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TECHNICAL REPORT

RURAL ROADS II PROJECT UPPER VOLTA

CONTRACT No. AFR-0929-S-00-2048-00

PROJECT No.686-0247

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PREPARED FOR USAID MISSION

OUAGADOUGOU, UPPER VOLTA

by

Lloyd R. Crowther, Consulting Engineer

Wheaton, Maryland, USA

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July 23, 1982

Ms. Patricia J. Lerner,
Capital Projects Development Officer,
U.S.A.I.D. ,
C/O American Embassy,
Boite Postale 35,
Ouagadougou, Upper Volta.

Dear Ms. Lerner,

This report is a technical analysis of the possible construction of two roads, Fada N'Gourma to Bilanga and Gouguin to Comin-Yanga, under Project 686-0247, Rural Roads II Project, Upper Volta. The analysis was made during the eight week period between June 1, 1982 and July 23, 1982 under a contract for consulting services, number AFR-0929-S-00-2048-00.

That contract called for a highway engineer to serve as a member of an AID project paper design team. Objectives included the technical analysis for the Project Paper and inputs, as required, on matters relative to the design, construction and costing of the project roads.

I wish to express my appreciation to the Upper Volta AID Mission for its cooperation in the preparation of this report. I especially want to acknowledge the assistance of AID engineer

V

Alan Strom who not only showed me the project area on June 9 through 11, but also provided considerable assistance by supplying information and by cooperating in the determination of the project's drainage requirements.

Sincerely

Lloyd R. Crowther

Lloyd R. Crowther

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LOG OF MEETINGS INVOLVING NON-USAID PERSONNEL

6/15/82	8:00 AM at Caisse Centrale de Cooperation Economique to discuss the recent French road project with M. Christian Teysseyres.
6/15/82	3:30 PM at Canadian International Development Agency to discuss the on going Canadian road project with M. Laz of Lavallin International.
6/16/82	4:00 PM at Travaux Publics to discuss the World Bank loan with M. Kone, T.P. representative for World Bank matters. M. Kone had to leave before any discussion took place.
6/16/82	8:00 AM at SERAGI, a local engineer/contractor, to discuss their capabilities and experiences building the recent French road project with M. Wicenzeski.
6/16/82	10:55 AM at SOVOTP, a local contractor, to discuss their capabilities with M. Bealet.
6/17/82	3:30 PM at Travaux Publics to meet Assistant Director General M. Nouktara to discuss project. Was asked to return on 6/21/82 as he was busy.
6/17/82	4:00 PM at Manutention Africaine Haute-Volta local Caterpillar dealer to ask M. Doguet, Director for price quotes and to look at their facility.
6/21/82	7:30 AM at Travaux Publics for previously scheduled meeting with M. Nouktara. Nobody appeared.
6/22/82	at USAID with M. Lompo, new T.P. regional engineer at Fada N'Gourma. Presented him with list of requests for information from T.P.

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6/23/82 8:00 AM at Centre Regional de Teledetection, Ouagadougou to have two U.S. personnel there check my air photo interpretation of water crossing locations.

6/24/82 9:00 AM at Travaux Publics to finally meet with M. Nouktara and formally ask him for the information required to estimate cost of projects.

7/2/82 10:00 AM at Travaux Publics to pick up information requested on 6/24/82. Asked to return at 5:00 PM.

7/2/82 5:20 PM at Travaux Publics to receive information from M. Nouktara, M. Lompo, and M. Liehoum, Director General.

7/13/82 at United Nations Office to discuss their current road construction project and their local contractor, ECEA, who builds small drainage structures, with M. Savaran.

7/15/82 3:30 PM at U.S. Embassy Personnel Office to discuss local employee payroll benefits and charges with M.Gilbert.

7/21/82 3:30 PM at Travaux Publics to attend formal USAID presentation of cost estimate data to M. Lieboun, M.Nouktara and M. Lompo.

The following observations are offered as a result of the previous visits and the development of the data which was prepared for inclusion in the Project Paper.

1. Design Criteria Section H - 3 contains sufficient information to locate and design the roads. Travaux Publics has standard drainage structure design standards.

2. Capacity of Travaux Publics This agency was asked the design cost for them to design the two roads under consideration. They prepared a cost for the design but then indicated they did not have the capability to design the Fada-Bilanga road and would have trouble scheduling the Gounghin-Comin-Yanga Road. When asked if they could supply any personnel, either supervisors or mechanics, for a brigade operation, they indicated they would have no available personnel.

From all reports T.P. is basically an administrative agency, set up to except gifts from donor agencies, with little mid-management capability except in the soils-evaluation field.

The design, supervision of construction, or management of a brigade appears to beyond both their capability and their interest.

3. In-Country Design Capability appears to be quite strained. The local designs are sketchy and the one group who indicated an interest in designing the project, SERAGRI, who designed and built the recently completed French road, showed no sensitivity to soils problems (they used topsoil for fill) or compaction (no compaction tests were taken by them or T.P.) If an in-country design capability can be found, it will probably be less costly than an International consultant but USAID should budget an expatriate to spend a month helping the local firm get a proper start and another 60 days to review the design after it has been completed.

4. International Consultant Usage Any contract with a consulting firm should include both design and construction supervision or brigade management with a provision that the second phase can be cancelled at USAID's option.

5. Contract Construction The local contractors with the exception of KANAZOE are too small or less than 51% locally owned. With the projected highway work, World Bank and African Development Bank projects, etc, in full swing when this project could be expected to start, there may be little local interest in bidding on this project. The estimated costs for contract construction are based on competitive bidding.

6. Brigade Construction Supervision of any brigade construction should be in the hands of expatriates. Travaux Publics should not have control of the hiring or firing of the brigade personnel and should only be able to remove the expatriates for cause with the consurance of USAID.

7. Equipment Costs Additional equipment is required for brigade work. The financial costs will therefore differ from the economic costs. The existing equipment, which in my opinion is less that 30% depreciated at this time, represents a reduction to the economic cost since it is already on-hand. An example of a financial evaluation is included in section H - 1.

