



**AfCAP**  
Africa Community Access Partnership



## Long Term Pavement Performance Monitoring of Trial Sections in Mozambique incorporating Capacity Building of Road Research Centre Personnel

### Inception Report



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*Project No. MOZ2093A*

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Cover Image: Construction of Trial Sections under AFCAP 1

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## ReCAP Completion Report Template

ReCAP Database Details: Economic Growth through Effective Road Asset Management			
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Theme		Sub-Theme	
Lead Implementation Organisation	Civil Design Solutions	Partner Organisation	Paige-Green Consultants Independent Software ASCO (Z) (Pvt) Limited
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## **Abstract**

AfCAP is assisting the Mozambique National Roads Administration (ANE) to evaluate existing road experimental sections constructed previously in Mozambique. These trial sections were designed to demonstrate and verify different options in design, material utilisation and construction methods for rural roads. The ultimate objective is to influencing future policy in the road sector.

The objectives of the project are to evaluate the data available from the existing trial sections, refine and implement regional guidelines and protocols for the establishment and monitoring of road trials, and to assist ANE to identify and establish new trial sections.

The project has a strong capacity development component for the emerging ANE Road Research Centre. It will assist the RRC in the development of an Electronic Document Management System (EDMS) to manage data generated from the trial sections and other research projects. Capacity building and training of the RRC personnel will include data input, processing and archiving of research data, including implementation of the regional protocols, and preparation of technical papers. The RRC is expected to take the lead in the research process from the outset.

The Inception Report is the first output of the project. It includes a summary of discussions held at the Kick-Off Meeting, a summary of documents obtained by the Consultant and an initial list of trial sections. Initial proposals for the capacity development component and research database are given, as well as proposals for additional inputs by the technical experts.

## **Key Words**

Rural Roads, Design Standards, Capacity Development

## **Acronyms, Units and Currencies**

\$	United States Dollars
AFCAP	Africa Community Access Partnership
ANE	Administração Nacional de Estradas; National Road Administration
ARMFA	African Road Maintenance Fund Association
ASCAP	Asia Community Access Partnership
BADEA	Arab Bank for Economic Development in Africa.
CDS	Civil Design Solutions
CSIR	Council for Scientific and Industrial Research
DFID	Department for Further International Development
DIMAN	Directorate of Maintenance
DIPLAN	Directorate of Planning
DIPRO	Directorate of Projects
EDMS	Electronic Document Management System
EU	European Union
FWD	Falling Weight Deflectometer
GDP	Gross Domestic Product
GPS	Global Positioning System
LEM	Engineering Laboratory for Mozambique
LNEC	Laboratório Nacional de Engenharia Civil (Portugal)
LVR	Low Volume Road
LVSR	Low Volume Sealed Road
PMU	Project Management Unit
RAI	Rural Access Index
ReCAP	Research for Community Access Partnership
RRC	Road Research Centre
SC	Steering Committee
UK	United Kingdom (of Great Britain and Northern Ireland)
UKAid	United Kingdom Aid (Department for International Development, UK)

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## **1 Introduction**

### **1.1 Background to the Project**

The Africa Community Access Partnership (AfCAP) is building on the programme of high quality research established under AfCAP phase 1 and taking this forward to a sustainable future. The aim is to ensure that the results of the research are adopted in practice and influence future policy in the roads sector.

As part of this initiative AfCAP is assisting the Mozambique National Roads Administration (ANE) to evaluate existing road experimental sections constructed previously in Mozambique under several programmes, including with AfCAP support. These trial sections were designed to demonstrate and verify different options in design, material utilisation and construction methods for rural roads (particularly low-volume rural roads- LVR).

Useful data have already been obtained from both old and newer trial sections and some have been monitored over time by ANE and with the support of AfCAP and TRL (UK). In order to achieve the objective of influencing future policy in the road sector, it is necessary to review the outcomes of more of the trial sections constructed in Mozambique and to start a process of establishing new trial sections.

As-built information and performance data are available from previous project reports but may not be consistent between the projects and over the monitoring periods. Also, the establishment of the trial sections was not always geared towards providing all of the data that will enable researchers to assess the performance of the pavements. A monitoring protocol will therefore be developed for Mozambique for the establishment and monitoring of experimental sections. The protocol will be based on existing guidelines currently being applied on AFCAP projects in Kenya and Ethiopia, which are being used as a basis for development of standard regional protocols. Reference will also be made to the draft protocol for establishing LTPP sections that was prepared by CSIR in their work on the ANE RRC strategic plan, which was prepared in 2014. The protocols will be harmonised under a separate regional research project known as “Development of guidelines and specifications for low volume sealed roads through back analysis – phase 1” (RAF2069A).

