Crown Agents

AFCAP

UKaid
from the British people

Preparation of a Design Manual
For
Low Volume Roads in South Sudan

FIRST REVIEW REPORT

August 2012

UNOPS
SOUTH SUDAN OPERATIONS CENTRE

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

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

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

This material has been funded by UKaid from the Department for International Development, however the views expressed do not necessarily reflect the department's or the managing agent's official policies.

For further information visit https://www.afcap.org

ISSUE AND APPROVAL CONTROL SHEET

CLIENT:	Crown Agents for Oversea Governments and Administrations Ltd (Contracting Agents for DfID)
ADDRESS:	St Nicholas House, St Nicholas Road, Sutton, Surrey, UK
PROJECT:	Design Manuals for Low Volume Roads in South Sudan
DOCUMENT TITLE:	Inception Report
DOCUMENT NO:	AFACAP/SUD/085/001

TITLE	REV NO.	DATE	FORMAT
1ST DRAFT	001	01/08/2012	

	Approvals
Team Leader	
Quality Reviewed	

PROJECT ABBREVIATIONS & ACRONYMS

CSIR	Council for Scientific and Industrial Research (South Africa)
DBM	Dry Bound Macadam
DCP	Dynamic Cone Penetrometer
DfID	Department for International Development
EDCs	Economically emerging and Developing Countries
EOD	Environmentally Optimised Design
ERA	Ethiopian Road Authority
esa	equivalent standard axles
GoSS	Government of South Sudan
HQ	Headquarters
ILO	International Labour Organisation
Km	kilometre
LVR	Low Volume Road
m	metre(s)
mm	Millimetre(s)
MAF	Ministry of Agriculture and Forestry
MPI	Ministry of Physical Infrastructure
MRB	Ministry of Roads and Bridges
ORN	Overseas Road Note
PIARC	World Road Association
QA	Quality Assurance
Ref.	Reference
SS	South Sudan
ToR	Terms of Reference
UNOPS	United Nations Office for Project Services
UKAID	Development assistance provided by the UK Department for International Development
USAID	United States Agency for International Development
VOCs	Vehicle Operating Costs
WLC	Whole Life Costs

Preparation of a Design Manual For Low Volume Roads in South Sudan

FIRST REVIEW REPORT

1 Introduction

In line with the key programme stages identified in the Inception Report this document presents a summary of the review undertaken of the application existing Ethiopian LVR Design Manual within the context of the South Sudan low volume road environment. It also aims to summarise the key contents of each of the previously identified chapters and sections of the proposed South Sudan Low Volume Road (SSLVR) Manual.

This report will enable members of the Technical Working Group (TWG) and other key stakeholders to review progress; comment on the prosed SSLVR Manual; and to suggest amendments and additional inclusions.

Following this Introduction, Chapter 2 of this document reiterates the structure of the proposed document as agreed at the First TWG Meeting and Workshop, with minor subsequent adjustments.

Chapter 3 presents the summary review of the Ethiopian document and the following Chapters 4 to 6 summarise the sections within the proposed SSLVR Manual.

Appendix A to this report contains notes and presentations from the 2nd Technical Working Group Meeting held in the UNOPS offices on 6th August 2012. Appendix B presents the discussed and agreed modifications to the project programme.

2 Structure of the South Sudan LVR Manual

The South Sudan Low Volume Roads Manual (the LVR Manual) will comprise the following components:

- Volume 1. Principal text, Road Design, A4 format including References & Appendices
- Appendices A (Volume 2).Text- Cross Drainage & Structures, A4 format
- Appendices B (Volume 3) Standard Drawings Cross Drainage & Structures, A3 format
- Appendix C (Volume 4) Maintenance Booklet, A5 format

The main text content will be in line with that discussed at the First TWG meeting in June 2012; as summarised in Table 1.

Table 1 Structure of the South Sudan LVR Manual

Main Volume: (Volume I)	
1	Introduction
2	Legal Framework and Ownership
3	The Approach to LVR Design
4	South Sudan Road Environments
5	Route Selection and Investigation
6	Geometric Design
7	Natural Construction Materials
8	Surfacing and Pavement Design
9	Drainage and Structures
10	Road side Slope Stability
11	Spot Improvement
12	Maintenance
Appendices A (Volume II)	
A1	Traffic Analysis
A2	Laboratory Soil, Rock and Materials Testing
A3	Marginal Materials
A4	Drainage calculations
A5	Swelling Clays
A6	Design Compliance
A7	Environmental Assessment
A8	Complementary Initiatives
Appendices B: Cross Drainage and Structures (Volume III)	
1	Detail
2	Standard Drawings
Appendix C: Maintenance Booklet (Volume IV)	

Notes: Main Volume and Appendices A & B(1): A4 format
Appendix B (2) A3 format
Appendix B A5 format

The Main Manual Volume 1 will contain the following in advance of the main text:

- Foreword by a representative of the principal user (custodian)organisation
- Preface advising of the custodianship of the Manual, its roots and arrangements for harvesting contributions for future update editions
- Change Control register to log any official changes or amendments made after initial publication

- Acknowledgement to advise financial and professional inputs, and Technical Working Group membership
- List of Abbreviations and Acronyms
- Glossary of Technical Terms
- Table of Contents (all Volumes)

3 Review of the Ethiopian LVR Design Manual

Part A: DESIGN STANDARD APPROACHES

Chapter 1: The content of this chapter needs to be re-drafted for the South Sudan context whilst retaining the basic concepts and principles: to be included in the SS LVR Chapter 1 (Introduction)

Chapter 2: This will require a complete re-draft and inclusion within SS LVR Chapter 1 (Introduction).

Chapter 3: To be re-drafted as a part of SS LVR Chapter 1 (Introduction).

Part B: DESIGN STANDARDS FOR LOW VOLUME ROADS

Chapter 1 Introduction: Sections of suitably adjusted text to be included within SSLVR Chapter 1 (Introduction) and other relevant chapters of the SS LVR Manual.

Chapter 2 Policy and Legislative Control: The detail within the chapter is not relevant to the SSLVR Manual; however, the concepts will be included within the new Chapter 2 (Legal Framework and Ownership).

Chapter 3 Design Parameters: Contents of this chapter to be included within SSLVR Manual Chapter 3 (The Approach to LVR Design) and Chapter 4 (South Sudan Road Environments)

Chapter 4 Geometric Design Standards: Basic principles, including key tables and text are in the main suitable for inclusion, after some amendment, into LVRR Manual Chapter 6 (Geometric Design).

