Development of Pavement Design Standards for Low Volume Roads in Ethiopia

PROJECT INCEPTION REPORT

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Transport Research Laboratory

PROJECT REPORT CPR582

Development of Pavement Design Standards for LVRs in Ethiopia

Inception Report

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ABBREVIATIONS AND TERMINOLOGY

AADT	Average Annual Daily Traffic (sum in both directions in PCUs –passenger car units)
AASHTO	American Association of State Highway and Transportation Officials
ADT	Average Daily Traffic
AFCAP	Africa Community Access Programme
CBR	California Bearing Ratio
DBST	Double Bituminous Surface Treatment
DCP	Dynamic Cone Penetrometer
DFID	Department for International Development
ERA	Ethiopian Road Authority
ERTTP	Ethiopian Rural Travel and Transport Program
ESA	Equivalent Standard Axles
KM	Kilometres
LVR	Low Volume Road
M	Metre(s)
PCU	Passenger Car Unit
RRA	Regional Roads Agency
RSC	Research Steering Committee
SBST	Single Bituminous Surface Treatment
TOR	Terms of Reference
TRL	Transport Research Laboratory
WBM	Water Bound Macadam
WLC	Whole Life Costs

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EXECUTIVE SUMMARY

The principle outputs from this AFCAP funded project are pavement design recommendations for low volume roads (LVRs) for both paved and unpaved roads that will lead to increased durability, lower user costs and lower long term maintenance requirements. These recommendations will be incorporated into a comprehensive design manual for LVRs that is being prepared under a separate but closely related AFCAP project.

This project has a two pronged approach;

(1) Demonstration of approaches that have been successful elsewhere which could be applicable to LVRs in Ethiopia. These include alternative surfacing options as well as surface treatments such as Otta seals and sand seals.

(2) Derivation of specifications for the use of locally available materials that currently do not meet the criteria for use in roads.

Key activities include construction of demonstration and trial sections, monitoring their performance, data analysis and recommending appropriate pavement design standards and specifications. Some of the parameters to be measured/monitored are traffic volume and composition, materials properties, climatic conditions and construction options for different terrain. There will also be a social impact study conducted to establish the extent of the impact associated with the trial sections.

Technology transfer and exchange will form the cornerstone of the implementation methodology. The project team office will be located within the Ethiopian Road Authorities (ERA) Engineering Research Branch in order to facilitate regular liaison and knowledge exchange.

The 40 months project commenced on 1 October 2009 and, to date, project staff are in place and consultations with key stakeholders have occurred. The current main activity is liaison with ERA and the Regional Road Authorities (RRAs) in the selection of candidate roads on which the demonstration/research sections will be constructed.

1 Introduction

The review of 12 years of roads development in Ethiopia has shown significant progress in expanding the road network. However, this growth has not always been matched by a commensurate level of road maintenance due to financial constraints. In order to continue expanding the network whilst preserving the existing network, it is imperative that the lifecycle costs of road provision is optimised through appropriate standards and specifications that leverage the use of locally available materials and of proven techniques that can be adapted to Ethiopian conditions.

The issue of poorly performing gravels is well documented and the research programme on Performance Criteria and Life-Cycle Costing for Low-Volume Labour-Based and Unpaved Roads helped quantify the effects of the deterioration of roads in Ethiopia as well as in other countries in Africa. The Ethiopia country component of this programme commenced at the end of 2004 and the project was carried out in Oromia East and West Regions, Amhara Region and in the Southern Region of the country.

During discussions on the selection of test sites in the Southern Region, the issue of the poor performance and maintenance problems of gravel roads constructed with local limestone emerged. As a result of these discussions, it was decided that a number of test sections should be constructed in the Southern Region as part of the project 'Improving the Performance of Limestone Wearing Course Gravel and Low Cost Surfacing', which commenced in November 2007. The current project is an expansion of the approach used in the trials in the Southern Region to other regions in the country, with funding for the construction of the trials being provided by the Ethiopian Roads Authority (ERA) and the collaborating Regional Road Authorities (RRAs).

This project has a two pronged approach;

(1) Demonstration of approaches that have been successful elsewhere which could be applicable to roads in Ethiopia.

(2) Derivation of specifications for the use of locally available materials that currently do not meet the criteria for use in roads.

This project is a component of the DFID-funded African Community Access Programme (AFCAP), which is managed by Crown Agents. It started in October 2009 and it is scheduled to be completed in 40 months. To date, consultations have been held with ERA and most of the RRAs which have shown an interest in collaborating in the project.

This report gives details of the inception phase of the project and the preparatory work that has been undertaken, together with issues arising from initial discussions, and other activities to date. An outline of the project is given together with the planned activities and an approximate time plan. A more accurate plan for these activities will evolve following discussions with ERA and the RRAs to identify opportunities and to understand what projects are on-going or planned that provide construction opportunities for the trials.

Target roads for test sections will include both unsealed and sealed roads mainly on the Federal Road network.

2 Project Overview

The results of the research/demonstration programme will contribute to an ongoing project entitled 'Pavement Design Standards and Specifications for Low Volume Roads in Ethiopia' (AFCAP/ETH/005/F) which has also been commissioned by the Ethiopia Roads Authority under AFCAP. The Terms of Reference for the research is based on recommendations of the recent ERA/TRL study of 'Performance Criteria and Life-Cycle Costing for Low Volume Labour Based and Unpaved Roads', and lessons learned from another associated project entitled 'Improving the Performance of Limestone Wearing Course and Low-Cost Surfacing'.

Ethiopia currently has a road network of around 46,812km of which approximately 85% are gravel or rural roads. The network is divided approximately equally between federal roads maintained by ERA and regional roads maintained by the RRA's. Significant improvements have been made to the paved road network over the last decade resulting in 70% of the paved network now being classified as being in good condition. For federal gravel roads and regional roads, approximately half are considered as being in poor condition. Expected project outputs such as increased use of materials currently not used in road construction should therefore significantly assist both ERA and the RRA's in providing cost effective improvement and further extension of the rural road network.

2.1 Project Goal and Objectives

Project Goal

The main goal of the project is to promote sustainable livelihoods and contribute to socio-economic development of poor rural populations through the provision of improved and sustainable road access.

Project Objective

The key objective of this project is to develop and demonstrate revised pavement design standards for Low Volume Roads in Ethiopia that will maximize the use of local resources and promote the cost-effective and sustainable provision of roads. These design standards are to be disseminated to stakeholders in the federal and regional governments, the private sector and academic institutions.

Outputs and Outcomes

The principle outputs from this assignment are pavement design recommendations for LVRs for both paved and unpaved roads that will lead to increased durability, lower user costs and lower long term maintenance requirements. These recommendations will be incorporated into a comprehensive design manual for LVRs that is being prepared under a separate, but closely related AFCAP project.

The bulk of LVRs are under the jurisdiction of rural road authorities. These are the envisaged major beneficiaries/uses of recommendations and specifications to be derived from monitoring and analysis of demonstration and trial test sections.

Since 1997, 7% of road construction and maintenance work has carried out by ERA's direct labour force, with 55% of the value of work awarded to foreign contractors. Technology transfer and mainstreaming of project outputs is therefore also expected to encourage capacity building of local contractors allowing them to win a greater share of the market.

2.2 Key Factors Affecting Deterioration of Roads

2.2.1 Traffic

Geometric design is based on traffic level. However, structural design is different. For structural design knowledge of the axle loading is required. Details of axle loads are unlikely to be available when designing LVRs. In other countries, designs have been provided for a particular traffic volume based on 'light vehicles only' and 'light plus some heavily loaded vehicles' based on engineers estimate of the two categories and two assumptions namely average equivalent standard axles (esa's) of light trucks = 0.5 and average esa of the heavier classification of trucks = 5. This is a rather crude approach but it is better than nothing. In Ethiopia, the esa estimate may need to be refined if not available from the database of of traffic and axle load data which has been collected over many years. This will be consulted when making assumptions with regards to traffic. The geometric design options for LVRs will be addressed in the separate design and standards project.

Other types of traffic, such as non-motorised are common in Ethiopia and need to be considered at design stage and appropriate provisions incorporated.

Traffic is a major factor in road deterioration. On highly trafficked roads it is the major contributor, although pavement environment has been found to be significant factor in the deterioration of LVRs, especially unsealed roads which allow more ingress of surface water. Traffic engineering is therefore an important component of the solution design process. For these demonstration and research trials several aspects need to be considered.

1. Traffic volume
2. Traffic categories
3. Traffic loading

It is necessary to determine these variables to a reasonable degree of accuracy. Traffic counts will be carried out regularly on all the sections throughout the course of the project together with axle load surveys, where possible, as part of the monitoring programme.

Currently, the 300 vehicles per day ceiling used for defining the scope of the project does not have a defined traffic composition in the current design manual, although this could change in the new version. However, many low volume roads in Ethiopia, even those carrying less than 50 vehicles per day, sometimes have a composition of heavy vehicles that exceeds 30%.

2.2.2 Road Geometry

The effect of road geometry on road performance is critical, particularly on steep gradients where it severely affects water runoff and erosion, regravelling frequencies and maintenance needs, accommodation of the prevailing modes of transport, traffic speed, and so on. Research as part of SEACAP and also in Africa has shown that steep sections of gravel and earth roads are not sustainable in many situations and therefore alternative surfacings are required. It is a major element of this project to investigate the performance of a variety of such surfacings. However, the scope of the project is such that the influence of road geometry cannot be covered fully. The first step is to demonstrate the viability of such surfacings in Ethiopia and to determine their basic performance characteristics. The locations and characteristics of the trial sections are constrained by the location of current construction sites on which the trials can be built but it is anticipated that some sections might be constructed in areas of difficult terrain where factors such as gradient and curvature are influential on road performance.

The effect of gradient on unpaved roads was also monitored on the test sections that were included in the Performance Criteria and Life-Cycle Costing for Low-Volume Labour-Based

and Unpaved Roads Project. The results from the Performance Criteria project will be applied in this project as appropriate.

Although every effort is usually made in designing a road to ensure that performance is independent of whether a section of road is in cut or fill, differences in performance are often observed. Such differences are caused by the influence of the water regime in the two situations and are controlled by the drainage measures that are incorporated in the design. The objective of this project does not include investigating the effectiveness of drainage provision and therefore care will be needed in selecting the trial sites to ensure that all trial sections on each site are similar in terms of their drainage characteristics and water regimes

Terrain has a great influence on the nature of a road and on design speeds. At an early stage of road planning, general knowledge on types of terrain is needed to acquire information on soil and rock types and their engineering behaviour. It is also possible to evaluate the availability of construction materials in the surroundings of the project site and to indicate the general location of quarry sites. Often, the recognition of landscape units in an area gives a preliminary assessment of the variation of materials to be expected. This can then be used to decide appropriate places and frequencies of sampling during site investigation. Besides, terrain data is useful to identify major river crossings and areas on instability. Ethiopia has three physiographic regions: the northwestern highlands, the rift valley and the southeastern plateaus. The terrain in each of these regions varies from place to place. In the geometric design manual of the Ethiopian Road Authority (ERA), transverse terrains are broadly categorized as flat, rolling, mountainous and escarpments. It is always important to bear in mind that the cost of construction can increase significantly as a road passes from flat through to difficult mountainous terrains or escarpments.

Significant work has already been carried out in Ethiopia regarding the different terrain and other geographical aspects. The 2002 site investigation manual of ERA shows the country is divided into 67 land regions based on a relatively uniform climate, geology, topography and soils.