### **1.2 Objectives**

The objectives of the project are as follows:

1. To evaluate the nature and quality of information available from the existing trial sections.
2. To refine and implement existing regional guidelines and protocols to ensure that the establishment of road trials and collection of the information is standardised across Mozambique and the African region.
3. To establish new trial sections, and to collect data on the old and new trial sections in Mozambique on a consistent and continuous basis over a number of years.

ANE RRC is the agency responsible for the implementation of the research programme. The project Objectives will therefore be achieved through a team effort between the ANE RRC and the advisory team. This “Long Term Pavement Monitoring” programme is expected to continue for a minimum of 5 years. The advisory team will assist ANE RRC in the project tasks over the first 15 months.

The project will provide training and capacity building to the ANE Road Research Centre (RRC) for the development of an Electronic Data Management System (EDMS) to manage data generated from the trial sections and other research projects. Capacity building and training of the RRC personnel will include data input, processing and archiving of research data, including implementation of the regional protocols.

### 1.3 Project Team

The Project Team will be led by the Director of Maintenance in ANE. He will have overall responsibility for the delivery of the project objectives.

The Project Team includes the RRC members, who are drawn from ANE (DIMAN and DIPRO), ANE Provincial Delegations, and LEM. At present, none of the RRC members are full time researchers. They all have other responsibilities. However, some are expected to be assigned full-time to the RRC as the research programme develops.

The advisory team provided by CDS comprises the following:

- Project Director (Richard Rawson)
- Team Leader (Robert Geddes)
- Materials Expert (Phil Paige-Green)
- Assistant Team Leader (Adilson Vilinga)
- Data Management Expert (Alexander van Oostenrijk).

The responsibilities of the advisory team members are summarised in the table below.

**Table 1-1: Advisory Team Responsibilities**

Position	Responsibilities
Project Director	<ul style="list-style-type: none"> <li>• Oversight of project activities</li> </ul>
Team Leader	<ul style="list-style-type: none"> <li>• Planning and coordination of the advisory team activities</li> <li>• Advising ANE RRC on research programme</li> <li>• Development of capacity building plan</li> <li>• Liaison with AFCAP PMU and ANE Management</li> <li>• Coordination and delivery of advisory team reports.</li> </ul>
Materials Expert	<ul style="list-style-type: none"> <li>• Review of regional and international protocols for long term pavement performance monitoring</li> <li>• Preparation of draft protocol for LTPP monitoring for Mozambique.</li> <li>• Identification of research projects for RRC</li> </ul>

Position	Responsibilities
	<ul style="list-style-type: none"><li>• Review of RRC research outputs</li><li>• Training and mentoring of RRC staff.</li></ul>
Assistant Team Leader	<ul style="list-style-type: none"><li>• Assistance to Team Leader on planning and logistical organisation</li><li>• Accompanying RRC research teams on site work</li><li>• Training and mentoring of RRC staff</li><li>• Preparation of site visit reports.</li></ul>
Data Management Expert	<ul style="list-style-type: none"><li>• Development of research database</li><li>• Training and mentoring of RRC staff.</li></ul>

#### 1.4 Outputs

The outputs of the project will include:

- Inception report.
- Technical reports following each in-country visit, including reports on any workshops and training carried out.
- An electronic relational database of LVSR performance and related road design and environmental impact factors linked into the regional database.
- Technical papers and other dissemination materials: ANE RRC researchers will be assisted to prepare technical papers for presentation at national, regional and international forums and for publication in recognised journals.
- Capacity building and skills development report.
- Final Report of the project.

#### 1.5 Purpose of this Report

This report covers the activities carried out in the Implementation Phase of the project. It includes a record of the Kick-Off Meeting held at ANE offices on 6<sup>th</sup> October 2016, the outline of the project approach to capacity development in the RRC, recommendations for the research database, and planned activities for the next phase of the project implementation.

## **2 Approach and Methodology**

### **2.1 Approach**

The approach to the project puts ANE and LEM at the centre of the research process. The previous support from AFCAP in Mozambique was successful in establishing trial sections in various parts of the country and conducting some follow-up monitoring visits. However, after the AFCAP support was withdrawn with the closure of AFCAP 1 (July 2014), there was no further attention given by ANE to the trial sections. The current project should avoid a similar outcome.