8. Time Schedules The time schedules for each option and for design are included in the following sections. The overall time frame depends on USAID capability to expedite the necessary pape work.

9. Maintenance Section H - 11 gives projected maintenance costs starting in 1987 with the factors that were used to determined those costs. The costs are not very well founded. Travaux Publics does not seem overly keen on the maintenance aspect of a highway network. Maintenance will probably be a major problem after the project is built, not because of the design or construction of the project, but because of T.P.'s attitude towards the importance of maintenance.

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Annex H - Technical Feasibility

H - 1 Estimates of Options

H - 2 Lateritic Material Evaluation

H - 3 Road Design Features

H - 4 Estimated Construction Quantities

H - 5 Equipment Included in Estimates

H - 6 Brigade Personnel List

H - 7 Personnel Costs

H - 8 Drainage Costs

H - 9 Contractor's Additional Charges

H -10 Consultant's Costs

H -11 Maintenance Costs.

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ESTIMATE No. 1: Fada-Bilanga Road, 7.0 m by Contractor (74 km)
Contract time - 15 months, working time-60 weeks.

Item	Amount	
Equipment Costs	$1,713,300	
POL Costs	414,300	
Personnel Costs	496,800	
Drainage Costs	555,400	
	3,179,800	
+ 40% Contractor's Charge	1,271,900	
Contract total	4,451,700	($60,158 per km)
Design by Consultant	505,000 1/	
Supervision by Consultant	294,000	
Consultant Fee	799,000	($10,797 per km)
Total 1982 dollars	5,250,700	
+ 10% Contingencies	525,100	
Funding Amount	$5,775,800	($78,051 per km)
at 12% 1983 dollars	6,468,900	
at 12% 1984 dollars	7,245,200	

1/ Design Fee is reduced to $434,000 if two roads are designed.

ESTIMATE No. 2 : Fada-Bilanga Road, 5.5 km by Contractor
Contract time - 12 months, working time - 44 weeks

Item	Amount	
Equipment Costs	$1,268,900	
POL Costs	318,400	
Personnel Costs	365,000	
Drainage Costs	544,200	
	2,496,500	
+ 40% Contractor's Charge	998,600	
Contract total	3,495,100	($47,231 per km)
Design by Consultant	505,000 1/	
Supervision by Consultant	231,000	
Consultant Fee	736,000	($9946 per km)
Total 1982 dollars	4,231,100	
+ 10% Contingencies	423,100	
Funding Amount	$4,654,200	($62,895 per km)
at 12% 1983 dollars	5,212,700	
at 12% 1984 dollars	5,838,200	

1/ Design Fee is reduced to $434,000 if two roads are designed

ESTIMATE No. 3: Fada-Bilanga Road, 7.0 m by Brigade
Construction time-25 months, working time-103 wks

Item	Amount	
Equipment Costs	$911,100	
POL Costs	562,200	
Personnel Costs	367,300	
Drainage Costs	555,400	
Brigade Costs	2,396,000	($32,378 per km)
Design by Consultant	505,000 1/	
Consultant Technical Assistance	1,125,000	
Local Soils crew	105,000	
Consultant Fee	1,735,000	($23,446 per km)
Total 1982 dollars	4,131,000	
+ 10% Contingencies	413,100	
Economic Cost	$4,544,100	($61,407 per km)
at 12% 1983 dollars	5,089,400	
at 12% 1984 dollars	5,700,100	

1/ Design fee reduced to $434,000 if two roads are designed

ESTIMATE No. 4 Fada-Bilanga Road, 5.5m by Brigade
Construction time-19 mo, working time 76 weeks

Item	Amount	
Equipment Costs	$ 683,700	
POL Costs	425,300	
Personnel Costs	269,900	
Drainage Costs	544,200	
Brigade Costs	1,923,100	($25,989 per km)
Design by Consultant	505,000 1/	
Consultant Technical Assistance	855,000	
Local Soils Crew	79,800	
Consultants Fee	1,439,800	($19,456 per km)
Total 1982 dollars	3,362,900	
+ 10% Contingencies	336,300	
Economic Cost	$3,699,200	($49,989 per km)
at 12% 1983 dollars	4,143,100	
at 12% 1984 dollars	4,640,300	

1/ Design fee reduced to $434,000 if two roads are designed

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ESTIMATE No. 5- Gounghin-Comin Yanga Road, 5.5 m by Contractor
Contract time-11 months, working time-43 weeks (58.5 km)

Item	Amount	
Equipment Costs	$ 939,100	
POL Costs	210,100	
Personnel Costs	354,300	
Drainage Costs	192,500	
	1,696,000	
+ 40% Contranctors Charge	678,400	
Contract total	2,374,400	($40,588 per km)
Design by Consultant	425,000 1/	
Supervision by Consultant	210,000	
Consultant Fee	635,000	($10,855 per km)
Total 1982 dollars	3,009,400	
+ 10% Contingencies	300,900	
Funding Amount	$3,310,300	($56,586 per km)
at 12% 1983 dollars	3,707,500	
at 12% 1984 dollars	4,152,400	
at 12% 1985 dollars	4,650,700	
at 12% 1986 dollars	5,208,800	

1/ Design fee reduced to $346,000 if two roads are designed

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ESTIMATE No. 6-Gounghin-Comin Yanga Road, 5.5m by Brigade
Construction time-18 months, working time 73 weeks

Item	Amount	
Equipment Costs	$ 536,500	
POL Costs	311,400	
Personnel Costs	259,700	
Drainage Costs	192,500	
Brigade Costs	1,300,100	($22,224 per km)
Design by Consultant	425,000 [1]	
Consultant Technical Assistance	810,000	
Local Soils Crew	75,600	
Consultants Fee	1,310,600	($22,403 per km)
Total 1982 dollars	2,610,700	
+ 10% Contingencies	261,100	($49,091 per km)
Economic Cost	$ 2,871,800	
at 12% 1983 dollars	3,216,400	
at 12% 1984 dollars	3,602,400	
at 12% 1985 dollars	4,034,700	
at 12% 1986 dollars	4,518,800	

