CHAPTER 4 PROJECT FORMULATION AND EVALUATION

4.1 Project Formulation of Priority Projects

4.1.1 Preliminary Road Design

(1) Design Standards and Specifications

The design standards and specification applied to the priority projects are tabulated below. The Road Design Manual, generally applied to the road projects in Lao PDR, was used as the basis for the design of the priority projects while other standards and manuals were used in a supplementary role in this study.

Table 4.1.1 Design Standards and Specification Applied

Design Items	Design Standards and Specifications	Remarks
Geometric Standards	● Road Design Manual 1996 (MPWT) ● AASHTO- A Policy on Geometric Design of Highways and Streets ● Road Structural Ordinance (Japan) ● Asian Highway Standards	
Pavement	● AASHOT- Guide for Design of Pavement Structures 1993 ● Overseas Road Note 31 (TRD), England	● Asphalt & Concrete ● DBST
Bridge	● Design Specification of Highway Bridges (Japan) ● AASHTO LRFD Bridge Design Specifications	

(2) Road Class and Design Speed

Roads in Lao PDR are classified into seven classes, depending on functional classification and traffic volume as defined by the Road Design Manual. The NR-9 was upgraded under Japan’s Grant Aid with assistance from ADB. Specifications of Class II, determined by the future traffic demand for the target year of 2020, were used for the project.

The improvement of NR-15A will be undertaken by ADB and its road class will be defined by the forthcoming engineering study to be undertaken by the ADB. Assuming the same classification is applied to both NR-13S and NR-15A, this study will thus apply specifications of Class-III for NR-15A.

Table 4.1.2 Road Class and Design Speed

Road Class		I	II	III	IV	V	VI	VII
Design Traffic Volume (PCU/day)		>8000	3000 -8000	1000 3000-	300 -1000	100 -300	50 -100	<50
Design Speed (km/h)	Flat	100	100	80	80	60	60	40
	Rolling	80	80	60	60	40	40	30
	Mountainous	60	60	40	40	20	20	20

Source: Road Design Manual

As a result, the design criteria for both NR-9 and NR-15A are summarized below.

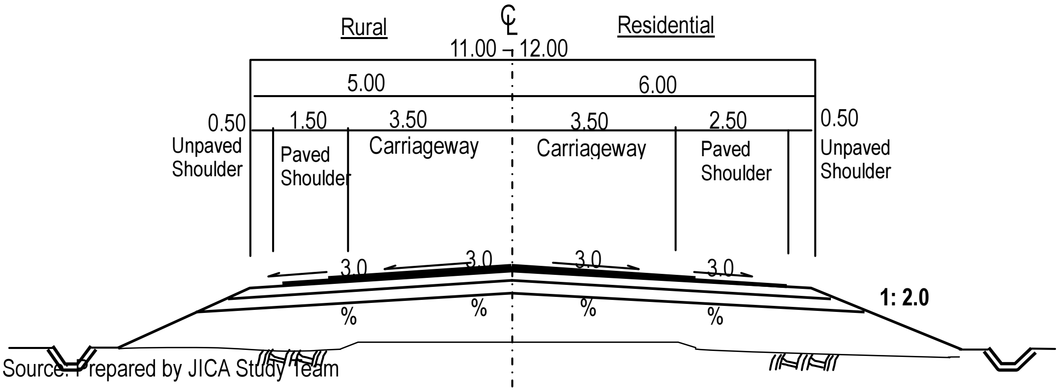
Table 4.1.3 Design Criteria for Priority Project Road

Road	NR-9	NR-15A
Road Class	Class II	Class III
Traffic Volume（PCU）	3,000~8,000	1,000~3,000
Design Speed（Km/h）	100 (Flat), 70 (Hilly)	80 (Flat)
	50 (Residential)	50 (Residential)
Traffic Lane(m)	3.5	3.5
Shoulder (m)	1.5 (Rural)	1.5 (Rural)
	2.5 (Residential)	1.5 (Residential)

Source: Prepared by JICA Study Team based on Road Design Manual

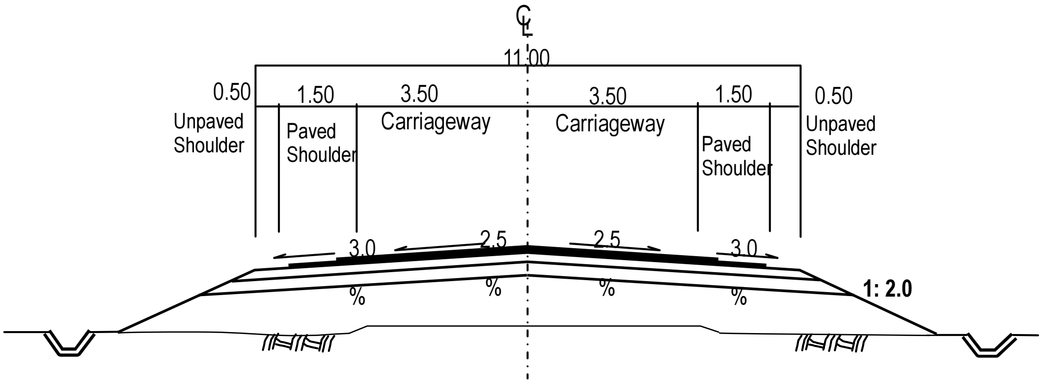
(3) Cross Section

The structures of the cross sections of both NR-9 and NR-15A are illustrated the figures below.



Source: Prepared by JICA Study Team

Figure 4.1.1 Typical Cross Section of NR-9 (Class II)



Source: Prepared by JICA Study Team

Figure 4.1.2 Typical Cross Section of NR-15A (Class III)

(4) Geometric Design Conditions

Table 4.1.4 shows geometric design conditions applied to this study. For NR-9, a maximum gradient of less than 5% should be considered so as to smoothen the traffic flow, especially that of heavy vehicles: a significant portion of traffic observed along NR-9 is of heavy vehicles.

Table 4.1.4 Geometric Standards

Item	Unit	NR-9 (Flat)	NR-9 (Hilly)	NR-15A
Design Speed	Kph	100	70	60
Horizontal alignment:				
Minimum curve radius	m	435	195	130
Vertical alignment:				
Maximum gradient	%	5	6	7
Minimum radius of crest	m	2200	2200	2000
Minimum radius of sag	m	2000	2000	1500
Cross section:				
Cross fall (Traffic Lane)	%	3.0	3.0	2.5
Cross fall (Shoulder)	%	3.0	3.0	3.0

Source: Prepared by JICA Study Team

(5) Pavement Design

1) Design Life Span

Table 4.1.5 shows the design life span of pavement by pavement type.

Table 4.1.5 Design Life Span by Pavement Type

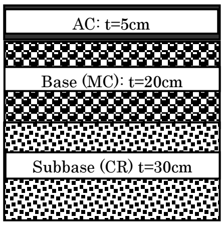
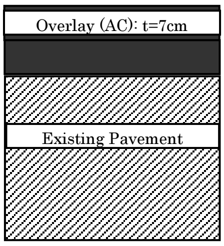
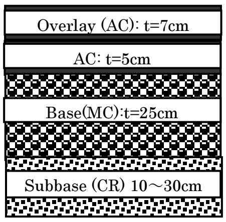
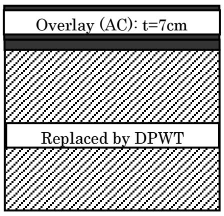
Items	DBST	Asphalt	Concrete	Remarks
Design Life Span	10 years (Refer ADB PPTA in future)	10 years (Traffic demand for 20 years)	20 years	Consideration of future upgrading if necessary

Source: Prepared by JICA Study Team

2) Pavement Structure

The Follow-up Study on NR-9 recommended the following pavement structure for rehabilitation works on the NR-9.

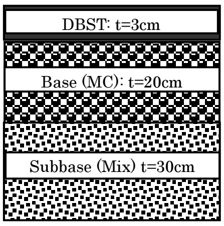
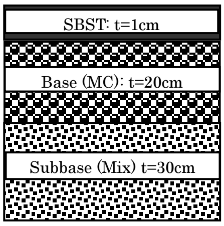
Table 4.1.6 Pavement Structure of NR-9 proposed by the Follow-up Study

Section	Replacement	Overlay		
Method	Replacement	Overlay on Partly Replaced pavement	Overlay on Existing Pavement	Overlay on DBST
Pavement Structure				
S/N	3.11	3.23	4.18	3.21
Predicted Life Period	9.4 years	11.2 years	31.3 years	10.9 years

Source: Prepared by JICA Study Team based on Follow-up Study on NR-9

Table 4.1.7 shows the pavement structure for the approach road of the Sedone Bridge (NR-15A).

Table 4.1.7 Pavement Structure of NR-15A (Approach Road of the Sedone Bridge)

Section	Improvement
Method	New Construction
Pavement Structure	 Traffic Lane  Shoulder
Predicted Life Period	10 years (Design)

Source: Prepared by JICA Study Team

(6) Earth Works

The slope gradients in both cut and embankment sections are summarized in Table 4.1.8.

Table 4.1.8 Slope Gradient in Cut and Embankment Sections

	Soil type	Gradient		Remarks
		(H<6m)	(6m<H<10m)	
Embank-ment	Normal	1:1.5	1:2.0 Berm shall be set every 5m in height	Refer Road Design Manual
Cut	Normal	1:1.0	1:1.0 Berm shall be set every 5m in height	Ditto
	Rock :weathered :fresh	1:0.5 1:0.3	Berm shall be set every 5m in height	Ditto

Source: Road Design Manual

(7) Drainage Facilities

Drainage facilities are installed at specific road sections (see Table 4.1.9). The drainage facilities generally used in Lao PDR are concrete U-shaped type for side ditch and RC pipe culvers for transverse drainage crossing the road.

Table 4.1.9 Drainage Facilities

Type	Road Section requiring Drainage Facility
Side ditch	- toe of both cutting / fill slope - roadside in flat and residential areas where necessary
Transverse drainage	- cross road drainage connecting with existing drainage facility

Source: Prepared by JICA Study Team

(8) Other Facilities

Table 4.1.10 summarizes the other facilities, mainly road safety facilities, necessary for the priority projects.

Table 4.1.10 Other Necessary Facilities

Facility	Remarks
Traffic Signboard	Refer to local guidelines
Guardrail	Embankment section with height exceeding 3m
Intersection plan	Access with existing roads
Bus bay	Residential area

Source: Prepared by JICA Study Team

4.1.2 Preliminary Bridge Design

(1) Design Standards and Specifications

The Road Design Manual is the sole standard and specification for road and bridge design in Lao PDR. However, it only designates the design live load and the return period for the design HWL for bridge design. Consequently, the Japanese standards and other international standards were applied in this study for the design of the bridge structure.

(2) Major Design Conditions for Bridge

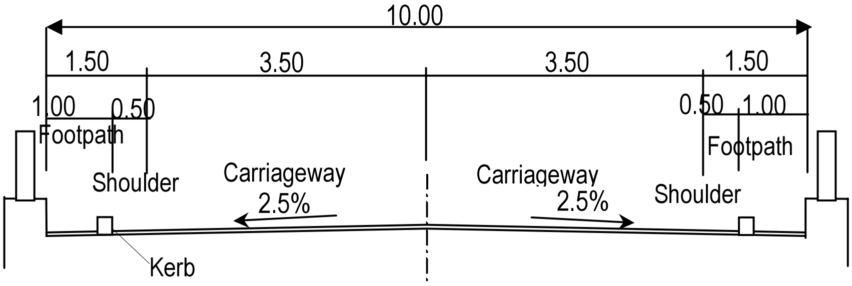
Table 4.1.11 summarizes the major design conditions for the project bridge.

Table 4.1.11 Major Design Conditions for Project Bridge

Items	Specifications
(1) Width Formation	10.00m = 1.50m + 2@3.50m + 1.50m
(2) Cross-fall	2.5%
(3) Pavement	Asphalt Pavement t=50mm
(5) Ancillary Facilities	Railing, Expansion Joint, Lighting
(6) Design Return Period for Flood	50 years
(7) Freeboard	1.2m

Source: Prepared by JICA Study Team

The Figure 4.1.3 shows the typical cross section of the bridges on the national roads.

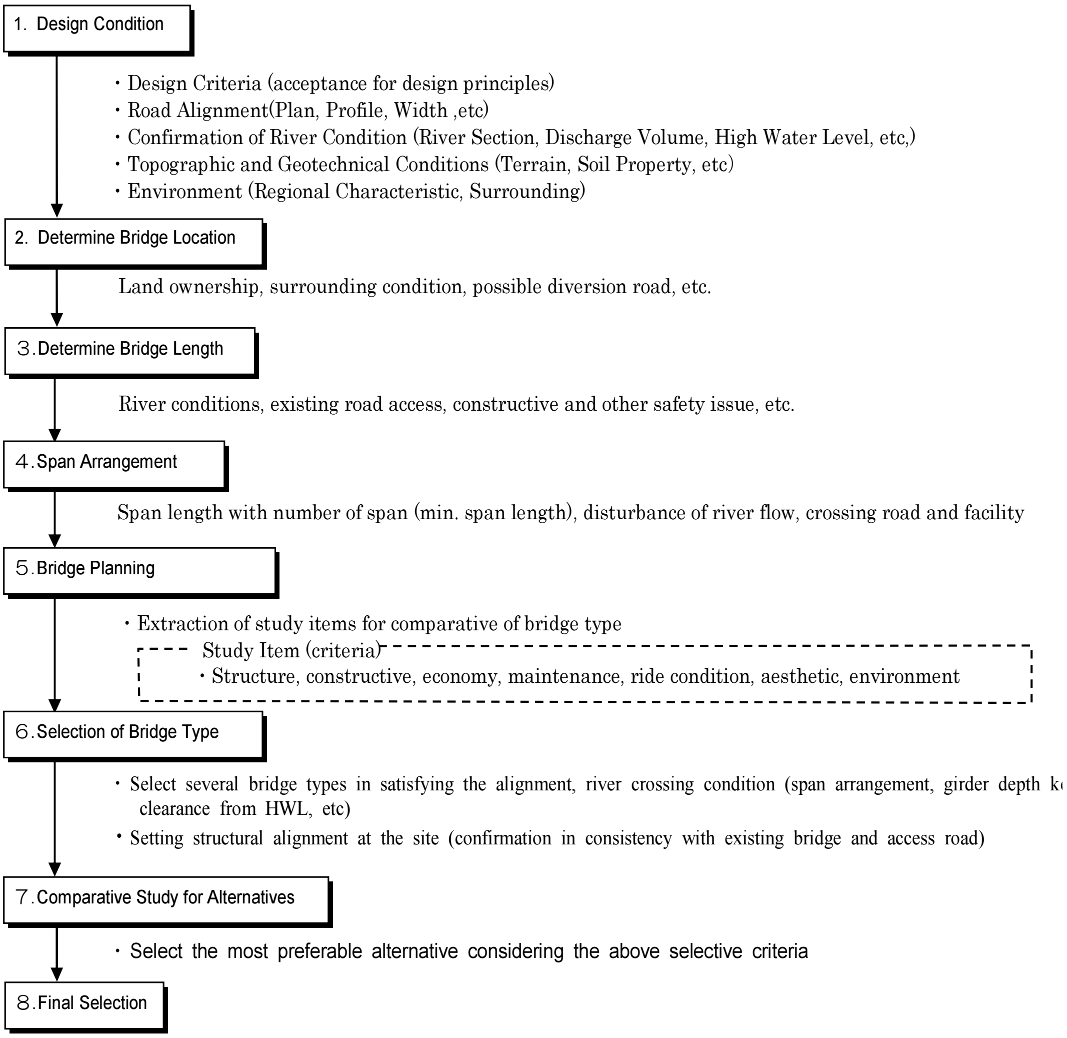


Source: Prepared by JICA Study Team

Figure 4.1.3 Typical Cross Section of Bridge on National Roads

(3) Process of Bridge Planning

The process of bridge planning is illustrated in Figure 4.1.4.



1. Design Condition

- Design Criteria (acceptance for design principles)
- Road Alignment(Plan, Profile, Width ,etc)
- Confirmation of River Condition (River Section, Discharge Volume, High Water Level, etc,)
- Topographic and Geotechnical Conditions (Terrain, Soil Property, etc)
- Environment (Regional Characteristic, Surrounding)

2. Determine Bridge Location

Land ownership, surrounding condition, possible diversion road, etc.

３.Determine Bridge Length

River conditions, existing road access, constructive and other safety issue, etc.

４.Span Arrangement

Span length with number of span (min. span length), disturbance of river flow, crossing road and facility

５.Bridge Planning

- Extraction of study items for comparative of bridge type

Study Item (criteria)
- Structure, constructive, economy, maintenance, ride condition, aesthetic, environment

６.Selection of Bridge Type

- Select several bridge types in satisfying the alignment, river crossing condition (span arrangement, girder depth k clearance from HWL, etc)
- Setting structural alignment at the site (confirmation in consistency with existing bridge and access road)

７.Comparative Study for Alternatives

- Select the most preferable alternative considering the above selective criteria

８.Final Selection

Source: Prepared by JICA Study Team

Figure 4.1.4 Bridge Planning Process

(4) Design Loads

Live Load

As regards the live load, HS20-44x1.25 is applied for the project bridges since they are located along the NR-15A and NR-9, both of which are categorized as major trunk roads in Lao PDR.

Other Loads

Apart from the live load, the following loads need to be considered when designing the project bridges:

- Dead load
- Impact load
- Wind load
- Influence of creep for concrete

- dry shrinkage for concrete
- Earth pressure
- Static water pressure
- Water pressure during flood
- Buoyancy
- Settlement

(5) Superstructure Type

Considering the maximum span length as part of the study on span arrangement, four types of superstructure were evaluated as being applicable to the project bridges. These four types of superstructure will be compared in terms of cost effectiveness, construction method and construction time and the most appropriate superstructure type for candidate bridges on NR-9 and the Sedone Bridge will be selected.

Table 4.1.12 Applicable Superstructure Type

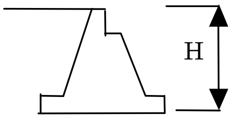
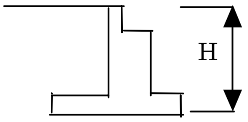
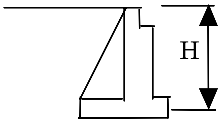
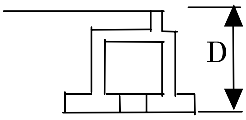
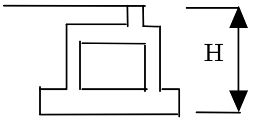
Superstructure Type		Span Length										Girder depth／Span
		20m		30m		40m		50m		60m		
PC type	Continuous T−shaped		━	━	━	━						1/15
	Continuous Box Girder with equal depth (Inremental launching method)				━	━	━	━	━	━		1/16
	Continuous Box Girder with Variable Depth (Cantilever method)								━	━	━	1/18-1/35
Steel	Continuous I−shaped				━	━	━	━				1/20

Source: Prepared by JICA Study Team

(6) Abutment Type

The abutment type will be selected depending on the structure height in combination with foundation as shown in Table 4.1.13.

