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REPORT ON AGGREGATE AND WATER SURVEYS FOR THE RURAL ROAD DEVELOPMENT PROJECT

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1. INTRODUCTION

The Mauritania Rural Road Project (682-0214) was first considered by AID/Nouakchott in early 1978, upon request from the Government of the Islamic Republic of Mauritania (G.I.R.M.).

The purpose of the Project is to provide a year round farm to market road network to selected agricultural areas in the Region of GUIDIMAKA (10th Region), for subsequent replication in other areas. The GUIDIMAKA Region, with an average rainfall of 600 mm, is the area with the most agricultural potential in Mauritania, especially the Senegal River floodplain.

The PID was written in November 1978, and a Social Soundness Report was submitted in May 1979.

The PID states that approximately 300 kilometers of existing rails and tracks will be upgraded over a 5 year-period to conform to minimum standards (45 km/h reference speed) permitting all-weather use. This will involve upgrading road sections, elevating the road surface where necessary, and creating new roads, side drain ditches, culverts, fords, and possibly bridges.

The PID also states that the Project will be implemented by using a modified force account approach which has a substantial village labor component. A mobile brigade with U.S. professional and technical know-how for leadership is desirable. It is doubtful whether even the major local contractor (E.G.B.) has the capabilities to do the rehabilitation of the rural roads under the Project. The possibility of requesting proposals from international contractors(COLAS, G.T.R., etc.) from neighboring countries might be investigated at the PP stage.

A team consisting of a Civil Engineer (Chief of Party), a Soils and Materials Engineer, and an Aerial Photography Specialist spent ten days in the Project area in May 1980, in order to provide inputs for the PP.

This report deals with the findings of the Soils and Materials Engineer, with the objective of evolving a materials investigation plan for an aggregate and water survey, and assisting in preparation and negotiation of a contract to conduct the aggregate and water survey.

Additional input for the aggregate and water survey can be found in documents provided to the survey contractors by the Aerial Photography Specialist.

2. OVERVIEW OF THE PROJECT AREA

2.1 Geology

The GUIDIMAKA Region consists of alternating plains and minor relief features, except the Assaba Plateau.

The rural roads under study are located between the WaWa Mountains on the West, the Karakoro River on the East, the Mbout to Kiffa road on the North, and the Senegal River on the South.

This area includes, from east to West :

- the depression between the Affole Plateau and the Assaba Plateau,
- the Assaba Plateau,
- the transition between the Assaba Plateau and the Senegalo-Mauritanian Basin.

The geological formations encountered are, from East to West :

- the Kiffa and Hodh series (Cambro-Ordovician),
- the Assaba-Tagant series (Cambro-Ordovician),
- the Selibabi series (Cambro-Ordovician), same as Faleme series,
- the Diala-Bouenze series (Precambrian),
- the Precambrian base,
- the Mbout and Bakel series (Cambro-Ordovician),
- the Senegalo-Mauritanian Tertiary Basin formations.

The prevailing rocks found in these geological formations are listed in the following Table.

Series	Rocks
Kiffa and Hodh	Fine-grained sandstone Pelite and hematite schist Jasper Dolomite
Assaba-Tagant	Quartzite sandstone Fine-grained quartzite and schist Dolomite
Selibabi	Tuff, cinereous tuff, gray wacke, pelite, dolomite, sandstone
Diala-Bouenze	Feldspar micaschist Green schist
Base	Granite Granodiorite, diorite, mylonite
Mbout and Bakel	Micaschist and quartzite

The rocks that were actually found to be in evidence during the field trip (May7-17, 1980) are indicated on the data sheets for each route in Appendix.

The bedrock was found to be rather shallow along most of the rural roads under study, except in the alluvial plain of the Senegal River.

Some of the landforms typical of the warm desert environments are present in the GUIDIMAKA Region :

- relatively narrow bedrock plains, called pediments,
- isolated steep-sided hills rising above and behind pediments, called inselbergs.

Domed inselbergs are especially developed well in granite (along the Selibabi-Mbout route), the structure of which renders it especially prone to inselberg development. Inselbergs are also developed frequently in sandstone and quartzite.

Scales, sometimes several meters thick, have broken away from cores of rock, especially igneous rock, by the process of exfoliation.

Alluvial fans are a common phenomenon between the front of the Assaba Plateau, or of most inselbergs and hills (Toumiat Hills, for instance), and the alluvial basins.

Many rock outcrops are covered by a thin patina of lacquer, usually called "desert varnish".

Iron-rich crust developed through a process of eluviation (laterite or ironstone) was seldom found along the rural roads under study.

2.2 Soils

On a geotechnical as well as pedological point of view, the soils generally belong to the Senegal River plain, the sandy interior, or the rocky Assaba Plateau. Rocky landforms are discussed in the preceding paragraphs.

Alluvial lands along the Senegal River comprise the following :

- falo, riverbank (silts and clays),
- fonde, ridge at top of riverbank (silt),
- walo, depression beyond ridge (clay).

Interior soils -dieri- comprise the following :

- signa (sandy soils)
- katamagne, or niawalle, resembling walo soils (soils of interior drainage systems)

The sandy soils are red sand dunes, usually settled (although there are some shifting sand dunes near Ould Yenje). The red sand is mixed in various proportions to the only soils that tend to develop extensively on the more or less flat surface of the interior -the silty soils with fine particles. Hence, most of the soils found along the alignment of the rural roads under study are silty sands, the color of which varies from red to brown.

The soils of the interior drainage systems, locally called oueds, are predominantly clayey soils. The soils of the low areas, hollows or depressions located between the settled sand dunes, are also clay-silt mixtures. Because water tends to accumulate in these low areas, where it is eventually evaporated, salts are precipitated and a build-up of salinity occurs.

A large proportion of the silty sand areas, especially of rock outcrops, is covered with stone pavement, usually 5 to 10 cm thick. Stone pavement develop through deflation, with an initial alluvial sediment containing both fine and coarse materials being subjected to deflation, until such time as the surface is lowered to such an extent that a layer of coarse material is left at the surface, the fine material having been blown away. Stone pavement consists of armoured surfaces composed of rock fragments, either angular (quartzite) or rounded (granite), usually one or two stones thick, set on matrices of finer material such as sand and silt.

2.3 Hydrology

The hydrographic grid is dense and outstanding. It is submitted each year to violent floods which recharge the alluvial aquifers. These alluvial aquifers can locally extend over a wide area.

All oueds in the area under study are not perennial, and belong to the Senegal River basin. The flow in the Senegal River itself is low in the dry season (it was estimated to be about 250 l/s in May near Khabou during the field trip).

The main oueds in the area under study are Oued Garfa (Km 64 on the Selibabi-Mbout route), Oued Niorde (Km 32 on the same route), and Oued Amague (just North of Selibabi). Oued Ferkane (just South of Mbout) is a tributary of the Black Gorgol River. Oued Karakoro constitutes the Mauritanian border with Mali between Oued Yenje and Khabou. Smaller oueds are either tributaries of these, or direct tributaries of the Senegal River (Oued Bounoukole and Oued Goulia, on the Gouraye-Khabou route).

The alluvial aquifers in these oueds are recharged every year, and feed the existing wells in the area under study. Data concerning these wells were collected in the middle sixties and need to be updated. The yields in the traditional oglats or the more modern wells vary from 1 to 5 m3/h, mostly from 1.5 to 3 m3/h. Brackish waters are the exception, and the amount of solids is usually less that 0.2 g/l.

During the field trip, most oglats and wells were examined, and the depth of the water table was recorded, as well as the nature of the water-bearing stratum when it could be ascertained. This information can be found on the data sheets for each route in Appendix.

Precambrian or Cambro-Ordovician rocks, which constitute the bedrock in the area under study, are normally massive and impermeable, and therefore sterile. However, these rocks can be water-bearing under certain conditions :

- zones of superficial weathering, especially in granite and other igneous rocks,

- zones of faults, which can bear a productive aquifer if they make up a dense enough system.

Few wells were found to be in the Precambrian base or the Diala-Bouenze series : granites (Artemou, Oulombome), micaschists and green schists (Keninkoumou, Djajibine). Their yields are generally very low.

In the Mbout and Bakel metamorphic series, yields are very low . The same applies to the Selibabi volcano-sedimentary series.

Aquifers in the water-bearing substratum are recharged every year, and provide water of excellent quality, but their practical sustained yield is small.

During the field trip, several wells were found to be dry, especially in Artemou (two dry wells out of three), Agouemit, Sanba Kandji, Hassi Chaggar, and Selibabi.

Several springs exist at the front of the Assaba Plateau, especially in Ndieo-Although they are perennial, their yield is low and barely sufficient to satisfy the needs of the local population.

In the area around Ould Yenje, sand dunes may provide one major reservoir of water. This is because the sand itself is both porous and permeable, and because the dune height permits the water to accumulate below the zone of intense evaporation.

According to a report by B.R.G.M. on underground water in the Sahel, local populations in the Project area draw mainly on zones of superficial weathering and alluvions, but zones of faults and karstic zones, especially in the dolomitic facies on the edge of the Assaba Plateau (Oumm Tahala Messouma), might be more of interest. Aquifers in the Project area are discontinuous. It is expected that pumping large quantities of water will require 50 m deep drillings in the area considered.

3. IMPLICATIONS ON THE SURVEYS

Lateritic gravels, which are widely used in roadmaking in West Africa, were seldom encountered in the project area :

- along the Selibabi-Bouly route (Km 12 to 24),
- along the Selibabi-Gouraye route (Km 5 to 13),
- along the Selibabi-Mbout route (laterite-shows only),
- along the Selibabi-Koumba Ndao and the Sei Delema-Aouinat sections, which were not included in the rural roads under study -but could be considered as alternate routes (Selibabi-Koumba Ndao - Guemou - Diogountourou and Selibabi - Sei Delema - Bouele - Aouinat - Ould Yenje).

These potential sites should be carefully studied during the aggregate survey.

Pockets of quartzitic rounded gravels were occasionally found, especially in the banks of stream beds, but their extent is probably small. Only the most important of these pockets, justifying further study, have been recorded.