[1] Design fee reduced to $346,000 if two roads are designed

ESTIMATE No. 7 Reduction in cost if contractor does not build Southern 7;5 km of Gounghin-Comin Yanga Road (8 weeks work)

Item	Amount
Equiment Costs	$ 167,800
POL Costs	38,800
Personnel Costs	64,800
Drainage Costs	61,200
	332,600
+40% Contractors Charge	133,000
Contract reduction	465,600
Supervision by Consultant	42,000
Total 1982 dollars	507,600
10% Contingencies	50,800
Reduced Funding Amount -	$ 558,400 1/
at 12% 1983 dollars	625,400
at 12% 1984 dollars	700,500
at 12% 1985 dollars	784,500
at 12% 1986 dollars	878,700

1/ The high cost of this section is in part due to hauling laterite from a pit which is more than 2 km beyond the end of the project.

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ESTIMATE No. 8 Reduction in cost if brigade does not build Southern 7.5 km of Gounghin-Comin Yanga Road (17 weeks work)

Item	Amoun
Equipment Costs	$ 115,600
POL Costs	59,300
Personnel Costs	60,300
Drainage Costs	61,200
Brigade Reduction	296,400
Consultant Technical Assistance	180,000
Local Soils Crew	16,800
Consultants Fee	196,800
TOTAL 1982 dollars	493,200
+ 10% Contingencies	49,300
Reduced Economic Cost	$542,500 1/
at 12% 1983 Dollars	607,600
at 12% 1984 dollars	680,500
at 12% 1985 dollars	762,200
at 12% 1986 dollars	853,600

1/ The high Cost of this section is in part due to hauling laterite from a pit which is more than 2 km beyond the end of the project.

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ESTIMATE No. 9 Reduction in cost if contractor does not build new Gounghin-Zanré connection of 9 km. (8 weeks work)

Item	Amount
Equipment Costs	$149,800
POL Costs	36,300
Personnel Costs	60,500
Drainage Costs	9,300
	255,900
+ 40% Contractors charge	102,400
Contract reduction	358,300
Design by Consultant	40,000
Supervision by Consultant	42,000
Reduced Consultant's Fee	82,000
Total 1982 dollars	440,300
+10% Contingencies	44,000
Reduced Funding Amount -	$ 484,300
at 12% 1983 dollars	542,400
at 12% 1984 dollars	607,500
at 12% 1985 dollars	680,400
at 12% 1986 dollars	762,100

ESTIMATE No. 10 Reduction in cost if brigade does not build new Gounghin - Zanré connection of 9 km (15 weeks work)

Item	Amount
Equipment Costs	$ 99,100
POL Costs	56,700
Personnel Costs	50,100
Drainage Costs	9,300
Brigade Reduction	215,200
Design by Consultant	40,000
Technical Assistance	157,500
Local Soils Crew	14,700
Consultant Fee	212,200
Total 1982 dollars	427,400
+ 10% Contingencies	42,700
Reduced Economic Cost	$470,100
at 12% 1983 dollars	526,500
at 12% 1984 dollars	589,700
at 12% 1985 dollars	660,500
at 12% 1986 dollars	739,700

Financial Costs-Brigade (Depreciation included in Equipment Costs)

Equipment Depreciation-Fada at 7.om (25 mo)		
Existing Equipment	$300,800	
New Equipment	$251,800	552,600
Equipment Depreciation - Fada at 5.5 m (19mo)		
Existing Equipment	$225,500	
New Equipment	$186,800	
	412,300	
Equipment Depreciation-Diabo (18 mo)		
Existing Equipment	$193,800	
New Equipment	$128,200	322,000

Cost of New Equipment, Delivered

2 ea Cat D-6 Bulldozers	at 153,500	=	307,000
2 ea Water-Truck, 10 m^3	at 65,800	=	131,600
3 ea Dump Truck, 6 m^3	at 61,000	=	183,000
1 ea Fuel Truck	at 66,500		66,500
1 ea Lubrication Truck	at 77,900	=	77,900
1 ea Lowbed Truck, 50T	at 115,500	=	115,500
			$881,500

Equipment inflation 3% per 4 months = 12.55% /year

Equipment Cost 1982	=$ 992,100
Equipment Cost 1983	=$1,116,700
Equipment Cost 1984	=$1,256,800

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Financial Costs-Brigade (If Fada is 7. om and Drabo is 5.5 m)

Current total cost, new equipment	$881,500
Credit for existing equipment	
Fada at 7.0m = 300,800	
Diabo at 5.5m= 193,800	$494,600
Additional Cost of Project =	$386,900

Current total cost, new equipment	$881,500
Depreciation of new equipment	
Fada at 7.0m = 251,800	
Diabo at 5.5m =128,200	380,000
Remaining value of new equipment	$ 501,500 (56.9%)

Cost of Spare Parts and Tires (Included in Equipment Costs)

Fada at 7.0 in 1982 dollars	=$ 358,500
at 12% 1983 dollars	401,500
at 12% 1984 dollars	449,700
Fada at 5.5 in 1982 dollars	$ 271,400
at 12% 1983 dollars	304,000
at 12% 1984 dollars	340,400
Diabo at 5.5 in 1982 dollars	$214,500
at 12% 1983 dollars	240,200
at 12% 1984 dollars	269,100
at 12% 1985 dollars	301,400
at 12% 1986 dollars	337,500

