REPUBLIC OF GHANA

REPORT ON FEASIBILITY SURVEY FOR TELEVISION NETWORK EXPANSION PROJECT

MARCH 1973

OVERSEAS TECHNICAL COOPERATION AGENCY
GOVERNMENT OF JAPAN

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PREFACE

The Government of Japan determined to execute a feasibility survey in regard to the expansion project of network for television broadcasting in the Republic of Ghana in compliance with the request on the part of the Government of the Republic of Ghana and entrusted the execution of the survey to the Overseas Technical Cooperation Agency.

The Agency organized a survey team of 6 members with Mr. Hiroyuki Fukaya, special assistant to the Director General of Radio Reguratory Bureau, Ministry of Posts and Telecommunications, as the chief, and executed survey for 50 days on the site.

The survey on the site had the purpose of the measurement and technical investigations in regard to the establishment of television broadcasting stations in the Northern Region as well as the microwave links for the relaying of braodcast programmes as a link of the expansion project of network for television broadcasting in the Republic of Ghana.

Further, after the survey team returned to Japan, it analyzed the data surveyed and collected on the site and prepared this report of the expansion project which is presented herewith.

We express here our hearty thanks to the related agencies and organizations of the Government of the Republic of Ghana who generously endowed us their help and cooperation for the execution of our task. We also express our hearty thanks to the Japanese Embassy in Ghana, the Japanese Ministry of Foreign Arrairs, the Japanese Ministry of Posts and Telecommunications, NHK, as well as Nippon Telecommunications Consulting Co., Ltd. At the same time, we express our hearty wishes that this report will be useful for the realization in early date of the expansion project of television broadcasting in the Republic of Ghana and contribute for the development of the society and economy as well as the propagation and improvement of education in the Republic of Ghana, and, as the result, contribute to the friendship between the Republic of Ghana and Japan.

March, 1973.

K. Tazuke

Keiichi Tazuke

Chief Director,
Overseas Technical
Cooperation Agency

LETTER OF TRANSMITTAL

March, 1973.

Mr. Keiichi Tazuke
Director General
Overseas Technical Cooperation Agency

Dear Sirs:

I have the honour of presenting you herewith the survey report related to the expansion project of television broadcasting in the Republic of Ghana.

This survey team was dispatched by the Overseas Technical Cooperation Agency to the Republic of Ghana and surveyed for 50 days beginning on November 7, 1972 in the Northern State and the Upper State of the said Republic based in Accra, the Capital of the Republic of Ghana. In this survey, we have investigated the expansion project of microwave radio relay system for television programme between Kumasi and Tamale, the planning of establishment of television boradcasting station at Bolgatanga, the construction project of microwave radio relay system for television programme between Tamale and Bolgatanga, and the construction project of studios at Bolgatanga, Tamale, and Kumasi. Further, we have also discussed with Ghana Broadcasting Corporation and Department of Posts and Telecommunications, Ministry of Transport and Communications of the Republic of Ghana and collected data for the abovementioned investigations.

After we returned Japan, we, the survey team, analyzed and studied the survey results for the purpose of investigation of the realization of the project in an early date. This report represents the results of abovementioned endeavour.

In this report, differing from the usual practice, the recommendations and the process of calculation and basis of system design and others are described in detail to meet the request of the technical experts of the Ghana Government.

In the field of broadcasting and telecommunications, the Republic of Ghana is today realizing an excellent results. It is also true, however, that the Republic has various difficulties for the realization of higher and more effective service. Also, it is our opinion that many of existing situations are to be readjusted in the future. It goes without saying that, for the purpose of realizing new construction project, long range forecast as well as abundant experience are indispensable. So, we hope, on the basis of the consideration of the cooperative relations for long years between Ghana and Japan, to actualize the technical cooperation also in the field of braodcasting and telecommunications.