Granitic and schistose gravels were seen at the bottom of a few wells along the Selibabi-Mbout route, but it is very likely that their recovery and their use will be uneconomical.

Coarse sand and gravel was also found in several stream beds, but it is expected that the available quantities are small, except in the Senegal River (coarse sand) and Oued Farkane (where a gravel deposit just downstream from the existing bridge looks very promising, with an estimated cubage of 25 000 m3). The smaller deposits, however, can provide sand, and possibly gravel, for making concrete.

It is therefore likely that most of the roadmaking aggregates will have to be detrital gravels, recovered from colluvions and stone pavement, and from alluvial fans between the front of the Assaba-Tagant series especially and the sand-silt basins.

Quartzitic stone pavement was found to reach 30 cm in several places, and to be workable.

The detrital gravels must be differentiated on the basis of the petrology of the parent rock. Granitic and quartzitic gravels will provide excellent material for base and surface courses, provided that the proportion of clay is limited. This is evaluated by the plasticity index which for the Project roads should be not more than 8 per cent -although a plasticity index of 10 per cent can be tolerated, depending on material availability.

Sandstone gravels would be expected to provide very satisfactory materials for the base course, but the lack of clay may make for increased liability to dusting and corrugation on the surface course in dry weather.

Schistose gravels are usually considered unsuitable for unsurfaced gravel roads, because : a) such materials cannot easily be compacted with normal rollers ; b) they are generally permeable and when the moisture content increases, a very large and rapid fall in strength occurs ; c) hydratation during weathering is known to cause biotite mica to swell, an undesirable characteristic in a potential base course material. If the use of these gravels cannot be avoided for the base course, the plasticity index required should be much lower than for granitic gravels.

The gravels will probably be easily worked with roadbuilding equipment such as a dozer with ripper, although the rate of wear of cutting edges may be high owing to the abrasiveness and dryness of the materials. Locally, areas of rock occur that are more resistant to disintegration than those surrounding them, and these will have to be avoided in working the borrow areas.

The volume of gravel available in a borrow area is related to the depth of desintegration of the parent material, or to the thickness of the rock fragments in the stone pavement.

Because of the gradation requirements specified (no aggregate over 50 mm or 2 inches), some sorting of the gravels may be necessary. Blending of materials from two or more borrow areas may also be necessary. Hence, proper equipment must be accounted for. However, crushing of materials with large proportions (say more than 20 per cent) of boulders and stones retained on the 50 mm sieve is not contemplated at this time.

The Terms of Reference for the aggregate survey contract in Appendix do not specify the depths of the test pits. They specify the spacing between test pits (100 m), and the minimum cubage (15 000 m3) that should be gettable in a given borrow area. The number and the depth of the test pits required will have to be determined in the field by the contractor. It is expected that only gravelly layers 30 cm thick or more will be considered, and hence that every positive test pit will result in an available cubage of 3000 m3 or more.

Although the design of the cross-sections of the rural roads to be constructed under the Project is not final yet, it is expected that the technical standards of the ordinary gravel roads (Route en Terre Ordinaire - RTO) in Appendix will be retained.

The width of the base and surface course is then 6 meters (20 feet), with an average lift of 45 cm (18 inches) of gravel, over a formation width of 9 meters (30 feet). Hence 3.1 cubic meters of borrow materials will be applied on each meter of length of rural road, and a 15 000 m3 borrow will provide the materials for about 5 km of road. Since the Terms of Reference for the aggregate survey contractor specify that the borrow areas will not, if possible, be located more than 2.5 km form the proposed alignment, the maximum haul by truck should not exceed 5 km, with an average haul of 2.5 (1.5 mile), with the exception of several stretches where gravels will not be readily available.

The subgrade soils are mostly silty sands holding up well. It is therefore suggested that only base and surface courses be constructed on these alignment soils. Where the profile needs to be improved, or where embankments sections are required for drainage culverts and Irish crossings (fords), materials for fill are to be excavated from roadside ditches. In the low areas, however, where the soils have a higher clay content, sandy materials will have to be hauled for fill (dune sand is acceptable). It is suggested that these low areas be avoided wherever feasible, and the routes be relocated away from stream plains and depressions.

As for the water survey, the quantities required are estimated at 700 m3 per kilometer of road. The practical sustained yield of the wells will have to reach 250 m3 per day. It seems therefore very unlikely that the existing wells can provide the above quantities, the needs fo the local populations having the highest priority. New water resources will have to be found, capable of the practical sustained yield indicated, with an average spacing of 30 km. The water survey contractor will define the aquifers to be tapped, and the types and locations of the required facilities (wells, drillings, small earthfill dams).

Great care should be taken in tapping the alluvial aquifers, because their reserves are limited, and there is a risk of drying out the existing oglats and wells, on which the local population depends.

As a conclusion, it appears from the existing documents (especially the geological map and the hydrogeological map at the 1/200 000 scale established for the Selibabi region by BRGM and BURGEAP) and the field trip along the candidate routes that the supply of the required quantities of water will be difficult, risky and costly. Water supply will not, however, be a problem along the Gouraye-Khabou route, since water intakes in the Senegal River are the most obvious solution. The area under study is quite poor in roadmaking gravels, except the Selibabi-Bouly and (to a lesser extent)the Selibabi-Gouraye routes. Roadmaking materials will usually be detrital gravels, and locally be nodular lateritic gravels.

Stones being readily available in the area under study, particularly granite and sandstone colluvions, it is recommended that drainage structures (culverts and fords) be made of masonry, instead of concrete or steel. Downstream protections by means of gabions will be economical and efficient.

4. DESCRIPTION OF THE CANDIDATE ROADS

4.1 General

This chapter deals with the candidate roads, in the order of priority determined during the field exploration in May 1980 :

- Selibabi to Mbout (112 km)
- Gouraye to Khabou (48 km)
- Selibabi to Gouraye (41 km)
- Dafort to Ndieo (26 km)
- Selibabi to Bouly (49 km)
- Selibabi to Dafort (61 km)
- Mbedia Achar to Ould Yenje (45 km)
- Bouly to Ould Yenje (26 km)

This order of priority takes into account the fact that the Gouraye to Khabou route serves several large villages and agricultural schemes -financed by the European Development Fund- and its improvement is a must, and that there is currently no track linking Dafort and Ndieo (hence the route from Ndieo to Selibabi goes through Soufa Pass, Ould Yenje and Sei Delema, i.e. over 150 kilometers).

The Mbout-Selibabi-Gouraye route (153 km) is classified as a Route Nationale by G.I.R.M. (RN 5). The Selibabi-Bouly-Ould Yenje-Kankossa route (125 km) is classified as a Route Regionale (RP 8). Other candidate roads are only feeder roads.

A traffic survey performed in January 1974 by G.I.R.M. (Ministry of Equipment) showed an average of 4 vehicles/day on the Mbout to Selibabi route. Hence, the suggested design (45 cm of base and surface courses) is safe and largely sufficient, and bridges are not needed on the candidate roads.

The data sheets for the candidate roads in Appendix show the information collected during the field trip.

The distances were measured by means of the car odometer, with an accuracy estimated at 2 to 3%. Since in many places the tracks wind unnecessarily, it is expected that straightening the alignment will result in slightly shorter sections. The road alignment may, however, be adjusted to minimize to the fullest extent possible large cross drainage channels and to stay as close as possible to available water and aggregate sources. Stretches that need to be relocated, especially in order to avoid flooded areas, are indicated on the data sheets.

Based on visual examination of the oueds and drainage channels, a preliminary estimate of the masonry culverts and fords required was made. This estimate will have to be reviewed during the rainy season by the entity responsible for the drainage design. It is likely, however, that adjustments in the road alignment can result in less culverts being required. Only two types of masonry culverts were contemplated at this time : smaller ones (1 meter span) and larger ones (2-3 meter span). Fords are recommended for all the wider crossings.

A highway engineer will use available aerial photographs, and define the optimum alignment of the priority roads, under the following conditions :

- minimizing hauling distances,
- selecting most appropriate crossing locations,
- avoiding unnecessary turns and excessive earthworks,
- complying with Mauritanian design standards, as far as possible.

Altogether, the length of the improved roads will not be much different from the length of the existing tracks.

Points of intersection (P.I.s) of the new aligments will be marked on the aerial photographs, and if possible marked in the field with suitable stakes and tied in to permanent reference points, for use by the surveying teams before Project implementation.

4.2 Selibabi-Mbout

This track is part of the RN 5 trunk road. Only about 80 km are in the Region of GUIDIMAKA (Selibabi to Djajibine). Two Subdivisions des Travaux Publics are therefore responsible for this route : the Subdivision of Kaedi for Mbout to Djajibine, and the Subdivision of Kiffa for Djajibine to Selibabi.

Very little maintenance work, if any, appears to be performed on the existing track. The route runs Northwest from Selibabi to Mbout, with a total length of about 112 kilometers. The main villages along the existing track are Keninkoumou, Tachout, Artemou, Agouemit and Djajibine. Major stream crossings are Oued Amague, Oued Tourime, Oued Niorde, Oued Garfa, Oued Boudama and Oued Ferkane. The route is impassable during part of the rainy season.

The road from Selibabi to the airport is paved, but poorly maintained (potholes). The bridge and the embankment at the Oued Amague crossing are ruined. Another bridge over Oued Ferkane is in good condition. Bedrock is mostly granite, micaschist and quartzite. The route goes through four different geological formations : the Selibabi series, the Diala-Bouenze series, the Precambrian base, and the Mbout and Bakel series. The stretch between Boudama and Djadibine (where the route should be relocated) is geologically more complicated.

Subgrade soils are generally red to brown silty sands, often covered with stone pavement. Rock outcrops and hills can be seen along most of the route, including inselbergs and pediments.

The area is flat to gently rolling, and covered with bushy savannah (acacia).