Table 4.1.13 Applicable Abutment Types

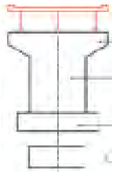
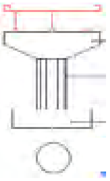
Abutment Type		Applicable height H(m)	Characteristics
Gravity Type		H≦5	- Simple structure - Easy to construct - Relatively heavy
Inverted-T Type		5< H ≦12	- Cost effective within applicable height range - Easy to build
Buttressed Type		10 ≦ H	- Complicated to build - Careful compaction of back filling is required
Rigid-Frame Type		10 ≦ H ≦ 15	- Structurally complicated - Higher cost - Possible expansion of discharge capacity
Box Type		15≦ H	-Structurally complicated - Only required for heights greater than 15m

Source: Prepared by JICA Study Team

(7) Pier Type

Possible pier types are shown in Table 4.1.14. A cantilevered wall-type pier is recommended in order to prevent swirling of the water flow, which may cause scouring.

Table 4.1.14 Applicable Pier Type

Type	Sketch	Characteristics
Cantilevered Wall (square wall)		- Most common structural type - Conventional cantilever to support superstructure with minimum wall area.
Cantilevered Wall (rounding wall)		- Applied inside of river - Rounding of wall to relieve the water pressure
Cantilevered Pillar (round pillar)		- Adapted if necessary to control river flow -Round pillar corresponds to variable current direction

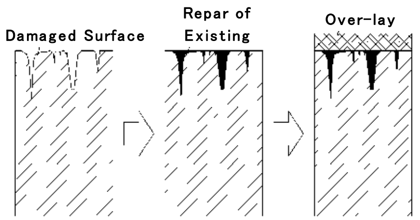
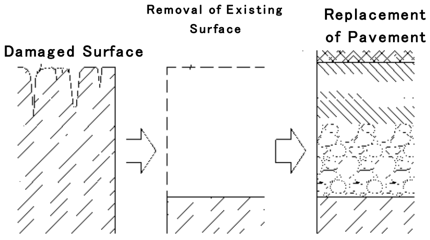
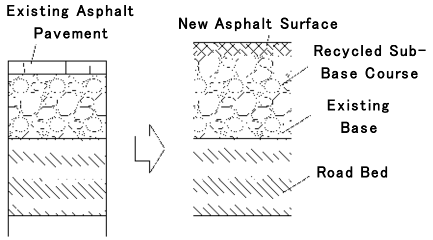
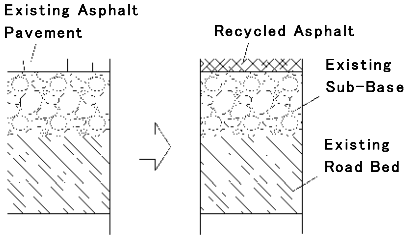
Source: Prepared by JICA Study Team

4.1.3 Project Formulation of Upgrade of NR-9

(1) Pavement Type

Table 4.1.15 compares the alternative pavement structures for the purpose of upgrading the NR-9. In the comparison, it was established that overlay and replacement of the pavement are the most commendable for upgrade of the NR-9. The alternative structures of the pavement will be tested and the optimum pavement structure will be determined in the forthcoming basic design of rehabilitation of the NR-9 under Japan's Grant Aid Assistance.

Table 4.1.15 Comparison of Rehabilitation Methods of Pavement

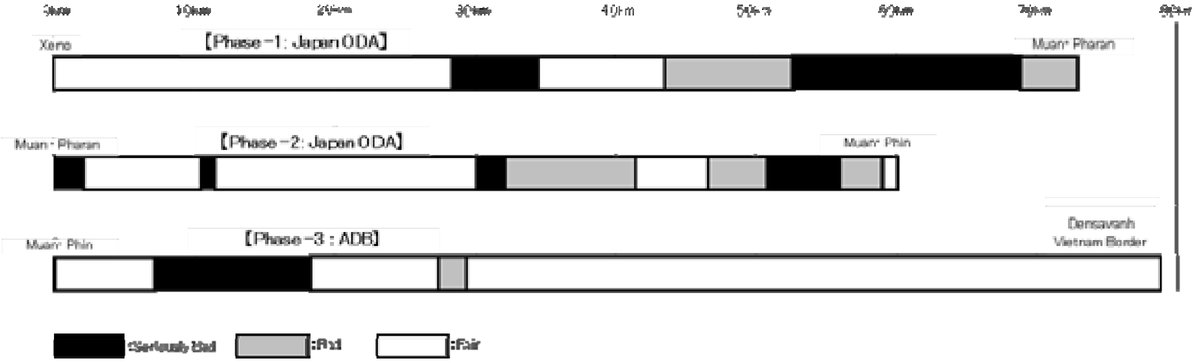
	Overlay	Pavement Replacement	Recycled Base Course	Recycled Asphalt Surface
				
Construction Method	After repairing existing surface, over-lay new asphalt concrete on the existing surface.	After existing surface and sub base course removed, replace with new material.	Remove the existing surface and sub base and base course, mix with stabilizer and then reuse for sub base course.	Remove the existing surface, mix with stabilizer and reuse for sub base course.
Recommended Section	Damage is comparatively limited and does not affect the sub base and base course.	Crack reaches and affects sub base and base course.	Crack reaches and affects sub base and base course.	Damage is comparatively limited and does not affect the sub base and base course, and pavement design will not be changed. (in case pavement design is changed, asphalt overlay is required.)
Construction efficiency	Standard road construction method, and comparatively easy to employ. Good	Transportation and depository of waste material (asphalt concrete and gravel) are required. Fair	Stabilizer (automotive) to remove the existing surface and sub base course, and motor grader to maintain flat surface are required. Quantity of material, construction schedule and cost can be reduced. Fair	Asphalt recycle plant should be developed. Material of asphalt concrete can be reduced. Fair
Economical efficiency	Asphalt concrete and tuck coat. Fair	Additional costs for removal, transportation and disposal of existing material are incurred. Worst	Cost of material and schedule can be reduced. However, other construction machinery is required. Bad	Cost of material and schedule can be reduced. However, other construction machinery is required. Good
Maintenance efficiency	Standard road maintenance. Good	Standard road maintenance. Good	Standard road maintenance. Good	Standard road maintenance. Good

Environmental Aspect	Mountain crashed-stone for material of asphalt concrete is required. Bad	Mountain crashed-stone for material of asphalt concrete and depository for waste material is required. Worst	Crashed stone pit and depository for waste material can be minimized. Good	Crashed stone pit and depository for waste material can be minimized. Good
Others	Thickness of over lay asphalt concrete should be decided after careful analysis of existing surface condition.	Detailed evaluation of CBR at design stage is necessary.	Quality control of recycled material	Quality control of recycled material
Evaluation	Construction and maintenance method is locally applicable. Good	Construction and maintenance method is locally applicable. Good	Ideal construction method as regards environmental aspects; however quality control is difficult. Bad	Ideal construction method as regards environmental aspects; however quality control is difficult Worst

Source: JICA Study Team

(2) Road Section to be Upgraded/Rehabilitated

The improvement of NR-9 was officially requested by the Government of Lao PDR in 2009. This request includes upgrading the pavement structure to concrete pavement for the whole stretch of NR-9 (244km), including replacement of 51 bridges. The Follow-up Study on NR-9 was carried out this April by JICA to determine the optimum scope for the rehabilitation of NR-9. Following the Follow-up Study, JICA will soon conduct the basic design study for rehabilitation of NR-9 under Japan's Grant Aid Assistance. Following the results of the Follow-up Study, this study proposed that the scope of the Upgrade of NR-9 be confined to the replacement of pavement for 43-km of seriously deteriorated road ('seriously bad' in figure 4.1.5) and application of overlay to 31-km of bad road surfaces ('bad' in figure 4.1.5).



Source: Prepared by JICA Study Team based on Follow-up Study on NR-9

Figure 4.1.5 Pavement Condition of NR-9

Table 4.1.16 Pavement Condition of NR-9

Phase	Phase-1		Phase -2		Phase -3		Total	
	Xeno- MuanPharan		Muan Pharan- Muan Phin		MuanPhin- Densavanh			
Donor	Japan				ADB			
	km	%	km	%	km	%	km	%
Serious	22	30.14	10	16.95	11	13.92	43	20.38
Bad	13	17.81	16	27.12	2	2.53	31	14.69
Fair	38	52.05	33	55.93	66	83.54	137	64.93
Total	73	100.00	59	100.00	79	100.00	211	100.00

Source: Prepared by JICA Study Team based on Follow-up Study on NR-9

Therefore, in light of the results of the Follow-up Study on the NR-9, it is proposed that the project scope be comprised of project components, namely: rehabilitation of existing road surface and installation of drainage facilities and road safety facilities.

Table 4.1.17 Project Components of Upgrade of NR-9

Facility		Remarks
a)	Rehabilitation of existing road surface	Replacement / overlay
b)	Installation of supplementary drainage facilities	Side ditch, pipe culvert, box culvert, etc
c)	Road safety facilities	Lane marking, traffic sign board, etc

Source: Prepared by JICA Study Team based on Follow-up Study on NR-9

Table 4.1.18 shows the preliminarily estimates of the volume of the rehabilitation works for the Upgrade of NR-9 as established by the Follow-up Study.

Table 4.1.18 Preliminary Estimates of Rehabilitation Works

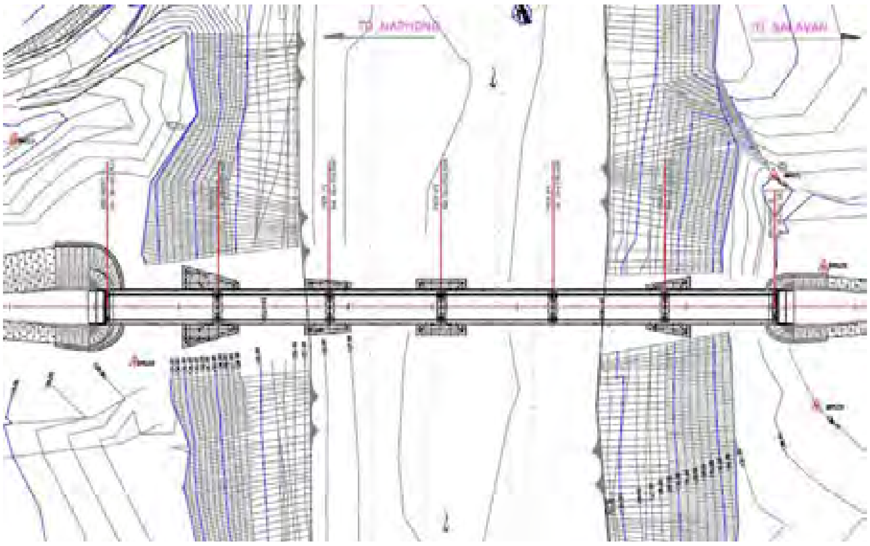
Item		Replacement	Overlay
Phase-1	m2	75,700	257,600
Phase-2	m2	27,600	167,200
Total	m2	103,300	424,800

Source: Prepared by JICA Study Team based on Follow-up Study on NR-9

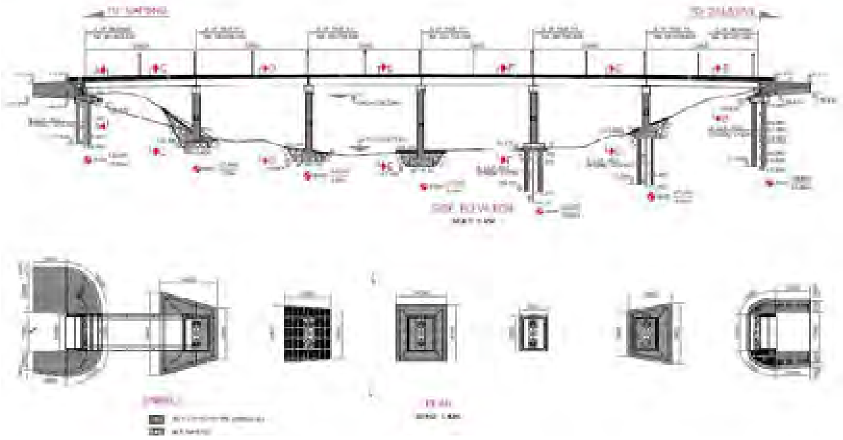
4.1.4 Project Formulation of Construction of Sedone Bridge

(1) Review of Existing Design of Sedone Bridge

The study of the design of the Sedone Bridge was conducted by a local consultant in 2008. The bridge type, recommended in the said study, was PC post-tension six (6) span simple girder bridge. The design of PC girder was simply conducted with reference to the available local standard girder, which is limited to the maximum span length of 33m. The span arrangement for the Sedone Bridge was determined by combination of the standard girders without technical justification for the control of the river flow. The general view of the Sedone Bridge is given below.



General View



Side View and Plan

Bridge Type: Six(6) spans PC simple girder bridge (Length :198m =32.6+4x33.05m+32.6)

Figure 4.1.6 Sedone Bridge (designed by local consultant in 2008)

(2) Revision of Design of Sedone Bridge

The Sedone River is a major tributary of the Mekong river and its discharge volume is estimated at more than V = 4,000m^3/s (refer to the high water level and sectional area of river). The span arrangement of bridge is critical to the disturbance of the river flow. The bridge length combined with minimum span length should be technically justified by the characteristics of river such as the discharge volume, current direction, and the variable topography of river bed. The water pressure during floods may cause serious damage to the bridge; hence the appropriateness of span arrangement and bridge type for the Sedone Bridge are discussed in more detail below.

1) Bridge Length

The bridge length should be determined at the crossing point such that the design flood discharge flows without any disturbance. The river width both upstream and downstream of the bridge site should be considered in order to determine the bridge length.

The river width during floods ranges from 180 to 200m at both upstream and downstream of the bridge site. Despite the fact that the river width at the design HWL is approximately 240m at the crossing point of the new bridge, a bridge length of around 200 - 230m is appropriate, considering the lower altitude of the left river bank and the clearance underneath the girder.

2) Span Arrangement

The span arrangement should be determined based on the following factors according to the Japanese River Structure Ordinance (JRSO). The effect of flow disturbance caused by the existing piers will be negligible because the Sedone Bridge is designed to be located 200m downstream of the existing submerged crossing.

- The disturbance ratio by piers against the river width during the flood should be less than 5%.
- The span length should exceed the standard span length calculated by the discharge volume according to the Japanese standard.

The study of the span arrangement is summarized in Table 4.1.19.

Table 4.1.19 Results of Span Arrangement Study

Factors	Study Contents	Results
Disturbance ratio of the cross-sectional area of a river by piers	In case the pier width is 2m for each pier, 200mx0.05/2.0＝5 spans shall ideally be required.	Less than or equal to 5 spans shall be appropriate (span length ≧40m)
Base span length	BSL=20＋0.005Q＝20+0.005 x 4000 =40.0m	Min. span length≧40.0m

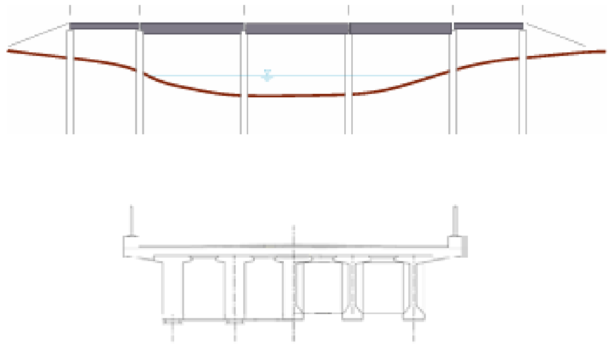
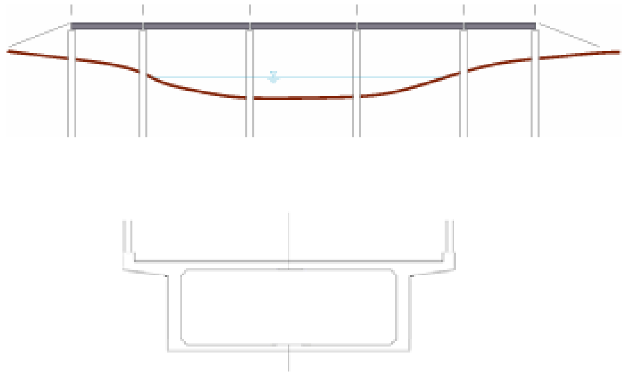
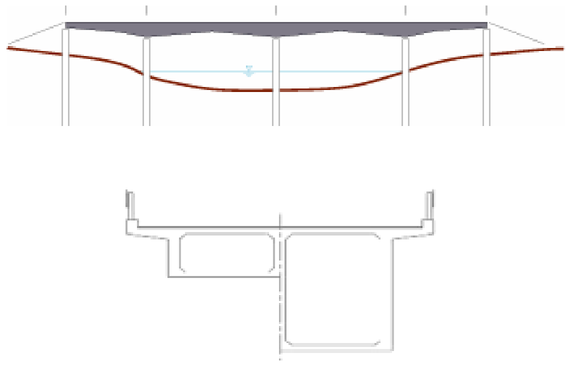
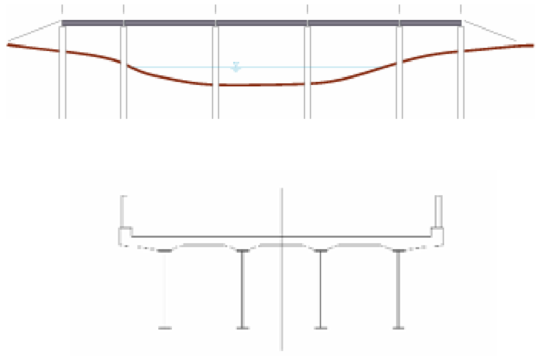
Source: Prepared by JICA Study Team

Considering the above-mentioned bridge length and span arrangement, the recommended design for the Sedone Bridge is five (5) span bridge (35m + 3X50m + 35m) with total bridge length of 220m.

3) Comparison of Alternative Superstructure Types

Table 4.1.20 proposes alternative superstructures and compares them in terms of (1) structural stability, (2) constructability, (3) cost effectiveness, and (4) ease of maintenance. As a result, PC Box Girder with equal girder depth (Alternative-II) is recommended as the optimum bridge design for the Sedone Bridge.

