LAO PEOPLE'S DEMOCRATIC REPUBLIC
PEACE INDEPENDENCE DEMOCRACY UNITY PROSPERITY

MPWT - SEACAP 21 - DFID

SLOPE STABILISATION TRIALS ON ROUTE 13N KASI – PHOU KHOUN – LUANG PRABANG AND ROUTE 7 PHOU KHOUN – LUANG PRABANG/XIENG KHUANG BORDER




MODULES 2 & 3 REPORT

SUBMITTED BY

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in association with

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LAO CONSULTING GROUP

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SEACAP 21 Slope Stabilisation Trials
Modules 2 & 3 Report

REPRESENTATIVE DATA CAPTURE AND INTERPRETATION

CONTENTS

LIST OF ABBREVIATIONS

ADB	Asian Development Bank
ASIST-ILO	Advisory Support, Information Services and Training – International Labour Organisation
BAC	Basic Access Component
CMC	Community Road Maintenance Committee
CRM	Community Road Model
DCP	Dynamic Cone Penetrometer
DFID	Department for International Development
DPWT	Department of Public Works and Transport
ESCAP	Economic and Social Commission for Asia and the Pacific
FOMACOP	Forest Management and Conservation Programme
FORCAP	Forest Conservation Project
JFM	Joint Forest Management
LCG	Lao Consulting Group
LRD	Local Roads Division
LSRSP	Lao-Swedish Road Sector Project
MAF	Ministry of Agriculture and Forests
MCBRP	Microfinance Capacity Building and Research Programme
MCTPC	Ministry of Communication, Transport, Post and Construction, now MPWT
MPWT	Ministry of Public Works and Transport
NAFRI	National Agriculture and Forestry Research Institute
NAWACOP	National Watershed Conservation Project
OPWT	Office of Public Works and Transport
PBMC	Performance-Based Maintenance Contract
PMO	Project Management Office
PRTP	Participatory Rural Transport Planning
RAD	Road Administration Division
RMP	Road Maintenance Project
SEACAP	South East Asia Community Access Project
SIDA	Swedish International Development Agency
SPT	Standard Penetration Test
TOR	Terms of Reference
UNDP	United Nations Development Programme
VMC	Village Maintenance Committee
WG	Weathering Grade

SUMMARY

The scope of work for SEACAP 21 is divided into four modules. This report is concerned with Modules 2 & 3, covering Representative Data Capture and Interpretation, over the period February 2007 to September 2008. The modules are divided into a number of key activities, and the report deals with them according to the way they are listed in the project's terms of reference.

Module 2 - Construction

This was undertaken in two Phases. Phase 1 comprised work on three sites, that predominantly involved bio engineering with some minor structures. Phase 2 comprised work on ten further sites, that was mainly structural but with some bio-engineering. The activities involved were: (a) instruct the contractors appointed by MPWT for conducting the trials; (b) supervise the construction at the identified locations; and (c) supervise any necessary rehabilitation works

Although the Phase 1 works were undertaken as planned, some of the bio-engineering planting was unsatisfactory. As a result, re-planting was instructed and some specifications were revised. The Phase 2 works were altered to some extent, including the addition of two walls and a change of wall shape dictated by the MPWT. The contractor over-ran the contract period and the quality of construction of the masonry retaining walls gave cause for concern.

Module 2 - Data Capture

The activities undertaken in this respect were: (a) liaise with survey teams appointed for data collection; (b) instruct survey teams on objectives, methodology and procedures; (c) supervise initial data collection surveys in selected provinces; (d) incorporate adjustments in procedures; (e) implement data collection programme in liaison with RAD; (f) complete principal slope condition data; (g) collect relevant village and district information; (h) ensure quality of data by cross checks; (i) carry out laboratory testing and document results; (j) input acquired data into a database; and (k) submit reports detailing project actions and outcomes.

Data capture and research included numerous elements, such as: rainfall records; GPS data; topographical mapping; aerial photography; geological mapping; soil and land use mapping; and bio-engineering data. For selected project sites, ground investigation and dynamic probe data were collected, and ground movement monitored. In addition, information gathering under this heading included: regular inspections and assessments of both the stabilised slopes and the remaining untreated slopes within the project area; assessment of areas with similar topography and rainfall in other parts of Lao PDR, with respect to slope instability and the remedial measures adopted; a landslide inventory of slope failures and remedies; and a review of the community management of roadside slopes. Generally, data collection was carried out directly by SEACAP 21 team members and so quality assurance comprised internal cross-checks within the team. The site investigation and ground movement monitoring were carried out as sub-contracts under the consultants' supervision.

Module 3 - Data Interpretation

This module included the following activities, which were carried out simultaneously with the data capture work in Module 2: (a) quality assure collected data; (b) analyse data; (c) recommend ranking of specific material/technique usage; and (d) report on rural road decision-making processes and long term monitoring. Tables are presented that provide the main response options to individual slope instability problems, once they have been identified and understood. When the treatment has been chosen on the basis of the identified problem, each technique can be cross-checked. This allows the user to ascertain that the techniques chosen are appropriate for the actual site conditions. A further table categorises the ranking in terms of relative strength and whether they have an immediate or longer term effect. A separate detailed review documents the situation regarding road management and decision-making in Laos. Responsibility for management is decentralised to the Provincial DPWTs, with the central divisions retaining the remit for planning and monitoring, as well as budgetary control. Routine maintenance activities are labour-based on all categories of roads, but community involvement occurs only in the lowest category of rural roads. Almost all slope management comes under the emergency maintenance category.

1. INTRODUCTION

In late 2007, the Ministry of Communication, Transport, Post and Construction (MCTPC) was reorganised and renamed the Ministry of Public Works and Transport (MPWT). In order to avoid confusion, the term MPWT is used throughout this report. This similarly applies to the Departments (DCTPCs) which are termed DPWTs.

The scope of work for SEACAP 21 is subdivided into four modules:

- Module 1 Project Planning and Initiation
- Module 2 Representative Data Capture
- Module 3 Data Interpretation
- Module 4 Information Dissemination and Training

In accordance with the TOR, the Consultant is required to submit detailed 'End of Module' Reports which should include a summary that can be used to disseminate the main outcomes of the Modules. Each of these Reports is to be submitted to MPWT for comments and feedback, and these comments are then appended to the Report before submission to SEACAP PMO. Accordingly, now that the scope of work for Modules 2 and 3 is complete, this second Module Report is submitted to MPWT.

Although the TOR envisaged a stepped progression from one Module to the next, this was found to be impracticable, and in the Inception Report submitted in November 2006 the Consultant proposed a revised workplan and staffing schedule (see Appendix A). This was accepted. It will be seen that Modules 2 and 3 considerably overlap both Modules 1 and 4. Since data capture and interpretation are interlinked, it was later agreed that the Consultant should submit a combined Module 2 and 3 Report. Initial data capture for Module 2 commenced in February 2007 and the final data interpretation for Module 3 was completed in September 2008.

The TOR subdivide each Module into a series of key activities, and for ease of reference these are repeated in the next section for Modules 2 and 3 with a detailed commentary on the work actually carried out.

2. KEY ACTIVITIES – MODULE 2

Construction

2.1 Instruct the contractors appointed by MPWT for conducting the trials

As explained in some detail in the Module 1 Report, the construction work was subdivided into two phases; Phase 1 comprised work that predominantly involved bioengineering with some minor structures, Phase 2 comprised work that was predominantly structural but with some bioengineering. Phase 1 construction was awarded to Vone Thyling on 17th May 2007 with a required completion date of 14th August 2007; Phase 2 construction was awarded to Asean Civil Road Bridge and Irrigation Construction Co Ltd on 16th November 2007 with a required completion date of 13th May 2008.

2.2 Supervise the construction at the identified locations

Phase 1

The table following summarises the scope of work under Phase 1:

Location	**Scope of work**
km 238.0 Road 13N	*Cut slope on LHS*. Trim back scar and loose slope debris, re-profile and compact. Construct stone-lined slope drains. Construct gabion check dam. Shrub seeding in rock areas as required. Plant diagonal grass lines. *Fill slope on RHS*. Trim slope debris to a rounded profile. Smooth remaining debris and compact. Construct live check dams. Plant grass strips on slopes less than 35 deg and brush layers on slopes greater than 35 deg
km 316.6 Road 13N	*Cut slope on LHS*. Trim back scar and loose slope debris, re-profile and compact. Construct composite masonry revetment wall at toe and plant brush layers in backfill. Construct new side drain. Plant diagonal grass lines. *Fill slope on RHS.* Edge of debris bench to be trimmed and re-profiled. Plant truncheon hardwood cuttings throughout debris slope.
km 337.7 Road 13N	*Cut slope on LHS.* Trim back scar and loose debris. Fill and compact tension cracks. Plant diagonal grass slips. Sow shrub seeds. Form slope drainage channel. Construct masonry side drain. *Fill slope on RHS.* Construct earth bund along edge of road. Plant tree seedlings and grass slips on debris bench. Plant truncheon cuttings throughout bare debris slope.

Full-time supervision was provided by Bounthavy Siliphon, Construction Supervisor, and Bounhome Malaythong, Bioengineer 2, both from LCG, supported by Sengmany Sysouvanthong, Project Co-ordinator, MPWT. Regular additional visits were made by Xayphone Chonephetsarath, the Deputy Team Leader/Resident Engineer, supported by John Howell, Bioengineer 1, who also made a number of visits.

Monthly construction progress reports were produced by the site supervision team in accordance with the requirements of the World Bank RMP2 programme.

Although the works were undertaken as planned, it became apparent that despite earlier demonstrations to show the contractor how to carry out the bioengineering planting successfully, there was an unacceptably high failure rate of the grass planted slips. This was due to the workers improperly treating the slips, and a failure to water them in periods of dry weather. As a result of this, the contractor was instructed to replant the failed areas at the commencement of the following wet season, in June 2008. This was done.

As a result of the unsatisfactory performance of the bioengineering planting in general, the grass slip specifications were revised to provide a larger plant with two or three stems together with other revisions to the specifications to ensure greater robustness of the live check dams and truncheon cuttings.

Phase 2

The table below summarises the scope of work under Phase 2:

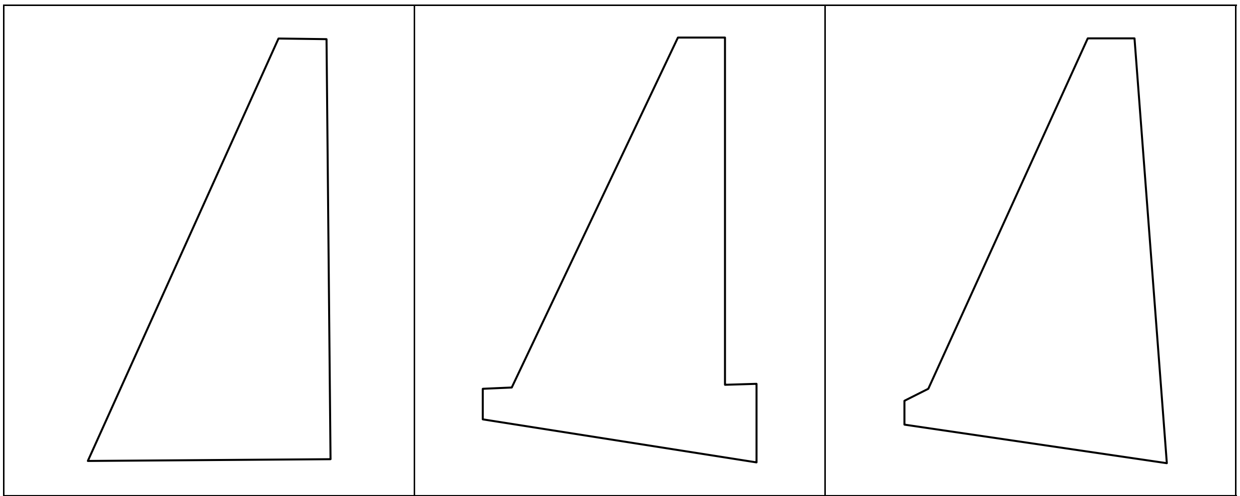
Location	**Original scope of work**	**Revisions during construction**
km 3.3 Road 7	*Fill slope on LHS*. Construct 75m x 6m high masonry retaining wall. Construct new masonry roadside drain. Construct gabion check dam. Plant grass slips.	*Fill slope on LHS*. Wall shape changed. Trimming and grass planting added above culvert inlet and outlet on each side of the road
km 6.1 Road 7	*Cut slope on LHS.* Plant truncheon cuttings and diagonal grass slips. *Fill slope on RHS*. Construct 40m x 6m high masonry retaining wall. Plant grass slips and brush layers. Plant live check dams in gulley.	*Cut slope on LHS.* Bioengineering works deleted. *Fill slope on RHS*. Wall shape changed.

Location	Original scope of work	Revisions during construction
Km 242.6 Road 13N	*Cut/fill slope on LHS*. Trim edge of backscar and re-profile upper 5m. Construct 75mm thick spray concrete slope protection. Repair asphalt road surface.	*Cut/fill slope on LHS.* Cast in-situ concrete panels substituted for spray concrete. Hand-applied in the end Grass planting added for small bare soil slope.
Km 254.0 Road 13N	*Cut/fill slope on LHS.* Construct 50m x 6m high masonry retaining wall. Construct 3m wide gabion drainage channel in existing gulley. Partially replace existing 1m dia cross culvert. Plant grass slips and brush layers. Plant live check dams in gullies.	*Cut/fill slope on LHS*. Retaining wall length reduced to approx 35m and shape changed. Cross channel replacement deleted. Masonry substituted for gabion. Drainage channel wall width increased downslope.
Km 260.3 Road 13N	*Cut slope on LHS.* Reconstruct roadside drain and remove slip debris. *Fill slope on RHS.* Remove and replace existing cross culvert. Construct gabion apron and check dams.	*Cut slope on LHS*. Masonry retaining wall constructed. Grass planting and brush layers added above wall. *Fill slope on RHS*. Existing cross culvert cleared and retained.
Km 287.2 Road 13N	*Fill slope on LHS.* Construct 60m x 3m high masonry retaining wall. Plant bamboo at base of slope.	*Fill slope on LHS*. Wall shape changed. Bioengineering reduced.
Km 317.9 Road 13N	*Cut slope on RHS.* Construct gabion cascade down slope. Construct masonry stilling basin and new masonry roadside drain.	
Km 332.7 Road 13N	*Cut slope on LHS.* Construct 50m x 4m high masonry retaining wall. Install subsoil slope drainage and masonry drop channel outlet. Plant grass slips. Sow shrub and tree seeds below wall. *Fill slope on RHS.* Trim spoil slope and remove debris from existing culvert and channel. Plant grass slips, brush layers and truncheon cuttings.	*Cut slope on LHS.* Wall shape changed. Bioengineering works added to right of wall.
Km 336.4 Road 13N	*Cut slope on LHS*. Upgrade roadside drain to mortared masonry. *Fill slope on RHS.* Trimming and bioengineering works.	
Km 339.9 Road 13N	*Cut slope on LHS*. Construct 40m x 3-4m high masonry retaining wall. Install subsoil slope drainage and masonry drop channel outlet. Trim backscar and remove spoil. Plant grass slips. Sow shrub and tree seeds below wall. *Fill slope on RHS*. Construct bund. Trim top of spoil slope. Plant grass slips and shrub and tree seedlings on bench. Plant brush layers on debris slope.	*Cut slope on LHS.* Wall shape changed.
Km 357.1 Road 13N	Not included in original scope of work	*Fill slope on LHS*. 6m high masonry wall constructed.

Full-time supervision was provided by Bounthavy Siliphon, Construction Supervisor, and Keuthmany Sayasanh, Geotechnical Engineer/Inspector, both from LCG, and Thongphet from Luang Prabang DPWT. These were supported by Bounhome Malaythong, Bioengineer 2, from LCG, for the bio-engineering works and by Sengmany Sysouvanthong, Project Co-ordinator, MPWT. Regular additional visits were made by Xayphone Chonephetsarath, the Deputy Team Leader/Resident Engineer, supported by Tim Hunt (Team Leader), John Howell (Bioengineer 1) and Gareth Hearn (Geotechnical Engineer 1), who also made a number of visits.

Most revisions to the scope of work arose from practical considerations of the conditions exposed during the course of construction and of the funds available. In one particular respect however, namely the change of retaining wall shape, this was dictated by the MPWT and is worthy of further discussion. Furthermore, two additional sites were added and some minor but important slope protection works above the road at km 6.1 on Road 7 were removed.

The figure below shows the original shape of the masonry retaining walls as specified on the construction drawings, the shape preferred by MPWT and instructed to the contractor, and finally the compromise shape suggested by the Consultant.



Original Specified	**Preferred by MPWT**	**Constructed Compromise**

The advantages and disadvantages of each shape are given below:

Wall type	**Advantages**	**Disadvantages**
Originally Specified	Horizontal excavation easy to construct. Little danger of water ponding at the base of the wall.	Lower resistance to sliding compared to a sloping base.
Preferred by MPWT	Greater resistance to sliding and overturning compared to a horizontal base. Front step will reduce the effects of surface runoff from undermining toe.	Sloping excavation more difficult to construct. Some danger of water ponding at the base of the wall. Rear step will crack under load and cannot be relied upon to reduce overturning forces
Recommended compromise	Greater resistance to sliding and overturning compared to a horizontal base. Front step will reduce the effects of surface runoff from undermining toe. Sloping rear face reduces overturning compared to vertical rear face.	Some danger of water ponding at the base of the wall if no drainage provision incorporated at base of wall.

Although the specified completion date for Phase 2 works was set at 13th May 2008, the contractor over-ran the contract period and actually completed on 6th July, fortunately prior to the heaviest rains of the 2008 wet season. Outstanding works included the road pavement reinstatement at the rear of the fill slope retaining walls and this will be carried out at the beginning of the 2008 dry season in October but still within the contract defects liability period.

Concerns were repeatedly expressed by the Consultant to the contractor over the quality of construction of the masonry retaining walls. Although the retaining walls are essentially unreinforced gravity walls, from considerations of durability they should not contain voids. This arose from the contractor (probably deliberately) using insufficient water in his cement mortar mix which was then applied too sparingly, as well as the poor placement of individual stones. Both the contractor and the supervisory staff were cautioned to ensure that the mix was of a sufficient consistency to fill the voids between the masonry stones and to ensure that there was good mechanical interlock between stones.

In his initial work on site the contractor was seen to have dumped surplus excavated material downslope, despite provision for payment in the contract documents for removing and dumping the surplus spoil in safe locations. This was rectified and the contractor then adhered to the provisions in the contract.

2.3 Supervise any necessary rehabilitation works

As noted in 2.2 above, remedial planting was carried out by the Phase 1 contractor in June 2008 during the course of the Phase 2 construction work. This was supervised by the site supervision team.

Data Capture

2.4 Liaison with survey teams appointed for data collection

Generally, data collection was carried out directly by SEACAP 21 team members and so liaison simply comprised internal discussions within the team. In respect of the site investigation and ground movement monitoring, these were carried out as subcontracts under the direct supervision of the project Consultants.

As noted in the Module 1 Report Section 2.3, initial data capture for this project comprised the following elements:

- Rainfall records
- GPS data
- Topographical mapping
- Aerial photography
- Geological mapping
- Soil mapping/land use
- Bioengineering data

The project Inception Report proposed that the data collection programme would include:

- Regular inspections and assessments of the stabilised slopes within the project area
- Regular inspections and assessments of the remaining 'unstabilised' or untreated slopes within the project area
- Inspection and assessment of areas with similar topography and rainfall in other parts of Lao PDR particularly with respect to slope instability and the remedial measures adopted.

During the course of Modules 2 and 3, inspections and assessments of the project area were carried out on a regular basis by the team members. Due to the relative paucity of rainfall in the 2007 wet season, no meaningful conclusions could be drawn – other than the need for greater care with the timing of planting work. For the 2008 wet season however, it is apparent that the study area experienced significant rainfall, reportedly well above the annual average. Unfortunately, the rainfall records at the two rain gauges located in the vicinity of the study area (Phou Khoun and Kasi) have only been in existence since 2006, and so therefore time-series analysis of magnitude/frequency cannot be undertaken. Nevertheless, in the month of July 2008, in excess of 1000mm was recorded at Kasi, which is approximately twice that recorded in "usual" wet season months.

As a consequence, a number of new landslides have been triggered along Road 13N and other existing landslides have been enlarged. During the Consultant's visit to site between 13th and 15th September a total of 64 new landslides were recorded over 150 km. In order to be counted each landslide had to be at least 5m by 5m in dimension. There were numerous features that were smaller than this, but these were considered to represent such a low level of hazard as to be inconsequential. Of the 64 recorded 53 or 82% were located in cut slopes and natural slopes above the road and the remainder were located below the road. In total, the density of recorded new landslides amounted to an average of 1 landslide every 2.2 kilometres.

By comparison, the landslide inventory undertaken by the Consultant in February 2008 identified 38 landslides over the same 150 km length in February 2008. The data suggest that the 2008 wet season has been responsible for the creation of a significantly more than average number of landslides. This is consistent with the observations made of slope movements and related activity at some of the SEACAP 21 trial sites during the 2008 wet season.

Road 13N alignment sections	**February 2008 Landslide Inventory**			**September 2008 Field Visit Record of New Slides**		
	Below Road	**Above Road**	**Total**	**Below Road**	**Above Road**	**Total**
Km 230-240	1	1	2	3	8	11
Km 240-250	2	1	3	1	2	3
Km 250-260	2	2	4	1	3	4
Km 260-270	2	2	4	0	1	1
Km 270-280	0	3	3	0	0	0
Km 280-290	0	2	2	0	1	1
Km 290-300	1	1	2	1	2	3
Km 300-310	0	0	0	0	0	0
Km 310-320	1	3	4	1	1	2
Km 320-330	2	1	3	1	6	7
Km 330-340	3	2	5	3	20	23
Km 340-350	0	0	0	0	3	3
Km 350-360	2	1	3	0	5	5
Km 360-370	0	1	1	0	0	0
Km 370-380	0	2	2	0	1	1
Total	16	22	38	11	53	64

Further data capture and investigation included:

- Ground investigation data for selected project sites
- Dynamic probe data for selected project sites
- Ground movement monitoring for selected project sites
- A landslide inventory of slope failures and remedies of areas with similar topography and rainfall. This inventory also overlapped with the requirements of SEACAP21/002 'Feasibility Study for a National Programme to Manage Slope Stability'.
- Community management of roadside slopes

2.5 Instruct survey teams on objectives, methodology and procedures

As noted in 2.4, the only external data collection was carried out by subcontract in which the objectives, methodology and procedures were specified and/or discussed prior to the work being carried out.

2.6 Supervise initial data collection surveys in selected provinces

Data collection in other selected provinces was confined to rainfall records and landslide inventory, as described in 2.4. The work was carried out by SEACAP 21 team members

2.7 Incorporate adjustments in procedures

Since no training programme in data collection was necessary, no adjustments in procedures were needed or incorporated.

2.8 Implement data collection programme in liaison with RAD

Specifically, the landslide inventory data collection was carried out in liaison with RAD who requested that National Roads 12 and 18b be reviewed, albeit under SEACAP 21/002.

2.9 Complete principal slope condition data

As noted in 2.4, a landslide inventory was carried out to satisfy both the requirements of SEACAP21/001 as well as SEACAP21/002. For completeness, the inventory and its conclusions are also presented in this Module Report.

2.10 Collect relevant village and district information

The ToR suggest that this information might include maintenance activity, flood data, local climate. Maintenance activity is discussed in Appendix D ‘Community Management of Roadside Slopes’ and is not repeated here. During the course of the project it was ascertained that there was no flood data or local climate records that would be relevant to the project.

2.11 Ensure quality of data by cross checks

Apart from the landslide inventory, no other cross checking was considered appropriate.

2.12 Carry out laboratory testing and document results

Laboratory testing was carried out as part of the ground investigation work on selected Phase 2 sites and the results fully documented in a Geotechnical Work Report issued in March 2007. For completeness, this is summarised in 3.2.1.

2.13 Input acquired data into a database

Acquired data comes in many forms, e.g. small scale hard copy aerial photography and topographical maps, soft copy rainfall records and landslide inventory. Hard copy data will be filed and all soft copy data will be burnt onto CDs. These will be handed over to RAD upon project completion.

2.14 Submit reports detailing project actions and outcomes

The bi-monthly progress reports have detailed project actions and outcomes throughout the project.

3. KEY ACTIVITIES – MODULE 3

Data Interpretation

3.1 Quality assure collected data

Although every effort was made to quality assure collected data, where this data came from a local source (e.g. publications and records) it was very rarely possible to carry out an independent check on its veracity. Consequently, most of the data acquired has had to be taken at face value.

3.2 Analyse data

In this section of the report, the following data and research are summarised and analysed:

- Ground investigation data for selected project sites
- Dynamic probe data for selected project sites
- Ground movement monitoring for selected project sites
- Landslide inventory of slope failures and remedies of areas with similar topography and rainfall
- Rainfall
- Community management of roadside slopes

3.2.1 Ground Investigation Data

In February 2007 a ground investigation comprising rotary augured boreholes and trial pits was carried out at nine of the Phase 2 sites, the results of which were formally reported in early March 2007. Details are provided in the table below.

A total of seven boreholes were carried out primarily to gain information on ground conditions beneath proposed retaining walls. Three of the boreholes were also completed with inclinometers/slip indicators that were intended to be able to indicate the depth of landsliding at these sites during the 2007 wet season.

Trial pits were predominantly carried out by mechanical excavator although hand dug pits were carried out at several sites, such as Km 6.1 on Road 7, due to access restrictions. The trial pits allowed a relatively economical and rapid assessment of ground conditions to be made and it was intended that at locations such as Km 260.3 on Road 13 they would also be able to delineate the extent of ground movement more accurately.

Site	Fieldwork	Reason	Outcome
Road 7 Km 3.3	1 Borehole 2 Trial Pits	To gain information on ground conditions, particularly depth to suitable founding horizon for proposed retaining wall. Trial pits carried out to determine extent and depth of fill material.	WG IV-V argillaceous rock to 7.5m. SPT refusal at 7.5m. Gravity retaining wall likely to be suitable
Road 7 Km 6.1	2 hand dug Trial Pits 1 Borehole	Hand dug pits carried out first to identify depth to suitable founding horizon for proposed retaining wall. Since trial pits could not identify a suitable founding horizon at shallow depth, a borehole was considered necessary.	Mainly WG V phyllite to 15m. SPT refusal at 15m. Depth of weathered material may preclude gravity retaining wall

Site	Fieldwork	Reason	Outcome
Road 13N Km 254	1 Borehole	To gain information on ground conditions, particularly the depth to suitable founding horizon for proposed retaining wall.	WG IV-V phyllite to 15m. SPT refusal at 15m. Depth of weathered material may preclude gravity retaining wall.
Road 13N Km 260.3	1 Borehole 3 Trial Pits/Trenches	Borehole drilled to determine rock type in area of complex geology. Inclinometer/slip indicator installed to determine depth of movement of landslide. Trial trenches excavated at up chainage and down chainage end of landslide to identify shear plane in road bench.	Trial trenches failed to identify presence of shear planes. Made ground to 6m(?) followed by WG IV-V argillaceous rock to 17.5m Mass movements make site unsuitable for retaining wall
Road 13N Km 287.2	1 Borehole	To gain information on ground conditions, particularly depth to suitable founding horizon for proposed retaining wall.	WG IV-V argillaceous rock to 6.5m. SPT refusal at 6.5m Gravity wall likely to be suitable
Road 13N Km 317.9	1 Borehole	Borehole drilled to allow installation of inclinometer/slip indicator to determine landslide depth of movement.	WG IV-V phyllite or colluvium to 6.8m. SPT refusal at 6.5m Gravity wall may be suitable
Road 13N Km 332.7	1 Hand dug pit / slope strip.	Hand dug pit/slope strip in failed cut slope above road to identify retaining wall founding level.	Gravity wall at break in slope will be founded on reasonable quality rock
Road 13N Km 336.4	2 Trial Pits 1 Borehole	Trial pits excavated at up-chainage and down-chainage end of landslide to identify shear planes in the road bench. Borehole drilled to allow installation of inclinometer/slip indicator to determine landslide depth of movement.	Trial pits failed to identify presence of slip planes. WG IV-V argillaceous rock to 8.5m. SPT refusal at 8.5m
Road 13N Km 339.9	1 Slope strip.	Slope strip in failed cut slope above road to identify retaining wall founding level.	Gravity wall at break in slope will be founded on reasonable quality rock

In addition to the fieldwork, limited laboratory geotechnical testing was also carried out on some of the soil samples to determine basic soil characteristics such as particle size distribution (7 No) and Atterberg limits (7 No).

In general the results of the ground investigation were both useful and disappointing. Standard Penetration Tests (SPTs) carried out in the boreholes or shallow trial pits allowed the retaining wall designs to proceed on a rational basis for km 3.3 and 6.1 on Road 7, and km 254.0, 287.2, 332.7 and 336.9 on Road 13N. However, it was hoped that the investigation would reveal the depth of sliding at km 260.3, km 317.9 and km 336.4, but this was not the case. Furthermore, in 2007 none of the slip indicators gave any meaningful data, possibly as a result of the relatively dry 2007 wet season which was insufficient to induce further ground movement at these locations. However, during the course of the 2008 wet season, ground movements were observed both on the surface and in the slip indicator at km 317.9 (see section 3.2.3 below).

The value of a ground investigation is that it will usually allow the engineer to design with greater confidence, particularly in respect of retaining wall foundation depths. As a consequence the design will be economical and less subject to change during construction. Where construction contracts values are essentially fixed and very difficult to revise upwards during construction, this is an important factor.

Ground investigation data is only relevant to the locations where the work was carried out, and have no meaningful implications for sites elsewhere within Laos, except where similar ground conditions might be inferred, using the reference condition approach, for example.

3.2.2 Dynamic Cone Penetrometer Data

In order to assess the actual ground conditions within the proposed base of retaining wall excavations, the site supervisory staff were instructed to carry out Dynamic Cone Penetrometer (DCP) tests. The DCP used was hired from LTEC and comprises an 8kg cylindrical weight that can be manually lifted on an upper steel rod for a fixed height of 575mm. The weight is then allowed to drop freely onto a collar which directly transmits the force to a hardened 20mm diameter 60deg cone screwed to the bottom of a lower steel rod resting on the ground. The depth penetrated in mm by the probe into the ground for 5 or 10 blows is then recorded. A total depth of up to 1.2m can be penetrated unless refusal is reached at a shallower depth. A typical test sheet is given below:

Dynamic Cone Penetration Data Sheet			
Location: **Sta:** **Layer:** **Depth:**		**Sheet:** **Date:** **Operator:** **Checked by:**	
Number of blows	**Sum of blows**	**Depth (mm)**	**Equivalent mm/blow**
10	10	177	18
10	20	318	14
10	30	427	11
10	40	520	9
10	50	529	1
10	60	537	1
10	70	548	1
10	80	576	3
10	90	608	3
10	100	651	4
10	110	673	2
10	120	685	1

In general between 3 and 6 tests were conducted within each retaining wall excavation. As a broad rule of thumb, the following table can be used as guidance on the support that the excavation will provide:

No of blows for 300mm penetration	Equivalent mm per blow	Allowable bearing pressure (kN/m2)	
		2m width footing	4m width footing
5	60	90	70
10	30	140	100
20	15	200	160
30	10	270	220
40	7.5	340	290
50	6	400	350

Given a typical bearing pressure requirement of about 120 kN/m2 for a 6m high retaining wall with a 4m wide base, it will be seen that when the mm/blow is less than about 15 the subsoil should be able to provide adequate support.

The DCP is very simple to operate and is readily transportable. Its main benefit is to give added confidence that the correct excavation level has been reached, or alternatively that further excavation is necessary.

DCP data is only relevant to the locations where the work was carried out, and has no meaningful implications for sites elsewhere within Laos.

3.2.3 Ground Movement Monitoring Data

Ground movement monitoring was carried out as a subcontract at two sites (km 260.3 and km 317.9) over the 2007 wet season. The scale of both failures was such that the cost of any appropriate remedial measures would be far in excess of the amount budgeted for stabilisation, with each failure encompassing the entire road bench. Since it was considered that further instability was unlikely to be catastrophic, but more likely to result in gradual movement of the entire road bench, it was decided to get some idea of the response of both sites to rainfall. In this manner at least the magnitude of movement could be assessed.

Temporary benchmarks and monitoring points were established in pre-determined locations at each site. Monthly surveys were carried out over the period May to October 2007 to a required accuracy of 1mm. The results are given in Appendix B.

The results indicated movements generally downslope of up to 200mm but with the majority indicating less than 20mm and often less than 10mm. Disappointingly, the benchmarks themselves appeared to move up to 20mm at km 260.3, most probably indicating the true accuracy of the survey work.

In addition to the survey work, the slip indicators installed during the ground investigation detailed in 3.2.1 were also checked at the same time. These indicated that no movement was apparent within the depths they had been installed.

Visual observations backed up the conclusion that the actual slope movements during the 2007 wet season were probably insignificant, and most likely due to the absence of any significant and prolonged periods of rain.

However, this situation was not repeated for the 2008 wet season, when higher rainfall gave rise to increased observed and monitored ground movements. At km 317.9 the slip indicator record suggested shear at a depth of 2.4m below ground level. This corresponded to the visual observation of the active movement on the slope surface. The surface monument monitoring indicated that ground movements at one location below the road had resulted in an elevation change of 1.6m and a lateral (down slope movement) of 4.5m. However, the other surface monuments in the area showed considerable less movement, for example of the order of 90mm or less. The larger recorded ground movement (1.6m) is therefore considered to be spurious.

3.2.4 Landslide inventory of slope failures and remedies

The Inception Report proposed that the data collection programme would include the inspection and assessment of areas with similar topography and rainfall in other parts of Lao PDR particularly with respect to slope instability and the remedial measures adopted. This work was commenced under SEACAP 21/001 and completed under SEACAP 21/002, and has been reported in Part E of the Background Paper, SEACAP 21/002 Feasibility Study for a National Programme to Manage Slope Stability (Sept 2008). For completeness it is reproduced in Appendix C at the end of this report. Data collection was carried out by international members of the SEACAP 21 team prior to the onset of the 2008 wet season.