Roadmaking materials are fairly limited along this route. The two largest potential sources are in the Oued Ferkane channel between Mbout Chorfa and Mbout, and West of Agouemit, where slope wash materials on the East side of Artemou Mountain appear workable. The other sources noted - including the sources listedin the 1977 U.N.D.P. report concerning this road - will most likely yield limited quantities of roadmaking gravels. Sand and coarse aggregate for concrete, and blocky stones for masonry and rip rap, seem to be available along this route. It is likely that more roadmaking materials can be found South of Selibabi, along the Selibabi-Koumba Ndao route.

Water resources are expected to be a problem along this route. The practical yield of the alluvial aquifers, or of the water-bearing granites, was found to be very low. Water may have to be hauled over a long distance for the construction of this road. Special care should be taken so that the aquifers selected do not impact on the water supply of the villages.

It is estimated that 58 fords totalling about 1470 meters are needed along the alignment of the existing track. Extensive drainage is required along this road, which intercepts numerous catchment areas (one every 750 meters) and several major <u>oueds</u>.

A recent preliminary study by G.I.R.M. led to the conclusion that the cost of bringing this road to R.T.A. (improved gravel road) standards would be $ 71 270 per kilometers, based on 1980 contract prices. It is doubtfull, however, that local contractors are qualified for the upgrading work contemplated, under prevailing conditions. This estimated cost could somewhat be brought down by using masonry instead of steel pipe for culvert construction, and by calling for R.T.O. standards only, with a 45 cm gravel lift ($ 65 330 per kilometer).

4.3 Gouraye-Khabou

This track connects to the RN 5 trunk road at Gouraye.

The route runs mostly Southeast from Gouraye to Khabou, with a total length of about 48 kilometers. It is located in the Senegal River plain, and follows the meanders of the river. The main villages along the existing track are Diaguili, Moulessimou, Diogountourou, and Solou. There are three agricultural schemes under construction along the route. Major stream crossings are Oued Touna, Oued Doukole, Oued Gounoukole and Oued Goulia, all tributaries of the Senegal River. The route is impassable during most of the rainy season. There are no drainage structures along the existing track.

Bedrock is mostly micaschist and sandstone. The route goes through two different geological formations : the Mbout and Bakel series, and the Selibabi series.

Subgrade soils are generally brown silts, corresponding to fonde soils. The existing track crosses several depressions, with walo clayey soils. As can be expected in the Senegal River plain, rock outcrops are few along this route. There are micaschist hills just outside of Gouraye, with steep slopes that will require some rock excavation, and a sandstone inselberg at Solou.

The area is flat to gently rolling, but for a pass in the hills East of Gouraye, and covered with bushy savannah.

Roadmaking materials are fairly limited along this route. Low gravel hills North of the track were spotted East of Diogountourou, past Solou and near Khabou, requiring further investigation by the aggregate survey contractor. There were no other shows of materials along this route, except deposits of medium to coarse sand in the riverbed, usable for making concrete. It is likely that more roadmaking materials can be found farther from the existing track, especially along the Solou-Guemou track.

No aerial photographic coverage of this area was available for the field study.

Water for construction along this section will be obtained from the Senegal River, with a low crest, a water intake, a mobile pump and a water tank. There is no need for a water survey along this route. The flow at low water is over 500 m3/h in the Senegal River, and the impact of drawing up to 12 m3/h is negligible.

It is estimated that only 6 fords totalling about 255 meters are needed along the alignment of the existing track. Average culvert spacing will be about 1500 meters.

A check of the highest water level during the rainy season is suggested, in order to determine the height of the roadway fill, and to define where relocation of the route is justified.

The cost of upgrading this track should be altogether somewhat lower than in the case of the Selibabi-Mbout road (fewer cross drainage channels, water availability, but more fill materials).

4.4 Selibabi-Gouraye

This track is part of the RN 5 trunk road. It is currently an improved track (Piste Améliorée), with five bridges, four masonry culverts, a riprap ford, and several hundred meters of embankment. Two of the bridges and one of the culverts are in urgent need of repair. Most of the bridges are of composite design : masonry abutments, steel girders, and wood deck. The bridge at Km 6 has badly deteriorated reinforced concrete girders, and is useless now. It appears that some maintenance work was done on this section a few years ago (stockpiles of gravel remain), but very little has been done for the last few years.

The route runs Southwest from Selibabi to Gouraye, where a new ferry to Bakel -Senegal- is under construction, with a total length of about 41 kilometers. The main villages along the existing track are Mamaeli, Sanba Kandji and Boutanda. A major stream crossing is Oued Amague at Km 28. Because of the improvements noted above, the route is passable during most of the rainy season, and is holding up well.

Bedrock is mostly micaschist and sandstone. The route goes through two different geological formations : the Selibabi series, and the Mbout and Bakel series.

Subgrade soils are generally red to brown silty sands, often with a stone pavement cover. Rock outcrops and hills are present along the route, and usually show micaschist bedrock from the Mbout and Bakel series.

The area is flat to gently rolling covered with bushy savannah (acacia). It is expected that roadmaking gravels will be available in sufficient quantities along this route. Stockpiles of materials from adjacent areas were found between Mamaeli and Boutanda to prove it. The gravels are weathered granite and lateritic nodules. Several potential gravel sources were also seen on colluvial slopes of sandstone outcrops.

Water supply is expected to be a problem along the first half of this route. Wells are very few, with some of them dry at the time of the field trip. High water table in the stream at Mamaeli is worthy of investigation. For the second half of this route, the Senegal River can provide the quantities of water required, by means of an intake (which could be used also for the Gouraye-Khabou route).

It is estimated that 4 additional fords, plus the upgrading of one existing ford, totalling about 60 meters, are needed along the alignment of the existing improved track. Average culvert spacing will be about 1000 meters, including existing culverts.

The cost of upgrading this track should be plainly lower than in the case of the Selibabi-Mbout road, especially because of the improvement work already done and of the water availability on part of the route.

4.5 Dafort-Ndieo

There is no existing track and no vehicle traffic between Dafort and Ndieo. During the reconnaissance, two routes were followed : one Eastern route along the Assaba Plateau, and one Western route closer to a straight line. The Western route was found to be shorter and requiring less earthworks and drainage structures, and it is recommended that the Western route be retained. The final detailed alignment will be determined at a later stage. The only obstacle along the Western route is a cluster of small hills Southwest of Ndieo, which can easily be passed around.

The total length of the suggested route is about 26 kilometers. There are no permanent villages between Dafort and Ndieo. The village of Dioubali is about 6 kilometers East of Km 13 of the proposed route. A major stream crossing is at Km 13 (Oued Garfa), and an extensive area is flooded several times during the rainy season. The best crossing location will have to be determined during the rainy season.

Bedrock along the proposed route is mainly sericitoschist, quartzite and sandstone. There is an extensive sand cover along the Assaba Plateau South of Ndieo, of Ogolian (Quaternary) origin. The geological formations encountered are the Selibabi series and the Assaba-Tagant series.

Subgrade soils are generally red to brown sands, with gravel-size particles. Stone pavement is frequent. Soils of the last four kilometers are settled dune sands. Major rock outcrops, except the Assaba Plateau, are small sandstone hills Southwest of Ndieo (Selibabi series).

The area is generally flat, and gently rolling as the route approaches Ndieo. Vegetation is scattered bush, turning to dense bush at the Oued Garfa crossing and near Ndieo.

There seems to be a large potential borrow area about 5 kilometers North of Dafort along the proposed route. Quantitites should be sufficient for the entire road section, and can possibly be supplemented by slope wash materials from the hills Southwest of Ndieo.

Water resources are expected to be limited along this route. Oued Garfa is a possible source of water, but whether it can provide the required quantities is questionable. Springs along the Assaba Plateau supply only limited quantities, and are needed for local populations.

Although the future alignment is still undefined, it is estimated that 11 fords totalling about 300 meters are needed, and that the average culvert spacing will be about 1000 meters. The cost of construction of this road should be slightly lower than in the case of the Selibabi-Mbout link.

4.6 Selibabi-Bouly

This track is part of the RR 8 trunk road, linking Selibabi and Kiffa. The Subdivision of Kiffa is responsible for its maintenance, but very little work has been done along this route in the Region of GUIDIMAKA.

The route runs East from Selibabi to Bouly, with a total length of about 49 kilometers. The main villages along the existing tracks are Sei Delema, Louare and Bandiougou. There are no major stream crossings along the existing alignments, although several fords up to 30 meters appear to be necessary. The route is impassable during part of the rainy season.

It is worth mentioning that there is an alternate route from Selibabi to Ould Yenje, bypassing Bouly, branching off at Sei Delema.

There are no drainage structures along the existing track.

Bedrock is basically sandstone, with some quartzite. The route goes through three different geological formations : the Selibabi series, the Assaba-Tagant series and the Kiffa and Hodh series.

Subgrade soils are generally red to brown silty sands. Stone pavement is often found. The main rock outcrops are the Toumiat Hills (inselbergs and pediments), and hills near Louare and about five kilometers West of Bouly. All these hills are essentially sandstone.

The area is flat to rolling, with a rather short steep slope five kilometers West of Bouly. The alignment is winding and could easily be staightened. The surroundings of the track are covered with bushy savannah (acacia).

As far as roadmaking materials are concerned, this route appears to be the most promising of all the routes observed, although gravels were seen between Selibabi and Sei Delema only.

The main potential borrow areas are listed below :

- small pockets of gravel in oued banks, approximately 5 kilometers East of Selibabi,
- small gravelly area near sandstone Toumiat Hills North of the track, approximately 10 kilometers East of Selibabi,
- some lateritic gravel, approximately 12 kilometers East of Selibabi,
- large gravelly and sandy colluvial deposits off sandstone hills, approximately 12 kilometers East of Selibabi,
- lateritic gravel over a large area, approximately 14 kilometers East of Selibabi,
- other potential borrow areas South of the track, 12 to 14 kilometers East of Selibabi.

Other workable borrow areas were found along the Sei Delema-Aouinat stretch of the alternate route to Ould Yenje. These areas which are mostly colluvial or slope wash from sandstone outcrops are located 10 to 18 kilometers Northeast of Sei Delema.