2.2.3 Materials

Experience regarding the performance of gravel materials especially on unpaved roads both in Ethiopia and elsewhere led to the formulation of this research project. The use of poor quality materials for road construction is a major contributor to accelerated road deterioration and an increase in frequency of the cycle of deterioration and the need for repair. Many gravels are useable if selected correctly, treated appropriately or blended into the prevailing local environment. An assessment of all materials used in the pavement trials will be carried out through a rigorous testing programme.

The standard designs for sealed roads state a minimum PI of 6 and the standard CBR is 80. These values still exist in many design documents. TRL research has shown that these values can be relaxed in some circumstances without increased risk, especially on LVRs. Research evidence has shown that a PI limit of 6 is unnecessarily low for many materials, such as calcretes and laterites, where pavements have performed well with very much higher PI's. Similarly, materials with a CBR as low as 45% have performed well on quite heavily trafficked roads where the pavement environment is relatively dry. This is generally achieved in conditions of relatively low rainfall, or if the shoulders are sealed (>1.0m - moving the zone of moisture variation into the shoulder), or when drainage is good such as on a high embankment or where the crown height is > 0.75m. For other materials such as weathered basalts a low PI is much more important but for virtually all materials, a drier road environment ensures higher in-situ material strength.

The materials utilised in the trials will reflect the types and availability of materials found locally. Figure 1 shows one of the typical locally available materials.

Figure 1: Red Ash (cinder gravel) borrow pit

2.2.4 Climate

Climate is a very important parameter and rainfall, in particular, can have far reaching effect on the performance of unpaved roads. The high volume of intense storm rainfall that occurs in many African countries, even in areas of low annual rainfall, can be particularly damaging especially on roads with steep gradients.

For sealed roads it is important to maintain the surface impermeable to water as cracks and/or stripping of aggregate could lead to water ingress and accelerated deterioration of the base layers.

In high rainfall areas it may not be possible to construct test sections until the rains subside to a level allowing work to proceed.

The amount, duration and frequency of rains greatly affect the performance of roads and construction materials in many countries. In Ethiopia, a variation in geographical location and altitude has produced a variety of rainfall regions and associated problems on roads. In 2002 the Drainage Design Manual produced by ERA, categorises the country into seven regions of rainfall on the basis of increments of 400mm variation. Generally, annual precipitation in the country varies from 800 to just over 2400 mm in areas where the elevation is greater than 1500 meters in the highland regions, rains often occur from June to September. These long and heavy rains constitute the main wet season of the country and are called *kiremt*. Moderate rains fall from February to May in the dry season called *bega.* In the lowlands rainfall is generally below 200 mm. In contrast to the highland areas, the east and south-eastern lowlands of the country have rains from October to January.

2.2.5 Ground and Surface water

The soundness of the foundation of the road is critical to the performance of all road pavement structures. The effects of ground water include:

1. A high water table or high moisture content in the road foundation and base may reduce the bearing capacity below the thresholds of the required minimum strength, resulting in excessive deformation and premature failure. Also high levels of moisture may reduce the stiffness of the layers resulting in high deflection under loading. This will ultimately cause the surfacing to crack prematurely and fail.

2. Water penetrating through or drawn through capillary action can enter the interface between the surfacing and the base course resulting in stripping or peeling of the surfacing.

Thus ground water will need to be monitored throughout the course of the project. These data and information on ground water fluctuations may be vital to explaining the future behaviour of the pavements.

Good roadside and cross drainage needs to be provided on all roads. On paved roads, with unsealed shoulders, there is a risk of ingress of water into the pavement layers near the edge of the paved surface thereby reducing the bearing capacity near the outer wheel path, which may then deform under traffic.

Other parameters such as fill; crown-height; cross-fall; shoulder design; ditch-design will also be taken onto consideration during the design stage. The different water regimes associated with cut sections and fill sections is also important and has been discussed briefly in section 2.2.2.

Both laboratory and in-situ methods will be used to assess and monitor moisture of the pavement materials used for test sections. A nuclear moisture-density gauge such as Troxler is commonly used during road construction. However, for monitoring moisture within a specific pavement layer it is generally not effective as it measures from the surface where the gauge us placed to the bottom of the probe. A double probe moisture-density gauge such as Strata gauge is likely to provide more accurate measurements as both probes can be inserted to a depth corresponding to the layers to be measured.

2.2.6 Mitigatory measures

The design of test sections will incorporate measures to mitigate/counter any negative influence or risk to the road structure e.g.

- using geometric parameters to control the type of traffic;
- use of sealed shoulders to reduce ingress of water into the road pavement and reducing the bearing strength ;
- providing deeper drains to reduce capillary action and effect of ingress of water from the fill slope;
- construction approaches e.g. increased compaction
- Maintenance methods

It should be noted that whilst there are many variables that influence the performance and deterioration of roads it is beyond the scope of this project to investigate all of them.

3 The Research Programme

The project will develop and test appropriate designs based on materials found locally in Ethiopia, which will result in reduced maintenance and life-cycle costs, and will improve the cost-effective provision of all-weather access roads in the country. The focus will be on materials that are currently not utilised as road building materials or are used to a limited extent because they do not conform to existing standards and specifications.

It is anticipated that trial sections will be constructed in at least four regions and the resultant data will be used to develop more appropriate approaches, standards and specifications which can also be incorporated into specifications which would be incorporated into future revisions of the Low Volume Roads Manual (2010) and Standard Technical Specifications (2010).

The project components are shown below and in Figure 2, as set out in the Terms of Reference.

3.1 Key Activities:

1. **Research Steering Committee:** Participate in Research Steering Committee meetings arranged by ERA, to meet quarterly for the first year of the project and six monthly thereafter;
2. **Design Standards:** Prepare recommendations based on the results of analysis of the data from the trials, which can be incorporated into future revisions of the Ethiopia road design manuals.
3. **Technical Review:** Undertake a technical review of the draft LVR Design Manual;
4. **Specifications:** Prepare draft specifications for the construction of LVR pavements and surfacing based on research findings;
5. **Construction of Demonstration Sections:** Assist ERA and the Regional Road Authorities to establish demonstration sites in at least four regions to include at least 2km of LVR at each site, using machine-based and/or labour-based technologies where appropriate;
6. **Monitoring and Data Collection:** Establish a technical monitoring system at each of the test sites to collect data over a two year period, and establish a Memorandum of Understanding with local universities in the pilot project areas to assist with collection of technical and social data;
7. **Social Impact Study:** Conduct a social impact study at each of the demonstration sites;
8. **Data Analysis and Whole Life Costing:** Develop a research matrix to cover different wearing course materials, surfacing options, climatic conditions, terrain and traffic found in Ethiopia, and estimate the whole life cost of each construction type over the desired design period, comparing machine and labour-based approaches where possible
9. **Quality Review:** Review and refine the pavement design recommendations;
10. **Maintenance Guidelines:** Prepare maintenance guidelines for each type of construction and demonstrate the routine maintenance tasks at each site;
11. **Dissemination:** Participate in two dissemination workshops for the draft LVR design manual in each participating region;

12. **Technology transfer and Capacity Building**. A major objective within AFCAP is to transfer knowledge to local practitioners and to facilitate the mainstreaming of technologies currently not used in Ethiopia in so far as these might be applicable and beneficial to the transport sector. The exposure of local engineers and technicians to the design, monitoring and data analysis of research activities are expected to contribute to building research capacity within the road sector in Ethiopia.

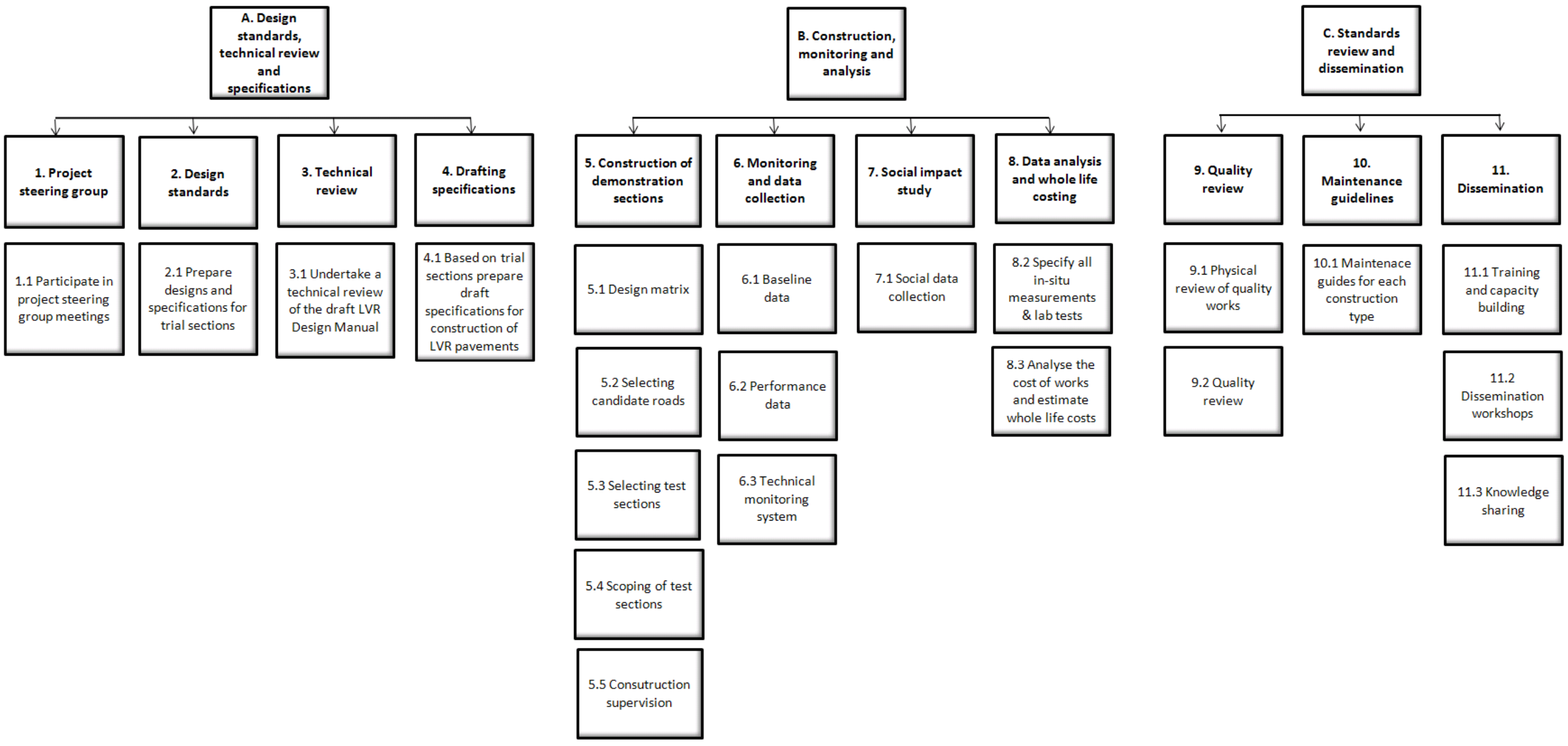


Figure 2: Main project components of AFCAP/ETH/005/A

4 Methodology

4.1.1 Technical Review

The approach used for this project will be based, at least in part, on knowledge derived from previous research into low volume roads. Literature such as the SADC Guideline for Low Volume Sealed Roads and the results of other published research provides documentation of research-based evidence and of new approaches to the provision of low volume sealed roads. This evidence, together with experiences from a similar programme (SEACAP) undertaken in South East Asia, which preceded AFCAP, will also be used, where applicable, to guide the approach in Ethiopia.

Where new problems are identified, such as materials which do not meet the standards and specifications for road construction, or a combination of other specific factors such as climate or terrain, which might adversely affect road performance in Ethiopia, then research sections will be included to help solve them.