This inventory covered a little over 1,500 kilometres of the Lao PDR national road network. The network is slightly more than 7,000 kilometres in length, of which approximately half is judged to be in steep hilly or mountainous terrain. The inventory therefore covered about 50% of the national road network located through steep hilly or mountainous areas where landslide and earthworks failures are likely to pose the greatest hazards. In total over 150 landslides were recorded in the inventory, and a hazard and risk classification was assigned to each (Appendix C). It should be noted that the assessment of the size and impact of recorded slope failures was based on an interpretation of landslide scars, remaining slide debris and evidence of road damage. Some of this evidence will have been removed by landslide clearance and repair operations, and so a degree of interpretation was required.

The majority of the landslides recorded appeared to have been caused by the effects of higher wet season groundwater and perched water levels in soils and weathered rock masses exposed in steep roadside cuts. Slope failures were often observed to originate from the upper portions of cut slopes where colluvium or the weaker, more weathered material, predominates in the weathering profile. Ground movements affecting the carriageway or outside edge of road from below appeared to be associated with localise shallow failures in fill slopes and construction spoil or more extensive areas of deeper failure of the natural hillside, in some instances associated with river scour. It should be noted that ground movements taking place on slopes below the road are often less easily identified than those above, and some of these may therefore be missing from the inventory.

The table below shows the percentage distribution of landslide risk number assigned according to whether failures were recorded above, below or through the road (involving failure of the road formation itself). The distribution of mapped landslides is shown on the figure below.

	Risk Number								
	3	**6/8**	**12**	**18**	**24/27**	**36**	**54**	**81**	**Total %**
Above Road	21	20	20	6	4	0	0	0	**71**
Below Road	0	0	6	0	5	6	4	5	**26**
Through Road	0	0	0	0	0	0	0	3	**3**

Slopes adjacent to the road network can be divided into three main categories; cut slopes, fill slopes and natural slopes.

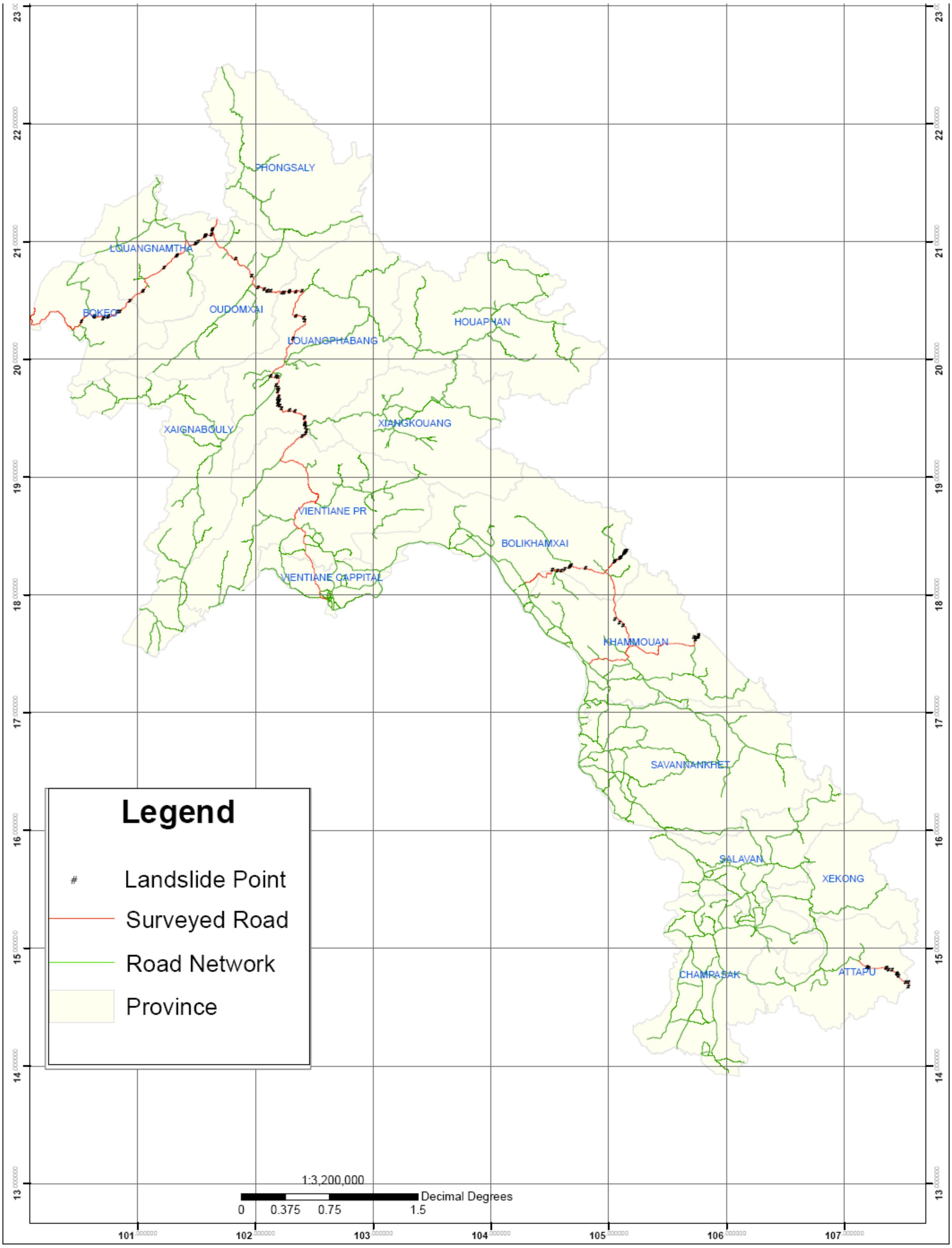
Characteristics of roadside slopes

Cut slopes

Cut slopes formed during the construction of a road should take into account the nature of the soil or rock they expose. Stable cut slopes can vary from as little as 1V:4H (i.e. vertical: horizontal) to close to vertical, depending on underlying geological conditions, namely rock type and its structure.

For most roads built to a limited budget, cut slopes do not appear to have been designed to take into account the engineering geology of the underlying soil and rock, since this often requires prior ground investigation, especially where deep cuttings are involved. In mountainous areas, access is often made difficult for drilling equipment. Also, since ground conditions are usually very variable, exploration boreholes would need to be placed at close intervals to provide any meaningful data, thus increasing the cost of the investigation. It is likely, however, that cut slopes have been excavated to the steepest angles possible for the materials concerned, and this will have led to assessments being made by site staff based on precedent and experience. This is a reasonable way forward in the absence of engineering geological expertise and ground investigation data.

This situation is not unique to Laos, but applies to most developing countries and to less important roads in many developed countries. The alternative is to use detailed site assessments based on engineering geology, to determine the expected ground conditions.


PHONGSALY
LOUANGNAMTHA
BOKEO
OUDOMXAI
LOUANGPHABANG
HOUAPHAN
XAIGNABOULY
XIANGKOUANG
VIENTIANE PR
VIENTIANE CAPPITAL
BOLIKHAMXAI
KHAMMOUAN
SAVANNAKHET
SALAVAN
XEKONG
CHAMPASAK
ATTAPU
Legend
Landslide Point
Surveyed Road
Road Network
Province
1:3,200,000
0 0.375 0.75 1.5
Decimal Degrees
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As a consequence of this, cut slopes are usually designed to set guidelines that are likely to be based on engineering precedent, using broad, though practicable in an engineering sense, differentiation between rocks and soils. As an example, the provisional *Road Design Manual* (MCTPC, 1996) recommends slope angles for cutting depths of up to 8 metres as given in the following table:

MPWT slope cutting grades

Material	Slope Angle	Depth (d)
Cohesionless sands	1V:2H	
Residual soils	1.5V:1H	For d < 4 m
	1V:1H	For d > 4 m
Weathered rock	2V:1H to 4V:1H	
Sound rock	5V:1H to 10V:1H	

Source: *Road Design Manual* (MCTPC, 1996)

For depths greater than 8 metres, or for situations where material or groundwater may be problematic, the Manual states that an analytical approach, possibly including a ground investigation, may be considered.

In the absence of any ground investigation, it appears that many road designs in Laos assume a cut slope angle of around 1V:1H, which is then usually steepened if rock is encountered as the excavation proceeds. This has a number of undesirable effects.

- The upper portion of the cut slope where the soils are most weathered is usually cut too steeply, creating the potential for minor instability and erosion. A slope angle of 1V:1.5H is often more appropriate in these circumstances, if the mountainside above allows it to be attained.
- If weathered or sound rock is then encountered lower down during the formation of the slope, then the upper part of the slope could have been placed closer horizontally to the road edge. This would then reduce the cut volume and therefore the volume of spoil to be disposed. If the natural ground is sloping towards the road, as it usually is then the height of the cut slope is reduced as well.

These variations are shown in the sketch in the figure on the next page:

Fill slopes

Although fill slopes should also take into account the nature of soil or rock they are founded on, this is less important compared to cut slopes, and fill slope angles are inevitably designed to set guidelines. The *Road Design Manual* recommends the slope angles for heights of up to 10 metres shown in the Table below:

MPWT grades for fill slope formation

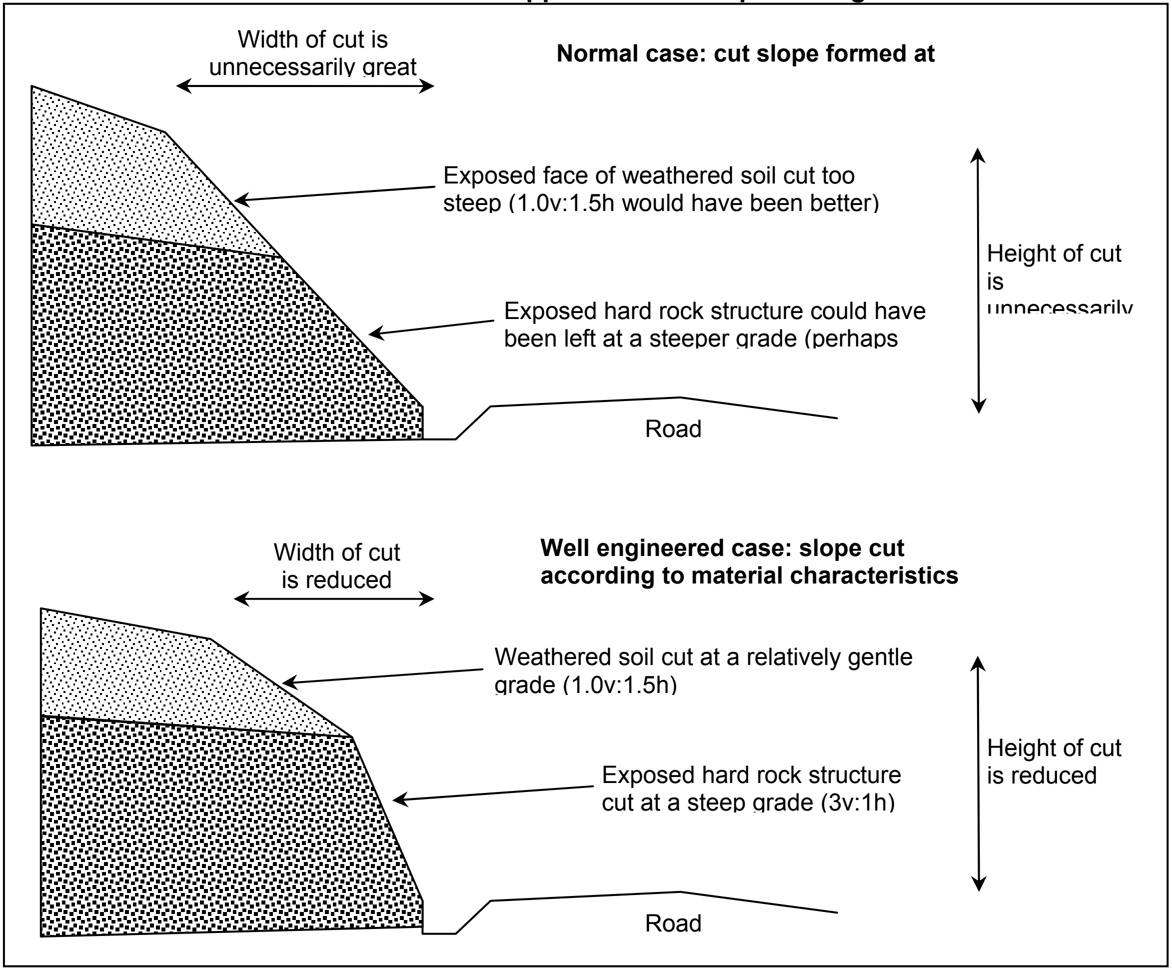
Material	Slope Angle	Height (h)
Cohesionless sand	1V:3H	h < 1 m
	1V:2H	h > 1 m
Other materials	1V:3H	h < 1 m
	1V:2H	1 < h < 3 m
	1V:1.5H	3 < h < 10 m

Source: *Road Design Manual* (MCTPC, 1996)

The shallower slope angle at the top of fill slopes is for traffic safety considerations. For the purpose of this report, fill slopes can be taken to be designed and constructed at 1V:1.5H.

Most fill slope failures in Laos appear to be caused by the absence of benching into the underlying ground to ‘key’ the fill mass into the natural hillside, and the lack of compaction of the fill material. Failures then occur at the interface between the fill and the original ground, or by deep gullying.

Effects of different approaches to slope cutting



Natural slopes

In mountainous terrain the act of cutting a road along a sloping hillside can destabilise the natural slope above and below the road in a number of ways.

- The natural slope may only be marginally stable, so that removal of support by excavating the road may trigger instability on the hillside above. Examples of this are found at Road 12 (km 141+500) and Road 13N (km 260+300).
- The surface water drainage regime down the natural slope will be changed by the construction of the road. The surface water will be concentrated into culverts, and unless the outfalls are properly designed, the concentrated flow may cause local erosion and slope failure. Road 13N (km 254) is a good example.
- The dumping of loose fill on the top of an existing hillside slope may then eventually destabilise the natural slope itself. Road 13 North (km 357) appears to be an example of this.

Slope failure processes

Rock failures

These predominate where bedding, foliation, or tectonic joint sets dip adversely to slope stability. Plane failures and wedge failures are often the most common forms of rock collapse, whereby failure takes place along a single joint or a combination of intersecting joints. In road cuttings and natural slopes adjacent to roads, these failures are relatively infrequent, compared to soil failures (see below) but they are sometimes represented by the presence of rafted boulders and colluvial deposits derived from previous deep-seated rock failures that have since ‘broken up’ to form deep deposits of rock on hillsides.

Soil failures

Soil failures are the most frequent collapses observed along road lines. They are usually developed in weathered rocks and soils, and often occur in the upper weathered portion of cut slopes. Soil failures also frequently occur in colluvial masses derived from earlier rock failures, especially where ground water levels are high.

Soil failures are typically shallow, perhaps a few metres in depth and usually occur along a planar surface in granular soils.

Complex failures

There are sections of the Laos road network where large, deep-seated and often slow-moving landslides are affecting the stability of the road formation. In these cases, the underlying processes of failure are likely to be a combination of failure planes and materials, and the mechanisms of movement are unknown.

Slope erosion

Slope erosion can be considered to be a form of instability, particularly when the erosion creates gullying and surface instability. The most easily observed roadside erosion in Laos usually takes place on the surface of the cut slopes (although it can also take place on natural slopes as noted above). There are several failures along Road 18b that fall into this category. This erosion is sometimes reduced by the presence of intermediate unsurfaced horizontal benches, of 1-metre in width and spaced at vertical intervals of around 8 metres, formed at the time of construction. Occasionally, crest drains are constructed in an attempt to reduce the flow of water from the natural ground above on to the slope surface itself. Rarely, bio-engineering techniques are used to encourage plant growth to create a more stable surface. Often natural processes take over and in the course of time the slope surface stabilises.

Fill slope erosion can become problematic, particularly if the slope surface has not been protected (e.g. by planting) and/or if the slope has not been adequately compacted. This is particularly the case where the fill is the result of surplus spoil and has been dumped on the hillside with no attempt at any compaction, and is a frequent occurrence in Laos, for example on Roads 12 and 18B.

3.2.5 Rainfall

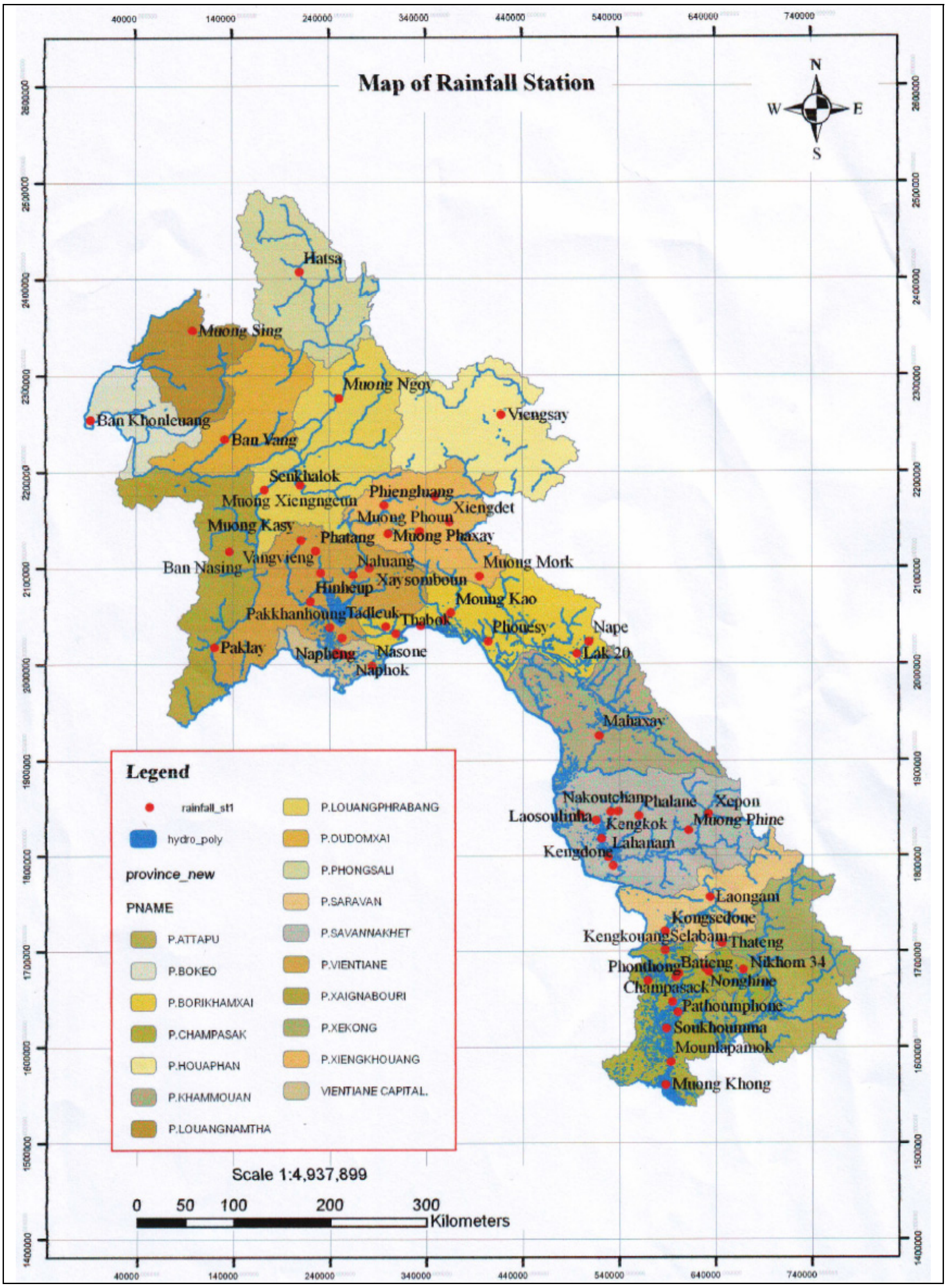
Rainfall patterns in Laos are dominated by the south-west monsoon and the relief of the country. Widespread extreme rainfall events are most often associated with typhoons tracking inland from the South China Sea or Gulf of Thailand

The network of daily (24 hour) rain gauge stations is shown in the following figure. Many of these stations have more than 15 years of recording. This is sufficient for frequency analysis for rainfall of return period up to 1 in 20 years which is appropriate for the small scale drainage works used for slope stabilisation. Unfortunately the stations are usually located for convenience in provincial and district towns and not at elevation in the hills and upper river catchments. There is significant localized variation in rainfall due to the topography and therefore detailed analyses of a record will only yield a broad indication of actual rainfall at a nearby location.

There are few recording rain gauge[1] records. There are several recently installed recording gauges and the network will probably expand in the future but no record was identified sufficient for frequency analysis. When such records exist it is possible to derive short term rainfall-intensity-duration relationships from daily rain gauge records. These relationships are needed for a rigorous drainage design. A detailed rainfall analysis is outside the scope of this project. Therefore at this time drainage design must rely on current MPWT standards or relevant design studies.

[1] A recording or autographic rain gauge provides a continuous record of variations in rainfall over every 24 hour period. This allows the calculation of rainfall intensity. For example a monsoon rainstorm recording 50 mm of rainfall on a 24 hour rain gauge may actually peak at an initial intensity >200 mm per hour for 5 minutes and the rain may all fall within one hour.

Distribution of daily raingauge stations in Lao PDR

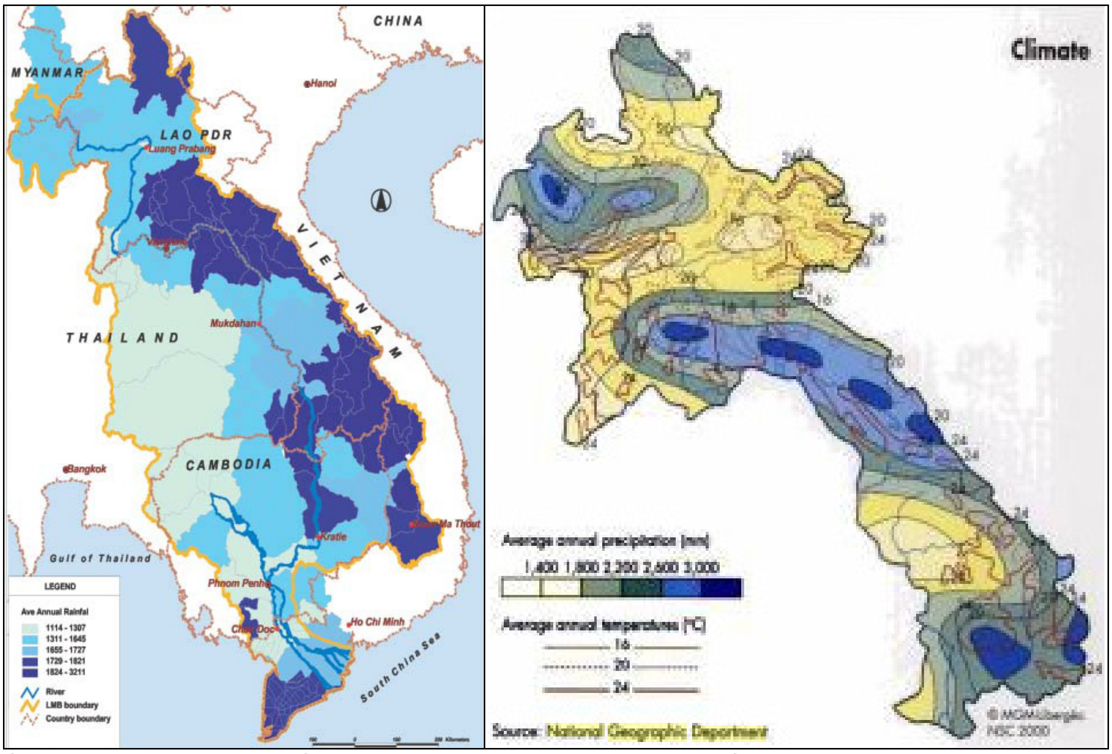


Source: Department of Meteorology

In the absence of detailed studies it is difficult to obtain a sound overview of the situation. The figure below shows two rainfall maps, which show good correspondence in the centre and south of the country, where there is generally high rainfall except across much of Savannakhet Province. For the north the agreement is less precise although both show higher rainfall in Phongsaly; the national map shows an area of higher rainfall in Bokeo, Luang Namtha and Oudomxai which does not feature in the Mekong regional map. The greater rainfall in the central and southern areas is related to cyclonic activity in the South China Sea, and the two main westward tracks of cyclonic storms across Vietnam. These have the effect of extending the wet season beyond the period of the south-west monsoon.

Rainfall in the north is also affected by the wider effects of cyclones, but is more dominated by the monsoon. Since the monsoon air mass is affected by its passage from the Bay of Bengal over Thailand and Burma, it becomes somewhat erratic by the time it reaches Laos.

Rainfall maps of (a) the lower Mekong basin and (b) Laos



Sources: (a) Mekong River Commission (2005); (b) Bounthavy and Sisouphanthong (2000).

The picture is generally supported by looking at the data supplied from two weather stations in northern Laos for monthly rainfall in mm over the period 1996 to 2005. These are given in the following tables. The annual total is high at Vang Vieng, with a ten-year average of nearly 3900 mm, and a yearly range between 3150 and 4550 mm. It is much lower in Luang Prabang, where the same ten years showed an average of only 1430 mm, with a range between 1150 and 1800 mm. A glance through the tables shows that the monthly totals can vary considerably at both locations.

(a) Luang Prabang

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Annual**
1996	21	54	76	126	221	136	292	374	203	45	17	46	**1611**
1997	65	25	68	87	89	166	290	176	81	99	19	41	**1206**
1998	78	50	57	130	110	129	152	241	53	136	12	21	**1169**
1999	42	59	85	87	106	166	75	179	243	113	82	111	**1348**
2000	105	138	110	65	241	217	197	112	94	108	55	13	**1455**
2001	45	88	169	194	175	127	349	229	160	169	51	54	**1810**
2002	49	1	24	56	269	156	384	259	161	71	76	97	**1602**
2003	15	20	77	140	68	315	196	314	223	35	0	0	**1401**
2004	15	0	0	143	241	208	287	233	152	166	28	0	**1473**
2005	0	5	89	33	102	238	196	322	183	19	33	0	**1219**
Average	43	44	75	106	162	186	242	244	155	96	37	38	**1429**

(b) Vang Vieng

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Annual**
1996	1	15	63	299	376	503	716	1030	472	228	215	6	**3923**
1997	16	0	18	165	387	479	978	753	616	99	0	0	**3512**
1998	0	16	47	239	288	459	780	682	457	102	65	5	**3140**
1999	2	0	87	294	645	750	668	835	473	164	118	55	**4088**
2000	0	118	7	259	742	1047	513	1012	642	166	38	0	**4545**
2001	0	0	248	15	522	888	815	717	448	168	26	1	**3849**
2002	42	0	31	51	742	920	800	743	359	229	24	34	**3975**
2003	24	48	105	78	389	465	931	702	373	95	0	0	**3209**
2004	27	38	22	273	558	671	1087	797	618	10	4	0	**4105**
2005	0	40	8	60	312	1025	1102	1049	690	129	16	3	**4435**
Average	11	28	64	173	496	721	839	832	515	139	51	10	**3878**

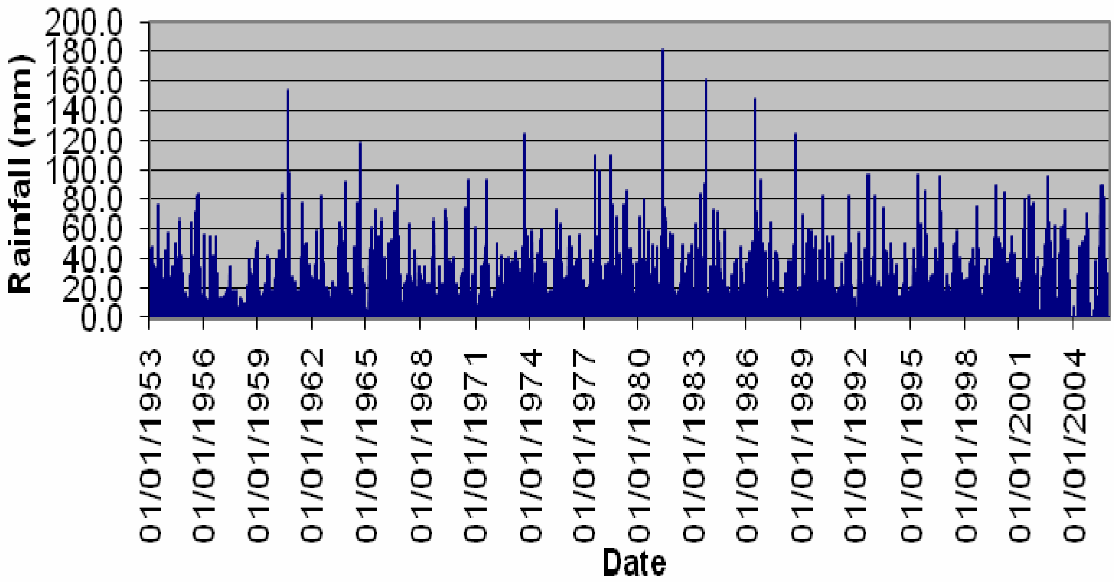
Slope instability can also be related to rainfall, both to the total rainfall (mm) over a period of one to several days, or the rainfall intensity (mm/h) which varies over the duration of the storm. Wet season thunderstorms are characterised by an initial high intensity which then falls away. Typhoons are characterised by lower intensity but sustained for much longer for the duration of the storm. Often failures occur as a result of a build up of significant rainfall over a period of a few days or even a week, and sometimes it is related to a single particularly intense event.

Luang Prabang has a dataset of fifty years of daily rainfall readings. In that period there have been only twelve occasions when rainfall has been at least 100 mm in one day as shown on the table below:

Date	Rainfall (mm)	Comments
27/08/1960	154.0	212 mm between 19 and 24/8, otherwise no rainfall for some days.
26/08/1964	118.0	55 mm in the 2 days before, virtually no rain in the 3 days afterwards.
27/08/1973	124.0	170 mm between 19 and 24/8, otherwise no rainfall for some days.
22/07/1977	109.0	6 mm day before, 38 mm day after.
29/10/1977	100.0	Isolated: virtually no rainfall for 3 days either side.
28/06/1978	109.0	24 mm day before, 2 mm day after.
10/05/1981	181.0	69 mm in 3 days before, 4 mm in 3 days afterwards.
16/09/1983	139.0	This was an extraordinary period (assuming the data to be correct). There was 16 mm of rain in the 3 days before 16/9, 9 mm between 17 and 20/9, no rain on 22/9 and 9 mm in the 3 days after 23/9.
21/09/1983	126.0	
23/09/1983	161.0	
24/06/1986	148.0	Isolated: virtually no rainfall for 3 days either side.
10/09/1988	124.0	Isolated: virtually no rainfall for 3 days either side.

These have occurred any time between early May and late October, and so can occur as a result of either monsoonal or cyclonic weather systems. The following chart gives the complete set of daily rainfall for the fifty year period of records from Luang Prabang. Obviously the printing of over 18,000 individual readings cannot be very clear at this scale, but the chart nevertheless shows that there are relatively very few rain days with more than 60 mm of rain. The twelve high peaks are mainly isolated occurrences, with significant rainfall build-up occurring only in August 1960, August 1973 and September 1983. This rather simplistic assessment of the peak events of course misses other periods of longer rainfall build-up: for example, 141 mm fell in four days at the end of May 1983, and 170 mm fell in five days in August 1983, but not with any single daily total exceeding 100 mm.

Daily rainfall at Luang Prabang, 1953 to 2005



The Vang Vieng station, with its much higher amounts, experienced 36 days with totals between 100 and 200 mm in the ten years from 1996 to 2005, mainly towards the lower end of this range as shown on the following table. Only on one occasion (in 2005) did the 48-hour total approach 300 mm; and only on three occasions (1998, 2000 and 2005) did the 72-hour total exceed 300 mm.

Year	Date	Rain (mm)	Year	Date	Rain (mm)	Year	Date	Rain (mm)
1996	12 Aug	147	2001	3 Jun	101	2004	5 Jul	132
1997	21 Jul	138		10 Jun	107		12 Jul	102
	29 Aug	147		27 Jun	184		6 Aug	153
	2 Sep	105		2 Jul	130		31 Aug	119
1998	2 Jul	231		13 Jul	141		8 Sep	132
	22 Sep	115	2002	10 Jun	116	2005	30 Jun	129
1999	20 Jun	150		13 Jun	100		1 Jul	161
	26 Aug	130		17 Aug	111		8 Jul	130
2000	7 Jun	124	2003	21 Jun	100		24 Jul	186
	23 Jun	147		22 Jul	130		12 Aug	161
	26 Jun	138		30 Jul	107		21 Aug	199
	15 Aug	133		22 Aug	121		6 Sep	104
	4 Sep	142						

What this demonstrates is that the large rainfall events likely to trigger significant levels of slope instability are very sporadic and unpredictable. Local effects of terrain on the patterns of air movement almost certainly complicate the situation further, so that the actual rainfall at a particular site 50 km from Luang Prabang may be very different from what is recorded in the rain gauge at the weather station. It seems that unusually damaging bursts of rainfall can occur throughout the middle six months of the year, but that they do so only very occasionally.

3.2.6 Community Management of Roadside Slopes

The project's research trials have been undertaken on national highways managed by central government. Ways were sought to involve communities in this work, but it was found to be impractical for a number of reasons. Not least among these were the difficulties in identifying suitable community structures with which to work, the inexperience of the MPWT in contracting and managing works through communities, and the difficulties of applying World Bank procurement rules to community groups. As a result, the research on this aspect remained theoretical, and the findings are documented in Appendix D.

There has certainly been some success in the introduction of community management in the Lao road sector. This has been mainly at the "basic access" level, where Village Management Committees are made responsible for short road sections serving specific villages. However, while this can be made to work close to settlements, the sparse rural population in Laos means that communities of sufficient size are not always available close enough to particular sections of road, particularly in the steeper mountainous areas. In addition, it is clear that a wage-based arrangement is essential for the engagement of workers for activities on all but the very lowest category of public road, where a clear vested interest exists for a community to open a basic track for access. Demands for voluntary labour contributions can be ethically unsound and contrary to good development. Rural communities do not necessarily want paid work, especially at times when they are busy with agricultural work. It is partly for these good reasons that governmental agencies rely on contractors to produce workers.