Table 4.1.20 Comparison of Superstructure Type for Sedone Bridge

		Alt.-I:PC T-shaped Girder Type	Alt.-II: PC Box Girder Type with Equal Girder Depth	Alt.-III PC Box Girder with Variable Girder Depth	Alt.-IV: Steel I-Shaped Girder Type
Sketch					
Features of Alternatives	Br. L/Span	220m＝42.5+45+45+45+42.5	220m＝35+50+50+50+35	220m＝40+70+70+40	220m=35+50+50+50+35
	Br. Type	5 span continuous PC T-shaped girder Type	5 span continuous PC box girder with equal depth	4 span continuous PC box girder with variable depth	5 span continuous steel I-shaped girder
	Erection	Erection girder method	Incremental Launching erection method	Canti-lever erection method	Erection by crane
	Structural Features	■ Applicable span length: 25-45m(max.45m) ■ Girder depth: 2.8m (depth/span ratio: 1/16).	■ Applicable span length: 30-60m(max.65m) ■ Girder depth: 2.8m (depth/span ratio: 1/16).	■ Applicable span length: 15-120m(max.150m) ■ Girder depth: 3.3m (depth/span ratio: 1/18-1/35).	■ Applicable span length: 25-60m ■ Girder depth: 2.5m (depth/span ratio: 1/18).
Constructability		■ Large-scale erection girder with portal frame crane shall be used for erection due to heavier girders. ■ Longest 45m girder length is rarely used for this type. ■ Possible for erection to continue during rainy season because no materials are supplied from the river. ■ Need for fabrication space at the backside of abutment.	■ Erection nose girder is required in order to incrementally launch the girders. This span length is most suitable for this method. ■ Construction yard for this method shall be available at the left bank. ■ Possible for erection to continue during rainy season because no materials are supplied from the river. ■ Need for fabrication yard at the backside of abutment.	■ Girder is launched from pier heads by 2-4m at both sides using form traveler ■ Very commonly practiced in bridge building ■ Supply of the materials to the pier head is required during the erection of girder; hence there is significant concern with cost increase for using temporary platform during higher water season.	■ Erection by using crane with 80-100 ton lifting capacity from the riverbed or temporary platform ■ Shortest erection time among the alternatives. ■ Erection girder method is possible during the rainy season. ■ Pre-fabricated girder will be transported to the site from a third-party country.
Construction time for superstructure)		Approximately 14 months	Approximately 14 months	Approximately 18 months	Approximately 14 months （including order process, fabrication and transportation）
Cost for superstructure		1.00 (Higher cost shall be required due to its applicability limit)	1.00	1.17	1.67 Procurement from a foreign country leads to high cost
Maintenance		● Less maintenance cost than the steel girder ● Expansion j joint required in 4 places	● Less maintenance cost than steel girder ● Expansion joint required in 2 places.	● Less maintenance cost than steel girder ● Expansion joint required in 2 places.	● Periodic painting leads to the highest costs of maintenance. Expansion joint required in 2 places.
Aesthetics		● The girder depth variation gives inferior impression	● Equal girder depth and span balance between the center and the end give good impression.	● Variable girder depth gives rhythmical impression and good balance between the center and the edge also give good impression.	● Equal girder depth and span balance between the center and the end give good impression.
Comprehensive Evaluation		**Not recommended** due to maximum applicable length for PC-T girder requiring higher facility costs.	**Recommended** since it's most economical and rational in structure. Possible year round erection despite the changing season and water level; the incremental launching method experiences limited effects on constructability, construction time and maintenance	**Not recommended** since the girder depth in vicinity of pier is high such that the elevation of bridge profile needs to be raised so as to maintain clearance over high water level. Besides, the supply of the materials to pier head during flood water season is complicated.	**Not recommended** in terms of maintenance; requires more technique and costs are higher than those of concrete girder.

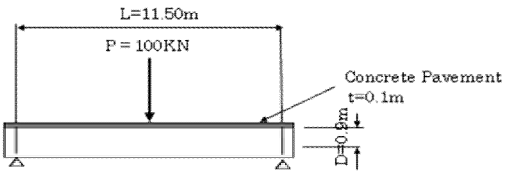
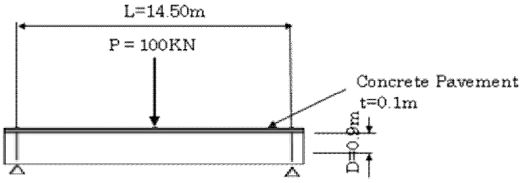
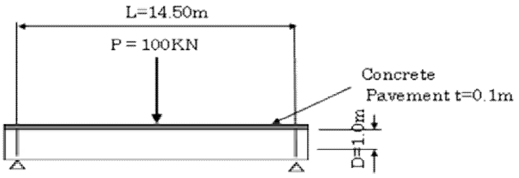
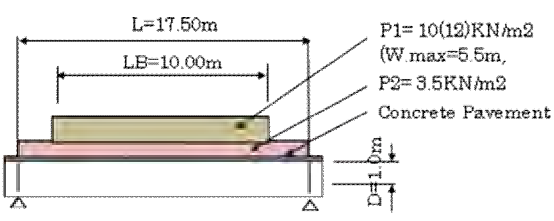
Source: Prepared by JICA Study Team

4.1.5 Project Formulation for Replacement of Bridges along NR-9

(1) Preliminary Structural Analysis for Bridges along NR-9

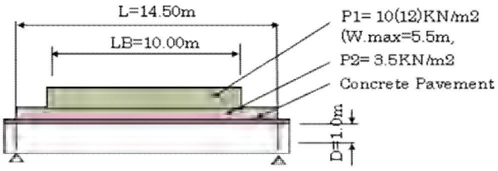
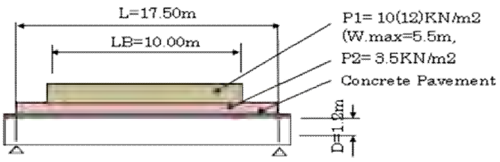
Table 4.1.21 and 4.1.22 show the results of preliminary structural analysis for RCTG by specific axle loading. As a result, the capacity of RCTG for both Russia and Vietnam sections were mostly evaluated as being inadequate for each loading case. In particular, the shear capacity is considerably inadequate against the specific load and this is indicative that the section of girder is too short. It is noted that further detailed study is necessary to confirm the results of the structural analysis.

Table 4.1.21 Summary of Preliminary Structural Analysis for RCTG (Russia Section)

	Loading Case by Type of Girder	Section Force	Max. Stress (N/mm2)	Allowable Stress (N/mm2)
Russia Section :RCTG(i)	Case-1 L=12.0 (D=0.9) 	M=786.9KNm S=273.3KN	σs=224.5 σc=5.7 τ=2.01	< 180 < 8.0 < 0.39
	Case-1 L=15.0 (D=0.9) 	M=1,071.4KN/m S=323.9KN	σs=306.1 σc=7.7 τ=2.38	< 180 < 8.0 < 0.39
	Case-1 L=15.0 (D=1.0) 	M=1,068.5KNm S=294.8KN	σs=269.3 σc=6.4 τ=1.93	< 180 < 8.0 < 0.39
	Case-1 L=18.0 (D=1.0) 	M=1,492.2 KNm S=371.6KN	σs=243.5 σc=8.8 τ=1.63	< 180 < 8.0 < 0.39

Source: Prepared by JICA Study Team

Table 4.1.22 Summary of Preliminary Structural Analysis for RCTG (Vietnam Section)

	Loading Case by Type of Girder	Section Force	Max. Stress (N/mm2)	Allowable Stress (N/mm2)
Vietnam Section :RCTG(ii)	Case-1 L=15.0 (D=1.0) 	M=1,304.6KNm S=394.6KN	σs=329.9 σc=8.6 τ=2.19	< 180 < 8.0 < 0.39
	Case-1 L=18.0 (D=1.2) 	M=1,835.5KNm S=456.8KN	σs=238.1 σc=6.97 τ=2.19	< 180 < 8.0 < 0.39

Source: Prepared by JICA Study Team

(2) Observatory Analysis for Bridges along NR-9

Major findings obtained during the site visit are listed by bridge type and structure. Both reinforced concrete bridges and steel bridges, observed along the NR-9, are more or less observed to be damaged.

Table 4.1.23 Major Findings from Site Visit

Superstructure	
Item	Major Findings
RCTG Bridge	- Many cracks on the concrete girders varying in width from 0.1 to 0.5mm; should be subjected to structural analysis (overstress) - Absence of bearing device leads to damage on shoe seat concrete and edge of girders - Serious honeycomb (exposure of steels inside of girder) with free lime due to poor quality control at the construction
STG Bridge No.6,7 & 34	- Supplementary steel truss girder with posts underneath beam disturbs the water current. Should be subjected to detailed structural analysis to review the function of reinforcement.
STG Bridge No.13 & 17	- Unique profile (abrupt profile out of geometric standard) bending at the pier head that could possibly cause traffic accidents - Large deformation at the center of span (residual deformation) subject to detailed structural analysis. - Strengthening supplementary steel truss girder underneath beam disturbs the water current
Other bridges	- Cracks on the concrete beam and slab - Honeycomb due to poor quality control at the construction
Substructure	
Item	Major Findings
Abutment & Piers	- Cracks on the wall vary in width from 0.1 to 0.5mm - Serious honeycomb due to poor quality control at the construction - Scoured around pile-bent piers - Accumulation of Debris stack at piers

Source: Prepared by JICA Study Team

(3) Evaluation of Bridge Durability and Selection of Priority Bridge

The bridge inventory survey was carried out to assess durability of existing bridges along NR-9. The evaluation criteria and items applied during the bridge inventory survey were obtained from the Japanese maintenance manual and were modified for this study. They are summarized in the Tables 4.1.24 and 4.1.25.

Table 4.1.24 Evaluation Criteria for Bridge Durability

State of damage	Rate	Class	Necessary Measures
- No damage	A	I	Continue monitoring during maintenance activity
- Minor damage needs to be observed	B		
- Damage monitored during maintenance	C	II	Require detailed study followed by detailed inspection for assessment of severity of damage to justify the necessary measures
- Level of damage necessitates repair - Detailed survey is required - Does not affect safe travel	D		
- Critical damage - Affects safe travel	E	III	Urgent replacement or rehabilitation is required followed by detailed study of the damage.

Source: Prepared by JICA Study Team

Table 4.1.25 Evaluation Items for Bridge Durability

Category	Bridge Function	Loading Capacity	Damage Level
Concrete Bridge	- width, cross-section, profile - clearance from flood level - drainage arrangement	- Check design load and calculation - Assumption data analysis based on the information and data collected from the site - Loading test	- Crack width, density and splitting of girder - honeycomb - quality of concrete (strength of concrete) - Erosion, scouring, - Damage to shoes, expansion joints and other accessories.
Steel Bridge	- ditto to the above	- deflection, deformation - rupture	- Corrosion, damage to members,

Source: Prepared by JICA Study Team

Table 4.1.26 shows the summary of evaluation results of bridge durability along the NR-9. 2 STG bridges (No.13 and 17) were evaluated as being in class-III; it was confirmed that both bridges require urgent replacement or rehabilitation. Details of the priority interventions on bridges along the NR-9 are given below:

- 2 STG bridges, No.13 (Xe Kumkam Bridge) and No.17 (Xe Tha Mouak Bridge), like other steel bridges, have engineering deficiencies that include corrosion of strengthening girder and exposure of reinforcement steel in concrete of both slabs and abutments. These 2 bridges are given highest priority of intervention since there is higher risk of traffic accidents due to abrupt change in bridge profile.
- RCTG bridges are critically damaged and require urgent rehabilitation. These bridges are currently undergoing minor repair works by DPWT Savannakhet and it’s expected that the conditions of these bridges will improve as a consequence of the works. Having said that, the preliminary structural analysis confirmed that the RCTG bridges, especially those built by the former Soviet Union, have inadequate capacity against the standard load; hence major repair works or replacement of these bridges should be considered.
- Some steel girder bridges have been maintained with the financial assistance of the World Bank. Amongst them, Bridges No.6, 7 and 34 (except RC girder located at side-span of bridge) are relatively better-off than other steel bridges. Scouring around the abutment during the flood is found at steel girder bridges of No.6 and 7. Steel truss supports were additionally installed onto the existing steel bridges by Sepone Mining Company. These additional steel trusses should be carefully assessed in terms of disturbance of the river flows.

Table 4.1.26 Summary of Evaluation Results of Bridge Durability

No.	Bridge Name	Bridge Type	Findings Rate					Assesment	Rank	Remarks
			A	B	C	D	E	(A<E)	(I <II<III)	
1	Houay Lay	RC T-Girder	0	5	4	14	0	D	II	Japan Grant Aid (Phase -1)
2	Houay Ka Sae	RC T-Girder	0	5	3	15	0	D	II	
3	Houay Long Kong	RC T-Girder	0	3	4	16	0	D	II	
4	Houay Moung	RC T-Girder	0	6	3	14	0	D	II	
5	Houay Ta Bong Phet	RC T-Girder	0	5	4	14	0	D	II	
6	Xe Cham Phone	Steel and RC	0	11	6	8	0	D	II	
7	Xe Xam Xoy	Steel I-Girder	0	5	5	15	0	D	II	
8	Houay Koa	RC Slab	1	3	2	15	0	D	II	Japan Grant Aid (Phase -2)
9	Houay Ya Phuid	RC T-Girder	0	1	2	20	0	D	II	
10	Houay Ngoa	RC T-Girder	0	1	4	18	0	D	II	
11	Houay Sa Loung	RC T-Girder	0	1	4	18	0	D	II	
12	Houay Sa Leang	RC T-Girder	0	5	3	15	0	D	II	
13	Xe Kum Kam	Steel I-Girder	0	13	2	9	1	E	III	
14	Houay Jon	RC T-Girder	0	5	2	16	0	D	II	
15	Houay Tho	RC T-Girder	0	2	5	16	0	D	II	
16	Houay La Kouay	RC T-Girder	0	4	4	15	0	D	II	
17	Xe Tha Mouak	Steel I-Girder	0	6	8	10	1	E	III	
18	Houay Ta Sap	RC T-Girder	0	6	3	14	0	D	II	
19	Houay Po Lo	RC T-Girder	0	5	3	15	0	D	II	
20	Houay Ta Yeung	RC T-Girder	0	4	6	13	0	D	II	
21	Houay Pa Khi	RC T-Girder	0	9	3	11	0	D	II	ADB Loan
22	Houay A Lang	RC T-Girder	0	4	4	15	0	D	II	
23	Houay A Kai	RC T-Girder	0	6	4	13	0	D	II	
24	Houay Xe Chon 1	RC T-Girder	1	2	4	16	0	D	II	
25	Houay Koy	RC T-Girder	0	12	4	7	0	D	II	
26	Houay Xe Chon 2	RC T-Girder	0	4	4	15	0	D	II	
27	Houay Xe Chon 3	RC T-Girder	0	8	4	11	0	D	II	
28	Houay La Vi	RC Beam	0	12	4	7	0	D	II	
29	Houay Ki	RC T-Girder	0	5	4	14	0	D	II	
30	Houay Yone	RC T-Girder	0	3	4	16	0	D	II	
31	Houay Xay	RC T-Girder	0	4	4	15	0	D	II	
32	Houay Kok 2	RC T-Girder	0	7	3	13	0	D	II	
33	Houay Kok 1	RC T-Girder	0	2	4	17	0	D	II	
34	Xe Bang Hiang	Steel and RC	0	10	4	13	0	D	II	
35	Houay Cheng	PC I-Girder	18	2	2	1	0	D	II	
36	Houay Sa Niam	RC T-Girder	0	17	5	1	0	D	II	
37	Houay Ma Houn	RC T-Girder	0	12	4	7	0	D	II	
38	Houay Sa Mang	RC T-Girder	0	11	4	8	0	D	II	
39	Houay None	RC T-Girder	0	16	4	3	0	D	II	
40	Houay Ta Pouan	RC T-Girder	0	9	4	10	0	D	II	
41	Houay Luang	RC T-Girder	0	16	5	2	0	D	II	
42	Houay Ma Heng	RC T-Girder	0	11	4	8	0	D	II	
43	Houay Pa Xuoan	RC T-Girder	0	8	4	11	0	D	II	
44	Houay Pa Lin	RC T-Girder	0	10	4	9	0	D	II	
45	Houay Ta Khoan	RC Slab	3	12	3	3	0	D	II	
46	Houay Sa Ki	RC T-Girder	0	11	4	8	0	D	II	
47	Houay Sa Moun	RC T-Girder	0	6	4	13	0	D	II	
48	Houay Lua	RC T-Girder	0	14	4	5	0	D	II	
49	Houay Ka Hanh	RC T-Girder	0	9	4	10	0	D	II	
50	Houay Pa Lath	RC T-Girder	0	7	4	12	0	D	II	
51	Houay A Lone	RC T-Girder	0	15	4	4	0	D	II	

Source: Prepared by JICA Study Team

4.2 Project Implementation and Maintenance Plan

4.2.1 Project Implementation Plan

(1) Preconditions for Implementation Plan

Assuming that the priority projects are implemented under Japan's Grant Aid Assistance, the preconditions for designing the implementation plan are suggested below.