The results of this research will assist in filling any gaps that may be present in existing documentation that govern the design standards and specification for rural roads in Ethiopia.

Wherever possible, the trial sections will be included in ongoing road projects. This will reduce the mobilisation costs. As a first step in the process of locating possible sites for the trial sections, questionnaires were distributed at a recent workshop in which regional representatives were asked to identify up to five possible candidate roads based on various criteria.

This information will be used in discussions with each of the participating regions to supplement the process of locating possible trial sites and will help reduce the need for a more extensive survey of all the regional road networks. The regional road authorities, other stakeholders and the research steering committee will be informed and consulted at each stage of the process leading to the construction of the trials through meetings and/or workshops as appropriate.

Pre-construction workshops will be held with participating ERA units, RRAs and contractors in order to share lessons learned from previous research trials and clarify new approaches. Where practical, field visits to existing research trial sections will be arranged to compliment workshops.

Communities in the project area will also be sensitised to expect deviations from normal practice. This is particularly important where the visible/aesthetic aspects might be different from what they expect.

4.1.2 Rationale for selection of demonstration/research sites

The basis for deciding on what to investigate, and where, is guided by a number of considerations including the following;

1. Chosen Approach

(a) Demonstration of approaches that have been successful elsewhere which could be applicable to ROADS in Ethiopia. This will be done through demonstration test sites.

(b) Derivation of specifications for the use of locally available materials that currently do not meet the criteria for use in ROADS. This will be done through trial test sites.

2. Proximity to regional centres

Ideally, trial sites should be located within reasonable proximity (100km) to regional centres and ERA districts to;

- Facilitate quick equipment repairs,
- Ensure the availability of materials testing facilities in order to minimise delays associated with sampling and testing,
- Minimise travelling time for monitoring teams,
- Facilitate access to depots with essential material resources such as bitumen.

If sites are to be constructed in other locations due to various constraints, such as the need to locate the sites near a source of available material or in a particular terrain, etc, then these will, where possible, be located as near as possible to an existing paved road or regional road depot where plant and materials will be available.

3. Responsible road authority

Trial sections are expected to be established predominantly on ERA roads with some additional sections on RRA roads if necessary.

4. Existence of ongoing projects

The target timescale for the construction of trial sites is for completion within the first year of the project. This assumes that funding and other resources will be available when needed. Therefore, where possible, the test sections will be included as part of ongoing projects and this will go some way towards mitigating against the risk of delays.

Currently the sealed roads in the regions are almost exclusively ERA roads. This means that if trial sections are to be piggy-backed onto existing/ongoing projects then the sealed road trial sections would have to be mainly constructed on ERA roads.

5. Rainy season

Different regions of Ethiopia have different rainy seasons. This will impact on the timing of construction of the trial sections. Most areas are expected to receive rains between June and August. If there is to be a minimum deviation from the target completion date, then trial sections in semi-arid regions will need to be constructed during the wet season. If specific operations designed to improve performance, such as drying-back the base before sealing, are to be included, then these sections may need to be constructed in the dry season. Table 1 shows the ideal/recommended times for constructing trial sites in some of the regions.

Table 1: Recommended times for constructing trial sites in some of the regions

REGION	RECOMMENDED PERIOD TO CONSTRUCT TRIAL SITES
Afar (semi arid)	July
Amhara	Before June or after September
Tigray	July to September
Oromia East	July onwards
Oromia West	September onwards

6. Contractor

Road projects that are implemented by 'force account' are easier to modify and to incorporate trial sections within a short period than those implemented by private contractors. In either case, variation orders will need to be prepared to enable activities to be undertaken in the construction of the trial sections that might differ from normal practice in Ethiopia.

7. Desired rate of deterioration

Although the objective of this project is to develop standards for low volume roads, it may also be necessary to construct some trial sections on high volume roads in order to increase traffic volume and assess its impact within the available short monitoring period. Sections constructed on the ERA network are likely to be more heavily trafficked.

8. Machine or labour based construction

It may be appropriate to construct trial sections using both machine–based and labour-based methods. Therefore, labour and/or equipment availability may impact on both technology choice and the location of trial sites.

4.1.3 Site Selection Framework

The following clarifications to the test sites selection process were made following a meeting comprising AFCAP, ERA and TRL in Awassa on 16 February 2010. The final details of the test sites will be elaborated in the Design Report.

(a) All demonstration and trial test sections to be sealed by way of surface treatment. At least 2 test sections to be an upgrade of what would have been a gravel road to surface treatment. At least 2 test sections to be modification of what would have been asphalt concrete to surface treatment. Control sections can be in the original design for comparison purposes. Caution was made to ensure proper dissemination of information about expectations. For example, if a surface dressed test site performs worse than a nearby asphalt concrete the public may have negative perception about surface dressing if they have not been primed about the differences and what to expect.

(b) One test section to be on black cotton soil.

(c) At least 4 out of 5 test sites to be on ERA roads. This will largely simplify logistics associated with construction of the test sections and allow test sections to carry relatively higher traffic during the short monitoring period.

(d) Rural Roads Authorities to be involved on test sites to be built in their respective regions – this is mainly in terms of capacity building and dissemination of information about project activities and outputs.

4.1.4 Evaluation and Design

The design process for the research sections will be as follows;

1. visual condition survey
2. material investigation and testing
3. in-situ strength tests
4. evaluation of materials and existing road condition
5. preliminary design
6. design review
7. final design

Clarity in the design process will be essential for mainstreaming any new techniques in a situation where capacity is sometimes limited. In order to encourage widespread application of the outputs of the research, the designs and techniques need to be commensurate with the resources available. The designs and specifications will be based on existing Ethiopian standards as far as possible.

The construction costs should be sufficiently low to encourage uptake of the designs and techniques. This will also facilitate funding for further projects and maintenance.

4.1.5 Construction of Test Sites

Table 2 shows the advantages and disadvantages of using ERA/RRAs (force account), ERA District Roads Maintenance Contractors (force account) or private contractors to construct trial sections.

Assuming that both the public and private sector contractors have the capacity to do the work, the order of preference will be as follows:

(1) ERA/RRAs own force

(2) ERA District Roads Maintenance Contractors

(3) Private contractors.

It is proposed to hold a pre-construction workshop for participating ERA/RRAs force account units and ERA District Roads Maintenance Contractors. The purpose of the workshop will be to explain the reasons that construction of the trial sections will differ from normal practice. The workshop participants would also benefit from a field visit to the Improving the Performance of Gravel Wearing Course and Low Cost Surfacing Project trial sections in Awasa.

Table 2: Advantages and disadvantages of options to construct trial sections

CONSTRUCTION RESPONSIBILITY	ADVANTAGES	DISADVANTAGES
ERA and Rural Roads Authorities (force account)	They are the custodians of most low volume roads and hence they will gain useful technical capacity	They have limited technical capacity (qualified people and equipment) to implement construction work, especially with sealed roads.
	Easy to apply variation orders	Longer procurement process for items not normally stocked
ERA District Roads Maintenance Contractors (force account)	Easy to apply variation orders	Longer procurement process for items not normally stocked
		Training and additional supervision may be required possibly escalating costs.
		Equipment may not be available when required
Private contractors (for ongoing projects)	Possibly improved opportunities of finding contractor with relevant experience	Variation order is contractual and may lead to delays for activities not foreseen at tendering stage.
		Trial sections may be too short to attract private contractors
		Private contractors may be less flexible in the time required to construct research sections.

4.1.6 Contractual issues

The intention is to link with newly awarded or on-going projects. TRL will prepare designs of test sections and based on these ERA will issue variation orders to the contractor (force account or private contractor). The client will shoulder the risk associated with performance of the test sections. The contractor's defects liability will be limited to the implementation of the variation order as per specification but not the subsequent performance of the test sections.

4.1.7 Monitoring of Research test sections

The measurements taken and the frequency of monitoring are likely to vary between the test sections depending on the parameters being studied and the information required. A monitoring programme will be developed before construction of the trial sections.

The monitoring will be carried out by the local team and the TA team. The local team will be drawn from the RRRs with technical support from the ERA where appropriate. Where possible universities will also be involved.

Equipment will be calibrated and maintained in a good condition to ensure accuracy and reliability of the data collected.

Data collection collation and analysis will be carried out by the team in collaboration with the project partners. The team will ensure compliance with mandatory procedures to achieve acceptable levels of data integrity.

A programme will be developed in collaboration with the Engineering Research Branch to ensure continuity and the longer term monitoring of the trial sections.

4.1.8 Social Impact Study

The requirements of the Social Impact Study in this contract are for data collection, surveys, interviews, and analysis of data at each demonstration site, which enables a record to be made of the impact of the project on local communities.

In our original proposal we suggested a 'before, during and after' social impact study to be conducted at each of the demonstration sites using household surveys, focus group discussions and labourer questionnaires.

Given that within the scope of this project, the social impact study is small in scale and with limited resources, a slightly modified approach is proposed.

While it would be pertinent to undertake a longitudinal study over the course of the project to identify impact before, during and after the construction of demonstration sections, this approach is restricted since the test sections will be of reduced length and therefore not representative of the whole roads that traverse communities in the study regions.

Rather, a more practical approach is to assess whether use of the different design standards, locally resourced materials and construction practises have a significant effect on the accessibility of surrounding communities. In addition, it will explore whether households directly benefit from the trial sites, for instance from employment on the road, in cases where a more labour intensive approach has been adopted for the trial section. With this in mind, the following research question is proposed:

Research Question: How do design standards and construction methods for low volume roads in different regions, affect the livelihoods of surrounding populations?

It is proposed that the social impact study collect a sub-set of data representative of trial sites that experience extreme environmental conditions (for instance terrain and climate) and collect anecdotal evidence that livelihoods have been improved as a result of the trial sites, either from improved passability or from increased income where labour is employed locally.

At the time of writing, the site selection process has not been finalised, which gives us an opportunity to influence which roads, and sections of road are best suited from the perspective of the social impact study, in order that two such roads can be selected for empirical data collection. The field studies will hence be based on key passability sites, for instance over rough ground or on steep slopes, where trial site variability can be explored.

It is anticipated that certain construction materials will perform better under extreme conditions, and it is the effect of the performance of these road sections and the opportunities they provide for men and women to access employment on the road works that will most demonstrate impact on the surrounding communities with regards to income earning opportunities, economic activity and service delivery.

4.1.8.1 Research Approach

It is envisaged that a baseline study will be undertaken to obtain 'before' data prior to the test sections being constructed.[1] Monitoring data will be collected during the trials to assess impact throughout the period of construction and demonstration works. 'After'

[1] Data collection activities may be scaled down if sufficient data can be obtained from the WIDP datasets and reports.

data will be collected towards completion of the assignment (20 months after completion of the demonstration works). It is recommended that a control site be selected in addition to the two research sites, in order to factor out any externalities that may be influencing the impact of the road which are not related to the trial sites.

A variety of research methods will be employed during each of the data collection periods to establish the extent of impact and benefits/disbenefits associated with two of the demonstration sites with regard to labour based methods and associated employment opportunities.

- Household surveys comprising questions on household composition, income and expenditure, transport requirements, ownership and access to means of transport and transport problems and solutions
- Focus group discussions with designated social groups within the communities surrounding the test sites to establish the pattern of daily mobility, and the impact of transport interventions on the livelihoods and wellbeing of different income groups.
- Questionnaire aimed at labourers working on the test sections to elicit information on employment generation, pay and conditions, skills acquisition, labour quotas, gender impacts, contracting, labour conditions and HIV/AIDS.