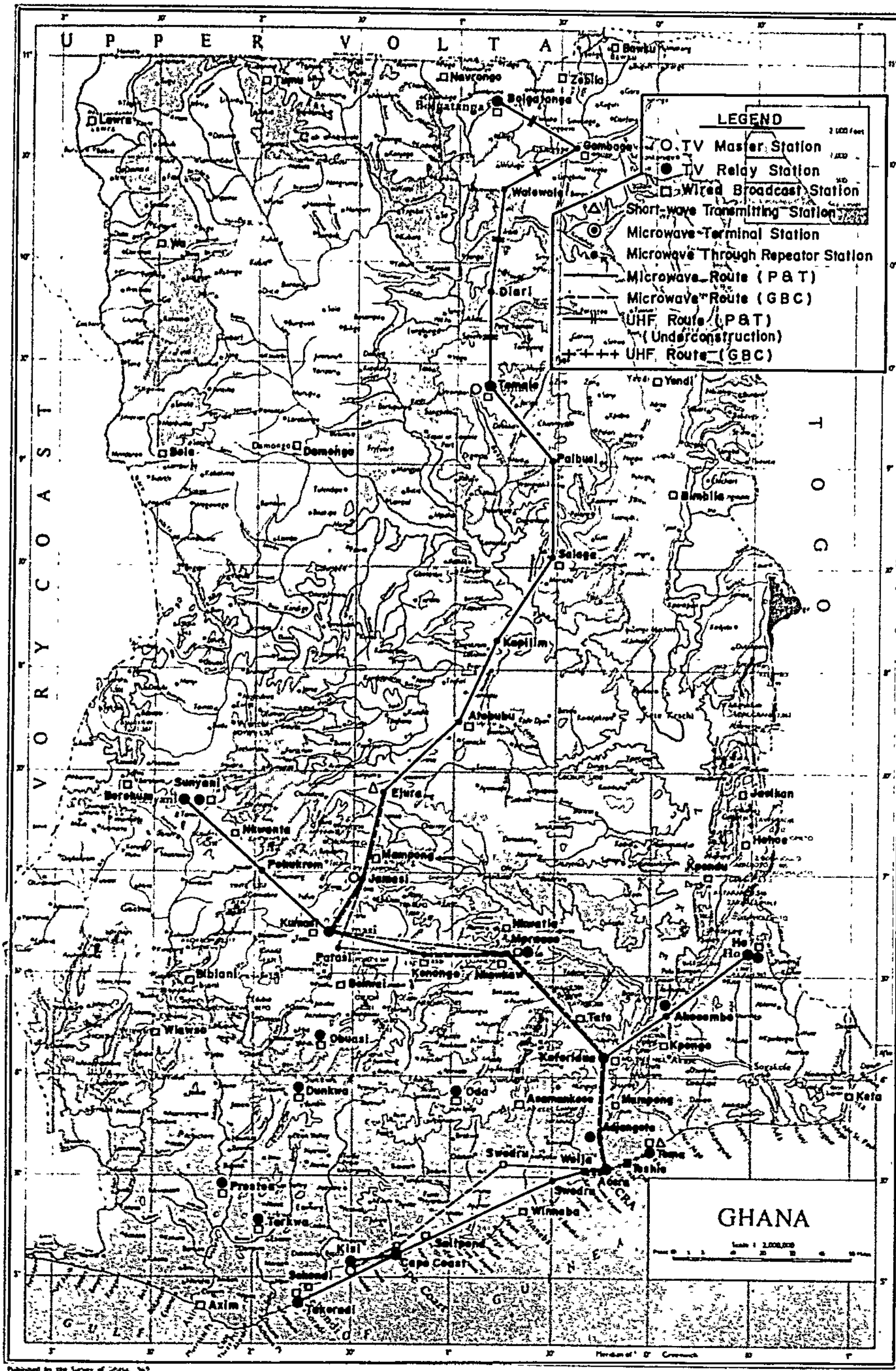
At the occasion of presentation of this report, we express our sincere desire that the survey results of our survey team will contribute to the development of braodcasting and telecommunications in the Republic of Ghana and offer the opportunity for the promotion of prosperity and happiness of the people of the Republic of Ghana by accelerating the economical progress in the Republic.

We conclude our letter by expressing our hearty thanks to those related to the Government of Ghana and the Japanese Embassy in Ghana who were most generaous for giving the survey team their cooperation as well as the Ministry of Foreign Affairs, the Ministry of Posts and Telecommunications, NHK, and Nippon Telecommunications Consulting Co., Ltd. who have assisted the dispatch of this survey team.