Development and many activities associated with it (such as road maintenance) are still very much top-down processes in the Lao PDR, and are largely determined and directed by central government. Organised development is still a relatively recent phenomenon, since it dates mostly from 1975. Before that, the indifference of colonial powers, political instability and wars limited rural development and disrupted communities. Historical factors mean that some groups tend not to participate widely in resource management.

There are major differences in the ways of life, livelihoods and relative wealth between urban people, sedentary agriculturalists and shifting cultivators in Laos. The agricultural system and process of land reform are still in transition, with the government's stabilisation policies bringing about major changes to rural society. Many features still remain of the tradition of independent, shifting and sparsely scattered communities. Although many villages have been established in certain locations for many years, they lack the fully settled, nucleated and well-defined community structures of ancient sedentary societies. Elsewhere in Asia it tends to be in those strongly defined communities that participatory techniques have been most widely successful.

There is a very sparse rural population, with large average land areas per capita, relative to many other parts of south-east and south Asia. Hence the sheer number of people in the rural communities is limited compared with many other geographical areas. This means that there is relatively little pressure on land resources because there is little incentive for rural people in upland Laos to use difficult or even dangerous steep slopes when there is adequate better land available. By comparison, in some upland areas in south Asia where there are heavy population pressures, productivity is important even from very marginal unstable roadside land.

The inter-linked forestry and agriculture sectors offer many useful lessons in this respect, since community participation has been practiced widely here. This experience demonstrates the importance of careful local assessment of needs and opportunities, and of adaptation to local requirements.

The conclusion is therefore that, although there is considerable understanding of community-based resource management in Laos, its application to roadside slopes needs to be introduced and tested in a sensitive manner. If it is to be undertaken, it should first be based on low category village and district roads, where the scale of works is likely to be relatively limited, communities of adequate size are available, and there are obvious links between needs and benefits for the communities involved.

3.3 Recommend ranking of specific material/technique usage

Under SEACAP 21 a number of techniques have been tested and some empirical data has been derived on their performance. These can therefore be recommended in certain situations. However, it is not possible to decide how to stabilise mountain slopes on the basis of techniques alone. The use of a technique can only be determined when the problem is understood and an overall treatment programme has been devised. The difficulty is that slope instability problems cannot be simplified: the variables are numerous and most slopes show an interaction of several different factors.

Ultimately the only successful approach to slope stabilisation is through the diagnosis of instability, so that the problems are understood; and then to identify a course of treatment that will resolve the problems. Diagnosis is highly judgemental without recourse to expensive ground investigation data. A recommended method of diagnosis based on site observation is given in section 14 of the Background paper to the Feasibility Study for a National Programme to Manage Slope Stability (SEACAP21/002).

The table below provides the main response options to individual slope instability problems, once they have been identified and understood. When the treatment has been chosen on the basis of the identified problem, each technique can be cross-checked against the next table. This allows the user to ascertain that the techniques chosen as part of the treatment are appropriate for the actual site conditions.

The third table provides a different approach to ranking the techniques, in that it categorises them in terms of relative strength and whether they have an immediate or longer term effect. As a general rule, cost increases with relative strength, so the engineer should select the weakest and cheapest technique that will serve the purpose required. At this stage, factors of safety are not taken into consideration.

Problem-based treatment selection

Problem	Likely consequences	Most likely treatment option(s)
Below road		
Erosion of the fill slope.	Part of the road may be lost if the erosion extends back into it.	Control of runoff, usually by constructing a kerb and outfall structure. Bio-engineering, usually using brush layers.
Failure in fill slope only.	Part of the road will be lost.	Retaining wall founded on original valley slope (i.e. below level of fill material) and backfilling behind wall. Bio-engineering works to prevent erosion above and below wall.
Failure in fill slope and original valley slope.	Part of the road will be lost.	Same as above, but retaining wall likely to be larger, depending on site and location of failure.
Failure in original valley slope only: unconsolidated material.	Headward retreat will endanger the fill slope and the road.	Retaining wall with backfill. Possibly some trimming of head scar. Bio-engineering works to prevent erosion above and below wall.
Failure in original valley slope only: slope dominated by hard rock structure material.	Headward retreat will endanger the road (fill slope probably not present).	Shotcrete surfacing to reduce rate of degradation of steep rock slope (assuming degradation of slope is due to surface raveling and not structural failure).
Deep failure in original ground below road.	A whole section of road will eventually be lost.	This is usually the “worst case” scenario, and the problem that is hardest and most expensive to resolve. Treatment may be based on either realignment or a major slope retaining wall, or other sizeable structural solution.
Above road		
Erosion of cut slope.	Debris may block side drain; blocked drain may lead to damage below road if runoff is allowed to discharge over the road edge.	On small sites (< 15 metres slope length), bio-engineering works alone are usually adequate; these will normally be based on grass planting. On larger sites, a revetment wall is needed, with bio-engineering above.
Failure in cut slope only.	Debris will block side drain and partially block road.	Slope retaining wall with backfill, trimmed head scar and grass planting work.
Failure in cut slope and original mountain slope.	Debris will block side drain and may block road.	As above, but possibly a larger retaining wall, depending on the site.
Failure in original mountain slope only.	Debris may slip on to side drain or road.	Debris removal, trimming of headscar and bio-engineering works, usually with grass planting. A retaining wall may also be required.
Any location: complicating factors		
Water seepage is present during most of the year in any of the above cases.	The failure may be enlarged, or the failure mechanism may be a liquefied flow rather than a mechanical slide.	Slope drains in addition to the other treatment options. These may be surface or sub-soil drains, depending on site characteristics. Bio-engineering treatment is usually added to reduce erosion and blockage of drains.

Problem	Likely consequences	Most likely treatment option(s)
Large erosion gully or seasonal drainage channel.	Gully may enlarge, affecting nearby infrastructure through headward or lateral extension, and debris discharge.	Check dams, according to the length, gradient and discharge of the gully. Surface protection between check dams, using stone rip-rap, or bio-engineering works such as brush layers or live check dams. In some cases, fully engineered discharge channels are necessary, with cascades or chutes of masonry or gabion.

Technique-based cross-check: situations where individual techniques are probably suitable

Technique	Description	Main uses
Geotechnical engineering		
Slope retaining walls: masonry.	A wall of concrete-bound stone masonry that is designed to resist a lateral pressure.	The support or retention of unstable slope masses where sound foundations can be achieved and there is no obvious water seepage.
Slope retaining walls: gabion.	A wall of stone-filled wire baskets that is designed to resist a lateral pressure.	The support or retention of unstable slope masses where foundation conditions are likely to be weak or slightly unstable/variable, such as on colluvium, or where there is evidence of regular water seepage.
Slope retaining walls: reinforced concrete.	A wall of solid reinforced concrete that is designed to resist a lateral pressure.	The support or retention of unstable slope masses where foundation conditions are known to be good, there is no water seepage and space is too limited for a lower cost wall of masonry or gabion.
Revetment walls: crib-structure composite masonry and dry stone construction.	A thin wall with a concrete-bound stone masonry framework and dry stone panels where lateral deformation is not expected.	The protection of a limited section of slope surface from degradation. This is usually required at the base of long slopes or where a weak band of rock may erode to undermine harder strata above, or where shallow failures are taking place that could expand/regress into larger instability
Shotcrete surface covering.	A cement-concrete covering 75 mm thick, based on steel mesh nailed to the slope.	The protection of an extensive area of slope surface from degradation. This is usually on steep slopes dominated by hard rock structure, but where surface erosion or fragmentation threatens to undermine a structure immediately above or damage one below.
Check dams: masonry or gabion.	A structure that combines a small retaining wall with a water drop structure.	In large erosion gullies, check dams are used to allow water to flow without causing further down-cutting, and to retain debris and stabilise the gully bed.
Surface drainage structures: masonry.	A channel or cascade built of concrete-bound stone masonry, usually 0.3 to 0.75 m in depth.	This is often required on slopes where water from seepage points needs to be channelled away from where it emerges, to avoid it saturating a weak mass of material. In other situations, it may be to help discharge large volumes of water over sections of slope where erosion might otherwise occur. A firm foundation is required for masonry structures, since they are inflexible and crack with the slightest slope movement.
Surface drainage structures: gabion.	A channel or cascade built of stone-filled wire baskets, usually 1 m deep.	As above, but in areas where foundation conditions are poor. Gabion drainage systems also tend to be quite large structures. Impermeable membrane to base?
Sub-soil drains.	A drainage structure set into the ground to a depth of 1.0 or 1.5 metres or more, usually with a pipe and gravel-filled trench.	To remove groundwater seepage from weak soil masses. The drying out of a soil mass through the removal of groundwater can greatly increase its factor of safety.
Rip-rap	Armouring of a slope surface using stone. It may be grouted to help provide a stronger covering no, it needs to be flexible, and grout is weaker than rock.	Protection of the beds of erosion gullies or other areas subjected to periodic heavy water flows.

Technique	Description	Main uses
Geotextile membranes.	A permeable synthetic fabric that allows water seepage without transporting fine soil particles.	Placed behind all retaining structures and revetments, to allow water to weep out of the slope, while preventing the loss of fine particles that might lead to a collapse of the soil matrix.
Slope trimming.	Unconsolidated material is removed from the head of a slope or slope failure, to reduce the slope grade where it cannot be stabilised.	Mainly on landslide failure head scars, or sections of cut slope that are found to be too steep.
Spoil removal.	Loose material is removed, either to reduce surcharge caused by excessive weight on the upper part of a slope, or to reduce a mass that must be retained.	Mainly on fill or spoil slopes, particularly where excess spoil has been dumped when clearing landslide debris from a nearby location during emergency maintenance operations. Above the road, debris from landslides high on the slope may need to be removed to stop it from continuing to fail into the road.
Bio-engineering		
Grass planting.	Slips (sections of the roots and stems) of large grasses are planted in lines across the surface of a slope.	Protection of soil slopes against erosion, where extensive areas are liable to erode due to rainfall, but where streams of water do not regularly flow. On materials with high clay content and low permeability, lines may be diagonal; otherwise they are contoured.
Grass seeding.	The seeds of grass plants are spread over the slope surface and covered in mulch to help them germinate and grow.	Protection of soil slopes where the grade is gentle (usually 1:2 or less) and there is a possibility of erosion due to rainfall but where streams of water do not regularly flow. This technique is commonly used on embankment and other fill slopes.
Brush layering.	Woody cuttings (typically 0.5 m long) from the stems of vigorous shrubs are laid in trenches across the slope.	Protection and shallow reinforcement of fill slopes where the material is poorly consolidated and there is a risk of significant erosion.
Truncheon cuttings.	Large woody cuttings (typically 2 m long) from the stems of vigorous trees are set upright into the ground.	Long term reinforcement through the establishment of a tree cover on fill slopes where erosion is not expected to be a problem and where the material is poorly consolidated.
Shrub and tree planting.	Seedlings of shrubs or trees (typically 0.5 m high) grown in a nursery in polythene pots, are planted on a soil slope.	Long term reinforcement through the establishment of a cover of shrubs or trees on relatively gentle soil slopes (typically 1.0:1.5 or less), where it is not expected that erosion will be a problem or that there will be significant settlement of the soil.
Shrub and tree seeding.	The seeds of tough species of shrubs and trees are inserted into voids in slopes of fractured rock.	Long term reinforcement and slope protection through the establishment of a cover of shrubs or trees on steep but fragmented rocky slopes.
Large bamboo planting.	Sections of the roots and stems (typically 2 m high) of large bamboos are planted in a soil mass.	Gradual addition of weight and reinforcement to the base of debris or fill slopes, in locations where enhanced stability is desired but not urgent.
Live check dams.	Woody cuttings of various lengths from the stems of vigorous shrubs are planted in an inter-woven structure across small erosion gullies.	Protection of small gullies that allows water to flow but retains small amounts of debris and stabilises the gully bed.

Ranking of slope stabilisation and protection techniques by strength and rapidity of effect

Slope stabilisation		Relative strength	Slope protection	
Rapid effect	**Long term effect**		**Rapid effect**	**Long term effect**
• Slope trimming	• Shrub and tree seeding or planting	Least		• Grass seeding
			• Grass planting	
• Spoil removal				
	• Large bamboo planting		• Brush layering • Live check dams	
• Surface drainage structures				
	• Sub-soil drains		• Rip-rap	
			• Crib-structure composite revetment walls	
• Masonry retaining walls				
• Gabion retaining walls			• Check dams: masonry or gabion.	
• Reinforced concrete retaining walls		Most	• Shotcrete surface covering	

Shouldn't earthworks appear in this table

3.4 Report on rural road decision-making process and long term monitoring

These issues were investigated under this project, but much of the material was then adapted and built on in the SEACAP 21/002 'Feasibility Study for a National Programme to Manage Slope Stability'. A detailed assessment is given in the Background Paper to the Feasibility Study, and the paragraphs below are modified from the Final Report.

Road management in Laos is divided between National Roads, under the Road Administration Division, and Provincial, District and Rural Roads, under the Local Road Division. Responsibility for implementation of management activities is decentralised to the Provincial DPWTs, with the central divisions retaining the remit for planning and monitoring. Budgetary control is kept at the centre, with approval from the MPWT required for the letting of contracts by the DPWTs. All works, including emergency maintenance, are implemented through contracts. Routine maintenance activities are labour-based on all categories of roads, but community involvement occurs only in the lowest category of Rural (or Village, Community or Basic Access) Roads.

Routine maintenance is carried out by the DPWTs, following well-established procedures based on a series of maintenance activity codes. The introduction of Performance-Based Maintenance Contracts (PBMCs) on nearly a third of the National Roads network in the last year or so has altered the programming timeframe because they require a three-year plan. However, these are still administered through the DPWTs.

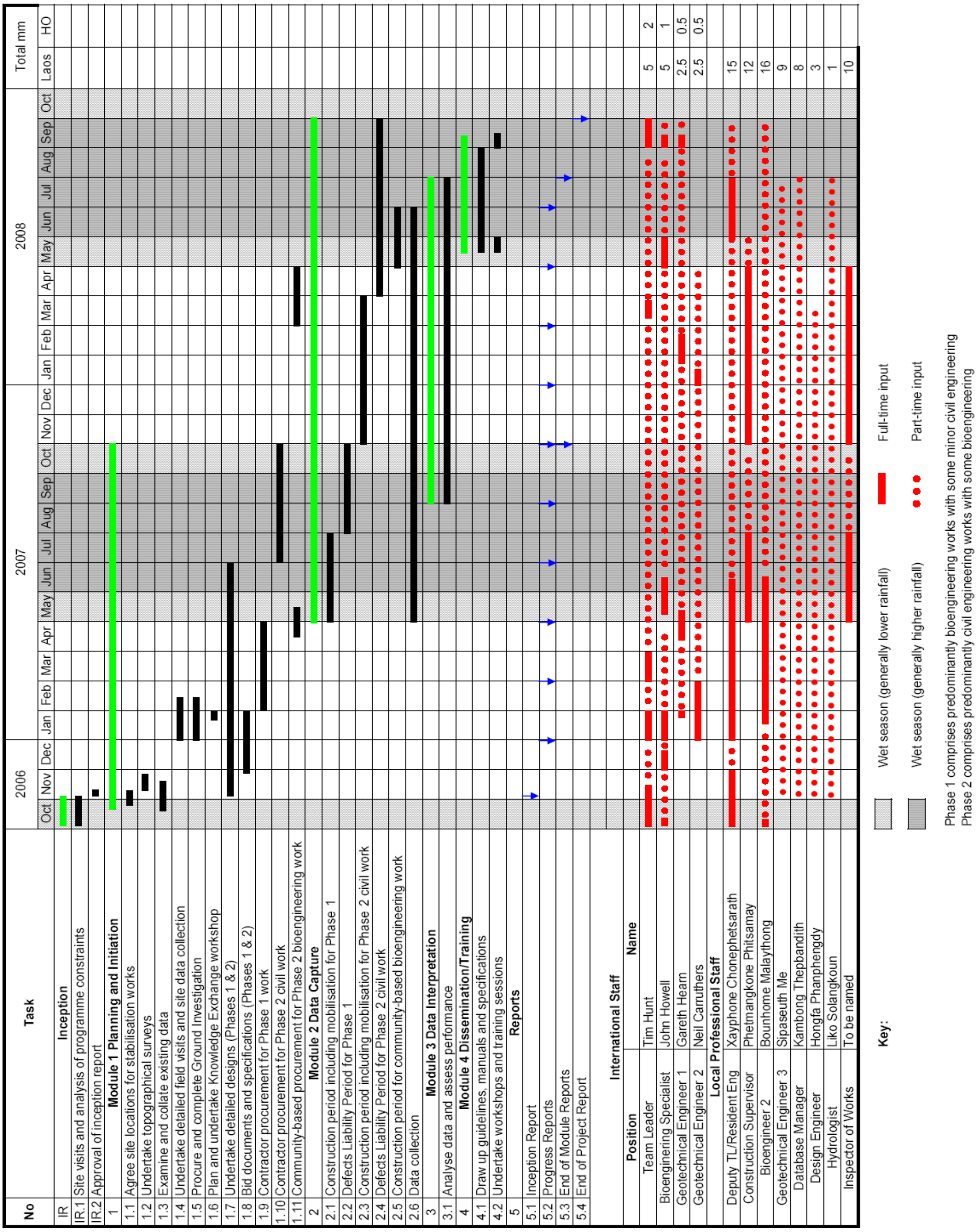
Emergency maintenance (which covers slope repairs) is usually linked to routine maintenance, in that an annual budget estimate is also made and funds allocated from the Road Maintenance Fund in the same way. If the rains are particularly bad and emergency items cost too much, then a greater proportion is drawn from central government funds, through the Ministry of Finance. Where PBMCs are in place, they also cover emergency maintenance.

Periodic maintenance is planned annually through the Road Management System (RMS) for National Roads and the Provincial Road Maintenance Management System (PRoMMS) for Local Roads. These both follow a computer-based, menu-driven format, which channels decisions of maintenance interventions into a relatively narrow set of options. They are particularly restricted for off-road problems. While these systems are effective, they tend to dominate the decision-making process at road section level. Priorities are set through the computerised systems, but the level of expenditure is determined by a five-year rolling budget. Limited resources for maintenance overall mean that the centralised decisions on allocations between the Provinces are often not ideal.

In effect, all slope management comes under the emergency maintenance category, and this demonstrates the approach that is used. Proactive slope stabilisation works are rare, beyond a range of standard retaining walls and drainage systems for the higher standard roads. Most works are of a reactive nature, and the DPWT staff react as quickly as possible once a slope failure occurs; hence the advanced planning for an expected emergency budget and inclusion in the PBMCs. If a road is blocked, the first priority is to get it open and this is the stated purpose of the first emergency maintenance activity code (no. 311). There is considerable flexibility in the way that emergency funds can be used on both National and Provincial Roads, and the assistance of the Provincial Governor's Office, contractors and local people may be sought. In extreme cases, special additional central funds may be released through a process of declaring a big landslide as a National Disaster.

APPENDIX A: WORKPLANS

A.1 Inception Report Workplan



A.2 Actual Modules 2 and 3 Workplan

No	Task	2007								2008								
		May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
	Module 2 Data Capture																	
	Construction																	
2.1	Instruct contractors conducting the trials																	
2.2	Supervise construction of slope stabilisation trials																	
2.3	Supervise rehabilitation where necessary																	
	Data capture																	
2.4	Liaise with survey teams																	
2.5	Instruct survey teams																	
2.6	Supervise initial data collection surveys																	
2.7	Incorporate minor adjustments																	
2.8	Implement data collection programme																	
2.9	Complete slope condition data capture																	
2.10	Collect relevant village and district informaton																	
2.11	Ensure quality of recovered data																	
2.12	Cary out lab testing on collected samples	Done in Feb 07																
2.13	Input acquired data																	
2.14	Submit reports detailing project actions and outputs																	
	Module 3 Data Interpretation																	
	Data Interpretation																	
3.1	Quality assurance of collected data																	
3.2	Analyse data																	
3.3	Rank specific material/technique usage																	
3.4	Report on performance, including rural road decision-making																	

APPENDIX B: SLOPE MOVEMENT MONITORING RESULTS

Monitor Points	First Set up and Measuring			Second Measuring			Third Measuring			Fourth Measuring			FIFTH MEASURING			SIXTH MEASURING			SEVENTH MEASURING		
	Date 07/May/07			Date 13/June 07			Date 13/July 07			Date 15 /Aug /07			Date 14/Sep/07			Date 16/Oct/07			Date 5/Sep/08		
Number	Northing	Easting	Elevation	Northing	Easting	Elevation	Northing	Easting	Elevation	Northing	Easting	Elevation	Northing	Easting	Elevation	Northing	Easting	Elevation	Northing	Easting	Elevation
F1	1926858.814	10225202.972	1318.070	1926858.815	10225202.970	1318.071	1926858.820	10225202.950	1318.062	1926858.818	10225202.959	1318.043	1926858.818	10225202.957	1318.065	1926858.814	10225202.956	1318.060	1926858.816	10225202.988	1318.023
F2	1926877.657	10225195.339	1316.989	1926877.649	10225195.359	1316.983	1926877.651	10225195.354	1316.976	1926877.655	10225195.344	1316.957	1926877.656	10225195.342	1316.971	1926877.654	10225195.363	1316.971	Not available (Damaged by the construction)		
F3	1926905.499	10225220.350	1311.469	1926905.498	10225220.352	1311.463	1926905.461	10225220.405	1311.463	1926905.484	10225220.372	1311.463	1926905.486	10225220.368	1311.465	1926905.455	10225220.389	1311.460	1926905.467	10225220.374	1311.460
F4	1926897.680	10225198.745	1315.972	1926897.661	10225198.781	1315.968	1926897.644	10225198.812	1315.961	1926897.653	10225198.795	1315.959	1926897.657	10225198.789	1315.956	1926897.589	10225198.794	1315.945	Not available (Damaged by the construction)		
F5	1926895.302	10225189.969	1316.087	1926895.301	10225189.972	1316.081	1926895.278	10225190.017	1316.071	1926895.283	10225190.008	1316.049	1926895.285	10225190.004	1316.070	1926895.260	10225190.015	1316.055	Not available (Damaged by the construction)		
F6	1926891.494	10225176.596	1318.371	1926891.488	10225176.611	1318.364	1926891.464	10225176.665	1318.342	1926891.472	10225176.646	1318.353	1926891.474	10225176.644	1318.345	1926891.466	10225176.695	1318.344	1926891.452	10225176.738	1318.341
F7	1926883.062	10225139.549	1338.760	1926883.062	10225139.548	1338.774	1926883.061	10225139.553	1338.771	1926883.061	10225139.551	1338.774	1926883.062	10225139.549	1338.764	1926883.041	10225139.591	1338.748	Not available (Damaged by the construction)		
F8	1926875.308	10225111.082	1361.670	1926875.310	10225111.074	1361.674	1926875.305	10225111.093	1361.668	1926875.308	10225111.083	1361.674	1926875.308	10225111.080	1361.644	1926875.261	10225111.142	1361.650	1926875.311	10225111.283	1361.590
F9	1926866.348	10225085.150	1378.402	1926866.348	10225085.152	1378.384	1926866.347	10225085.157	1378.384	1926866.348	10225085.153	1378.384	1926866.348	10225085.152	1378.364	1926866.354	10225085.237	1378.378	1926866.377	10225085.226	1378.387
F10	1926860.851	10225054.588	1388.042	1926860.849	10225054.599	1388.044	1926860.848	10225054.608	1388.043	1926860.848	10225054.606	1388.044	1926860.848	10225054.608	1388.034	1926860.805	10225054.649	1388.032	1926860.799	10225054.830	1388.034
F11	1926852.375	10225022.745	1401.305	1926852.375	10225022.749	1401.314	1926852.372	10225022.774	1401.315	1926852.373	10225022.764	1401.314	1926852.374	10225022.758	1401.304	1926852.398	10225022.869	1401.300	1926852.431	10225022.868	1401.308
F12	1926917.637	10225186.492	1315.443	1926917.627	10225186.509	1315.436	1926917.610	10225186.535	1315.424	1926917.641	10225186.485	1315.404	1926917.644	10225186.481	1315.413	1926917.642	10225186.480	1315.413	Not available (Damaged by the construction)		
F13	1926931.474	10225216.545	1301.930	1926931.470	10225216.550	1301.921	1926931.459	10225216.562	1301.927	1926931.465	10225216.555	1301.921	1926931.468	10225216.552	1301.901	1926931.467	10225216.552	1301.901	1926931.473	10225216.57	1301.906
F14	1926929.352	10225246.925	1291.147	1926929.353	10225246.924	1291.133	1926929.343	10225246.933	1291.147	1926929.347	10225246.929	1291.133	1926929.350	10225246.926	1291.093	1926929.350	10225246.926	1291.093	1926929.336	10225246.95	1291.061
F15	1926934.246	10225188.118	1314.104	1926934.231	10225188.138	1314.098	1926934.211	10225188.165	1314.087	1926934.223	10225188.149	1314.069	1926934.227	10225188.144	1314.074	1926934.214	10225188.160	1314.067	Not available (Damaged by the construction)		
F16	1926934.078	10225184.695	1314.252	1926934.048	10225184.737	1314.245	1926934.048	10225184.737	1314.233	1926934.059	10225184.721	1314.216	1926934.060	10225184.720	1314.222	1926934.037	10225184.735	1314.213	Not available (Damaged by the construction)		
F17	1926933.697	10225173.513	1317.019	1926933.697	10225173.513	1317.011	1926933.672	10225173.551	1317.012	1926933.677	10225173.543	1316.967	1926933.681	10225173.538	1316.980	1926933.597	10225173.647	1316.975	1926933.672	10225173.614	1316.974
F18	1926936.540	10225159.777	1331.154	1926936.536	10225159.783	1331.164	1926936.530	10225159.793	1331.163	1926936.535	10225159.785	1331.164	1926936.537	10225159.782	1331.144	1926936.480	10225159.923	1331.142	1926936.528	10225159.862	1331.145
F19	1926937.643	10225134.029	1346.071	1926937.640	10225134.034	1346.074	1926937.637	10225134.040	1346.076	1926937.640	10225134.034	1346.074	1926937.641	10225134.033	1346.064	1926937.585	10225134.229	1346.051	1926937.637	10225134.155	1346.048
F20	1926938.900	10225103.302	1362.215	1926938.897	10225103.308	1362.214	1926938.891	10225103.320	1362.217	1926938.896	10225103.311	1362.214	1926938.896	10225103.310	1362.209	1926938.839	10225103.450	1362.203	1926938.862	10225103.415	1362.203
F21	1926942.088	10225069.359	1384.670	1926942.085	10225069.365	1384.684	1926942.085	10225069.365	1384.690	1926942.089	10225069.356	1384.684	1926942.089	10225069.357	1384.674	1926942.084	10225069.402	1384.650	1926942.122	10225069.563	1384.574
F22	1926946.547	10225056.990	1394.902	1926946.549	10225056.986	1394.914	1926946.547	10225056.991	1394.915	1926946.547	10225056.991	1394.914	1926946.548	10225056.988	1394.894	1926946.480	10225057.061	1394.878	1926946.540	10225057.094	1394.874
F23	1926943.556	10225037.655	1405.324	1926943.552	10225037.664	1405.334	1926943.553	10225037.662	1405.337	1926943.552	10225037.664	1405.334	1926943.553	10225037.663	1405.319	1926943.475	10225037.780	1405.314	1926943.538	10225037.756	1405.303
F24	1926945.763	10225008.639	1422.446	1926945.758	10225008.653	1422.454	1926945.762	10225008.642	1422.460	1926945.761	10225008.643	1422.454	1926945.763	10225008.639	1422.443	1926945.676	10225008.784	1422.441	1926945.753	10225008.829	1422.440
F25	1926946.110	10225195.250	1312.729	1926946.103	10225195.258	1312.736	1926946.095	10225195.268	1312.733	1926946.101	10225195.260	1312.727	1926946.104	10225195.257	1312.739	1926946.075	10225195.261	1312.732	Not available (Damaged by the construction)		
F26	1926949.234	10225190.595	1312.657	1926949.234	10225190.595	1312.657	1926949.227	10225190.603	1312.655	1926949.233	10225190.596	1312.636	1926949.231	10225190.599	1312.647	1926949.192	10225190.603	1312.644	Not available (Damaged by the construction)		
F27	1926959.186	10225176.584	1317.746	1926959.187	10225176.583	1317.739	1926959.178	10225176.594	1317.737	1926959.184	10225176.586	1317.739	1926959.179	10225176.593	1317.755	1926959.122	10225176.565	1317.748	Not available (Damaged by the construction)		
F28	1926978.067	10225154.690	1344.680	1926978.055	10225154.704	1344.684	1926978.061	10225154.697	1344.684	1926978.059	10225154.700	1344.684	1926978.059	10225154.699	1344.670	1926977.980	10225154.759	1344.668	1926978.074	10225154.751	1344.646
F29	1926990.773	10225137.054	1359.399	1926990.771	10225137.057	1359.394	1926990.776	10225137.050	1359.395	1926990.773	10225137.054	1359.394	1926990.774	10225137.052	1359.379	1926990.734	10225137.054	1359.379	1926990.678	10225137.205	1359.340
F30	1927022.380	10225097.708	1382.911	1927022.375	10225097.714	1382.914	1927022.376	10225097.713	1382.918	1927022.378	10225097.710	1382.914	1927022.379	10225097.709	1382.881	1927022.235	10225097.757	1382.887	Not available (Damaged by the construction)		
F31	1926965.160	10225202.958	1311.469	1926965.145	10225202.973	1311.267	1926965.141	10225202.976	1311.254	1926965.149	10225202.969	1311.246	1926965.153	10225202.965	1311.245	1926965.202	10225202.918	1311.242	1926965.068	10225203.030	1311.240
BM1	1926883.000	10225203.000	1317.000	1926883.001	10225202.999	1316.994	1926882.995	10225203.012	1316.984	1926882.999	10225203.003	1316.962	1926883.001	10225202.999	1316.986	1926882.976	10225202.994	1316.981	1926882.942	10225203.041	1316.981
BM2	1926951.030	10225200.000	1312.246	1926951.013	10225200.019	1312.257	1926951.008	10225200.024	1312.246	1926951.015	10225200.016	1312.229	1926951.016	10225200.016	1312.225	1926950.826	10225200.042	1312.226	Not available (Damaged by the construction)		
BM3	1926957.350	10225204.355	1311.903	1926957.342	10225204.363	1311.902	1926957.337	10225204.368	1311.886	1926957.340	10225204.365	1311.875	1926957.342	10225204.363	1311.871	1926957.310	10225204.398	1311.867	Not available (Damaged by the construction)		
BM4	1926819.219	10225344.734	1327.782	1926819.219	10225344.734	1327.782	1926819.219	10225344.734	1327.782	1926819.219	10225344.734	1327.782	1926819.219	10225344.734	1327.782	1926819.219	10225344.734	1327.782	1926819.219	10225344.734	1327.782
BM5	1927046.476	10225293.974	1304.841	1927046.467	10225293.976	1304.833	1927046.464	10225293.977	1304.833	1927046.464	10225293.977	1304.833	1927046.468	10225293.976	1304.833	1927046.420	10225293.987	1304.833	1927046.438	10225293.979	1304.821

A1 Km 260.3 Survey Points

Monitor Points	First Set up and Measuring			Second Measuring			Third Measuring			Fourth Measuring			Fifth Measuring			Sixth Measuring			SEVENTH MEASURING		
	Date 08/May/07			Date 13/June 07			Date 13/July 07			Date 15 /Aug/ 07			Date 14/Sep/07			Date 16/Oct/07			Date 5/Sep/08		
Number	Northing	Easting	Elevation	Northing	Easting	Elevation	Northing	Easting	Elevation	Northing	Easting	Elevation	Northing	Easting	Elevation	Northing	Easting	Elevation			
B1	1936277.637	10212363.412	988.818	1936277.650	10212363.417	988.817	1936277.654	10212363.418	988.817	1936277.641	10212363.413	988.817	1936277.639	10212363.412	988.813	1936277.636	10212363.411	988.813	1936277.770	10212363.834	988.821
B2	1936288.515	10212373.684	987.668	1936288.508	10212373.682	987.670	1936288.507	10212373.682	987.671	1936288.510	10212373.683	987.668	1936288.507	10212373.682	987.658	1936288.517	10212373.685	987.664	1936288.531	10212374.143	987.673
B3	1936301.101	10212386.004	986.396	1936301.103	10212386.004	986.399	1936301.089	10212386.003	986.399	1936301.101	10212386.004	986.397	1936301.099	10212386.004	986.389	1936301.099	10212386.004	986.390	1936301.187	10212386.268	986.402
B4	1936316.453	10212392.054	982.604	1936316.462	10212392.053	982.596	1936316.445	10212392.054	982.600	1936316.456	10212392.054	982.586	1936316.458	10212392.053	982.579	1936316.483	10212392.374	982.318	Not available (damaged by landslide)		
B5	1936331.221	10212432.798	995.643	1936331.243	10212432.752	995.638	1936331.224	10212432.790	995.641	1936331.238	10212432.761	995.630	1936331.235	10212432.767	995.598	1936331.231	10212432.776	995.590	Not available (Damaged by the construction)		
B6	1936330.693	10212425.019	991.476	1936330.700	10212425.008	991.474	1936330.692	10212425.021	991.469	1936330.698	10212425.010	991.456	1936330.695	10212425.016	991.448	1936330.696	10212425.015	991.428	Not available (Damaged by the construction)		
B7	1936329.787	10212410.065	984.354	1936329.786	10212410.066	984.357	1936329.790	10212410.063	984.349	1936329.784	10212410.068	984.338	1936329.783	10212410.069	984.336	1936329.790	10212410.062	984.336	Not available (Damaged by the construction)		
B8	1936328.460	10212388.501	982.309	1936328.455	10212388.500	982.297	1936328.453	10212388.500	982.302	1936328.459	10212388.500	982.289	1936328.456	10212388.500	982.277	1936328.504	10212388.422	981.950	1936333.105	10212389.07	980.69
B9	1936327.586	10212374.097	980.026	1936327.589	10212374.098	980.017	1936327.572	10212374.095	980.018	1936327.583	10212374.097	980.017	1936327.585	10212374.097	979.987	1936327.684	10212373.775	979.655	Not available (damaged by landslide)		
B10	1936326.322	10212353.450	967.367	1936326.334	10212353.453	967.380	1936326.365	10212353.462	967.384	1936326.331	10212353.452	967.360	1936326.323	10212353.450	967.330	1936326.423	10212353.426	967.013	Not available (damaged by landslide)		
B11	1936361.952	10212391.122	983.071	1936361.959	10212391.122	983.070	1936361.955	10212391.122	983.066	1936361.959	10212391.122	983.057	1936361.958	10212391.122	983.054	1936361.968	10212391.123	983.050	1936362.049	10212391.23	983.079
B12	1936377.135	10212389.565	981.554	1936377.141	10212389.565	981.550	1936377.099	10212389.562	981.549	1936377.141	10212389.565	981.537	1936377.140	10212389.565	981.537	1936377.149	10212389.565	981.534	1936377.149	10212389.565	981.534
B13	1936350.217	10212390.780	983.269	1936350.213	10212390.780	983.261	1936350.209	10212390.779	983.261	1936350.215	10212390.780	983.255	1936350.214	10212390.780	983.260	1936350.208	10212390.779	983.262	1936350.208	10212390.779	983.262
BM1	1936351.397	10212390.667	983.354	1936351.397	10212390.667	983.226	1936351.397	10212390.667	983.225	1936351.393	10212390.661	983.214	1936351.393	10212390.661	983.214	1936351.393	10212390.661	983.214	1936351.385	10212390.669	983.210
BM2	1936381.981	10212393.730	982.201	1936381.975	10212393.729	982.065	1936381.960	10212393.727	982.055	1936381.975	10212393.726	982.044	1936381.982	10212393.730	982.040	1936381.982	10212393.730	982.070	1936381.981	10212393.73	982.067
BM3	1936481.799	10212396.808	977.833	1936481.799	10212396.808	977.833	1936481.799	10212396.808	977.833	1936481.799	10212396.808	977.833	1936481.799	10212396.808	977.833	1936481.799	10212396.808	977.833	1936481.789	10212396.803	977.837
BM4	1936470.125	10212416.775	979.874	1936470.130	10212416.767	979.878	1936470.125	10212416.775	979.878	1936470.125	10212416.775	979.878	1936470.127	10212416.772	979.878	1936470.127	10212416.772	979.879	1936470.127	10212416.77	979.879