The section between Selibabi and Bouly does not appear to have plentiful water. The area Northeast of Mbalou, towards Sei Delema, is known to be sterile. A shallow water table is likely in Sei Delema, but the practical sustained yield is expected to be limited. A pond in a stream just West of Bouly shows also a shallow water table. The area that looks the most interesting is the floodplain of the Karakoro River (water was found at a depth of 4.50 meters in wells in Bouly).

It is anticipated that 22 fords with a cumulative length of about 410 meters will be needed along the alignment of the existing road. Average culvert spacing will be about 850 meters.

The cost of upgrading this road should be quite lower than in the case of the Selibabi-Mbout link, due to the greater availability of roadmaking gravels along the alignment.

4.7 Selibabi-Dafort

The route runs North from Selibabi, with a total length of about 61 kilometers. The actual length is only 57 kilometers, because the first 3.5 kilometers are common to this route and to the Selibabi-Mbout route, and are accounted for with that route.

This route is a link between several major villages : Dangueremou, Hassi Chaggar, Mbedia Achar and Dafort, and with Selibabi and the RN 5 trunk road. There is a track going from Mbedia Achar to Ould Yenje, which will be discussed later. Another track linking Tachout and Dafort was not considered.

Very little maintenance work, if any, appears to be done on the existing track. There are no drainage structures between RN5 and Dafort.

Major stream crossings are Oued Gousdou and Oued Haira. The route is impassable during a large part of the rainy season, but is otherwise holding up well. Some traffic was encountered during the reconnaissance.

Bedrock is mostly granite, sandstone and micaschist. The route goes through three different geological formations : the Selibabi series, the Precambrian base, and the Kiffa and Hodh series.

Subgrade soils are generally red to brown silty sands, often covered with stone pavement. Although hills are seldom encountered, rock outcrops can be seen along most of the track.

The area is flat to gently rolling, and covered with bushy savannah (acacia).

Roadmaking materials appear to be fairly limited along this route -which is quite similar to the Selibabi-Mbout track. There are several low gravelly hills near Dangueremou that might reveal to be workable. Since this route seems rather poor in gravels, it is very likely that materials will have to be hauled over long distances.

Water resources are also expected to be a problem. Existing wells draw in alluvial and schistose aquifers, with limited yields. Special care should be taken so that the aquifers selected do not impact on the water supplies of the villages.

It is estimated that 22 fords totalling 350 meters will be needed along the alignment of the existing track. Average culvert spacing will be about 1000 meters.

The cost of upgrading this road should be quite lower than in the case of the Selibabi-Mbout link, due to the smaller amount of drainage structures to be constructed.

4.8 Mbedia Achar-Ould Yenje

This road section connects the Selibabi-Dafort-Ndieo feeder road to the RR 8 trunk road.

It runs mostly East from Mbedia Achar to Oued Yenje, with a total length of about 45 kilometers. Two completely different sections must be distinguished :

- The first section runs approximately Northeast from Mbedia Achar to Samba Ngoma, through Tektat Pass (the only way through the Assaba Plateau in this area). There are no permanent villages between Mbedia Achar and Samba Ngoma (Km 21). A major stream crossing is Oued Dar Degal near Km 15. Although this section has no drainage structures, it seems to be holding up well.

Bedrock along this section is sandstone of the Assaba-Tagant series.

Subgrade soils between Mbedia Achar and Samba Ngoma are red silty sands with rock fragments. Rock outcrops are frequent, due to the proximity of the Assaba Plateau.

The area is flat to gently rolling, and covered with bushy savannah (acacia).

- The second section runs East from Samba Ngoma to Ould Yenje. The main villages along the existing track are Ferlankobe and Gueleoual (between Gueleoual and Ould Yenje the alignment is undefined, and numerous tracks can be followed among the settled sand dunes). A major stream crossing is Oued Tektaka, just after Samba Ngoma. It has been reported that this road section remains passable during most of the rainy season.

Bedrock does not show on this section after Oued Tektaka -from the geological maps available it is known that sandstone of the Kiffa and Hodh series is prevailing under the sand dunes.

Subgrade soils are red to grey dune sands. In the low areas -depressions- separating the sand dunes, the sand exhibits silt and clay fractions.

The area is gently rolling, with alternating sand dunes and lower areas. A large forested area was seen between Ferlankobe and Gueleoual.

No large potential source of roadmaking materials was located along this route. Three limited sites were noted in the first section, between Mbedia Achar and Samba Ngoma (see the Aerial Photography Specialist's report for details).

The first section is very likely to have inadequate water resources. The second section, between Samba Ngoma and Oued Yenje, seems to present more possibilities of drawing the required quantities of water : the sand dunes under the large forested area may provide a major reservoir of water, and the flood plain of the Karakoro River has a shallow water table.

It is anticipated that 13 fords with a cumulative length of about 275 meters are needed along this route (most of these fords being located on the first section). Average culvert spacing will be about 1000 meters in the first section and 1200 meters in the second section.

The cost of upgrading this track should be altogether somewhat lower than in the case of the Selibabi-Mbout road (more earthworks, including rock excavation, but fewer drainage structures).

4.9 Bouly-Ould Yenje

This track is part of the RR 8 trunk road, linking Selibabi and Kiffa. It is the continuation of the Selibabi-Bouly route already discussed. The Subdivision of Kiffa is responsible for its maintenance, but very little work has been done along this route in the Region of GUIDIMAKA.

The route runs North from Bouly to Ould Yenje, on the right bank of the Karakoro River, with a total length of about 26 kilometers. There are several important villages along the Karakoro River, due to the availability of water : Kalinioro and Chelkha Dakhna are the largest on the Mauritanian side of the Karakoro River floodplain. The existing track intercepts all the tributaries of the Karakoro River, the major one being Oued Chelkha Dakhna (Km 22).

Drainage is expected to be a problem along this route. It is impassable during most of the rainy season. Relocation of the route farther from the Karakoro River is recommended, especially in the vicinity of Chelkha Dakhna. This may require spur roadways to some villages along the route. It is recommended that the entity responsible for determining the future alignment of this road section makes a reconnaissance during the rainy season in order to define the relocation needs and the most economical design.

Bedrock was found to be mostly fine-grained sandstone of the Kiffa and Hodh series.

Subgrade soils are either red silty sands, or grey clayey sands in the depressions. Silty sands have an occasional stone pavement cover. Due to the proximity of the river, there are no inselbergs along this route -only small sandstone outcrops.

The area is generally gently rolling, and covered with bushy savannah (acacia).

Roadmaking materials seem to be fairly limited along this route. Sand, gravel and cobbles were spotted on colluvial slopes (slope wash) from the escarpement West of the track between Bouly and Ould Yenje.

Villages along the route in the floodplain generally had water within 4 to 12 meters :

- 4.5 meters at Bouly,
- 8.3 meters at Kalinioro (water was found to be clear and plentiful),
- 12.5 meters at Ould Yenje.

As a general rule, the water table appears to drop from South to North, and the practical sustained yield is probably higher near Bouly.

It is estimated that 12 fords totalling about 220 meters are needed along the alignment of the existing track (with minor relocation). Extensive fill and drainage will be needed along this road, which crosses several low area, flooded in the rainy season, unless it is relocated on higher ground closer to the escarpment West of the Karakoro River. One culvert every 700 meters will have to be constructed along the existing track.

The cost of upgrading the existing track to R.T.O. (ordinary gravel road) standards will be quite higher than in the case of the Selibabi-Mbout link, due to the hydrological conditions. Relocating the route about one kilometer farther to the West, with spur roadways to villages, may well prove to be more economical, and should be thoroughly investigated.

5. AGGREGATE AND WATER SURVEYS

No single entity in Mauritania is capable of doing the aggregate and water survey. Two different contracts have therefore to be performed by two different contractors.

Soils and materials surveys in Mauritania have always been performed by the National Laboratory for Public Works (Laboratoire National des Travaux Publics - L.N.T.P.), a public corporation, which has the capabilities for the field work and the laboratory work involved in such a study. Their laboratory equipment and personnel enables L.N.T.P. to perform all the tests listed in the Terms of Reference in Appendix, except the resistance to abrasion (AASHTO T 96), for which samples will have to be shipped to laboratories outside Mauritania, possibly in Dakar (CEREEQ) or Casablanca (LPEE).

The possibility of calling a foreign contractor to do the aggregate (or the water) survey was investigated. It was found that G.I.R.M. does not support this idea. L.N.T.P. has a legal position of official monopoly. Moreover, foreign contractors would most likely be more expensive and less reliable, because they would not be familiar with local conditions in the Region of GUIDIMAKA.

Since L.N.T.P. was the sole entity found to be capable of performing the aggregate survey contemplated, a contract by mutual agreement based on specifications was drafted.

Assuming that funds will be available for the improvement of 200 to 250 kilometers of rural roads ($ 30 000 per km seems a reasonable figure if construction work is done by force account -contractor prices being much higher, i.e. an estimated $ 65 000 per km-), a choice of the rural roads with the highest order of priority was made, in connection with G.I.R.M. .

Experience of similar projects, together with a thorough review of local conditions, led to the following timetable, which was acceptable to L.N.T.P. :

- one month for the field work,
- one month for the laboratory work,
- two weeks for drafting the final report.

The timetable, the personnel assigned to the study, the logistics, the minimum material standards and the bill of quantities are all part of the contract documents, together with the Terms of Reference.

A section on "force majeure" was included in the contract, especially in view of the rainy season, when travel conditions are unpredictable and unreliable. It is, however, strongly recommended that if the field work cannot be started on June 10, 1980 at the latest, the aggregate survey be postponed until the end of the rainy season. The list of unit prices in the contract will remain valid until October 31, 1980.

Geological and hydrological surveys in Mauritania are usually performed by the Mining and Industry National Corporation (Société Nationale Industrielle et Minière - S.N.I.M.). This public corporation, among other activities, handles the iron-ore mining operations. S.N.I.M. performed the water survey for the Nouakchott-Nema road satisfactorily. S.N.I.M. is not, however, a drilling contractor, and subcontracts well sinking and drilling. There are no local drilling contractors. More drilling contractors in neighboring countries are SASIF in Senegal and SOLMAROC in Morocco, the latter being more experienced in desert and semi-desert environments. The prevailing cost of well drilling and fitting in Mauritania is about $ 900 per meter.