Sincerely yours,

Hiroyuki Fukaya

Chief,
Survey team of expansion project
of television broadcasting network
in the Republic of Ghana.


UPPER VOLTA
IVORY COAST
TOGO
LEGEND
TV Master Station
TV Relay Station
Wired Broadcast Station
Short-wave Transmitting Station
Microwave Terminal Station
Microwave Through Repeater Station
Microwave Route (P & T)
Microwave Route (G B C)
UHF Route (P & T)
(Underconstruction)
UHF Route (G B C)
Bawku
Navrongo
Zebilla
Tumu
Bolgatanga
Lawra
Gambaga
Walewale
Wa
Diari
Tamale
Yendi
Bole
Damongo
Bimbila
Salaga
Atebubu
Ejura
Sunyani
Berekum
Jasikan
Hohoe
Kpandu
Mampong
Jamasi
Kumasi
Ho
Mpraeso
Konongo
Nkawkaw
Bekwai
Bibiani
Tafo
Akosombo
Kpong
Koforidua
Wiawso
Obuasi
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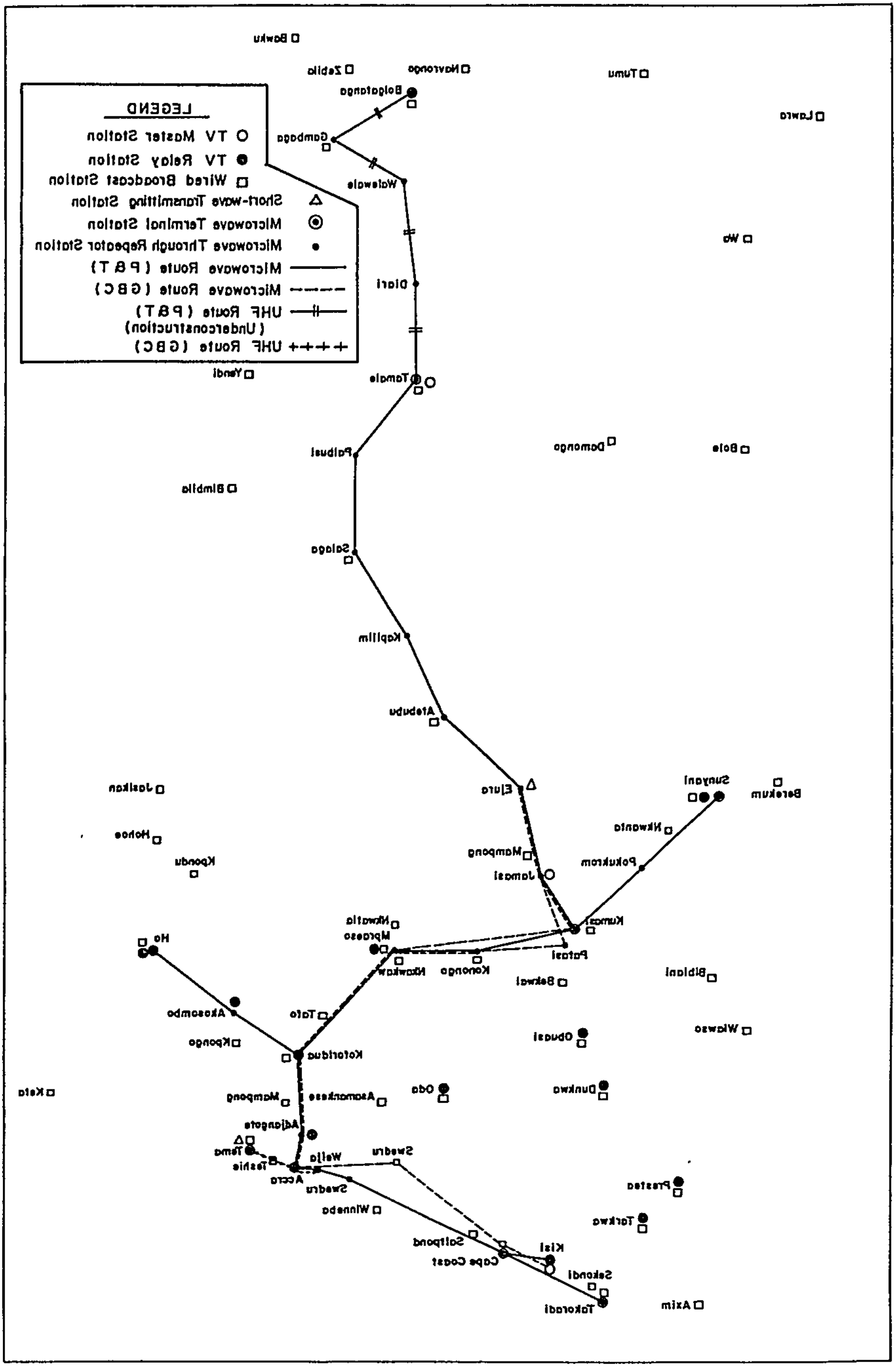
LEGEND
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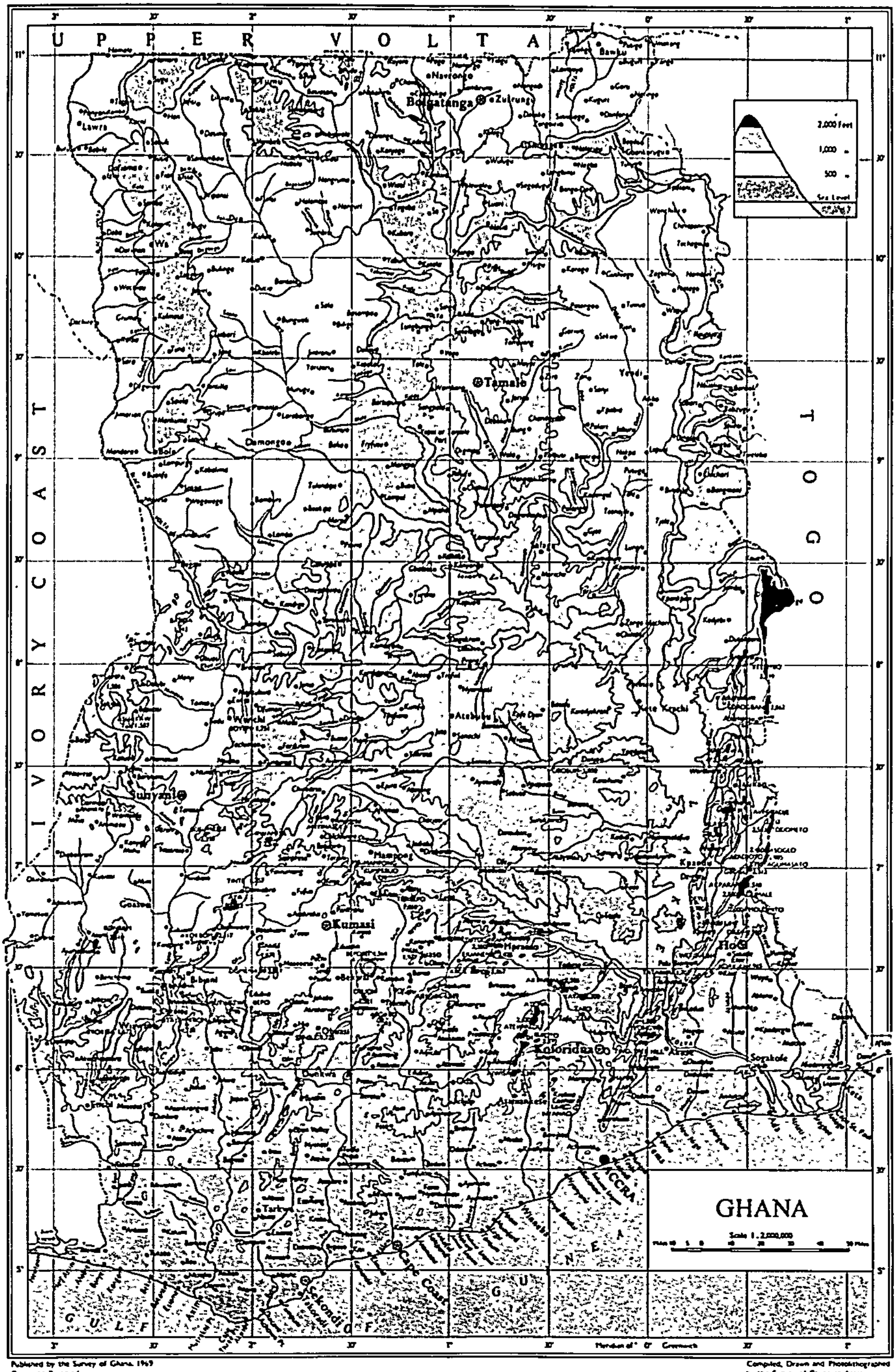
Cape Coast
Sekondi
Axim
Takoradi