Three sets of data will be acquired (before, during and after test site construction) to establish how the various design standards and construction practises, that are applied to different demonstration sites, affect the livelihoods of road users.

To ascertain the impact of the road improvements on household earnings, it is necessary to undertake some empirical research along with analysis of secondary materials, and hence the social impact study will be designed thus, adopting the methodological approach outlined in Overseas Road Note 22 'A Guide to Pro-Poor Transport Appraisal'.

It is recommended that the measurement of social impact on the range of stakeholders (including transport users, livelihood earner, roadwork labourers, residents living in the vicinity of the demonstration sites, community service users and community service providers), should follow a series of clear steps comprising the following:

Step 1: Creation of a study team

Step 2: Survey reconnaissance

Step 3: Questionnaire and focus group discussions

Step 4: Analysis

Step 1: Creation of a study team

ORN 22 recommends that the Team Leader (in this case the project social development adviser) have a team of at least three university graduate survey enumerators at their disposal to assist with administering survey questionnaires, assisting with the focus group discussions and any participatory appraisal exercises, as well as data entry and analysis.

In order to undertake the field surveys effectively, post-graduate students from appropriate academic departments (for instance engineering and development studies) are currently being sought at the University of Addis Ababa and other regional universities, who may be seeking to collect primary data for their theses. This project will present an opportunity to collect such data.

Step 2: Survey reconnaissance

This step will investigate secondary data sources in a systematic way in order to shape the background to the social impact study, with information about the transport sector in

Ethiopia, existing research projects undertaken on the socio-economic impacts of roads in Ethiopia, and environmental and demographic data that may influence the direction of research.

The secondary research and 'reconnaissance' activities will be desk based and will include the following information:

- Maps showing the wereda boundaries, and the federal, regional and community roads within each region,
- Latest detailed Census and household budget data,
- Background information on transport infrastructure, services and conditions including routine road maintenance activities from ERA,
- Existing survey material relating to the study areas, including household and transport surveys, participatory mapping etc.

There is a wealth of existing research material and reports from Ethiopia that require comprehensive review in order to build up a picture of prevailing socio-economic conditions in Ethiopia, and in particular the regions of Afar, Amhara, Tigray and Oromiya that are tentatively under study.

Secondary data sources for the social impact study will include the following:

- Transport Poverty Observatory, National Consulting
- MDG Indicator Study, WT Consult
- TWRRP Evaluation, David Mason, Consultant to the ILO
- Tigray and Wollo Road Rehabilitation Project, Final Report, ILO (2001)
- Ethiopia Rural Travel and Transport Program Wereda Integrated Development Plans (WIDP) covering 100 weredas
- Framework for the Inclusion of Social Benefits in Transport Planning, Ethiopia Case Study, TRL (2004)
- Road Fund in Ethiopia: from Inception to Realization, Office of the Road Fund Administration (2001)
- The Third Stage Road Sector Development Project, World Bank (2007)
- Performance Monitoring System of the Ethiopian Road Sector Development Program, World Bank (2004)
- ERA document on Working with Road Contractors on HIV/AIDS Prevention
- Transport, GIS and DHS Surveys: Mapping the Evidence on Access, Mobility and MDG Impact, The Trust Fund for Environmentally and Socially Sustainable Development (2005)
- Interaction between Rural Road investment and Agricultural Productivity, IFPRI
- The World Factbook on Ethiopia
- Information from the WSP cross-cutting themes team in ERA
- Cross-cutting themes chapter from Ethiopia LVR Manual

It is proposed that these documents form the basis of the background socio-economic data of Ethiopia, and where possible, provide specific information relating to the four regions under investigation. The WIDP documents in particular will provide current data relevant to the specific wereda's under investigation, which may result in adjustments to primary data collection activities.

Step 3: Questionnaire and focus group discussions

An approach combining focus group discussions and questionnaire is recommended whereby the key informants in the community help organise focus group discussions with groups of adult women, men and secondary school students in the community. Before participating in the focus group, each individual will have a short questionnaire administered to them to gain information on:

- Household composition and livelihood (income and expenditure)
- Household travel patterns
- Income and expenditure
- Trip frequency
- Transport requirements
- Use of motorised transport
- Ownership and access to means of transport
- Transport problems and solutions

After administering the household survey questionnaire to the randomly selected groups of the sample of adult men, women and students, each group will be requested to give its views about the community in a focus group discussion that will provide valuable anecdotal commentary on livelihood impacts associated with the trial sites.

In addition, a questionnaire aimed at local labourers working on the trial sections will be undertaken during trial construction to explore the social impact of labour processes, and will address the following issues:

- Labour sourcing – how labour is sourced from the local community, how labour is contracted, male/female quotas, on-site training
- Labour protection – wages, minimum age, health and safety, HIV/AIDS
- Labour standards – pay, working hours, conditions, equal opportunities
- Income earning capability and purchasing power

This combined approach will generate a sample of up to 90 households from villages at each trial section, along with other qualitative data. While this will not comprise a sufficient sample to be statistically significant, it will provide discreet data that will indicate where the trial sections have influenced accessibility under extreme environmental conditions, and where improvements in income earning opportunities and labour conditions can be investigated. The research approach and data collection activities will remain flexible to account for datasets already available in the WIDPs.

Step 4: Data analysis

Analysis and interpretation of data collected in the field is key to providing an overall impression of the pre-impact (and post-impact) condition of the different research sections at a selection of demonstration sites. Assuming the data has been collected correctly and provides an accurate representation of trip-making activities prior to road investment, it can be analysed to determine key relationships between the status of the road infrastructure and the prevailing socio-economic situation in the surrounding communities.

4.1.9 Analysis of Time Series Data from Research Test Sections

Data collation and analysis will be carried out in a continuous manner as monitoring data from research test sections becomes available. Preliminary recommendations will also be developed in a progressive manner. The data will be analysed in a way that will enable life cycle costs to be calculated and the results to be assimilated into investment models.

A draft final report, consolidating findings during the entire project period, will be prepared and subjected to peer review before the end of the project.

4.1.10 Draft Pavement Design Specifications for LVRs

Draft pavement design specifications will be developed for consideration after the location of the test sections has been selected and a decision made on the most appropriate demonstration/trial to be constructed at each location. The design of the test sections will leverage in-situ strengths of the sub grades gained through consolidation under traffic. The in-situ sub grade strengths obtained through tests such as the Dynamic Cone Penetrometer, and represented as CBR values, will be used to design the subsequent pavement layers.

The road building materials available locally will be an important factor in pavement design. Field investigations will be carried out to determine material availability. The quality of the selected materials will be determined in laboratory tests so that they can be classified and assessed for their suitability for use in the each of the pavement layers as appropriate.

The results of these investigations will determine if the materials can be used as-dug or if they need to be processed in some way to enable their use in pavement construction. Options for improving materials for use in the pavement structure include crushing, blending, stabilising, etc whilst other techniques such as Otta seals, for example, enable weaker aggregates than is usual to be used as surfacing stone.

Generally sub-base and road base thickness designs will be based on the bearing capacity of the – materials being used.

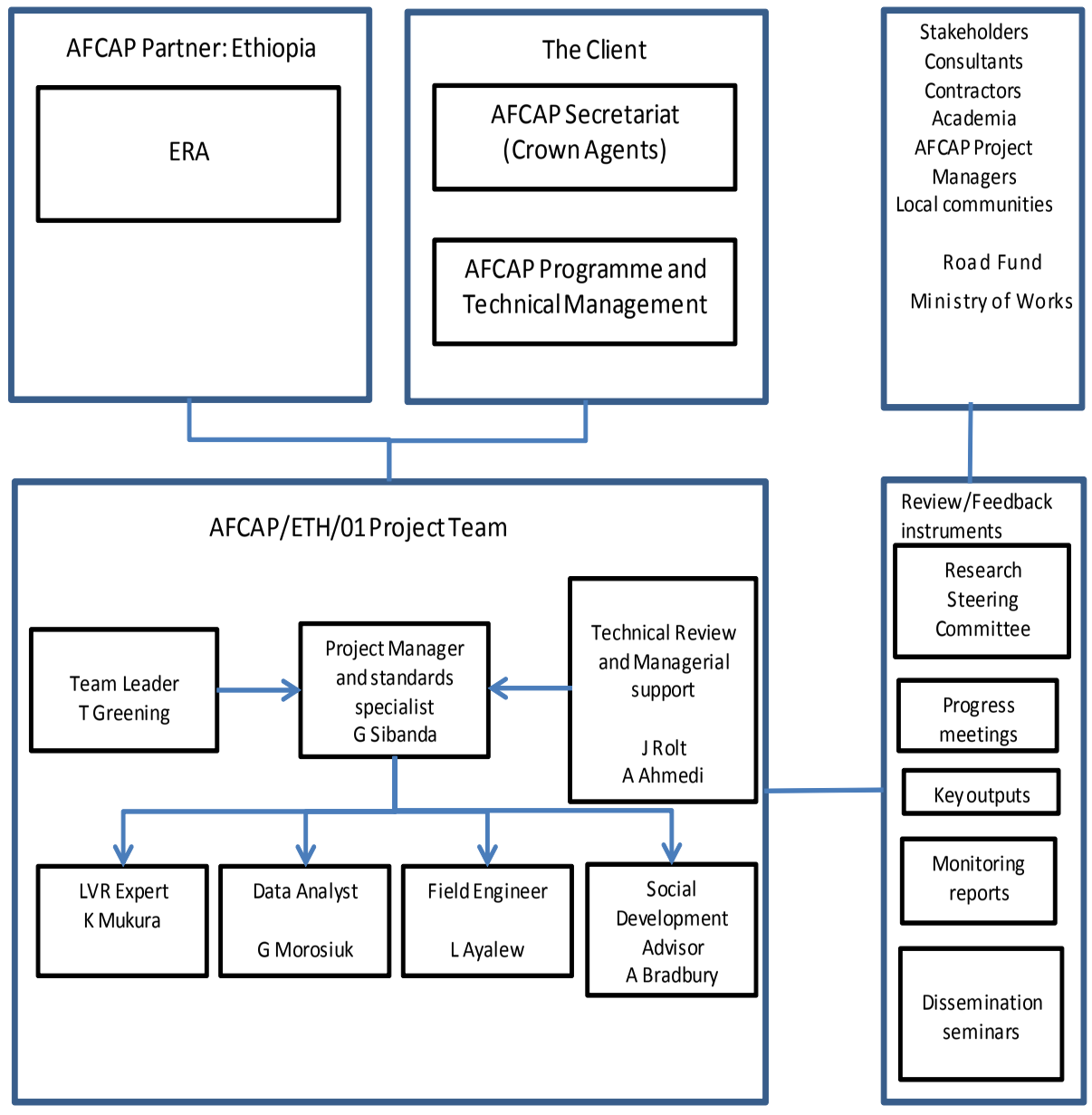
Surface treatments will include but will not be limited to;

- Sand Seals or Slurry Seals
- Otta Seals
- Surface treatment
- Stone/ Brick Paving
- Penetration MacAdam.

5 Project Structure

5.1 Project Teams

The revised team will be structured as depicted in Figure 3:



5.2 Institutional Arrangements

In terms of the institutional agreement ERA will liaise with the RRAs for all aspects of the implementation of the project, and will ensure that funding is in place for the construction of the demonstration sections. ERA has provided office space at the Research Unit premises in Addis Ababa. ERA and the RRAs will provide transport to the field for their own staff, where this cannot be shared with the consultant. ERA and the RRAs will provide accommodation and subsistence for their staff while in the field.