The possibility of having the Directorate of Hydraulics of G.I.R.M. to do the water survey was investigated, but no effect was finally given to this idea, because due to administrative constraints the time granted to them would have to be much longer, and their logistics and personnel capabilities are far from being as good as S.N.I.M.'s. Moreover, there is no guarantee that a water survey performed by the Directorate of Hydraulics would be less costly. And contracting with the Government itself did not appear to be desirable.

A contract by mutual agreement based on specifications was therefore drafted with S.N.I.M., for the water survey of 200 to 250 kilometers of rural roads. No water survey was deemed necessary for the Gouraye-Khabou route along the Senegal River.

The contract is basically the same as the one with L.N.T.P., adapted where required (especially the Terms of Reference).

The proposed timetable, acceptable to S.N.I.M., is as follows :

- two weeks for the study of existing documents, and preparation of the mission,
- three weeks for the field reconnaissance,
- ten days for drafting the final report.

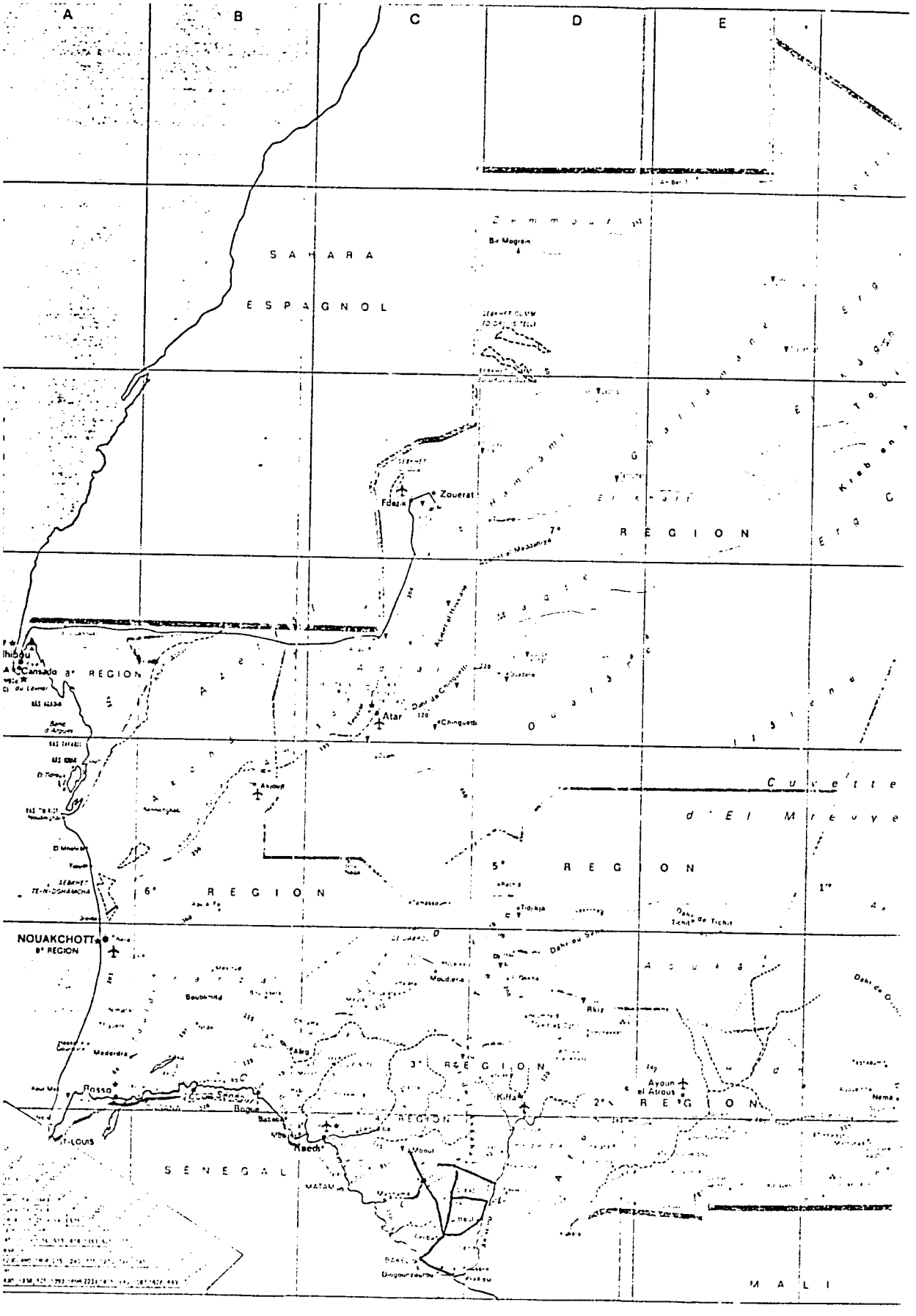
The same provisions on "force majeure" as in the aggregate survey contract, with special reference to the rainy season, hold for the water survey contract. It is also strongly recommended that the water survey be postponed until the end of the rainy season, if the field work cannot be started on June 20, 1980 at the latest. The list of unit prices in the contract will also remain valid until October 31, 1980.

Both the aggregate survey contract and the water survey contract must be approved by the Directorate of Infrastructure of G.I.R.M. before taking effect.

It is expected that both contractors will make intensive use of this report, and of the report written by the Aerial Photography Specialist, incorporating a map at the 1/50 000 scale (approximately) showing six basic soil units in a 5-kilometer strip along preselected high priority routes within the area of photographic coverage.

APPENDIX 1

LOCATION MAPS



PROJECT LOCATION MAP

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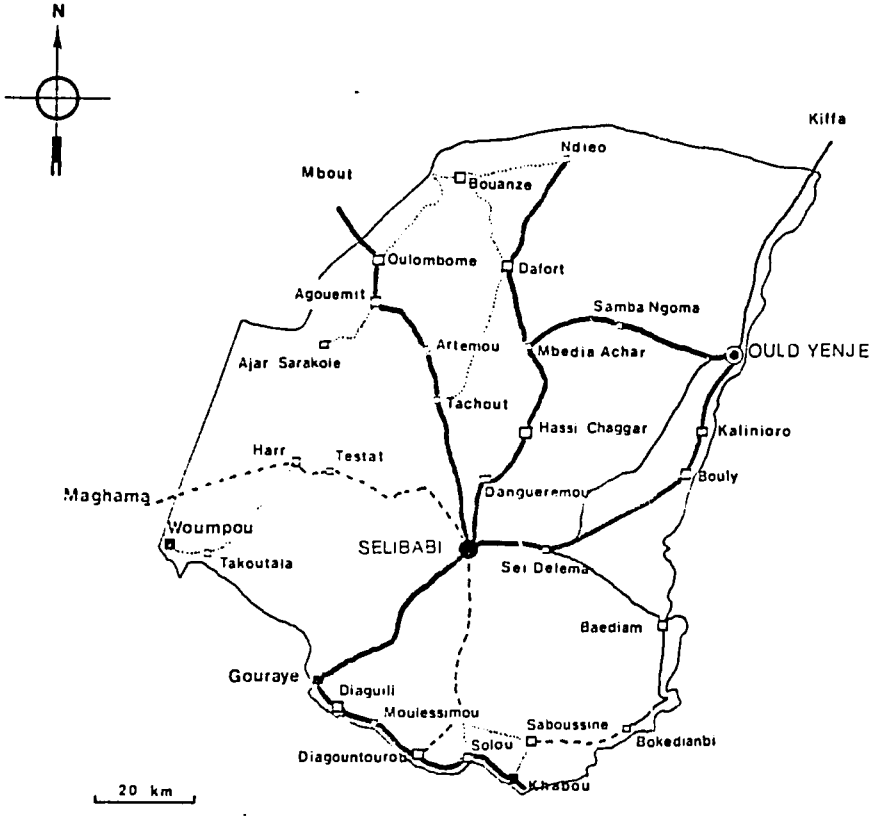

Administrative centres :

- ● of region and departement
- ◉ of departement
- ■ of arrondissement
- □ ▫ other settlements

—— principal routes permanently practicable

----- intermittently practicable

..... secondary routes intermittently practicable

▬▬ Project routes

Guidimaka: settlements and communications

APPENDIX

DATA SHEETS FOR CANDIDATE ROADS

Station (km)	Geology	Soils	Smaller culverts	Larger culverts	Fords	Villages & Oueds	Wells	Alignment	Profile
0	Pelite (Selibabi series)	Brown silty sand				Selibabi		Street	Flat
18		Brown silty sand			100m+emb (ruined bridge)	Oued Amagué	Water about 25 m	Paved	Fill
3,7		Red silty sand			⊥ Airport ⊥ Dafort			Winding	Flat
5,5	Granite (base)		3	1	10m+20m	(Hills)			
7,3	Sandstone & Emicaschist		4	2	20m			To be relocated	Gently rolling
9,2	(Diala Bouenze series)	Stone pavement	3	1	20m				
11	Micaschist (Diala Bouenze series)	Red silty sand & stone	4		30m+10m+20m				Flat
12,9			6	1				To be relocated	
14,7		Red silty sand	6	1	10m+10m				
16,5	Quartzite Micaschist	Brown silty sand	4	1	30m+10m	Kéninkoumou	Water 6,20m	Winding	Gently rolling
18,4	Quartzite (Diala Bouenze series)	Stone pavement	3	2					Flat