A2. Km 317.9 Survey Points

Monitor Points	(First - Second)			(First - Third)			(First - Fouth)			(First - Fifth)			(First - sixth)			(First - seventh)		
Number	Northing	Easting	Elevation	Northing	Easting	Elevation	Northing	Easting	Elevation	Northing	Easting	Elevation	Northing	Easting	Elevation	Northing	Easting	Elevation
F1	-0.001	0.002	-0.001	-0.006	0.022	0.008	-0.004	0.013	0.027	-0.004	0.015	0.005	0.000	0.016	0.010	-0.002	-0.018	0.048
F2	0.008	-0.020	0.006	0.006	-0.015	0.013	0.002	-0.005	0.032	0.001	-0.003	0.018	0.003	-0.024	0.018			
F3	0.001	-0.002	0.006	0.038	-0.055	0.006	0.015	-0.022	0.006	0.013	-0.018	0.004	0.044	-0.039	0.009	0.031	-0.022	0.003
F4	0.019	-0.036	0.004	0.036	-0.067	0.011	0.027	-0.050	0.013	0.023	-0.044	0.016	0.091	-0.049	0.027			
F5	0.001	-0.003	0.006	0.024	-0.048	0.016	0.019	-0.039	0.038	0.017	-0.035	0.017	0.042	-0.046	0.032			
F6	0.006	-0.015	0.007	0.030	-0.069	0.030	0.022	-0.050	0.018	0.020	-0.048	0.026	0.028	-0.099	0.027	0.036	-0.127	0.023
F7	0.000	0.001	-0.014	0.001	-0.004	-0.011	0.001	-0.002	-0.014	0.000	0.000	-0.004	0.021	-0.042	0.012			
F8	-0.002	0.008	-0.004	0.003	-0.011	0.002	0.000	-0.001	-0.004	0.000	0.002	0.026	0.047	-0.060	0.020	-0.001	-0.209	0.084
F9	0.000	-0.002	0.018	0.001	-0.007	0.018	0.000	-0.003	0.018	0.000	-0.002	0.038	-0.006	-0.087	0.024	-0.030	-0.074	-0.003
F10	0.002	-0.011	-0.002	0.003	-0.020	-0.001	0.003	-0.018	-0.002	0.003	-0.020	0.008	0.046	-0.061	0.010	0.051	-0.230	0.010
F11	0.000	-0.004	-0.009	0.003	-0.029	-0.010	0.002	-0.019	-0.009	0.001	-0.013	0.001	-0.023	-0.124	0.005	-0.056	-0.119	0.006
F12	0.010	-0.017	0.007	0.027	-0.043	0.019	-0.004	0.007	0.039	-0.007	0.011	0.030	-0.005	0.012	0.030			
F13	0.004	-0.005	0.010	0.015	-0.017	0.003	0.009	-0.010	0.010	0.006	-0.007	0.030	0.007	-0.007	0.030	-0.003	-0.018	0.014
F14	-0.001	0.001	0.014	0.009	-0.008	0.000	0.005	-0.004	0.014	0.002	-0.001	0.054	0.002	-0.001	0.054	0.017	-0.027	0.072
F15	0.015	-0.020	0.006	0.035	-0.047	0.017	0.023	-0.031	0.035	0.019	-0.026	0.030	0.032	-0.042	0.037			
F16	0.030	-0.042	0.007	0.030	-0.042	0.019	0.019	-0.026	0.036	0.018	-0.025	0.030	0.041	-0.040	0.039			
F17	0.000	0.000	0.008	0.025	-0.038	0.007	0.020	-0.030	0.052	0.016	-0.025	0.039	0.100	-0.134	0.044	0.025	-0.101	0.037
F18	0.004	-0.006	-0.010	0.010	-0.016	-0.009	0.005	-0.008	-0.010	0.003	-0.005	0.010	0.060	-0.146	0.012	0.008	-0.079	0.019
F19	0.003	-0.005	-0.003	0.006	-0.011	-0.005	0.003	-0.005	-0.003	0.002	-0.004	0.007	0.058	-0.200	0.020	0.004	-0.121	0.026
F20	0.003	-0.006	0.001	0.009	-0.018	-0.002	0.004	-0.009	0.001	0.004	-0.008	0.006	0.061	-0.148	0.012	0.034	-0.107	0.011
F21	0.003	-0.006	-0.014	0.003	-0.006	-0.020	-0.001	0.003	-0.014	-0.001	0.002	-0.004	0.004	-0.043	0.020	-0.037	-0.197	0.110
F22	-0.002	0.004	-0.012	0.000	-0.001	-0.013	0.000	-0.001	-0.012	-0.001	0.002	0.008	0.067	-0.071	0.024	0.008	-0.108	0.040
F23	0.004	-0.009	-0.010	0.003	-0.007	-0.013	0.004	-0.009	-0.010	0.003	-0.008	0.005	0.081	-0.125	0.010	0.015	-0.091	0.031
F24	0.005	-0.014	-0.008	0.001	-0.003	-0.014	0.002	-0.004	-0.008	0.000	0.000	0.003	0.087	-0.145	0.005	0.005	-0.177	0.014
F25	0.007	-0.008	-0.007	0.015	-0.018	-0.004	0.009	-0.010	0.002	0.006	-0.007	-0.010	0.035	-0.011	-0.003			
F26	0.000	0.000	0.000	0.007	-0.008	0.002	0.001	-0.001	0.021	0.003	-0.004	0.010	0.042	-0.008	0.013			
F27	-0.001	0.001	0.007	0.008	-0.010	0.010	0.002	-0.002	0.007	0.007	-0.009	-0.009	0.064	0.019	-0.002			
F28	0.012	-0.014	-0.004	0.006	-0.007	-0.004	0.008	-0.010	-0.004	0.008	-0.009	0.010	0.087	-0.069	0.012	-0.019	-0.047	0.038
F29	0.002	-0.003	0.005	-0.003	0.004	0.004	0.000	0.000	0.005	-0.001	0.002	0.020	0.039	0.000	0.020	0.092	-0.148	0.054
F30	0.005	-0.006	-0.003	0.004	-0.005	-0.007	0.002	-0.002	-0.003	0.001	-0.001	0.030	0.145	-0.049	0.024			
F31	0.015	-0.015	0.202	0.019	-0.018	0.215	0.011	-0.011	0.223	0.007	-0.007	0.224	-0.042	0.040	0.227	0.077	-0.057	0.027
BM1	-0.001	0.001	0.006	0.005	-0.012	0.016	0.001	-0.003	0.038	-0.001	0.001	0.014	0.024	0.006	0.019	0.058	-0.042	0.013
BM2	0.017	-0.019	-0.011	0.022	-0.024	0.000	0.015	-0.016	0.017	0.014	-0.016	0.021	0.204	-0.042	0.020			
BM3	0.008	-0.008	0.001	0.013	-0.013	0.017	0.010	-0.010	0.028	0.008	-0.008	0.032	0.040	-0.043	0.036			
BM4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
BM5	0.009	-0.002	0.008	0.012	-0.003	0.008	0.012	-0.003	0.008	0.008	-0.002	0.008	0.056	-0.013	0.008	0.030	-0.003	0.012

A3. Km 260.3 Slope Movements

Monitor Points	(First - Second)			(First - Third)			(First - Fouth)			(First - Fifth)			(First - sixth)			(First - seventh)		
Number	Northing	Easting	Elevation	Northing	Easting	Elevation	Northing	Easting	Elevation	Northing	Easting	Elevation	Northing	Easting	Elevation	Northing	Easting	Elevation
B1	-0.013	-0.005	0.001	-0.017	-0.006	0.001	-0.004	-0.001	0.001	-0.002	-0.001	0.005	0.001	0.000	0.005	-0.133	-0.422	-0.003
B2	0.007	0.002	-0.002	0.008	0.002	-0.003	0.005	0.001	0.000	0.008	0.002	0.010	-0.002	-0.001	0.004	-0.016	-0.459	-0.005
B3	-0.002	0.000	-0.003	0.012	0.001	-0.003	0.000	0.000	-0.001	0.002	0.000	0.007	0.002	0.000	0.006	-0.086	-0.264	-0.006
B4	-0.010	0.000	0.008	0.007	0.000	0.005	-0.004	0.000	0.018	-0.006	0.000	0.025	-0.030	-0.321	0.286			
B5	-0.022	0.046	0.005	-0.004	0.008	0.002	-0.018	0.037	0.013	-0.015	0.031	0.045	-0.010	0.022	0.053			
B6	-0.007	0.011	0.002	0.001	-0.002	0.007	-0.005	0.009	0.020	-0.002	0.003	0.028	-0.003	0.004	0.048			
B7	0.002	-0.001	-0.003	-0.002	0.002	0.005	0.003	-0.003	0.016	0.005	-0.004	0.018	-0.003	0.003	0.018			
B8	0.005	0.000	0.012	0.007	0.001	0.007	0.001	0.000	0.020	0.004	0.000	0.032	-0.044	0.078	0.359	-4.645	-0.567	1.619
B9	-0.004	-0.001	0.009	0.013	0.002	0.008	0.002	0.000	0.009	0.000	0.000	0.039	-0.098	0.322	0.371			
B10	-0.013	-0.004	-0.013	-0.043	-0.012	-0.017	-0.010	-0.003	0.007	-0.001	0.000	0.037	-0.101	0.023	0.354			
B11	-0.007	0.000	0.002	-0.003	0.000	0.005	-0.007	0.000	0.014	-0.006	0.000	0.017	-0.016	-0.001	0.021	-0.096	-0.104	-0.008
B12	-0.006	0.000	0.004	0.036	0.002	0.005	-0.006	0.000	0.017	-0.005	0.000	0.017	-0.014	-0.001	0.020	-0.014	-0.001	0.020
B13	0.004	0.000	0.008	0.008	0.000	0.008	0.002	0.000	0.014	0.003	0.000	0.009	0.009	0.000	0.007	0.009	0.000	0.007
BM1	0.000	0.000	0.128	0.000	0.000	0.129	0.004	0.006	0.140	0.004	0.006	0.140	0.004	0.006	0.140	0.012	-0.002	0.144
BM2	0.006	0.001	0.136	0.021	0.002	0.146	0.006	0.003	0.157	-0.001	0.000	0.161	-0.001	0.000	0.131	0.000	0.000	0.134
BM3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.010	0.005	-0.004
BM4	-0.005	0.008	-0.004	0.000	0.000	-0.004	0.000	0.000	-0.004	-0.002	0.003	-0.004	-0.002	0.003	-0.005	-0.002	0.003	-0.005

Km 317.9 Slope Movements

Feb,2007	1rst Check-May,07	2 nd Check-June 07	3 rd Check-July 07	4th Check-Agust 07	5 th Check-Sep 07	6 th Check-Oct 07	7 th Check-Sep 08
	Date: 7 May 07	Date: 13 June 07	Date: 13 July 07	Date: 14 Aug 07	Date: 14 Sep 07	Date: 16 Oct 07	Date: 5 Sep 08
Original Depth (m)	Depth (m)	Depth (m)	Depth (m)	Depth (m)	Depth (m)	Depth (m)	Depth (m)
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000
3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000
4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000
5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000
6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000
7.000	7.000	7.000	7.000	7.000	7.000	7.000	7.000
8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000
9.000	9.000	9.000	9.000	9.000	9.000	9.000	9.000
10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000
11.000	11.000	11.000	11.000	11.000	11.000	11.000	11.000
12.000	12.000	12.000	12.000	12.000	12.000	12.000	12.000
12.000	11.40	11.40	11.40	11.40	11.40	11.40	11.40

Km 260.3

Feb,2007	1rst Check-May,07	2 nd Check-June 07	3 rd Check-July 07	4th Check-Agust 07	5 th Check-Sep 07	6 th Check-Oct 07	7 th Check-Sep 08
	Date: 7 May 07	Date: 13 June 07	Date: 13 July 07	Date: 14 Aug 07	Date: 14 Sep 07	Date: 16 Oct 07	Date: 5 Sep 08
Original Depth (m)	Depth (m)	Depth (m)	Depth (m)	Depth (m)	Depth (m)	Depth (m)	Depth (m)
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000
3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000
4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000
5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000
6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000
7.000	7.000	7.000	7.000	7.000	7.000	7.000	7.000
8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000
9.000	9.000	9.000	9.000	9.000	9.000	9.000	9.000
10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000
11.000	11.000	11.000	11.000	11.000	11.000	11.000	11.000
12.000	12.000	12.000	12.000	12.000	12.000	12.000	12.000
7.000	6.700	6.770	6.50	6.55	6.50	6.50	2.40

Km 317.9

Feb,2007	1rst Check-May,07	2 nd Check-June 07	3 rd Check-July 07	4th Check-Agust 07	5 th Check-Sep 07	6 th Check-Oct 07	7 th Check-Sep 08
	Date: 7 May 07	Date: 13 June 07	Date: 13 July 07	Date: 14 Aug 07	Date: 14 Sep 07	Date: 16 Oct 07	Date: 5 Sep 08
Original Depth (m)	Depth (m)	Depth (m)	Depth (m)	Depth (m)	Depth (m)	Depth (m)	Depth (m)
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000
3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000
4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000
5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000
6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000
7.000	7.000	7.000	7.000	7.000	7.000	7.000	7.000
8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000
9.000	9.000	9.000	9.000	9.000	9.000	9.000	9.000
10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000
11.000	11.000	11.000	11.000	11.000	11.000	11.000	11.000
12.000	12.000	12.000	12.000	12.000	12.000	12.000	12.000
8.500	8.460	8.460	8.460	8.450	8.460	8.450	Not found it (affected by the construction)

Km 336.4

A.5 Inclinometer/Slip Indicator Results

APPENDIX C: LANDSLIDE INVENTORY

The document presents information collected by the SEACAP 21 team as a means of gaining an overall assessment of the magnitude of slope instability affecting the national road network. Sampling was done by drive-over inspections of selected sections of road. The purpose of the exercise was not to develop a rigorous, comprehensive database. Instead, it was to gain an overall impression of the nature of slope hazards affecting roads, their relative size and impacts, and the relative risk they pose to road stability and the operation of the road network. An assessment was also made of any mitigation measures employed, and the residual risks remaining with these works in place.

The risk computation is given in the table below. In each case an assessment was made of the original risk posed by each hazard to the section of road involved, prior to mitigation (if any). A separate assessment was then made of the residual risk remaining through the likely performance of mitigation works, and the observed or anticipated effect on Probability (P). In some instances it was necessary to assess the potential risk of a given hazard based on residual geological and geomorphological conditions.

It must be stressed that the assessments given below are based on rapid observations and judgement. Important ground conditions and construction details may have been omitted.

Risk computation

Risk components	**Assigned Relative Values**			
	0	**1**	**2**	**3**
Magnitude of hazard (M)		Small (shallow and extending over up to 500m^2)	Moderate	Large (deep and extending over area of 5000m^2 or more)
Probability of hazard occurring during 20 year period (P)	Not expected to happen	Possible	Expected to happen	Definite
Value of road elements at risk (Va)		Existing slope works and side drain	Existing slope works, side drain, and up to 50% of carriageway width (one lane)	Entire carriageway and adjacent structures
Vulnerability of elements to the hazard, should it occur (Vu)	No effect	Deformation or blockage	Partial loss	Total loss
Risk = M x P x Va x Vu				

Road	Km	Grid Ref (E/N)	Geology	Hazard Type	Risk (without mitigation) R = M x P x Va x Vu	Measures Taken	Degree of Success/ Residual Effects	Risk (with mitigation, if undertaken) R = M x P x Va x Vu
Road 1E: The section of road examined is the road realignment along the south-western shoreline of the reservoir full supply level (FSL) for Nam Theun 2. The realignment took place between 1 and 2 years prior to the field visit. Earthworks are therefore recent and slopes and drainage systems are still in the process of adjusting to the new topographic condition. Chainages are from the southern end of the road realignment. The list of slide locations given below is not comprehensive, though it is anticipated that the main slide areas have been recorded. The inspection was undertaken on 11 February 2008. it should be noted that the contractor indicated that he intended to carry out further slope remedial works along this section of road, and therefore the observations below concerning total mitigation are incomplete.								
Road 1E	3+600	105°07'38" 17°43'45"	Sandstone WGIII-VI	Above Road: Slide along adverse bedding orientation in cut slope	Above Road: M = 1 P = 3 Va = 2 Vu = 1 R = 6	Above Road: Cut slope has been laid back to an angle approaching dip of strata, though no other mitigation, other than clearance, has been undertaken.	NA	Above Road: M = 1 P = 2 Va = 2 Vu = 1 R = 4
Road 1E	5+300	105°07'09" 17°44'17"	Sandstone with silt/clay horizons WGIV-VI	Above Road: A slide took place in this cut slope and was probably associated with perched water in the silt/clay horizons within the sandstone sequence. It is likely that the original failure blocked the box cut.	Above Road: M = 2 P = 3 Va = 3 Vu = 1 R = 18	Above Road: Landslide material largely removed, but remaining debris has been benched.	Tension cracks developing in benched slope.	Above Road: M = 2 P = 2 Va = 3 Vu = 1 R = 12
Road 1E	9+500	105°05'26" 17°45'43"	Mudstone/ sandstone WG III-VI	Above Road: Cut slope failure, possibly within mudstone layer(s) within sedimentary sequence, and probably in association with perched water. Cut slope angle slightly steeper than dip of bedding.	Above Road: M = 2 P = 3 Va = 2 Vu = 1 R = 12	Above Road: Landslide material largely removed, and presumably cut slope laid back.	Tension cracks continuing to develop in steeper, upper section of slope.	Above Road: M = 2 P = 2 Va = 2 Vu = 1 R = 8
Road 1E	14+600	105°03'35" 17°03'35'	Assumed sandstone mudstone WG II-III	Above Road: Failure in rock within benched cut and probably along adverse bedding	Above Road: M = 1 P = 3 Va = 2 Vu = 1 R = 6	Above Road: Cut recently benched back, no other measures taken, though measures under consideration include, concrete screeding to prevent water ingress, bolting and toe support.	NA	Above Road: M = 1 P = 3 Va = 2 Vu = 1 R = 6

Road	Km	Grid Ref (E/N)	Geology	Hazard Type	Risk (without mitigation) R = M x P x Va x Vu	Measures Taken	Degree of Success/ Residual Effects	Risk (with mitigation, if undertaken) R = M x P x Va x Vu
Road 1E	16+100	105°03’06” 17°47’24”	Sandstone mudstone WG II-III	Above Road: Rock slide in cut slope. 100m of road affected. Assume original failure blocked road.	Above Road: M = 2 P = 3 Va = 3 Vu = 1 R = 18	Above Road: Cut slope angle reduced to being slightly greater than angle of dip of strata. No other mitigation undertaken, though rock bolting is under consideration by the contractor.	Tension cracks continue to develop.	Above Road: M = 2 P = 2 Va = 3 Vu = 1 R = 12
Road 3: is located between Huay Xai and Na Tuey. Road upgrade construction completion was substantially complete at the time of the field inspection (16 and 17 February 2008). and the road was due to be handed over to the MPWT in March 2008. Construction contracts were let under three different financing and construction packages: Thai in the west, Chinese in the east and Lao (ADB-financed) in the centre. Deep cuttings characterise much of the Road. In the western and central sections they are benched and are laid back at shallow angles. In the east, cut angle appear to be generally steeper. Due to the ongoing construction activity on each of the three packages at the time of the field visit, chainage referencing was inconsistent along the alignment. Driving from west to east, from Huay Xai, chainages were found to increase in an easterly direction, but this then became superseded by a different set of chainages apparently originating from the eastern end. This inconsistency in chainage location reference at the time of the visit should be borne in mind when considering the locations described below. Chainages are reconciled as commencing at Na Teuy. The grid references provided should therefore be used as the definitive locator. It should also be noted that the observations given below are based on a rapid drive-through assessment of very recently formed cut slopes, and it may have been too early to have formed any representative assessment of medium to long term earthworks performance. Furthermore, observations were, in the main, made from road level with the help of a pair of binoculars to view distance tops of cutting. Clearly there is a limit to what can be identified in this way. The observations below exclude spoil dump instability and erosion problems; these were numerous and quite extensive in places at the time of the field visit.								
Road 3	2+150	101°37’46” 21°03’20”	Not known	Below Road: Road failed to ¾ width over a distance of 25m due to failed spoil/fill slope below. Seepage below is a possible contributor.	Below Road: M = 2 P = 3 Va = 3 Vu = 3 R = 54	Below Road: None, road bench reinstated (?). No other mitigation apparent.	NA	Below Road: M = 2 P = 3 Va = 3 Vu = 3 R = 54
Road 3	2+850	101°37’31” 21°03’23”	Not known WG VI?	Above Road: Small slump in cut slope	Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3	Above Road: None, clearance only (?)	NA	Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3
Road 3	9+050	101°34’43” 21°02’53”	Not known WG VI?	Above Road: Small slump in cut slope	Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3	Above Road: None, clearance only (?)	NA	Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3

Road	Km	Grid Ref (E/N)	Geology	Hazard Type	Risk (without mitigation) R = M x P x Va x Vu	Measures Taken	Degree of Success/ Residual Effects	Risk (with mitigation, if undertaken) R = M x P x Va x Vu
Road 3	9+850	101°34'19" 21°02'46"	Not known	Below Road: Failure of ¾ of road width due to slide in embankment/spoil slope below, and probably continuing into natural ground. Toe erosion in stream was possible original trigger of movement.	Below Road: M = 2 P = 3 Va = 3 Vu = 3 R = 54	Below Road: Road reconstructed, no apparent other mitigation	NA	Below Road: M = 2 P = 3 Va = 3 Vu = 3 R = 54
Road 3	10+300 (approx)	101°34'12" 21°02'36"	Not known	Below Road: Road constructed on fill slopes along ridge line. It is apparent that these fill slopes have previously failed	Below Road: M = 2 P = 3 Va = 2 Vu = 3 R = 36	Road edge reconstructed on mortared rip rap	Only partially successful. Standard of rip rap wall construction is poor and foundation appears to be on failing ground	Below Road: M = 2 P = 3 Va = 2 Vu = 3 R = 36
Road 3	19+500	101°30'50" 20°59'48"	Not known	Below Road: Site of apparent road failure due to landslide (?) to river (?) below.	Below Road: M = 2 P = 3 Va = 3 Vu = 3 R = 54	Below Road: Road reconstructed on fill slope with concrete herringbone surface erosion protection structure on fill slope. Upslope drainage diverted to small culvert.	Partially successful. Appears that bulk of drainage seeps through embankment, cracking to reconstructed road surface.	Below Road: M = 2 P = 2 Va = 3 Vu = 3 R = 36
Road 3	22+200	101°29'51" 20°59'03"	Slaty phyllite	Above Road: Potential rock falls along steep foliation Below Road: Assume old slide area on river bend.	Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3 Below Road: M = 3 P = 1 Va = 3 Vu = 3 R = 27	Above Road: None Below Road: 4-5m high mortared masonry edge wall.	Appears successful to date, though RC wall has no weep holes	Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3 Below Road: M = 3 P = 1 Va = 3 Vu = 3 R = 27

Road	Km	Grid Ref (E/N)	Geology	Hazard Type	Risk (without mitigation) R = M x P x Va x Vu	Measures Taken	Degree of Success/ Residual Effects	Risk (with mitigation, if undertaken) R = M x P x Va x Vu
Road 3	22+400	101°29'43" 20°58'59"	Not known	Below Road: Assumed previous road failure at this location. Slope failure may have been triggered by river scour below	Below Road: M = 2 P = 3 Va = 3 Vu = 3 R = 54	Below Road: 4m high RC road edge wall, apparent diversion of culvert	Appears successful to date, though RC wall has no weep holes	Below Road: M = 2 P = 1 Va = 3 Vu = 3 R = 18
Road 3	22+600	101°29'26" 20°58'56"	Slaty phyllite WG Adverse jointing	Above Road: Steep cut allows high angle wedges to daylight	Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3	None	NA	Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3
Road 3	45+200	101°20'11" 20°52'48"	Not known	Above Road: Small slump into side drain/adjacent road section. NB adjacent village huts at potential risk	Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3	Above Road: 1.5m high mortared masonry wall constructed	Appears successful	Above Road: M = 1 P = 1 Va = 1 Vu = 1 R = 1
Road 3	45+900	101°19'53" 20°52'35"	Phyllite/ meta siltstone WGV (tecton-ically highly disturbed)	Above Road: Shallow failure and ravelling in benched cut slope (cut too steep for materials) Below Road: Cracks developing in road pavement indicative of embankment failure	Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3 Below Road: M = 1 P = 3 Va = 2 Vu = 2 R = 12	None	NA	Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3 Below Road: M = 1 P = 3 Va = 2 Vu = 2 R = 12

Road	Km	Grid Ref (E/N)	Geology	Hazard Type	Risk (without mitigation) R = M x P x Va x Vu	Measures Taken	Degree of Success/ Residual Effects	Risk (with mitigation, if undertaken) R = M x P x Va x Vu
Road 3	46+100	100°19'44" 20°52'31"	Not known WG V?	Above Road: Small debris slide and flow in cut slope, probably originally into road. Below Road: Apparent failure of embankment slope with flow lobes to terrace below. Much seepage	Above Road: M = 1 P = 3 Va = 2 Vu = 1 R = 6 Below Road: M = 2 P = 3 Va = 2 Vu = 2 R = 24	Above Road: 1.5m high masonry wall Below Road: No apparent measures taken, though patches to cracked to pavement.	Above Road: Wall apparently successful, though potential remains for falls and small slides in upper steep cut Below Road: Embankment edge still appears to be failing	Above Road: M = 1 P = 1 Va = 2 Vu = 1 R = 2 Below Road: M = 2 P = 3 Va = 2 Vu = 2 R = 24
Road 3	64+500 (approx)	101°13'31" 20°46'38"	Not known WG IV?	Above Road: Failing rock mass forming cut slope. Original failure probably partially blocked road	Above Road: M = 2 P = 3 Va = 2 Vu = 3 R = 36	Above Road: None, clearance only.	NA	Above Road: M = 2 P = 3 Va = 2 Vu = 3 R = 36
Road 3	100+800	101°02'52" 20°34'50"	Not known	Below Road: Failure of road edge on meander bend of river, though road located on slope above flood plain terrace, therefore river scour was not responsible	Below Road M = 2 P = 3 Va = 3 Vu = 3 R = 54	Below Road: Timber piles used as toe restraint against landslide heave on fp terrace below, slope reconstructed in concrete	Appears successful, though timber piles unlikely to provide much resisting force	Below Road: M = 2 P = 1 Va = 3 Vu = 3 R = 18
Road 3	101+000	101°02'50" 20°34'44"	Not known	Above Road: Mudslide (mostly evacuated), blocked side drain only	Above Road: M = 2 P = 3 Va = 1 Vu = 1 R = 6	Above Road: None, probably clearance only.	NA	Above Road: M = 2 P = 3 Va = 1 Vu = 1 R = 6
Road 3	122+700	100°55'58" 20°29'43"	Not known	Below Road: Embankment failure	Below Road M = 2 P = 3 Va = 2 Vu = 2 R = 24	Below Road: Construction of gabion wall on embankment slope and concrete screed to surrounding embankment slope	Poor wall construction, ravelling continuing	Below Road M = 2 P = 2 Va = 2 Vu = 2 R = 12

Road	Km	Grid Ref (E/N)	Geology	Hazard Type	Risk (without mitigation) R = M x P x Va x Vu	Measures Taken	Degree of Success/ Residual Effects	Risk (with mitigation, if undertaken) R = M x P x Va x Vu
Road 3	139+600	100°50'53" 20°24'20"	Siltstone WG V	Above Road: Planar slope failure in cut slope plus erosion and flow into side drain	Above Road: M = 2 P = 3 Va = 1 Vu = 1 R = 6	None	NA	Above Road: M = 2 P = 3 Va = 1 Vu = 1 R = 6
Road 3	140+650	100°50'12" 20°24'02"	Phyllite/ Meta-siltstone WG IV-VI	Above Road: Debris slide in residual soil above 'rock head' in cut slope	Above Road: M = 2 P = 3 Va = 2 Vu = 1 R = 12	None, clearance only.	NA	Above Road: M = 2 P = 3 Va = 2 Vu = 1 R = 12
Road 3	152+300	100°45'14" 20°21'39"	Phyllite ? WG V	Above Road: Failure of upper 3 benches of cut	Above Road: M = 1 P = 3 Va = 2 Vu = 1 R = 6	None, clearance only.	NA	Above Road: M = 1 P = 3 Va = 2 Vu = 1 R = 6
Road 3	153+000	100°44'50" 20°21'32"	Slaty phyllite WG III?	Above Road: Tectonically disturbed rock mass in cut undergoing deep creep into road side drain	Above Road: M = 2 P = 3 Va = 1 Vu = 1 R = 6	None	NA	Above Road: M = 2 P = 3 Va = 1 Vu = 1 R = 6
Road 3	156+700	100°43'12" 20°21'15"	Meta-siltstone with shaley horizons WG II-V	Above Road: Tectonically disturbed rock mass with shallow and localised sliding and ravelling.	Above Road: M = 2 P = 3 Va = 2 Vu = 1 R = 12	None	NA	Above Road: M = 2 P = 3 Va = 2 Vu = 1 R = 12
Road 3	159+100	100°42'21" 20°21'42"	Phyllite/ Schist	Above Road: Localised failure from upper bench of cut. Flowed over cut and onto road.	Above Road: M = 2 P = 3 Va = 2 Vu = 1 R = 12	None	NA	Above Road: M = 2 P = 3 Va = 2 Vu = 1 R = 12

Road	Km	Grid Ref (E/N)	Geology	Hazard Type	Risk (without mitigation) R = M x P x Va x Vu	Measures Taken	Degree of Success/ Residual Effects	Risk (with mitigation, if undertaken) R = M x P x Va x Vu
Road 3	164+400	100°39'47" 20°21'32"	Meta-siltstone WG V	Above Road: Shallow failure in lower bench of cutting.	Above Road: M = 2 P = 3 Va = 2 Vu = 1 R = 12	None	NA	Above Road: M = 2 P = 3 Va = 2 Vu = 1 R = 12
Road 3	167+600	100°38'12" 20°21'19"	Phyllite/ Meta-siltstone WG III-IV	Above Road: Incipient deep seated toppling along high angle joints or faults	Above Road: M = 2 P = 2 Va = 2 Vu = 1 R = 8	None	NA	Above Road: M = 2 P = 2 Va = 2 Vu = 1 R = 8
Road 3	169+250	100°37'46" 20°21'50"	Mudstone WG IV	Above Road: Deep box cut, local plane failures on adverse bedding, possible deeper seated rock creep along high angle wedge structures	Above Road: M = 2 P = 2 Va = 2 Vu = 1 R = 8	None	NA	Above Road: M = 2 P = 2 Va = 2 Vu = 1 R = 8
Road 3	187+120	100°31'20" 20°19'06"	Mudstone WG IV	Above Road: Adverse jointing in box cut. Benched cut. Apparent kinematic feasibility in bench risers, not in overall slope. Hence failures currently confined to individual benches	Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3	None	NA	Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3
Road 4 Pakvait to Sayaburi (total length approx 60km): This road was visited on 18 February 2008. Chainages from Pakvait. The road is not sealed and so therefore any settlements to the road formation are not readily apparent upon a quick drive-through. Edge failures should, however, be anticipated, due to steep slopes below the road pavement in many areas.								
Road 4	19+500	102°04'32" 19°38'16"	Siltstone? WG VI	Above Road: Slump in cut slope	Above Road: M = 2 P = 3 Va = 1 Vu = 1 R = 6	None	NA	Above Road: M = 2 P = 3 Va = 1 Vu = 1 R = 6
Road 8: Ban Sok Kam (Road 13S junction) to Vietnam Border. Recent (probably completed 2006) slope stabilisation, flood protection and road reinstatement works have been constructed at a number of locations within the eastern 10km or so of this road. Neither the design nor as-built drawings for these works were available at the site of the field inspection (13 February 2008) and so the observations made below are based on visual observation and inference. Given the recent construction of these works, it is perhaps too early to judge performance. Chainages are from Ban Sok Kam.								