Chapter 5 Materials: The chapter structure and principles should form the basis for SSLVR Manual Chapter 7 (Natural Construction Materials). Details regarding individual material types and the use will need to be extensively re-drafted to take into account the location and types of material available in South Sudan.

Chapter 6 (Pavement Design): The chapter structure and principles should form the basis for SSLVR Manual Chapter 8 (Surfacing and Pavement Design). Details on individual options will need extensive editing, particularly with regard to unsealed gravel design and the selection and use of non-bituminous options.

Chapter 7 (Drainage and Erosion): Although the principles should form the basis for SSLVR Manual Chapter 9 (Road Drainage) there is probably a need to shorten this extensive chapter with much of the support detail moved either to Appendix A4 (Drainage Calculations) or Volume II (Cross Drainage and Structures). Text on slope protection should be included within SSLVR Manual Chapter 10 (Roadside Slope Stability).

Chapter 8 (Structures): Completely new text on the principles of cross drainage and structures is required to be included in of SSLVR Manual Chapter 9 (Drainage and structures) as an introduction to the detail in SS LVR Manual Volume II.

Chapter 9 (Road Furniture and Signage): Further discussion required with key stakeholders on the relevance of this chapter.

Part C: COMPLEMENTARY INTERVENTIONS

The principal content of the chapters in this Part C of the Ethiopian Manual will form the basis for a compact Appendix 8 (Complementary Initiatives). Some further discussion with key stakeholders is required to finally decide on what key content is required.

Part D:

Chapter 1 Introduction. No relevance to the SSLVR Manual.

Chapter 2 Site Investigation for Route Selection and Design: Key issues within this chapter are suitable for inclusion in SSLVR Manual Chapter 5 (Route Selection and Investigation). Sections of this chapter after suitable minor amendment are more suitable inclusion within Appendices A2 (Material Testing); A3 Marginal Materials; and A5 (swelling Clays).

Chapter 3 Roadside Stability: The text, tables and figures can form the basis of the SSLVR Manual chapter 10 (Road-side Slope Stability) with minor adjustment and editing. The principle exception will be the sections dealing with specific bio-engineering options which may not be suitable.

Chapter 4 (Geometric Design): Amended sections within this chapter can be added to SSLVR Manual Chapter 6 (Geometric Design) with some text and tables include within Appendix A1 (Traffic Analysis).

Chapter 5 (Drainage): Appropriate sections within this chapter can be included within the following elements of the SSLVR Manual:

- Chapter 9 (Road Drainage)
- Chapter10 (Road-side Slope Stability)
- Appendix A4 (Drainage Calculations)
- Volume II (Cross Drainage and Structures).

Chapter 6(Materials and Pavement Design): Sections of this large chapter are suitable for editing and amendment and then inclusion in the following elements of the SSLVR Manual:

- Chapter 3 (Approach to LVR Design)
- Chapter 4 (South Sudan Road Environments)
- Chapter 7 (Natural Construction Materials)
- Chapter 8 (Surfacing and Pavement Design)
- Chapter 9 (Drainage)

Chapter 7 (Surfacing): Slightly amended sections on bituminous surfacing suitable for inclusion in SSLVR Manual chapter 8 (Surfacing and Pavement Design). Sections on non-bituminous surfacing may require re-drafting.

Appendix D1 Material Selection and Quality Assurance for Labour-based Unsealed Road Projects: Directly relevant sections of this appendix can be extracted for inclusion within SSLVR Appendix 6 (Design Compliance). Otherwise, there is significant overlap with other Chapters and Appendices.

Appendix D2: Hydrological Calculations: May be included with SSLVR Manual Volume II.

Appendix D3 Comparison of Options. Include where relevant in SSLVR Manual chapter 8 (surfacing and Pavement Design).

Part E: EXPLANATORY NOTES AND DESIGN STANDARDS FOR SMALL STRUCTURES

This volume may be included as SSLVR Manual Volume II with suitable editing of text and inclusion of appropriate local illustrations. Sections dealing specifically with materials; slope retaining walls and maintenance may best be included in the relevant sections in the main volume I of the SSLVR Manual. This structures section of the Ethiopian LVR Manual deals almost exclusively with cross drainage structures.

Section 10 of this Part E deals with maintenance of cross drainage structures. This information is better presented under Volume 3 of the South Sudan LVR Manual.

Part F: TRAIL BRIDGE MANUAL

Material from this volume will not be included in the SSLVR Manual

Part G: ROAD MAINTENANCE BOOKLET

This volume may be included as SSLVR Manual Volume III with suitable editing of text and inclusion of appropriate local illustrations

4 SS LVR Manual Volume I

Chapter 1: Introduction

This chapter will comprise new South Sudan Specific text. It will introduce the SS LVR Manual and its aims and target user audience. It will contain many of the basic concepts and principles contained within the Ethiopian Manual Part A.

It will set out the geographic applicability of the Manual and will state the organisations that will endorse the Manual for use in their investments and programmes (e.g. MRB, MAF, State Governments etc.). It will state the types of roads that the manual will be appropriate for (all roads from Engineered Natural surfaces – ENS, through to various types of paved roads), but excluding tracks and footpaths. It will state the scope of the guidance provided by the manual (applicable for routes carrying up to 300 motor vehicle equivalent vehicles per day). It will summarise the various components of the manual under each volume and chapter heading. It will also detail specific separate complementary guidance that will fall OUTSIDE the scope of the Manual (This will include Design Specifications, Maintenance Specifications, Standard Bidding and Contract Documentation, Quality Control Manual, Main Roads and Bridges Manual, Cost-Benefit Assessment Manual and Cost model).

Chapter 2: Legal Framework and Ownership

This chapter will state the ownership and South Sudanese entities contributing to the development of the manual, and authority to use the manual for different types of road.

By the expected date of publication of the Manual, it is expected that the South Sudanese existing physical and planned road network will neither be fully classified nor officially inventoried. Therefore this chapter will need to be flexibly written to encompass possible future developments on these key aspects of road asset management.

An assumption will have to be made for each road that legal authority will at some stage be vested in an organisation, other entity or private owner within certain road margins (or right of way), which should realistically include all land from the road centre line to at least the back of the side drain or footway/sidewalk.