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PART II

PART I. SUMMARY

Chapter 1. RECOMMENDATIONS

1.1. Expansion Project of Microwave Radio Relay System for Television

1.1.1. Utilization of Existing Microwave Radio Relay Stations

As regard to the microwave radio relay system for television projected to be constructed between Kumasi - Tamale and Tamale - Bolgatanga, the utilization of existing buildings of radio station and facilities shall be considered as far as possible because of the economical reasons.

1.1.2. Transmission Capacity required for a Microwave Radio Relay System

The transmission capacity of the microwave radio relay system projected to be constructed on the abovementioned section shall be more than one (1) colour (or monochrome) television signal with four (4) sound (music) channels or 960 telephone channels.

Further, its stand-by radio bearer shall be provided with the capacity of transmitting the abovementioned television or telephone signals.

Therefore, in case a microwave radio relay system for telephone is constructed between Tamale - Bolgatanga before a microwave radio relay system for television is constructed, a system provided with the abovementioned conditions shall be constructed in consideration of television transmission in the future.

1.1.3. Performance required for a Microwave Radio Relay System

(1) This system comprises a part of the trunk communication network in the Republic of Ghana, which is anticipated to be connected with international circuits linking various countries in West Africa. Therefore, its performance shall be designed to perfectly comply with CCIR, CCITT recommendations. However, for the purpose of simultaneous transmission of four (4) sound channels and one (1) television video signal, it is desirable to adopt radio equipments with the capacity of transmitting 1800 telephone channels.

However, even when radio equipments with the capacity of transmitting 960 telephone channels is employed, a sufficiently good channel quality will be expected when the purpose is limited to domestic transmission in the Republic of Ghana. In this case, a signal-to-noise ratio not far from 57 dB, which is the recommendation of CCITT, may be expected.

This system comprises the following radio bearers.

Radio bearer for television (Forward and return) ..... One (1) route
Radio bearer for stand-by (Forward and return) ..... One (1) route

(2) In case construction of microwave radio relay system is projected, it is necessary to carry out a perfect map survey, actual field survey, and system design, and, on those hops where a great number of fadings are anticipated, to carry out propagation test so that the countermeasure may be taken into the construction project.

In addition, when a construction work is ordered, it is necessary to clearly set out the prescriptions of system performance and the scope of their guarantee in the tender specification.

After the construction work is completed, it is necessary to carry out acceptance test on such months when the propagation conditions are anticipated to be the worst so that the system performance may be confirmed.

1.1.4. Composition of Microwave Radio Relay System

(1) As mentioned above, common stand-by radio bearer shall be used for the microwave radio relay system for television and telephone, and the buildings, antennas, antenna towers, and power facilities shall be also commonly used.

(2) After new system is completed, it is desirable to use the new stand-by radio bearer as the common stand-by bearer for both of telephone and television. The existing stand-by radio bearer may be disignated to other use.

1.1.5. Selection of Radio Frequency Band

The radio frequency band of microwave radio relay system of Department of Posts and Telecommunications (P & T) belongs to 7.5 GHz band. Therefore, it will be economical to select the same band for the radio frequency band of this system because the common use of antenna system becomes available.

In case other radio frequency band is selected, it is assumed that the common use of existing antenna towers will be impossible at greater number of stations as it becomes necessary to construct new antennas.