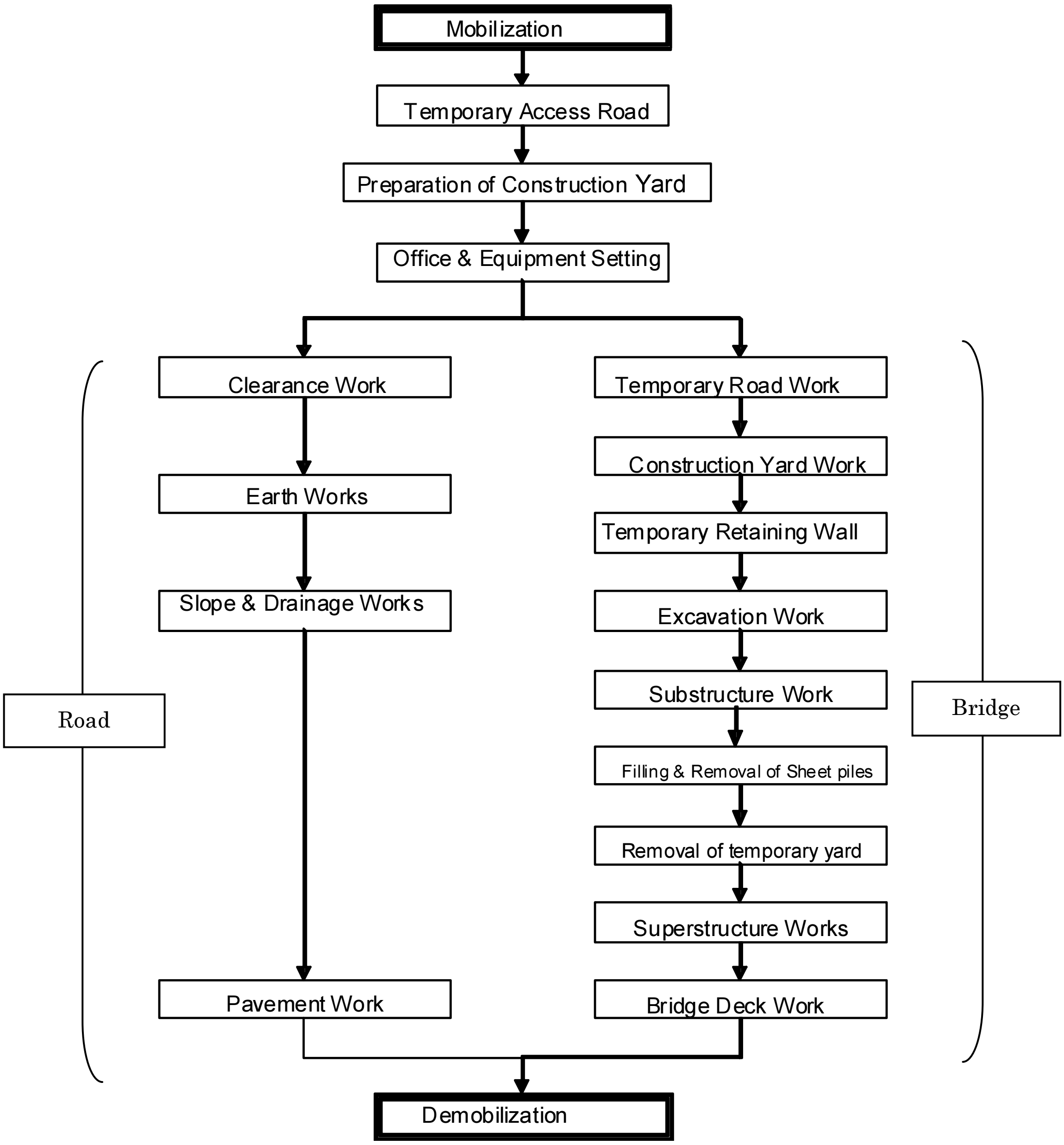
Table 4.2.1 Preconditions for Implementation Plan of Priority Projects

Project	Upgrade of NR-9	Replacement of Bridges along NR-9	Construction of Sedone Bridge
Cabinet Approval	● July (D/D) ● April (S/V, Construction)	● October (D/D) ● May (S/V, Construction)	● October (D/D) ● May (S/V, Construction)
Coordination with other donors	Implementation schedule for upgrading of NR-9 project to be considered.		Implementation schedule for improvement of NR-15A by ADB fund to be considered.
Resettlement EIA/IEE	● Time span for the implementation of resettlement program should be established in accordance with the official process of recipient government. ● Critical process for acquiring EIA license or IEE's approval via stakeholders should be considered if necessary.		
Construction	Rehabilitation and improvement of roads ● Overlay : 31km ● Reconstruction:43km ● Maintenance: 137km ● Rehabilitation of facilities	Construction of two bridges on NR-9 ● Bridge Length No.13: 95.0m No.17:165.0m ● Approach roads	Construction of Sedone Bridge ● Bridge Length: 220.0m ● Approach roads
	● Two clear seasons comprising rainy season from May to October and dry season from November to April around the project site. For road works, the earth works and pavement shall be limited to dry season. For bridge works, foundation and substructure construction shall be limited to dry season. ● The effective time for the commencement of works should be two months before the dry season starts so as to minimize the total construction period.		
	● Temporary diversions for the works shall be necessarily so as not to completely stop the traffic on international corridor or national roads.		
	● Ensure safe access for people using road during construction.		

Source: Prepared by JICA Study Team

(2) Construction Works

Overall road and bridge construction works are shown in the Figure 4.2.1.



Source: Prepared by JICA Study Team

Figure 4.2.1 Overall Road and Bridge Construction Works

(3) Domestic and Overseas Procurement

The procurement conditions of construction materials affect both construction schedule and project cost. Table 4.2.2 shows the quality and procurement conditions of the major construction materials.

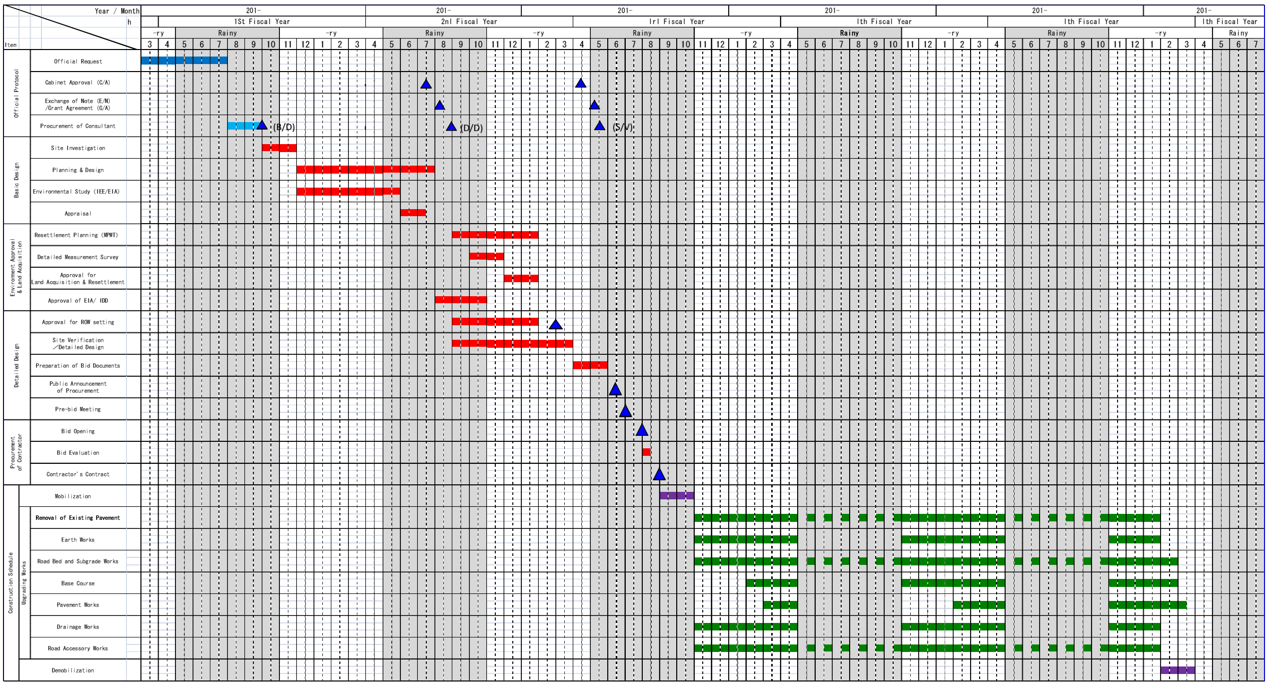
Table 4.2.2 Procurement Conditions of Major Construction Materials

Name	Locally procured	Procured in third county	Procured in Japan	Remarks
Cement	Y (Yes)	Y		For high strength:Thailand or Others For others:Laos
Concrete admixture		Y		Thailand or Vietnam
Reinforcement	Y	Y		Thailand or Vietnam
Structural steels	Y	Y		Laos or Thailand
PC bar & cables		Y	Y	Thailand or Japan
Bituminous materials		Y		Thailand or Vietnam
Crushed stone, sand	Y			Laos
Form(plywood)	Y	Y		Laos or Thailand
False work & scaffolding	Y	Y		Laos or Thailand
RC pipe	Y			Laos
Expansion joint		Y		Thailand or Others
Bearing		Y		Thailand or Others

Source: Prepared by JICA Study Team

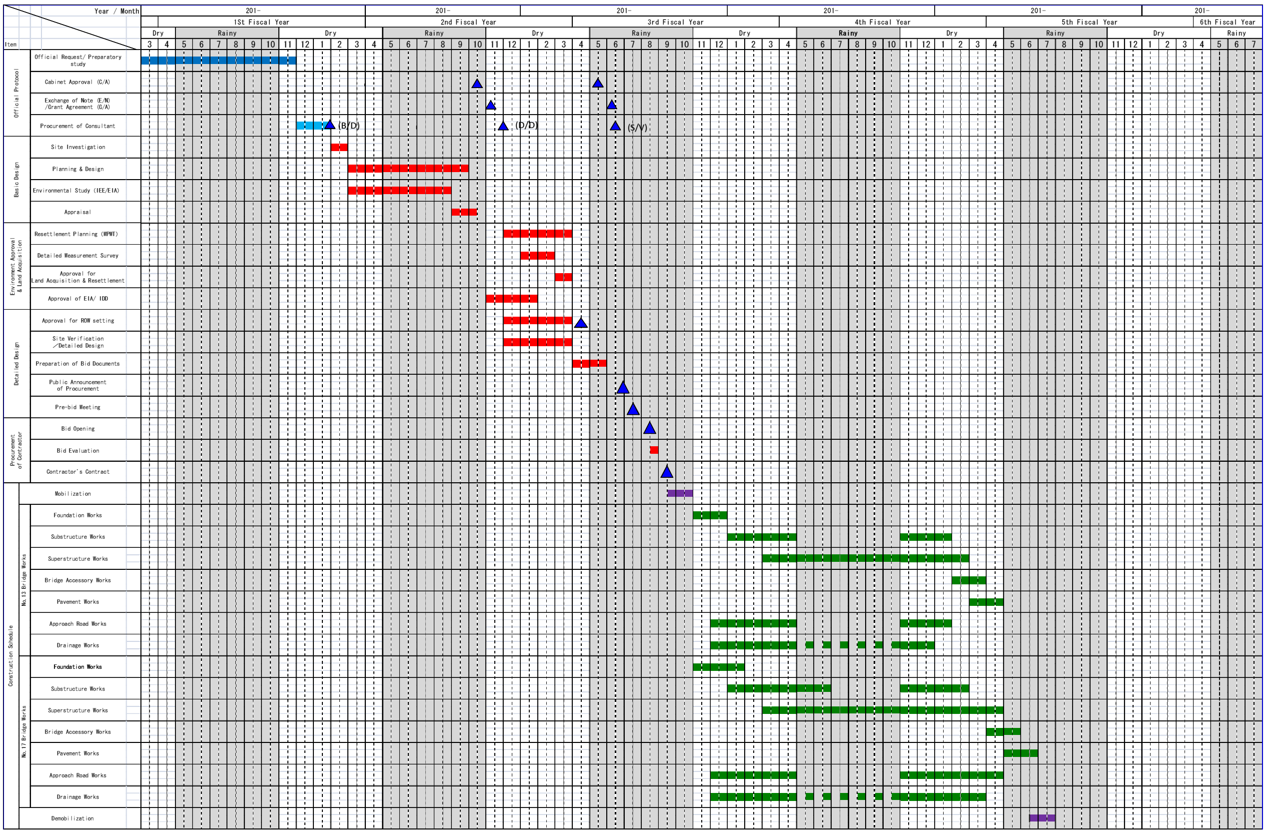
(4) Implementation Plan

Figures 4.2.2 to 4.2.4 show the tentative implementation schedule of each priority project. Each schedule was planned based on the aforementioned preconditions and construction works assumed in the study. It should be noted that the proposed implementation schedule is subject to the progress of undertakings by the Lao Government; for instance, Japan's Grant Aid Project cannot commence without completion of resettlement and approval of environmental licensing when necessary.



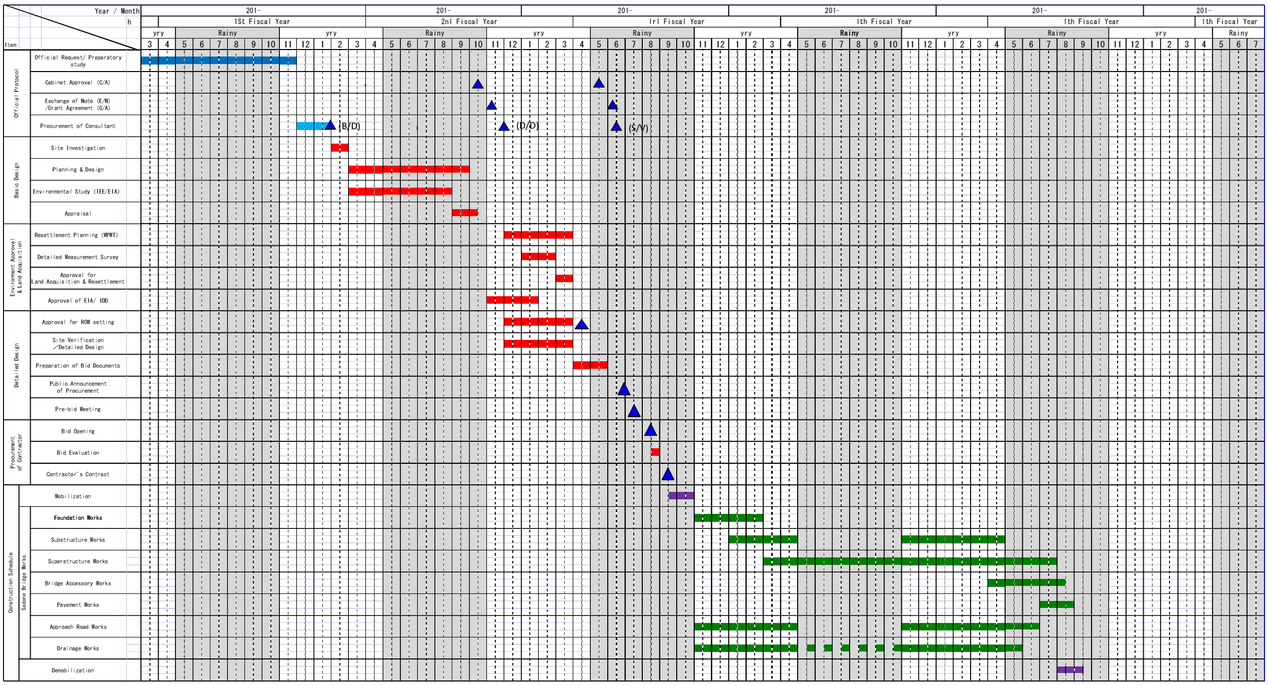
Source: Prepared by JICA Study Team

Figure 4.2.2 Implementation Schedule for Upgrading of NR-9



Source: Prepared by JICA Study Team

Figure 4.2.3 Implementation Schedule for Replacement of Bridges along NR-9



Source: Prepared by JICA Study Team

Figure 4.2.4 Implementation Schedule for Construction of Sedone Bridge on NR-15A

4.2.2 Project Operation and Maintenance Plan

Roads and bridges are in general maintained by the DPWT of each province. Table 4.2.3 shows the proposed desirable intervention levels of the inspection and maintenance activities for each major road facility. It should be noted that the inspections should be carried out periodically, especially before and after the rainy season so as to identify the damage caused by the rain and flooding.

Table 4.2.3 Maintenance & Inspection Schedule

	Item	Maintenance & Repair Works	Inspection Interval
Road	• Pavement	Patching, smoothing	3 months
	• Backside of bridge abutments	Repair of height difference	6 months
	• Shoulder/slope	Planting turf, reinforcement of soils, repairing riprap	3 months
	• Drainage	Clearing of sediment and debris	3 months
Bridge	• Drainage pipe	Clearing of sediment	3 months
	• Expansion joint	Inspection of looseness of expansion joint and clearing of sediment	3 months
	• Railing	Repairing damage from collisions	3 months
	• Bearing	Removal of soil deposits & grasses	6 months
	• Pavement	Repairing of cracks	6 months
	• Substructure	Removal of debris, Inspection of scouring	6 months
	• Around substructures	Repair of stone masonry & gabions	6 months

Source: Prepared by JICA Study Team

4.3 Preliminary Cost Estimate

(1) Project Cost

The preconditions for the project cost estimate are as follows:

- Month/year of cost estimate: April 2010
- Exchange rate: 1US$ = JPY90.67 = 8,474LAK
- Implementation period: Tendering process and construction period are shown in the implementation schedule as discussed above.

Assuming that the priority projects are implemented under Japan's Grant Aid Assistance, the total cost of each priority project is summarized in Table 4.3.1. The project cost estimates are provisional and will be finalized during the basic design study of each project.

Table 4.3.1 Preliminary Cost Estimate of Priority Projects (Unit: Million Japanese Yen)

Project Costs	Upgrading of NR-9	Two Bridge (NR-9)	Sedone Bridge (NR-15A)
Construction	3,305	1,245	1,029
Tendering Support & Supervision (6%)	198	75	62
Administration (2%)	66	25	21
Total Cost (Million Yen)	3,569	1,345	1,112

Source: Prepared by JICA Study Team

(2) Cost Borne by Lao Government

The administration costs of the project will be borne by the government of Lao PDR and these costs include land acquisition cost, resettlement cost, removal and relocation of public utilities and clearing and demining of the UXOs at the project site when necessary. The administration costs are tentatively estimated at 2% of the construction cost and should be determined more accurately during the basic design study of each project.

(3) Operation and Maintenance Cost

Table 4.3.2 summarizes operation and maintenance costs of the priority projects. The total operation and maintenance costs of all three priority projects is estimated at US$ 1.67 million/year and accounts for 20.4% of the maintenance budget (US$ 8.19 million) in 2008/09. These maintenance costs are to be borne by the government of Lao PDR after commencement of operations.