Chapter 3: The Approach to LVR Design

This will be based broadly on Part A of the ERA LVR Manual. However, the following considerations will require major adaptions. The Chapter will include sections on:

- Design Principles, the road environment, use of local resources
- Maintenance capacity and development
- Earth and Gravel Roads
- Surfacing and Paving
- Technology Rationale, Options and Choice
- Environment protection and sustainability (including Appendix)

South Sudan is in a unique situation in terms of recent history of conflict, past neglect or severe underdevelopment of transport infrastructure, limited institutional capacity and skill base, immature and fragile revenue raising, planning, budgeting and control arrangements. There is a lack of public understanding and appreciation of road infrastructure, and major problem with inaccessibility and lack of engineering materials issues in vast tracks of the country (the north east). There is understandably enormous demand for new and improved roads to support economic and social development and indeed nation building. However, capacities for transport infrastructure asset management, and funded and effective maintenance regimes are currently lacking.

The current circumstances of South Sudan are unique and make it necessary to develop and adopt a very South Sudan-specific approach to the design of the Low Volume Roads network that allows:-

- Best use to be made of existing limited sector funds and resources
- Rapid provision of strategic routes with year round (full) access
- Rapid provision of basic access to the majority of the population for most of the year
- Roads that are suitable for the types of traffic that will use them
- Roads that are serviceable and safe for the users and general public
- Roads that are cost-effective in consideration of their life cycle investments in initial construction and maintenance costs, and indeed road user costs
- Minimisation of the impact on the environment
- The best use of available local resources, allowing a range of technology options
- Encouragement of the development of local capacity

Environmentally Optimises Design (EOD) allows all of these objectives to be met in the circumstances of South Sudan. Environmentally Optimised Design is the over-arching framework for the application of appropriate LVR designs. It covers a spectrum of solutions for improving or creating low volume rural access, from Basic Access through to total whole rural link rehabilitation/improvement (Full Access).

Under an EOD approach, the road is designed to suit a variety of task and environmental factors such as rainfall, available materials, construction capacity, gradient, flood risk, maintenance regime and so on. Some of these

factors vary from road to road and even from location to location along a road. Therefore a road design may vary along the length of a road with, for example, a sealed surface up a hill or gravel along a level section. This variable nature is referred to as 'variable longitudinal design'.

The following concepts form components of the EOD approach.

Basic Access

Reliable all-season access for the prevailing means of transport with limited periods of inaccessibility (typically for a period of up to about 24 hours during/after rain when the road can be impassable to motorized traffic). In practical terms; the provision of Basic Access consists of taking or bringing back the route to a minimum motorable and maintainable standard by:

- clearing of vegetation,
- reforming or providing the running surface camber, and
- opening of drains and any existing culverts/drifts.

These are the basic requirements for a serviceable low volume traffic access road. In most cases the in situ soil will form the running surface for the road (Engineered Natural Surface – ENS). To ensure all-season access, it may be necessary to provide Spot Improvements (Chapter 11) at critical locations along the route. Although low cost to provide, Basic Access roads will require essential maintenance (Chapter 12) every year for continued passability.

Full Access

Uninterrupted all-year, high quality, high speed, low surface roughness access, with no closures in the rainy season. In practical terms this may involve the provision of a gravel or sealed surface throughout the length of the route link. This level of access will also require appropriate levels of maintenance.

Chapter 4: South Sudan Road Environments

It has become increasingly recognised that the life-time performance of LVRs is influenced to a greater extent than higher volume roads by the impacts of what is termed the Road Environment. It will be essential to consider the recommendations within the SSLVR Manual within the context the range and variation of road environment factors in South Sudan, Table 1.

Table 1 Road Environment Impact Factors

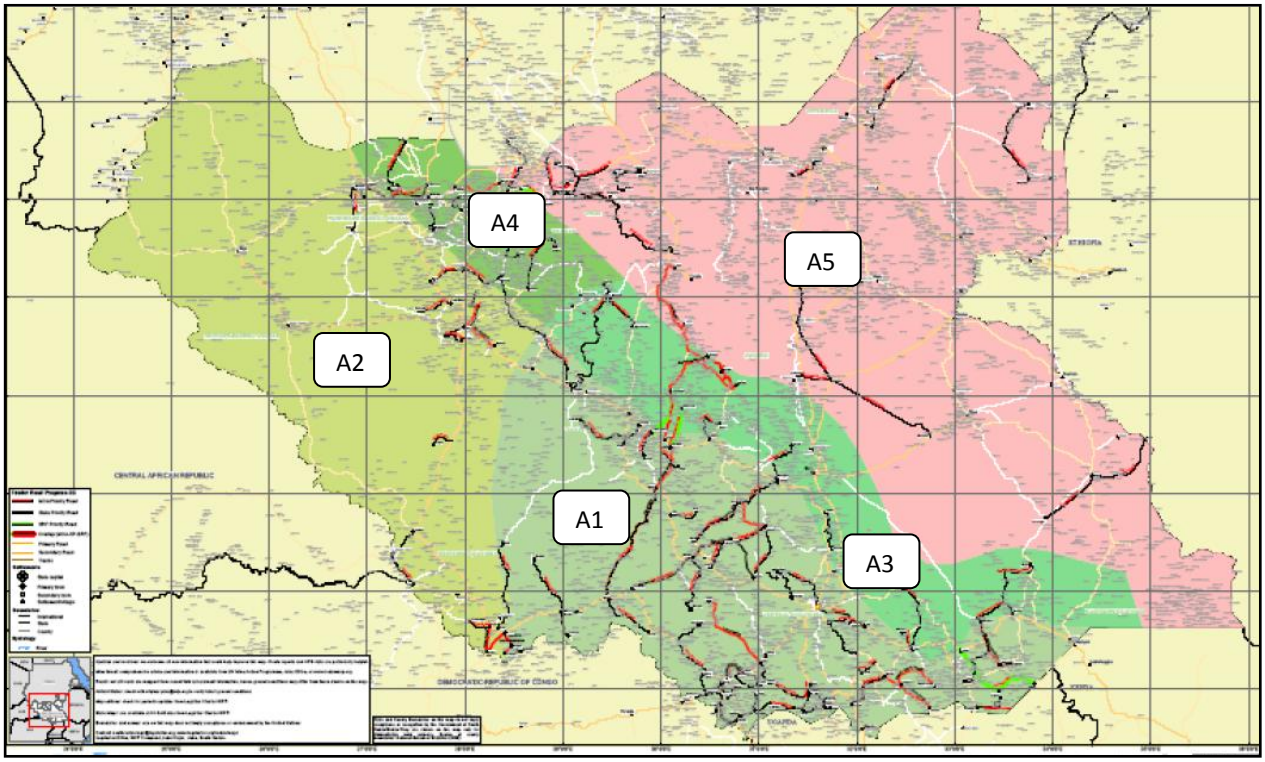
Impact Factor	Description
Construction Materials	The nature, engineering character and location of construction materials are key aspects of the road environment assessment.
Climate/rainfall	The prevailing climate will influence the supply and movement of water and impacts upon the road in terms of direct erosion through run-off and influences the groundwater regime.
Surface and sub-surface hydrology	It is often the interaction of water, or more specifically its movement, within and adjacent to the road structure that has an over-arching impact on the road performance.
Terrain	The terrain, whether flat, rolling or mountainous reflects the geological and geomorphological history. Apart from its obvious influence on the long section geometry (grade) of the road, the characteristics of the terrain will also reflect and influence the availability of materials and resources.
Sub-grade conditions	The sub-grade is essentially the foundation layer for the pavement and the assessment of its condition is fundamental to the road design.