Financial Cost for Brigade, 1982 Costs

Assume 7.0 m Fada plus 5.5 m Gounghin roads

Economic Cost including 10% contingencies

Fada	= $4,544,100	
Gounghin	= $2,871,800	$7,415,900

New Equipment Costs	= $881,500	
Old Equipment Depreciation	= $494,600	
Additional Equip. Cost	= $386,900	
Design of Fada	$505,000	
Design of Gounghin	425,000	
	$930,000	
Design of Both Roads		
New Cost Fada	434,000	
New Cost Gounghin	346,000	
Design Costs	$ 780,000	
Reduction in Cost[1/]	($ 150,000)	
Corrected Cost	$ 236,900	
10% Contingencies	23,700	
		$260,600
Funding Amount of Brigade Package		$7,676,500
Contract Funding Amount[1/]		$8,921,100
1982 Dollars Difference in Funding		$1,244,600

[1/] Also reduction to contract cost estimate if both roads are designed

LATERITIC MATERIAL EVALUATION

The Laboratoire National du Bâtiment et des Travaux Publics investigated the laterite gravel supply for both the Fada/Bilanga and the Diabo/Comin-Yanga routes. Their study of the Fada route encompasses the area currently under investigation. Their Diabo study begins at an intersection in Diabo that is 6.1 km from the Route N4 intersection in Zanre. Our current project includes that 6.1 km between Diabo and Zanre plus another 9 km section called Zanre/Gounguin. The last section attempts to connect Comin-Yanga with the new paved Ouaga-Fada highway. There is no materials information for the latter two sections.

The Fada/Bilanga route study identified thirteen gravel deposits. Further T.P. evaluation indicated that only six of these pits contained lateritic gravel that met the design criteria of a 4 day soaked CRB% equal to or greater than 30 at 95% modified Proctor density. This is a GOUV requirement for laterite surfaced roads carrying 30 or more vehicles a day. All pits produced the required CBR value at 98% modified Proctor density. Since material from all pits is required, additional compaction is included in the estimate. This compaction hopefully will be achieved by placing the 20 cm compacted surface in two lifts rather than one.

The Diabo/Comin-Yanga route study identified nine deposits. T.P. evaluation indicated that six of these pits met the above design criteria. All nine will be required to build the road.

These laterite locations play a key factor in the cost of the road. The distance between them determines the composition of the equipment train, and the cost of extracting, moving, and placing the material makes up a substantial portion of the total roadway cost.

Each pit was evaluated individually because the thickness of the gravel starta and the amount of overburden which must be removed to expose the gravel varied so significantly. Any generalized composite value would be extremely misleading and its inaccuracy would increase as the actual, rather than possible, quantity required from each pit was computed.

Table A-1 was developed to evaluate the laterite requirements for four roadway widths on the Fada/Bilanga route and one option on the Diabo/Comin-Yanga route. The volumes are shown in compacted cubic meters. The volumes in the T.P. report are given in bank cubic meters, and the loading and hauling requirements must of course be considered in loose cubic meters.

The length of road to be constructed from each pit is calculated as that length which runs between one half the distance to each adjacent pit. This is the most economical method of construction. The underlined tabulated figures indicate quantities exceeding the proven resources. (see attachment for Table A-1)

Future maintenance also requires a supply of lateritic gravel. The 15 year design life of the road requires periodic recharging of the road surface. A conservative estimate of environmental lateritic gravel loss on low-volume rural roads is about 2 cm/year. Assuming a recharge is necessary when one-half or more of the road is lost (to ensure reasonable user's costs) the road must have a 10 cm recharge in year 7 to insure a 15 year life. Table A-2 represents the number of recharges available for each optional width for each pit after the road is constructed. Zero values indicate that there is not enough material to provide a 15-year economic life. The theoretical life of the road can be determined by multiplying the number of available recharges by seven and adding that value to the original seven years. (see attachment for Table A-2)

Since the project area has been refered to as "rich is lateritic material" and the attached tables indicate a shortage of such material, some judement must be made concerning the completeness of the T.P. search. The values given for the materials discovered seem consistant with laterite deposits I have observed in Brazil and Kenya, however one must draw further inferences from what is not given, namely other pit locations, and the manner in which the given date are presented. Four deductive observations are evaluated below:

1. Normally, in a material-rich area, pits are located at evenly spaced intervals so that the controlling haul distance is consistant. This spacing insures economical equipment usage. The Fada pit locations vary from 1.7 km to 8.5 km spart while the Diabo pit locations vary from 3.0 km to 9.5 km apart. One must assume that at the very least multiple distance increments were investigated.

2. Where material is abundant, the reports usually list a nominal amount of material in each pit. This amount is usually similar throughout a series of pits and implies that an adequate supply is available. The T.P. pit quantities vary from 10,500 (bank) m3 to 38,250 m3 on the Fada project and from 12,500 m3 to 26,250 m3 on the Diabo project. While some of the documentation indicate the possibility of expanding particular pits the inference can be made that the soils crew have at least identified the major quantity of economically extractable gravel in each pit.

3. The two pits nearest Cominyanga provide material for 10 km or 20% of the 49.5 km of road the soils crew were investigating. Not only do these pits lack sufficient material to build the road economically, but also the CBR values of these pits are far less than those of the other pits. One pit (No8) just meets the 30 CBR requirement at 98% density while the other pit, which is located more that 1 km/

beyond the end of our project, has a CBR of only 20 at 98% density. A CBR of 20 at 95% density is acceptable by the GOUV for roads with traffic volumes below 20 per day.

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This material quality should have been evident to anyone capable of producing a report of the Caliber of the T.P. reports so it is safe to assume that special emphasis was placed on finding better material near Comin-Yanga.

4. The Canadians claim that they have been able to locate additional laterite for embankment, (which T.P. missed) every 3 Km. or so along their roadway. However the project areas are not really comparable since the optumin moisture content of their material is several percentage points above the OMC of the lateritic gravel on our project. The Canadians also say they reduced their base platform width from 8 to 7 meters and plan to use a 6 meter platform on any future work. This indicated material resource problems. They further remarked that they are only able to achieve a 92% density in some of the material they are using. At this density only two pits on the entire Fada project would meet the stated CBR requirement. 1)

In light of the difficulty experienced in locating laterite for the first USAID rural roads project, and in the off-chance that the Canadians may be using inferior material on their project because of the major investment they have already made, the prudent conclusion must be to consider lateritic gravel as a limited resource and commit only proven quantities to any proposed new work. While more gravel may be found by expanding the band of investigative effort, any estimates made which assume an adequate supply of material from the existing pits will merely indicate the floor from which the cost per km will rapidly rise if other pits located further from the road are necessary to provide required laterite.