As per the project terms of reference, training will be provided to the ERA Research Unit and to Regional Road Authority staff involved in the design and construction of the test sections. This will be achieved through on-the-job training of counterpart engineers in the development of research procedures and in carrying out research activities as well as the requirements for supervision of construction activities. The training will ensure that current and future test sections are constructed in accordance with the required specifications. The Design Division and Contract Implementation Divisions will be consulted in the development of designs for test sections.

The training programme will also involve the local construction industry in collaboration with academic and training institutions and will include the dissemination of the findings of the study and the LVR Design Manual. Where appropriate, visits to the demonstration sites will be organized together with dissemination seminars in participating regions. Where appropriate, universities are also expected to participate in data collection and analysis.

Where feasible, university students will be afforded opportunities for attachment to the project and the possibly for pursuing higher degree qualifications will also be examined. This will contribute to creating a cadre of graduates familiar with new approaches. Opportunities for inputs by students will depend on a number of factors which might vary from site to site and on the timing of the work.

The project will work closely with the Research Steering Committee. Collaboration will be forged with complementary initiatives such as the Ethiopia Rural Travel and Transport Programme (ERTTP), the Rural Access Group under the Transport Working Group and other relevant local groups.

5.3 Risk Management

Table 3 is a summary of possible risks and how they will be mitigated.

Table 3: Risk Management

Project: Ethiopia AFCAP – Development of Pavement Design Standards for LVRs		**Risk Register Prepared By:** Project Manager		**Issue Number:**	
				Date: 24 February 2010	
Risk ID	**Description**	**Risk Rating**	**Effect**	**Reduction Strategy**	**Risk Owner**
1	Most potential candidate roads for test sites are ongoing projects being implemented by private contractors. Possible delays in agreeing contractual changes may delay construction of test sections.	Med	Delays in construction of some sections making it impossible to carry out the desired number of monitoring cycles. This would reduce the integrity of the research findings by the end of the project period.	Try to construct a number of trial sections concurrently to the extent possible. It may be necessary to hire-in extra field supervision expertise or reassign some TRL staff to oversee and ensure compliance with research objectives. Maintain close liaison with ERA and share any information that can help meet the target duration.	ERA, PM and Field Engineer (FE)
2	Construction of some test sites may be delayed by rain	Med	Project not delivered on time or to budget	If construction is expected to fall within the rainy season, work will be prioritised to commence in semi-arid regions which are likely to be less adversely affected by rains. The Project Manager and Field Engineer must liaise with ERA and partner regions to promote sharing of relevant information and timely implementation of activities in the project critical path.	ERA, PM and FE
3	Contractors may be reluctant to adopt the less familiar work norms required for the research.	Low	Research specifications may not be fully complied with compromising attainment of the research objectives.	Carry out pre-construction sensitization workshops for participating road authority staff and contractors. Field engineer to work closely with the contractors and supervising road authorities.	ERA, PM and FE

6 Activity Schedule

Appendix 1 shows the planned activity and staffing schedule. Month 1 is October 2009. Although the Project Manager arrived in Ethiopia on 16 November 2009 the project had already started. Efforts will be made to accelerate some activities where possible (without compromising quality) in order to deliver the project within the agreed period.

6.1 Supervision Component

Demonstration sections and trial sections will be carried out concurrently (within the capacity of available human and equipment resources) to optimise resources and deliver the project on time. ERA will be responsible for the supervision of the construction of the trial sections with technical guidance from the field engineer.

6.2 Quality Assurance Component

Prior to construction of trial sections, a design report will be produced, specifying the objectives and methodology for constructing each of the trial sections.

During construction, the normal supervision will be provided by the regional rural road authorities, ERA or consultants but the project field engineer will be on site to ensure compliance with the agreed design and specifications for each of the trial sections. The monitoring teams will also be trained in all aspects of data collection and collation.

6.3 Research Component

Data collected both during and beyond the specified project duration will contribute to future addition and revisions of the ERA Design Manuals and Specifications.

7 Progress to Date

7.1 Consultative meetings

The team has held several consultative formal and informal meetings with key staff and partners of ERA.

The team's participation in the workshops on Low Volume Roads Design Manual, Specifications and Bidding Documents (AFCAP/ETH/005) plus the meeting of the Research Steering Committee (Adama 23 to 26 November 2009, Dire Dawa 18 to 20 January 2010 and Awassa 15 to 18 February 2010) provided an opportunity to interact with representatives from RRAs and ERA. During the first workshop most regions provided feedback on questionnaires that had been circulated earlier regarding potential candidate roads for research trial sections.

7.2 Field visits

The team participated in a number of field visits with a team working on the project on Low Volume Roads Design Manual, Specifications and Bidding Documents. The field trips focussed on familiarisations with various locally abundant materials that are or may be used for road building.

7.3 Selection of test sites

The process to select possible test sites comprises;

- Requesting RRAs to complete a questionnaire about conditions and materials relating to their roads and to provide a list of possible candidate roads. Most regions supplied the information requested (Appendix 2).
- Acquiring more detailed information about the roads in order to assess their suitability for the inclusion of trial sections that will provide the required data.
- Reviewing ERA's ongoing and planned projects in order to identify additional candidate roads with higher traffic in order to be able to obtain data on traffic induced deterioration in the event the target regional roads have very low traffic. This exercise is ongoing.
- Physical inspection of the target roads to identify ideal locations of trial sections. This task commenced in January 2010.

7.4 Procurement

Procurement of office equipment and furniture is in progress. The procurement of the project vehicle has been delayed but is in progress. ERA will pay for customs duty and levies. However, since the project contract is between TRL and AFCAP (although ERA is specified as the recipient body with rights and obligations) a collaboration agreement between TRL and ERA has been prepared to enable purchase of a new vehicle which is being imported. In the meantime the project is using the two vehicles purchased for use in the Improving the Performance of Gravel Wearing Course and Low Cost Surfacing research project.

7.5 Equipment to be provided by AFCAP

AFCAP is expected to provide some equipment for each of the participating regions. (Appendix 3). TRL has, through its technical proposal, provided detailed specifications for the items to be procured by AFCAP to enable procurement under a separate supply contract.

Although another project, "Ethiopia Road Sector Capacity Building Project" funded by the EC is expected to supply most regions with new equipment (computers, laboratory, surveying equipment, etc) it is not recommended that this project should rely on that equipment as it:

- may not be available when needed for the research
- may not be suitable.
- RRAs may not have been sufficiently trained in its use to be able to carry out some of the required tests at the time that the sections are being constructed.

However, survey equipment should be of the same type/model as purchased under the EC funded project to the extent possible.

Appendix 3 also provides a list of equipment that is recommended for provision by AFCAP based on information available to date.

8 Plan for Next Reporting Period

The next report will be a Design Report which is due by month 5. Activities that will be carried out between now and the next reporting period are detailed in the activity and staffing schedule.

Acknowledgements

The work described in this report was carried out in the International Group of the Transport Research Laboratory. The authors are grateful to the Director General and staff of ERA and also General Managers and staff of RRAs and also staff on other AFCAP and parallel programmes who have assisted in various ways, especially for sharing their knowledge on local issues. Thanks also go to Dr John Rolt who carried out the technical review and auditing of this report.

Appendix 1: Activity and staffing schedule

ANNEX 1: STAFFING AND ACTIVITY SCHEDULE - DEVELOPMENT OF PAVEMENT DESIGN STANDARDS FOR LVR IN ETHIOPIA

Primary responsibility
Secondary responsibility

Activities	MAN MONTHS	STAFF INPUT SCHEDULE (all inputs are subject to change and pending the construction schedule)																																		Man-months and Responsibilities					
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	2	11	4	4	10	3
		Year 2												Year 3																								Year 4				Tony	Gama	Ken	Greg	Lul	Ann
Mobilisation phase																																									○	●	○			
Inception phase																																									○	●	○	○	○	○
Implementation phase																																									○	●	○	○	○	○
INTERNATIONAL																																														
T Greening - Project Director	**2**																																													
G Sibanda - Project Manager / Standards	**11**																																													
K Mukura - Low Volume Roads Expert	**4**																																												
G Morosuik - Data Analyst	**4**																																													
L Ayalew - Field Engineer	**10**																																													
A Bradbury - Social Development Advisor	**3**																																													
REVIEW PANEL																																														
J Rolt - Technical Reviewer	**2**																																													
A Ahmedi - Logistical Support	**2**																																													
MOBILISATION																																														
Consultative Meetings	3																																								○	●				
Procurement -proj equipment	3																																									●				
Collaborative Agreements	5																																									●			○	
Setting Up Local Teams	4																																									●				
PROJECT INCEPTION																																														
Desk Study and Research Matrix	1																																								○	●	○		○	○
Selection of Candidate Roads	3																																									●			○	
Site Selection	2																																									●			○	
SITE INVESTIGATION																																														
Material Investigation	2																																									○			●	
Sampling	2																																									○			●	
Testing	3																																									○			●	
Road Condition Survey	2																																									○			●	
In-situ Strength Tests	2																																									○			●	
Topographic Survey	2																																									○			●	
Visual Condition Surveys	2																																									○			●	
Drainage Condition Surveys	1																																									○			●	
DESIGN																																														
Trial Options	1																																									○	○	●		○	
Materials Design	1																																									○	○	●		○	
Cross - Sections Design	1																																										○	●			
BoQs	1																																										○	●			○	
PROCUREMENT																																														
Approval of contract docs	1																																										●			○	
Bidding/signing agreements	1																																										●			○	
CONSTRUCTION OF TRIAL SECTIONS																																														
Site Mobilisation	1																																										○			●	
Execution of Works																																											○			●	
Setting Out	1																																										○			●	
Drainage Structures	1																																										○			●	
Earthworks/pavement layers	1.5																																										○			●	
Construction of Surfacings	0.5																																										○			●	
Final Clearing	0.5																																										○			●	
Maintenance guidelines for each site	0.5																																										○		●		○	
MONITORING																																														
Design monitoring programme	0.5																																									○	○	●	○	○	
Visual Condition Surveys	0.5																																										○			●	
Pavement Strength Tests																																											○			●	
Materials tests																																											○			●	
DATA ANALYSIS																																														
Data Collation & Processing	1 x 4																																										○		●	○	
Dev. Performance Info and lifecycle costing.	1																																									○	○	●		
Peer review workshop	1																																									●	○	○		○	
Review/Dev. of Design Standards and Specifications	1																																									○	○	●		○	
SOCIAL COMPONENT																																														
Establishing baseline requirements	0.5																																										○				●
Data collection activities	1																																										○				●
Intermediary analysis	0.5																																										○				●
Impact report at end of study period	1																																										○				●
KNOWLEDGE TRANSFER AND DISSEMINATION																																														
Knowledge transfer to ERA Research Unit and				*Continuous support input*										*Continuous support input*												*Continuous support input*																●				○	
Regional Workshops (2 workshops by 5 regions)																																										●				○	
National Workshops (2)																																										●	○			○	
International Seminars/study tour (venue and date to be advised)																																											●				
Websites				*Continuous support input*										*Continuous support input*												*Continuous support input*																●	○	○	○	○	
																																												○	
Milestones and reports																																														
Inception report				◆																																					○	●	○		○	○
Bi-monthly reports		●	●	●	●	●	●	●	●	●	●	●		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●		●			○	
Detailed design reports						●																																			○	○	●		○	
Detailed construction and baseline monitoring reports													▼																												○	○			●	○
Pavement monitoring/data collection and analysis report													■						■					■						■		▼									○	○	○	●	●	
Preliminary design standards and material specifications report																																■									○	○	●		○	
Draft final report																																	▼									○	●	○	○	○	○
Draft social impact monitoring report																																		●								○	○				●
Final report- Revised Pavement Design Manual																																							●			○	●	●		○	○