The monitoring of the experimental sections and drawing conclusions from the results is of great importance to Mozambique. However, of equal importance is establishing local capacity to continue this work into the future. On AFCAP 1 the consultants who were providing technical support to ANE also assisted with some equipment needs (DCP, straight edge and wedge), and provided lunch and refreshments for ANE staff in the field. This was justified on the basis that it was a small cost but necessary to ensure the success of the project. Under AFCAP 2 there is a shift of emphasis, with participating roads agencies required to assume a higher level of responsibility. Therefore, the current project will assume, from the outset, that the ANE Road Research Centre is fully self-sufficient and able to provide the required equipment for the monitoring.

For the current project, it is also assumed that the ANE and LEM staff appointed to the Research Centre are self-motivated and committed to the success of project. It is assumed that sufficient time has been set aside in their work programmes for them to engage meaningfully in the research activities. Furthermore, the manager of the RRC must have sufficient time in his work programme to coordinate the research activities including being able to plan well in advance for forthcoming events. The effectiveness of the technical assistance will be significantly undermined if the experts are left waiting for ANE/LEM teams to mobilise on site.

If any of the above assumptions are not met, the overall effectiveness of the project will be diminished. However, if ANE/LEM can fulfil these requirements, and if appropriate incentives are built into the project methodology (see below), the project has every chance of success.

### **2.2 Methodology**

The implementation of the project is the responsibility of ANE RRC. The advisory team will assist ANE RRC to prepare a programme of monitoring of the selected trial sections in accordance with the available resources under the project. This will include participating in capacity building efforts on site in accordance with the agreed programme of inputs and the budget available to the advisory team. This will ensure the effective implementation of the project.

The capacity building plan for the RRC staff is at the heart of the implementation of the project. Each member of the RRC will participate in a well-defined research project which can be monitored over the duration of the project. The research projects will include the establishment and monitoring of experimental sections on existing roads. The approach to capacity building is described below.

## **2.3 Capacity Development**

### *2.3.1 Road Research Unit*

The National Roads Administration (ANE) is in the process of setting up a Road Research Centre (RRC) in Maputo. The objective of the RRC is to undertake relevant, high quality research relating to the road sector and to use evidence from the research to influence policy and practice.

A Strategic Plan was developed for the RRC in 2014<sup>1</sup>. The plan addresses future research needs identified by the main stakeholders in the RRC and provides direction for the implementation of a research agenda. Staff have subsequently been allocated to the research unit, albeit none yet on a full time basis. Three staff have been nominated by DIMAN, three by LEM and two by DIPRO. Management of the group is being provided by the Director of Maintenance in DIMAN. A study is currently in progress on knowledge management within the RRC including the establishment of an Information Centre, but the project for “Long Term Pavement Performance Monitoring of Trial Sections” is the first research project embarked on by the RRC since its establishment.

### *2.3.2 RRC Human Resource Development*

The 2014 Strategic Plan for the RRC includes a list of required skills for the RRC. The list includes engineers, organic chemist, geologist, GIS expert, etc. However, there was no assessment of the availability of these skills in Mozambique at the time or a strategic plan of how they might be acquired or developed.

Unique skills are required by researchers. These include strong mathematical and analytical skills, report writing ability and should be naturally inquisitive. Most of all, researchers need patience and dedication, and need to be self-motivated. They must have a strong belief in the process of data collection and analysis, leading to results that are meaningful and beneficial to society. There is a risk of embarking on a capacity development programme with individuals who do not possess the required basic attributes of a researcher. If this is the case it will be difficult for the project to achieve its objectives.

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<sup>1</sup> Mgangira, M., Verhaeghe, B., Paige-Green, P. & Antunes, M.L. (CSIR/LNEC). Establishment of a Road Research Centre in Mozambique/Road Research Strategic Plan. March 2014. Contract Ref No. AFCAP/MOZ/092.

It is recommended that ANE should prepare an appropriate skills development plan for the RRC.<sup>2</sup> The plan should set out the basic attributes for the researchers. Only those individuals that show these attributes should participate in the research programme. The assessment of individuals could be based on holding an existing MSc (or higher) degree from a recognised university; but given that there is no appropriate MSc programme in Mozambique it may be better to develop a customised cognitive aptitude test for screening applicants.