As we have no data relating to antenna towers at present, it is extremely difficult to calculate the strength. All those towers are of guy type and it is assumed that there remains only small allowance of strength.

1.1.6. Conditions to be provided by New Facilities

The new facilities used for this system shall be provided with at least the following conditions.

(1) It is desirable that the facilities shall be of all solid state type as far as possible for the purpose of attaining the simplification of maintenence, the reduction of power consumption, and the stabilization of performance.

(2) No interruption system by means of batteries shall be adopted for the source of electric power.

(3) Consideration shall be paid for the switchover between the working radio bearers and the stand-by radio bearer to cope with the increase of radio bearers in the future. Further, its switchover time shall be as small as possible in consideration of avoiding the generation of trouble to the transmission of television signal etc.

1.1.7. Improvement of the Reliability of Existing Microwave

As explained in the sub-section 1.1.2, the reliability of existing microwave radio relay system for telephone between Kumasi - Tamale exceedingly deteriorates in a certain season.

That is to say, in worst period, sometimes both radio bearers may fade out continuously for 7 - 8 hours from midnight till early morning.

The cause is assumed to lie in the specific meteorological conditions in Harmattan season. However, it is difficult to give an accurate judgment on the basis of only the existing trouble data.

For the purpose of improving this system reliability, it is necessary to carry out the following test as soon as possible.

(1) Re-examination of Existing Microwave Radio Relay System

It is necessary to confirm whether the receiving input level corresponds to the calculated value in the normal propagation path conditions.

Periscope type antennas are used at each station. It is necessary to confirm that they keep their optimum state. Further, it is also necessary to reconfirm the squelch setting level of the receiver.

(2) Execution of Propagation Test

It is necessary to carry out propagation test between Atebubu - Tamale in Harmattan season. The propagation test shall be carried out for the purpose of investigating the state of Rayleigh fading generation and the variation of K (coefficient of equivalent earth's radius).

The data obtained by the investigation of the state of Rayleigh fading generation is one of the most important elements for determining the adoption of space diversity. Also, the data of distribution of K variation is one of the most important elements for determining the antenna height.

In this case, the propagation test shall be operated by using the parabolic antenna and measuring equipment exclusive to the propagation test. At the same time, it is necessary to investigate the correlation between the said test data and the field strength data recorded by existing microwave system.

1.1.8. Time Schedule of the Construction Work of Microwave Radio Relay System for Television

The construction work of microwave radio relay system for television between Kumasi - Tamale - Bolgatanga shall be divided in two phases as follows.

The first phase:	Kumasi - Tamale
The second phase:	Tamale - Bolgatanga

That is to say, the route up to Tamale, where existing television transmitting station is located, shall be constructed as the first order. Then, the route between Tamale - Bolgatanga shall be constructed in coordination with the construction work of the television transmitting station at Bolgatanga.

1.2. Expansion Project of Television Broadcasting Facilities

For the construction of television broadcasting station at Bolgatanga, the following items shall be taken into consideration.

1.2.1. Selection of Transmitting Site

Three suitable sites are selected as the proposed site for the establishment of television broadcasting station at Bolgatanga. The three probable sites are provided with almost similar propagation conditions. But, as the proposed site considered to be the optimum lies near the existing broadcasting station of Ghana Broadcasting Corporation (GBC) and no obstacle exists on the viewpoint of city planning, the site of broadcasting station should be selected in or near the site of existing broadcasting station with the consideration of power source, maintenance, and ST link etc.

1.2.2. Selection of Frequencies

According to the measurement results of field strength of interference radio waves emitted from other stations and received in the range of the frequency band for television at and around Bolgatanga, E-7 channel among the television broadcasting frequency band is optimum on the basis of the frequencies operated at present for the television broadcasting in the Republic of Ghana, although there are many other usable frequencies.

1.2.3. Scale of Transmission

For the purpose of improving television reception at Navrongo, Bawku, and other important cities in Upper Region, it will be the minimum requirement to have 5 kw as the effective radiation power of the transmission power and 1 kw as the transmitter output.

Although the increase of power will be considered for the purpose of improving the receiving quality, the abovementioned values seem to be adequate when the low noise level in the concerned area and the difficulty of maintenance are taken into consideration.