Table 4.3.2 Operation and Maintenance Costs (Upgrade of NR-9)

Period	Works	Unit	Unit Price	Unit	Quantity	Frequency per 10 years	Total (x1000 Yen)
Routine Maintenance (Road) - Every Year	**Road (AC)**						
	Repair of pave. (sealing, filling pothole, patching	1.0% of total area / year	360	m2	5,281	8	15,209
	Slope repair (earth works)	0.5% of total area / year	200	m2	2,641	8	4,225
	Bridge (N/A)						
	Repair of deck (sealing)	1.0% of total area / year	360	m2	0	8	0
	Operation cost	20% of above					3,887
	Sub-total (i) for Routine Maintenance (for cumulate over 10 years)						23,321
Periodic Maintenance (Road & Bridge) - 5th & 10th year	**Road (AC)**						
	Repair of pave. (overlay: t=3cm)	100% of total area	2,295	m2	528,100	1	1,211,990
	Slope repair (earth works)	5% of total area	200	m2	26,405	2	10,562
	Bridge (N/A)						
	Repair of deck (overlay: t=3cm)	area	2,295	m2	0	1	0
	Repair of railing & curbs, lighting facility	5% of total bridge area	950	m2	0	1	0
	Miscellaneous						
	Retaining wall, gabion, etc	5% of total area	1,800	m2	26,405	2	95,058
	Sub-total (ii) for Periodic Maintenance (per time : 10 y)						1,317,610
Operation Cost (10% of Sub-total-(i)+(ii))							134,093
Operation & Maintenance Cost (for cumulate over 10 years)							1,475,023

Source: Prepared by JICA Study Team

Table 4.3.3 Operation and Maintenance Costs (Construction of Sedone Bridge)

Period	Works	Unit	Unit Price	Unit	Quantity	Frequency	Total (x1000 Yen)
Routine Maintenance (Road) - Every Year	**Road (DBST)**						
	Repair of pave. (sealing, filling pothole, patching	1.0% of total area / year	360	m2	40	8	115
	Slope repair (earth works)	0.5% of total area / year	200	m2	20	8	32
	Bridge						
	Repair of deck (sealing)	1.0% of total area / year	360	m2	40	8	115
	Operation cost	20% of above					52
	Sub-total (i) for Routine Maintenance (for cumulate over 10 years)						315
Periodic Maintenance (Road & Bridge) - 5th & 10th year	**Road (DBST)**						
	Repair of pave. (Repave: t=12.5cm)	100% of total area	809	m2	4,000	2	6,468
	Slope repair (earth works)	5% of total area	200	m2	200	2	80
	Bridge						
	Repair of deck (overlay: t=3cm)	area	2,295	m2	2,200	1	5,049
	Repair of railing & curbs, lighting facility	5% of total bridge area	950	m2	110	1	105
	Miscellaneous						
	Retaining wall, gabion, etc	5% of total area	1,800	m2	200	2	720
	Sub-total (ii) for Periodic Maintenance (per time : 10 y)						12,422
Operation Cost (10% of Sub-total-(i)+(ii))							1,274
Operation & Maintenance Cost (for cumulate over 10 years)							14,010

Source: Prepared by JICA Study Team

Table 4.3.4 Operation and Maintenance Costs (Replacement of Bridges along NR-9)

Period	Works	Unit	Unit Price	Unit	Quantity	Frequency	Total (x1000 Yen)
Routine Maintenance (Road) - Every Year	**Road (AC)**						
	Repair of pave. (sealing, filling pothole, patching	1.0% of total area / year	360	m2	60	8	173
	Slope repair (earth works)	0.5% of total area / year	200	m2	30	8	48
	Bridge (AC)						
	Repair of deck (sealing)	1.0% of total area / year	360	m2	60	8	173
	Operation cost	20% of above					79
	Sub-total (i) for Routine Maintenance (for cumulate over 10 years)						472
Periodic Maintenance (Road & Bridge) - 5th & 10th year	**Road (AC)**						
	Repair of pave. (overlay: t=3cm)	100% of total area	2,295	m2	6,000	1	13,770
	Slope repair (earth works)	5% of total area	200	m2	300	2	120
	Bridge (AC)						
	Repair of deck (overlay: t=3cm)	area	2,295	m2	2,600	1	5,967
	Repair of railing & curbs, lighting facility	5% of total bridge area	950	m2	130	1	124
	Miscellaneous						
	Retaining wall, gabion, etc	5% of total area	1,800	m2	300	2	1,080
	Sub-total (ii) for Periodic Maintenance (per time : 10 y)						21,061
Operation Cost (10% of Sub-total-(i)+(ii))							2,153
Operation & Maintenance Cost (for cumulate over 10 years)							23,686

Source: Prepared by JICA Study Team

4.4 Initial Environmental Examination

4.4.1 Introduction

Preliminary environmental site inspection for the priority projects was carried out in March and August 2010. Based on empirical study reports and major findings obtained from this site inspection, the Initial Environmental Examination (IEE) of those project sites was carried out separately, using 30 environmental factors, listed in JICA Guideline of Environmental and Social Considerations. Throughout the IEE study, potential environmental issues were shed light upon. Basically, the examination was carried out for two scenarios, namely: (i) Do - Nothing scenario, and (ii) Do – Project scenario. Under Do – Project scenario, possible negative environmental impacts to be caused during and/after the road and bridge improvement works were highlighted. It should be noted that the IEE of the NR-9 was broken up into two parts, namely: (i) road section (Upgrade of NR-9) and (ii) bridge portion (Replacement of 2 Bridges along NR-9), for the purpose of simplification.

4.4.2 Initial Environmental Examination

(1) Upgrade of NR-9

Figure 4.4.1 shows photo records of the NR-9. This road is one of the important international highways, i.e., East-West Economic Corridor, connecting Laos with both Thailand and Vietnam. The entire road section was renovated such that there are enough Right-of-Way spaces along this road. Construction of “Michi-no-Eki”, a collective roadside vending center, is on-going at the roadside of NR-9 in order to boost the local economy.

In general, the western part of this road runs through the flat Mekong floodplain while the eastern part runs through the hilly mountainous area. The most prevailing roadside land use is classified as agricultural land such as the rice paddy fields. Several tributaries run across this road (all rivers flow in a north to south direction), and significant roadside erosions were observed at the discharge points of the regional drainage, mainly due to lack of proper mitigation measures.

There are several monuments/archeological and cultural sites along this road, namely:

- Fossil site (dinosaur foot print) - Phalanxay District
- Lao-Vietnam Monument - Phine District.
- Ning Lom & Dong Natad – Suburb Area of Savannakhet

Besides, the northern boundary of Dong-Phu-Vieng NPA runs close to the eastern part of NR-9. Figures 4.4.2 and 4.4.3 show the rainfall data, observed at both Xepon and Meuang Phin meteorological stations in Savannakhet Province. As shown in these figures, there are frequent heavy rains during the rainy season (May – October), sometimes exceeding 200 mm/day. Such heavy rains are however not experienced during the dry season (November – May). Inundation tends to occur when the heavy torrential rains exceed the discharge capacity of the regional drainage system. It is noted that both stations are located in the hilly eastern part of Savannakhet Province.

The Upgrade of NR-9 does not have any alignment modification or road widening, so it is likely that no expropriation due to this road improvement will occur. UXOs around NR-9 have been cleared already. Table 4.4.1 summarizes the Preliminary Environmental Evaluation for the Upgrade of NR-9.

NR-9 around Savannakhet Suburban Area

NR-9 around Xeno

Agricultural land (dried up rice paddy field)

Large-scale roadside Erosion

Roadside Inundation at bridge construction site

NR-9 near Laos-Vietnam Border

Figure 4.4.1 Technical Site Visit (NR-9, all photos taken on March 02, 2010)

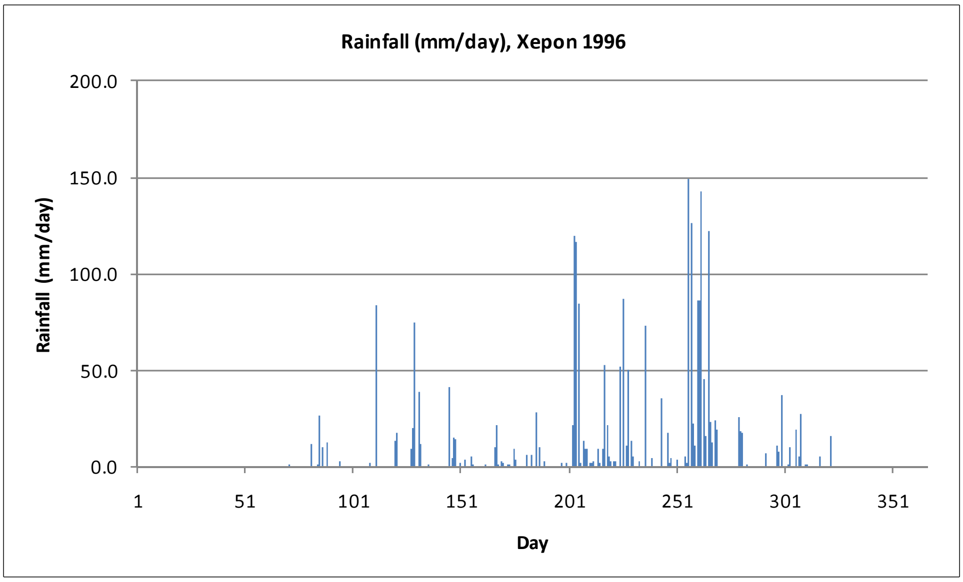


Figure 4.4.2 Rainfall, Xepon, Savannakhet, 1996

Note that X-axis corresponds to monitoring date, starting from January 1st.

Source: Prepared by JICA Study Team

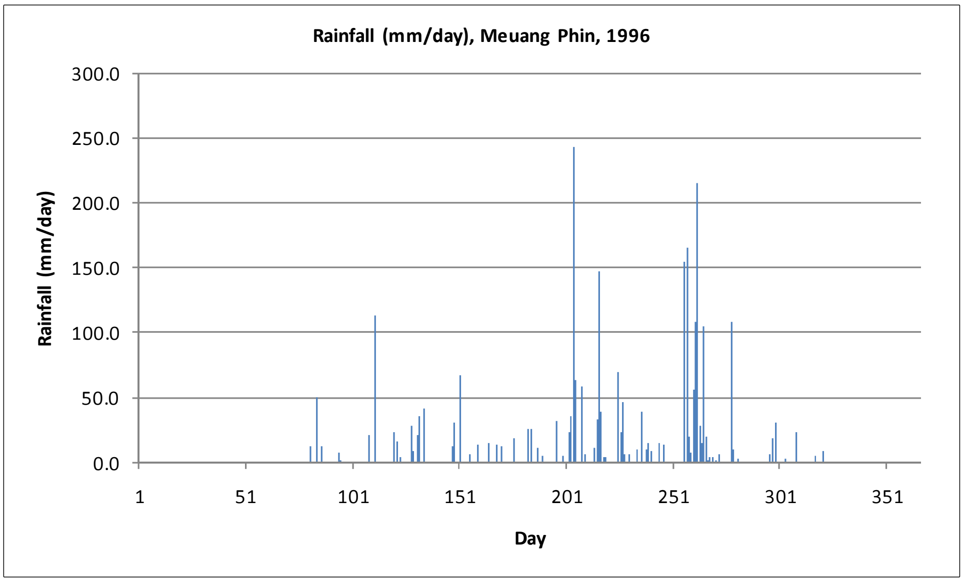


Figure 4.4.3 Rainfall, Meuang Phin, Savannakhet, 1996

Note that X-axis corresponds to monitoring date, starting from January 1st.

Source: Prepared by JICA Study Team

Table 4.4.1 Preliminary Environmental Scoping Results (Upgrade of NR-9)

Environmental Factor				Evaluation	
				Do-Nothing	Do-Project
Socio-Cultural Environment	1	Involuntary Resettlement	Land expropriation due to construction yard	D	B
			Demolition of roadside houses.	D	D
	2	Local Economy	Impact on regional tourism industry due to worsened road condition	B	D
			Increased vehicle maintenance costs due to worsened traffic condition	B	D
			Impacts on local economy, caused by temporal traffic congestion during construction period.	D	B
	3	Land use and Utilization of Local Resources	Conflict with current local land use/or development plans	D	D
	4	Social Institutions	Possible Impact on social infrastructure and local decision-making institutions	D	D
	5	Existing social infrastructures and services	Conflict with current local transport system. Conflict with current local energy/ communication/water supply system.	D	D
	6	The poor, indigenous of ethnic group	Existence of ethnic minority around the site.	D	D
	7	Misdistribution of benefit and damage	Risk of possible concentration or localization of damage or negative impacts.	D	D
	8	Cultural Heritage	Conflict with the setting of historical, cultural or monumental sites.	D	D
	9	Local Conflict of interests	Conflicts between regional environmental conservation and development.	D	D
	10	Water use/or water right	Impact on irrigation of agricultural land (e.g., rice paddy fields)	D	B
	11	Public Heath	Working Environment (Malaria, Dengue and others). Household waste treatment at construction camp	D	B
	12	Infectious Disease (e.g., HIV.AIDS)		D	B
	13	Accidents	Worsened traffic safety due to discontinuity of vehicle lanes	B	D
			Worsened traffic safety due to degraded road surface (e.g., pot hole)	B	D
			Worsened traffic safety due to temporal increase of traffic volume during construction period.	D	B
			UXO	D	D
Bio-Physical Environment	14	Topography and Geology	Significant topographical change due to construction	D	D
	15	Soil Erosion	Potential for soil erosion. Occurrence of new sedimentation at downstream side.	B	B
	16	Groundwater	Temporal water quality degradation during construction period	D	B
	17	Hydrological condition	Disruption of regional drainage pattern due to large-scale earthworks	D	B
	18	Coastal condition		D	D
	19	Flora/fauna and biodiversity	Destruction of roadside vegetation and habitats	D	D
			Disturbance to aquatic ecosystem or habitats	D	B

Environmental Factor				Evaluation	
				Do-Nothing	Do-Project
	20	Meteorology	Impact on local meteorological condition	D	D
	21	Landscape	Disruption of local townscape or landscape	D	D
	22	Global warming	Increased regional CO2 emission	B	B
Pollution	23	Air Quality	Temporal roadside air quality degradation during construction period	D	B
			Roadside air quality degradation due to traffic volume increase during operation period.	B	B
	24	Water Quality	Temporal water quality degradation of nearby surface/sub-surface water during construction period.	D	B
	25	Soil Contamination	Risk of soil contamination due to accidental spill of construction chemical.	D	B
	26	Waste	Treatment of construction waste during construction period.	D	B
	27	Noise/Vibration	Worsened roadside noise due to degraded road surface (e.g., pot holes)	B	D
			Temporally worsened roadside noise/vibration during construction period.	D	B
			Worsened roadside noise/ vibration during operation period.	B	D
	28	Ground subsidence	Potential of large-scale consolidation due to earthworks	D	D
	29	Obnoxious smell	Potential of newly created bad smells	D	D
	30	River bed	Disturbance to river bed condition.	D	D

Note A: significant, B: major, C: minor, D: less significant, U: Unknown

Source: Prepared by JICA Study Team

(2) Replacement of Bridges along NR-9

Figure 4.4.4 shows photo records of typical riverbed and riverbank conditions, commonly observed at bridge sites along NR-9. As discussed earlier, there were 51 bridges of which 2 bridges (No.13 and 17) were selected as the priority projects. The following discussion is not limited to the Initial Environmental Examination (IEE) of the 2 bridges. However, the results of the IEE exercise can be appropriated to the 2 bridges along the NR-9.

In general, there are many traces of the scouring across the river beds. Significant sand deposits were observed at flow-attenuated sections such as the inner sides of bends in the course of the river. There are many large boulders and/or gravels, presumably conveyed during the rainy season floods. Some of the river banks around bridge sites do not have proper bank/slope stabilization measures: consequently, severe erosion and/or minor landslides were observed therein. Anti-erosion measures such as Gabion mattresses were observed at the river banks of some bridge sites. Considerable quantities of debris presumably conveyed by rivers during the rainy season flood events were observed trapped at the upstream ends of bridge piers.

Significant on-going erosion was observed at the bridge discharge points of the local drainage system, mainly due to the lack of appropriate anti-erosion measures and/or inappropriate design of the roadside drainage system. Some of them seem to induce small-scale landslides at river banks.

There are several hydrological and meteorological stations around this region. Figure 4.4.5 shows the observed water level values of the Xe Thamouak River at the crossing point with NR-9, located around the central region of Savannakhet Province. From this figure, it can be seen that there is no significant change of the water level during the dry season (varies around '0' meter). The water level starts to increase at the beginning of rainy season (May – October) and reaches a maximum of about 10 meters. After the rainy season, the water level falls gradually until it approaches the dry season's water level asymptotically (Note that relevant hydrological data near NR-9, Savannakhet Province, is attached in Appendix A). Similar annual water level variation patterns are observed at all hydrological stations located across the entire Southern Laos (see Appendix A). There is no measured flow rate data for tributaries crossing NR-9 (except the Mekong River). However, from the measured water level data, it can be deduced that flow rates of all tributaries crossing NR-9 increase considerably during the rainy season. Figures 4.4.6 and 4.4.7 show the rainfall data, observed at Meuang Phin (Savannakhet) and the water level of the Xe Thamouak River, observed at the crossing point with NR-9, respectively. From the comparison of both figures, it can be seen that water level peaks tend to appear after heavy rainfall events occur. In other words, there is a close correlation between the annual rainfall and the water level variation of the Xe Thamouak River. The regional run-off of the Xe Thamouak River Basin occurs within a relatively short period.

UXOs around NR-9 have been cleared already. However, Southern Laos was one of the heavily bombarded areas during the Indo-China War. Therefore, the risks of encountering UXOs, transported from upstream ex-war zones to bridge construction sites during rainy season flood events are not negligible.

Table 4.4.2 summarizes the Preliminary Environmental Evaluation of bridges along NR-9.

Dried up river bed condition of small-middle class bridge. Several large boulders exist

Low water level-river bed condition. Many traces of scouring are observed across entire river bed.

Gabion-mattress-based River bank protection around the bridge

On-going large scale erosion around the bridge site.

Debris, wood trapped at the bridge pier

Small-scale landslide occurred on the riverbank slope.

Figure 4.4.4 Technical Site Visit (Bridge Sites of NR-9, all photos taken on March 02, 2010)

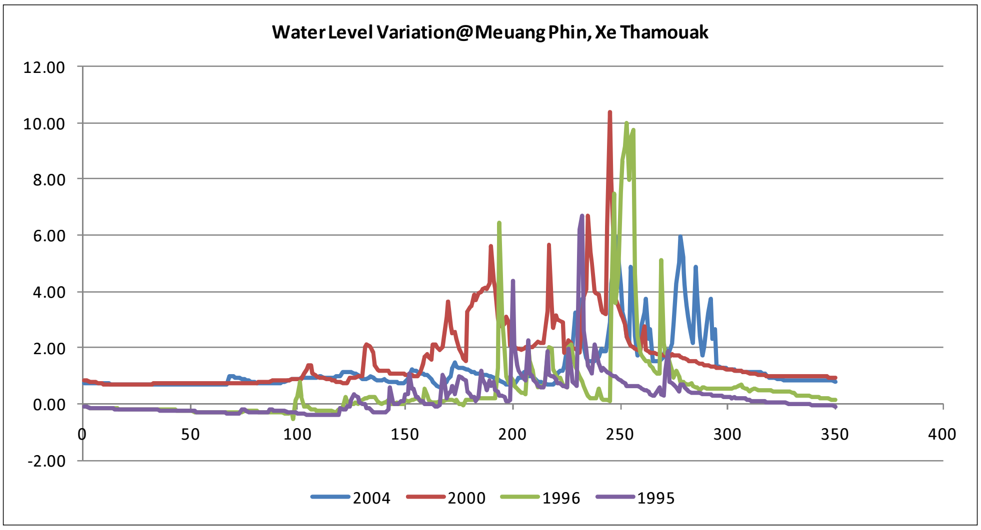


Figure 4.4.5 Water Level Variation of Xe Thamouak River (Savannakhet Province)

Note that X-axis corresponds to monitoring date, starting from January 1st while Y-axis corresponds to the measured value of the water gauge. Exact elevation corresponding to "zero-point" of the water gauge is unknown (Source: This Study, 2010).