Based on the above assumptions, the only realistic estimate that can be made is for a 5.5 meter road between Fada N'Gourma and Bilanga.

1) These assumptions confirmed at a meeting with Travaux Publics on July 2, 1982.

Attachment 1

TABLE A-1

LATERITIC MATERIAL PIT EVALUATION

Pit No. Fada	(000m3) Quantity	(Km) Road Length	Quantity for Road Width 5.5m	6.0m	6.5m	7.0m
1	25.2	5.7	10.55	11.97	13.45	14.99
2	34.4	6.8	16.50	18.33	20.33	22.38
3	26.3	7.0	13.39	15.15	16.99	18.91
4	21.6	7.0	14.69	16.50	18.42	20.41
5	17.2	6.4	12.71	14.34	16.05	17.83
6	18.0	5.3	9.81	11.13	12.51	13.94
7	18.0	6.3	12.53	14.13	15.82	17.57
8	20.7	4.8	10.62	11.88	13.23	14.62
9	9.5	2.8	7.35	8.13	8.98	9.86
10	13.5	6.2	12.77	14.37	16.06	17.81
11	13.6	5.6	12.97	14.46	16.07	17.73
12	21.6	4.8	9.75	10.98	12.28	13.62
13	14.2	5.3	11.54	12.93	14.41	15.94

Diabo (15 cm surface)

1	12.6	3.9	6.84
2	15.3	4.7	11.20
3	14.2	4.5	7.40
4	20.3	6.0	13.65
5	23.6	5.5	9.40
6	20.3	4.0	9.63
7	11.3	4.8	10.48
8	14.9	5.0	10.79
9 1)	20.3	5.0	12.53

1) Pit No9 is used for additional laterite in pit 8 zone because Pit 8 does not contain enough material to build the length of road within its most economical haul distance. Additional material left in Pit 8 is for maintenance purposes.

Attachment 2

TABLE A-2

NUMBER OF RECHARGES AVAILABLE IN EACH PIT

Pit No. Fada	Road Length	Recharges Available 5.5	6.0m	6.5m	7.0m
1	5.7	4	3	2	2
2	6.8	4	3	2	2
3	7.0	3	1	0	0
4	7.0	1	1	0	0
5	6.4	1	0	0	0
6	5.3	2	2	1	1
7	6.3	1	0	0	0
8	4.8	3	2	2	1
9	2.8	1	0	0	0
10	6.2	0	0	0	0
11	5.6	0	0	0	0
12	4.8	4	3	2	2
13	5.3	0	0	0	0

Diabo (15 cm surface)

1	3.9	2
2	4.7	1
3	4.5	2
4	6.0	1
5	5.5	4
6	4.0	4
7	4.8	0
8	5.0	1
9	5.0	2

H - 2.7

ROAD DESIGN FEATURES

Certain design features have a very significant impact on the all-weather capability of a low-volume soil-agregate surface roadway. These features are mostly drainage related and are therefore not a function of traffic volume. Each feature is in some way related to the following drainage principles:

1. Surface runoff must be prevented from reaching the roadway.
2. Water must be removed from the roadway surface itself.
3. Excess water must be removed from under the roadway.
4. Erosion must be controlled on the roadway, the side slopes and the side ditches.
5. Water following in all natural and man made drainage channels must be able to pass without undue damage to the roadway.

Roadway Cross slope provides for the adequate removal of surface water from the travelway. Insufficient crown on a road permits the rainfall to stand in puddles which soften the road surface and cause structural failure. Potholes are the most visible evidence of structural failure caused by an inadequate crown. Potholes rarely appear on soil-aggregate roads when the longitudinal slope is steeper than 2.5%, however if such roads are not properly crowned erosion soon appears in the wheel tracks. Studies by Cornell University indicate that the likelyhood of potholing on roads with flat longitudinal grades reduces rapidly as the rate of crown is increased to 5%. Above that slope potholes are not a problem, however with steeper cross slopes vehicles tend

to slide off the side of the road if the surface gets slippery from rainfall. The project roads should have a 5% cross slope.

Gravel pavement thickness is usually determined by the number of heavy vehicles using the roadway. However clay and silt such as are found in situ in the project area rapidly loose strength when wet. In such cases a 15 to 20 cm layer of more stable material is usually superimposed over the in situ material regardless of the theoretical thickness required by the projected traffic volume. Additional lateritic borrow is included in the proposed project typical section to insure a 20 cm blanket even after the surface begins to wear.

Embankment height is used to raise the bottom of the gravel surface above the surrounding terrain in flat country. This prevents water from intruding into the subgrade from the outside and permits the water which enters through the pavement to drain out along the surface of the less permeable subgrade. The proposed typical section includes two side ditches from which borrow material can be taken to build a crown on the existing subgrade. A cross slope of 5% on the subase material will encourage free drainage flow from the bottom of the lateritic layer. While the road surface is in fact only 25cm above the existing ground, it is 50 cm above the adjacent ditch bottom.

Side borrow ditches are to be of the maximum width (3.0 meters) that can be cut and later cleaned with a single grader pass. Since much of the terrain is flat the water will not flow in some of these ditches but will evaporate or be absorbed into the ditch

bottom. The subgrade under the roadway itself is to be compacted to make it less permeable than the ditch bottom. The width of the ditch should reduce the depth of flow where the terrain is not flat thereby minimizing ditch bottom erosion.