LEGEND

Primary Responsibility/intermittent input

Intermittent input in supporting role

Appendix 2: Site selection information provided by RRAs

ROADS AUTHORITY	OTHER (please state)				AVAILABLE MATERIALS (please tick)						EXISTING TRAFFIC VOLUME (tick)			TYPICAL GRADIENT (tick)			ANNUAL RAINFALL (tick)			POPULATION SERVICED BY ROAD (tick)			VEHICLE COMPOSITION (state % of each vehicle type served by the road)							ECONOMIC ACTIVITY (indicate main road function with a tick)					COMMENT ON THE ROAD CONDITION OR SOCIO-ECONOMIC CHARACTERISTICS OF THE ROAD - NOTE ANY PARTICULAR PROBLEMS OR ISSUES THAT NEED ATTENTION
PROPOSED CANDIDATE ROADS (please indicate the name and location of the candidate road you are shortlisting)	Distance to Regional Centre (km)	Length of Road (km)	Availability of labour along the road (tick)	% unemployed labour	Red Ash (Cinder)	Basalt	Limestone	Sand	Expanding Clays	Other (please state)	Low (< 50vpd)	Med (50-100vpd)	High (100-300vpd)	Flat (gradient = 0)	Gentle (gradient = <10%)	Steep (gradient = <18%)	Arid (< 400mm/yr)	Semi-arid (400-700mm/yr)	Wet (> 700mm/yr)	Low (< 500 people)	Medium (500-1000 people)	High (> 1000 people)	Motorised (car, lorry, tractor, bus)	Bicycle	Pedestrians	Animal Cart	Motorcycle	Other (please state)	Transporting agricultural produce	National/regional access route	Social amenities (health centre, school)	Market place	Other (please state)	
Oromia Roads Authority																																			
1.Gindo - Qota – Darge	126	35	√						√		√			√					√			√	√	√	√	√	√	√	√	√	√		Highly expansive soil and difficult to get sub-base material
2.Waliso – Dulale	116	29	√						√			√			√			√				√	√	√	√	√	√	√	√		√	√		
3.Dhera – Amude	125	30	?		√			√				√		√			√					√	√	√	√	√	√	√	√		√	√		Difficult to compact at OMC as it is sandy and has small amount of clay
4.Bishoftu – Hidi	50	9	√		√			√	√		√			√				√				√	√	√	√	√	√	√	√		√	√		Difficult to compact at OMC as it is sandy and has small amount of clay
5.Bantu – Botonne	85	20	?		?	?	?	?	?		?				√			√				√	√	√	√	√	√		√		√	√		
AMAHRA Roads Authority																																			
1.Jiga - Quarit	200	43	√		√				√				√	√					√			√	√	√	√	√	√		√	√	√	√		Expansive soil
2.Metema – Abdegafi	330	120	√					√	√				√		√				√			√	√	√	√	√	√		√	√	√	√		Expansive soil
3.Tsitsica - Arbatsquare	420	120	√			√						√				√	√					√	√	√	√	√	√		√	√	√	√		Topography (mountainous)
4.Adet - Feres bet	42	69	√			√							√		√				√			√	√	√	√	√	√		√	√	√	√		Sand
5.Bahirdar – Kunzela	0	60	√		√			√	√			√		√					√			√	√	√	√	√	√		√	√	√	√		Expansive soil

ROADS AUTHORITY	OTHER (please state)				AVAILABLE MATERIALS (please tick)						EXISTING TRAFFIC VOLUME (tick)			TYPICAL GRADIENT (tick)			ANNUAL RAINFALL (tick)			POPULATION SERVICED BY ROAD (tick)			VEHICLE COMPOSITION (state % of each vehicle type served by the road)						ECONOMIC ACTIVITY (indicate main road function with a tick)					COMMENT ON THE ROAD CONDITION OR SOCIO-ECONOMIC CHARACTERISTICS OF THE ROAD - NOTE ANY PARTICULAR PROBLEMS OR ISSUES THAT NEED ATTENTION
PROPOSED CANDIDATE ROADS (please indicate the name and location of the candidate road you are shortlisting)	Distance to Regional Centre (km)	Length of Road (km)	Availability of labour along the road (tick)	% unemployed labour	Red Ash (Cinder)	Basalt	Limestone	Sand	Expanding Clays	Other (please state)	Low (< 50vpd)	Med (50-100vpd)	High (100-300vpd)	Flat (gradient = 0)	Gentle (gradient = <10%)	Steep (gradient = <18%)	Arid (< 400mm/yr)	Semi-arid (400-700mm/yr)	Wet (> 700mm/yr)	Low (< 500 people)	Medium (500-1000 people)	High (> 1000 people)	Motorised (car, lorry, tractor, bus)	Bicycle	Pedestrians	Animal Cart	Motorcycle	Other (please state)	Transporting agricultural produce	National/regional access route	Social amenities (health centre, school)	Market place	Other (please state)	
AFAR Roads Authority																																		
1.Afderd - Dodom	200	45			√	√		√	√	√	√			√			√					√	√		√	√			√	√	√		√	
2.Semis – Drbti	5	12	√		√	√			√				√	√			√					√	√	√	√	√	√	√	√	√	√	√	√	
3.																																		Corrugations, dispersive soils, compaction failure and water scarcity
4.																																		
5.																																		
HARARI Roads Authority																																		
1.Ererber – Erer	0	10	√					√				√				√		√			√		70		15		5	10	√		√	√		Very steep slopes and lack of drainage structures, easily erodible
2.Hamarasa – Hasanga	0	5.8	√					√				√			√			√			√		80		20				√		√			Very steep slopes and lack of drainage structures, easily erodible
3.Erer – Dodota	10	12	√					√				√				√		√			√		90		10				√		√			Lack of drainage structures
4.Erer Weldya – Ulanula	10.3	8.3					√	√				√				√		√			√		90		10				√		√			Very steep slopes and the only road for Unanula village
5.Aratagna – Awberchedla	0	8	√				√						√		√			√				√	70		15			5	√	√	√	√		Very bad road condition

ROADS AUTHORITY	OTHER (please state)				AVAILABLE MATERIALS (please tick)						EXISTING TRAFFIC VOLUME (tick)			TYPICAL GRADIENT (tick)			ANNUAL RAINFALL (tick)			POPULATION SERVICED BY ROAD (tick)			VEHICLE COMPOSITION (state % of each vehicle type served by the road)						ECONOMIC ACTIVITY (indicate main road function with a tick)					COMMENT ON THE ROAD CONDITION OR SOCIO-ECONOMIC CHARACTERISTICS OF THE ROAD - NOTE ANY PARTICULAR PROBLEMS OR ISSUES THAT NEED ATTENTION
PROPOSED CANDIDATE ROADS (please indicate the name and location of the candidate road you are shortlisting)	Distance to Regional Centre (km)	Length of Road (km)	Availability of labour along the road (tick)	% unemployed labour	Red Ash (Cinder)	Basalt	Limestone	Sand	Expanding Clays	Other (please state)	Low (< 50vpd)	Med (50-100vpd)	High (100-300vpd)	Flat (gradient = 0)	Gentle (gradient = <10%)	Steep (gradient = <18%)	Arid (< 400mm/yr)	Semi-arid (400-700mm/yr)	Wet (> 700mm/yr)	Low (< 500 people)	Medium (500-1000 people)	High (> 1000 people)	Motorised (car, lorry, tractor, bus)	Bicycle	Pedestrians	Animal Cart	Motorcycle	Other (please state)	Transporting agricultural produce	National/regional access route	Social amenities (health centre, school)	Market place	Other (please state)	
SOMALI Roads Authority																																		
1.Kebribeyah - Harteshek	42	21	√	70				√	√			√			√			√				√	50		30	15	5		√	√	√	√		Black cotton soil? It is a regional access road and also networked with four districts. They use this road to transport their goods to the market places of the districts.
2.Jijiga – Tuliguled	0	30	√	40				√	√		√				√			√		√			30		30	30	10		√		√	√		Black cotton soil? The community uses this road to transport their agricultural produce to the market place (e.g. wheat and sorghum)
3.West Imey - East Imey	1000	33	√	30			√	√			√			√			√				√		30		40	20	10				√	√		This road joins the west and east Imey waredas. This road is also a regional access route & is also essential for the peace of the region.
4.Tuliguled – Jaradenbel	30	42	√	50	√			√	√		√				√			√	√				20		40	30	10		√		√	√		Water shortage. This road is connects Denbel wareda with the capital town for the peace of the region of the region (JiJia) and also pass Djibouti through Denbel.
5.Godey – Bargel	700	110		60			√	√					√	√			√				√		40		30	20	10		√		√	√		This road is essential for the community to transport agricultural produce produced in Gode to Bargel town and also it also links to social amenities, health centre and school etc.
SNNPR Roads Authority																																		
1.Wormuma – Garugodo	160	21	√	55						√		√		√	√			√				√	30	10	√	50	10		√			√		
2.Butajira - Goga	135	11	√	40	√					√		√			√	√		√	√			√	40		√	30	√		√		√	√	√	(No Comment)
3.Adislcofe – Haramo	385	16	√	60			√		√		√				√			√				√	50		√	15	35		√			√		
4.Belesa - Chingo	180	19	√	60			√		√		√					√			√		√		20		√	60			√	√	√	√		
5.Morocho – Leku	24	3.6	√	40			√		√				√		√			√				√	√	√	√	√	√		√	√		√		The road segment crosses one of the most productive cash crops areas (coffee) and the route is one of the shortest to reach the regional city.

ROADS AUTHORITY	OTHER (please state)				AVAILABLE MATERIALS (please tick)						EXISTING TRAFFIC VOLUME (tick)			TYPICAL GRADIENT (tick)			ANNUAL RAINFALL (tick)			POPULATION SERVICED BY ROAD (tick)			VEHICLE COMPOSITION (state % of each vehicle type served by the road)						ECONOMIC ACTIVITY (indicate main road function with a tick)					COMMENT ON THE ROAD CONDITION OR SOCIO-ECONOMIC CHARACTERISTICS OF THE ROAD - NOTE ANY PARTICULAR PROBLEMS OR ISSUES THAT NEED ATTENTION
GAMBELLA Roads Authority																																			
1.Ababo - Pugndwo	50	54	√	50	√			√			√				√			√				√			60	10	20		10		√	√	√	√		
2.Kobon – Bonga	38	18	√	25				√			√				√			√			√			20	30	40		10		√		√	√		
3.Itang Junction – Warkaya	43	45	?	50	√						√			√				√			√			5	20	65		5		√		√	√		The roads enable the community to transport commodities and agricultural products. The standard of the Roads is RR 10 (All weathered road). Lack of good road building material
4.Meti - Gelesha	360	27	√	25	√						√				√				√			√			50	20	10	5	15		√		√	√		
5.Gambula – Aliya	0	38	√	25				√				√		√				√					√		60	5	25		10		√	√	√	√		
DIRE DAWA																																			
1. Dire Huno Road Junction - Gede	13	17	√	23			√	√				√		√				√					√		60		5	30	5		√	√	√	√		
2. Dire Djibouti Road Junction - Chirimiti	78	36	√	16			√	√				√			√		√						√		65		5	25	5		√	√	√	√		
3. Biku Awalw – Awale	21	18	√	20			√	√					√		√			√					√		70		2	18	10		√	√	√	√		

NB
Complete all applicable columns, and if appropriate tick more than one column in each group of variables (materials, traffic, gradient etc). √

Please note that only 1-2 short sections of road will be selected and not whole roads. Site visits will finalise the candidate roads.