Source: Prepared by JICA Study Team

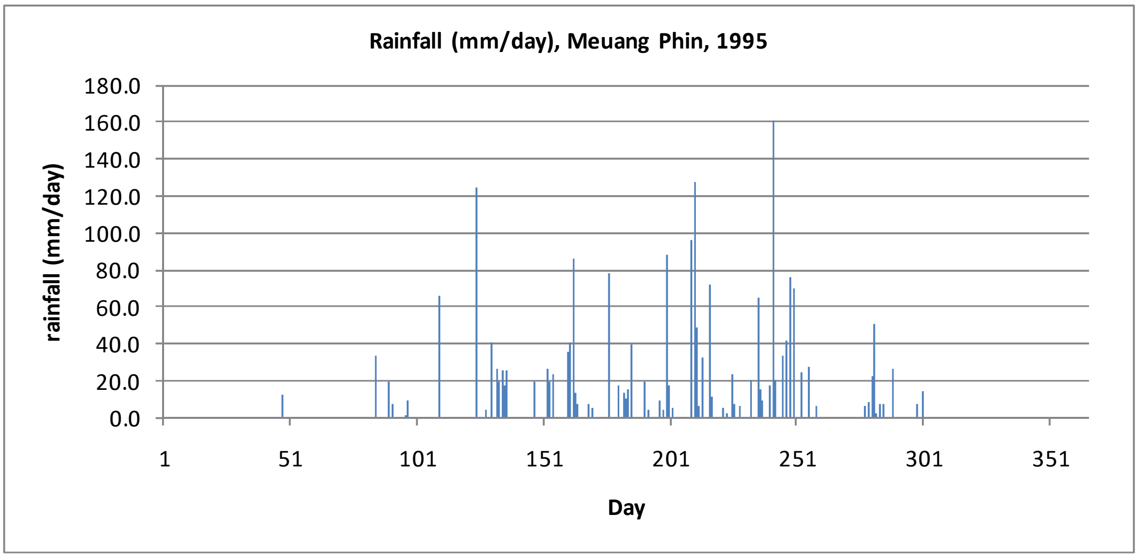


Figure 4.4.6 Rainfall, Meuang Phin, Savannakhet, 1995

Note that X-axis corresponds to monitoring date, starting from January 1st.

Source: Prepared by JICA Study Team

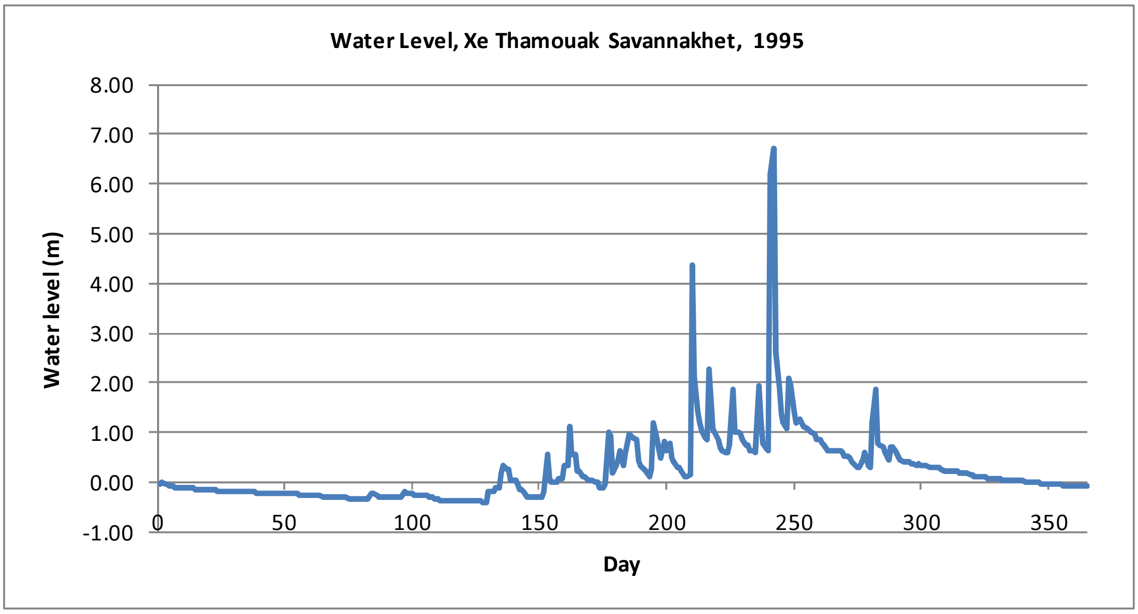


Figure 4.4.7 Water Level Variation of Xethamouk, Savannakhet, 1995

Note that X-axis corresponds to monitoring date, starting from January 1st while Y-axis corresponds to the measured value of the water gauge. Exact elevation corresponding to "zero-point" of the water gauge is unknown (Source: This Study, 2010).

Source: Prepared by JICA Study Team

Table 4.4.2 Preliminary Environmental Scoping Results (Replacement of Bridges along NR-9)

Environmental Factor				Evaluation	
				Do-Nothing	Do-Project
Socio-Cultural Environment	1	Involuntary Resettlement	Land expropriation due to construction yard	D	B
			Demolition of roadside houses.	D	D
	2	Local Economy	Impact on regional tourism industry due to worsened road condition	B	D
			Increased vehicle maintenance costs due to worsened traffic condition	D	D
			Impacts on local economy, caused by temporal traffic congestion during construction period.	D	B
	3	Land use and Utilization of Local Resources	Conflict with current local land use or development plans	D	D
	4	Social Institutions	Possible Impact on social infrastructure and local decision-making institutions	D	D
	5	Existing social infrastructures and services	Conflict with current local transport system. Conflict with current local energy/ communication/water supply system.	D	D
	6	The poor, indigenous of ethnic group	Existence of ethnic minority around the site.	D	D
	7	Misdistribution of benefit and damage	Risk of possible concentration or localization of damage or negative impacts	D	D
	8	Cultural Heritage	Conflict with the setting of historical, cultural or monumental sites.	D	B
	9	Local Conflict of interests	Conflicts between regional environmental conservation and development.	D	D

Environmental Factor				Evaluation	
				Do-Nothing	Do-Project
	10	Water use/or water right	Impact on irrigation of agricultural land (e.g., rice paddy fields)	D	B
	11	Public Heath	Working Environment (Malaria, Dengue and others). Household waste treatment at construction camp	D	B
	12	Infectious Disease (e.g., HIV.AIDS)		D	B
	13	Accidents	Worsened traffic safety due to discontinuity of vehicle lanes	B	D
			Worsened traffic safety due to degraded bridge condition	B	D
			Worsened traffic safety due to temporal increase of traffic volume during construction period.	D	B
			UXO	D	U
Bio-Physical Environment	14	Topography and Geology	Significant topographical change due to construction.	D	D
	15	Soil Erosion	Potential for soil erosion. Occurrence of new sedimentation at downstream side.	B	B
	16	Groundwater	Temporal water quality degradation during construction period	D	B
	17	Hydrological condition	Disruption of regional drainage pattern due to large-scale earthworks	D	B
	18	Coastal condition		D	D
	19	Flora/fauna and biodiversity	Destruction of roadside vegetation/habitat.	D	D
			Disturbance to aquatic ecosystem or habitats	D	B
	20	Meteorology	Impact on local meteorological condition	D	D
	21	Landscape	Disruption of local townscape or landscape	D	D
	22	Global warming	Increased regional CO2 emission	B	B
Pollution	23	Air Quality	Temporal roadside air quality degradation during construction period	D	B
			Roadside air quality degradation due to traffic volume increase during operation period.	B	B
	24	Water Quality	Temporal water quality degradation of nearby surface/sub-surface water during construction period.	D	B
	25	Soil Contamination	Risk of soil contamination due to accidental spill of construction chemicals.	D	B
	26	Waste	Treatment of construction waste during construction period.	D	B
	27	Noise/Vibration	Worsened roadside noise due to degraded road surface (e.g., pot holes)	B	D
			Temporally worsened roadside noise/vibration during construction period.	D	B
			Worsened roadside noise/ vibration during operation period.	B	D
	28	Ground subsidence	Potential of large-scale consolidation due to earthworks	D	D
	29	Obnoxious smell	Potential of newly created bad smells	D	D
	30	River bed	Disturbance to river bed condition.	D	B

Note A: significant, B: major, C: minor, D: less significant, U: Unknown

Source: Prepared by JICA Study Team

(3) Construction of Sedone Bridge

Figure 4.4.8 shows photo records of existing Sedone Bridge. The existing bridge is located at the Sedone River crossing point of NR-15A. The existing bridge is submerged during the rainy season. Usually, this impassable period lasts 1 to 2 months during which period ferry operations are carried out. Figure 4.4.9 shows the water level values of the Sedone River, observed at Khonsedon (approximately 40 km downstream of the current bridge point). From this figure, a similar water variation pattern to the Xe Thamouak River of NR-9 can be discerned. There is no significant change to the water level during the dry season (varies around 1 meter). The water level starts to increase at the beginning of rainy season and reaches a maximum of around 12 meters. After the rainy season, the water level gradually subsides to dry-season water levels. From interviews with local residents, it was established that the flow rate of the Sedone River tends to change rapidly, and a peak time flow condition does not persist for a long period. Similar observations can be derived from hydrological discussions of the Xe Thamouak River of NR-9, in the previous section. Based on these facts, it can be said that flow rates of major tributaries across Savannakhet and Saravan Provinces have strong correlation with the regional rainfall pattern due to the short-time run-off periods.

No flow rate data for the Sedone River exists at the existing bridge site. Regional inundations due to the flood events of the Sedone River occurred in the past. In general, the Sedone River meanders downstream through the Mekong floodplain, with several traces of old river channels across the floodplains of Saravan and Champasak Provinces. In other words, it can be said that the Sedone River is morphologically unstable.

There aren’t any illegal squatter areas that exist around this site. Neither are there any schools, watt (temple), hospitals, and historical or cultural sites. UXOs around NR-15A have already been cleared. However, Southern Laos was one of the heavily bombarded areas during the Indo-China War. As such, the risks of encountering UXOs, transported from upstream ex-war zones to bridge construction sites during rainy season flood events are not negligible.

This preliminary study specifies that alignment of the new bridge and its approach roads will be located downstream of the existing bridge. The vertical clearance of the new bridge will be high enough and bridge piers will not be set up within the river space so as to ensure safe passage of flood current. However, a site-specific maximum flood flow rate is not measured along the Sedone River. Due to the high vertical clearance of the new bridge, some portion of the approach roads on both sides will be embanked. Consequently, it is likely that the new bridge facilities including approach roads could serve the role of long-distance levee/ dyke in case of floods.

Table 4.4.3 summarizes the Preliminary Environmental Evaluation of the Construction of the Sedone Bridge. It should be noted that the alignments of the approach roads on both ends of the bridge have not been finalized yet. Therefore, the associated environmental impacts, including involuntary resettlement, are evaluated as “U (Unknown)”.

Westside River Bank (downstream side)

Westside River Bank (upstream side)

Existing Sedone Bridge (toward Salavan)

Ferry let at Westside River Bank (rainy season operation only)

Overview of Eastside River Bank

Unprotected River Bank (Eastside)

Figure 4.4.8 Technical Site Visit (Sedone Bridge, all photos taken on March 03, 2010)

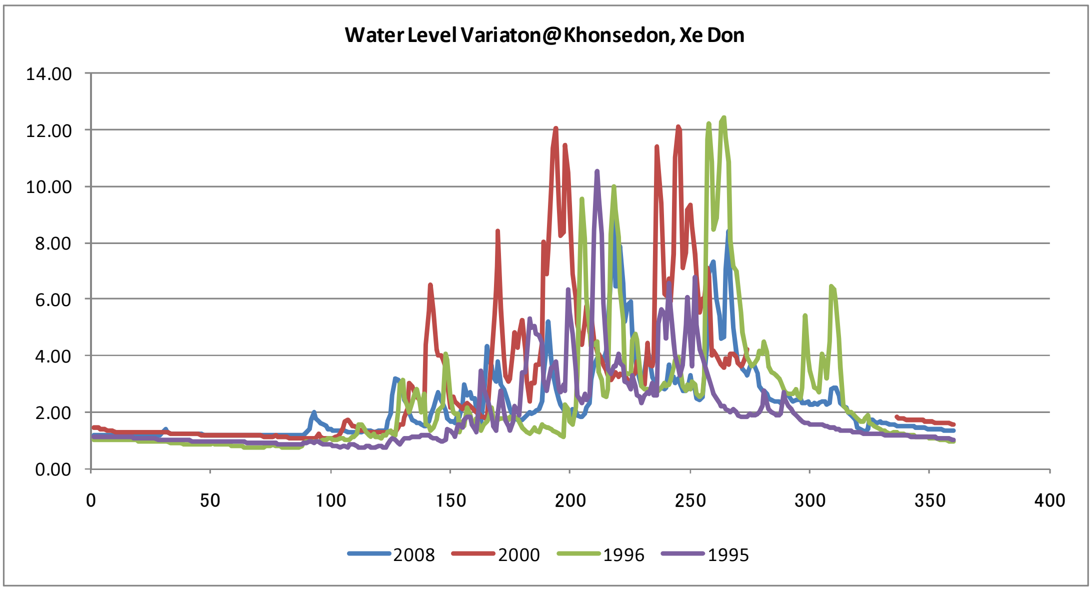


Figure 4.4.9 Water Level Variation of Sedone River (Khonsedon, Saravan Province)

Note that X-axis corresponds to monitoring date, starting from January 1st while Y-axis corresponds to the the measured value of the water gauge. Exact elevation corresponding to "zero-point" of the water gauge is unknown (Source: This Study, 2010).

Source: Prepared by JICA Study Team

Table 4.4.3 Preliminary Environmental Scoping Results (Construction of Sedone Bridge)

Environmental Factor				Evaluation	
				Do-Nothing	Do-Project
Socio-Cultural Environment	1	Involuntary Resettlement	Land expropriation due to construction yard	D	B
			Demolition of roadside houses.	D	B
	2	Local Economy	Impact on regional tourism industry due to worsened road condition	B	D
			Increased vehicle maintenance costs due to worsened traffic condition	D	D
			Impacts on local economy, caused by temporal traffic congestion during construction period.	D	B
	3	Land use and Utilization of Local Resources	Conflict with current local land use or development plans	D	D
	4	Social Institutions	Possible Impact on social infrastructure and local decision-making institutions	D	D
	5	Existing social infrastructures and services	Conflict with current local transport system. Conflict with current local energy/ communication/water supply system.	D	D
	6	The poor, indigenous of ethnic group	Existence of ethnic minority around the site.	D	D
	7	Misdistribution of benefit and damage	Risk of possible concentration or localization of damage or negative impacts.	D	D
	8	Cultural Heritage	Conflict with the setting of historical, cultural or monumental sites.	D	D
	9	Local Conflict of interests	Conflicts between regional environmental conservation and development.	D	D

Environmental Factor				Evaluation	
				Do-Nothing	Do-Project
	10	Water use/or water right	Impact on irrigation of agricultural land (e.g., rice paddy fields)	D	B
	11	Public Heath	Working Environment (Malaria, Dengue and others). Household waste treatment at construction camp	D	B
	12	Infectious Disease (e.g., HIV.AIDS)		D	B
	13	Accidents	Worsened traffic safety due to degraded bridge condition	B	D
			Worsened traffic safety due to temporal increase of traffic volume during construction period.	D	B
			UXO	D	U
Bio-Physical Environment	14	Topography and Geology	Significant topographical changes due to construction	D	U
	15	Soil Erosion	Potential for soil erosion. Occurrence of new sedimentation at downstream side.	B	B
	16	Groundwater	Temporal water quality degradation during construction period	D	D
	17	Hydrological condition	Disruption of regional drainage pattern due to large-scale earthworks.	D	U
	18	Coastal condition		D	D
	19	Flora/fauna and biodiversity	Destruction of roadside vegetation/habitat.	D	D
			Disturbance to aquatic ecosystem or habitats.	D	B
	20	Meteorology	Impact on local meteorological condition	D	D
	21	Landscape	Disruption of local townscape or landscape	D	D
	22	Global warming	Increased regional CO2 emission	B	B
Pollution	23	Air Quality	Temporal roadside air quality degradation during construction period	D	B
			Roadside air quality degradation due to traffic volume increase during operation period.	B	B
	24	Water Quality	Temporal water quality degradation of nearby surface/sub-surface water during construction period.	D	B
	25	Soil Contamination	Risk of soil contamination due to accidental spill of construction chemicals.	D	B
	26	Waste	Treatment of construction waste during construction period.	D	B
	27	Noise/Vibration	Temporally worsened roadside noise/vibration during construction period.	D	B
			Worsened roadside noise/ vibration during operation period.	B	D
	28	Ground subsidence	Potential of large-scale consolidation due to earthworks	D	D
	29	Obnoxious smell	Potential of newly created bad smells	D	D
	30	River bed	Disturbance to river bed condition.	D	B

Note A: significant, B: major, C: minor, D: less significant, U: Unknown

Source: Prepared by JICA Study Team

4.5 Project Evaluation

4.5.1 Economic Evaluation

(1) Basic Assumption

Economic feasibility of the 3 priority projects was evaluated separately in this section. The following basic assumptions and facets were employed in the analysis:

- Indicator to evaluate economic feasibility: In order to evaluate economic feasibility, Economic Internal Rate of Return (EIRR) was calculated for each project.
- With-project case and without-project case: The with-project case is a situation whereby the priority project will be implemented. On the other hand, the without-project case refers to the situation whereby the priority projects are not implemented while only existing roads and bridges are utilized.
- Project implementation schedule: Project implementation schedule consists of 2 years of engineering service, 2 years of construction and 30 years of operation.
- Lifetime: Lifetime of civil works in the projects was assumed to be 50 years. Residual value which is 40% of project cost (20 years of residual lifetime divided by 50 years) was evaluated and calculated for the final year of operation.
- Physical contingency, tax, and consultant services and administration costs: Physical contingency and tax were not included in the economic analysis. Costs for consultant services which are 6% of the cost of the projects and administration costs which are 2% of the cost of the projects were considered.

(2) Upgrade of NR9

1) Economic Benefit

The following effects are expected from upgrading NR9:

- Reduction of Vehicle Operating Costs,
- Reduction of vehicle travel time, and
- Reduction of traffic accidents.

Economic value of reducing traffic accidents is estimated from probability of traffic accidents, damage to vehicles, cargo and passengers. Since this data is not available at the project site, reduction of traffic accidents was not included in the economic benefit.

Reduction of VOC is determined from the product of unit VOC and reduction in vehicle travel distance while savings in travel time are calculated from opportunity cost per person which is equal to the product of time value of labor and reduction in travel time.