1.2.4. Antenna Height above Ground

When the broadcasting station at Bolgatanga is considered in relation to the installation plan of television broadcasting stations in the overall area of Upper Region, the problem of antenna height above the ground represents one of important elements. On the basis of the results of profile analysis and measurement of field strength, the tower for transmitting antenna shall be at least as high as 50 m above ground level in consideration of the construction of radio relay stations in the mountenous western region in the future. The hilly eastern area can approximately be within the preferable level of television receiving by the abovementioned antenna height above ground.

1.2.5. Use of Directional Antenna

As Bolgatanga lies near the border with the Republic of Upper Volta to the north, radio wave interference may be caused in the neighbour land if a broadcasting station will be installed there. For the purpose of avoiding such inconvenience and realizing an effective broadcasting on the basis of the population distribution around Bolgatanga, it is necessary to adopt the directional antenna for the broadcasting.

1.2.6. Design of Transmitting Station

The transmitter room shall provide the floor space capable of installing 2 units of 1 kw transmitters considering of the installation of stand-by transmitter in the future. Further, it is desirable to construct an independent building for the transmitter room for the purpose of avoiding noise conveyed to the studio and connect the room with the studio by means of connection corridor for the convenience of maintenance.

1.2.7. Links

One forward and return circuit is necessary between the television broadcasting station and the microwave terminal station as the programme transmission channel. Provided that the microwave terminal station and the television broadcasting station are installed at the existing telephone station and the existing broadcasting station respectively, it will be economical to select coaxial cable system rather than radio system as the section is a short distance.

1.2.8. Installation of Television Studio

For the purpose of realizing the expansion of the project for television programme production in accordance with the expansion project of television broadcasting network, it is necessary to install television studios in the following three local stations; Kumasi, Tamale, and Polgatanga. As to Bolgatanga station, the television studio should be constructed on the premise that the television transmitting station is installed.

On the basis of the contents and preparation process of programmes to be prepared in such local stations as well as on the ground of the fund for construction work, the work shall be carried out dividing in two terms.

The work of the first phase will have the television studios including required attached rooms and studio broadcasting equipments and other equipments corresponding to the abovementioned television studios as the object, while the work of the second phase will include installations coping with the expansion of the arrangement of broadcast programmes, buildings for presentation studios, master control and film processing room, garages of television OB Van, and their equipments concerned.

1.3. General Matters

1.3.1. Establishment of Basic Construction Project of Microwave Circuits

In case a construction project of microwave radio relay system for television or telephone is established, satisfactory consultation between Ghana Broadcasting Corporation (GBC) and the Department of Posts and Telecommunications (P & T) is a prerequisite.

At present, sometimes construction works are carried out which may be regarded as double investment by the hand of either of them.

In case construction project is established, the system design and construction of facilities shall be carried out after presuming the species and amount of television programmes to be transmitted as well as the number of telephone channels in the final stage. In other words, consideration shall be paid so that there will be no requirement for addition of new stations, increase of tower height, and other important amendment work when the radio bearers will be increased in the future.

1.3.2. Arrangement of Plant Record

It is necessary to keep the plant record at each station always up-to-date. In particular, completion drawings of construction work, drawings and strength calculation of antenna towers and their foundations are extremely useful for the project of additional work in the future.

It is necessary to require the presentation of these data to the contractors as soon as a construction work is completed. For example, it is necessary to check whether the existing microwave radio system for television between Accra - Kumasi satisfies the prescribed system performance or not.

1.3.3. Fortification of Maintenance System

(1) Installation of Measuring Equipments

The installation of measuring equipments is insufficient at the existing terminal stations. The installation of more measuring equipments for maintenance use is required at telephone or television terminal stations.

(2) Monitoring of Television Video Signal

According to the existing maintenance system, television video signal is not always monitored. So, it is unable to judge whether a trouble is generated at studio or at microwave radio relay system.

It is necessary to monitor the picture at both sides of studio and microwave terminal station while television video signal is being transmitted for the purpose of clearly spotting the location of trouble generation.

