dia. culvert. **Photo 8** illustrates the site and the topographical survey is included in **Appendix A**.



*Photo 8: Guezanhe: Proposed Road Dam  
R521 crossing of Rio Tomere headwaters in a triple 800mm dia. culvert.  
Note the very good approach gradients for raising the embankment.*

There has been a previous attempt to store water at this site with an earth embankment or “barrage” constructed approximately 200m downstream of the road culvert. It is reported the embankment was breached on first-filling, most probably due to poor compaction and / or the lack of or an undersized spillway. The breach was repaired in 2006 with a masonry wall financed by the Government of Belgium. However, although there is evidence of the barrage spilling, it is reported not to retain water for more than 2 – 3 days, the water most likely being lost through seepage beneath the masonry wall, which does not have a positive cut-off.

The community of Chitendeua lives in the vicinity of the site. The nearest borehole is 3.3kms distant in Guezanhe. The Guezanhe borehole is part of a Ministry of Agriculture nursery for cashew trees and comprises a motorised pump (Lister diesel engine) and a 20,000 litre overhead steel tank serving the nursery and two water fountains for public use. There is intense competition at the water fountains between people and livestock. Consequently, there is a need to enhance water supplies for the community.

Provisionally, the principal features of the proposed road dam are:-

- Catchment area – 3.0km<sup>2</sup>
- Full Supply level (FSL) – 272.0mamsl
- Storage capacity – 28,237m<sup>3</sup>
- Length of embankment to be raised – 170m
- Finish Road Level (FRL) of embankment – 273.0mamsl
- Invert Level (IL) of existing triple 800mm dia. culvert – 266.8mamsl
- Freeboard – 1.0m
- Maximum water depth – 5.2m
- Maximum height of embankment – 6.2m
- Spillway type – Drop inlet of approximately 15m length discharging into the existing triple pipe culvert

#### 4.2.5 SITE MAN/5: TUCENE: EXCAVATED RESERVOIR

Additional field reconnaissance as mentioned in **Section 3** above identified an existing borrow pit along the R520 road from Cruz. N1 to Dombe with the potential for off-river storage. The borrow pit is 20kms from Cruz. N1 and is within 100m of a left-bank tributary of the Rio Lucite. The tributary is crossed by a twin 4m span x 4.5m high bridge, 100m to the east of the borrow pit. **Photo 9** illustrates the site and the topographical survey is included in **Appendix A**.



*Photo 9: Tucene: Proposed Off-River Storage in an Existing Borrow Pit*

Off-river storage would take the form of an excavated reservoir by deepening the existing borrow pit, similar to the ARA-Sul scheme at Mavanza. Although the river bed is lower than the base of the borrow pit, i.e. 121.0mamsl and 122.0mamsl respectively, it appears feasible to excavate a channel, approximately 200m in length, from a bend in the river to the borrow pit. Of necessity the borrow pit would have to be deepened in order to provide off-river storage capacity. Deepening by 4.0m would provide an estimated storage capacity of approximately 6,000m<sup>3</sup> below the river bed level of 121.0mamsl.

A trial pit excavated to a depth of 2.1m in the base of the borrow pit indicates that the underlying material is a hard yellowish / grey clay. Consequently, seepage losses are likely to be minimal.

The scheme for an excavated reservoir at Tucene is not strictly within the ToR for road works to enhance community water supplies. However, it is included out of interest and also because of its similarity with the ARA-Sul scheme in Mavanza.

## 5 PRELIMINARY SOCIOLOGICAL SURVEY

### 5.1 INTRODUCTION

Preliminary sociological surveys were carried out at each of the sites using the structured questionnaire that was presented in the *Pre-Inception Report*. In conjunction with field observations, the preliminary survey provides sufficient inputs for the planning of project interventions. The main relevant social characteristics of the project sites are described below. Some relevant social characteristics of the project sites are given in **Appendix B**.

### 5.2 INHAMBANE PROVINCE

#### Population

Nhambuica, Tambajane and Inhamussua are established communities with estimated populations of 1,000, 9,800 and 1,500 respectively. Pambarra is habituated by transient stone breakers, woodcutters and charcoal makers.