Road	Km	Grid Ref (E/N)	Geology	Hazard Type	Risk (without mitigation) R = M x P x Va x Vu	Measures Taken	Degree of Success/ Residual Effects	Risk (with mitigation, if undertaken) R = M x P x Va x Vu
Road 8	43+100	104°32'41" 18°12'38"	Phyllite (?) WG IV-VI	Above Road: Erosion, shallow sliding and rock falls into side drain and adjacent carriageway	Above Road: M = 2 P = 3 Va = 2 Vu = 1 R = 12	None, clearance only.	NA	Above Road: M = 2 P = 3 Va = 2 Vu = 1 R = 12
Road 8	45+800 (approx)	104°34'01" 18°12'02"	Not known	Above Road: Small debris slide, side drain blocked	Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3	None, clearance only.	NA	Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3
Road 8	50+750	104°36'02" 18°11'54"	Mudstone WGIV (?)	Above Road: Large slope failure from weathered zone towards top of cut, some adverse jointing. Original failure probably partially blocked road for distance of 40m	Above Road: M = 2 P = 3 Va = 2 Vu = 1 R = 12	None, clearance only.	NA	Above Road: M = 2 P = 3 Va = 2 Vu = 1 R = 12
Road 8	58+500	104°37'26" 18°13'02"	Not known	Above Road: Shallow debris slide in cut	Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3	None, clearance only.	NA	Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3
Road 8	60+800	104°40'02" 18°14'03"	Mudstone WG IV-VI	Above Road: Shallow cut slope failure, 10-15m	Above Road: M = 2 P = 3 Va = 1 Vu = 1 R = 6	None, clearance only.	NA	Above Road: M = 2 P = 3 Va = 1 Vu = 1 R = 6
Road 8	61+500 (approx)	104°40'13" 18°14'13"	Mudstone (?) WG III-IV?	Above Road: Shallow cut slope failure	Above Road: M = 2 P = 3 Va = 1 Vu = 1 R = 6	None, clearance only.	NA	Above Road: M = 2 P = 3 Va = 1 Vu = 1 R = 6

Road	Km	Grid Ref (E/N)	Geology	Hazard Type	Risk (without mitigation) R = M x P x Va x Vu	Measures Taken	Degree of Success/ Residual Effects	Risk (with mitigation, if undertaken) R = M x P x Va x Vu
Road 8	61+500 (approx)	104°40'13" 18°14'13"	Mudstone (?) WG III-IV?	Above Road: Shallow cut slope failure	Above Road: M = 2 P = 3 Va = 1 Vu = 1 R = 6	None, clearance only.	NA	Above Road: M = 2 P = 3 Va = 1 Vu = 1 R = 6
Road 8	63+200	104°40'59" 18°14'45"	Phyllite WGIV-V	Above Road: Shallow cut slope failure with erosion	Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3	Above Road: Wattle fence at base of cut slope to trap debris	Fence broken/not performing as intended	Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3
Road 8	77+100	104°48'05" 18°13'23"	Phyllite WGIV-V	Above Road: Shallow cut slope failure with erosion	Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3	Above Road: Wattle fence at base of cut slope to trap debris	Appears successful in controlling small debris volumes	Above Road: M = 1 P = 2 Va = 1 Vu = 1 R = 2
Road 8	110+700	105°02'44" 18°16'28"	Phyllite WGVI	Above Road: Minor slump and erosion	Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3	None	NA	Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3
Road 8	112+500	105°03'19" 18°17'07"	Schist/ Phyllite WGIII	Above Road: Shallow cut slope failure, 30-40m of road affected. Failure into side drain only, though original landslide may have part-blocked the road	Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3	None, clearance only.	NA	Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3
Road 8	118+000	105°05'39" 18°18'31"	Granite (?)	Below Road: Slope failure below road, possibly to river below	Below Road: M = 2 P = 3 Va = 2 Vu = 2 R = 24	Below Road: Gabion wall and mattress/RE slope protection constructed on slope below road.	Appears intact and functioning	Below Road: M = 2 P = 2 Va = 2 Vu = 2 R = 16

Road	Km	Grid Ref (E/N)	Geology	Hazard Type	Risk (without mitigation) R = M x P x Va x Vu	Measures Taken	Degree of Success/ Residual Effects	Risk (with mitigation, if undertaken) R = M x P x Va x Vu
Road 8	118+100	105^{o}05'39" 18^{o}18'31"	Granite (?)	Below Road: Bend in river, failure of slope below road, possibly originally triggered by toe erosion.	Below Road: M = 2 P = 3 Va = 3 Vu = 2 R = 36	Below Road: Combined gabion toe wall, gabion mattress/RE protection and edge wall below road.	Structures and protection work appear to be currently intact	Below Road: M = 2 P = 2 Va = 3 Vu = 3 R = 24
Road 8	119+300	105^{o}06'07" 18^{o}18'50"	Granite (?)	Below Road: Bend in river, river scour	Below Road: M = 3 P = 3 Va = 3 Vu = 3 R = 81	Below Road: Gabion toe wall without concrete toe protection, gabion mattress/RE protection to fill slope above.	Gabion toe wall subsided due to under scour of foundation.	Below Road: M = 3 P = 2 Va = 3 Vu = 3 R = 54
Road 8	119+700	105^{o}06'12" 18^{o}19'01"	Granite (?) WGV	River meander bend, toe erosion by river. Shallow sliding and erosion in soil above the road.	Above Road: M = 1 P = 3 Va = 2 Vu = 1 R = 6 Below Road: M = 3 P = 3 Va = 3 Vu = 3 R = 81	Concrete scour protection structure, gabion toe wall and gabion mattress/RE protection to fill slope beneath the road. No action taken above road	Below road retaining and protection works appear to be functioning. Only minor erosion taking place on slope above.	Above Road: M = 1 P = 3 Va = 2 Vu = 1 R = 6 Below Road: M = 3 P = 1 Va = 3 Vu = 3 R = 27
Road 8	124+800	105^{o}07'45" 18^{o}20'56"	Granite WG II-III	Above Road: Possible original wedge failure along adverse joints in cut slope.	Above Road: M = 2 P = 3 Va = 2 Vu = 1 R = 12	Above Road: 4m gabion retaining wall.	Localised ground movements continue behind wall but structure appears intact	Above Road: M = 2 P = 1 Va = 2 Vu = 1 R = 4

Road	Km	Grid Ref (E/N)	Geology	Hazard Type	Risk (without mitigation) R = M x P x Va x Vu	Measures Taken	Degree of Success/ Residual Effects	Risk (with mitigation, if undertaken) R = M x P x Va x Vu
Road 8	125+100	105°07'54" 18°21'04"	Granite, variable WG, above road WG V	Probable previous complete loss of road caused by failure of slope on meander bend. Toe erosion likely trigger	Above Road: M = 2 P = 3 Va = 2 Vu = 2 R = 24 Below Road: M = 3 P = 3 Va = 3 Vu = 3 R = 81	Road presumably reconstructed at this location. Concrete toe protection at river level, 4-5m gabion toe wall above and sloping gabion apron/RE to road level above. Above road 4m gabion wall.	Evidence of flood level to top of gabion wall below road (base of sloping apron). Gabion locally broken open/infill removed by flooding but predominantly intact. Above road slope failures continue in weathered granite with sand and silt fans over top of wall caused by seepage	Above Road: M = 2 P = 2 Va = 2 Vu = 2 R = 16 Below Road: M = 3 P = 1 Va = 3 Vu = 3 R = 27
Road 8	125+650	105°07'58" 18°21'19"	Granite WG iv-V	Above Road: Shallow (?) movements in cut slope	Above Road M = 1 P = 3 Va = 2 Vu = 1 R = 6	5m gabion wall	Appears successful, possibly over-designed for the scale of movement currently noted.	Above Road: M = 1 P = 1 Va = 2 Vu = 1 R = 2
Road 8	126+500 (approx)	105°08'08" 18°21'41"	Granite, variable WG	Original landslide probably triggered by toe erosion, leading to formation loss. Failure extended above road.	Below Road: M = 3 P = 3 Va = 3 Vu = 3 R = 81 Above Road: M = 3 P = 3 Va = 2 Vu = 1 R = 18	7-8m high gabion toe wall at river level below road with gabion mattress/RE protected fill slope to road. Road reconstructed and slope above supported by 4- 5m gabion wall over total length approx 100m.	Minor road surface displacements noted. Active movements including fresh slide scars in slope above road. Deposited (?) boulders (1-1.5m dia) at toe of gabion wall alongside river offer protection, but presumably are mobile during large floods.	Below Road: M = 3 P = 1 Va = 3 Vu = 3 R = 27 Above Road: M = 3 P = 1 Va = 2 Vu = 1 R = 6
Road 8	126+700 (approx)	105°08'12" 18°21'48"	Assumed granite, variable WG	Above Road: Large area of slope failure above road.	Above Road: M = 3 P = 3 Va = 2 Vu = 1 R = 18	Above Road: 4m gabion wall supporting slope above road. Subsoil drains beneath roadside drain.	Drains functioning, though cracking and heave to road inside shoulder suggests movement continues	Above Road: M = 3 P = 2 Va = 2 Vu = 1 R = 12

Road	Km	Grid Ref (E/N)	Geology	Hazard Type	Risk (without mitigation) R = M x P x Va x Vu	Measures Taken	Degree of Success/ Residual Effects	Risk (with mitigation, if undertaken) R = M x P x Va x Vu
Road 8	126+830	105°08'13" 18°21'53"	Granite WG V and debris	Above Road: Probable debris slide, up to 3m deep in cut slope	Above Road: M = 2 P = 3 Va = 2 Vu = 1 R = 12	Above Road: 3-4m gabion cut slope retaining wall, constructed from rounded river boulders	Appears successful	Above Road: M = 2 P = 1 Va = 2 Vu = 1 R = 4
Road 8	127+400	105°08'24" 18°22'07"	Granite WG II-III	Below road scour potential from river Above road, ravelling, minor erosion in cut	Below road: M = 3 P = 3 Va = 3 Vu = 3 R = 81 Above road: M = 1 P = 3 Va = 1 Vu = 1 R = 3	Below road: 8m or 9m high gabion road fill RW with concrete protection to base. Above road: None	Below road: Appears stable, gabion structure partly founded on rock Above road: Limited residual effects	Below road: M = 3 P = 1 Va = 3 Vu = 3 R = 27 Above road: M = 1 P = 3 Va = 1 Vu = 1 R = 3
Road 8	128+300	105°08'45" 18°22'17"	Granite WG III	River scour on river bend, ravelling and shallow failure in jointed rock in cut slope above.	Below Road: M = 3 P = 3 Va = 3 Vu = 3 R = 81 Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3	Below road: Approx 6m high gabion wall supporting fill to road level Above Road: None	Below road: Appears stable, though toe protection might not be adequate Above road: Limited residual effects	Below Road: M = 3 P = 1 Va = 3 Vu = 3 R = 27 Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3
Road 8	128+600	105°08'57" 18°22'16"	Granite WG ii - III	Large deep-seated failure on bend of river, subjected to river scour.	M = 3 P = 3 Va = 3 Vu = 3 R = 81	Above road: 5m gabion RW, horizontal drains Below road: RC river scour protection, gabion toe wall and gabion protection/RE to fill slope	Appears successful, though slope movements are continuing behind gabion wall above road	M = 3 P = 1 Va = 3 V u = 3 R = 27

Road	Km	Grid Ref (E/N)	Geology	Hazard Type	Risk (without mitigation) R = M x P x Va x Vu	Measures Taken	Degree of Success/ Residual Effects	Risk (with mitigation, if undertaken) R = M x P x Va x Vu
Road 8	128+800	105°09'00" 18°22'16"	Granite WG II	Above Road: Deep seated rockslide in cut slope. Approx 40m road length, extends approx 80m upslope	Above Road: M = 2 P = 2 Va = 3 Vu = 1 R = 12	Above Road: None, debris clearance only. Only other option would be large RW	OK, probable continued movement of debris into road	Above Road: M = 2 P = 2 Va = 3 Vu = 1 R = 12
Road 12: Thakhek to Ban Na Phao on Lao/Vietnam border (total length 146km). Road inspected on 7 April 2008. Last 90km completed in 2004 and handed over in 2005. Chainages from junction with Road 13S.								
Road 12	136+900	105°44'06" 17°37'16"	Colluvium above WG II	Above Road: 40m high x 30m wide up to 10m deep failure in colluvium above road	Above Road: M = 2 P = 3 Va = 3 Vu = 1 R = 18	Above Road: None, debris clearance only	Will continue to fail in wet season	Above Road: M = 2 P = 3 Va = 3 Vu = 1 R = 18
Road 12	138+400	105°44'25" 17°37'43"	Colluvium above WG III to IV	Above Road: 20m high x 100m wide up to 5m deep failure in colluvium 4-10m above road	Above Road: M = 2 P = 3 Va = 3 Vu = 1 R = 18	Above Road: None, debris clearance only	Will continue to fail in wet season	Above Road: M = 2 P = 3 Va = 3 Vu = 1 R = 18
Road 12	139+000	105°44'36" 17°37'51"	Colluvium	Above Road: 10m high x 70m wide failure above road	Above Road: M = 2 P = 3 Va = 1 Vu = 1 R = 6	Above Road: None, debris clearance only	Above Road: Will continue to fail in wet season	Above Road: M = 2 P = 3 Va = 1 Vu = 1 R = 6
Road 12	139+800	105°44'49" 17°38'06"	Colluvium above WG IV-V	Above Road: 20m high x 70m wide x 7m deep failure in colluvium 10m above road	Above Road: M = 2 P = 3 Va = 1 Vu = 1 R = 6	Above Road: None, debris clearance only	Will continue to fail in wet season	Above Road: M = 2 P = 3 Va = 1 Vu = 1 R = 6
Road 12	141+000	105°45'08" 17°38'30"	Colluvium above WG IV shale	Above Road: Up to 15m high x 100m wide x 5m deep failure in colluvium 3m above road	Above Road: M = 2 P = 3 Va = 2 Vu = 1 R = 12	Above Road: None, debris clearance only	Will continue to fail in wet season	Above Road: M = 2 P = 3 Va = 2 Vu = 1 R = 12

Road	Km	Grid Ref (E/N)	Geology	Hazard Type	Risk (without mitigation) R = M x P x Va x Vu	Measures Taken	Degree of Success/ Residual Effects	Risk (with mitigation, if undertaken) R = M x P x Va x Vu
Road 12	141+500	105°45'13" 17°38'39"	Colluvium	Above Road: 20m high x 55m wide x 5m deep failure in colluvium above road	Above Road: M = 2 P = 3 Va = 3 Vu = 1 R = 18	Above Road: None, debris clearance only	Will continue to fail in wet season	Above Road: M = 2 P = 3 Va = 3 Vu = 1 R = 18
Road 12	142+600	105°45'32" 17°39'04"	Colluvium	Above Road: 20m high x 40m wide x 5m deep above road	Above Road: M = 2 P = 3 Va = 2 Vu = 1 R = 12	Above Road: None, debris clearance only	Will continue to fail in wet season	Above Road: M = 2 P = 3 Va = 2 Vu = 1 R = 12
Road 12	143+300	105°45'37" 17°39'19"	Colluvium above WG II to III shale and Limestone	Above Road: 25m high x 25m wide x 3m deep failure 4m above road	Above Road: M = 2 P = 3 Va = 2 Vu = 1 R = 12	Above Road: None, debris clearance only	Will continue to fail in wet season	Above Road: M = 2 P = 3 Va = 2 Vu = 1 R = 12
Road 12	143+600	105°45'39" 17°39'29"	Colluvium above WG III to IV shale	Above Road: 15m high by 15m wide up to 7m deep failure in colluvium 5m above road	Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3	Above Road: None, debris clearance only	Will continue to fail in wet season	Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3
Road 13N: Na Teuy to Chinese Border. This road is posted as Road 13N.This section of road was inspected on 17 February 2008. Chainages from Na Teuy.								
Road 13N	0+100	101°38'30" 21°03'43"	Terrace Gravels over rock (type unknown) WG V	Above Road: Probable large cut slope failure	Above Road: M = 2 P = 3 Va = 2 Vu = 1 R = 12	Above Road: Slope benched. 1m masonry wall at up-chainage end	Appears successful, though erosion could become an issue on unvegetated slope	Above Road: M = 2 P = 1 Va = 2 Vu = 1 R = 4

Road	Km	Grid Ref (E/N)	Geology	Hazard Type	Risk (without mitigation) R = M x P x Va x Vu	Measures Taken	Degree of Success/ Residual Effects	Risk (with mitigation, if undertaken) R = M x P x Va x Vu
Road 13N	6+900	101°38'13" 21°05'50"	Phyllite WG IV-V	Above Road: Benched cut undergoing erosion due to undermining and outflanking of concrete bench drain system. Below Road: Signs of road edge failing due to ground movement on slope below to river.	Above Road: M = 2 P = 3 Va = 1 Vu = 1 R = 6 Below Road: M = 2 P = 3 Va = 2 Vu = 1 R = 12	None	NA	Above Road: M = 2 P = 3 Va = 1 Vu = 1 R = 6 Below Road: M = 2 P = 3 Va = 2 Vu = 1 R = 12
Road 13N	19+000	101°38'13" 21°05'53"	Phyllite WG V-VI	Above Road: Debris slides in cut slope	Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3	Above Road: 2m high mortared masonry wall	Appears successful	Above Road: M = 1 P = 1 Va = 1 Vu = 1 R = 1
Na Teuy to Oudomxay (total length approx 79km): This section of road does not appear to have a Road No but, by implication, it might be anticipated to be part of Road 13N. The road is apparently several decades old, and cut slopes are therefore mature and have been undisturbed for a considerable period of time. Vegetation is therefore well-established. This section of road was visited on 17 February 2008. Chainages from Na Teuy.								
Na Teuy to Oudomxay	19+100 (approx)	101°42'37" 20°56'55"	Not known	Below Road: Edge of road lost for 15m due to failure in spoil/fill material (?) below	Below Road: M = 1 P = 3 Va = 2 Vu = 2 R = 12	None	NA	Below Road: M = 1 P = 3 Va = 2 Vu = 2 R = 12
Na Teuy to Oudomxay	43+800	101°49'43" 20°51'02"	Not known	Above Road: Cut slope failure	Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3	Above Road: 2.5m high mortared masonry wall	Appears successful	Above Road: M = 1 P = 1 Va = 1 Vu = 1 R = 1
Na Teuy to Oudomxay	75+000	101°57'58" 20°42'35"	Phyllite WG IV-VI Adverse jointing	Above Road: Cut slope failure	Above Road: M = 2 P = 3 Va = 1 Vu = 1 R = 6	None	NA	Above Road: M = 2 P = 3 Va = 1 Vu = 1 R = 6

Road	Km	Grid Ref (E/N)	Geology	Hazard Type	Risk (without mitigation) R = M x P x Va x Vu	Measures Taken	Degree of Success/ Residual Effects	Risk (with mitigation, if undertaken) R = M x P x Va x Vu
Road 13N Oudomxay to Patmong (total length approx 82km): The road is apparently several decades old, and cut slopes are therefore mature and have been undisturbed for a considerable period of time. Vegetation is therefore well-established. This section of road was visited on 18 February 2008. Chainages from Oudomxay.								
Road 13N	15+600	102°01'18" 20°36'33"	Phyllite (?)	Below Road: Slope failure below road to river below. Extends over 40m with ½ road width failed over distance of 10-15m	Below Road: M = 2 P = 3 Va = 3 Vu = 3 R = 54	Below Road: None seen, except road bench reinstatement	NA	Below Road: M = 2 P = 3 Va = 3 Vu = 3 R = 54
Road 13N	16+800	102°01'50" 20°26'42"	NA	Below Road: Collapse of road edge due to apparent seepage erosion of embankment fill	NA	None	NA	NA
Road 13N	24+100	102°04'28" 20°35'34"	Phyllite WG V-VI	Above Road: Shallow slide in cut slope	Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3	None	NA	Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3
Road 13N	29+750	102°06'12" 20°34'44"	Not known	Above Road: Shallow sliding and ravelling in cut slope above existing masonry wall. Apparent runoff in wet season main cause.	Above Road: M = 2 P = 3 Va = 1 Vu = 1 R = 6	Above Road: 1m high masonry wall	Insufficient to deal with extent of problem. Slide daylights above wall, and extends further upslope.	Above Road: M = 2 P = 3 Va = 1 Vu = 1 R = 6
Road 13N	30+600	102°06'35" 20°34'38"	Meta Siltstone WG IV-VI	Above Road: Shallow slide in cut	Above Road: M = 2 P = 3 Va = 1 Vu = 1 R = 6	None, Slide scar revegetated naturally	NA	Above Road: M = 2 P = 3 Va = 1 Vu = 1 R = 6
Road 13N	33+150	102°07'57" 20o34'33"	Not known	Below Road: Masonry road edge wall collapsed due to undermining caused by erosion in river below	Below Road: M = 1 P = 3 Va = 2 Vu = 2 R = 12	None	NA	Below Road: M = 1 P = 3 Va = 2 Vu = 2 R = 12

Road	Km	Grid Ref (E/N)	Geology	Hazard Type	Risk (without mitigation) R = M x P x Va x Vu	Measures Taken	Degree of Success/ Residual Effects	Risk (with mitigation, if undertaken) R = M x P x Va x Vu
Road 13N	52+300	102°13'48" 20°33'41"	Meta Siltstone/ Phyllite WG IV-V	Above Road: Active slides and erosion in soil/weathered rock appears to cause partial blockage to road over a distance of 80m	Above Road: M = 3 P = 3 Va = 2 Vu = 1 R = 18	None, clearance		Above Road: M = 3 P = 3 Va = 2 Vu = 1 R = 18
Road 13N	53+850	102°14'25" 20°33'53"	Siltstone WG V-VI	Above Road: Small debris slide in cut slope, culvert inlet blocked and spoil dumped into stream channel downstream. Mortared masonry wall destroyed	Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3	Above Road: Masonry breast wall	Wall destroyed by continuing failure	Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3
Road 13N	55+580	102°15'12" 20°34'13"	Siltstone? WG IV? Adverse jointing	Above Road: Shallow and localised rockslide along adverse joints in cut	Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3	None, clearance only	NA	Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3
Road 13N	61+000	102°17'18" 20°34'34"	Not known WG VI?	Above Road: Debris slide into side drain and road edge	Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3	None, clearance only	NA	Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3
Road 13N	62+900	102°17'34" 20°34'15"	Not known	Below Road: Washout of road edge due to road runoff	Below Road: M = 1 P = 3 Va = 2 Vu = 2 R = 12	Below Road: Reinstatement by construction of masonry edge wall	Design/ construction unlikely to prove effective long-term	Below Road: M = 1 P = 2 Va = 2 Vu = 2 R = 8

Road	Km	Grid Ref (E/N)	Geology	Hazard Type	Risk (without mitigation) R = M x P x Va x Vu	Measures Taken	Degree of Success/ Residual Effects	Risk (with mitigation, if undertaken) R = M x P x Va x Vu
Road 13N	72+700	102°20'44" 20°34'22"	Not known	Above Road: Old debris slide in cut, extends 50m or so upslope, now completely revegetated Below Road: Failure of road shoulder due to sliding/erosion to river below	Above Road: M = 1 P = 1 Va = 1 Vu = 1 R = 1 Below Road: M = 1 P = 3 Va = 2 Vu = 2 R = 12	None	NA	Above Road: M = 1 P = 1 Va = 1 Vu = 1 R = 1 Below Road: M = 1 P = 3 Va = 2 Vu = 2 R = 12
Road 13N	80+450	102°23'43" 20°34'36"	Not known	Below Road: Road shoulder failure due to sliding/erosion to river below	Below Road: M = 1 P = 3 Va = 2 Vu = 2 R = 12	None	NA	Below Road: M = 1 P = 3 Va = 2 Vu = 2 R = 12
Road 13N Patmong to Luang Prabang (total length approx 109km): The road is apparently several decades old, and cut slopes are therefore mature and have been undisturbed for a considerable period of time. Vegetation is therefore well-established. This section of road was visited on 18 February 2008. Chainages from Patmong.								
Road 13N	30+100	102°20'49" 20°22'00"	Limestone WGVI	Above Road: Erosion and slumping in benched cut caused by lack of drainage control	Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3	None	NA	Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3
Road 13N	43+050	102°25'01" 20°19'21"	Limestone WG VI	Above Road: Small debris slide in cut slope	Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3	None	NA	Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3

Road	Km	Grid Ref (E/N)	Geology	Hazard Type	Risk (without mitigation) R = M x P x Va x Vu	Measures Taken	Degree of Success/ Residual Effects	Risk (with mitigation, if undertaken) R = M x P x Va x Vu
Road 13N	68+100	102°18'56" 20°10'14"	Siltstone?	Below Road: Large slope failure, possibly caused by failing spoil area. Road on embankment with culvert (1m dia – undersized for size of catchment above road). Road requires regular re-surfacing. Masonry road edge wall continuing to crack	Below Road: M = 2 P = 3 Va = 3 Vu = 3 R = 54	Below Road: Masonry road edge wall	Movement appears to be taking place beneath wall foundation	Below Road: M = 2 P = 3 Va = 3 Vu = 3 R = 54
Road 13N Luang Prabang to Km 238.2 (total length inspected 142 km): This section of road was inspected on 19 February 2008. Chainages from Vientiane.								
Road 13N	238+200	102°24'00" 19°20'49"	Unknown WG II-VI	Above Road: Retrogressing shallow landsliding and erosion in cut slope and slope above. Electricity pylon at risk from retreating back scar has since been removed.	Above Road: M = 2 P = 3 Va = 3 Vu = 1 R = 18	Above Road: Bio-engineering: including planting and masonry slope drains.	Partially successful, seepages taking place on slope, causing ongoing movement and erosion.	Above Road: M = 2 P = 2 Va = 3 Vu = 1 R = 12
Road 13N	239+400	102°24'40" 19°20'54"	Phyllite?	Below Road: Active failure of spoil(?) with slip scarp developed approx 1m from road shoulder. Pylons likely effected. Above Road: Recent slide in weathered rock forming benched cut slope.	Below Road: M = 2 P = 3 Va = 2 Vu = 3 R = 36 Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3	None evident other than debris clearance, though road may have been realigned through this section in the past to avoid instability below.	NA	Below Road: M = 2 P = 3 Va = 2 Vu = 3 R = 36 Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3
Road 13N	242+600	102°25'27" 19°21'49"	Slaty phyllite	Below Road: Deep erosion and rock fall area below road. Road has been realigned in the past to avoid the receding back scar cliff. Approx 50m of road affected.	Road Below: M = 2 P = 3 Va = 2 Vu = 3 R = 36	Below Road: Phase 2 SEACAP 21 site Trimming and shotcreting of slope below road	Works in progress during site visit	Below Road: M = 2 P = 1 Va = 2 Vu = 3 R = 12

Road	Km	Grid Ref (E/N)	Geology	Hazard Type	Risk (without mitigation) R = M x P x Va x Vu	Measures Taken	Degree of Success/ Residual Effects	Risk (with mitigation, if undertaken) R = M x P x Va x Vu
Road 13N	247+550	102°25'57" 19°23'16"	Unknown	Above Road: Shallow slide in cut slope	Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3	None evident	NA	Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3
Road 13N	247+750	102°25'52" 19°23'18"	Unknown	Below Road: Slope failure with back scar 2m from road shoulder. Above Road: Area of previous erosion and shallow sliding affecting road over 50m length.	Below Road: M = 2 P = 3 Va = 2 Vu = 2 R = 24 Above Road: M = 2 P = 3 Va = 3 Vu = 1 R = 18	2m high gabion toe/containment wall constructed. Slope re-establishing vegetation. No evident mitigation below road	Gabion wall probably not functioning as intended due to vegetation regrowth	Below Road: M = 2 P = 3 Va = 2 Vu = 2 R = 24 Above Road: M = 2 P = 2 Va = 3 Vu = 1 R = 12
Road 13N	254+000	102°25'37" 19°25'23"	Meta-siltstone? WG III-IV	Below Road: Road edge failure with scour beneath culvert giving rise to failure of adjacent slopes and possibly road bench. Failed masonry edge wall	Below Road: M = 2 P = 3 Va = 2 Vu = 3 R = 36	Below Road: Phase 2 SEACAP 21 site Reconstruction/extension of masonry edge wall and channel protection	Ongoing at time of site visit	Below Road: M = 2 P = 1 Va = 2 Vu = 3 R = 12
Road 13N	257+850	102°25'12" 19°26'31"	Phyllite?	Above Road: Ravelling and shallow erosion. Recently constructed drain wall pushed over.	Above Road: M = 1 P = 3 Va = 2 Vu = 1 R = 6	None evident, other than clearance	NA	Above Road: M = 1 P = 3 Va = 2 Vu = 1 R = 6

Road	Km	Grid Ref (E/N)	Geology	Hazard Type	Risk (without mitigation) R = M x P x Va x Vu	Measures Taken	Degree of Success/ Residual Effects	Risk (with mitigation, if undertaken) R = M x P x Va x Vu
Road 13N	258+500	102°24'53" 19°26'33"	Phyllite?	Below Road: Erosion and shallow sliding on jointed rock Above Road: Erosion and shallow debris sliding	Below Road: M = 1 P = 3 Va = 2 Vu = 2 R = 12 Above Road: M = 2 P = 3 Va = 2 Vu = 1 R = 12	Masonry toe/containment wall constructed in cut slope	Partially effective	Below Road: M = 1 P = 3 Va = 2 Vu = 2 R = 12 Above Road: M = 2 P = 2 Va = 2 Vu = 1 R = 8
Road 13N	259+900	102°25'07" 19°26'48"	Phyllite?	Above Road: Debris slide/rock slide above road. Cut benches and slope above have failed.	Above Road: M = 2 P = 3 Va = 3 Vu = 1 R = 18	Above Road: 1.5m masonry containment wall constructed.	Wall has little if no effect on stability of main slope and limited containment potential.	Above Road: M = 2 P = 2 Va = 3 Vu = 1 R = 12
Road 13N	260+200-300	102°25'11" 19°26'50"	Meta Siltstone? WGIII-IV Limestone pinnacle	Deep-seated landslide above and through road. Approx 120m or road affected.	M = 3 P = 3 Va = 3 Vu = 3 R = 81	Phase 2 SEACAP21 site Previously, approx 1m masonry toe wall constructed in cut slope. SEACAP21 works, include improvements to culvert outlet and slope monitoring	Toe wall cracked, and pushed forward due to slope failure daylighting at or beneath road surface	M = 3 P = 3 Va = 3 Vu = 3 R = 81
Road 13N	260+500	102°25'12" 19°27'02"	Phyllite	Above Road: Failed cut slope benches above road along adverse jointing.	Above Road: M = 2 P = 3 Va = 1 Vu = 1 R = 6	Above Road: 2m gabion containment wall	Slope regained/regaining stability. Containment wall largely empty.	Above Road: M = 2 P = 2 Va = 1 Vu = 1 R = 4

Road	Km	Grid Ref (E/N)	Geology	Hazard Type	Risk (without mitigation) R = M x P x Va x Vu	Measures Taken	Degree of Success/ Residual Effects	Risk (with mitigation, if undertaken) R = M x P x Va x Vu
Road 13N	262+900	102°25'20" 19°27'57"	Phyllite	Below Road: Deep slope failure below road with back scar 1m from shoulder. 40m road length affected Above Road: Active debris slide with fresh striated shear surface towards top of slope. 60m length of road affected. Probably originally blocked road. It is possible that these two failures form parts of the same landslide, with the road now reinstated.	Below Road: M = 2 P = 2 Va = 3 Vu = 1 R = 12 Above Road: M = 2 P = 3 Va = 2 Vu = 2 R = 24	1-1.5m high masonry toe wall constructed in base of cut slope.	Active movement in cut slope taking place. Active retrogression of back scar (?) below road	Below Road: M = 2 P = 2 Va = 3 Vu = 1 R = 12 Above Road: M = 2 P = 3 Va = 2 Vu = 2 R = 24
Road 13N	272+900	102°24'56" 19°30'08"	Phyllite?	Above Road: Area of shallow debris sliding and erosion in cut slope. Possibly originally blocked road	Above Road: M = 2 P = 3 Va = 2 Vu = 1 R = 12	Above Road: 1-2m high masonry toe/containment wall	Slope appears to be regaining stability	Above Road: M = 2 P = 1 Va = 2 Vu = 1 R = 4
Road 13N	272+950	102°24'56" 19°30'09"	Phyllite WG V-VI	Above Road: Localised failure from upper portion of cut in WGVI	Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3	None evident	NA	Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3
Road 13N	273+100	102°24'53" 19°30'13"	Limestone WG NA	Above Road: Old debris slide in cut slope	Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3	None evident	NA	Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3
Road 13N	288+400	102°20'19" 19°33'03"	Phyllite?	Above Road: Old debris slide in cut slope	Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3	None evident	NA	Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3

Road	Km	Grid Ref (E/N)	Geology	Hazard Type	Risk (without mitigation) R = M x P x Va x Vu	Measures Taken	Degree of Success/ Residual Effects	Risk (with mitigation, if undertaken) R = M x P x Va x Vu
Road 13N	289+050	102°20'18" 19°33'22"	Phyllite? With limestone boulders	Failure in cut slope over road length of 50m. Likely to be associated with an possible original deeper seated failure that extended beneath road level, i.e. failure of entire slope.	Below Road: M = 2 P = 2 Va = 3 Vu = 3 R = 36 Above Road: M = 2 P = 3 Va = 2 Vu = 1 R = 12	Below Road: Not known, non observed Above Road: 1m high masonry toe wall. Slope above road revegetating and appears stable.	Below Road: No apparent distress to road Above Road: Slope above road revegetating and appears stable.	Below Road: M = 2 P = 1 Va = 3 Vu = 3 R = 18 Above Road: M = 2 P = 1 Va = 2 Vu = 1 R = 4
Road 13N	297+350	102°17'29" 19°33'47	Phyllite?	Above Road: Shallow cut slope failure in weathered, jointed rock.	Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3	None evident	NA	Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3
Road 13N	299+300	102o16'40" 19°33'54"	Phyllite WG V-VI Jointing adverse to stability	Below Road: Apparent slope failure/erosion originally caused partial or total road failure. Above Road (offset): Cut slope failure in weathered phyllite. Bare and potentially unstable back scar with steep lope above.	Below Road: M = 2 P = 3 Va = 3 Vu = 3 R = 54 Above Road: M = 2 P = 3 Va = 2 Vu = 1 R = 12	Below Road: Construction of RC road edge wall. Above Road: None, clearance only	Below Road: Wall construction appears to have led to successful road reinstatement Below Road: NA	Below Road: M = 2 P = 0 Va = 3 Vu = 3 R = 0 Above Road: M = 2 P = 3 Va = 2 Vu = 1 R = 12
Road 13N	311+600	102°10'07" 19°04'54"	Phyllite WG IV-V Jointing adverse to stability	Above Road: Cut slope failure, probably originally partially blocked road. Some of slipped mass and back scar remains potentially unstable.	Above Road: M = 1 P = 3 Va = 2 Vu = 1 R = 6	Above Road: Probably debris clearance only.	NA	Above Road: M = 1 P = 3 Va = 2 Vu = 1 R = 6