Traffic	Although recent research indicate that the relative influence of traffic on LVRRs is less than that from other road environment parameters, consideration still needs to be given to the influence of traffic and, in particular, the risk of axle overloading.
Construction Regime	The construction regime governs whether or not the road design is applied in an appropriate manner. Key elements include: • Appropriate plant use • Selection and placement of materials • Quality assurance • Compliance with specification • Technical supervision
Maintenance Regime	All roads, however designed and constructed, will require regular maintenance to ensure that the design life is reached. Achieving this will depend on the maintenance strategies adopted, the timeliness of the interventions, the local capacity and available funding to carry out the necessary works
The "Green" Environment	Road construction and ongoing road use and maintenance have an impact on the natural environment, including flora, fauna, hydrology, slope stability, health and safety. These impacts have to be assessed and mitigated as much as possible by appropriate design and construction procedures.

Aspects of road design, pavement options, road side slope stability and drainage will be significantly impacted by variable road environments. Guidance on the assessment of road environments will be included within the Manual.

An initial review suggests that the five broadly defined in the Inception Report could be utilised as a regional road environment model, Figure 1.

Figure 1 Initial Broad Regional Road Environments

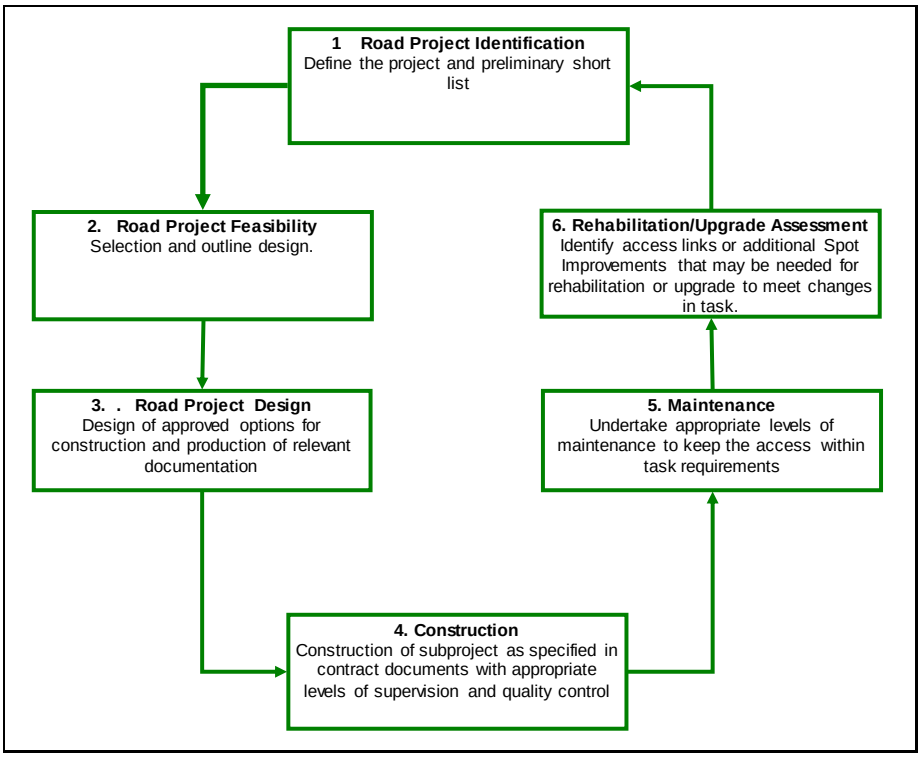


Chapter 5: Route Selection and Investigation

This chapter will be based on Part D (Chapter 2) of the Ethiopian Manual with an emphasis on logically phased investigations that are linked into the overall Road Life Cycle. (Figure 2) Additional use may be made of flow charts to guide users in making key decisions. There is likely to be an increased emphasis on remote sensing and geomorphological assessment of route alignment options within potentially difficult terrain.

This Chapter will be backed up by detail from Appendix A2 – Laboratory testing of soil-rock materials.

Figure 2



Concise advice will be tabulated on the stages of investigation; the required outputs and the appropriate procedures within the likely constraints of LVR projects:

Field Activity
Surface Mapping
Exposure and Sample
Description
Boreholes
Trial Pits
Augering
Probing
Hydrology Data
Climatic Data
DCP
Engineering Geophysics

The importance of in situ observation and low cost in situ testing will be emphasised.

Chapter 6: Geometric Design

This Chapter will contain key aspects of Part B (chapter 4) and Part D (Chapter 4) of the Ethiopian Manual modified to suit the emerging traffic environment in South Sudan.

The basis of this Chapter will be that geometric design should be founded on geometric standards that are a minimum level of quality that should be achieved at all times and nationwide. Amongst other things this ensures consistency across the country. Thus for roads this means that people know exactly what to expect. Drivers, for example, are not 'caught out' by unexpected changes in quality. Thus they will not unexpectedly find that a road is too narrow, or that they have to alter their speed drastically to avoid losing control of their vehicle. Thus standards are a guarantee of a particular quality level and, for roads, this enhances safety.

The emphasis in this Chapter will be on the practical selection aspects of geometric design, covering road width; cross-fall; horizontal and vertical alignments and sight lines; and the transverse profile or cross-section. There will be less emphasis on the theoretical basis for geometric design.

The geometry of embankments, drainage and cut-slopes will not be dealt with this chapter but will be considered under Road-side Stability and Drainage section of the SSLVR Manual.

Chapter 7:Construction Materials

This Chapter will contain key elements of Chapter 5, Part B (Materials and Chapter 6, Part D (Material and Pavement design) of the Ethiopian Manual. Cross reference will be made, where appropriate, to sections within other chapters dealing with structures and slope stabilisation. Relevant detail on testing of material will be included in Appendix A2.