REGIONAL ROADS AUTHORITY	CONTACT	TELEPHONE	EMAIL ADDRESS
Oromia	Ato Addissu Mosissa	0911857504	addeso-2058@yahoo.com
Amahra	Ato Tenaw Sewunet	0918762676 and 0912443740	contacttenaw@yahoo.com
Afar	Fisseha Abate	0911707171	fish27@yahoo.com
Harari	Ato Nebil Mohamed	0915743004	nebili@yahoo.com
Somali	Abdiselam Yusuf and Asad Omar	0915749381 and 0911821789	abdiselamyusuf@yahoo.com and asadnev2005'hotmail.com
SNNPR	Ato Sisay Belachew	0916825662	sisaybelachew@yahoo.com
Gambella	Solomon Arefayne	0911067898	
Dire Dawa	Benyam Wubshet	0915734956	binwub@yahoo.com

Appendix 3: List of Equipment to be provided by AFCAP

The following list shows equipment that is recommended to be provided by AFCAP for each of the participating regions

EQUIPMENT PLANNED TO BE PROCURED BY AFCAP FOR PARTICIPATING RRAs AS PER TRL PROPOSAL		REVISED AFCAP EQUIPMENT LIST FOR COMPATIBILITY WITH EQUIPMENT TO BE SUPPLIED TO EACH RRA BY EU FUNDED THE ETHIOPIA ROAD SECTOR CAPACITY BUILDING PROJECT	
ITEM	QUANTITY	ITEM	QUANTITY
Notebook computer and the software required for data storage, analysis and reporting	1	Notebook computer and the software required for data storage, analysis and reporting	1
Printer and printer consumables	1	Monochrome Network Laser printer	1
		UPS 650 VA	1
Automatic level, tripod and staff	1	Digital level, electronic range 100m plus tripod and levelling staff	1
Cone penetrometer and adequate spares for three years	1	Cone penetrometer and adequate spares for three years	1
Straight edge plus wedge	1	Straight edge plus wedge	1
50m tape measure	1	50m tape measure	1
10m tape measure	1	10m tape measure	1
Vehicle mounted bump integrator (including	1	Vehicle mounted bump integrator (including	1

installation in the vehicle)		installation in the vehicle) plus MERLIN	
Digital camera (min 6 megapixel)	1	Digital camera (min 6 megapixel)	1
Mobile phones	2	Walky talky (15km range on flat open surface)	2
		Traffic counter and inductive loops	1

It is also recommended that AFACP supplies the following equipment to be shared project wide.

- One vehicle mounted bump integrator (including installation in the vehicle) plus MERLIN.
- One nuclear density measuring device. A double probe (e.g. strata gauge) is recommended instead of the single probe (such as Troxler) 2 generators and (long) drills of appropriate diameter for use with the double probe nuclear density measuring device.
- 2 deflection beams for measuring pavement stiffness.
- Safety equipment for use in monitoring 2 sites concurrently – 12 orange traffic channelling cones, 4 flash lights, 8 reflective neon colour adult size jackets.
- Field test kit developed by CSIR and ILO.

This equipment will be owned by ERA following supply by AFCAP. Equipment to measure pavement stiffness on the demonstration sites will be hired by AFCAP.

Appendix 4: Terms of Reference

Development of Pavement Design Standards & Specifications for Low Volume Roads in Ethiopia

The Africa Community Access Programme1 (AFCAP) is a research programme funded by the UK government's Department for International Development (DFID), which is promoting safe and sustainable rural access in Africa. AFCAP supports knowledge sharing between participating countries in order to enhance the uptake of low cost, proven solutions for rural access that maximise the use of local resources.

AFCAP has been asked by ERA to support a research consultancy outlined in these terms of reference. The project will assist the Government of Ethiopia in the "Development of Pavement Design Standards and Specifications for Low Volume Roads".

Background

Infrastructure development generates significant reduction in poverty by improving the income earning opportunities of rural people and by reducing the cost of goods. Low Volume Roads (LVRs) in Ethiopia provide links from homes, villages and farms to markets, offer the public access to health, education and other essential services. These roads also provide an important link between wereda centres and the federal road network. Low volume roads typically carry less than 300 vehicles per day and traffic composition is predominantly light vehicles. Depending on local circumstances, up to 30% of the vehicles may be heavy.

Most LVRs in Ethiopia are unpaved with gravel or earth wearing surface. Very few of these roads are paved. In many areas the only available gravels for use as a gravel wearing course are poorly graded and non-plastic. These types of materials, when used as a wearing course, deteriorate rapidly. Even under light traffic such materials result in high levels of road roughness, severe corrugation, deep pot-holing and rutting and dangerous surfaces. The performance of such materials suffers further under the influence of the local environmental conditions, including both wet and dry weather, the challenges of terrain and poor drainage. Severe scouring, erosion, poor bearing strength and traction loss are predominant features of many unpaved roads in Ethiopia and complete loss of access is not uncommon. Maintenance demands and costs are high with re-gravelling and major repairs required on many road sections, almost on an annual basis. This situation puts additional stress on the scarce financial resources and the authorities charged with management of these LVR networks.

Traditional road design methods for paved roads focus primarily on influence of traffic and the bearing strength of the road subgrade. These determine the required pavement structure, materials specifications and the geometric design parameters. Research in sub-Saharan Africa and elsewhere has shown that this approach is often either inadequate or overly conservative for the design of LVRs. Understanding the influence of the local environment and working with nature becomes as important as traffic when developing successful and economically viable road designs for LVRs.

ERA is presently receiving support from DFID for the construction of trial sections on a LVR in the Southern Region (SNNPR) under a TRL research programme titled "Improving the Performance of Wearing Course Gravel and Low Cost Surfacing". The trials include improvements to natural gravel materials for use in wearing course, low cost bituminous seals, and dressed-stone paving. Improved methods of working with "marginal" materials are also being demonstrated.

To move this programme from a research platform in the Southern Region and into countrywide practice and application, ERA now wishes to formalise a national design standard for LVRs. These design standards will cover all engineering aspects for the provision of both paved and unpaved low-volume roads including geometric, design, hydrology and hydraulic design, design of appropriate drainage structures, structural pavement design, surfacing design options and maintenance requirements. ERA intends to roll out the lessons learned from the trials in Southern Region through the construction of a series of demonstration sections in the remaining principal regions in the country. ERA requires support and guidance for the development of the standards

1 AFCAP is a DFID funded programme of research, knowledge dissemination and training designed to address the challenges of providing safe and sustainable access to poor communities in Africa. The management of AFCAP has been contracted by DFID to Crown Agents.

and specifications, training and dissemination. It is envisaged that a range of innovative pavement and surface treatments will be used on the project sites in order to demonstrate application of a range of appropriate technologies for LVR in Ethiopia

To facilitate the development of design recommendations for LVRs that are appropriate to most parts of Ethiopia, ERA will make available a range of sites for construction of the demonstration sections. These will capture the range of materials, terrain and climatic factors typical in other regions of the country. The costs for construction of these demonstration sections will be met through ERA's own resources.

Objectives

The objective of this assignment is to develop and demonstrate revised pavement design and surfacing standards for Low Volume Roads in Ethiopia, and furthermore to disseminate the application of these standards to stakeholders in the federal and regional governments, the private sector and academic institutions.

Scope of the Services

The consultant will provide the following services, which will be detailed in his methodology:

1) **Project Steering Group -** Participate in Project Steering Group meetings arranged by ERA. It is expected that the group will meet quarterly for the first year of the project and six-monthly thereafter.
2) **Design Standards** - Prepare draft recommendations for the design of pavements and surfacing for LVRs in Ethiopia, as well as technical specifications. The design standards will be holistic and will capture all elements affecting the design selection and expected performance, including drainage. The recommendations must be sufficiently comprehensive for incorporation into a Design Manual for LVR. They should be based on the recommendations of the recent ERA/TRL study of "Performance Criteria and Life-Cycle Costing for Low-Volume Labour-Based and Unpaved Roads", as well as any lessons learned on the "Improving Limestone Wearing Course and Low-Cost Surfacing" project in Southern Region. They should also reflect regional and international standards for LRV. The design standards will maximize the use of local resources and promote the cost-effective and sustainable provision of LVRs. The design standards will apply to paved and unpaved roads and will include pavement layers as well as wearing courses, sealed surfacing options and drainage requirements. The standards will take into account local variations in topography, climate, geology and availability of road construction materials, as well as typical traffic found on LVRs in Ethiopia. The standards will also take into account the maintenance capacity of road agencies and the private sector. The standards will contribute to lower vehicle operating costs on LVRs, as well as lower long term maintenance requirements. The design standards should reflect and complement the existing pavement design standards, methods and procedures used by ERA for federal roads.
3) **Technical Review** - Undertake a technical review of the draft LVR Design Manual that will be prepared under a separate consultancy. Comment, where necessary, on all aspects of the draft manual, reviewing any new road pavement technologies which are pertinent to LVR, and ensuring that recommendations emanating from both projects are complementary.
4) **Specifications** - Prepare draft specifications for the construction of LVR pavements and surfacing. These specifications must be suitable for inclusion in the standard tender documents for construction works as used in Ethiopia and should address all options, approaches and techniques recommended.
5) **Construction of Demonstration Sections** - Assist ERA and the Regional Road Authorities (RRA's) to establish research/demonstration sites in the regions of Afar, Amhara, Tigray, Oromiya (west) and Oromiya (east). Each site should include at least 2 km of LVR. The demonstration sections should be designed using locally available materials. Designs should mitigate any adverse effects resulting from the use of marginal materials for pavement layers and local environmental conditions. Surfacings will include (but will not necessarily be limited to the use of earth/gravel, surface treatment, Otta seals, sand seals, slurry seals and hand pack stone, as well as difficult road foundation conditions. At least one test section should cross black cotton soils. The designs should be based on the pavement design recommendations and specifications prepared under items 2) and 4) above. The consultant will provide all design details and specifications in a format as required by the contractors for each pavement type. The works will be

contracted by the Regional Road Authorities using their standard procedures and will include a mix of machine-based and labour-enhanced technologies.

6) **Monitoring and Data Collection** - Establish a technical monitoring system on each of the test sites to collect pertinent data concerning the behavior of the road over a two year period. The monitoring system should be designed so that the recipient organizations can continue monitoring and data collection beyond the initial two years if it so wishes. The consultant will provide specific training for data collection and monitoring teams (drawn from ERA, RRA's or tertiary education establishments). Training will cover all aspects of the technical monitoring including site marking and recording techniques, routine data collection and recording techniques, special sampling and testing, data verification, quality and statistical assessment and technical data presentation techniques and analysis. The consultant will draw up Memoranda of Understanding with the institutions collaborating on the project, including those charged with monitoring and data collection. These memoranda will set out arrangements and responsibilities with regards to all aspects concerning the training, monitoring of the road sections, collection of technical and social data, materials testing, data analysis and dissemination of results.
7) **Social Impact Study** – A social impact study will be conducted on each of the demonstration sites. This will include all necessary data collection, surveys, interviews, analysis of data and information and presentation that enables a record to be made of the impact of the project on local communities.
8) **Data Analysis & Whole Life Costing** - Use the technical data from the test sites to develop a research matrix to cover different wearing course materials, surfacing options, climatic conditions, terrain, traffic, etc. found in Ethiopia. Data from the test sites should be supplemented by data from other LVR development and maintenance projects being implemented by ERA and Regional Road Authorities. Analyze the cost of the works and estimate the whole life cost of each type of construction over a 20 year period. Compare these costs with traditional alternatives including gravel wearing course and asphalt concrete construction. Compare the costs of machine-based and labour-based approaches.
9) **Quality Review** - Review the pavement design recommendations and standard specifications prepared at the start of the assignment (items 2) & 4)), and propose any refinements in light of lessons learned on the demonstration sites and the completed research matrix.
10) **Maintenance Guidelines** – Prepare maintenance guidelines for each type of construction and demonstrate the routine maintenance tasks on each of the sites.
11) **Dissemination** – Prepare all necessary dissemination materials and participate in two dissemination workshops for the draft LVR Design Manual in ERA and in each of the participating regions (including Southern Region). The organization of the workshops will be the responsibility of ERA and the Regional Roads Authorities. The impact of the road improvement works on local communities, including benefits from employment opportunities on the sites, will be recorded and used as part of the dissemination activities. The maintenance guidelines for each type of construction will also form part of the dissemination programme.