Road	Km	Grid Ref (E/N)	Geology	Hazard Type	Risk (without mitigation) R = M x P x Va x Vu	Measures Taken	Degree of Success/ Residual Effects	Risk (with mitigation, if undertaken) R = M x P x Va x Vu
Road 13N	315+100	102°13'20" 19°34'44"	Phyllite?	Above Road: Cut slope failure, probably blocked road when it failed. Steep bare back scar, partly vegetated slip debris. Failure potential from back scar.	Above Road: M = 1 P = 3 Va = 2 Vu = 1 R = 6	Above Road: Probably debris clearance only.	NA	Above Road: M = 1 P = 3 Va = 2 Vu = 1 R = 6
Road 13N	316+600	102°18'00' 19°06'56"						
Road 13N	317+900	102°12'24" 19°36'20"	Slaty phyllite WG III-IV	Landslide has caused loss of original road, probably constructed on fill embankment. 75m length of road affected.	M = 3 P = 3 Va = 3 Vu = 3 R = 81	Failed road level probably reinstated by additional filling. Phase 2 SEACAP 21 site Minor drainage improvements works not implemented at time of field visit. Slope monitoring under SEACAP21	Not known. In the long term the road formation is likely to continue to move.	M = 3 P = 3 Va = 3 Vu = 3 R = 81
Road 13N	323+800	102°11'19" 19°36'49"	Phyllite?	Above Road: Old cut slope failure, now mostly revegetated. Back scar at top of cut remains bare	Above Road: M = 2 P = 3 Va = 1 Vu = 2 R = 12	Above Road: None, though presumably original failure required clearance	NA, slope appears to have stabilised due to natural vegetation regrowth	Above Road: M = 2 P = 1 Va = 1 Vu = 2 R = 4
Road 13N	326+900	102°11'36" 19°37'42"	Phyllite	Below Road: Deformation/failure to road surface behind failed masonry edge wall over road length of 30m	Below Road: M = 2 P = 3 Va = 2 Vu = 2 R = 24	Below Road: None evident, it is assumed the edge wall was constructed prior to the road surface failure	NA	Below Road: M = 2 P = 3 Va = 2 Vu = 2 R = 24
Road 13N	329+100	102°11'39" 19°38'15"	Unknown, assume phyllite	Below Road: Apparent slow failure of entire slope below above river meander bend. Ground movement currently effects road side berm, edge retaining wall and probably pylon. 60m of roadside affected	Below Road: M = 3 P = 3 Va = 2 Vu = 2 R = 36	None evident	NA	Below Road: M = 3 P = 3 Va = 2 Vu = 2 R = 36

Road	Km	Grid Ref (E/N)	Geology	Hazard Type	Risk (without mitigation) R = M x P x Va x Vu	Measures Taken	Degree of Success/ Residual Effects	Risk (with mitigation, if undertaken) R = M x P x Va x Vu
Road 13N	332+700	102°12'18" 19°39'08"	Phyllite WG V-VI	Above Road: Cut slope failure and failure of slope above	Above Road: M = 2 P = 3 Va = 2 Vu = 1 R = 12	Above Road: Phase 2 SEACAP 21 site earthworks, structural support and planting scheduled, but not implemented at time of site visit	Not known	Above Road: M = 2 P = 1 Va = 2 Vu = 1 R = 4
Road 13N	335+900	102°11'28" 19°39'39"	Phyllite WG V? Highly folded	Below Road: Road deflection/ deformation over 60m length	Below Rod: M = 2 P = 3 Va = 3 Vu = 2 R = 36	None evident	NA	Below Road: M = 2 P = 3 Va = 3 Vu = 2 R = 36
Road 13N	336+400	102°11'23" 190°39'46"	Phyllite WG V Folded and closely jointed	Below Road: Slope failure to river below caused deformation to road pavement over 35m length	Below Road: M = 2 P = 3 Va = 3 Vu = 2 R = 36	Below Road: Phase 2 SEACAP 21 site Road has been resurfaced by DPWT and slope monitored under SEACAP21	Surfacing appears adequate, long term movement of slope anticipated as mitigation not undertaken	Below Road: M = 2 P = 3 Va = 3 Vu = 2 R = 36
Road 13N	337+700		Not known, assumed phyllite	Below Road: Cracking to road edge due to failure of spoil wedge on slope below. Pylon probably affected Above Road: Shallow debris sliding, probably completely/partially blocked road	Below Road: M = 2 P = 3 Va = 2 Vu = 2 R = 24 Above Road: M = 2 P = 3 Va = 2 Vu = 1 R = 12	Phase 1 SEACAP 21 site Below Road: Planting on spoil slope and cut off drain alongside outside road edge Above Road: Planting to cut slope	Below Road: Cracking continuing to spoil slope adjacent to road shoulder and drain cracked. Above Road: Majority of planting appears to have died due to dry soil	Below Road: M = 2 P = 3 Va = 2 Vu = 2 R = 24 Above Road: M = 2 P = 3 Va = 2 Vu = 1 R = 12
Road 13N	339+900	102°12'0" 19°40'36"	Phyllite WG IV-V	Above Road: Cut slope failure and erosion, in part caused by seepage	Above Road: M = 1 P = 3 Va = 2 Vu = 1 R = 6	Above Road: Phase 2 SEACAP 21 site. Drainage, earthworks, structural support and planting scheduled, but not implemented at time of site visit	Not known	Above Road: M = 1 P = 1 Va = 2 Vu = 1 R = 2

Road	Km	Grid Ref (E/N)	Geology	Hazard Type	Risk (without mitigation) R = M x P x Va x Vu	Measures Taken	Degree of Success/ Residual Effects	Risk (with mitigation, if undertaken) R = M x P x Va x Vu
Road 13N	355+600 (approx)	102°11'38" 19°44'22"	Not known, assumed phyllite	Below Road: Deformation to outside carriageway for 50m. Slope failure below.	Below Road: M = 2 P = 3 Va = 2 Vu = 1 R = 12	Below Road: Gabion road edge wall.	Assumed that failure surface passes beneath gabion wall foundation	Below Road: M = 2 P = 3 Va = 2 Vu = 1 R = 12
Road 13N	357+100	102°11'25" 19°44'38"	Not known, assumed phyllite	Below Road: Road shoulder failed for approx 40m due to slope failure in spoil/fill below. Possible older failure extending above road, i.e failure below might be reactivation of pre-existing slide	Below Road: M = 2 P = 3 Va = 2 Vu = 2 R = 24	None	NA	Below Road: M = 2 P = 3 Va = 2 Vu = 2 R = 24
Road 13N	359+800 (approx)	102°11'19" 19°45'14"	Phyllite WG IV-V	Above Road: Rockslide in cut, probably half-blocked road.	Above Road: M = 2 P = 3 Va = 2 Vu = 1 R = 12	None, clearance only	NA	Above Road: M = 2 P = 3 Va = 2 Vu = 1 R = 12
Road 13N	363+500	102°10'42" 19°46'50"	Slaty phyllite WG IV-V	Above Road: Debris slide in cut slope	Above Road: M = 2 P = 3 Va = 2 Vu = 1 R = 12	Above Road: JICA experimental bio-engineering site. Benches slope, drainage, wire netting, wattle fences, planting, gabion toe wall.	Mostly successful	Above Road: M = 2 P = 1 Va = 2 Vu = 1 R = 4
Road 13N	373+500	102°11'18" 19°50'47"	Siltstone? WGVI	Above Road: Soil fall into side drain	Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3	None	NA	Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3
Road 13N	375+500	102°10'30" 19°51'09"	Siltstone? WG IV-VI	Above Road: Debris slide in cut slope	Above Road: M = 2 P = 3 Va = 2 Vu = 1 R = 12	Above Road: EU experimental bio-engineering site. Mortared masonry catch wall, slope benching and planting	Partially successful	Above Road: M = 2 P = 2 Va = 2 Vu = 1 R = 8

Road	Km	Grid Ref (E/N)	Geology	Hazard Type	Risk (without mitigation) R = M x P x Va x Vu	Measures Taken	Degree of Success/ Residual Effects	Risk (with mitigation, if undertaken) R = M x P x Va x Vu
Road 13N	380+100	102°07'55" 19°51'23"	Not known WG VI?	Above Road: Old small debris slide in cut slope, now mostly vegetated	Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3	None	NA	Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3
Road 18b: **Attapeu to Lao/Vietnam border**. (total length approx 120km). Road inspected on 8 April 2008. Road completed in 2006 and handed over in 2007. Chainages from Attapeu.								
Road 18b	49+000	107°11'45" 14°50'10"	WG-IV	Above Road: 30m high x 10m and 30m wide surface ravelling	Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3	Above Road: None, debris clearance only	Will continue to erode in wet season	Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3
Road 18b	49+200		WG-IV	Above Road: 40m high a 100m wide surface ravelling	Above Road: M = 2 P = 3 Va = 2 Vu = 1 R = 12	Above Road: None, debris clearance only	Will continue to erode in wet season	Above Road: M = 2 P = 3 Va = 2 Vu = 1 R = 12
Road 18b	49+700		WG II-V	Above Road: 40m high a 100m wide surface ravelling	Above Road: M = 2 P = 3 Va = 1 Vu = 1 R = 6	Above Road: None, debris clearance only	Will continue to erode in wet season	Above Road: M = 2 P = 3 Va = 1 Vu = 1 R = 6
Road 18b	50+300	107°12'20" 14°49'54"	WG III-IV	Above Road: 2 x 10m high x 40m wide x max 2m deep failure 30m above road	Above Road: M = 2 P = 3 Va = 2 Vu = 1 R = 12	Above Road: None, debris clearance only	Will continue to fail in wet season	Above Road: M = 2 P = 3 Va = 2 Vu = 1 R = 12

Road	Km	Grid Ref (E/N)	Geology	Hazard Type	Risk (without mitigation) R = M x P x Va x Vu	Measures Taken	Degree of Success/ Residual Effects	Risk (with mitigation, if undertaken) R = M x P x Va x Vu
Road 18b	67+800		WG IV-V	Above Road: Deep erosion gullies in 15m high slope above road	Above Road: M = 1 P = 3 Va = 2 Vu = 1 R = 6	Above Road: Gabion containing wall 3m high	Appears intact and functioning	Above Road: M = 1 P = 1 Va = 2 Vu = 1 R = 2
Road 18b	71+200	107°21'20" 14°49'57"	Granite WG V-VI	Above Road: Deep erosion gullies in 10m high slope above road	Above Road: M = 1 P = 3 Va = 2 Vu = 1 R = 6	Above Road: Gabion containing wall 3m high x 20m long	Appears intact and functioning	Above Road: M = 1 P = 1 Va = 2 Vu = 1 R = 2
Road 18b	71+300		Granite WG V-VI	Above Road: Deep erosion gullies in 15m high slope above road	Above Road: M = 1 P = 3 Va = 2 Vu = 1 R = 6	Above Road: Gabion containing wall 4m high x 70m long	Appears intact and functioning	Above Road: M = 1 P = 1 Va = 2 Vu = 1 R = 2
Road 18b	72+200	107°21'27" 14°49'37"	Granite WG II-V	Above Road: 30m high x 10m wide x 2m deep rock slide above road	Above Road: M = 1 P = 3 Va = 2 Vu = 1 R = 6	Above Road: None, debris clearance only	Will continue to erode in wet season	Above Road: M = 1 P = 3 Va = 2 Vu = 1 R = 6
Road 18b	75+700	107°22'31" 14°48'51"	WG III-V	Above Road: 40m high x 30m wide x 3m deep erosion above road	Above Road: M = 2 P = 3 Va = 2 Vu = 1 R = 12	Above Road: None, debris clearance only	Will continue to erode in wet season	Above Road: M = 2 P = 3 Va = 2 Vu = 1 R = 12
Road 18b	76+200			Above Road: Erosion gulley above road	Above Road: M = 1 P = 3 Va = 2 Vu = 1 R = 6	Above Road: None, debris clearance only	Will continue to erode in wet season	Above Road: M = 1 P = 3 Va = 2 Vu = 1 R = 6

Road	Km	Grid Ref (E/N)	Geology	Hazard Type	Risk (without mitigation) R = M x P x Va x Vu	Measures Taken	Degree of Success/ Residual Effects	Risk (with mitigation, if undertaken) R = M x P x Va x Vu
Road 18b	76+400		WG III-IV	Above Road: 2x 10m high x 5m wide x 3m deep erosion above road	Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3	Above Road: None, debris clearance only	Will continue to erode in wet season	Above Road: M = 1 P = 2 Va = 1 Vu = 1 R = 2
Road 18b	77+500		WG III-IV	Above Road: 3 x 5m high x 10m wide x up to 2m deep erosion above road	Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3	Above Road: None, debris clearance only	Will continue to erode in wet season	Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3
Road 18b	78+200			Above Road: 30m high x 20m wide x 10m deep erosion gulley above road	Above Road: M = 2 P = 3 Va = 2 Vu = 1 R = 12	Above Road: Gabion containing wall 4m high x 50m long	Appears intact and functioning	Above Road: M = 2 P = 1 Va = 2 Vu = 1 R = 4
Road 18b	81+000			Above Road: 40m high x 50m wide x 3m deep erosion above road	Above Road: M = 2 P = 3 Va = 2 Vu = 1 R = 12	Above Road: None, debris clearance only	Will continue to erode in wet season	Above Road: M = 2 P = 3 Va = 2 Vu = 1 R = 12
Road 18b	81+100	107°24'13" 14°48'30"	WG II-IV	Above Road: 40m high x 50m wide x up to 3m deep erosion above road	Above Road: M = 2 P = 3 Va = 2 Vu = 1 R = 12	Above Road: None, debris clearance only	Will continue to erode in wet season	Above Road: M = 2 P = 3 Va = 2 Vu = 1 R = 12
Road 18b	81+800		WG III-V	Above Road: 50m high x 80m wide x up to 5m deep failure/erosion above road	Above Road: M = 2 P = 3 Va = 3 Vu = 1 R = 18	Above Road: None, debris clearance only	Will continue to erode in wet season	Above Road: M = 2 P = 3 Va = 3 Vu = 1 R = 18

Road	Km	Grid Ref (E/N)	Geology	Hazard Type	Risk (without mitigation) R = M x P x Va x Vu	Measures Taken	Degree of Success/ Residual Effects	Risk (with mitigation, if undertaken) R = M x P x Va x Vu
Road 18b	82+100			Above Road: Localised failures in high cut slopes above road	Above Road: M = 1 P = 3 Va = 2 Vu = 1 R = 6	Above Road: None, debris clearance only	Will continue to erode in wet season	Above Road: M = 1 P = 3 Va = 2 Vu = 1 R = 6
Road 18b	91+700	107°26'42" 14°46'50"	WG II-V	Above Road: 60m high x 100m wide a 2m deep mainly erosion above road	Above Road: M = 3 P = 3 Va = 3 Vu = 1 R = 27	Above Road: None, debris clearance only	Will continue to erode in wet season	Above Road: M = 3 P = 3 Va = 3 Vu = 1 R = 27
Road 18b	93+700	107°27'07" 14°46'19"	WG II-V	Above Road: 20m high x 70m wide x 2m deep erosion and gulleying above road	Above Road: M = 2 P = 3 Va = 2 Vu = 1 R = 12	Above Road: None, debris clearance only	Will continue to erode in wet season	Above Road: M = 2 P = 3 Va = 2 Vu = 1 R = 12
Road 18b	96+000	107°27'37" 14°45'34"	WG II-V	Above Road: 120m high x 150m wide x up to 5m deep failure above road that occurred in 2006	Above Road: M = 3 P = 3 Va = 3 Vu = 1 R = 27	Above Road: None, debris clearance only	Will continue to fail in wet season	Above Road: M = 3 P = 3 Va = 3 Vu = 1 R = 27
Road 18b	97+200		WG III-IV	Above Road: 25m high x 100m wide x up to 2m deep erosion above road	Above Road: M = 2 P = 3 Va = 1 Vu = 1 R = 6	Above Road: None, debris clearance only	Will continue to erode in wet season	Above Road: M = 2 P = 3 Va = 1 Vu = 1 R = 6
Road 18b	105+500	107°30'58" 14°42'37"	WG III-VI	Above Road: 15m high x 120m wide erosion up to 5m deep above road	Above Road: M = 2 P = 3 Va = 2 Vu = 1 R = 12	Above Road: None, debris clearance only	Will continue to erode in wet season	Above Road: M = 2 P = 3 Va = 2 Vu = 1 R = 12

Road	Km	Grid Ref (E/N)	Geology	Hazard Type	Risk (without mitigation) R = M x P x Va x Vu	Measures Taken	Degree of Success/ Residual Effects	Risk (with mitigation, if undertaken) R = M x P x Va x Vu
Road 18b	108+500		WG III-V	Above Road: 20m high x 20m wide x up to 4m erosion above road	Above Road: M = 1 P = 3 Va = 2 Vu = 1 R = 6	Above Road: None, debris clearance only	Will continue to erode in wet season	Above Road: M = 1 P = 3 Va = 2 Vu = 1 R = 6
Road 18b	108+800		WG IV-V	Above Road: 20m high x 20m wide x up to 2m surface erosion above road	Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3	Above Road: None, debris clearance only	Will continue to erode in wet season	Above Road: M = 1 P = 3 Va = 1 Vu = 1 R = 3
Road 18b	109+700	107°32'37" 14°41'55"	WG II-V	Above Road: 90m high x 50m wide x 3m deep rock and soil slide above road	Above Road: M = 2 P = 3 Va = 3 Vu = 1 R = 18	Above Road: None, debris clearance only	Will continue to fail in wet season	Above Road: M = 2 P = 3 Va = 3 Vu = 1 R = 18
Road 18b	110+300	107°32'48" 14°42'05"	WG III-V	Above Road: 100m high x 60m wide up to 10m deep erosion gullying above road	Above Road: M = 3 P = 3 Va = 3 Vu = 1 R = 27	Above Road: None, debris clearance only	Will continue to erode in wet season	Above Road: M = 3 P = 3 Va = 3 Vu = 1 R = 27

APPENDIX D: COMMUNITY MANAGEMENT OF ROADSIDE SLOPES

1. SUMMARY

This document provides a review of the issues surrounding the possibilities for the involvement of communities in the management of roadside slopes in the Lao PDR road sector.

There has already been some success in the introduction of community participation in road asset management in Laos. This has been mainly in Village Management Committees that are made responsible for short road sections serving specific villages. However, the sparse rural population in Laos means that communities of sufficient size are not always available close enough to particular sections of road, particularly in the steeper mountainous areas. In addition, it is clear that a wage-based arrangement is essential for the engagement of workers for activities on all but the very lowest category of public road. Demands for voluntary labour contributions can be ethically unsound and contrary to good development.

A number of general conclusions can be drawn from this review, which gives a broad assessment of the potential for community participation in the management of rural infrastructure in upland areas.

- Development and many activities associated with it (such as road maintenance) is still very much a top-down process, largely determined and directed by central government.
- Organised development is still a relatively recent phenomenon, since it dates mostly from 1975. Before that, the indifference of colonial powers, political instability and wars limited rural development and disrupted communities. Historical factors mean that some groups tend not to participate widely in resource management
- There are major differences in the ways of life, livelihoods and relative wealth between urban people, sedentary agriculturalists and shifting cultivators in Laos.
- The agricultural system and process of land reform are still in transition, with the government's stabilisation policies bringing about major changes to rural society.
- Many features still remain of the tradition of independent, shifting and sparsely scattered communities. Although many villages have been established in certain locations for many years, they lack the fully settled, nucleated and well-defined community structures of ancient sedentary societies. Elsewhere in Asia it tends to be in those strongly defined communities that participatory techniques have been most widely successful.
- There is a very sparse rural population, with large average land areas per capita, relative to many parts of south-east and south Asia. Hence the sheer number of people in the rural communities is limited compared with many other geographical areas. This means that there is relatively little pressure on land resources: compared with some upland areas in south Asia, where dense population means that productivity is important even from very marginal unstable roadside land, there is little incentive for rural people in upland Laos to use difficult or even dangerous steep slopes when there is adequate better land available.
- Understanding of local decision-making processes is made additionally complex by the presence of a large number of ethnic groups, which have their own varying tendencies.
- There is already a considerable amount of road sector experience in community participation. However, this is limited to the provision and maintenance of basic access, and has not been tested on the wider management of infrastructure. Even with the basic access approach, there are still issues that need to be resolved, and the approach is not yet very widespread or mature.
- Numerous lessons can also be learnt from the inter-linked forestry and agriculture sectors, where community participation has been practiced widely. This experience demonstrates the importance of careful local assessment of needs and opportunities, and of adaptation to local requirements.

The conclusion is therefore that, although there is considerable understanding of community-based resource management in Laos, its application to roadside slopes needs to be introduced and tested in a sensitive manner. If it is to be undertaken, it should first be based on low category village and district roads, where the scale of works is likely to be relatively limited, communities of adequate size are available, and there are obvious links between needs and benefits for the communities involved.

2. INTRODUCTION

2.1 Scope and purpose

SEACAP is a 'Community Access Programme', with a key principle being 'to support sustainable ownership mechanisms for the construction and maintenance of rural roads'. What does this mean in SEACAP 21, a project that is testing methods of slope stabilisation alongside national roads? Even though they are in rural areas (as with most of the Laos road network), for this scale of infrastructure there can be no question of altering the ownership from the national level. The terms of reference require the researchers to find out how the current decision-making process works and to 'identify areas where increased participation would benefit users and managers in the rural transport sub-sector'. This implies that this project is not much about community participation, though it should suggest areas where there is scope for that approach in the future.

It is clearly important that the possibility for increased community involvement be investigated, since there are obvious advantages for the sustainability of slope protection and stabilisation works. This is particularly due to the fact that land management off the road is largely dictated by local inhabitants rather than being directly under the control of the DPWT. Yet it is also clear that local communities will only participate meaningfully in a decision-making process if they have a vested interest to do so: this might be difficult to achieve in the context of national highways, other than on the basis of a standard employment or contracting arrangement.

This document reviews recent and current thinking on the topic, using reports and other publications, discussions with sectoral and other specialists, and findings from the field. There is so much published information on the broad topic of community participation in development, both within Laos since the late 1980s and from the international community, that this paper is necessarily selective and covers only a small part of the enormous experience that is available. The findings are used to support an assessment of decision-making processes in the management of road assets and the opportunities for community participation in maintaining roadside slopes, as part of the project's overall findings.

Throughout the paper, the term "rural" is frequently used to describe all non-urban areas, rather than in the narrow sense of "Rural Roads" as used by the MPWT to describe the lowest class of Village, Access or Community Roads.

2.2 Terms of reference

This review paper is structured around providing the background information for the requirements given below, as they appear in the terms of reference for the SEACAP 21 consultants.

Scope of Research
"…the Consultant will be responsible for reviewing the following issues as part of this research:

- Community participation
  Rural transport, typically, tends to be a provincial activity with district and commune cadres' involvement limited to requesting investments from higher levels, based on officials' own assessment of need. This approach is repeated in the selection of alignments, construction standards, contractors, supervision methods and maintenance systems. In summary, there is limited consultation with, or participation of, the local community in the decision making process. There is a need to understand better how the current decision making system works and identify areas where increased participation would benefit users and managers in the rural transport sub-sector.

- Institutional building
  In order to determine community ownership and government responsibilities, and to ensure proper transfer of the technologies developed, the scope of the research will also cover recommendations on changing the institutional set up within the public sector and the international donors working in the country."

3. MANAGEMENT OF ROAD MAINTENANCE IN RELATION TO ROADSIDE SLOPES

An in-depth assessment of road maintenance organisation and practices in relation to roadside slopes is given in SEACAP 21/002 (2008), and so there is no need to repeat it here. This shows how there is a substantial and effective institution in place for the management of the national road assets. Funding constraints often mean that the lower levels of roads in the hierarchy do not receive adequate financial resources for maintenance, but in contrast the more important roads with higher traffic levels are generally well maintained.

It is clear from that assessment, however, that the maintenance of roadside slopes is not given the same degree of importance as on-road maintenance. As a result, it is not undertaken to the same standards. One reason for this is the very limited levels of skills available in the sector for understanding geomorphology and slope dynamics, and the design of slope stabilisation and protection systems. These aspects have generally been given only cursory coverage in standard civil engineering courses, and most Lao engineers come from lowland areas so do not have an intuitive understanding of slope processes. Foreign aid interventions have not passed on much in the way of skills or expertise in these practices. Hence SEACAP 21/002 (2008) identified a need for substantial training in slope management.

Another main factor is that slope problems have mostly been relegated to “emergency maintenance”, and treated only on a responsive basis. There is no process for proactive site assessment, or the design and construction of measures intended to minimise slope instability. Road maintenance provision assumes that a certain number of slope failures will occur, with the inevitable damage to the infrastructure and disruption to traffic that this will cause. This is the same for both the standard practices undertaken by the Provincial Departments of Public Works and Transport, and through the pilot trials of performance-based maintenance contracts that were started in 2007. The problem with this is that slope treatment is dominated by short term emergency works, required urgently following road blockages. These can occur over a wide space of time from May to October, but are very unpredictable since they depend on complex factors linked to rainfall. Communities that derive their main livelihoods from other means are not well placed to be involved in activities of this nature, since their priorities may well differ from those of the authorities responsible for managing the road network.

The MPWT’s involvement with communities is mostly linked to the provision of basic access at village level. The process by which this is generally done involves Village Maintenance Committees, which are given responsibility for keeping a defined section of road in a condition that meets certain standards. This is still effectively at a pilot stage and no evaluations have been published to demonstrate how effective it is as an approach. Initial evidence suggests that, as in other countries, it is best restricted to short sections of road that serve only a single village or a clearly defined cluster of settlements. For a community to be properly motivated, there must be a clear link between the road asset under its responsibility, and the benefits that are derived from it; if benefits go to other, non-contributing users of the road, then the community will soon be discouraged from the effort of maintaining it.

Also emerging from a consideration of roadside slope management is the potential synergy between the skills of the farm-based people who dominate the rural population, and the possible use of vegetation in slope protection. There is no tradition of building with masonry in the Lao uplands, but there is a long-standing custom of using plants. For this reason, the next parts of this review give detailed consideration to the possible linkages between vegetation use through bio-engineering, and the community structures that manage the agricultural and forest land that dominates the rural areas.

4. BIO-ENGINEERING IN THE LAO ROAD SECTOR

4.1 What is bio-engineering?

Bio-engineering is the use of vegetation, either alone or in conjunction with civil engineering structures, to reduce instability and erosion on slopes. Bio-engineering should be a fundamental part of the design and construction of all roads in rural hill areas. This is mainly because it provides the best way to protect slopes against erosion. It is relatively low in cost, it uses local materials and skills, and provides livelihoods benefits (i.e. economically useful products).

Bio-engineering is simply part of wise and sustainable asset management: it helps to ensure the life of a road in the long term, and to reduce overall maintenance costs. Plants reduce the supply of debris from degrading slopes, which can be a significant contributor to road maintenance costs through blocked drains and damaged pavements. Because of the steep and dynamic slopes found in the mountainous parts of Laos, many sections of hill roads are engineered near to the margin of safety. Bio-engineering is an “appropriate” way of enhancing civil engineering structures to increase stability as far as possible; the vegetative structures are also flexible, being capable of absorbing movement and recovering from damage.

Vegetation as a key component of off-road engineering is also environmentally sound and effectively forms a practical environmental mitigation measure. In the hills, roads are an inseparable part of the slopes that they cross, and they must be fully integrated into this landscape if they are to be sustainable. Bio-engineering techniques offer the best way of blending roads into the landscape and limiting damage to surrounding agricultural and forest land. They allow the restoration of something of the original vegetation and ecosystems, and particularly of tipping sites and spoil disposal areas. Through both implementation and later productivity, they offer social and economic benefits for poor rural farmers. It is because of these potential benefits to local communities that a detailed assessment of bio-engineering is given here.

4.2 Summary of world-wide road sector bio-engineering expertise

The options for the use of vegetation in engineering are numerous and have been covered well in the literature. Techniques are well established, with much practical experience coming from the Alpine countries, particularly Austria (Schiechtl, 1980), and the United States (Gray and Lieser, 1982), which have formed the basis of recent thinking and practice. The current most comprehensive examples of text books are Coppin and Richards (1990), Gray and Sotir (1996), Morgan and Rickson (1995), and Schiechtl and Stern (1996). Conferences regularly either focus on bio-engineering (e.g. Barker et al., 2004), or contain a significant number of articles on the subject (e.g. HMG Nepal and PIARC, 2003). Country- and terrain-specific examples of adaptation for particular application in the road sector may be found in many instances, such as the Caribbean (Clark and Hellin, 1996), Nepal (Howell, 1999), Hong Kong (Geotechnical Engineering Office, 2000), and geologically recent mountain belts (TRL, 1997). More general texts on the use of vegetation for land stabilisation include the use of vetiver grass promoted over many years by the World Bank (National Research Council, 1993).

The most widespread use of bio-engineering in association with low cost geotechnical engineering works is probably in Nepal, where extensive research in the 1980s was put into practice in the 1990s (Howell, 1999). This experience is still being widely applied in the current programmes of the Government of Nepal itself, as well as those supported by multilateral and bilateral donors (see, for example, the Nepali Times of August 2006). In the late 1980s and early 1990s, the Nepal programmes also conducted research on a range of livelihoods opportunities in the management of roadside slopes in rural areas. This later formed the basis of pro-livelihoods rural road development on a significant scale (e.g. DFID and HMGN, 2001; ADB, 2004).

Other examples of bio-engineering works are numerous and many can be found in the documents to which reference has already been made. The great breadth of international experience is nowhere fully documented, though the International Erosion Control Association, while somewhat Americo-centric, probably has the best reach to documented broad expertise through its publications, especially its large annual conferences (see http://www.ieca.org).

One of the key lessons from the practical experience gained in other countries is that geotechnical and bio-engineering disciplines need to be integrated in their approach to slope management. Neither is a total solution on its own and this is illustrated by failures that have occurred when either the wider slope conditions have been ignored or the engineering or planting materials used have proven inappropriate for the site.

4.3 Summary of bio-engineering experience in South-east Asia

Although research theses commonly refer to the evidence of bio-engineering used in ancient China, written references covering the topic in south-east Asia are available only for the last few decades. An example of how bio-engineering emerged in the region is provided from the Philippines by Agpaoa et al. (1976). This comprehensive manual was written for use in the forest sector. Since its compilation received significant German support, it benefited from the inclusion of traditional Alpine "biological engineering", which covers most of the techniques now used routinely in many countries as part of bio-engineering works on steep slopes. This approach has proved valuable in Asia, since it has helped to bridge the divide between vegetative slope protection provided by the agriculture and forest sectors, and the requirements of the infrastructure engineering sectors. This transfer of technology was also considered important by Barker (1999), who provided an outline of the various ways in which bio-engineering was introduced to many parts of Asia between the 1970s and late 1990s. While at one end of the spectrum there was a strong focus on labour-based methods in rural areas where labour was cheap (e.g. Howell, 1999, for Nepal), at the other end there has been reliance on higher-technological approaches for urban areas with steep slopes but high economic values on the protection of infrastructure (e.g. Geotechnical Engineering Office, 2000, for Hong Kong).

An extraordinarily wide range of bio-engineering applications was described by IECA (1999) in the substantial proceedings of a major regional conference on the subject. Many of the key papers were republished in edited form by Barker et al. (2004), and for Asia these remain the biggest documentary records of activity in this technical field. The general coverage can be summarised as follows.

Agriculture
- Hedgerows and other inter-crop vegetative erosion control measures.
- Soil management practices, indigenous approaches and perennial vegetation in cropping systems.

Forestry
- Agro-forestry and non-timber forest products in improving fertility and reducing erosion.
- Re-afforestation as a means of controlling erosion.

Watershed management
- Vegetative soil conservation in particular environments.
- Bio-engineering measures for embankments, bunds and dams.

Mining
- Revegetation and stabilisation of mine tailings.

Waterways
- Methods of streambank stabilisation using bio-engineering and other measures.

Infrastructure, particularly in the transport sector
- Bio-engineering methods as applied in particular environments in a large number of countries.
- "Appropriate" methods of landslide stabilisation, mainly focussed on bio-engineering.
- Modelling and academic assessments of slope instability.

It is clear that there is a great deal of experience in the region, though care has to be taken in two main ways. One is the tendency for many writers, particularly in the Indian sub-continent, to write broad review papers that describe works undertaken in specific areas but described in general terms as if they are widespread and unequivocally successful, with very limited critical analysis of the benefits and shortcomings they provide. The other is the tendency of mainly young researchers to suggest that methods devised for very specific conditions of soil, landform and climate will be widely applicable elsewhere. Nevertheless, there is enough information available in the published literature to demonstrate that there is a large amount of active experimentation from which to draw significant lessons as to the validity of using bio-engineering measures for slope protection.

4.4 Previous experience of bio-engineering in Lao PDR

There are two examples of the previous use of bio-engineering techniques in the road sector, both near to Luang Prabang on Road 13 North. One is some SIDA-funded works that were implemented through the EU-supported Rural Development Micro Project, which has now ended. This was at km 375.8 and used grass plants imported from Thailand (possibly vetiver). These plants failed, apparently partly because they were not in good condition at the time of site planting. In addition, much of the slope is very hard and rocky, and grass establishment would be very slow, if not impossible, on such a material. The other example is at km 363.6, and was a trial of bio-engineering techniques carried out in 2004-06 by the Infrastructure Development Institute of Tokyo under JICA funding, in collaboration with MPWT's Planning and Technical Division. Documentary outputs include a manual and handouts from a seminar held in March 2006. The paragraphs below give a detailed assessment of this work.