Interceptor ditches are proposed in all areas where sheet flow occurs. Most of the sheet flow will occur on the east side of the roads. These ditches are intended to prevent this overland flow from filling the side borrow ditches. The ditches should have a minimum slope of 0.5% and an average minimum depth of 0.5 meters. The top of these V ditches will be 2 meters wide if 2:1 side slopes are used. The inside edge of the ditch as proposed would be 3 meters from the side borrow ditch to allow the material excavated from the V ditch by grader to be piled at the downhill edge of the ditch.

Clearing the undergrowth is necessary to permit the road work to take place. However in the case of rural roads such as these project roads clearing also serves to assist in keeping the road in all weather condition by allowing the sun to dry out the roadway area. Standard practice in tropical areas is to clear the alignment back from the edge of the roadway by a distance equal to the height of the surrounding trees on east-west roads and a distance of 1 1/2 the height of the trees on north-south roads. Since evaporation will account for a portion of water removal for this project the additional clearing is particularly important. The cleared width of the right of way for the proposed typical section is 30 meters. This will not only satisfy the tree height requirement but will also provide grader access to the interceptor ditches where required.

Miter ditches are used to divert the flow from side ditches when the road alignment is down hill. They are used to control side ditch erosion. These ditches are usually flat and discharge on the hill side. The number and width of the ditches are a function of the amount of water flowing in the side ditch, in this case the side borrow ditch. Miter ditches will not occur in the same areas as interceptor ditches since they serve different purposes. In this estimate, the costs for each type of ditch is considered the same.

Roadway width affects drainage to the extent that it determines the amount of storm water run-off which must be collected in the side ditches. At curves where the road is superelevated (all sloping in one direction) the probability of the side slope on the lower side eroding from the road surface runoff is very sensitive to roadway width. Studies conducted by the University of California at Berkeley indicate that for low volume traffic a narrow road is acceptable even if opposing traffic must reduce speed to pass, since passing is infrequent at such volumes. At 100 vpd for instance, assuming 80 vehicles during the 12 hours of daylight evenly divided directionally, a driver would meet an oncoming vehicle every 18 minutes. At 60 KPH a meeting would take place once every 18 kilometers. In such circumstances the MVWS (maximum vehicle width standard i.e. the legally allowable width) controls the minimum lane and roadway width. The most common MVWS is 2.5 meters. For this vehicle width the minimum two way roadbed width is 18 feet or 5.49 meters. As a term of reference, the largest 1982 Jeep 4 wheel drive pickup truck is 2.00 meters wide.

Summary: The typical section of the Fada/Bilanga road should consist of a 5.5 meter wide surface of Lateritic Gravel 20 cm in depth placed in two layers. The surface cross slope should be 5%. Additional lateritic borrow should be used between the gravel surface and the subgrade material. Subgrade material should be borrowed from two side ditches, each with a bottom width of 3 meters. This side ditch borrow should be placed on a platform of previously compacted in-sity sub base material. The side ditch borrow should be placed with a 5% cross slope to insure internal drainage.

The side slopes of the embankment and the ditches should be 2:1. Interceptor V ditches should be placed with the downhill edge 3 meters uphill of outer edge of the uphill side borrow ditch where sheet flow occurs. Miter drains should be approperiately placed where the longitudinal profile of the side borrow ditches dictate.

Approximately 10 cm of top soil must be removed in the area between the outer edges of the side borrow ditches. The side borrow ditches should be approximately 15 cm in depth below the bottom of the topsoil or approximately 25 cm below ground level. The edge of the 5.5 meter wide surface should be at least 50 cm above the bottom of the side borrow ditch or at least 25 cm above the existing ground. The longitudinal profile of the roadway should follow the slope of the existing terrain as much as possible to minimize pit borrow material requirements. The alignment should be cleared for a width of 30 meters.

The Gounguin/Comin-Yanga road should be designed to the same standards except the surface should consist of only 15 cm of lateritic gravel placed in one lift. The edge of the surface should be at least 20 cm above the existing ground. In the Zanre-Diabo section (6.1 km) where the current road is in good condition, only a 5.5 meter surface of lateritic gravel with a 5% cross slope should be placed and the existing drainage structures should remain.

Both roads should be placed on a new horizontal alignment to the west (uphill) of the existing tracks except where the roads currently go through major settlements. In these locations the existing routing should be followed and the side borrow ditches eliminated. One major deviation is recommend on each route. At the river crossing at KM 72 + on the Fada/Bilanga route a 60 meter bridge is required. This bridge should be placed near an old crossing about 1.2 km down stream (to the east) of the two existing fords. The existing fords should be left in place to retain the current hydraulic characteristics of the river.

The existing Diabo/Comin-Yanga track crosses on the top of a dam approximately 13 km south of Diabo. This dam is in poor repair and the top width is insufficient. The new alignment should be routed to the west of this reservoir. Two 2 x200 x 200 box culverts wre included in the estimate for this realignment. The relignment is sketched on air photo Number 4934 at the USAID mission in Ouagadougou.

The horizontal alignment of either road presents no other great difficulties. The design criteria should be 60 km/h.

The drainage design will present some difficulties due to lack of data. However the following information for Fada-N'Gourma has been located:

Yearly rainfall: Max = 1314 mm (1959), Min = 569 mm (1944)
Monthly rainfall: Max= 527 mm (August 1959)
Daily rainfall: Max = 135.5 mm (August 1958)
Min. August rainfall: 104 mm (August 1921)

Design Rainfalls
1 year-63 mm
10 year - 117.2
100 year - 183.7 mm

Twenty one years of observation provides an annual rainfall of 908 mm.

The 900 mm Isohyete design criteria includes the following

1 year-65 mm
10 year-120 mm
100 year-190 mm

Using this criteria, the follow values were tabulated.

Intensity Minutes	Probability Annual	10 year	100 year
10	107.7	157.5	193.4
20	75.7	105.0	142.3
30	61.4	86.6	111.9
40	53.6	75.0	95.3
50	48.6	67.2	84.9
60	42.0	60.9	78.0
90	30.6	50.2	63.5
120	24.4	40.3	55.7
180	17.9	29.1	42.0
300	10.8	19.2	28.1
600	6.5	10.5	16.4
900	4.5	7.9	11.3

This information was taken from a report by the African Development Bank.