### *2.3.3 Capacity Development Plan*

The overall approach to capacity development on this project will focus on the individuals assigned to the RRC, providing them with an opportunity to participate in a well-structured research project and to learn more about their own strengths and weaknesses. It will provide confidence to individuals to undertake more complex and longer term research assignments. They will be in a better position to decide whether they are able and willing to pursue a career in research.

The plan for capacity development is as follows:

- Each member of the RRC will select a research topic linked to the existing trial sections developed under AFCAP 1; the members will choose from a list developed by the consultant but will also be free to select topics that are not on the list.
- The consultant will assist each member of the RRC to develop a research methodology.
- The researchers will be responsible to ensure that all required data are collected reliably and accurately for their research component.
- The researchers will prepare brief monthly reports providing an update on their research projects. These should be circulated by email to the project team. These reports can be written in Portuguese.
- The consultant will assist and mentor the researchers to analyse their data, draw conclusions, and prepare a technical paper. Short formal training sessions will be presented where necessary.
- The researchers will present their papers at project workshop to be held in late 2017; the papers will be subject to peer review at the workshop.
- The best two papers will be put forward to a relevant regional or international conference on low volume roads and/or recognised journals.

Other aspects of capacity development that will be achieved through the project include:

- Development of guidelines (“protocol”) for the establishment and monitoring of experimental road sections appropriate to Mozambique

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<sup>2</sup> Capacity development is covered in the 2014 RRC Strategic Plan, but the targets are too ambitious for the short term.

- Skills enhancement amongst ANE and LEM staff at central and provincial level for collecting data from roads (e.g. use of an automatic level and DCP, mobile phone accelerometer readings for roughness measurements, etc.).
- Development of a work plan for the next agreed period after the end of this project.

Most importantly, the project will make research more visible in ANE operations and to the wider road sector. This is critical to ensuring ongoing future support for research by senior managers and political decision makers. But this success depends on the ability of the individuals in the RRC to respond to the challenge.

A detailed capacity development plan will be prepared once the existing capacity of the RRC to conduct research is better known.

## **2.4 Relational Database**

### *2.4.1 Available Databases*

The following is a summary of findings regarding existing and planned databases from the project kick-off meeting.

- ANE has a document management system which is used to store report documents in various formats (chiefly Microsoft Word and PDF). It is implemented using the iDoc DMS. This system was initially confused with a database where project management data is stored, possibly with GIS coordinates for the trial road sections, but this is not the case.
- ANE has implemented the HIMS Asset Management System. This system is used to store information on all roads maintained by ANE and it includes GPS coordinates that provide the location of these roads as line segments. The data include road construction materials and road quality status. However, these data are stored as an average value for a road as a whole, rather than as data points for every 25m or 50m of road. Furthermore, there are no historical data.
- The Asset Management System is of interest as it stores shape files of all roads maintained by ANE. These can be used as input to create line segments of roads covered by this project to be projected on a map in a software program used to perform measurements. A sample dataset for a single road was provided. This shapefile was subsequently tested in Mapshaper and is readable.
- Beyond the Asset Management System and the shape files, no database currently exists.

### *2.4.2 Custom field software*

It was agreed that the use of Android tablets or Android phones in the field would speed up the measurement process and reduce errors that are inherent to recording measurements using traditional paper forms. A software implementation for mobile phones is desirable since participants will likely already have their own phones, and phones are easily portable in the

field. Any software developed for Android phones will also run on Android tablets if these are available. (MS Excel can also be used on Android and iPhones).

Custom software can import the available shapefiles for all of the road trial sections of interest and use them as a reference for measurements.

It is proposed to develop an initial software prototype that will digitize a sample paper measurement form (normally used for the field surveys). Participants will use the software to enter measurements taken in the field and measurement data will be stored on the local device. When the phone is within range of a cellular network or a wireless internet network, the software will transfer the data to a central server and erase it from the device. The device will mark all measurements with GPS coordinates received by the phone, a timestamp, and its own unique ID which identifies the participant taking the measurements. It is also possible to extend the software to include photographic evidence of potholes or other features.

### *2.4.3 Integration*

AfCAP is supporting a regional “Back-Analysis” project that is also developing a relational database for road research. ANE (and AfCAP) would like to see this integrated with the database that the ANE project will develop for the Long Term Pavement Performance Monitoring. Since the ANE measurements database could be ready in the near future (approx. 2-3 months), it should expose an interface that allows other software to read data from it. This interface can either be an HTTP REST API or direct access through SQL queries.