Table 4.5.1 Reduction in Vehicle Travel Distance

(Unit: Vehicle-km)

Vehicle type	2015	2025
Motorcycle	-4,782,353	-7,829,120
Passenger Car	-840,216	-8,846,500
Bus	-21,606	-205,166
2 Axles Truck (Loading)	0	-133,467
3Axles and more (Loading)	0	21,775
Trailer (Loading)	0	-34,403
2 Axles Truck (Empty)	0	-274,733
3Axles and more (Empty)	0	-278,031
Trailer (Empty)	-1,585,646	618,925
Total	-7,229,822	-16,960,720

Source: JICA Study Team calculated from demand forecast model

The figures in Table 4.5.1 indicate the reduction in vehicle travel distance calculated from with project case and without project case for demand forecast in 2015 and 2025. Operation of the upgraded road will start in the 5th year from commencement of the project. The reduction in vehicle travel distance will thus start from 2015. The reduction in vehicle travel distance from 5th year to 25th year was estimated from annual average growth rate. It will be constant after the 26th year (2036).

The figures are negative for both 2015 and 2025, which means that vehicle travel distance will continue to increase during those years. Such a situation is caused by the expected increase in number of motorbikes and passenger cars and the transition of trucks and trailers from other routes onto the newly improved project route.

Table 4.5.2 indicates the unit VOCs by vehicle type which were calculated by JICA Study Team based on the data from “Preparatory Survey on Construction of the Neak Loeung Bridge in Kingdom of Cambodia.” The same figures as the economic analysis of the Master Plan in Chapter 3 were employed. Reduction in VOC is calculated from the product of reduction in vehicle travel distance and associated unit VOC. Table 4.5.3 shows the reduction in vehicle travel time in 2015 and 2025.

Table 4.5.2 Unit VOC by Vehicle Type

(Unit: USD/1000km)

Vehicle Type	Unit VOC
Motorcycle	26.3
Passenger Car	207.8
Bus	344.2
2 Axles Truck (Loading)	191.6
3Axles and more (Loading)	313.7
Trailer (Loading)	334.6
2 Axles Truck (Empty)	191.6
3Axles and more (Empty)	313.7
Trailer (Empty)	334.6

Source: Calculated by JICA Study Team based on “Basic Design on 2nd Mekong Bridge Development Project in Kingdom of Cambodia”

Table 4.5.3 Reduction in Vehicle Travel Time

(Unit: Vehicle-hour)

Vehicle Type	2015	2025
Motorcycle	156,693	295,880
Passenger Car	300,794	758,628
Bus	10,530	27,521
2 Axles Truck (Loading)	3,972	10,559
3Axles and more (Loading)	2,405	8,463
Trailer (Loading)	4,732	14,394
2 Axles Truck (Empty)	3,958	8,233
3Axles and more (Empty)	3,133	3,744
Trailer (Empty)	-1,695	30,576

Source: JICA Study Team

Table 4.5.4 shows change in time value of labor from 2010 to 2025, which is calculated from forecasts of GDP and labor force. The time value of labor is USD0.79/hour, 3 times higher than the value in the previous master plan (USD0.24/hour). This is due to GDP growth rates of 7% and appreciation of LAK against USD after 2004. These figures are the same as those used in the economic analysis of Master Plan in Chapter 3.

Table 4.5.4 Calculation of Time Value of Labor

	2010	2015	2020	2025
GDP (LAK billion)	47,855	68,312	99,397	139,409
Labor population (000 persons)	3,222	3,644	3,985	4,350
GDP per employee (USD)	1,732	2,186	2,909	3,737
Time value per Labor (USD/hour)	0.79	1.00	1.33	1.71

Note: USD1=LAK8575

Source: Calculation by JICA Study Team using Statistical Yearbook 2008

Table 4.5.5 shows the number of passengers, and time value of a vehicle and cargo by vehicle type. Time value of a vehicle is calculated from the product of time value of labor shown in Table 4.5.4 and the number of passengers by vehicle type. As regards the time value of cargo, the figures which were calculated in “The Comprehensive Study on Logistics Strategy in Lao PDR” were employed.

Table 4.5.5 Time Value of Vehicle and Cargo by Vehicle Type in 2010

Vehicle Type	Number of Passengers (Persons)	Vehicle (USD/hour)	Cargo (USD/hour)	Vehicle + Cargo (USD/hour)
Motorcycle	1.5	1.2	-	1.2
Passenger Car	2.5	2.0	-	2.0
Bus	30	23.8	-	23.8
2 Axles Truck (Loading)	1.5	1.2	0.4	1.6
3Axles and more (Loading)	1.5	1.2	1.1	2.3
Trailer (Loading)	1.5	1.2	2.7	3.9
2 Axles Truck (Empty)	1.5	1.2	-	1.2
3Axles and more (Empty)	1.5	1.2	-	1.2
Trailer (Empty)	1.5	1.2	-	1.2

Source: JICA Study Team

Time value of a vehicle will increase in accordance with the increase in time value of labor. However, the time value of cargo would remain constant during the project implementation period. Total time value of vehicles and cargo was calculated from the product of reduction in vehicle travel time and the total of time value of vehicles and cargo.

2) Economic Cost

Table 4.5.6 shows the construction cost of upgrading NR9. Total construction cost amounts to USD 36,449,000. Since the figure is a financial cost, the domestic portion of the construction cost was converted to economic cost by use of "Standard Conversion Factor".

Table 4.5.6 Construction Cost: Upgrading NR9

	Unit Cost (JPY/m^2)	Area (m^2)	Cost in JPY (000)	Cost in USD (000)
Re-pavement	6,752	103,300	697,489	7,582
Overlay	6,138	424,800	2,607,350	28,756
Total		528,100	3,304,838	36,449

Note: Width: 10m; Drainage and slope works are included.

Source: JICA Study Team

Domestic and foreign portions of the financial cost for road projects were estimated as 70% and 30% respectively. As regards the Standard Conversion Factor, a figure of 96.4% was employed. The figure was obained from "Study on Integrated Distribution Center in Savannakhet and Vientiane in Lao PDR," conducted by JETRO in 2005. After these calculations, economic cost of the projects was established as USD 35,531,000.

Table 4.5.7 Annual Investment Amount

(Unit USD million)

Year	1	2	3	4	Total cost	Remarks
Construction Cost	-	-	17,765	17,765	35,531	-
Consulting Services	765	765	328	328	2,187	6% of financial construction cost
Administration	182	182	182	182	729	2% of financial construction cost
Total Investment Cost	948	948	18,276	18,276	38,446	-

Source: JICA Study Team

Table 4.5.7 shows annual investment cost. Total investment cost including costs for consulting services and administration will amount to USD 38,446,000.

Table 4.5.8 shows operation and maintenance costs in both the 'without-project case' and the 'with-project case'. Currently DPWT of Savannakhet Province disburses around 20 billion Kip (USD 2.4 million) per year for operation and maintenance of the NR9. If the project were completed, the operation and maintenance costs would decrease to USD 32,000 for routine maintenance which would be conducted every year and USD 8.0 million for periodic maintenance which would be conducted every 5 years. Such a decrease in operation and maintenance costs improves EIRR.

Table 4.5.8 Operation and Maintenance Costs: Without Project Case and With Project Case

(Unit: USD 000)

Without Project	With Project	
Routine Maintenance Cost (Every year)	Routine Maintenance Cost (Every year)	Periodic Maintenance Cost (Every 5 years)
2,360	32	8,005

Source: JICA Study Team

3) Calculation of EIRR

Table 4.5.9 shows the annual economic cost, annual economic benefit and net cash flow. Economic Internal Rate of Return (EIRR) calculated from the Net Cash Flow is 11.9%. The amount is a little lower than the substitution cost of capital, which is set at 12%.

One of the causes of the low figure for EIRR is the low economic benefit during the initial stage of operation and maintenance. In the initial phase of operation and maintenance, the economic benefit ranges from 0.5 million to 1.5 million. After the 20th year of operation however, the amount increases to USD 17.7 million.

Table 4.5.9 Cash Flow of Upgrading NR 9

(Unit USD 000)

Year Const	Year O&M	Economic Cost				Economic Benefit	Net Cash Flow
		Engineering Service	Administration	Construction	O&M		
1		765	182				-948
2		765	182				-948
3		328	182	17,765			-18,276
4		328	182	17,765			-18,276
	1				-2,328	539	2,867
	2				-2,328	753	3,081
	3				-2,328	984	3,312
	4				-2,328	1,236	3,564
	5				5,645	1,509	-4,136
	6				-2,328	1,803	4,131
	7				-2,328	2,120	4,448
	8				-2,328	2,459	4,787
	9				-2,328	2,819	5,147
	10				5,645	3,197	-2,448
	11				-2,328	3,588	5,916
	12				-2,328	4,269	6,597
	13				-2,328	5,053	7,381
	14				-2,328	5,957	8,285
	15				5,645	7,000	1,355
	16				-2,328	8,205	10,533
	17				-2,328	9,598	11,926
	18				-2,328	11,209	13,537
	19				-2,328	13,073	15,401
	20				5,645	15,231	9,586
	21				-2,328	17,731	20,059
	22				-2,328	17,731	20,059
	23				-2,328	17,731	20,059
	24				-2,328	17,731	20,059
	25				5,645	17,731	12,085
	26				-2,328	17,731	20,059
	27				-2,328	17,731	20,059

	28				-2,328	17,731	20,059
	29				-2,328	17,731	20,059
	30			-14,212	5,645	17,731	26,298
						EIRR	11.9%

Source: JICA Study Team

(3) Replacement of Bridges along NR9

1) Economic Benefit

Economic effects of the replacement of bridges along NR 9 are the same as those for the upgrade of NR 9:

- Reduction in Vehicle Operating Costs (VOC),
- Reduction in vehicle travel time, and
- Reduction in traffic accidents.

Due to unavailability of data, the reduction in traffic accidents was not included as an economic benefit in the economic analysis.

Reductions in VOC and vehicle travel time were derived from the possibility of bridge collapses. In the case of ‘without-project’, each bridge faces the possibility of collapse. It was assumed that the probability of the event was 1% in this analysis. If the bridges collapsed, vehicles wouldn’t be able to pass the bridge for 3 days. During the period, vehicles would take detours and additional VOC and vehicle travel time would be generated at both bridges. The sum of these amounts was treated as economic benefit in the analysis.

Table 4.5.10 shows the reduction in vehicle travel distance calculated for ‘with project case’ and ‘without project case’ from demand forecasts in 2015 and 2025. Operation of bridges would start in the 5th year from the commencement of the project. Hence, reduction in vehicle travel distances would be experienced starting from 2015. The reduction in vehicle travel distance from the 5th year to the 25th year was estimated from the annual average growth rate. It would remain constant after the 26th year. Table 4.5.11 shows the reduction in vehicle travel times.

Table 4.5.10 Reduction in Vehicle Travel Distance

(Unit: Vehicle-km)

Vehicle type	2015	2025
Motorcycle	127,000	349,645
Passenger Car	1,086,482	2,390,346
Bus	117,149	324,879
2 Axles Truck (Loading)	2,429	10,093
3Axles and more (Loading)	4,302	22,450
Trailer (Loading)	184	16,124
2 Axles Truck (Empty)	-19,414	-43,331
3Axles and more (Empty)	-4,610	-3,325
Trailer (Empty)	-261,321	-362,912
Total	1,052,203	2,703,969

Source: JICA Study Team calculated from demand forecast model

Table 4.5.11 Reduction in Vehicle Travel Time

(Unit: Vehicle-hour)

Vehicle Type	2015	2025
Motorcycle	37,463	121,576
Passenger Car	84,779	213,758
Bus	4,231	7,071
2 Axles Truck (Loading)	1,015	2,677
3Axles and more (Loading)	676	1,678
Trailer (Loading)	1,154	3,174
2 Axles Truck (Empty)	676	1,373
3Axles and more (Empty)	414	968
Trailer (Empty)	-1,256	-1,169

Source: JICA Study Team

2) Economic Cost

Table 4.5.12 shows the construction cost of the project. The total construction cost amounts to USD 13,729,000. Since this is a financial cost, the domestic portion of the construction cost was converted to economic cost by use of “Standard Conversion Factor”.

Table 4.5.12 Construction Cost: Replacement of Bridges along NR9

	Unit Price	Quantity	Amount in JPY (000)	Amount in USD (000)
Bridge Works	411,607/m^2	2,860	1,177,196	12,983
Approach Road Works (AC)	5,687/m^2	6,600	37,528	414
Miscellaneous Works	50,099/m	600	30,060	332
Total	-	-	1,244,783	13,729

Source: JICA Study Team

The domestic and foreign portions of the project’s financial cost were estimated to be 40% and 60% respectively for bridge works; 70% and 30% respectively for road works and 100% and 0% respectively for miscellaneous works. As regards the Standard Conversion Factor, a figure of 96.4% was employed. The figure was obtained from “Study on Integrated Distribution Center in Savannakhet and Vientiane in Lao PDR,” conducted by JETRO in 2005. After these calculations, the economic cost of the projects was calculated as USD 13,426,000.

Table 4.5.13 Annual Investment Amount

(Unit USD million)

Year	1	2	3	4	Total cost	Remarks
Construction Cost	-	-	4,475	4,475	13,426	-
Consulting Service	288	288	124	124	824	6% of financial construction cost
Administration	69	69	69	69	275	2% of financial construction cost
Total Investment Cost	357	357	6,905	6,905	14,524	-

Source: JICA Study Team

Table 4.5.13 shows annual investment cost. Total investment cost includes costs for consulting services and administration. It amounts to USD 14,524,000.

Table 4.5.14 shows operation and maintenance costs in 'the without project case' and 'with project case'. Routine maintenance cost which would be disbursed every year amounts to USD 700 per annum while the periodic maintenance cost which would be disbursed every 5 years amounts to USD 128,000.

Table 4.5.14 Operation and Maintenance Costs: Without Project Case and With Project Case

(Unit: USD 000)

Case	Without Project	With Project	
Items	Routine Maintenance Cost (Every year)	Routine Maintenance Cost (Every year)	Periodic Maintenance Cost (Every 5 years)
Total Cost	0	0.7	128

Source: JICA Study Team

3) Calculation of EIRR

Table 4.5.15 shows the annual economic cost, annual economic benefit and net cash flow. Economic Internal Rate of Return (EIRR) calculated from the Net Cash Flow is 12.8%. The amount is over substitution of capital, which is set at 12%. Therefore, the project is viable as far as the national economy of Lao PDR is concerned.

Table 4.5.15 Cash Flow for Replacement of Bridges along NR9

(Unit USD 000)

Year Const	Year O&M	Economic Cost				Economic Benefit	Net Cash Flow
		Engineering Service	Administration	Construction	O&M		
1		288	69				-357
2		288	69				-357
3		124	69	6,713			-6,905
4		124	69	6,713			-6,905
	1				0.7	592	591
	2				0.7	672	671
	3				0.7	763	762
	4				0.7	866	865
	5				128	983	855
	6				0.7	1,116	1,116
	7				0.7	1,268	1,268
	8				0.7	1,442	1,441
	9				0.7	1,640	1,639
	10				128	1,866	1,738
	11				0.7	2,125	2,124
	12				0.7	2,421	2,421
	13				0.7	2,762	2,761
	14				0.7	3,154	3,153
	15				128	3,606	3,478
	16				0.7	4,129	4,128
	17				0.7	4,736	4,736
	18				0.7	5,445	5,445
	19				0.7	6,279	6,278
	20				128	7,265	7,137
	21				0.7	8,445	8,444
	22				0.7	8,445	8,444
	23				0.7	8,445	8,444
	24				0.7	8,445	8,444

	25				128	8,445	8,317
	26				0.7	8,445	8,444
	27				0.7	8,445	8,444
	28				0.7	8,445	8,444
	29				0.7	8,445	8,444
	30			-5,370	128	8,445	13,687
						EIRR	12.8%

Source: JICA Study Team

(4) Construction of Sedone Bridge

1) Economic Benefit

Economic effects of the construction of Sedone Bridge at NR 15A are the same as the other two projects:

- Reduction in Vehicle Operating Costs (VOC),
- Reduction in vehicle travel time, and
- Reduction in traffic accidents.

Due to unavailability of data, the reduction in traffic accidents was not included in the economic analysis as an economic benefit.

Reductions in VOC and vehicle travel time were derived from the additional VOC and vehicle travel times due to detour travel during the rainy season. In the case of 'without-project', all vehicles would not be able to pass the existing Sedone Bridge for 30 days when the bridge is submerged. During such a period, vehicles would take detours and thus additional VOC and vehicle travel time would be generated. The sum of these amounts was treated as an economic benefit in this analysis.

Table 4.5.16 shows reduction in vehicle travel distance calculated for 'with project case' and 'without project case' for demand forecasts in 2015 and 2025. Operation of bridges will start in the 5th year from the commencement of the project. As such the reduction in vehicle travel distance would start in 2015. The reduction in vehicle travel distance from the 5th year to the 25th year was estimated from annual average growth rate. It would remain constant after the 26th year. It should be noted that the reduction in vehicle travel distance would be negative in both 2015 and 2025. Table 4.5.17 shows the reduction in vehicle travel time.

Table 4.5.16 Reduction in Vehicle Travel Distance

(Unit: Vehicle-km)

Vehicle type	2015	2025
Motorcycle	4,105,970	7,911,890
Passenger Car	749,466	1,181,598
Bus	30,408	18,888
2 Axles Truck (Loading)	43,573	109,107
3Axles and more (Loading)	17,580	43,863
Trailer (Loading)	6,816	4,637
2 Axles Truck (Empty)	40,837	114,085
3Axles and more (Empty)	0	14,922
Trailer (Empty)	-136,099	-323,705
Total	4,858,551	9,075,285

Source: JICA Study Team calculated from demand forecast model

Table 4.5.17 Reduction of Vehicle Travel Time

(Unit: Vehicle-hour)

Vehicle Type	2015	2025
Motorcycle	119,430	340,950
Passenger Car	36,627	102,339
Bus	1,193	1,229
2 Axles Truck (Loading)	1,687	4,312
3Axles and more (Loading)	873	3,047
Trailer (Loading)	702	2,245
2 Axles Truck (Empty)	1,605	4,190
3Axles and more (Empty)	435	2,372
Trailer (Empty)	-736	-2,642

Source: JICA Study Team

2) Economic Cost

Table 4.5.18 shows the construction cost of the project. The total construction cost amounts to USD 11,353,000. Since this is a financial cost, the domestic portion of the construction cost would be converted to economic cost by use of “Standard Conversion Factor”.

Table 4.5.18 Construction Cost: Construction of Sedone Bridge

	Unit Price	Quantity	Amount in JPY (000)	Amount in USD (000)
Bridge Works	411,607/m^2	2,420	996,089	10,986
Approach Road Works (DBST)	3.313/m^2	4,000	13,253	146
Miscellaneous Works	50,099/m	400	20,040	221
Total	-	-	1,029,382	11,353

Source: JICA Study Team

The domestic and foreign portions of the project were estimated as: 40% and 60% respectively for bridge works; 70% and 30% respetively for road works and 100% and 0% respectively for miscellaneous works. As regards the Standard Conversion Factor, a figure of 96.4% was employed. The figure was obtained from “Study on Integrated Distribution Center in Savannakhet and Vientiane in Lao PDR,” conducted by JETRO in 2005. After these calculations, the economic cost of the project was established to be USD 11,183,000.