Best Available Document

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ESTIMATED CONSTRUCTION QUANTITIES

Fada/Bilanga (74km)

1. Clear Right of way
   5.5 - 2,220,000 m2
   7.0 - 2,220,000 m2

2. Scarify & scrape at 10 cm thick
   5.5 m - 111,000 m3
   7.0 m - 122,100 m3

3. Prepare & compact subgrade
   (includes discing, shapping, watering & rolling)
   5.5m - 510,600 m2
   7.0m - 621,600 m2

4. Excavate & place side borrow
   (includes scarifing, excavating & shaping, watering and rolling)
   5.5m - 63,600 m3
   7.0m - 63,600 m3

5. Clear pit areas
   (includes clearing, scarifing and excavating cover on pit areas)
   5.5m - 46,300 m3
   7.0m - 64,400 m3

6. Excavate & place pit borrow
   (includes piling, loading, hauling, dumping, dozing, spreading, watering and rolling)
   5.5 m-66,400 m3
   7.0 m-104,600 m3

7. Shape intercepter & miter ditches
   5.5 m - 111,000 LM
   7.0 m - 110,000 LM

8. Excavate & place laterite surface material
   (2 lifts, includes piling, loading, hauling dumping, dozing, spreading, watering and rolling)
   5.5 m - 88,800 m3
   7.0 m - 111,000 m3

9. Drainage structures
   3 ea 1Ø80 CMP
   2 ea 2Ø80 CMP
   6 ea 1Ø100 CMP
   12 ea 2Ø100 CMP
   5 ea Radier, 215 LM total
   1 ea 200X100 Box culvert
   2 ea 2X200X100 Box culvert
   1 ea Bridge, 5 span, total length 60 meters.

EQUIPMENT INCLUDED IN ESTIMATES

BRIGADE

2 Bulldozers, D - 6
2 Bulldozers, D - 6 (new)
2 Graders, 120
1 Tractor with harrow
4 Water Truck, [illegible] -10 m3
2 Water Truck, [illegible] (new) 1) -10 m3
2 Rollers
2 Loaders, 920
6 Dump Truck, 4,5 m3
3 Dump Truck, 6.0m3 (new) 2)
1 Flatbed Truck w/crane
4 Pickup Trucks
1 Backhoe
1 Lowbed Truck (new)
1 Lubrication Truck (new)
1 Fuel Truck (new)
2 Tool trailer
1 Compressor
3 Generators
1 Welding outfit
1 Fuel trailer
4 Hand compactors
2concrete mixers
3 water pumps
2 Radios
1 Survey Equipment

CONTRACTOR

4 Bulldozers, D-6
2 Graders, 120
1 Tractor with harrow
9 Water truck, 10 m3
2 Rollers
1 Loader 950
11 Dump truck 9.0 m3
1 Flatbed truck w/crane
4 Pickup trucks
1 Backhoe
1 Lowbed truck
1 Lubrication truck
1 Fuel truck
2 Tool trailer
1 Compressor
3 Generators
1 Welding Outfit
1 Fuel trailer
4 Hand compactors
2 Concrete mixers
3 Water pumps
6 Radios
1 Survey Equipment

1) Not required for Gounghin -Cominyanga Road

2) Only 2 required for Gounghin -Cominyanga Road

The cost of the brigade's existing equipment was taken from shipping documents. The new equipment was priced, tax free, by the local dealer and by Caterpillar in the U.S. The rental fee for contractor's equipment was submitted by a local contractor.

The daily cost of brigade equipment was determined by including depreciation, cost of tires or replacement tracks, and spare parts. The equipment usage was calculated using the Catterpillar performance handbook. Brigade operators were considered poor because of lack of motovation while contractor operators were considered to be average because of closer supervision.

The brigade costs were figured on the basis at an eight hour work day while the contractor costs represent a ten hour day. A 200 day year was used for both production units which means that work will continue during the rainy season although some time will be lost during the month of August.

POL costs were figured on actual equipment usage and horse power, oil changes were assumed to occur every 100 hours. POL costs are based on tax free supplies.

BRIGADE PERSONNEL LIST

The brigade is made up of the following groups:

A) Administrative Office-10 people

2 Administrators
1 Bi-lingual Secretary
1 Typist
1 clerk
1 warehouse man
2 drivers
1 Timekeeper
1 laborer

B) Maintenance Unit-16 people
2 Mechanics
4 Assistant mechanics
1 welder
1 machinest
1 lowbed driver
1 lub truck driver
1 Fuel truck driver
2 laborers
3 Guards

C) Survey crew-6 people
1 Instrument man
1 Head chain man
4 laborers

D) Road building Unit-33 people
1 Supervisor
2 Grader operators
4 Bulldozer operators
2 Loader operators
2 Roller operators
1 Tractor driver
15 Truck drivers
6 laborers

E) Drainage Unit-42 people
1 Supervisor
1 Foreman
3 masons
1 Backhoe operator
2 Drivers
1 Iron worker
1 Carpenter
32 Laborers

PERSONNEL COSTS

Payroll Evaluation of E. ORD Rural Roads Project 686-0215

1. Two types of workers were employed Permanent, and Occasional.

2. Permanent workers get a 3% longitivity pay increase after 3 years, then a 1% longitivity pay increase for each additional year of work.

3. A deduction of 4.5% for social security is taken from each permanent worker. The employer makes an additional 18.5% contribution to the S.S. fund for each permanent worker. (not shown on payroll)

4. Income tax is withheld from both classes of employees.

5. All employees receive a one month bonus each year as holiday pay. Permanent employees receive this payment at the end of the year but occasional employees receive one twelveth of their earnings each month to account for their bonus.

6. Occasional employees other than laborers receive thirty days pay per month. Laborers are paid for days worked as a ratio of a monthly thirty day salary.