Regarding the interface between the ANE research database and the "Records Management" component that has been proposed as part of the ANE Knowledge Management system<sup>3</sup> it is recommend at this stage to take a “defensive” position by developing a system for the RRC that allows:

- remote systems to interface with it and read data
- export of data to Excel format (or CSV).

This will enable flexibility and avoid the need to conform to a foreign system interface.

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<sup>3</sup> See Technical Assistance to Mozambique Road Research Centre (Interim Phase). Progress Report: Knowledge Management Study. Council for Scientific and Industrial Research (CSIR), South Africa. Contract Ref No. AfCAP/MOZ/2045A. August 2016.

### **3 Progress**

#### **3.1 Kick-Off Meeting**

The Kick-Off Meeting was held at the offices of DIMAN on Thursday 6<sup>th</sup> October 2016. The meeting was attended by the manager of the RRC and the RRC members, the AfCAP Regional Technical Manager, and the consultant's team. The list of participants is in Annex A.

The following is a summary of the main discussion points:

1. The meeting was opened by the RRC Manager who introduced the project. This was followed by further explanation of the project background and purpose by the AfCAP Regional Manager. The project will provide the RRC with basic capacity to carry on with the monitoring of the research sites into the future.
2. The CDS Team Leader outlined the approach of the consultants to the project as set out in their Technical Proposal. It was emphasised that an appropriate balance would need to be found between ANE being in charge of the research process and achieving the expected outputs (relational database and technical papers). It was noted that the project will generate data from the trial sections thereby providing excellent opportunities for analysis and reporting.
3. The Team Leader requested a list of all trial sections and copies of all previous design, construction, as-built and monitoring reports. (It will also be necessary to obtain maintenance records and costs; this should comprise costs for additional maintenance compared with control sections, i.e., not including activities such as grass cutting and drain clearing).
4. The RRC Manager confirmed that ANE was committed to leading the research process despite the gap in the monitoring of the sites after the end of AFCAP 1. ANE requires a simple but accessible database representing all trial sections. There are a number of trial sections built on high volume roads, which also need to be monitored (monitoring higher volume roads can be equivalent to accelerated pavement testing in many respects). A methodology will be required on how to select which trial sections to monitor in detail. Initially the project should concentrate on Inhambane, Gaza and Maputo Provinces (this is also related to security concerns further north).
5. The Team Leader noted that the scope of the project will depend on RRC resources for the mobilisation of data collection teams.
6. The AfCAP Regional Manager noted the importance of a capacity building plan so that ANE will know what to expect.
7. The Team Leader proposed the first round of data collection to be carried out in Inhambane in the week starting 24<sup>th</sup> October 2016. The RRC Manager requested a letter covering this request in order to obtain approval from the National Director.
8. There was some discussion on deflection testing and whether this was feasible. It was suggested by RRC members that ANE could procure a light-weight FWD.

9. It was reported that maintenance has been carried out by the provinces on the trial sections, though on some the maintenance is only off-carriageway.
10. The RRC Manager offered to provide the consultants with the list of their monitoring equipment (procured previously through AFCAP 1) and the list of equipment to be procured under a World Bank project.
11. It was agreed that the Inception Report would be submitted within 2 weeks.
12. A short discussion was held on the use of the contingency budget in the CDS contract. It could be used for more time inputs from the experts and the procurement of equipment for the monitoring.
13. It was noted that there is currently no database in the RRC for the storage of research data. Therefore, the consultant will probably need to develop one. However, it should be linked where possible to the knowledge management system being proposed for ANE under a parallel AFCAP-funded initiative and also to the ANE database of roads being developed by DIPLAN.
14. The proposal to use mobile phones or tablet computers to input data on site was welcomed. This would include taking photographs of (for example) defects which would be part of the database. The use of this technology would ensure that all data are geo-referenced.

### **3.2 Information Obtained by the Consultant**

#### *3.2.1 Reports*

The following key reports from the design, construction and monitoring of the ANE/AFCAP trial sections and establishment of the RRC have been obtained during the inception phase. It is requested that ANE urgently provide any other key documents that may be missing from this list.