2.1

Station (km)	Geology	Soils	Smaller culverts	Larger culverts	Fords	Villages & Oueds	Wells	Alignment	Profile
20,2	Sandstone & quartzite	Brown silt & stones	2	2		(Hills)			Gently rolling
22	Weathered quartzite	Red silty sand Brown silty clay & some gravel	3		100m + emb	Oued Tourimé			Low area
23,9	(Diala Bouenze series)		2	2	20m				Flat
25,7	Sandstone	Stone pavement	2	1	20m+10m+30m				
27,5		Stone pavement	1						
29,4	Weathered sandstone	Brown silt & stones (lat.)	1	1	2 x 20m (deep)				
31,2	Brown silty clay (Gravel in well)			1	100m + emb	Tassota B. Oued Niordé	Water 5.10m	To be relocated	Low area
33	Granite & Quartzite		5		10m + 10m				
34,9	(Base)	Red silty sand & stones	2	2	20m + 20m				Flat
36,7		Fech fech	4	3	20m				
38,6	Sandstone & granite	Red silty sand	1	2	20m				Low area
40,4	Granite (Base)					Artémou	Water 31m		

2.2

Station (km)	Geology	Soils	Smaller culverts	Larger culverts	Fords	Villages & Oueds	Wells	Alignment	Profile
42,2		Red sand	3	2		(Dunes)	(2 dry)		
44,1		Red silty sand	1		20m + 20m				Flat
45,9	Granite (base)			2	20m+10m+10m				
47,7	Granite (base)	Red silty sand & stones				(Scattered bush)		Slightly winding	Flat
49,6	Sandstone & quartzite		1						
51,4	Granite (Base)	Coarse sand & gravel (West)				Agouemit	Water 4 m		
53,2		Stone pavement	1		30m (deep)		(1 dry)		
55,1		Red silty sand & stones	3		20m				
56,9		Red silty sand	1					Winding	
58,8		Stone pavement	1	1	10m				
60,6		Brown silt (Sand in Oued)	3	1	20m				
62,4	Weathered Granite	Stone pavement		1	10m + 10m	Oulombomé	Water 20 m		Gently rolling
64,3	(Base)	Brown silty clay & stones	1	2	100m + emb + 30m + 50m	Oued Garfa			Low area

2.3

Station (km)	Geology	Soils	Smaller culverts	Larger culverts	Fords	Villages & Oueds	Wells	Alignment	Profile
66,1		Brown silty sand	1		10m + 20m				Flat
67,9		Red silty sand	1	4					
69,8	Granite (base)		1	1		Boudama			
71,6		Stone pavement	3	1	100m + emb + 30 m	Oued Boudama			Low area
73,4	Granite & quartzite		1						Gently rolling
75,3	Diorite Quartzite		1			(Hills)			
77,1	Mylonite (Base)	Stone pavement	1		10m + 10m + 20m			To be relocated	
78,9	Schist (green)				10m	Djajibine	Water 6.40m & 4.20m		
80,8	Micaschist (Mbout & Bakel series)	Brown silty sand	1	1	20m + 10m				Flat
82,6		White silty sand	1		50m			To be relocated	
84,5	Micaschist & quartzite		1					Idem	Gently rolling

2.4

32

Station (km)	Geology	Soils	Smaller culverts	Larger culverts	Fords	Villages & Oueds	Wells	Alignment	Profile
86,3	(Mbout & Bakel series)	Stone pavement	1	2	10m+10m			To be relocated	
88,1	Micaschist & quartzite	Silt & sand	1						
90	(Mbout & Bakel series)	Stone pavement	1		10m+30m				
91,8	Micaschist	Some gravel near oued	2						Flat
93,6	Micaschist & Quartzite	Stone pavement	2		10m			To be relocated	Gently rolling
95,5		(Gravel in Oued)	2		10m				
97,3	Granite	Red silty sand	2		10m			Winding	Flat
99,1	Rhyolite		2						
101	Granite Quartzite	Stone pavement	2						
102,8	Micaschist & quartzite	Stone pavement	2	1					Flat
104,7	(Mbout & Bakel series)	Stone pavement	4	1					
106,5	Micaschist (Mbout & Bakel series)	Red silty sand	2	1	20m	(Dunes)			

2.5

33

Station (km)	Geology	Soils	Smaller culverts	Larger culverts	Fords	Villages & Oueds	Wells	Alignment	Profile
108,3		Red sand	1			Mbout Chorfa		To be relocated	
110,2		(Gravel in oued)	3		Bridge 45m (damaged emb.)	Oued Ferkane		Tight	Flat
112	Micaschist (Mbout & Bakel series)					Mbout	Water 5,50 m (West)	Street	

May 12, 1980

Station (km)	Geology	Soils	Smaller culverts	Larger culverts	Fords	Villages & Oueds	Wells	Alignment	Profile
0	Sandstone (Selibabi series)	Brown silty sand				Gouraye			Low area
1,8		Red silty sand & stones	3	1		(Hills)		Winding	
3,7	Micaschist & quartzite	Rock	1					Pass	Steep Flat
5,5	(Mbout & Bakel series)	Stone pavement	1		10m	(Hills)			
7,4	Micaschist (Mbout & Bakel series)	Red silty sand	1	1					
9,2		Brown silty clay			100m + emb.	Oued Touna Diaguili			Low area
11,1		Brown silty sand	1						Flat
12,9		Brown silt							
14,8			1						
16,6	Pelite (Selibabi series)		1		25m + emb.	Moulissimou Oued Doukolé	Water about 25m		
18,5		Coarse sand in Senegal River				Perimeter			Gently rolling

2.7

35

Station (km)	Geology	Soils	Smaller culverts	Larger culverts	Fords	Villages & Oueds	Wells	Alignment	Profile
20,3									Flat
22,2									
24			1						
25,8		Brown silt	1	1					
27,7						Diogountourou			Gently rolling
29,5		Gravelly hills	1			Falémé River			Flat
31,4									
33,2		Brown clayey silt	1		50m + emb.	Oued Boumoukolé			
35,1									
36,9	Sandstone (red)	(Gravelly hills)	1			Solou			
38,8	(Selibabi series)	Brown silt	2			Perimeter			Gently rolling
40,6	Phyllite		2					Winding	Gently rolling
42,5	Sandstone (Selibabi series)	Brown silt clay	4	2	50m + emb. + 20m	Oued Goulia		To be relocated	Low area
46,2									
48		Fine sand in Senegal River				Khabou			

Station (km)	Geology	Soils	Smaller culverts	Larger culverts	Fords	Villages & Oueds	Wells	Alignment	Profile
0	Pelite (Selibabi series)	Brown silty sand			Bridge 20m	Selibabi			
1,9			1	1	Bridge (to repair) 5m			Winding	Flat
3,7		Red silty sand	3		1 culvert (to repair)				
5,6		Stone pavement (traces lat.)	1	1	Bridge (to repair) 2,50m				
7,5		Red silty sand	1						
9,3		Traces lat.		1	10m	(Hills)		Winding	
11,2		Stone pavement Red silty sand	2		10m	Mamaeli		To be relocated	
13		Lateritic nodules Red silty sand	1	1	2 culverts				Gently rolling Low area
14,9	Micaschist & quartzite	Rock Red silty sand							
16,8	(Mbout & Bakel series)	Quartz gravel Grey silt	1		Bridge 5 m Ford 5 m			Fill	Flat Low area

May 12, 1980.

Station (km)	Geology	Soils	Smaller culverts	Larger culverts	Fords	Villages & Oueds	Wells	Alignment	Profile
18,6		Red silty sand				(Hills)			
20,5		Stone pavement (quartz)	1			Village			Gently rolling
22,4	Sandstone (Selibabi series)	Red silty sand & stones	6	1	1 culvert			To be relocated	
24,2						Sanba Kandji	7,30m dry		
26,1		Red silty sand			Bridge 5m			Fill	Low areas
28		Red silty sand	2	2	20m	Moudji B. Oued Amague			
29,8		Red silty sand & stones	1						Flat
31,7	Micaschist (Mbout & Bakel series)	Red silty sand & stones				(Hills)			
33,5		Red silty sand	2	1					
35,4		Rock	1		10m			Pass	Rolling
37,3		Grey sandy silt							Flat
39,1			2						Low area
41	Sandstone (Selibabi series)	Grey silt	1			(Dune) Gouraye			

2.1C

38

Station (km)	Geology	Soils	Smaller culverts	Larger culverts	Fords	Villages & Oueds	Wells	Alignment	Profile
0	Sericitoschist	Brown silt			30m + 20m	Dafort	Water about 12 m	Undefined	Low area
1,9	Pelite (Selibabi series)				20m				Flat
3,7		Stone pavement		2					
5,6	Quartzite (Selibabi series)	Gravel in oued		3	10m + 10m				Flat
7,4		Red sand & gravel		1					
9,3		Red sand & gravel		1					
11,1									
13		Brown silt			100m + emb.	Oued Garfa			Low area
14,9				1	20m				
16,7		Some gravel		2	10m				
18,6				3	30m				Flat
20,4					30m + 20m				
22,3		White sand				(Dense bush)			Gently rolling

Station (km)	Geology	Soils	Smaller culverts	Larger culverts	Fords	Villages & Oueds	Wells	Alignment	Profile
24,1	Sand (Ogolian)					(Dune)			
26	Sandstone (Assaba Tagant series)					Ndieo	Water about 12m + spring		

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SELIBABI-BOULY 1/2

Station (km)	Geology	Soils	Smaller culverts	Larger culverts	Fords	Villages & Oueds	Wells	Alignment	Profile
0	Pelite	Brown silty sand				Selibabi			
1,8	Sandstone (Selibabi series)	Grey silty sand	1	1	20m				
3,6		Red silty sand	4	2	10m + 10m				Flat
5,4		Red silty sand & stones *	1	1	30m	* (some gravel in oueds)			
7,3		Red silty sand & stones *	1	1	30m + 20m + 30m				
9,1		Brown silt & stones	2			Toumiat Hills		Winding	Rolling
10,9	Quartzite (Selibabi series)	Stone pavement	4	1	10m	Toumiat Hills			
12,7		Red silty sand & stones - Lat.	3	1	10m				
14,5		Stone pavement & lat. gravel	1						
16,3		Grey silty sand	1					Winding	Flat
18,1		Red silty sand	2		30m				
20		Brown silty clay	1	1		Sei Delema ⊥ Ould Yenjé	Water 5,50m & 4,50m		