The materials from the seminar (Hada and Yoshida, 2006) show a similar diagnosis of slope stability problems on Road 13N to that arrived at by SEACAP 21. Failures are divided into major lower side slips requiring geotechnical investigations, into which they looked no further; and small cut slope failures. These are considered to be due to: (a) finishing slopes at angles inappropriate to the soil characteristics; (b) no attempt made to protect the slope surface; and (c) no measures to repair damage once a slope starts to fail, so that damage is compounded year-by-year. The project conducted a preliminary trial in Vientiane in May 2004, which employed various approaches to seed sowing, sometimes in trenches, and "stone mulching". On the basis of findings there it then implemented a pilot project in Luang Prabang in March 2005. This incorporated slope drainage and physical toe walls, of both bamboo and gabion, and then several different approaches to seed sowing in trenches. The drainage system was considered most essential to ensure general stability of the slope, and the gabion toe wall was thought good to stop the slope unravelling; the bamboo wall was questioned on account of its limited durability. Reinforcing works using "nailing" and wire netting were installed in some parts of the site, but the evaluation suggested these were not worthwhile on the grounds that the cost and difficulty outweighed their function. The seed sowing approach using trenches, stone mulching and "grass mats" were relatively costly (¥ 1,700/m^2, about Kip 143,000), but in an early evaluation appeared to be performing well. The stated target was for a community of woody vegetation, but it was too early to tell whether that would emerge properly.

Beyond the engineering functionality of the slope protection trial in Luang Prabang, Hada and Yoshida (2006) stress the environmental and ecological importance of the approach. The underlying principle is "lending a hand to allow nature to restore itself naturally", through the use of appropriate pioneer plants suited to the local ecological conditions, thereby ensuring that the damaged landscape is restored as far as possible. The plan was to use pioneer herbaceous plants to make way for successional higher woody plants, that will be the long term solution for surface stabilisation and protection. The importance of seeding the woody plants was stressed, since the root development is then more likely to be even, extensive and inter-twining than from seedlings grown in containers in a nursery. The species used should be mainly pioneers, with a variety of types, particularly legumes, and a mixture of ground-cover, shrubs and small trees that grow up to about 6 metres in height. Most legumes seed prolifically and so are easy to collect.

The method introduced by the Infrastructure Development Institute for mixing soil and seeds is quite complex and time-consuming. Topsoil is brought from a nearby location and mixed with used rice husks, seeds and water, and placed in bags that are then laid in shallow trenches in the slope. The details are as follows.

1. Excavate contour furrows about 200 mm wide and 200 mm deep, spaced 500 mm apart.
2. Spray with water to dampen the surface.
3. Place straw or grass mats in the furrows and again spray with water.
4. Place the seed-mixed soil over the mats and compact it by hand.
5. Place a layer of small stones or coarse gravel over the top ("stone mulching"), and fill the voids with soil. This should bring the furrows back to the level of the natural ground.

Further details of the Japanese approach are given by the Infrastructure Development Institute (IDI) (2006). It is clearly intended only for slopes of about 30 metres or less, formed to a maximum grade of 1:1 in relatively soft soil. The assessment of failure types and their causes in roadside cut slopes is generally similar to those of the SEACAP 21 consultants, since they are in line with standard perceptions. The criteria for plant selection is also similar in this respect. Where the approach becomes questionable is in the Japanese assertions about plant rooting characteristics. The IDI recommends woody rather than herbaceous plants, on the grounds that herbaceous plants wilt easily in the Laotian climate. Yet large perennial grasses are common pioneers in Laos and provide much better surface protection than woody plants; and while the stems and leaves die back in the dry season, the dense root mat provides thick, strong armouring of the surface and reinforcement to at least 500 mm depth. Woody plants tend to have significant gaps between the stems, reducing their capacity to armour the surface. The IDI approach also recommends direct seeding on site, which gives fewer larger roots that extend deeply: but while this promotes anchoring, its effectiveness depends to a large extent on the substrate and the ability of the plant roots to penetrate to depth. The use of planted nursery container seedlings is discouraged by the IDI because roots tend to be slimmer and more numerous. Yet this is important for soil reinforcement, as root studies (published in standard text books) have shown that the larger the number of roots and their bifurcations, the greater the effect in resisting soil deformation. Although it is difficult to generalise, on most weak soil slopes where failures are very shallow and related to the loss of cohesion under saturated conditions, multiple lines of reinforcement throughout the upper layers are much more likely to be effective than relatively few larger and deeper lines of anchorage.

The Japanese recommendations for physical slope treatments also follow common understanding. The main area that is questionable here is the recommendation to install benches to break up long slopes. These are a fairly common practice in some countries, but have the disadvantage of requiring steeper sections of slope between the benches, than could be formed if there was a straight cut from top to bottom. Where the overall slope stability is marginal, this can have a significant effect in lowering the slope's factor of safety close to, or even below, the limit. The IDI recommends installing drains along benches, which is necessary to reduce infiltration in these locations (which would otherwise increase pore water pressure to critical limits), but drains on benches are invisible from the road and so are not maintained; this can lead to blockages and considerable damage from concentrated water flows. On balance, it is often best to avoid benching on cut slopes altogether, and for the same reason drains along the top of cut slopes are also best avoided.

A detailed critical site assessment in December 2006 identified the following issues.

- The plants are growing up vigorously, but still within the lines of the planting trenches and with no lateral spreading. The high density of plants means that they are competing with each other for light and have grown straight up, developing long, thin, weak stems. The canopy was about four metres in height and there was no ground cover of vegetation at all. The surface had a cover of dead leaves, but these were very weak and friable, and would not give much mulching effect by the next wet season. There seemed to be a strong chance of erosion occurring between the stems of the plants. The understanding and skills required for maintenance of the vegetation on this site do not seem to have been communicated to the DPWT.
- Where the thouaheir (*Cajanus cajan*) has self-seeded between the rows, all of the seedlings have died off since the monsoon. It appears that this species will not survive well on undisturbed natural ground, though it may grow well for at least a few years in a cultivated trench. This species was also recorded as performing poorly in nearby trials by Roder and Maniphone (1998).
- The health of the plants was hard to judge, as they were suffering from the seasonal effects of cooler and drier weather, and losing many leaves as a result.
- The line of fall of the branch drains on the benches is definitely too flat. One was completely blocked by debris that had fallen in from just above the bench. If water now overflowed, it would run straight down the soil slope rather than there being any hope of it re-entering the drain further down.
- The main slope drains are a good design, and are self-cleaning.
- The wire mesh used as a surface covering on the rockier parts of the site is 50 mm square chain link mesh, normally used for security fencing. It is poorly galvanised and is already corroding in places. It is pegged with wholly inadequate bars of 8 x 300 mm re-bar, which pull out very easily. Possibly because of the design flaw over the bars, or perhaps because it had been poorly placed during construction, in many concavities the netting did not touch the surface and was serving no function.
- Part of the toe wall just above the side drain was of mixed rounded stone (river gravel), faced with cut culms of bamboo and then with live *Jatropha curcas* cuttings planted in front. Weathering and termites have combined to weaken the bamboo culms quickly, so that they will not have the strength to retain the loose stone fill for more than another year or two. This will leave an unsupported vertical face of stones that will spill out between the *Jatropha* cuttings.

A number of appropriate plant species were identified during the Japanese trials: these are listed in the table below, with some comments added.

List of species used in the seed mixes of the trials on Road 13N, km 363.6, described by the Infrastructure Development Institute (2006), with comments added

Category	Lao name	Botanical name	Comments
Herbaceous	Nha nhoup	*Mimosa pudica*	Creeping small legume
	Nha khaa	*Imperata cylindrica*	Large grass, very common invader of disturbed forest.
Shrubs	Hingmaa	*Crotalaria mucronata*	
	Thouaheir	*Cajanaus cajan*	Pigeon pea, a pan-tropical leguminous shrub. Not growing well on undisturbed hard ground.
	Pohou	*Trema orientalis*	Aggressive coloniser of hard sites and rocky areas, but the seed is quite difficult to collect.
	Tong thao, Sa thao	*Mallotus barbatus*	
	Kakalau	*Lagerstoemia macrocarpa*	
Small trees	Tiou dam, Tiou deng, Tious luang	*Cratoxylon prunifolium*	
	Samsa	*Samanea saman*	
	Khileckdong	*Cassia garrettiana*	Leguminous.
	Kathin	*Leucaena leucocephala*	A fast-growing, pan-tropical leguminous tree.
	Sa phang, Sa kham	*Peltophorum dasyrhachis*	
	Fang hangnhung	*Delonix regia*	Flame tree: a pan-tropical leguminous tree, but not a small one.
	Koun	*Cassia fistula*	A common pan-tropical leguminous tree with striking yellow flowers.

The Planning and Technical Division of MPWT has liaised with the Japanese Public Works Research Institute about a possible follow-up to the previous trials, but so far no definite plans have been finalised. The Division considers that further trials and dissemination are required in order to move the approach towards mainstream use.

The Ministry's guidelines for environmental appraisal (MCTPC, 1999b) lists erosion as a potential environmental hazard. As a means to mitigating against this, it suggests that projects be required to include provisional sums for slope stabilisation and revegetation works as a standard part of the bills of quantities. The guidelines also stress the importance of ensuring that design standards for roads are sensitive to the characteristics of steep and hilly terrain. These are sound advice, of course, but are simply two of many appropriate possible mitigation measures.

Outside the road sector there is some additional experience with bio-engineering. A little to the north of Vientiane Capital City is the Huayson Huaysua Agriculture Development and Service Centre (near km 22 on Road 13N). This comes under the Government's agricultural extension service, as opposed to the research service, which is mentioned in the next section. It was here that the King of Thailand, a well-known exponent of the use of vetiver grass in erosion control, supported a small project to develop a mass production facility for the species Vetiveria zizanioides, which has been promoted widely by the World Bank and other agencies (see National Research Council, 1993). The project ended some years ago, but the Service Centre is still distributing tillers of the grass to farmers for planting in contour hedgerows to reduce erosion on cultivated land. It has also entered into a larger supply arrangement for the contractors constructing access roads for the Nam Theun Power Company in southern Laos: in the first half of 2007 it was to produce one million tillers, and the size of this order was expected to be exceeded in 2008. When SEACAP 21 staff visited in January 2007, tillers were being multiplied from existing stock on the Service Centre's land and neighbouring farms. They were broken out from existing clumps and soaked in rooting hormone for 48 hours, before being planted out to grow into clumps that would in turn provide multiple tillers for delivery to site.

The Nam Theun Power Company had resorted to the use of vetiver as a result of a series of difficulties. In 2005-06, a Thai hydro-seeding company was sub-contracted to provide protection to a number of steep cut slopes, apparently formed in deep residual soils. The hydro-seeding seems to have been done without first installing some form of surface netting or other system to hold the sprayed mulch and seed to the surface. As a result, when the wet season came, it slid off the surface over large sections, as the plant roots had not penetrated into the original ground. In any case the choice of species was inappropriate, since it used forage species suited to planting on cultivated land, but not on exceptionally steep cut slopes. This was also not approved by the environmental monitoring specialists of the World Bank, who pointed out that, since the project area is in an area of protected forest, exotic species should not be used. For the same reason, the contractors were forbidden to collect grass planting material from the forests around the site, and therefore were forced to look elsewhere. Vetiver, which might arguably be considered native to such an area, was considered acceptable because it is reputed not to spread on its own. However, its performance on steep, hard cut slope sites is not well proven.

Investigations for the design of slope stabilisation trials on Roads 13N and 7 showed that there is a strong potential for the use of a number of labour-intensive bio-engineering techniques for slope protection, based on proven methods used in mountainous parts of south Asia and elsewhere. The sites give scope for a range of methods to be tested, using designs that adapt standard approaches to local conditions. The availability of suitable plant species also appears to be good. The traditional practice of shifting cultivation means that there is a common prevalence of pioneer species well adapted to re-colonising disturbed open ground.

5. LAND MANAGEMENT IN UPLAND LAO PDR

5.1 Shifting cultivation

Land management in the uplands of Laos is dominated by the practices of shifting cultivation or swidden farming. Although this is gradually being reduced as cultivation is stabilised, its effects are still very widespread; this is partly because “stabilised agriculture” often still uses many of the practices of shifting cultivation, but with very much shorter fallow periods. The situation is complex, but the paragraphs below summarise the situation with relation to what useful knowledge can be derived for bio-engineering and community participation in the road sector. This draws heavily on the NAFRI Sourcebook (NAFRI, 2005) and on communications with NAFRI staff and other professionals working in the joint agriculture-forestry sector.

Simply put, shifting cultivation is a practice whereby the forest vegetation is cut and burnt between January and April, and cropped between March and November (the precise times depending on locational factors); it is then left fallow for a long period, traditionally for ten to twenty years. However, there are many variations on this: for example cleared areas are often cultivated for two or three consecutive years before being left fallow. With changing socio-economic conditions, fallows are tending to become much shorter than is sustainable in the long term using traditional methods and crops alone, and government policies are increasingly helping the move towards sedentary agriculture. MAF (2005) distinguishes between shifting cultivation, where new areas of forest are cut, and rotational cultivation, where farmers rotate around the same areas of land with fallow periods in between. Shifting cultivation is the process by which households produce food for basic subsistence, but their cash incomes mainly depend on the collection, processing and sale of non-timber forest products, and through livestock.

In most ecological areas, if the fallow period of a shifting cultivation system is long enough, a forest canopy will eventually reassert itself. This seems to happen even on lands that become infested with a dense grass cover, though it can take ten to fifteen years to happen. The implication is that natural forest succession is a robust process, if trees can eventually overcome the strong competition provided by vigorous grasses. And therefore it is safe to assume that grass-based bio-engineering sites will eventually revert to forest unless tree seedlings are selectively weeded out.

Among the grasses, broom grass or nyar khaem (*Thysanolaena latifolia* and *T. maxima*) is a very important non-timber forest product, with many of the seed heads collected by farmers and exported to Thailand for brooms. For this reason, planting this species even on marginal roadside land will give potential benefits to neighbouring communities. Another very common grass, nya kha (*Imperata cylindrica*), is often seen as a problematic invader. However, there are also reports of it being actively cultivated in some places (specifically in Xieng Khouang Province), and certainly it is often favoured for thatch in many areas. Hence the use of this species, widely detested by foresters throughout the tropics as a weed, may in fact bring some benefits.

Dense areas of grass are very difficult to cultivate, as the dense roots of the clump survive fire and have to be dug out by hand. Therefore these areas are generally not used by cultivators until the fallow period has been long enough for a tree storey to develop and shade out the grasses. Clearance of fallow vegetation and weeding account for by far the greatest amounts of labour in shifting cultivation.

The management of sloping fields is a very delicate business, on account of the potential for high rates of soil erosion to take place. With no tillage, there is very limited erosion: this can be achieved by sowing crops directly into untilled soil following burning. The old traditional practice of a long fallow with a single year of cropping, with the seed dibbled into holes, means that there is never any tillage and the system is generally sustainable. But systems are becoming more common with shorter term fallows and two or three years of cropping: these lead to an increase in erosion. Weeding must also be balanced carefully to reduce competition so that crop yield is maximised, while still keeping a residue of weeds to minimise erosion and shade the surface to limit the germination of other weeds. There have been some promising results of trials with planted legumes as a fallow crop that both reduce erosion and fix nitrogen (Roder and Maniphone, 1998, and NAFRI, 2005), and these strengthen observations of the performance of legumes in the bio-engineering trial at km 363.6 on Road 13N.

The literature reviewed and individuals interviewed show that not very much is known about soil nutrient fluxes. It is generally supposed that the burning of vegetation at the end of a fallow returns many nutrients to the soil, especially phosphorus, but the annual cycles and rates of nutrient leaching seem not to be understood. Roder (2001) states that “Quantitative data on soil, water, plants and other biophysical factors of the systems remain limited”.

5.2 Soil conservation practices in Lao PDR

The main organisation co-ordinating research on upland land management in Laos is the National Agriculture and Forestry Research Institute (NAFRI) of the Ministry of Agriculture and Forestry. This has various divisions, but none that deal with soil conservation on very steep slopes. The general focus is towards the improvement of agricultural practices on sloping land and the stabilisation of shifting cultivation. This means emphasis is given to on-farm practices that reduce erosion and nutrient losses from bare soils, such as mulching, contour hedgerows, agroforestry and the use of a wider range of perennial crops, especially fruit trees. Staff at NAFRI talk of the use of vegetation for soil erosion control, particularly with vetiver grass, and leguminous shrubs in the *Flemingia* and *Leucaena* genera, but only on slopes up to about 30 degrees in steepness. This is, of course, a fairly predictable finding from the natural resources sector in a country that is hilly but does not have a particularly high prevalence of excessively steep slopes: it is only along the sides of roads that instability is a serious issue.

NAFRI organises major international conferences on issues related to hill land use from time to time. Those in January 2004 and December 2006 have covered the broad topics of poverty alleviation and the stabilisation of shifting agriculture in the Lao uplands (NAFRI, 2004; and NAFRI, 2006). The proceedings are comprehensive on the range of topics covered by NAFRI in its general research, examining the numerous facets of forestry, agriculture and the livelihoods of the poor. Yet the emphasis is more on farming systems and the general encouragement of settled agriculture, than on the details of soil stabilisation. They cover the major options of perennial cropping, utilisation of non-timber forest products, rotations that allow a reduction in frequent fallowing and other possibilities that will encourage shifting cultivators to settle. In effect the problems are wider than the technical issues, and the impression given is that overall livelihoods need to be changed before researchers are able to look at improvements to the details of farming practices.

In September 2004, the first conference on Sustainable Sloping Lands and Watershed Management, “Innovative Practices for Sustainable Sloping Lands and Watershed Management”, was held in

Chiang Mai. The conference was intended to be a forum for exchanging knowledge on the management and implementation of sustainable land and water resources, and creating a bridge between researchers and decision makers. So far we have not been able to obtain a copy of the proceedings.

The proceedings of the second conference in this series, which focussed on “Linking Research to Strengthen Upland Policies and Practices”, have also been published (NAFRI, 2006). As with most conferences of this type, the topics covered were broad, but appeared mainly related to relatively narrow niches of research in specific geographical areas. For the specialist there are some interesting examinations of features of soil erosion and land degradation. Among papers of relevance to this review of community issues, are the following.

- Chandrapatya assessed the use of incentives in a watershed management research project to encourage the participation of poor farmers. Project partners provided incentives based on their belief that conservation measures had limitations in tangible direct benefits (yield and income) in the short term, and that this resulted in reluctance among farmers to adopt new practices. The study concluded that direct incentives (in cash form such as wages, subsidies and loans, or in kind through the provision of food aid, seeds, seedlings etc.) do not assure participation or adoption. However, indirect incentives (extension services, technical guidance and support, training and capacity building programmes, social recognition etc.) were more effective at promoting desirable human behavioural changes.
- Clement assessed research in northern Vietnam to understand farmers’ decision-making processes through analysis using a participatory, inter-disciplinary, community- and catchment-based framework. He found that research projects have had little impact on farmers’ perception of uplands and land degradation, and that policies were much more powerful in affecting their beliefs. However, institutional analysis showed that, in one area, a shift from annual cropping to tree plantations was an accident rather than the result of farmers’ faith in reforestation incentives provided by national policies. Promotion of forest benefits, along with policies, had little impact on farmers’ final decisions. The collapse of local rules, due to a combination of soil fertility decrease and change in land tenure, was the decisive factor in land use change. He pointed out the need for a multi-level assessment if the very complex factors behind farmers’ decision-making is to be understood properly.
- Connell, Pathammavong and Boupha reported on an innovative approach to rural livelihood promotion in parts of Laos and Vietnam, using agro-enterprise development. The process first identifies which local products have robust market demand. Secondly, through participatory market chain analysis, weaknesses are identified along the chain that have inhibited trade and production. While there can be no prescription for the design of action plans, it appeared that there is a hierarchy of interventions which can guide practitioners towards the most effective ways to stimulate change. In the case of non-timber forest products, this can lead to the domestication of products, thus providing an alternative to shifting cultivation. In some cases there had been rapid improvements in household economies.
- Lestrelin, Pelletreau and Valentin record the local understanding of increasing land degradation around a village in northern Laos. Farmers were aware of the long term trend of increasing soil erosion and the fact that, within 10 to 40 years, the land would become uncultivable. Within their own resources, they had therefore started to adapt their land use strategies accordingly, so as to sustain viable livelihoods in the face of change. They considered that an understanding of this approach would help to improve other participatory development initiatives in similar environments.
- Phanvilay, Thongmanivong, Fujita and Fox described early research into changing land use practices in upland Lao PDR, associated with the transformation from shifting to stabilised agriculture. These are complex and as yet poorly understood in detail. Numerous localised socio-economic factors underpin the behaviour of different households, in communities that are making dramatic changes to their ways of life. Many farmers do not have access to the support that is supposed to be available, partly because of limited access to the credit required to change to more commercialised farming.
- Sophathilath described a different project approach to improve livelihoods among stabilised shifting cultivators, through promotion of appropriate upland farming technologies and support systems. It was concluded that success depended on strong local leadership and involvement, the development of project staff capacity in participatory research, training based on local rather than researchers’ needs, strong trust between researchers and farmers, technologies with clear

short-term economic benefits, farmer familiarisation with new technologies (which can take some time), and the use of participatory research methodologies.

Research into perennial farm crops, both to help reduce erosion on slopes and to improve livestock productivity, has been underway by the Colombia-based International Centre for Tropical Agriculture (CIAT in Asia) since 1995 (NAFRI, 2005). It started with the introduction of 152 forage varieties (35 grasses and 118 legumes), the suitability of which was evaluated through a series of trials, mainly in the north of Laos. This led to the selection of ten species, of which the following four were considered most appropriate to Lao conditions.

- Marandu (*Brachiaria brizantha*): a tall grass that is suitable for cutting and grows well on moderately fertile, acid soils. It stays green into the dry season and produces more seed than basilisk (*Brachiaria decumbens*). It should not be fed to goats, sheep, or young cattle.
- Mulato (a *Brachiaria* hybrid): this is a cross between marandu and ruzi (*Brachiaria brizantha* and *B. ruziziensis*) that produces fertile seed. It establishes rapidly from tillers, grows well in the dry season, and produces better quality feed than other *Brachiaria* varieties, but it needs at least moderate soil fertility and seed production is low.
- Simuang (*Panicum maximum*): a tall grass suitable for cutting that produces high quality feed. It is generally suited to more fertile soils and must be fertilised regularly to maintain high productivity. It becomes stemmy if not cut frequently and is not suited to long dry seasons.
- Stylo or CIAT 184 (*Stylanthus guianensis*): an erect, short-lived (two or three years) perennial legume that will grow on low fertility and acid soils, and produces large quantities of good quality feed for cutting. It stays green into the dry season. Leaves can be fed fresh, or dried and stored as leaf meal. Stylo needs to be planted by seed and does not tolerate heavy grazing or frequent cutting.

The research project has also produced a number of extension manuals and other supporting documentation, and the work continues.

CIAT staff consider that the main species used for forage hedgerows across South-east Asia is *Setaria sphacelata* var. *splendida* (khae or dork in Lao), a non-seeding upright grass that does not spread, is easy to propagate vegetatively and is found to be very palatable to animals. They consider marandu (*Brachiaria brizantha*) to be widely used by Lao farmers as a contour hedge and for erosion control in gullies. However, a difficulty with all forage crops is the strong likelihood of them attracting grazing by animals, which is a distinct disadvantage on steep roadside slopes where the control of grazing is very difficult.

6. COMMUNITY PARTICIPATION IN RURAL INFRASTRUCTURE DEVELOPMENT

6.1 What is “community participation”?

This phrase is widely used by different people to cover a range of possibilities. The MCTPC-UNDP (1999) summarises it as: “A process whereby beneficiaries influence the direction and execution of development projects rather than merely receiving a share of projects benefits.”

ESCAP (1998) describes community participation as: “An active process whereby beneficiaries influence the direction and execution of development projects rather than merely receiving a share of project benefits. The objectives of community participation are recognized as social empowerment, building beneficiary capacity, improving project effectiveness and project cost sharing.” This was in the context of a case study on best practices in community-based rural infrastructure planning, and concluded that: “The taking of responsibility by people for their own development is a better way to achieve improvements in economic and social conditions, and it is more likely to be successful, cost effective and sustainable. This way of organizing development is appropriate because it:

- Gives local people a direct and active stake in organising themselves to develop their areas economies;
- Encourages the mobilisation of local resources such as land, labor, savings, assets, plus indigenous knowledge of specific local conditions such as environmental and socio-cultural norms;
- Helps build the capacity of the people to effectively plan and implement projects;

- Increases community control over resources and development and promote greater self reliance;
- Enhances the sense of community ownership needed to ensure maintenance of completed projects; and
- Encourages more equitable distribution of benefits because project management is accountable to a more representative community".

According to the MCTPC-UNDP (1999), the World Bank's stance at the time was that "the participation of beneficiaries is central to the effective delivery of rural infrastructure; for participation to be successful, beneficiaries must be involved in decision making related to planning, design, implementation, operation and maintenance of rural infrastructure; they must also contribute in kind or cash at such a scale as to gain a sense of ownership of the infrastructure and a commitment to operating and maintaining it". (Quoted from the *Lao PDR Sector Memorandum; Priorities for Rural Infrastructure Development* of 1997).

In this context, community participation is something most appropriate for very local infrastructure, since it is tied to the issue of ownership. If it is to be linked to national infrastructure, then the definition of "ownership" needs to be examined carefully. For small roads, a Village Maintenance Committee can be the legal owner, and hence a relatively small and well defined number of people are the current "owners" as members of that community. In addition, because the road is, or should be, of direct benefit to them, they can be expected to take pride in its good appearance and serviceability. In this respect they can be said to have moral as well as legal ownership. For a highway of national level, legal ownership is vested in the government, which represents such a large number of people that it is rare for individuals to feel that they have genuine personal responsibility. The best that might be hoped for is some sense of moral ownership, if road neighbours have a strong acceptance of a large road close to their property. This can certainly be increased for people who receive a financial gain from it, such as through payment for maintenance work, particularly if it is a long term relationship. But it is entirely inappropriate for people in local rural communities to make a contribution in kind or cash to this level of infrastructure. It is probably true that by requiring people to invest time or money in something helps to bring ownership, but it requires a clear promise of a reward for doing so. This is a difficult link to make for a poor rural villager in connection with national assets, unless it involves the payment of wages for clearly defined tasks.

Ultimately the argument for community participation in rural areas comes down to the prevalence of poverty in those areas, the striking and increasing difference with the urban situation, and the relatively large investment per person to improve access. But it can also mean that the biggest personal burdens have to be borne by the people who can least afford them. A number of strong issues of developmental and ethical principles arise from this, and represent the main difficulties faced in the involvement of communities for the management of infrastructure.

6.2 General recommendations on community participation

It is widely suggested in the available development literature that community participation is an essential prerequisite for successful development in Laos. This is a perception that is expressed not just for infrastructure, but also in natural resources development, health and education, as well as in narrower fields such as mine clearance and the eradication of opium production. However, although this perception is everywhere clear, it appears simplest at the policy level but most complex at the operational level. There seem to be more recorded instances of community participation being seen as a need for successful development, than of it actually producing beneficial results.

A typical example of the approach as a general principle comes from DIPECHO (2005), which states that:

- "Community participation is essential for successful project implementation.
- Very good understanding of local culture is essential.
- Infrastructure should be built using locally available materials and labour, drawing on appropriate, high quality engineering design; ostensibly more 'sustainable' (yet poorly designed) structures (e.g. of concrete) have proved to be irreparable when damaged (by flash-floods for instance)."

The common misconceptions and misunderstandings of community participation are summarised by Jupp (1995) in a paper documenting the experiences of an infrastructure project in Bangladesh. "For many the idea that poor unskilled and uneducated people can contribute anything to development initiatives undertaken on their behalf beyond their labour and cash is unthinkable. They feel that planning decisions, including site selection and choice of technology, should be left entirely to the technical experts. If participation is embraced at all, it is limited to involving villages in manual labour and local cost sharing. It is assumed that contributions of cash and physical labour constitute a willingness on the part of the people to participate and indicate a commitment to the development scheme. This, in turn, is assumed to generate a sense of ownership of the facility and collective pride which will ensure its maintenance. These assumptions have been proved over and over again to be dubious. The fact is people will not value anything which does not meet their needs. If the location is inconvenient, the service too expensive and inadequate to meet their needs then regardless of whether they were involved in construction or cost sharing, the facility will not be used, will gradually fall into disrepair or will be abandoned altogether. There could have been a number of reasons why they became involved in the construction which may not correlate with the usefulness of the scheme. For example, it may have been regarded as a chance for earning daily wages, albeit minimal, or they may have been coerced by influential leaders".

The natural resources sector has considerable experience of community participation in development activities, internationally and increasingly in Laos itself. A recent general perspective is provided in the box below, which demonstrates how natural resource management by communities is often linked to developments of infrastructure.

Community participation in natural resource management

The communities that depend directly on natural resources are often disadvantaged because of little formal education, poverty or isolation. As a result, their voices are often unheard and their concerns unaddressed in decision making and policy development that affect their natural resources. Government officials, private economic interests and other stakeholders often do not value or understand the perspectives of local people and are less likely to include them in decision making.

Improving community participation in natural resource management is important for several reasons. Natural resource dependent communities are particularly vulnerable to environmental change or degradation. When new roads encroach on forests, local villages might struggle, transform or disappear completely. If water sources are contaminated or grow scarce, households cannot carry out daily activities such as cooking, cleaning and washing. Large-scale development investments, such as mines or dams, can threaten the very existence of communities. Communities should have the right to be able to protect their interests and livelihoods, and participate in the decisions that affect their natural resources and well-being.

Just as importantly, community participation in decision making promotes sustainable management. Politicians and businesses tend to focus on short-term benefits; communities have a much bigger stake in guaranteeing that natural resources are available for future generations. In fact, communities can be the most effective champions of sustainable management when given a voice in decision making.

There are other good reasons for community empowerment: participatory decision making minimizes conflict and maximizes equitable benefit-sharing. In fact, community participation does not have to be detrimental to other stakeholders; rather, including communities in decision making can create a win-win outcome where everyone benefits.

(Evans et al., 2006)

6.3 Road sector aspirations and experience of community participation in Laos

6.3.1 Ministry and Department level approach

This section assesses the ways in which the MPWT has gradually increased its interest in liaising with and calling upon communities to participate in its activities. The rural environmental context is important: the sparse, scattered population means that the provision of infrastructure has a relatively high cost per person, which is difficult for a resource-constrained country to afford.

The overall framework for community participation in the transport sector is summarised in the National Growth and Poverty Eradication Strategy (Government of Lao PDR, 2003). This states as follows.

> "Local communities are encouraged to participate in the processes of the planning, construction and maintenance of local road networks. Through this process, road planners can be made more fully aware of community concerns and aspirations, and the community itself can be better informed of what is being planned and how there are likely to be affected.
>
> Communities participate in the maintenance of access and feeder roads in their areas; local people supply labour and the Government assists with technical expertise and equipment. Local communities, looking to fight poverty, are to be paid in cash for their labour on feeder roads, for it would not be considered fair that such poor communities provide unpaid labour that would normally be put to productive use in agricultural or other subsistence earning activities.
>
> Increasingly, a community participation process is used for the selection of feeder/access roads and project identification. Once the village survey has collected the baseline data and identified the priority zones, community participation in road projects involves each village:
>
> - Identifying and prioritising village road infrastructure needs.
> - Identifying the activities that need to be undertaken to meet these needs.
> - Indicating who is willing to participate and/or take responsibility for project implementation and detailing individual inputs.
> - Selecting a project manager to ensure preparation of the work plan for implementation.
>
> Such a participatory approach will be followed when planning access/community roads."

The Ministry's guidelines for environmental appraisal (MCTPC, 1999b) list a number of ways in which roads can cause disruption to local communities, such as through forced resettlement, and in dissatisfaction over the distribution of labour opportunities and other benefits. A recommended mitigation measure is that "local communities should be given opportunities to provide labour on road projects and attention should be paid to providing training and experience in skills which will increase the employment potential of local people post-project". But this is only a general manual and it does not offer suggestions as to how this should actually be achieved.

The MCTPC-UNDP (1999) reports the successful outcome of community participation supported by its Pilot Project on Participatory Planning of Rural Infrastructure, in the first three main phases of a project: planning, design and implementation. It drew on the experience of the International Labour Organisation in integrated rural accessibility planning (IRAP) and introduced participatory activities at both the district and village levels. This showed that there are various methods to involve people in planning physical developments for their villages, some more time-consuming than others. It demonstrated how close involvement of the local people through the whole process led to firm commitments during project design, which were then translated into actual participation during implementation. At the village level this seems to have worked effectively, though mainly on very small construction activities like water supplies, and few roads were attempted. It is also clear from this document, though not explicitly described in the text, that participation was only achieved through the provision of significant staff inputs by the project, to add to the limited resources available to the existing authorities at district level.

In its strategic document, the MCTPC (2000) made one of its nine goals "to encourage community participation in the planning and execution of road sector activities". Under this were the twin objectives of developing guidelines for, and involving village communities in, the construction and maintenance of district and village roads. The rationale given was that this would help planners to provide what communities really need, and for implementation might typically involve a partnership with government, with at least a portion of the labour coming from the local community. The supporting information behind these objectives acknowledges that, while popular involvement in planning is essential to aid the proper targeting of resources, it must be managed carefully to avoid possible dissatisfaction if groups then feel that their interests have been overlooked. It states that, while the sparse population means that involvement in maintenance is more straightforward than in construction, "there have been some limited examples of community participation in road maintenance in Laos, but there are issues to be resolved in regard to formal contracts between the provincial authorities and village groups." The IRAP process, then relatively new in Laos, had initiated consultation early in the planning process, but did not extend it through the design and implementation phases. The key components of a successful community participation programme were seen as:

- obtaining government support for the approach;
- starting early in the planning cycle and consulting broadly;
- identifying and involving the stakeholders;
- encouraging villages to build alliances and trust in the community;
- being open with information;
- continuity of contact with concerned parties;
- using appropriate techniques to encourage participation from weaker or reticent groups; and
- develop agreed procedures in advance for identifying, debating and resolving differences.