Construction material are a vitally important element of the over Road Environment and emphasis will be put on the adaption of recent research on LVR materials where a key objective is seen in sustainable rural road construction to best match the available construction material to its road task and its local environment. More cost-effective road designs that incorporate appropriate materials allow more kilometres to be built, rehabilitated and maintained for the funds available. The benefits of utilising locally available materials arise from: a reduction in haulage costs; less damage to existing pavements from extended haul; stimulation of the local economy and local enterprise; road designs compatible with local maintenance capabilities and, generally, reduced whole life costs.

The combination of a varied geology, geomorphology, climate and residual weathering has resulted in the occurrence of a wide range of natural materials in South Sudan, in addition there are large areas with an almost complete lack of conventional road building materials. An emphasis there needs to put on looking for solutions based on available material types rather than the conventional approach of trying to find materials to suit standard specifications.

Chapter 8: Surfacing and Pavement Design

This chapter will be based broadly on Part D, Chapters 6 and 7 of the ERA LVR Manual. However, the circumstances in South Sudan necessitate a number of changes. The following are some of key issues that have been identified to date.

Expansive Clays

Expansive clay (often referred to locally as black cotton soil), is a major challenge in the north eastern part of the country. The soil is capable of taking up large qualities of water in the rains (or if otherwise soaked); with a

corresponding almost total loss of strength. In the dry season it will shrink with extensive cracking. This gives rise to serious stability problems in road foundations, for pavements and structures. There are a number of proven amelioration techniques. Unfortunately, these are all expensive in the context of South Sudan LVRs. Further detail will be included in Appendix A5.

Axle Loading.

There are currently no legal axle load limits in South Sudan. Anecdotal evidence suggests a 'freeloading' situation. This can have serious consequences for structures and road pavements. With the prospects for early control of loadings to reasonable limits in doubt, it will be necessary to provide pragmatic guidance in the SS LVR Manual.

Design of Gravel Roads

The design procedure for gravel roads will be simplified and the principal governing factors will be:-

- Quality of available material and QA regime
- Haul distance
- Subgrade characteristics
- Traffic
- Geometrics
- Routine maintenance regime
- Likelihood of periodic re-gravelling

High Impact Compaction Rollers - The references to this technique will not be adopted. It requires specialist skills and plant which are not appropriate for South Sudan's current circumstances.

Ultra-Thin Reinforced Concrete Pavement (UTRCP) -

The references to this technique will not be adopted. It requires specialist skills and a very high quality assurance regime. It is not tolerant of heavy vehicle overloading. For these reasons it is not appropriate for South Sudan's current circumstances.

Paved wheel strips

This technique can provide all-weather access at a substantially reduced cost compared to full paving. It is used on some rural access roads in Europe and has been used in some African countries. Guidance will be included in the SS LVR Manual.

Chapter 9: Road Drainage

This Chapter of the South Sudan Manual will be based on Part A and Part D of the Ethiopian LVR Manual.

This section will retain and supplement the information presented in Part D of the Ethiopia LVR Manual, as the basics of road drainage design do not differ for low volume roads in South Sudan as compared to many countries. An emphasis on differing construction methods, not labour based methods alone, will be referred to throughout the Chapter through referral to the appropriateness of v-shaped drains and other design options for construction through intermediate technology approaches as well as equipment based methods. Where relevant sections of Chapter 3, *The Approach to LVR Design,* referring to intermediate technology approaches will be cross-referenced.

South Sudan Manual, Main Volume 2, Part 1, *Cross Drainage and Structures* will be cross-referenced to refer the designer to the material relating to design of relief culverts and relief drifts such that the user will be directed to the information required to design all road drainage components as required.

Chapter 7, *Construction* Materials and Chapter 8, *Surfacing and Pavement Design* will be cross-referenced when detailing design options for road drainage in areas of black cotton soil. Road design in areas of black cotton soil will require combinations of design elements including drainage to ensure basic access. It may also be useful to cross reference sections of Chapters of the manual dealing with Environmentally Optimised Design, Staged Construction and Spot Improvement when detailing drainage in black cotton soil.

Specific attention will be given to drainage in black cotton soil with the need for shallower drains and greater side slope to avoid erosion of this sensitive material due to the drainage system itself. Options for construction will be discussed in light of this. Therefore when revising the drainage section of the manual reference material other than the Ethiopian LVR Manual will be consulted inclusive of, but not limited to, the Roads 2000 documentation from Kenya, SADC Guidelines for LVR Sealed Roads (as referred to in the Inception Report) and possibly material from Uganda.

In the present section detailing drainage in Part D of the Ethiopian Low Volume Road Manual flood estimation is presented. It is proposed that this be presented under Main Volume 2, Part 1 – *Cross Drainage and Structures*, of the South Sudan LVR Manual detailing design of cross drainage structures. Flood estimation will in practice be used for cross drainage structure design and not for other components of road drainage on LVR as it would be for higher-level roads. As such it is better to present material where and as it will be used in the overall design process.

Chapter 10: Roadside Slope Stability

This chapter will aim to provide concise guidance on what action to take following a road-side problem event, in particular on

- Problem definition
- Appropriate information collection
- Decisions and actions required in the light of the recovered information
- Summary information on appropriate procedures
- Where to access more detailed guidance
- Selection of standard engineering options

There is some limited design information presented relating to retaining walls and earth retaining structures design methods within the Ethiopian Manual Part E (structures). While dry stone, mortared masonry, gabion and hybrid walls are presented under the materials section and under the design of structures section for wing-walls design there is no information provided for design details. Charts for sizing walls are detailed, however no standard design details such as weep-holes, joints, free-draining backfill etc. for mortared masonry walls or use of geotextile for gabion walls are provided. Since this is an extensive subject, which would add greatly to the length of the volume it is proposed to refer users to the TRL ORN 16 to deal with the issue of retaining wall structures and particularly design details.

The overall approach of this chapter is to provide engineers with a decision making framework within which they can work and select appropriate procedures, make knowledge-based decisions and eventually identify one or more options either to solve the problem or define further actions required.

Chapter 11: Spot Improvement

This will be a new Chapter and will be linked to earlier chapters setting out options between Basic Access and Full Access. Spot Improvements involves the appropriate improvement of specifically identified road sections or structures either in actual need of upgrade or deemed to be at high risk of failure, and allows the appropriate

application of limited resources to be targeted at key areas on for example existing earth or gravel road links to improve access throughout the year.

As part of a Spot Improvement strategy it may be necessary to provide one or more of the following treatments at critical or problem locations on the route.