2.13

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Station (km)	Geology	Soils	Smaller culverts	Larger culverts	Fords	Villages & Oueds	Wells	Alignment	Profile
21,8		Brown silty sand	2		20m				
23,6		Grey silt (traces lat.	1						
25,4		Red silty sand	2	1	10m				
27,2	Sandstone (red)	Grey clayey sand	1						
29	(Kiffa & Hodh series)	Red silty sand	1		20m + 30m	Louaré	Water 2,50m & 12 m	Pass	Rolling
30,9	Sandstone (Assaba, Tagant series)	Red silty sand (traces lat.)	3		10m				
32,7		Red silty sand	2	1					Low area
34,5		Stone pavement	2		10m	Bandiougou			
36,3	Sandstone (Kiffa & Hodh series)	Brown silty sand	1	1					
38,1		Grey silty sand & stones	1		10m				
40		Red silty sand	3		10m + 10m				Gently rolling

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Station (km)	Geology	Soils	Smaller culverts	Larger culverts	Fords	Villages & Oueds	Wells	Alignment	Profile
41,7		Red silty sand and boulders			10m+2 x 10m				Rolling
43,6	Sandstone	Stones & boulders Rock	1			(Ridge)		Winding	Steep
45,4	Sandstone (Kiffa & Hodh series)	Stone pavement Grey silt	3						
47,2		Red sand Grey clayey sand	2			(Dunes) Marigot meander		To be relocated	Flat
49		Grey silty sand			50.. + emb.	Bouly	Water 4,50m & 6m	Tight	

43

Station (km)	Geology	Soils	Smaller culverts	Larger culverts	Fords	Villages & Oueds	Wells	Alignment	Profile
0	Pelite (Sélibabi series)	Brown silty sand				Sélibabi		street	flat
1,8		Brown silty clay			100m + emb (ruined bridge)	Oued Amagué	Water about 25 m	paved	fill
3,7	Dolerite (Selibabi series)	Red slity sand & stones	1	1		⊥ Airport ⊥ Mbout		winding	flat
5,5		Stone pavement	1	2		(Hills)			
7,4	Granite (Base)	Grey silty sand & stones	3	1				winding	gently rolling
9,2	Micaschist (Base)	Brown silty sand	1			Enclosure			
11,1		Red silty sand & stones	2	1	10 m				flat
12,9		Grey silt Red silty sand	2						
14,8	Sericito-schist	Stone pavement (Gravel in oued)	1		20m + 20m	Danguérémou	Water 9,10 m (1 in progress)		

Station (km)	Geology	Soils	Smaller culverts	Larger culverts	Fords	Villages & Oueds	Wells	Alignment	Profile
16,6	(Selibabi series)	Brown silty sand	2	1	10m + 10 m + 20 m	Chikoye	Water		
18,5					10 m				
20,3		Stone pavement	4	1				winding	gently rolling
22,2	Granite	Red silty sand	3	1					flat
24	Schist (red)	Stone pavement	3	1	10m + 10m				
25,9	Granite & pelite	Rock	2		20 m	Hassi Chaggar	Water 5,60 m (brackish 20 m)	(1dry)	
27,7	(Selibabi series)	Red sand Red silty sand	1	2	50m + emb + 10 m	Oued Gousdou			
29,6		Sand & gravel	2		10 m			tight	flat
31,4		Red silty sand	1	1	10 m			winding	
33,3		Sand & gravel			10 m				
35,1	Pelite (Selibabi series)	Red silty sand & stones	2		10 m				

Station (km)	Geology	Soils	Smaller culverts	Larger culverts	Fords	Villages & Oueds	Wells	Alignment	Profile
37		Stone pavement Grey silt	1		50m + emb + 10 m	Oued Haira		to be re-located	
38,8	Sandstone (red)	Stone pavement (30 cm thick)	1						
40,7	Sandstone & pelite	Red silty sand	2	1	10m +10m				
42,5	(Kiffa & Hodh series)	Brown silty sand	2	1					
44,4	Quartzite	Red silty sand	4						flat
46,2	Quartzite (Selibabi series)	Red sand	1			Mbédia Achar	Water 5,50 m		
48,1		Red sand Red silty sand						winding	
49,9	Quartzite	Red silty sand & stones	1	1	20 m	(Hills)			gently rolling
52,8	Quartzite	Stone pavement Brown silt	2						flat
53,5	Micaschist (Base)								

Station (km)	Geology	Soils	Smaller culverts	Larger culverts	Fords	Villages & Oueds	Wells	Alignment	Profile
55,5			1	1	10 m				flat
57,3									
59,2			1						
61	Sericito-schist (Selibabi series)	Brown silt				Dafort	Water about 12m		flat

Station (km)	Geology	Soils	Smaller culverts	Larger culverts	Fords	Villages & Oueds	Wells	Alignment	Profile
0	Pelite (Selibabi series)	Red silty sand			30m	Mbédia Achar	Water 5,50m	Winding	Flat
1,9		Stone pavement	2						
3,7		Grey silt	1		2 x 10 m + 10m				Low area
5,6		Red silty sand & stones	3	1	10m + 10m				
7,5		Red silty sand	3	1	30m				Flat
9,4		Red silty sand							
11,2	Sandstone (Assaba Tagant series)	Red silty sand & rock	2			Tektat Pass			Gently rolling
13,1		Red sand	1						
15		Red silty sand	1		50m + emb.	Oued Dar Dégal			
16,9			1		10m				
18,7	Sandstone	Stone pavement		2	20m				
20,6	Sandstone (Assaba Tagant series)	Red silty sand & rock	2		10m	Samba Ngoma			Flat

2.20

May 14, 1980

MBEDIA ACHAR - OULD YENJE

Station (km)	Geology	Soils	Smaller culverts	Larger culverts	Fords	Villages & Oueds	Wells	Alignment	Profile
22,5			1	1	20m + 30m	Oued Tektaka (Dunes)			Gently rolling
24,4		Red sand	2			Ferlankobé	Water		
26,2			1						Gently rolling
28,1						(Dunes)			
30			2						
31,9			4						
33,7		Grey sand	2			(Dunes) Village	Water 4 m	Tight	Low areas
35,6			3						
37,5									Low areas
39,4			1			Guéléoual		Undefined (dunes)	Low area
41,2			1						
43,1			1						
43,1			4		25m				
45						Ould Yenjé			

2.21

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BOULY - OULD YENJE 1/1

Station (km)	Geology	Soils	Smaller culverts	Larger culverts	Fords	Villages & Oueds	Wells	Alignment	Profile
0		Grey silty sand				Bouly	Water 4.50m	Winding	Flat
1,9		Red silty sand			10m				
3,7		Stone pavement	3	1	20m				
5,6		Red silty sand	3						
7,4	Phyllite (Kiffa & Hodh series)	Grey clayey sand				Kalinioro	Water 8.30m		
9,3		Red silty sand	3		10m + 30m			Winding	Gently rolling
11,1	Sandstone & siltstone	Red silty sand & stones	1						
13	(Kiffa & Hodh series)	Red silty sand	5	1	10m + 20m				Flat
14,9	Sandstone & siltsone	Red silty sand & stones	2	1	20m	Village		Winding	Low area
16,7	(Kiffa & Hodh series)		1		10m + 20m	Village			Gently rolling
18,6		Brown silty & clayey sand	2		30m	Pond			Low area
20,4		Grey silty sand	2	1		Chelkha Dakhna			Gently rolling

2.22

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May 11 & May 14, 1980

Station (km)	Geology	Soils	Smaller culverts	Larger culverts	Fords	Villages & Oueds	Wells	Alignment	Profile
22,3		Grey clayey sand	2		30m	Oued Chelkha D.		To be relocated	Low area
24,1	Shale (Kiffa & Hodh series)	Stone pavement	7		10m			Winding	Flat
26		Red silty sand	1	1		Ould Yenjé	Water about 12m	Street	Flat

MAURITANIAN DESIGN STANDARDS FOR GRAVEL - SURFACED ROADS

	RTA (Improved Gravel Road)	RTO (Ordinary Gravel Road)
Design Speed (km/h)	100	60 - 80
Roadway width	9 m	7 - 8 m
Base course width	7 m	5 - 6 m
Roadway thickness	20 - 25 cm	15 - 20 cm
Minimum radius, horizontal curves	500 m	200 m
Minimum radius, vertical curves		
. sag	3 000 m	1 000 m
. summit	6 000 m	500 - 1 000 m
Maximum grade	6%	10%
Assumed lifespan (years)	10	5

TERMS OF REFERENCE FOR THE AGGREGATE SURVEY

GENERAL

The scope of these Terms of Reference is to set the framework for the aggregate survey in view of the improvement of about 200 kilometers of rural roads in the Guidimaka Region.

The experimental data that L.N.T.P. will provide to USAID, in order to design the Rural Road Project and estimate its cost, are defined hereafter for all the services required.

The means of reconnaissance and study are detailed as well, although they do not preclude the use of different equipment or methods leading to comparable or supplementary results.

Taking into account the general configuration of the ground, a nearly regular distribution of the services required (survey, tests, studies) is contemplated along the proposal routes, on the basis of similar material surveys.

Before starting the field work, L.N.T.P. will be provided by USAID with the approximate alignment of the proposed rural roads on 1/200,000 scale maps, with the results of analyses of aerial photography in a 5-kilometer strip along the proposed routes within the area of photographic coverage at the 1/50,000 scale. L.N.T.P. will also have access, for the survey of the Selibabi-Mbout road section, to a previous study prepared for U.N.D.P. in 1977.

All important changes proposed by L.N.T.P. on the basis of data already available during the survey must be submitted to USAID for approval.

Any changes proposed by USAID will, as far as possible, take into account the rhythm of work and the time requirements of L.N.T.P. for the completion of the survey.

Additional survey and studies (alternate route, outstanding point of the ground) proposed by USAID or L.N.T.P. will either be made up for by a reduction of required services of the same nature on the particular road section concerned, or result in increases in the time allowed and the amounts provided for in the bill of quantities, within limits acceptable to G.I.R.M. Additional survey and studies will also take into account the rhythm of work to be sustained by L.N.T.P. during the survey of each section of the proposed routes.