1. Targeted Interventions for Low Volume Roads in Mozambique, Construction Report, Phase 1 (September 2009), TRL, AFCAP
2. Targeted Interventions for Low Volume Roads in Mozambique, Summary Report, Phase 1 (August 2010), TRL, AFCAP
3. Targeted Interventions for Low Volume Roads in Mozambique, Design Report, Phase 3 (Jan 2012), TRL, AFCAP
4. Targeted Interventions for Low Volume Roads in Mozambique, Construction Report, Phase 2 (2013), TRL, AFCAP
5. Targeted Interventions for Low Volume Roads in Mozambique, Final Report, Phase 2 (2013), TRL, AFCAP
6. Targeted Interventions for Low Volume Roads in Mozambique, Final Monitoring Report (April 2013), TRL, AFCAP
7. Back Analysis of Previous Constructed Low Volume Rural Roads in Mozambique, Final Report (June 2013), AFCAP

8. Establishing of a Road Research Centre in Mozambique/Road Research Strategic Plan (March 2014), AFCAP
9. Technical Assistance to Mozambique Road Research Centre (Interim Phase, September 2016), AFCAP
10. Pavement Testing, Analysis and Interpretation of Test Data, Guideline No. 2 (May 2000), Roads Department, Botswana.

Standard forms used for data collection during the monitoring of the ANE/AFCAP trial sections have also been obtained.

### *3.2.2 List of Trial Sections*

From the above reports an initial list of trial sections has been prepared. The data are summarised below. It is requested that ANE verify this list and advise if there are any errors or omissions.

**Table 3-1: Trial/Research Sections (Monitored Sites)**

No.	Province	Site	Coordinates	Date of Monitoring					
				Feb– March 2011	July/August 2011	Nov 2011	March 2012	Aug/Sept 2012	March/April 2013
1	Maputo	Marracuene - Macaneta	Start: S24°13.383' E35°04.681' End: S24°13.728' E35°04.230'					√	√ S
2	Inhambane	Cumbana-Chacane	No coordinates	√	√	√ S	√ S	√	√
3	Manica	Inhacufera-Machaze	Section 1: 0+000 – 6+400 Start: S17°40.230' E35°42.849' End: S17°43.054' E35°44.591'		√		√ S	√	√
			Section 2: 6+400 – 13+400 Start: S17°43.064' E35°44.589' End: S17°46.700' E35°45.011'						
4	Zambezia	Zero-Mopeia	Section 1: 0+000 – 5+000 Start: S20°48.130' E33°59.391' End: S20°47.477' E33°02.151'		√	√ S	√ S	√	√
			Section 2: 5+000 – 11+186 Start: S20°47.477' E33°02.151' End: S20°48.272' E33°05.341'						
5	Cabo Delgado	Xitaxi-Moeda	No coordinates		√			√	√

√ S Selected Parameters

**Table 3-2: Trial Sections built using different interventions**

(Shaded sections have been monitored)

No.	Site No.	Province	Road Name	Passability Issues	Length km	Targeted Intervention	Comment
<b>Phase 1 – Constructed Sections</b>							
1	MP1	Maputo	Magude - Motaze	Loose sand.	0.3	Construction of pavement using chemical stabiliser (Romix) and surfaced with cold mix, surface dressing and sand seal.	
2	MP2	Maputo	Calanga - Checua	Loose sand; weak soil; swamps which are flooded and impassable for much of the year; absence of good materials	40	Construction of culverts.	
3	GZ1	Gaza	Macaritane - Chicualacuala	High gravel loss. Weak and slippery soil	2	Construction of cement stabilised sand base surfaced with block paving.	
4	IN1	Inhambane	Panda - Urene	Passability and problems; absence of good gravels. Inadequacy of the Cudingene crossing.	-	Gravel wearing course and an embankment Increased flow capacity of river crossing.	
5	MN1	Manica	Nhacufera - Machaze	Very coarse gravel causing very high roughness.	5	Process wearing course, compact as base and surface with Otta seal. A research section	
6	SF1	Sofala	Beira - Savane	Sandy soil impassable during floods.	45	Construction of water crossing structures and sealed embankments	
7	TE1	Tete	Bene – Fingue - Cachombo	Long steep hill, dangerous when wet and difficult to ascend. Weak soil.	1	A road base of large stones to be 'grouted' with concrete and covered with a further 50mm of concrete screed.	
8	TE2			Causeway with inadequate capacity.	0.5	Increase waterway area and reduce times of impassability	
9	ZA1	Zambezia	Zero - Mopeia	Low sections which flood.	44	ANE designs for raised embankments, water crossing structures and regravelling.	