#### Livestock

At each site there exists between 13 and 120 cattle. Also present are goats, pigs and donkeys.

#### Water availability and usage

The main source for drinking and cooking in the three permanent communities are boreholes, installed from 1997 – 2004 by Government and NGO's, distanced between 0.2 and 4.0kms from users. Two of them (Tambajane and Inhamussua) provide good quality water. Meanwhile the borehole in Nhambuica has broken down and an alternative borehole is quite far away and only provides saline water. At the time of the interview the borehole in Inhamussua was not working because the electric pump had been stolen.

The main source for drinking and cooking of the transient population in Pambarra is a polluted quarry pond. Their alternative source is a borehole on the N1, at 5.4km distance.

Alternative sources for communities are rivers and river ponds (Tambajane and Inhamussa), private wells (Tambajane) and yard tanks (Nhambuica). Incidence of malaria at sites ranges from plenty to very bad.

Water from boreholes is reported as generally being good. Nevertheless, there are plenty of stomach complaints.

Cultivation at sites is rainfed, except at the Inhamussua Ministry of Agriculture planting zone, which has a separate pumped system from the Rio Inhanombe.

### **Constraints**

A common problem is the breaking down of boreholes. There is generally no preventative maintenance or management of the water supply systems by the community. In the event of breakdowns, households contribute small cash amounts for spare parts and repair.

### **Need for improvement**

With the exception of river ponds, which are seasonal, the sources provide water all year round. Nevertheless, the availability of water from boreholes is perceived as not enough, particularly during the dry season when there is competition from livestock and generally no water for cultivation. There is a perceived need of increased water availability for cultivation in Inhamussua. As an alternative to a community borehole, households in Nhambuica are seeking permission for drilling private boreholes.

## **5.3 MANICA PROVINCE**

### **Population**

The total population of the four sites is 4,786 people, ranging from 41 (Dunda) to 3,000 (Magaro).

In “Gravel” there are 20 households, in Dunda 5, in Magaro 272, in Guezanhe 250 and in Tucene 135. Households are generally composed of the head of household (male), 1 to 3 women and 5 to 11 children.

### **Livestock**

Tucene has the largest amount of cattle (over 100) and goats (over 1,000), followed by Magaro with 20 cattle and 1,000 goats. “Gravel” and Dunda report no cattle but have around 20 goats each. Chickens are common, at least 30 birds per household. Other livestock includes sheep, turkeys, guinea fowl and a few donkeys.

### **Water availability and usage**

Water for drinking and cooking in all communities is from boreholes (one per community), installed by Government and NGO’s. Boreholes are localised between 50 and 400m from community centres. They provide good quality water all year. In three communities, water from

boreholes is also used for bathing and laundry. Nevertheless, of the perceived good water quality, plenty of stomach illnesses have been noticed in all communities.

Community maintenance systems for boreholes consist mainly of household cash contributions for the purchase of spare parts and technical support when broken down.

Alternative water sources are rivers, river pools and borrow pits (two communities). These are the main sources for livestock watering. Water from the Rio Lucite is available all year round at Magaro and Tucene but there is an ever present danger from crocodiles.

### Constraints

The availability of water in borrow pits is affected when the beginning of the rainy season is late. The quality of water in borrow pits is affected by pollution from multiples uses and livestock. River pools and borrow pits constitute breeding grounds for mosquitoes, as perceived in “Gravel”. The incidence of malaria is high at all sites. Bilharzia also is common.

### Needs for improvement

The perceived need of communities is for more boreholes (especially at Magaro and Tucene, which have high populations and large numbers of cattle and are also at risk from crocodiles in the Rio Lucite), and for more water for cultivation (in this regard “Gravel” and Dunda are cotton growing areas). There is also a need to improve the availability and quality of water where borrow pits are in use. A sustainable control system for mosquitoes should also be investigated, perhaps by the introduction of fish.

## **6 COMMENTS REGARDING ROAD DAMS**

With regard to road dams, the distinction between road works and dam works requires clarification - The proposed Guezanhe road dam, i.e. Site MAN/4 in section 4.2.4 above, illustrates the point.