- Installation of new culverts or drifts
- Replacement or rehabilitation of existing culverts
- Structure rehabilitation or reconstruction
- Raising of embankment
- Erosion protection
- Spot gravelling
- Provision of alternative more durable surfacing over limited distances, such as steep sections, swampy sections or through settlements

Guidance will be provided on selection and design of Spot Improvements which must be seen as fully engineered options to meet defined requirement over the design life of the road and not as interim maintenance options.

Chapter 12: Maintenance

Maintenance is the range of on-going activities to keep the roads within an acceptable band of serviceable conditions so that these infrastructure assets perform the function they were designed for in a cost effective way. There are serious maintenance deficiencies in many developing and emerging economies. The need, practical arrangements, and good practice for maintenance are well documented (TRRL 1985, TRL 2003, PIARC 1994 et al). However, the 'enabling environment' for arranging and delivering cost-effective maintenance is lacking in many countries (O'Neil et al 2010).

The World Bank's World Development Report 1994 advised that 'in Africa and elsewhere, costly investments in road construction have been wasted for lack of maintenance'. The report cites that "Inadequate maintenance has been an almost universal (and costly) failure of infrastructure providers in developing countries." Unfortunately insufficient changes have been achieved in many countries in the years since.

Consideration of the road maintenance regime should be an important input in the road design process. The current circumstances of very little road maintenance achievement in South Sudan make this a particularly important issue. All roads require maintenance to varying degrees throughout their intended life.

It is therefore proposed that assessment of the existing maintenance regime and development of maintenance capacity should be an integral part of the design process.

This Chapter will contain:

- The rationale and justification for maintenance
- The listing of maintenance activities required for unpaved and paved roads
- Options for organising road maintenance (including advantages and disadvantages)
- General Guidance on assessment and development of Maintenance capacity
- Introduction to the Maintenance Booklet

Volume I Appendices

A1: Traffic Analysis – will contain key back-up detail and sample calculations to support Chapter 6 (Geometric Design) and Chapter 8 (Surfacing and Pavement design).

A2: Laboratory Soil, Rock and Materials Testing. This will contain concise guidance on laboratory tests to use in investigations and materials assessments and their significance.

A3: Marginal Materials. This contains information on the use and/or adaption of so-called "marginal" materials in road construction, either by, for example, modifying their properties or modifying the design approach.

A4: Drainage calculations - will contain key back-up detail and sample calculations to support Chapter 9 (Drainage and Structures).

A5: Swelling Clays: This will contain a synthesis and review of expansive soil amelioration techniques and potential solutions.

A6: Design Compliance will contain principles and procedures related to ensuring appropriate construction quality.

A7: Environmental Assessment – will contain comment on the current and proposed environmental compliance measures required by road construction

A8: Complementary Initiatives – will comment on initiatives that are parallel to and support the development of a sustainable LVR framework; for example, institutional strengthening; human resource development or small contractor development.

5 MAIN VOLUME 2,

PART 1 – CROSS DRAINAGE AND STRUCTURES

A summary of the contents of this section will be prepared for Main Volume 1 to direct the user towards Main Volume 2 for the design of structures. This will be done upon completion of Main Volume 2.

This volume of the South Sudan Manual will be based largely on Part A and Part E of the Ethiopian Low Volume Roads Manual but account will be taken of the local environment and design parameters through available data and documentation. Consideration will also be given to the desire of the TWG to have the overall manual be as concise as possible.

Throughout Main Volume 2, Part 1 users will be referred to the USAID / MRB Bridge Design Manual 2006 for more detailed design of structures (larger RCC Bridges etc), which are outside the scope of this manual. The TRL ORN 9 (Design of Small Bridges) and TRL ORN 16 (Road Engineering in Mountainous Regions) may also be referenced as a design guide – this is required to be agreed by the TWG Members.

The road classification of the South Sudan Infrastructure Services Project (SISP) Report, South Sudan Road Network Classification, Michael Pinard, September 2008 will be referenced where necessary throughout this section and the South Sudan Manual as a whole and the road classification detailed within this report utilised.

Environmentally Optimised Design (EOD), design for Basic Access and the Spot Improvement approach will be referenced within this section (design criteria) to stress the importance of constructing structures, which are durable and of sufficient capacity to carry the discharges estimated. The temptation to reduce road construction

costs through minimising the number or cost of structures constructed will be discussed in light of this also. There will be a need to refer to, if not cross-reference, Chapters 3 (The Approach to LVR Design), Chapter 4 (South Sudan Road Environments), Chapter 11 (Spot Improvement) and Chapter 12 (Maintenance) to reinforce these messages. In some instances it may be necessary to cross reference specific sections of these Chapters and this will be a last step in the revision of the Main Volume 2, Part 1 of the South Sudan Manual.

Within Part D of the Ethiopian Manual the section of correlation tables to relate catchment size to cross sectional area of cross drainage structure openings and number of openings for varying types of culverts will be included within this section of SSLVR Manual.

Adaption of Section 8.5, Pipes, of Part E for design of culverts will entail further detailing of the advantages and disadvantages and the appropriate use of corrugated pipe culverts in light of durability concerns under an extremely limited maintenance regime coupled with high replacement cost. Design options to address this, inclusive of construction of run-on slabs and paving over the culvert to maintain cover will be detailed. Design drawings referred to in Main Volume 2, Part 2 may require to be updated in light of this also.

Section 7 of Part E of the Ethiopian LVR Manual details materials for use in structures. A great deal of this material will be transferred to the proposed Appendix for materials testing. The remaining text will be abridged. Field tests and descriptions of materials properties would be well placed in an appendix and some information detailing construction methods could be better placed in a separate manual for LVR construction.. Further the section dealing with brick as a material and subsequent sections dealing with design of brick structures may not be relevant. Given the early stage of the development of the road network and the limited public and private sector capacity available to do so, it may be preferable to remove brick construction from the manual and place a brief paragraph noting that it may be appropriate to introduce this technology at a later date. Alternatively the section could be retained and rewritten towards concrete block construction to allow for central production of blocks in a controlled environment for transport to sites where construction materials are rare. A decision is required from the TWG in this regard, based on their relevant local knowledge.

Section 9 of Part E of the Ethiopian LVR Manual details construction of cross drainage structures. It may be preferable to remove this section from the manual and compile a separate manual for labour based and intermediate technology construction methods for both roads and structures. Section 9 largely deals with labour-based construction methods. As noted in the Inception Report construction regimes vary from machine based to intermediate technology to labour based approaches with labour based methods not being applicable in some area due to very low population density. While this is relevant information both intermediate technology methods and machine based construction methods are likely to be used for other portions of LVR construction in South Sudan and as such a separate manual for LVR construction and quality control detailing choice of technology as well as actual methods may be preferable.