Draft reports (complete drafting of the synthesis of all the results, including maps , sketches and data from laboratory tests) will be submitted to USAID for discussion and approval. As soon as the drafts reports are approved, L.N.T.P. will proceed to the printing of the final reports in six copies in the French language, plus six copies of an English language translation.

As a general rule, the most effective collaboration will be established between USAID and L.N.T.P. Engineers.

It is recalled that fill materials (silty sands, etc.) will as much as possible be extracted from side ditches, and that the survey being the subject of the Contract deals only with base and surface course materials, and with sand and coarse aggregate for making concrete.

SURVEY AND STUDY OF BASE AND SURFACE COURSE MATERIALS

The purpose of the survey is to locate gravel borrow areas suitable for the base and the surface course, therefore in a 45 cm lift.

L.N.T.P. will make every effort to find gravel borrow areas with a cubage of over 15,000 m3 every five kilometers and less than 2.5 kilometers from the preliminary alignment. Every borrow area will be studied by hand auger borings and/or test pits with a 100 meter spacing.

Index properties (grain-size analysis and determining the plasticity index) will be determined every 5,000 m3. Moisture-density relations and the California Bearing Ratio will be determined for each class of materials within a given borrow area, and in any case every 15,000 m3.

The survey will be supervised by a Technician with at least ten years of experience, who will check the locations of the borrow areas (where a bench mark will be put in the field), the boring logs, and will collect all the results.

If along some sections existing materials do not meet the specifications in Appendix , L.N.T.P. will consider blending materials from different borrow areas rather than hauling them over long distances.

Sorting summarily the materials will also be considered if necessary. Crushing of oversize rocks is however left out at this time.

SURVEY AND STUDY OF MATERIALS FOR MAKING CONCRETE

The purpose of the survey is to locate sand and coarse aggregate borrow areas to be used for making structural concrete. L.N.T.P. will make every effort to find sand and/or aggregate borrow areas with a cubage of over 5,000 m3 every thirty kilometers and less than 2.5 kilometers from the preliminary alignment, and if possible close to the major crossings.

Index properties (grain-size analysis and determining the sand equivalent) will be determined for each sand bed. Grain size analysis with resistance to abrasion and soundness of aggregate by use of magnesium sulfate will be performed for each coarse aggregate bed. The latter tests will be performed if necessary in a foreign country at USAID's expense.

FINAL REPORT

The synthesis report will include :

. Locations of the workable borrow areas, indicated on 1/5,000 scale maps, tied in to existing tracks, villages, oueds and other permanent landmarks,

. A detailed sketch of each borrow area, with an estimate of available quantities,

. Classification of the materials, each class corresponding to different uses (base and surface course, concrete), to be specified,

. Results of all the laboratory tests performed, in Appendix

. If applicable, recommendations for carrying out the construction work.

TEST PROCEDURES

The aggregate survey and study being financed by USAID, the laboratory tests will be performed as far as possible according to the following United States standard procedures :

AASHTO T 88	(Particle size analysis of soils)
AASHTO T 27	(Sieve analysis of fine and coarse aggregates)
AASHTO T 11	(Amount of material finer than 0.075 mm sieve in aggregate)
AASHTO T 90	(Determining the plastic limit and plasticity index of soils)
AASHTO T 89	(Determining the liquid limit of soils)
AASHTO T 96	(Resistance to abrasion of small size coarse aggregate by use of the Los Angeles machine)
AASHTO T 180	(Moisture-density relations of soils using a 10-lb rammer and an 18-in drop)
AASHTO T 104	(Soundness of aggregate by use of sodium sulfate or magnesium sulfate)
AASHTO T 193	(California Bearing Ratio)
AASHTO T 176	(Plastic fines in graded aggregates and soils by use of the sand equivalent test)

If L.N.T.P. intends to conform to other standards, a detailed list must be submitted to USAID for approval prior to starting the laboratory work.

MINIMUM MATERIAL STANDARDS AGGREGATE

1/ Base and Surfacing

Tests	Specifications	
AASHTO T 88	Size	% Pass
AASHTO T 27	Up to 50 mm	
AASHTO T 11	AASHTO Sieve N°10	30%-70%
AASHTO T 89	AASHTO Sieve N°200	5%-20%
AASHTO T 90		
AASHTO T 96		
AASHTO T 99		
Gradation		
Liquidity Limit (LL)	Liquid limit 30 or less	
Plasticity Index (PI)	Plasticity index 8 or less	
Los Angeles Abrasion	L.A. Abrasion test 45 or less	

2/ Coarse Aggregate for Concrete

Tests	Specifications
AASHTO T 27	AASHTO M 80
AASHTO T 11	Aggregate clean and durable
AASHTO T 96	
AASHTO T 104	
Gradation	
Los Angeles Abrasion	L.A. Abrasion test 50 or less
Soundness	MgSO4 Soundness test 15 or less

3/ Fine Aggregate for Concrete

Tests	Specifications
AASHTO T 27	AASHTO M 6
AASHTO T 11	Aggregate clean and durable
Gradation	Aggregate passing Sieve N°200 5% or less
Sand equivalent	Sand equivalent 50 or more

TERMS OF REFERENCE FOR THE WATER SURVEY

GENERAL

The scope of these Terms of Reference is to set the framework for the water survey in view of the improvement of about 200 kilometers of rural roads in the Guidimaka Region.

The experimental data that the Contractor will provide to USAID, in order to design the Rural Road Project and estimate its cost, are defined hereafter for all the services required.

The means of reconnaissance and study are detailed as well, although they do not preclude the use of different equipment or methods leading to comparable or supplementary results.

Taking into account the general configuration of the ground, a nearly regular distribution of the services required (survey and studies) is contemplated along the proposed routes, on the basis of similar water surveys.

Before starting the field work, the Contractor will be provided by USAID with the approximate alignment of the proposed rural roads on 1/200,000 scale maps, with the results of analyses of aerial photography in a 5-kilometer strip along the proposed routes within the area of photographic coverage at the 1/50,000 scale.

It is recalled that no services are required from the Contractor for the road sections less than 10 kilometers from the Senegal River.

All important changes proposed by the Contractor on the basis of data already available during the survey must be submitted to USAID for approval.

Any changes proposed by USAID will, as far as possible, take into account the rhythm of work and the time requirements of the Contractor for the completion of the survey.

Additional survey and studies (alternate route, outstanding point of the ground) proposed by USAID or the Contractor will either be made up for by a reduction of required services of the same nature on the particular road section concerned, or result in increases in the time allowed and the amounts provided for in the bill of quantities, within limits acceptable to G.I.R.M. Additional survey and studies, if any, will also take into account the rhythm of work to be sustained by the Contractor

during the survey of each section of the proposed routes.

Draft reports (complete drafting of the synthesis of all the results, including maps, sketches and data from laboratory analyses) will be submitted to USAID for discussion and approval. As soon as the draft reports are approved, the Contractor will proceed to the printing of the final reports in six copies in the French language, plus six copies of an English language translation.

As a general rule, the most effective collaboration will be established between USAID and the Contractor's Engineers.

SURVEY AND STUDY OF WATER RESOURCES FOR CONSTRUCTION

The purpose of the survey is to locate water resources suitable for compaction of embankments and of the base and surface courses, and for making concrete. Water needs for rehabilitation work on the rural roads are estimated to be an average 700 m3 per kilometer. In spite of the limited rhythm of work contemplated, 50 to 60 kilometers per year, water resources must furnish up to 250 m3 per day in order to satisfy the projected needs. This daily requirement implies instant yields relatively high, within a range of 4 m3/h to 12 m3/h, during 20 hours of pumping.

It is emphasized that existing water resources (wells, oglats, springs and ponds) are less than sufficient for the needs of local populations, and therefore that the search for new resources is prescribed. Water will be pumped out of sunk wells, or out of drillings. Several of the water resources found (at least one in each road section) should meet the quality requirements of water to be used in concrete.

The Contractor will make every effort to find suitable water resources every thirty kilometers approximately, and less than 2.5 kilometers from the preliminary alignment.

Methods of investigation are expected to define the aquifers to be drawn on and to locate on the ground zones with exceptional faults, in order to obtain the highest yields possible.

The services to be performed within the framework of this Contract are the following :

Office work

. Detailed photogeology, in order to determine rocks and lithostratigraphic units prevailing in the area, fractures and major faulted zones, and hydrographic network with runoff and water concentration and recharge zones.

Field work

. Detailed structural and geological mapping, on limited areas around potential sites selected during the previous stage.

. Marking of faults on the ground, possibly with the help of geophysical methods.

. Study of the hydrographic network.

. Collection of all updated data on existing resources and structures , as much for instant yields and available quantities as for utilization by local populations.

. Inventory of ponds, and determination of their size and their duration.

. Definition of the structures to be constructed, wells and/or drillings, small earth dams, intakes in rivers, with approximate quantity surveying.

. Sampling of currently tapped aquifers, and laboratory analyses of selected samples, in order to define the possibilities that the water be used for making concrete, in accordance with minimum standards given in Appendix.

FINAL REPORT

The synthesis report will include all the data collected and justify all the conclusions and the suggested recommendations. I. will particularly include :

. Locations of future structures, indicated on 1/5.000 scale maps, tied in to existing tracks, villages, oueds and other permanent land marks.

. Type and approximate quantity surveying of future structures.

. Expected possible utilization of the water resources found (fill and roadway compaction, concrete making).

. Results of all the water analyses performed, in Appendix.

. If applicable, recommendations on specific methods of sinking wells, drilling and pumping.

. Location of areas, if any, requiring further investigations by geophysical procedures.

. Practical sustained yield to be expected from future structures.

. Impact of the projected pumping on the environment and on the yield and the recharge rate of existing resources.

. Possibilities of further utilization of the future water supply structures, especially by local populations.

MINIMUM MATERIAL STANDARDS WATER

1/ Compaction

Any water.

2/ Concrete

Should be potable.

Desirable tests : Solids less than 1,000 mg/l
Chlorides less than 250 mg/l
Acid or alkali less than 500 mg/l
Sulfates less than 250 mg/l

pH between 6.5 and 8