There has been a previous attempt to store water discharging from the pipe culvert at Guezanhe by dozing-up a barrage about 200m downstream of the culvert. This failed on first filling, most probably due to the lack of, or an undersized, spillway and/or because the barrage was un-compacted. Repairs in 2006 comprised a masonry wall, 1.5m in height incorporating a “spillway” or overflow of 4 nr x 200mm dia. AC pipes set at a high level, which have spilled. However, the “barrage” does not hold water for more than a couple of days, presumably because of seepage occurring beneath the masonry wall.

It is feasible to construct a relatively short 5m high embankment over the culvert thereby creating a road dam. However, there is still no guarantee that the “dam” will retain water because, without a positive cut-off, there may be excessive seepage beneath the road bed. In essence, we are now moving from road works into the realms of dam works. The cut-off and, indeed, the raised embankment are not strictly necessary for the road to function but they are necessary to enhance water storage potential.

From a design point of view, placing a road on embankment is necessary for two main reasons, often in combination, viz:-

- To improve the vertical alignment through a sag;
- To achieve sufficient height over a drainage structure to avoid flooding.

Neither reason is strictly applicable at Guezanhe but for purposes of the pilot project this site is representative and has been included for consideration.

Our understanding of the assignment is that the use of road works to enhance community water supplies should be at minimal additional cost to actual road construction. An estimate of \$40,000 per site was suggested by ANE in the Feasibility Study. This amount is at odds with, for example, the cost of approximately \$300,000 for the Birira road dam (weir) in Tete Province.

It must be noted that even the estimate of \$40,000 is relatively high in relation to the cost of \$8,000 to \$10,000 for drilling and equipping a borehole, subject to hydro-geological conditions being suitable for ground water extraction. However, some costs can be offset against the cost of the structure.

Ground water, unless saline, has the advantage of better quality in comparison to surface water sources from road ponds, i.e. either road dams or improved borrow pits, which can exacerbate health risks in the form of malaria and bilharzia.

A suggestion is that the use of road ponds to enhance community water supplies should complement existing boreholes with their use restricted more to livestock watering, cultivation and possibly some form of aquaculture.

## 7 WORK PLAN FOR NEXT STAGE

The Work Plan for the next (detail design) stage of the assignment will focus on carrying out the following activities:-



- Preparation of detailed technical designs and specifications for the pilot road pond structures;
- Establishment of participatory representative community road pond committees at each of the sites.

With regard to the detail design for borrow pit improvements we are proposing to utilise standard designs currently in use by ARA-Sul for the following components:-

- Fencing
- Well construction complete with apron and “Afridev” handpump;
- Laundry plinth;
- Livestock drinking trough.

The design of road dams is commented on in section 6 above. For purposes of this project the proposed dams will be designed using normal road embankment design criteria. Where possible existing embankments will be used or raised to achieve required storage.

**Table 6** below indicates preliminary cost estimates.

*Table 6 : Estimated Project Costs*

<i>Project</i>		<i>Main Work Items</i>	<i>Plan Estimated Cost USD</i>
<b>INHAMBANE</b>			
Site INH/1:	Nhambuica: Improved Borrow Pit	Addition of Bentonite to surface to make it impervious. Provision of fencing, water extraction and water distribution points.	45,000
Site INH/4:	Pambarra Calcrete Quarry: Improved Borrow Pit	Provision of fencing, water extraction and water distribution points.	15,000
Site INH/2:	Tambajane: Road Dam	3,000 m <sup>3</sup> earthworks - construct drop inlet.	60,000
Site INH/3:	Inhamussua: Road Dam	Use existing embankment - construct drop inlet.	20,000
<b>MANICA</b>			
Site MAN/1:	“Gravel”: Improved Borrow Pit	Provision of fencing, water extraction and water distribution points.	15,000
Site MAN/3:	Magoro: Improved Borrow Pit	Provision of fencing, water extraction and water distribution points.	20,000
Site MAN/2:	Dunda: Road Dam	14,000 m <sup>3</sup> earthworks - construct	180,000

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		drop inlet.	
Site MAN/4:	Guezanhe: Proposed Road Dam	8,000 m <sup>3</sup> earthworks - construct drop inlet.	60,000
		<b>Total Estimated Cost</b>	<b>415,000</b>