Assignment Period and Indicative Milestones

The total duration of the assignment is 40 months. The following key milestones will be achieved and will be reflected in the consultants work programme:

- Signature of contract and project commencement
- Submission of inception report by end of month 2
- Location of site(s), design testing, preliminary design with quantities, drawings, schedules and methodology of works will be completed within 4 months of the commencement date.
- Submission of detailed design report, draft contract documents and seminar by month 5
- Approval of design and contract documents by ERA of the demonstration sections by month 6.
- Preliminary report on the design of low volume roads and specifications for materials for low volume roads in Ethiopia as chapters for incorporation into the sister AFCAP project on "Design Manual and Standard Bidding Documents for Low Volume Roads in Ethiopia" by month 6.
- Commencement of construction of demonstration sections by month 8
- Completion of construction of the demonstration sections by month 10.
- Submission of construction report and baseline monitoring data for first series of demonstration sections by month 12
- Biannual submission of monitoring data and analysis report (all sites)

- Submission of the draft final report: by month 32
- Completion of dissemination workshops and submission of workshop reports and training materials by month 36.
- Approval of final report by ERA by month 38
- Project closure by month 40

Outputs and Deliverables

The principle outputs from this assignment are pavement design recommendations for LVRs for both paved and unpaved roads that will lead to increased durability, lower user costs and lower long term maintenance requirements. These recommendations will be incorporated into a comprehensive design manual for LVRs that is being prepared under a separate, but closely related AFCAP project (point 4 below). This manual will be used by ERA, regional road authorities, wereda administrations and consultants in the sector.

In addition, the following deliverables are required.

1. **Inception Report** - to be submitted within two months of the start of the assignment. It should include outline pavement design recommendations for selected sections on LVRs, specifications, details of the sections selected for the research/demonstration sites, , the design of the social impact monitoring study, and the work plan for the remainder of the project
2. **Detailed Design Reports** - providing details of the pavement designs and surfacing selected for each demonstration section(s). This will be supplemented with copies all draft contract documents for the works including all necessary instructions, conditions of contract, Bills of Quantities, drawings, details , schedules and the like by month 5. These reports should also contain detailed specifications for the equipment listed under "Facilities, services and resources to be provided by ERA" to enable it to be procured under a separate supply contract.
3. **Detailed Construction and Baseline Monitoring Reports**. These reports will include the design of the technical monitoring framework (including all testing required and frequency) and presentation of the baseline technical data for each of the demonstration section. These reports will also include copies of MOUs and agreements established with local universities for submission by month 12.
4. **Preliminary Report on Designs and Materials Specifications for Low Volume Roads in Ethiopia** – This report shall provide a) draft chapters for incorporation into the sister AFCAP project on "Design Manual and Standard Bidding Documents for Low Volume Roads in Ethiopia" and b) Specifications for the construction of LVR pavements and surfacing for inclusion in the standard tender documents for construction works.
5. **Pavement Monitoring Data Collection and Analysis Reports**. These reports shall be submitted for each and every monitoring visit conducted for the demonstration sections. These will include test data and information, condition analysis and recommendations for any remedial or maintenance actions. The first monitoring report should be submitted three months after completion of the construction of the demonstration sections.
6. **Draft Final Report** – The draft of the Final Report will capture the research activities including a summary of works completed on the demonstration sites, data collection and data analysis, results and conclusions. The report should include a cost analysis for each site and estimated whole life costs for each type of construction over a 20 year period. The report should include updated recommendations for the design of pavements and surfacing for LVRs, standard specifications, recommendations for maintenance, and justification for the expansion of the low volume sealed road approach in Ethiopia. The first draft of this report should be submitted by month 32. The report will capture in Annex all earlier and approved reports. Comments will be provided by the Recipient and Technical officer by month 34.
7. **Draft Social Impact Monitoring Report** - by month 35. Comments will be provided by the Recipient and Technical officer by month 36.
8. Submission of **Final Report** on:-
    a. Research Activities, including monitoring and data analysis techniques
    b. Conclusion of Social Impact Monitoring
    c. Designs and specifications for LVRs in Ethiopia, including maintenance approaches and options
    d. Dissemination strategy
    e. Recommendations for further work, if required all by month 38.
    Final approval of these reports by month 39.

In addition to the above the consultant will prepare Brief Bi-monthly Progress Reports summarising overall progress on the project.

All reports will be produced in four copies for approval by the Technical Officer and Supervisor/Recipient. Comments from the Technical Officer and Supervisor/Recipient will be provided within four weeks of submission. Final copies of all reports will be submitted within two weeks of receipt of comments by Technical Officer and Supervisor/Recipient. All reports are to be submitted in English. One hard copy and an electronic copy of each report (draft and final versions) should be submitted to each member of the Steering Group.

Transfer of Knowledge/Training
The project has an important training and capacity building component. Training will be provided to the ERA Research Unit and to Regional Road Authority staff involved in the design and construction of the test sections. This will be achieved through on the job training of counterpart engineers on how to develop research procedures and carry out research activities, as well as the requirements for supervision of construction. The training will ensure that the test sections are constructed in accordance with the specifications and that data is collected methodically.

The second part of the training will involve the local private sector construction industry, as well as academic and training institutions. It will include the dissemination of the findings of the study and the LRV Design Manual. This will be achieved through visits to the demonstration sites, dissemination seminars carried out in each of the participating regions, and the participation of universities in data collection and analysis.

Minimum Experience requirements
The consultant is required to provide the following staff under this assignment:

Project Manager/Road Design, Standards and Specifications Specialist: Degree in Civil Engineering (or equivalent) and a minimum of 20 years experience. Proven expertise in project management, development of standards and specifications for roadworks, materials design and specification, training, road pavement evaluation and design, road planning, construction and maintenance, machine-based and labour-based technologies, and road construction materials.

Low Volume Roads Expert - Degree in Civil Engineering (or equivalent) and a minimum of 15 years of experience. Proven expertise in the design and construction of low volume roads, machine-based and labour-based technologies, training and capacity building, manual preparation, and knowledge dissemination.

Data Analyst: Post graduate degree in an appropriate discipline and a minimum of 20 years experience. Proven expertise in road management systems, statistical analysis, data processing, design and construction of low volume roads, and presentation of results.

Social Development Specialist: Degree in Social Science (or equivalent) and a minimum of 10 years experience with the design and implementation of social impact surveys, assessments and evaluation of infrastructure projects in developing areas, including Africa.

Field Engineer: Degree in Civil Engineering (or equivalent) and a minimum of 5 years of experience the design and construction of low volume roads in Ethiopia.

Responsibilities and Inputs of Consultant's staff
The team members will be responsible or the following tasks:

Project Manager/Road Design, Standards and Specifications Specialist:
- Client liaison
- Planning and programming
- Mobilisation and procurement
- Selection of research/demonstration sites and design of test sections
- Training counterpart staff and oversight during construction
- Design of monitoring system, training and supervision of data collection teams
- Dissemination of project outputs
- Reporting.

Low Volume Roads Expert:

- Review of existing design documentation and practices for low volume roads, Ethiopia and elsewhere
- Preparation of recommendations for pavement design and specifications for LVRs
- Review of draft LVR Design Manual and preparation of maintenance guideline
- Preparation of appropriate training and dissemination documents.
- Quality assurance of all reports
- Preparation of specifications and maintenance guidelines.

Data Analyst:

- Preparation of quality control system for data collection and data entry
- Preparation of training materials as required
- Verification of data, data collation and storage, data analysis
- Verification of monitoring data
- Data processing, statistical and all data analysis
- Reporting analytical and analysis.

Social Development Specialist:

- Design of the social impact assessment study on the demonstration sites
- Preparation of survey and other related forms and documents
- Preparation of training materials as required
- Oversight and supervision of data collection
- Data analysis and preparation of reports.

Field Engineer:

- Supervision of construction
- Materials selection, testing and approval
- Supervision of site sampling and approval testing
- Reporting

The anticipated time inputs of the experts are as follows (in person months):

Post	Recommendations for LVR pavement design and LVR design manual review	Selection, design and construction of demonstration sites	Monitoring and maintenance demonstrations	Reporting	Total input
Project Manager /Standards Specialist:	1 pm	6 pm	6 pm	2 pm	15 pm
Low Volume Roads Expert	2 pm			2 pm	4 pm
Analyst			1 pm	3 pm	4 pm
Field Engineer		4 pm	6 pm		10 pm
Social Development Adviser		2 pm		1 pm	3 pm

Facilities, services and resources to be provided the consultant

The consultant is responsible for providing all transport and accommodation required by their staff in Addis Ababa, regional centres and in the field. For purposes of estimating transport costs the consultant should assume that all demonstration sites are less than 100 kilometres from the regional capital. The consultant is also responsible for providing office equipment including computers, printers, copiers, etc., as well as office consumables and communications for office at ERA Research Unit. The consultant should allow for testing of all materials by commercial laboratories and also any costs associated with the involvement of local universities, employment of casual labourers and survey personnel, secretarial, drivers and other support staff. The consultant will meet the cost of overtime worked by the ERA and RRA teams and provision should be made for this.

Facilities, services and resources to be provided by ERA

In its capacity as project supervisor, the ERA will also provide all necessary letters of introduction to other Ministries and authorities to facilitate entry and exit of expatriate personnel and equipment. The ERA will liaise with the Regional Road Authorities for all aspects of the implementation of the project, and will ensure that funding is in place for the construction of the demonstration sections. ERA will provide limited office space at the Research Unit premises in

Addis Ababa. ERA and the Regional Road Authorities will provide transport to the field for their own staff, where this cannot be shared with the consultant. ERA and the Regional Road Authorities will provide accommodation and subsistence for their staff while in the field.

The following equipment will be provided by AFCAP for each of the participating regions: However, the Consultant is required to provide detailed specifications for the items, to enable them to be procured under a separate supply contract:

- One notebook computer and the software required for data storage, analysis and reporting
- One printer and printer consumables
- One automatic level, tripod and staff
- One dynamic cone penetrometer and adequate spares for three years
- One straight edge, wedge
- One 50m and one 10m tape measure
- One vehicle mounted bump integrator (including installation in the vehicle)
- One digital camera (min 6 megapixel)
- Two mobile phones

AFCAP will also provide one nuclear density measuring device for use on the project. This equipment will be owned by ERA following supply by AFCAP. AFCAP will also provide for the hire of equipment to measure pavement stiffness on the demonstration sites.

Management and administration

A Steering Group will be established by ERA to oversee the implementation of the project. The group will include representatives of ERA, the participating regions, the Ethiopian Road Fund, the pavement research consultant, the consultant responsible for the preparation of the LVR Design Manual, and AFCAP. This group will work to a separate terms of reference.

The consultant will liaise with the project supervisor and recipient body through the Head of the Planning Unit or his representative in ERA for all day-to-day aspects of the implementation of the project.