Maintenance reduction as a design parameter is already detailed within the design process and this can be strengthened in the revision.

PART 2 – ANNEXES: STANDARD DRAWINGS

Design drawings in conjunction with technical specifications for works and bills of quantities convey the information required for construction. Since no national specifications have yet been developed a limited review of design drawings will be carried out. This will entail selecting which of the Ethiopia LVR Manual drawings are relevant, modifying the drawings to include a South Sudan drawings cage and a limited update of data presented on the drawings. It is noted that AASHTO Specifications are normally used. However many of these specifications are likely to be unsuitable for LVR in South Sudan and these are not national standards. Therefore the usual cross-reference of drawings to specifications cannot be carried out at present and the drawings should not be cross-referenced to an inappropriate specification.

6 MAIN VOLUME 3, Maintenance

It is intended that this stand-alone booklet will facilitate application for maintenance of Low Volume Roads throughout South Sudan, based on the principles outlined in Volume 1, Chapter 12.

The Booklet is applicable to earth, gravel and paved roads that may be carrying up to about 300 motor vehicles per day.

The Booklet specifically sets out guidance for road and other authorities and agencies, contractors, local communities, and private road owners on how to maintain road access making the best use of the limited resources available to them. It also advises how it may be possible to mobilise outside resources to enhance the impact of their own initiatives.

By focussing on the use and mobilisation of available local resources, such as a range of materials and local labour and skills, it is entirely possible to build and maintain durable all-weather road access suitable for all traffic from pedestrians and animal transport up to buses and trucks, and at reasonable cost.

The proposed contents will be

1. The Aims of this Booklet
2. Some Basic Questions
3. Road Features
4. Basic Access
5. Full Access
6. The Purpose of Maintenance
7. Regular Maintenance
8. Occasional Maintenance
9. Road Maintenance Tools
10. Maintenance Activities
    - Regular Maintenance (Routine)
    - Occasional Maintenance (Periodic)
11. Priorities
12. Work Options
13. Planning and Productivity
14. Further Advice and Assistance
15. Terminology

APPENDIX A
Notes from 2nd TWG Meeting
6th August 2012

Government of South Sudan, Ministry of Roads and Bridges (MRB)
Low Volume Road Design Manual, Technical Working Group (TWG)
Meeting no. 2, UNOPS Office Juba, 3pm 6th August 2012

PARTICIPANTS

	Name	Organisation	email
1	Jeremiah Turic Bairiak (Chairman)	Act DG - Roads & Bridges, MRB	jeremiahturic@hotmail.com
2	Kenyatta Warille	Executive Director, SSRA	warillek@yahoo.com
3	James Alam	Chief Engineer, MRB	alamjj2@yahoo.co.uk
4	Philip Marlow Wai Wa	D/D - Road Maintenance - MRB	philmwai3@yahoo.com
5	John Kenyi Sasa	D/D – MRB	kenyisasa@yahoo.co.uk
6	Dr. James Janthana	Asst. Prof, Univ. of Juba	jamesjanthana@gmail.com
7	Peter Keliona Wani	Lecturer, University of Juba	peterbouda@yahoo.com
8	Solomon Tombe	Teaching Assist. Univ.of Juba	tombesolomon@yahoo.com
9	William Patrick	Teaching Assist. Univ.of Juba	williampitia@yahoo.com
10	Roman Marghani	MPI, CES	
11	Peter Lakulogunu	MPI, CES	
12	Paul Pleva	USAID	ppleva@usaid.gov
13	Richard Nyarsuk	USAID	rnyarsuk@usaid.gov
14	George Wagwa	Infrastructure Engineer USAID	gwagwa@usaid.gov
15	Emmanuel Taban	World Bank	etaban@worldbank.org
16	Yuzo Mizota	Team leader, JICA	mizota@ctii.co.jp
17	Yosif Mussie	Civil Engineer, JICA	Yosiefay@gmail.com
18	Tony Nyakiore	WFP	tony.nyakiore@wfp.org
19	Stephen Odhiambo	Engineer – Civicon Ltd	steveo@civiconsudan.com
20	Rex Abdalla	Acting MD, Payii Roads Ltd	rxabdalla@yahoo.com
21	Steve Robinson	Head of Programme UNOPS	stever@unops.org
22	Mustafa Iqbal	Program Manager – UNOPS	mustafaaz@unops.org
23	Dr. Jasper Cook	LVR Manual Team Leader – UNOPS	jcook@otbeng.com
24	Nkululeko Leta	AFCAP Technical Manager	nkululeko.leta@uk.crownagents.com
25	Ezekiel Musili	Project Engineer – UNOPS	ezekielk@unops.org

SUMMARY OF PROCEEDINGS

Introduction

UNOPS Head of Program introduced himself and welcomed all participants in the meeting. The TWG Chairman introduced himself and requested all the members to fully participate after the briefing from the Lead team member.

The TWG was advised that the new LVR manual would be based principally on the 2011 ERA LVR manuals and with a secondary source as the 2006 SS Road Design manuals, adapted as suitable for LVRs in draft Contents and Format list for the SSLVR Manual was presented and discussed. Other relevant documents would also be reviewed for suitable input. A guidelines and documentation were also identified. However, funding for these initiatives is still being sought.

Progress Report Summary

Dr J R Cook (JRC) briefly summarised the progress to date by advising that the final version of Inception Report was now complete and submitted together with the Project Programme. There were some minor adjustments to the programme which would be submitted later in the discussion.

The review of the Ethiopian LVR Design Manual was now also complete and the Draft Review Report was being submitted and presented at this meeting.

At the request of the Chairman JRC made a Power Point Presentation based on the Draft Review Report. This is included as Appendix A to these minutes.

Presentation on the Review Report

The project aims to develop the design manual and maintenance guidelines suitable for South Sudan environment which will be achieved by modifying the Ethiopian LVR design Manuals. The second objective is to promote appropriate, affordable projects providing low volume roads (LVR) with the use of local resources; therefore delivering a cost effective and sustainable product.

This first review report provides the Technical Working Group and all the stakeholders with a chance to review the progress achieved, and make suggestions on amendments or additional inclusions required on the SSLVR, design manuals and maintenance guidelines which will meet the specific South Sudan environment.

Other areas of emphasises will focus on the key strategy points of discussion

- The basic structure;
- Appendices;
- Ownership and management of the final manual;
- Additional technical issues; and
- The programme.

Chapter 1 is an introductory part of the SS LVR Manual providing the user guidance. In addition it will outline basic concepts and principles.