10	NP1	Nampula	Gracio - Milhana	Mecuburi bridge and approaches overtopped during floods.	0.5	Additional flow capacity. Surfacing of approaches.	
11	NP2			Milhana crossing flooded for long periods.	0.5	Construction of embankment and causeway to provide all weather crossing.	
12	CD1	Cabo Delgado	Xitax i- Mueda	A steep hill with very weak, slippery and erodible soils.	1.3	Construction of concrete slabs, and bituminous seal on cement-stabilised sand base.	The site is 1.3km long consisting of Single Surface dressed sections on a base of 150mm of cement stabilised sand (4%) and a sand sub-base of 150mm, constructed in Phase 2, and a mix of Surface Dressing sections and Concrete Ramp sections constructed in Phase 1.
<b>Phase 2 – Constructed Sections</b>							
13	MP2	Maputo	Calanga - Checua	Loose sand, weak soil, swamps which are flooded and impassable for much of the year. Absence of good materials.	40	Continuation from Phase 1. Construction of embankments using sand blended with clay from the swamps.	
14	MP3	Maputo	Marracuene - Macaneta	Road liable to flooding. Expansive soils Absence of good materials.	10.7	Raising the level across the flood plain. First 780m were eroding badly and were earmarked for CTB/ETB with slurry seal.	The experimental section on this road consists of 780m of 15mm slurry seal surfacing on top of 100mm Emulsion Stabilised Sand Base. This section starts at the edge of Marracuene and ends at the ferry crossing.
15	GZ1	Gaza	Macaritanine - Chicualacuala	High gravel loss. Weak and slippery Subgrade.	Not known	Replacing the unsuccessful block paving of Phase 1. Five demonstration/research sections proposed with different surfacings.	
16		Gaza	Chinhacanine-Nalazi				No information obtained to date. Section was damaged by floods in 2013.
17	IN1	Inhambane	Panda - Urene	Passability problems; absence of good gravels. Inadequacy of the Cudingene crossing.	5	Completion of Phase 1	

18	IN2	Inhambane	Cumbane - Chacane	Very loose fine sand soil.		Research site – Otta seals	The project road begins in Cumbane and extends South-Westwards to Chacane. The experimental sections are located between chainages 18+200 and 24+700. These consist of 2Km of Otta sections and 4.4km of blended gravel sections.
19		Inhambane	Praia da Barra				No information obtained to date.
20		Inhambane	Homoine- Panda				No information obtained to date.
21	MN2	Manica	Nhacufera - Machaze	Very coarse gravel; very high roughness.	Not known	Continuation of Phase 1 Additional research of appropriate surfacings, primarily Otta seals.	The site consists of 5Km of Otta sections constructed in Phase 1, 6km of Otta Seal sections constructed in Phase 2, 500m of a Sand Seal section and 5km of Otta Seal sections constructed in Phase 3.
22		Manica	Muxungue- Chibabava				No information obtained to date.
23	SF1	Sofala	Beira - Savane	Road floods and is impassable.	45	Continuation of Phase 1 Experimental road designs using emulsion treated sand road bases and application of various surfacings. This is a key research site.	
24	TE3	Tete	Matema – Furancungu Daca	Maintenance/construction errors. Deep flows across submersible structures. Steep eroded hill near Furancungu that is impassable.	c. 5	Various spot improvements. The road is over 200km long.	
25	ZA2	Zambezia	Zero - Mopeia	Low sections which flood.	44	Continuation of Phase 1 Application of various seals to sections of the Phase 1 gravel wearing course.	The site consists of 6Km of Otta sections constructed in Phase 2 and 7km of Otta Seal sections constructed in Phase 3. The road links the town of Zero located on the N1 to the town of Mopeia located about 30km Eastwards of Zero.

26	NP2	Nampula	Gracio - Milhana	Milhana crossing flooding for long periods.	0.5	Continuation of Phase 1. Construction of embankment and causeway to provide allweather crossing	
27	NP3	Nampula	Mecane - Pilivili	Sandy soil, floods Two large structures vulnerable to collapse Long lengths of degraded gravel.	33	Exact plans not known. Expected to improve 2 structures and raise road level	
28	NP4	Nampula	Naguema - Chocas Mar	Sandy – floods.	8-10	Raise level across flood plain (c. 1km), improve cross drainage and surfacing.	
29	NS2	Niassa	Nova Madeira - Cz. Lupiliche	Loose sand and weak swampy soil.	4	Possibly blend soils to provide a tighter, less erodible pavement.	
30	NS1	Niassa	Mavago - Msawize	Approximately 10 km of road in rocky ground Approximately 20 km of road in plastic red clay.	c. 30	Most of the road must be improved to provide year-round access.	