Table 4.5.19 Annual Investment Amount

(Unit USD million)

Year	1	2	3	4	Total cost	Remarks
Construction Cost	-	-	5,592	5,592	11,183	-
Consulting Service	238	238	102	102	681	6% of financial construction cost
Administration	57	57	57	57	227	2% of financial construction cost
Total Investment Cost	295	295	5751	5751	12,091	-

Source: JICA Study Team

Table 4.5.19 shows annual investment cost. The total investment cost including cost for consulting services and administration would amount to USD 12,091,000.

Table 4.5.20 shows operation and maintenance costs for the ‘without project case’ and ‘with project case’. Routine maintenance would be conducted every year and would cost USD 400 per year while periodic maintenance would be conducted every 5 years and would amount to USD 76,000.

Table 4.5.20 Operation and Maintenance Costs: Without Project Case and With Project Case

(Unit: USD 000)

Case	Without Project	With Project	
Items	Routine Maintenance Cost (Every year)	Routine Maintenance Cost (Every year)	Periodic Maintenance Cost (Every 5 years)
Total Cost	0	0.4	76

Source: JICA Study Team

3) Calculation of EIRR

Table 4.5.21 indicates annual economic cost, annual economic benefit and net cash flow. Economic Internal Rate of Return (EIRR) calculated from the Net Cash Flow is 13.2%. The amount exceeds substitution of capital, which is set at 12%. Therefore, the project is viable as regards the national economy of Lao PDR.

Table 4.5.21 Cash Flow for Replacement of Sedone Bridge

(Unit USD 000)

Year Const	Year O&M	Economic Cost				Economic Benefit	Net Cash Flow
		Engineering Service	Administration	Construction	O&M		
1		238	57				-295
2		238	57				-295
3		102	57	5,592			-5,751
4		102	57	5,592			-5,751
	1				0.4	577	577
	2				0.4	640	640
	3				0.4	712	711
	4				0.4	794	793
	5				76	888	812
	6				0.4	996	995
	7				0.4	1,120	1,119
	8				0.4	1,262	1,262
	9				0.4	1,427	1,427
	10				76	1,617	1,542
	11				0.4	1,837	1,836
	12				0.4	2,096	2,095
	13				0.4	2,395	2,395
	14				0.4	2,743	2,742
	15				76	3,145	3,070
	16				0.4	3,613	3,613
	17				0.4	4,156	4,156
	18				0.4	4,787	4,787
	19				0.4	5,520	5,520
	20				76	6,373	6,297
	21				0.4	7,365	7,364

	22				0.4	7,365	7,364
	23				0.4	7,365	7,364
	24				0.4	7,365	7,364
	25				76	7,365	7,289
	26				0.4	7,365	7,364
	27				0.4	7,365	7,364
	28				0.4	7,365	7,364
	29				0.4	7,365	7,364
	30			-4,473	76	7,365	11,762
						EIRR	13.2%

Source: JICA Study Team

(5) Result of Economic Analysis

In the 2 bridge projects (Replacement of Bridges along NR9 and Construction of Sedone Bridge), the EIRR values exceed 12%, the substitution cost of capital. Therefore, these projects are feasible as regards the national economy of Lao PDR.

On the other hand, the EIRR value for the project of upgrading NR9 is slightly lower than the values for other priority projects and is estimated at 11.9%. The figure would exceed 12% if other economic effects such as reduction of traffic accident were included in the analysis. The EIRR value is thus significant enough to prompt project implementation.

4.5.2 Identification of Development Issues

In order to identify local development issues and to measure the impact derived from the priority projects, the social condition survey was carried out in two phases. The first phase of social condition survey was conducted by profiling each province through collection of secondary data and information. The second phase of social condition survey was carried out by interviewing village leaders at sampled villages. Table 4.5.22 summarizes the outline of social condition survey.

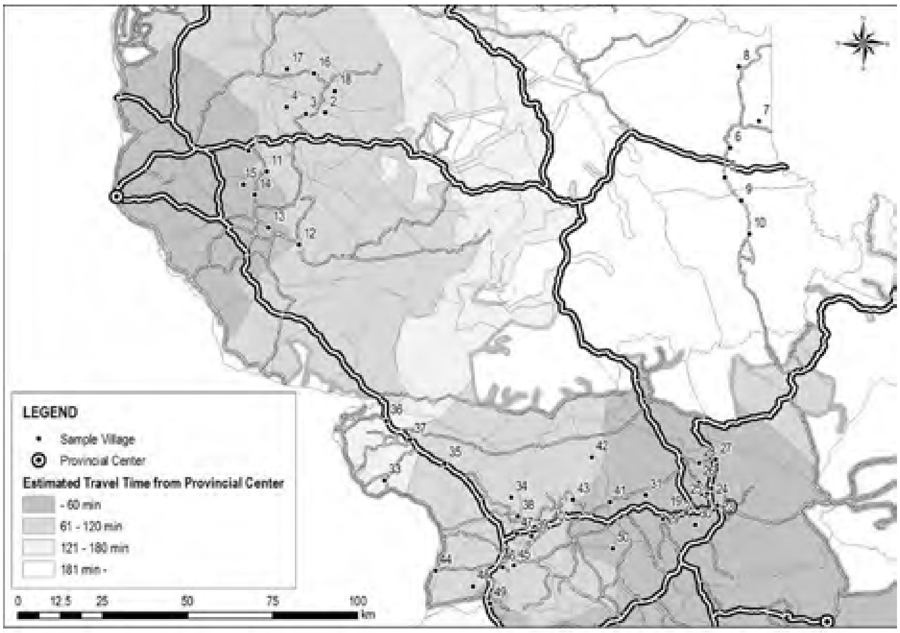
Table 4.5.22 Outline of Social Condition Survey

Survey Method	Interviews with village leaders
Survey Item	• Village attributes (population, no. of households, no. of workers, average household income/expenditure, availability of electricity/water, land price) • Accessibility to provincial center and social infrastructure • Overall development issues
Samples	50 villages were sampled from areas along the priority projects.

Considering the location of the priority projects, 50 villages, mostly distributed along the priority projects in both Savannakhet and Saravan Provinces, were sampled for the interview survey (see the table 4.5.23 and figure 4.5.1).

Table 4.5.23 Number of Sampled Villages

	Savannakhet Province	Saravan Province	Total
Poor Village	13	13	26
Not Poor Village	5	19	24
Total	18	32	50



Source: JICA Study Team

Figure 4.5.1 Location of Sampled Villages

Based on the results of the social condition survey, local development issues were identified and the impact of the project, particularly on poverty reduction through road improvement, was analyzed. Though the results of social condition survey are availed in detail in the appendix, some of the findings of the social condition survey are summarized below:

- Amongst the 50 sampled villages, only 4 villages had access to both electricity and water supply. 18 villages had neither electricity network nor water supply.
- There seemed to be a correlation between type of works, income, number of trips and distance from the provincial centre. The further a village was located from the provincial centre, the greater the proportion of workers who were engaged in the primary (agricultural) sector. Besides, less income was generated in the villages the further they were located from the provincial center.
- Comparing household incomes and expenditure, households at the sampled villages had a tendency of saving around 10% of their income no matter how small it was.
- Transport costs accounted for large share of the household expenditure with larger shares experienced for low-income households. The share of transport cost against the household expenditure ranged from 10 to 40 % of the household expenditure at the sampled villages.
- There was a correlation between land price and serviceability of the infrastructure, including the road condition and travel time.

- The serviceability of the road fluctuated seasonally. For instance, in the rainy season, the average travel times from the sampled villages to district center and provincial center increased by 15% and 7%, respectively.
- Overall evaluation of the infrastructure reveals an urgent need for road improvement projects from amongst the various infrastructure projects.

Table 4.5.24 Evaluation of Infrastructure

	Needs	Road	Water supply	Electricity	School	Hospital/Health center	Working (job opportunity)
Worst	1st	20	6	9	8	4	3
↑	2nd	9	12	4	16	5	4
	3rd	10	14	2	8	13	3
	4th	6	6	4	12	12	10
↓	5th	2	10	6	5	13	14
Good	6th	3	2	25	1	3	16
	Average	2.4	3.2	4.4	2.9	3.7	4.5

Source: JICA Study Team

In admission of the fact that the results of the social condition survey do not represent all the villages affected by the road improvement project, it was nevertheless discerned that there is an urgent need for road improvement projects from amongst various infrastructure projects at the sampled villages. A clear relationship was observed between serviceability of the road infrastructure and income/ land price. Consequently, it was deduced that road improvement projects would contribute to generating favourable economic and social impacts, particularly poverty reduction. The impacts derived from the priority projects are separately discussed in the project evaluation.

4.5.3 Impact on Poverty Reduction

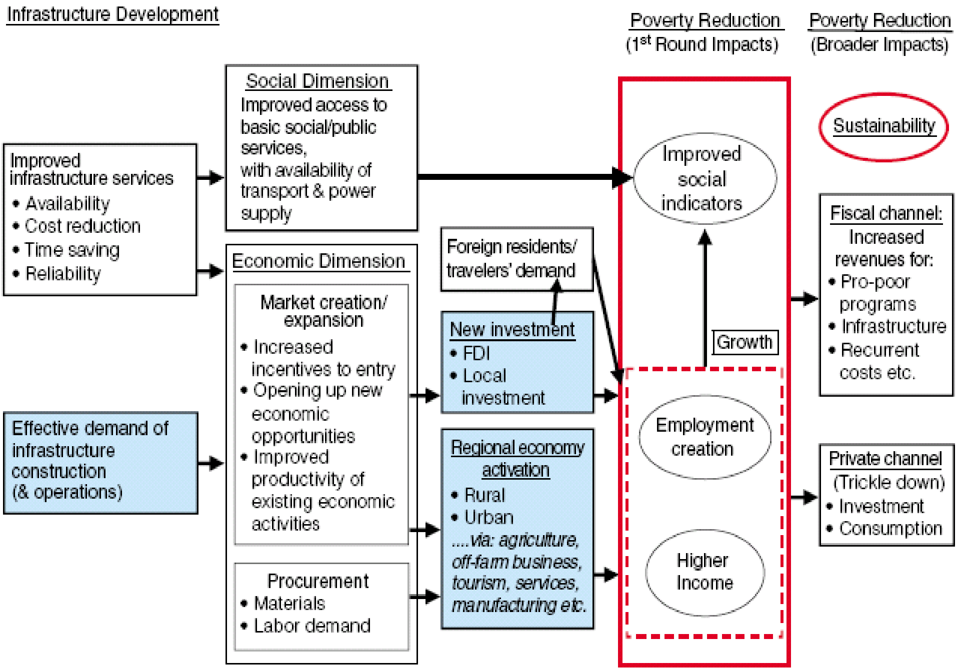
(1) General

In addition to the quantified economic benefits analyzed in this study, there are various social impacts to the region that would be brought about by the proposed projects. These social benefits are drawn attention to below:

- Improving connectivity and economic distance to markets, information, education and health service – road network and accessibility in rural areas, which are crucial to determination of provincial income and resource mobilization ability and thus improving the living conditions of the poor.
- Creating effective demand, off-farm jobs and income opportunities, for construction of large-scale infrastructure projects. The employment of local farmers for such unskilled works contributes to jobs and income generation in the surrounding rural areas, particularly during off-farm seasons.
- Reducing transaction costs and facilitating trade flows within and across borders.
- Lowering the costs of inputs used in the production of almost all goods and services. Opening up new opportunities for entrepreneurs, or making existing business more profitable.

- Improving environmental conditions, which are linked to improved livelihoods, better health and reduced vulnerability of the poor.

Figure 4.5.2 illustrates such linkages schematically. The empirical studies try to quantify these social benefits generated from infrastructure projects and seek for linkage between infrastructure development, economic growth, and poverty reduction. The following discussion reveals how the proposed priority projects would contribute to poverty reduction in the southern region.



Source: Linking Economic Growth and Poverty Reduction —Large-Scale Infrastructure in the Context of Vietnam's CPRGS— November 2003 GRIPS Development Forum

Figure 4.5.2 Linkages among Infrastructure Development, Growth, and Poverty Reduction

(2) Estimation of Impact on Poverty Reduction

Proposed priority projects are expected to increase household income along each project site and for other road users, hence reducing poverty in the southern region. Accordingly, this section estimates the extent to which proposed projects contribute to income generation of the household, assuming conventional economic benefits, such as savings in travel time, directly contribute to an increase in household income. These benefits were estimated by the following steps.

- Average travel time of "with project case" and "without project case" were calculated by traffic assignment of traffic volume in 2010 by each OD pair,
- Vehicle hours travelled by each OD pair are calculated for the cases of "with project " and "without project " ,
- Extract internal passenger vehicle trip (namely, motorcycle, passenger car and bus only) in the southern region of Lao PDR, and origin-based benefit of travel time saving was calculated by using time value,

- On the other hand, average monthly household expenditure as of 2010 by district was estimated based on the household expenditure by village zone in 2005 by "Socio-Economic Atlas" and GDP deflator calculated by IMF country report.

By comparing household expenditures (nearly equal to household income) and estimated benefits by saving travel time, contributions to poverty reduction by each proposed project are summarized as shown below (see Table 4.5.25).

- Upgrade of NR-9 would contribute to generating economic benefits for 132,000 households in Savannakhet Province.
- Construction of Sedone Bridge is expected to generate benefits for 73,000 households in Saravan Province.
- The Replacement of Bridges along NR-9 would contribute to increased benefits to 19,000 households in Savannakhet Province.

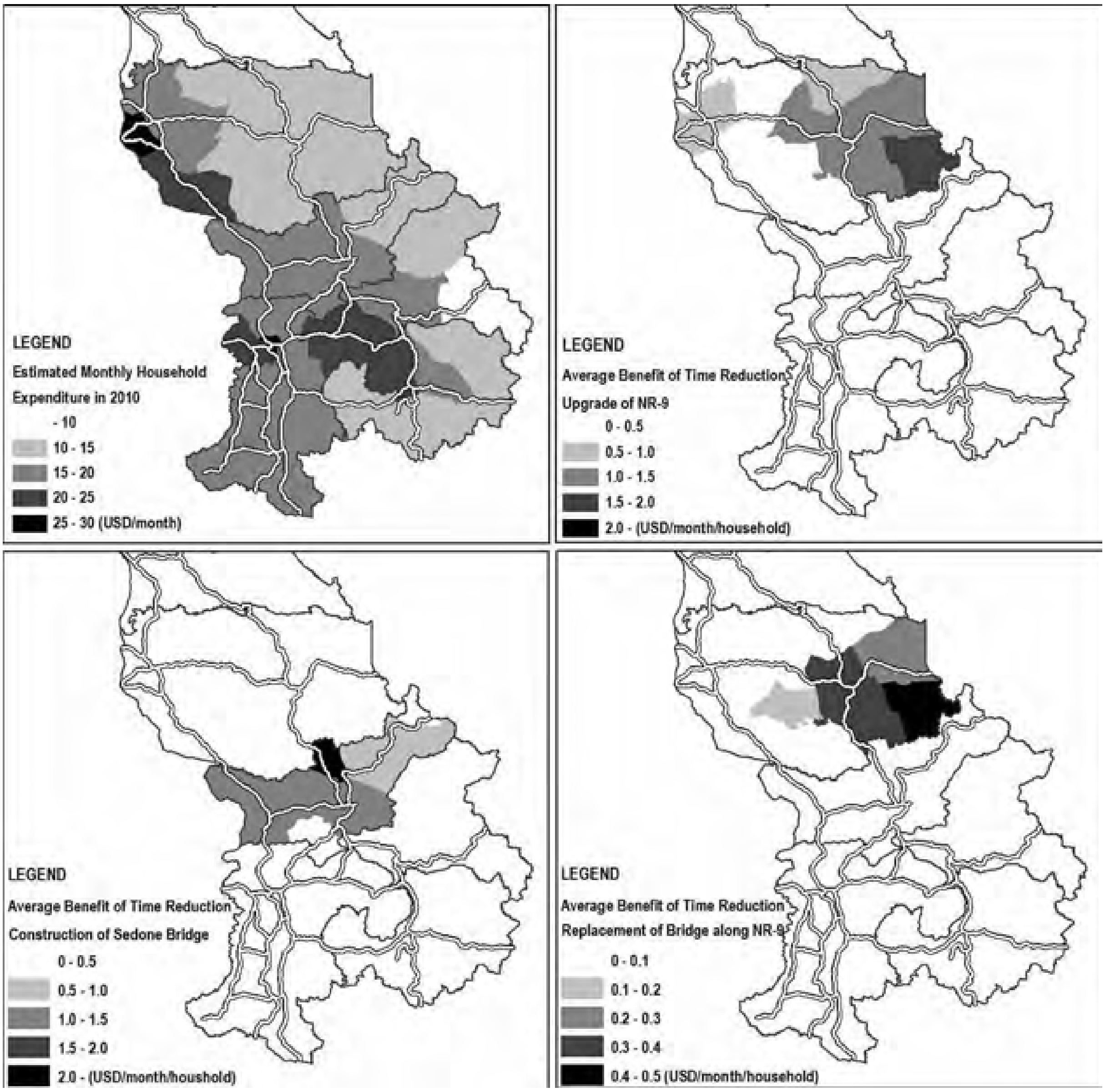
Table 4.5.25 Number of Households and Average Household Expenditure by Percentage Band of Benefit/Household Expenditure

	Increase by 1-5%	5-10%	Over 10%
Upgrade of NR-9	101,876 (18.6)	13,093 (12.3)	16,730 (13.1)
Construction of Sedone Bridge	29,851 (21.4)	40,359 (16.4)	2,696 (17.8)
Replacement of Bridge along NR-9	19,489 (12.7)	0 (N/A)	0 (N/A)

Source: JICA Study Team

Figures 4.5.3 and 4.5.4 show district-wise household expenditure and forecasted benefits through travel time savings. Contributions to poverty reduction by each proposed project are summarized as shown below.

- Households to benefit from the Upgrade of NR-9 are mainly spread over the eastern side of Savannakhet Province, where most districts are defined as poor and poorest districts.
- Construction of Sedone Bridge along NR-15A would benefit households throughout the Saravan Province. Ta-Oy District (poorest district) and Toumlan District (poor) are among the potential beneficiaries of this project.
- As is the case with the Upgrade of NR-9, the Replacement of Bridges along NR-9 would benefit the households in the eastern area of Savannakhet Province.



Source: JICA Study Team

Figure 4.5.3 Estimated Household Expenditure and Forecasted Benefit by Priority Projects in 2010