Chapter 2 this covers the ownership, mainstreaming and evaluation. JRC described the different roles of Owner, User and Researcher required to develop and upgrade this document from time to time.

Chapter 3 will focus on environmentally optimised design (EOD) and on the use of locally available resources. This takes into account the limited funds/resources with an aim of providing basic access to majority of the population.

Chapter 4 will provide a summary of road environment factors which influence road performance and hence road design. These are construction materials, climate/rainfall, surface & sub-surface hydrology, terrain, sub-grade conditions, traffic, construction and maintenance regime. A typical South Sudan classification of regions based on the construction cost of roads as prepared by the Feeder Road Technical Committee (FRTC) was presented as a typical example of varying road environments.

Chapter 5 will cover the logical investigation with concise tables and figures on stages of in situ observation and testing. The required output and appropriate procedures with the likely constraints of LVR projects will be outlined.

Chapter 6 – Geometric design issues taking into consideration of an appropriate standard with minimum level of quality, applicable to site conditions. This covers the road width, cross-fall; horizontal and vertical alignments etc.

Chapter 7 –This Chapter on construction materials will focus on the adaption of recent research on LVR materials where a key objective is seen in sustainable rural road construction to best match the available construction material to its road task and its local environment. An emphasis will be put on looking for solutions based on available material types rather than the conventional approach of trying to find materials to suit standard specifications.

Chapter 8 – Pavement and surfacing design; basically this chapter will be taken from part D of the ERA LVR Manual. However most of the parameters will be modified to suit South Sudan conditions with an emphasis on the following key issues:-

- Traffic pattern and axle loading
- Problem foundations
- Appropriate use of gravel
- Non-bituminous surfacing options
- Paved wheel strips

Chapter 9 – the basic and fundamentals and information in regard to road drainage design will be retained from Part D of the ERA LVR Manual. There is no great difference in the LVR drainage issues between Ethiopia and South Sudan.

Chapter 10 – this chapter will provide concise guidance on actions to mitigate road side slope stability problems. This chapter will focus on slope protection and stabilization; the concept of hazards and consequent risks associated, and associated costs.

Chapter 11- this chapter targets Spot Improvement. This objective is to identify and upgrade those sections of the road which have a high risk of failure and so provide good basic access with limited resources. Guidance on the selection and design engineered options will be defined.

Chapter 12- This covers the maintenance aspect of the LVR, by providing guidance and general rationale. It also provides an introduction to the standalone maintenance booklet, in addition to listing the maintenance activities required for low volume unpaved and paved roads.

Main Volume 2: Cross Drainage and Structures; this volume of the SSLVR Manual will be based largely on the Ethiopian Low Volume Roads Manual but account will be taken of the local environment and design parameters through available data and documentation. Users will be referred to the USAID / MRB Bridge Design Manual 2006 for more detailed design of structures (larger RCC Bridges etc), which are outside the scope of this manual. The TRL ORN 9 (Design of Small Bridges) and TRL ORN 16 (Road Engineering in Mountainous Regions) may also be referenced.

Since no national specifications have yet been developed a limited review of design drawings for structures will be carried out. This will entail selecting which of the Ethiopia LVR Manual drawings are relevant.

Main Volume 3: Maintenance: It is intended that this stand-alone booklet will facilitate application for maintenance based on the principles outlined in Volume 1, Chapter 12.

The following topics will not be included in the LVR Manual but a separate Final Report will recommend additional attention under separate funding

- Technical Design Specifications,
- Maintenance Specifications,
- Standard Bidding and Contract Documentation,
- Construction Good Practice
- Quality Control Procedures
- Main Roads and Bridges,
- Cost-Benefit Assessment
- Whole-life Costing and Cost model

DISCUSSION

A number of questions were raised by participants

1. *What was the composition of the Technical Working Group (TWG)?*

   It was decided that all the stakeholders and participants are the members of TWG, however further discussions would be held as to the composition of a smaller editorial group.

2. *Is the 300vpd appropriate for South Sudan?*

   A limit of between 200 and 300 equivalent 2 axle vehicles per day is normally accepted as the upper boundary for LVRs. In Ethiopia where there are axle load issues the limit of 300vpd is accompanied by a limit of 1 million equivalent standard axles (esas) to take into account heavier vehicles. This esa limit is also appropriate for south Sudan. The Authors of the SS LVR Manual are aware of potential problems with axle overloading in S. Sudan.

3. *Hydrology analysis is not included in the design manual despite its importance*?

   The expert dealing with the drainage calculation (Fergus Gleeson) will be consulted to provide details of hydrological analysis in the manual.

4. *Use of the actual materials data will be essential. Will materials testing be conducted from the various diverse regions?*

   The manual will be drafted on the basis of available construction materials information. However more detailed analysis will be conducted and be available in the future. This manual will be a living document and the owners and managers of the document should be prepared to update it. All the stakeholders working on different regions of South Sudan, including the University of Juba, should share details of materials investigations.

5. *When considering the traffic counts, is the manual considering different vehicles types in accordance with the axle load?*

   An explanation was yes the manual will follow the Ethiopian Manual in classifying vehicles and their loading for design purposes.

6. *Issues of ownership*?

   The issue of the SS LVR management and ownership was clarified that the Ministry of Roads and Bridges would currently be the owners of this document. However training workshops should be held with the states Ministry of Physical Infrastructure (MOPI) as they will be the end user of this document.

7. *Will Road Safety be included*?

   Road Safety wasn't included in the Ethiopian Manual; this will be additional work outside this contract.

8. *How will the SSLVR Manual deal with swelling clays?*

   There will be an appendix dealing with specific swelling clay issues. Swelling clay issues will be acknowledged where relevant in the various chapters. JRC emphasised the need for an additional "Road Note" type study starting from basic clay types through to solution (just on geology grounds there are at least two different generic types here)

9. *Programme changes?*

   The proposed programme changes to move the dates of the next TEG meetings were approved, Appendix B.

10. *The general layout, colour and format for this document?*

    Will be clarified later on further consultation.

FILE TRANSFER

The draft SSLVR manual in WORD format will be a very large document with individual chapters probably being above the normal limit size of an email attachment. Therefore drafts will be shared on Drop Box and all the stakeholders provided with an access password to read in advance prior to the next meeting of review.

CONCLUSION

The meeting was concluded, thanking all the TWG members for their attendance and positive contributions. The consultants should proceed to complete the first draft of the SSLVR Manual. The next meeting will be in the second week of October. The meeting ended with a vote of thanks.

Appendix B
Revised Programme