The proposed strategy would build on the achievements made in IRAP and other programmes, to develop a wider use of community participation in local roads using established good practices.

In an economic study of the linkages between roads and poverty in rural Laos, Warr (undated) did not mention the value of community participation as such. However, he calculated that road improvements could be attributed as the factor responsible for 13 percent of the overall reduction in poverty, and deduced that new roads where none exist are a very important consideration in the livelihoods of rural people, and probably well worth the high investment required.

In its five-year maintenance plan for local roads, the MCTPC (2004b) planned to use labour-based methods for as many routine maintenance activities as were appropriate: this mainly amounted to inspections and checks, cleaning drainage systems, and clearing debris and bushes. The labour-based work was costed at a wage rate of 25,000 Kip per day, leading to an overall estimate of 966,856 Kip per kilometre per year. Obviously this did not allow for daily interventions, but for a number considered relevant in each class, such as 40 per year for "inspection and move obstacles" at the rate of one person covering 5 km. The plan does not make any mention of community participation, but it is purely financial in coverage and does not describe any of the anticipated implementation arrangements.

A new Rural Transport Infrastructure Policy was due to be published in 2008. This is expected to lead to a number of procedural revisions in MPWT operations, but not to any major new strategies.

6.3.2 Local Roads Division approach

In the Department of Roads, it is the Local Roads Division (LRD) that is best placed to work with communities. While the Roads Administration Division is responsible for national highways, the LRD is responsible for overseeing the construction and maintenance of provincial, district and village roads through the DPWT in each Province. The LRD currently receives international support for its activities, with the World Bank assisting in the financing of provincial roads, and SIDA supporting activities on district and village roads. This comes under the Lao-Swedish Road Sector Project-3 (LSRSP-3), which has two main elements: the Maintenance Component, which seeks to improve periodic, routine and emergency maintenance; and the Basic Access Component (BAC), that aims to develop the lowest level of village link roads, so as to help reduce poverty through better access and support to rural development in the 26 poorest districts in the eight northern provinces of Laos. This project is intended to provide the most basic vehicular access to as many villages as possible that have none at present, and plans to support construction of 1000 km of roads in the four years from 2005/06 to 2008/09. Its strategy includes the full use of a participatory approach that takes into account people's rights, consideration of the needs of men and women, consideration of ethnic diversity, and different dimensions of poverty.

The BAC uses a process called Participatory Rural Transport Planning (PRTP), derived from the Integrated Rural Accessibility Planning approach, through a Community Road Model (CRM). This works closely with rural communities to identify and prioritise interventions on the basis of established criteria. Village roads cost on average about US $ 600 per kilometre, and are designed to carry only low volumes of light traffic. They are generally unsurfaced tracks, perhaps seasonal, of 3.5 to 4.5

metres in width and with very low specifications, and minimal structures. The LRD provides hand tools, including rollers, and benefiting villagers are expected to provide labour inputs that might equate to as much as 50 percent of the total road cost. This participatory labour is used for initial track opening, earthworks and drainage, and the LRD then engages small contractors to undertake minor structures and some surface improvements.

The CRM (described in MCTPC, 2005b) is now a well established procedure. It has the following ten main steps, which are given here because they demonstrate a practical approach to community involvement in the road sector.

1. Solicit applications: taking access as a basic need, communities are asked to submit an application if they wish to receive support in constructing simple access routes.
2. Data collection in the candidate communities, which involves representative gender-segregated and gender-balanced consultation groups to assess and rank village problems and needs. This leads to a prioritised inventory of road options.
3. Prioritisation of LRD interventions. This is based on: (a) screening of potential projects, to ensure that they serve adequate needs to justify the investment; (b) socio-economic ranking, to ensure that projects will have an adequate socio-economic impact; and (c) a cost-benefit assessment to check the ratio of total government cost to the population served and likely economic benefits. Communities have a right of appeal if they do not like the results of the screening.
4. Project profile and design: the highest potential projects are then subjected to an alignment and design assessment. There is further community-based discussion at this stage, as the people are given opportunities to discuss options and issues of long term sustainability. Technical feasibility is one output of this step; another is the determination of village versus government contribution. This last element is acknowledged as being very difficult to assess fairly, and there are various criteria used to judge appropriate responses from the village. This step ends in a project proposal document, that provides an accurate record of what has been found and agreed.
5. Environmental assessment, which looks mainly at biophysical issues (e.g. impacts on forests, soil erosion, etc), since socio-economic matters have mainly been addressed already.
6. A Village Maintenance Committee (VMC) must be put in place before implementation can start. This is selected by the villagers and originates as part of the PRTP process; if a proposed road serves more than one village, then the VMC must be representative of all the communities it serves. Often Village Heads are nominated, but in general the intention is to keep the VMC separate and avoid over-burdening the existing local administration. The VMC must sign, with the local authority, a Road Management Agreement that defines the community's contribution to construction and maintenance. The maintenance contribution is based on two free days of labour by each household per year, and needs beyond this (for example on very long roads or in unstable terrain) may be covered by a government subsidy. However, the maintenance contract form states that "The guiding policy of the government is that routine maintenance works should be carried out on a non-paid basis by the VMC". The VMC is given the authority to close the road to traffic of a size above its design standard, in order to limit the maintenance burden. Land compensation is also covered at this stage of the process.
7. Construction and procurement: this starts with training of the VMC members by the DPWT, so that these villagers are able to procure the necessary equipment support and contractors, and organise the villagers' labouring work.
8. Awareness or "road-wise" training: this introduces villagers to the type of problems that may arise through their new road, and is intended to improve their ownership and sense of responsibility. In addition, training is needed to ensure that people will benefit from the advantages that better access brings, and that they do not become vulnerable to negative influences.
9. Monitoring of the condition of the access: the new road link is formally taken into the DPWT's network monitoring programme.
10. Evaluation, to assess how far the intended impacts have been achieved. There are various ways in which this can be achieved.

There appears to be a conflict here between the Ministry's policy ("The guiding policy of the government is that routine maintenance works should be carried out on a non-paid basis by the

VMC": MCTPC, 2005b); and the policy stated in the National Growth and Poverty Eradication Strategy ("Local communities, looking to fight poverty, are to be paid in cash for their labour on feeder roads, for it would not be considered fair that such poor communities provide unpaid labour that would normally be put to productive use in agricultural or other subsistence earning activities": Government of Lao PDR, 2003).

6.3.3 Participation in road maintenance

There are no published guidelines for community participation in maintenance except those produced by the LRD/LSRSP-2 in September 2002 as part of a set of Road Maintenance Procedures for Local Roads (MCTPC, 2002). The financing system that was proposed by this document was based on the following stance. "The VMC undertakes to keep the road in a specified standard as described in Section 4.2 Performance Criteria. As the villages are the owner and the main beneficiaries of the road they do not receive full payment for their work but they receive a subsidy to support their effort to maintain the access and preserve the road network. The size of the subsidy depends on funding that can be made available." Subsidies would normally be paid for more complex work, such as re-profiling the camber, but not for simpler activities such as cleaning drains. Payment systems are also quite flexible: for example, a VMC could opt to provide free labour for certain activities so that government funds were used to build culverts to make the road less seasonal. It is therefore intended to be a fair and equitable means-tested approach to finding a sustainable funding arrangement for low-traffic rural roads. Administration at community level was envisaged by the LRD to be through a Community Roads Engineer stationed in the OPWT, supported by a number of Community Road Inspectors.

A review of rural road maintenance made in 2004 (ASIST-AP, 2004) concluded that the VMC model "can work well in the following circumstances:
(a) the road is short (normally not exceeding 5 km) and specifically serves a village or villages close to each other;
(b) the VMC is highly motivated, well organised and effectively led;
(c) the VMC receives adequate and timely support from the DPWT and OPWT in the form of training, guidance, tools and funds; and
(d) there is effective supervision and inspection with payment (e.g. of subsidies) related to satisfactory performance."
But despite this, the review felt that it was not necessarily appropriate to use the VMC model as part of a response to weak capacity in OPWTs. "In the absence of these conditions, maintenance work based on voluntary contribution is difficult to organise and supervise effectively, leading to productivity and quality control problems. On a long road serving a number of villages or a district road, the VMC model is unlikely to work. It is a mistake to think of a contract with selected community representatives (VMC) as a binding contract which commits the whole village. The VMCs or the CMC will find it difficult to motivate voluntary labour contributors to work effectively on roads which benefit a wider population and other users (for example, commercial vehicle operators) of the road because the commitment based on ownership will be lacking. It is proposed that the supervision of works will be done by the VMCs or CMCs. If the VMCs are contractors, they cannot also be supervisors and managers of funds. The precise role of VMCs and their accountability and the separation of the contractor and supervision and management roles need to be clarified. There is conflicting evidence on the willingness of villagers to make voluntary contribution of labour. LRD has found that in LSRSP-2 and RMP-supported projects, it has been possible to set up some VMC-based maintenance arrangements on short roads serving one or two villages. A study for the RMP project proposal [published by the World Bank in 2001] found that while paid employment would make a contribution to the rural economy, there was an unwillingness to contribute voluntary labour. Relying on voluntary contribution based on VMCs is unlikely to be effective for district roads and the more important longer rural roads."

In its conclusions, the ASIST-ILO (2004) review went further. "In examining maintenance options, all District and Rural roads are at present lumped together to be maintained by the voluntary contribution based VMC model with the CRM model proposed for improvement. The most important conclusion of this paper, from which all recommendations and implications follow, is that this treatment for all District and Rural roads is not an adequate strategy for this road network." However, the review recorded a positive finding with regard to rural employment if wages are paid, and this was certainly seen as an important part of the way forward. "Labour-based methods are now accepted for routine maintenance on all categories of roads in Lao PDR. Their suitability for periodic maintenance and improvement has also been demonstrated in Lao PDR and elsewhere. Labour-based methods are expected to be cheaper and would also contribute to the employment generation and poverty alleviation objectives."

6.4 The Lao agriculture and forestry sector's experience with community participation

6.4.1 Upland agriculture: shifting cultivation

In 2000, 39 percent of Lao's population depended on shifting cultivation (see section 5.1), covering 13 percent of the country's total land area. A cycle of 20 to 25 years is estimated as being necessary to allow forests to recover, though this seems to be based on the re-establishment of forest vegetation and canopy cover, rather than soil conditions, which may take longer. With much shorter cycles increasingly the norm, the government views shifting cultivation to be unsustainable, and therefore intends to stop it by:

- making agriculture sedentary through diversification and agroforestry;
- opening market access through feeder roads and market information;
- land allocation and land use entitlements;
- land use zoning based on slope and land capability; and
- rural savings and credit.

The approach to this is very much top-down in nature. Previously, governmental decrees made shifting cultivation illegal, but implementation of these was poor. A conference in 1989 proposed land allocations, and since then policies have been centred on "stabilisation". Land and forest allocation is the main way forward for the government, that "wants 'settled' upland communities practising permanent agriculture on defined land parcels, with access to infrastructure and social services, linking them to wider economic and social systems" (NAFRI, 2005).

Opium cultivation is seen as a special problem, brought about by the lack of upland paddy sites. There are many strategies to control the growing of this drug, and in recent years considerable steps have been made towards its eradication. This demonstrates that central government decision-making and policies can be highly effective in the Lao PDR.

The MAF's Land Use Planning and Land Allocation process takes communities through an 8-step participatory exercise. From 1996 to 2002, land allocation took place in 6,200 villages (more than 50 percent of the total) and more than 379,000 households (more than 60 percent of all agricultural households), covering some 8 million hectares. This is described as one of the clearest forest sector policies.

A "Focal Site Strategy" is also being used, in conjunction with village relocation and consolidation. The strategy is used to test out and demonstrate the implementation of development interventions in a range of areas and conditions, and it has been working for about ten years. Reviews have shown that village participation is unconvincing, though there is still potential for bottom-up participation in planning. Re-focussing in recent years has included the relocation of scattered families to sites with better access to extension and development services: this has resulted in a number of new villages along road corridors. Most of this is in upland areas, as settlements have always tended to be more settled in lowland areas, even if cultivation was rotated from place to place around each village.

All these policies put emphasis on an approach for decentralisation. This process is defined in a 2000 directive that redefined central-local relationships so that:

- the centre is the policy and target-setting body;
- the provinces are strategic planning units;
- districts are planning and budgeting units; and
- villages are implementation units.

But central targets mean that decisions tend to be delegated to provinces and districts, irrespective of the capacity and resources available to implement the tasks required to achieve the targets.

The current situation regarding rural livelihoods in Laos can be summarised as follows (NAFRI, 2005).

- Shifting cultivation systems and farming practices are diverse and are most common in the uplands.
- These farming systems are not static, and most are progressively evolving into more sedentary forms of agriculture.
- Government policy, population increase, social change and market integration are all major factors for change.
- Fallow periods are generally becoming shorter, making the systems less and less sustainable.
- Slash-and-burn agriculture is practised by all ethnic groups and has an important socio-cultural dimension.
- Upland rice is still the major crop grown by shifting cultivators, in association with several other crops and including some cash crops.
- Besides crop production, shifting cultivators are also involved in livestock production and the collection of non-timber forest products, which generally represent their major sources of income.
- The majority of shifting cultivators belong to the poorest section of society and are presently the focus of most rural development programmes.
- Shifting cultivators possess an intimate intuitive understanding of their biophysical environment, which can be combined with scientific knowledge to develop sustainable alternative land management practices.
- Shifting cultivation includes a range of both disadvantages (e.g. destruction of forest by cutting trees and devastation by fire, pollution from smoke, the extensive use of land, unsustainability under high population densities and a low level of socio-economic development), and a number of advantageous features (e.g. adaptation to forest farming in highly varied environments, low incidences of crop pests and diseases, independence from market unreliability and maintenance of agricultural biodiversity).

In 2004 a major conference was held to discuss issues around poverty reduction and the stabilisation of shifting cultivation in the Lao uplands (NAFRI, 2004). It is clear from the proceedings that although a great deal of headway has been made on these matters, considerable further work is still needed. While there are extension services working with many communities, they need greater capacity in terms of staff capabilities and levels of resources. Greater linkages are needed with both credit agencies and the private sector to boost people's ability to respond to market opportunities as a step towards higher levels of rural economic activity. Much of the conference focussed on difficulties in the institutional and agricultural systems behind upland management, but there were some interesting findings on extension services (i.e. the agencies responsible for managing community participation). Among these were the following.

- The extension system must be localised to the extent of including village representatives, who must be paid for their services. This is necessary to close existing gaps in communication and the resulting lack of co-operation.
- It is necessary to shift responsibilities for extension from government to local communities to create ownership. This can be achieved through groups of farmers, farmer-to-farmer extension and a changed role for district staff to act more like "facilitators" rather than "implementers".
- It is necessary to understand reasons for slow development and change. Lessons show that people need to be made aware and take decisions on their own, and that approaches are more fruitful if they are process oriented rather than target-driven.
- Lack of appropriate infrastructure: greater sectoral co-ordination was seen to be required to expand access and opportunities.
- There are risks that the poor and the women are forgotten in extension work, and experience shows the need to ensure that both groups are targeted.

Beyond this lies the importance attached to the development of village capacity to enhance community opportunities. The following main issues arose, many being thought to require greater time devoted to development initiatives in order to achieve success.

- Remote upland villages only understand shifting cultivation for survival, and need extension material in local languages to explain and motivate people about alternatives.

- Communication difficulties arise due to local variations in language and culture.
- Villagers do not necessarily listen and learn from outsiders. It may be better to apply farmer-to-farmer approaches for the transfer of ideas, and work with groups of farmers and clusters of villages.
- Upland villages often lack knowledge of, funding for, and access to markets. There is a widespread need for introducing the concepts of savings and loans, and to try to link up with the private sector.
- The lack of a "database" of knowledge and ideas being used or tested: many agencies are working in isolation and not sharing information to build up a body of accumulated knowledge. This finding was part of the impetus for NAFRI to put together its comprehensive sourcebook *Improving Livelihoods in the Uplands of the Lao PDR* (NAFRI, 2005).
- Shifting cultivation practices are labour intensive and time consuming with little reward, and it was suggested that there is a possibility to apply opportunity cost thinking in discussions with villagers. Focussing support on livestock and fisheries, as rewarding permanent agricultural practices, was seen as a useful potential starting point.

6.4.2 Management of forests by communities

The government's long term forestry strategy (MAF, 2005) makes it very clear that community participation is a key part of the sector's future: "the participatory approach to development and management is the official policy of the government as supported by the Forestry Law, the Water and Water Resource Law and other legislation, decrees and instructions". It is intended not just to involve rural villagers in the management of forests, but actively to boost their capacity to do so. This applies to a whole range of sectoral objectives, in timber production, utilisation of non-timber forest products, watershed management and biodiversity conservation. A number of mechanisms are being used to achieve this, including a Profit Sharing System for plantation establishment on a joint government-farmer arrangement.

Community forestry has been developed along a number of different models in Laos. A useful summary of these is given in NAFRI (2005). Part of the reason for the differences is the involvement of different donors, but the most significant determinant is the difference in the environments in which they have been tried. Two models have addressed the management of heavily forested areas, primarily in the southern lowlands: these are the Joint Forest Management Project of the Lao-Swedish Forestry Programme (JFM) and the Forest Management and Conservation Programme (FOMACOP). These have had the primary aim of developing participatory approaches to the management of natural forest, as a way to increasing opportunities for livelihoods enhancement using current forest resources. The other two models, which have addressed moderately to severely degraded areas in watersheds and the uplands, are the National Watershed Conservation Project (NAWACOP) and the Forest Conservation Project (FORCAP). These have focussed on participatory approaches to the rehabilitation and management of degraded watersheds, mainly through plantation forestry and agroforestry, and a range of livelihood options as an alternative to shifting cultivation. The main difference is that the first two approaches mainly involve the management of existing natural forest, while the second two approaches seek a range of other activities to replace the limited resources available from the degraded forest. Within each of the projects there tend to be different models for the actual management arrangements, and although they have all stressed the need for partnerships between the state and villagers, the degrees of bottom-up and top-down planning vary between the models. The result is that there are numerous different models for community forestry in Laos, rather than a single general model. Given the variations in terrain, forest condition and conservation needs (such as biodiversity or watershed condition), as well as socio-economic and cultural differences between participating groups, this is inevitable in a country with the rich diversity of Laos. It is clear, however, that Laos now has quite broad experience in operating a range of community forestry initiatives, and there is considerable knowledge that can be applied to future participatory activities, depending on the particular needs of the local situation.

NAFRI (2005) also describes the assessment methods that are used in village forestry to enhance community participation. There has been a tendency to focus more on bio-physical data to support forest management, but increasingly attention is being paid to socio-economic information. The main needs are seen as follows.

- Indigenous systems of forest resource classification and management.
- Traditional social groups and their decision-making authorities and capabilities.
- Customary tenure rules governing traditional use rights in land and forest resources.
- Gender differences in knowledge and use of forest resources.
- Economic strategies and household livelihood systems.
- Classification of the different livelihood systems found in a village (agricultural, forest-related and other).
- Diagnostic assessment of the needs and opportunities of different livelihood systems and social groups.
- The villagers' own assessments of what their most important problems are, what strategies they use in overcoming these problems, their own perception of possible solutions, and the opportunities they themselves would like to pursue.

Experience has shown that qualitative assessment is often more important than quantitative measurements. An example is over the status of both quantity and quality of non-timber forest products, as both are obviously very significant. Villagers are usually more familiar with qualitative appraisals, and these can help to increase participation.

A number of lessons recorded by the Lao-Swedish Forestry Programme (LSFP, 2001) are generally applicable to community participation throughout Laos. Perhaps most significant is that the village organisation for joint forest management (JFM) is best linked to the existing Village Committee. This is because separately elected community boards led to conflicts of authority and power, largely because the forest management board controlled far bigger resources than the Village Committee. In a number of cases the conflict worsened until all activities were stopped, though the situation could best be resolved by incorporating all members of the Village Committee on the JFM Board. The LSFP also found that the management of natural resources around a village need to be planned holistically to provide the optimum benefits for the community. Even in areas of the country with good natural forest, villages tend to have a scarcity of other resources, such as rice growing land, and shortfalls in one resource puts pressure on another. In order to achieve a balance, therefore, a comprehensively planned approach is necessary. The implementation of JFM activities by villagers is strongly influenced by the specific history and coherence of the village community, a feature that can vary between villages over short distances. Project responses had to be sensitive to this in designing the support and agreed courses of action. Technical understanding of forest dynamics was found to be limited, and some practices clearly still need to be supported by in-depth research to ensure that agreed management practices are both appropriate and sustainable.

The management of natural resources rarely comes without conflicts. A study by Hirsch *et al.* (1999) examined conflicts at different scales in the community management of resources in the Nam Ngum watershed. After it had been chosen as the site of the dam and reservoir, many parts of the watershed were the target of projects to improve management, partly because of the large amount of resettlement and partly to reverse degradation of the forests. The FORCAP model of participatory forest management was used here (see above). Intensification of resource use was already underway through population increase, changes in shifting cultivation and the long term effects of disruption and displacement during the war; but development of the basin for hydro-electric power made this more significant. There are over two hundred villages, comprising a number of ethnic groups and split most noticeably between lowland rice farmers and upland shifting cultivators. Although some communities are long-standing and fairly stable groups, many have been affected by the movement of themselves or others as a result first of bombing in the 1960s and 1970s, and then of resettlement in the 1980s to stabilise shifting cultivators and in the 1990s for people displaced by the flooding of the reservoir. Where upland people have been brought into lowland areas there are particular conflicts on resources, as forests are suddenly far more over-used. Administration changes to boundaries and weak responses to the Decree 169 and Forest Act provisions for participatory forest management have also made the situation worse in some villages. This study revealed a wide range of differing problems between communities and showed a need for management systems based on local needs and knowledge, not a general watershed-wide approach. It revealed that conflicts can easily be generated within communities and between neighbouring communities, as a result of changing pressures on resources. These are often made worse by lack of clarity in tenure rights and the activities of district authorities.

6.5 Decision-making at community and household levels

There does not appear to be much recorded information in English about decision-making at community and household levels, although some indications can be found in project reports and other publications. The paragraphs below provide a review of some of these.

It has generally been found in joint forest management work that villages have systems for distributing community work equitably between households. "The division of work is built upon village units ('nouai') within which a certain number of households are grouped. More work is allocated to units with more households resulting in an equitable distribution of the revenues generated by logging related work within the community" (LSRP, 2001). The decision-making process for this is not recorded, and presumably varies considerably between different ethnic groups, but it does demonstrate that village-level decision-making is generally well developed and equitable.

A study of household finances among ethnic minority groups shows variations between the different peoples at household level (MCBRP, 2005). All rural groups have irregular household income streams determined by the seasons and it is taken as natural that savings are made at certain times of year when there is surplus cash, to cover deficits at other times. Across all the groups, the majority of cash is used to buy food and medicine according to actual needs and without any dispute. The Hmong were found to be the most likely to use savings as investments in income-generating activities. On the subject of gender divisions in the control of household money, MCBRP (2005) states this: "Traditionally, ethnic minority women have played a major role in the economy in rural Laos. They have been in charge of marketing cash crops and running micro-enterprises and have had significant control over resources in their role as household financiers, a role they are expected to carry out with their husband". In fact, their survey found that about half of all spending decisions were made by husband and wife together, and the remainder were made almost equally by one or the other. Between ethnic groups, the general pattern was that women in the north of Laos have more control over household finances than those in the centre and south. Among the Khamu, women have the greatest level of control. By contrast, the Tri in central Laos showed a very male-dominated society.

The Hmong are the largest ethnic group in northern Laos. Before 1975 many were organised by the Americans against the Lao revolutionary forces that eventually formed the government from December 1975 onwards. The Hmong were then abandoned by their external backers, leaving them to fend for themselves as best they could. Disaffection is now greatly reduced, but this historical legacy means that there is a limited tradition of the participation of this group in decentralised resource management.

Gender disparities exist in Laos, though they are not as acute as in many countries. To help resolve this, a number of projects in both the road and forest sectors have specific measures to ensure that women's voices are heard separately from men's, and opportunities are provided for benefits particularly for women (LSRP, 2001; MCTPC, 2005b).

Decision-making at the village level is often imposed following directives made at a much higher level. An example is recorded by Jones *et al*. (2004) in a case study from Luang Prabang Province, where a number of Hmong villages were being relocated into Khamu areas. This was supported by the new settlers, and representatives indicated they would derive the following benefits from the move:

- access to roads and transportation;
- access to markets to buy and sell commodities;
- improved access to health services and better educational opportunities; and
- access to better domestic water supplies.

This paper records how the Provincial Governor's decision on certain grounds led to the village communities needing to make their own decisions on the basis of other criteria.

> "The Governor's Office indicated that the plan for relocation and village merging in Phonesay District aims to reduce the total number of 72 villages to 41 villages by the year 2005. An examination of the *District Relocation and Village Merging Plan - Phonesay District 2001-*

2005, indicates that this would entail the movement of [1,725 families and 11,472 people] between the year 2001 and the year 2004.

Relocation may be justified and undertaken for any one of the following reasons.

- villagers live in sensitive or critical watersheds,
- villagers grow opium in mountainous areas,
- provision of extension and development activities is difficult,
- settlements have less than 50 families, and
- villages are located outside of 'focal sites' or 'growth centres'.

The plan is not supported by any livelihood or land use analysis and leaves much of the responsibility for relocation with the communities themselves as indicated by an extract from the plan [presented in the paper]."

7. CONCLUSIONS FROM THE FINDINGS

7.1 Decision-making in the Lao road sector

Road management in Laos is divided between National Roads, under the Road Administration Division, and Provincial, District and Rural Roads, under the Local Road Division. Responsibility for implementation of management activities is decentralised to the Provincial DPWTs, with the central divisions retaining the remit for planning and monitoring. Budgetary control is kept at the centre, with approval from the MPWT required for the letting of contracts by the DPWTs.

Maintenance activities are planned annually through the Road Management System for National Roads and the Provincial Road Maintenance Management System for Local Roads. These both follow a computer-based, menu-driven format, that channel decisions of maintenance interventions into a relatively narrow set of options. These are particularly restricted for off-road problems. While these systems are effective, they tend to dominate the decision-making process at road section level. Priorities are set through the computerised systems, but the level of expenditure is determined by a five-year rolling budget. Limited resources for maintenance overall mean that the centralised decisions on allocations between the Provinces are often not ideal.

National, Provincial and District Roads are managed by the DPWTs under central direction, and all works, including emergency maintenance, implemented through contracts. Community involvement is only in the lowest category of Rural (or Village, Community or Access) Roads. In order to open up the most isolated villages to vehicular transport, a Basic Access Component under the Local Road Division is supporting construction of low standard earthen tracks. While the planning and control of this programme remains with central and provincial government, local communities are heavily involved in detailed planning. A Village Maintenance Committee (VMC) must also be formed to trigger government support, and this must arrange for part of the earthworks construction and the subsequent maintenance along prescribed guidelines.

Routine maintenance activities are labour-based on all categories of roads. The contractors employ local rural people to do these jobs, but so far there have been no attempts to contract this work to community-based groups other than the VMCs for the lowest class of road.

7.2 Rural communities and their management of resources in Lao PDR

The pattern of settlement in the Lao uplands has always been dynamic, dominated by a long tradition of shifting cultivation, disturbances due to war and, most recently, a changing socio-economic situation and government policies leading to resettlement to permanent villages. As a result, the communities are not as well established or firmly settled in the environment as is the case in many other parts of Asia. There is also a lower person to land ratio than in many countries, which means that common resources are generally not as intensively used as in other parts of Asia where community management has necessarily been developed to a considerable extent. Much remains to be understood by government agencies and development workers, of technical issues in both socio-economic and bio-physical systems.

The considerable experience of community participation in the combined agriculture and forestry sector has provided some useful lessons. It is clear that management arrangements and decision-making need to be based closely on local needs rather than to follow a centrally-developed model. As a result of this local focus in responses, arrangements for community resource management tend to be very varied, with less of a set approach than is the case in some countries. Because resources are very limited in most villages, management groups need to be linked to the existing Village Committee to ensure that conflicts of authority are avoided. For the same reason, resource management needs to be planned holistically, for example with forests, irrigation systems and road maintenance covered by a single broad arrangement.

There is evidence that many communities have quite well developed and equitable ways of dividing common work between households. Within families, women are often equal partners in decision making. However, in both these matters there are considerable variations between ethnic groups and geographical areas.

7.3 Community participation in SEACAP 21 research

Following an in-depth review of possibilities, the SEACAP 21 consultants have concluded that community participation in this research project is not appropriate for the following main reasons.

- The project's trials are being undertaken on National Roads. These are owned and managed by central government and there is no mechanism for the involvement of local communities. National Roads are of high economic importance and works must be carried out to a high standard, requiring skilled trades.
- The slope stability problems are large and complex. They require specialist skills that are not yet fully available in Laos, and certainly not in rural villages. It is not therefore appropriate to involve local communities in decision making on SEACAP 21 trials (although on some sites local people are useful witnesses of historic landslide activity).
- There are no organised community groups to be found in the areas of the trial sites, that have any experience of working on public infrastructure. Raising such groups in an equitable way requires special skills and a considerable amount of work. A great deal of training and a high level of works supervision would then be required. The SEACAP 21 team does not have the capacity to do this at present. While additional resources could be requested from DFID, there is no clear way that such an approach could be made sustainable beyond the project.
- There is no precedent for working with community groups on National Roads, and the procedural changes required to initiate such an approach would probably lead to considerable delays. SEACAP 21 does not have a long enough time frame to be able to accommodate this risk.
- Because of the low person to land ratio in Laos, there is not as much pressure on natural resources as there is in other parts of Asia, and so marginal land is not so important in supporting rural livelihoods in Laos. This means, for example, that while bio-engineering sites could specifically use plants yielding potentially valuable non-timber forest products, there is limited incentive for communities to manage them on steep and dangerous rehabilitated landslides.

Following discussions with staff in the Local Roads Division, particularly the Basic Access Component of the LSRSP-3, SEACAP 21 has proposed a broadening of its remit to include slope protection activities on local roads. These would have to be implemented through existing community groups in the form of Village Maintenance Committees. This is seen as being an excellent way of avoiding all of the difficulties outlined above, to achieve community participation via groups that already exist, in several ways.

- The lower specifications for access roads would mean that a significant proportion of the works, perhaps all of them, could be undertaken by communities managed by VMCs.
- Slope protection measures could be designed that allowed a considerable degree of decision making by local communities, although some technical guidance would always be required.
- Communities would be working on roads where they already have a degree of "ownership", and this would be strengthened through the broader responsibilities that would be required.

- There are excellent possibilities for cross-sectoral resource management. In particular, bio-engineering methods could be linked to the production of non-timber forest products in the less dangerous sections of roadside slopes.

7.4 Options for community involvement in slope management

The table below summarises the various options available for involving communities in slope management and off-road maintenance activities.

Summary of the options for community management of roadside slopes

Possible mechanism	Advantages	Disadvantages
Require regular contractors to employ a certain minimum proportion of local people among their labour forces.	• Easy to administer and monitor. • Reduces the need for itinerant workers and the social and environmental problems associated with work camps. • Ensures that cash is directed into the local economy.	• Contractors often have a standing workforce which they move from site to site. Locally recruited labourers can be unskilled and uncommitted. • It is difficult to ensure fair and safe employment.
Make provision for small-scale works, particularly bio-engineering, to be implemented by local small contractors.	• Allows the development of a cadre of specialist small contractors with particular skills.	• Skilled small contractors do not yet exist. • Small contractors tend not to be able to move around the country. • There are difficulties in sub-contracting small work packages on a large site. • Greater administrative burden on MPWT.
Contract an existing Village Maintenance Committee to undertake works.	• Mobilisation and organisation are already complete, greatly reducing the set up work required. • The Committee is already responsible for the road asset and likely to accept more work. • Local "ownership" of assets can be guaranteed through the long term involvement of local people.	• Off-road activities may not be seen as a priority. • Restricted to Rural (Village) Roads.
Contract existing well-organised groups (such as forest users) that are already active close to the site.	• Mobilisation and organisation are already complete, greatly reducing the work required in setting up.	• The contracted works may not be given the priority desired by the DPWT. • The group may not have the right skills. • New procedures would be required.
Organise specific groups to undertake bio-engineering or vegetation management activities.	• A group with particular interest in managing the vegetation can be chosen, with the right skills. • The group's attention will be focussed on the tasks required, not on other works.	• Requires special skills and much work to set up and manage specific community groups of this nature. • It may not be possible to generate enough work or economic benefits to ensure the sustainability of specific groups. • New procedures would be required.
Contract the village leadership to undertake works.	• Local "ownership" of assets can be guaranteed through the long term involvement of local leaders. • Works would be managed by persons accountable to the local community.	• The contracted works may not be given the priority desired by the DPWT. • Difficult to withdraw if the arrangement does not work.

Possible mechanism	Advantages	Disadvantages
The DPWT directly engages lengthworkers or gangs drawn from local communities, through small seasonal or annual contracts. This is a form of small contracting, not a return to the force account approach abandoned by the MPWT in the late 1990s.	• Local "ownership" of assets can be guaranteed through the long term employment of local people. • Workers are always available when required.	• Requires committed management by the DPWT. • New procedures would be required. • Greater administrative burden on MPWT.

7.5 Institutional development

The terms of reference require the SEACAP 21 consultants to provide "recommendations on changing the institutional set up within the public sector and the international donors", to help "determine community ownership and government responsibilities" and the transfer of the project's recommended new approaches. It is too early in the project to be able to do this, although a few general comments can be made.

- Routine and periodic road maintenance interventions are focussed almost entirely on the road and its side drains, and need to be broadened out to include slope drainage and stability issues.
- Emergency maintenance is entirely responsive to problems that are already threatening the road. Ways need to be introduced to initiate preventative action before an emergency is created.
- If the MPWT is to use community groups more widely for off-road maintenance, then it will need to introduce a new set of procedures and recruit staff with the right skills to mobilise communities and support them in implementing works. This is likely to be a long term process, and would involve a change of approach and thinking by a significant proportion of sector staff.

Further recommendations will be developed during the course of SEACAP 21's trials and information dissemination.

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