- Monday 24<sup>th</sup> October: Travel to Maxixe.
- Tuesday 25<sup>th</sup> October: Meeting at ANE Delegado office and visits to trial sections.
- Wednesday 26<sup>th</sup> to Thursday 3<sup>rd</sup> November: Data collection on existing monitored sections and establishing new sections for monitoring (on existing roads). Discussions with RRC staff on possible research topics and preparation of list of options. Review of ANE equipment used for monitoring and level of skills of researchers.
- Friday 4<sup>th</sup> November: Depart for home base.

The Team Leader, Materials Engineer and Data Management Specialist will accompany the team on site from 24<sup>th</sup> to 28<sup>th</sup> October. The Assistant Team Leader will accompany the team for the whole of the field work period.

The consultant team will be self-sufficient for transport for the period when the whole team is on site.

It is expected that the RRC team will be adequately equipped to carry out measurements on the roads. Basic equipment that will be required includes:

- Functioning DCP with spare cones (preferably disposable to avoid damage to the equipment)
- Automatic level and staff
- Digital camera
- GPS
- 3 metre straight edge with standard wedge
- Equipment for sand patch test and sand (correctly graded)
- Tape measures: 50 metre and 5 metre
- Wheel measuring device
- Tools for digging
- Sample bags for moisture content determination with cable-ties
- Equipment and calibrated sand for sand replacement field density test
- Steel pegs and hammer
- Paint for marking the road
- Standard forms for recording data including visual condition assessments.
- Clip boards and pens.
- Equipment/materials to patch any sample sites.

Part of the purpose of the initial field visit is to understand any constraints that the RRC might have in mobilising the required equipment. The need for more sophisticated equipment including roughness measuring devices and deflection measuring devices will be examined during the visit.

The initial field visit will provide an opportunity to assess options for discrete research topics to be considered by the RRC members.

### 4.3 Consultant Resources

It is expected that an increase will be required to the overall resources available to the consultant to provide the inputs currently envisaged. The key areas of increase are:

- Additional inputs for the Data Management Expert to participate in the initial site visit, to write a database for the project (and future use by the RRC) and to support the RRC staff in using the database. (It is noted that the additional 15 days proposed may still not be sufficient to incorporate all of the data fields required for monitoring road experimental sections).
- Additional inputs by the Team Leader for the coordination of the capacity development plan.
- Additional inputs by the Assistant Team Leader for an additional field visit.
- Provision for hire of a vehicle in the field when the full CDS team is on site.
- Additional provision for accommodation and subsistence to cover the additional field visit and additional time spent in Maputo.

**Table 4-1: Consultant Time Inputs**

Staff member	Days (Contract)	Days (Proposed)
Team Leader	36	42
Materials Expert	30	30
Data Management Specialist	10	25
Assistant Team Leader and Materials Expert	76	84
Other Experts	10	10
<b>Total Input</b>	<b>162</b>	<b>191</b>

**Table 4-2: Consultant Expenses Component**

Item	No. (Contract)	No. (Proposed)
Airfares Harare Maputo	5	6
Airfares Joburg Maputo	4	5
Airfares Lusaka Maputo	6	7
Airfares in Mozambique	5	7
Hotel nights	89	103
Per diems	89	103
Travelling costs	15	18
Car hire in Maputo	15	15
Car hire in the field	0	8
Taxis in Maputo	50	50
Translation of final report	1	1

It is expected that the 10 days of time allocated to “Other Experts” will be utilised mainly by the Materials Expert. However, this will depend on the level of uptake of the technical inputs by the Materials Expert by the ANE RRC staff.

#### **4.4 Next Steps**

The following is a summary of the next steps to be carried out in the project implementation:

- Site visit to Inhambane 24<sup>th</sup> October and 4<sup>th</sup> November 2016 (including report on activities carried out and outcomes).
- Preparation of draft LTPP monitoring protocol (by 31 December 2016)
- Preparation of relational database customised to the protocol and ready for data entry (by 31 January 2017)
- Establishment of research sections for monitoring by RRC staff (January/February 2017).

## Annex A. Participants in Kick-Off Meeting

No.	Name	Institution	Email	Phone
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