7. Overtime is paid on a separate payroll. A bonus of 15% is paid on the first two hours of overtime per day, other overtime hours earn a 60% bonus. Both permanent employees and occasional employees are eligible for overtime pay. The derivation of the hourly rate shown as the basis for calculation of overtime pay was not apparent.

8. Per diem was paid to forty four people in January, 1982, including thirty nine full time project employees. Per diem varied from eight to twenty five days, most employees received twenty two days of per diem.

PAYROLL EVALUATION

Heavy equipment operators received 400 CFA per diem, all other positions received 360 CFA. The regular T.P. employees who were on the government rather than the project payroll received from 1,000 to 5,000 CFA per diem.

9. The combination payroll, overtime pay and per diem for the previous brigade was used as the basis for estimating the costs of a future brigade. Two additonal bulldozer operators, two additional water truck operators, three dump truck drivers, a low-bed truck driver, a fuel truck driver, a lub. truck driver and two mechanic helpers were added to operate the additional equipment in the new brigade.

10. The contractor labor costs were calculated using the same laborer base costs as the brigade increased by two hours per day overtime. All other employees basic wages were doubled to account for higher base salary and additional overtime. In addition two expatriates are included for overall supervision and equipment maintenance. Equipment operators and truck drivers are not included in the contractor's cost as they are included in the equipment rental fee. The contractor's crew is estimated as having 31 permanent employees and 50 daily laborers.

DRAINAGE COSTS

Drainage structures were located in the field, principally by AID engineer Al strom while on previous field trips. Their locations were independently confirmed by aerial photography. The drainage areas were calculated by Mr. Strom. The costs were computed by Mr. Strom from prices supplied by the GOUV. These figures were recalculated for confirmation and also compared to prices supplied by a local con tractor and the local UNDP representative. Addition earthworks for the drainage structures is included in the estimate.

CONTRACTOR'S ADDITIONAL CHARGES

Based on discussions with two local contractors the following percentages were derived. They are percentages of the total construction costs but will be valid only in a competetive bidding situation.

Camp Facilities	- 5%
Insurance	- 5%
Performance Bond	- 10%
Overhead	-8.5%
Profit before taxes	11.5%
TOTAL	40.0%

Discussions with GOUV personnel indicate that their experience with local contractors doing drainnage work indicates that the contractor's prices range about 40% higher than GOUV estimates their own costs would be.

CONSULTANTS COSTS

Design - The GOUV submitted an estimate of their costs to design the Gounghin/Cominyanga Road before determining that they did not have suffucient capability to undertake that design. That estimate was used as a basis for the local component of the consultant's design fee. Two expatriates, a design engineer and a soils engineer, were added. It is estimated that a consultant would take nine months to design the Fada/Bilanga road, eight months to design the Gounghin/Cominyanga road or one year to design both roads.

CONSTRUCTION SUPERVISION -Supervision would be carried out by one expatriate and a locally recruited soils crew to monitor materials sources and compaction.

CONSULTANT TECHNICAL ASSISTANCE - This item consists of three expatriates, one highway supervisor, one master mechanic, and one warehouse/accountant/office manager person to run the brigade operation. A locally recruited soils crew will also be necessary to monitor materials sources and compaction.

CONSULTANT'S FEES - This item, which is included in all of the above costs, consists of the following percentages applied to the consultant's actual costs.

Home office/Overhead	20%
General Administration	20%
Fixed fee	10%
TOTAL	50%

MAINTENANCE COSTS

Because of the lack of suitably located lateritic gravel to recharge the road surfaces and (at the time this report was written) no valid traffic projections, it is difficult to estimate the maintenance costs with any reasonable accuracy.

When calculating the cost of the Southern most 7.5 km of the Gounghin/ Cominyanga Road, where there was insufficient laterite in Pit No8 to build the length which would normally be most economically built from that source, it was discovered that increasing the longest haul distance from 3.4 km to 7.7 km from pit No9 without adding extra trucks, (i.e. permitting the existing trucking capacity to control rather than the loader capacity which was the basis for these estimates), the entire brigade production dropped by one third. This equates to a 50% increase in brigade unit production costs.

Section H-2, Lateritic Material Evaluation, indicates that Fada Pits No 10 and 11 do not have enough material for the single recharge necessary to extend the economic life of the roadway to 15 years.

"AID Program Evaluation Report No5, Rural Roads Evaluation Summary Report"

dated March, 1982 contains the following "Rule of Thumb for New Roads" on page E - 15.

The new road is a good all-weather, gravel road, and replaces a track not suitable for motorized transport. The construction cost of the road ranges between $8,000 and $65,000 per KM depending on the terrain, climate, design standards, and types of construction. (If we consider the cost of construction for the Fada/Bilanga as the brigade cost without any technical assistance we will be in fact representing the construction cost by the same type of group that will be recharging the road. That construction cost is estimated to be $26,000 per km).

Periodic maintenance on the road is performed every seven years. The cost of this maintenance is equal to 50% of the initial construction cost ($13,000 per km in 1982 dollars)

Routine maintenance on the new road is performed each year that periodic maintenance is not performed, at an annual cost of 2.5% of the initial construction cost ($650 per km, in 1982 dollars).

Based on the above rule of thumb the following table has been developed for maintenance costs using both a 10% and a 12% inflation factor. However no periodic maintenance is included in year 14 since the time span being considered is only 15 years. The road maintenance is assumed to start in 1987.

Year	Date	10% Inflation	12% Inflation
1	1987	64,000	84,800
2	1988	70,400	94,900
3	1989	77,500	106,300
4	1990	85,200	119,100
5	1991	93,700	133,400
6	1992	103,100	149,400
7	1993	2,774,700	3,346,400
8	1994	124,800	187,400
9	1995	137,200	209,900
10	1996	151,000	235,100
11	1997	166,100	263,300
12	1998	182,700	294,900
13	1999	200,900	330,300
14	2000	221,000	369,900
15	2001	243,100	414,300
		$4,695,400	$6,339,400