For the above purpose, it is necessary to add a video monitoring room in microwave terminal station provided with through telephone line between monitoring equipment and studio.

In addition, it is desired to improve the capacity of maintenance personnel as to the detection of troubles of television by means of monitor equipments as well as the judgment of their causes.

1.3.4. Distribution of Mobile Power Plants

It is necessary to distribute mobile power plant of 30 KVA to each of Kumasi, Tamale, and Bolgatanga stations.

At present, 2 units of engine-generators are installed at each of the existing through repeater stations, while 1 unit is installed at the terminal station. It is, therefore, unable to use stand-by equipment at the time of overhauling.

It is necessary to dispatch mobile power plant as the stand-by equipment to a station whose engine-generator is to be overhauled.

1.3.5. Establishment of Reception Service

The service of broadcasting is never completed by simply transmitting broadcasting programmes from a transmitting station. Rather, the propagation of receivers and technical guidance for reception are also indispensable. In particular, the installation plan of the broadcasting station prepared by the hand of the government may be justified by grasping the situation of reception. In addition, data for the enlargement of the installation plan of station in the future may be also obtained. In particular, on the basis of the existing television stations on mountain tops, or the concept of wide broadcasting area, the receivers shall also be estimated as the bearer of the broadcast service.

Not only the abovementioned service directly rendered to the people, but also such service as obtaining the foundation for the determination of minimum necessary field strength by investigating the tendency of radio noise in urban districts are to be borne by the reception service. Further, it is also necessary to endeavour for the training of repair technicians of receivers.

1.3.6. Promotion of Installation of Television Receivers for Common Use

At the primary stage of the propagation of television broadcast, the measure for affording the benefit of television broadcast to such social classes limited by economical reasons should be taken by the hand of the state or organizations of public works. For the purpose of preventing such paradox as those belonging to a social class to which the educational effect of television broadcast is most expected cannot watch television programme, it is desirable to realize deliberately such measures as installing television receivers gratuitously at schools, assembly halls, offices and firms etc. so that television may be commonly viewed. By doing so, the television receivers installed at abovementioned places are required to be maintained as one of the abovementioned services for reception so that the receiving installations will be maintained in the best conditions.

Chapter 2. SCOPE OF WORKS

2.1. Agreement of the Scope of Works

The scope of works agreed upon by the survey team at the conference with the Government of Ghana on November 10, 1972 is as follows.

1. The following survey will be carried out by the Japanese Survey Team.

   I. The following field survey will be undertaken for a period of 50 days.

   A. Investigation of the technical possibility of an additional microwave radio channel on the existing KUMASI-TAHALE Microwave Relay System to permit transmission of TV programme signals over the same section.

      That is:

      (a) Measurement of Signal-to-Noise (S/N) ratio in the existing multiplex-telephone radio channel on the said microwave link.

      (b) System design for the above-mentioned TV transmission channel, taking into account the availability of the existing Microwave System Facilities including buildings, antenna towers, antennas, power supply systems, etc.

      (c) Verification of the technical possibility of the said TV transmission channel, by calculating the performances and characteristics of it.

      (d) Consideration of the establishment of three 15 KHz bandwidth music channels from Jamasi to Tamale and then from Tamale to Bolgatanga. The link should be both forward and reverse and should have stand-by facilities in both paths.

   B. Study of technical requirements for establishment of TV Station at BOLGATANGA.

      (a) Site selection for the transmitting points to be proposed.

      (b) Field intensity measurement at various points within the service area (50 km radius) against test radiation at each proposed site.

      (c) Measurement of noise intensity and measurement of interference intensity from any other radio stations, at various points within the service area (100 km radius).

      (d) Survey on distribution of houses in the service area.

(e) Study of the minimum required service area by investigating the maximum possible service area of the adjacent TV station (TAMALE) (by means of examining received image quality, measurement of field intensity of the wave from Tamale station and noise intensity, at various points on the fringe area of Tamale).

C. Investigation of technical feasibility of a microwave relay link which conveys TV programmes signals over the section of TAMALE-BOLGATANGA. This investigation shall include:

(a) Investigation of possibility of utilization to the maximum extent of the UHF Radio Relay System which is now under installation in the said section.

(b) System design of a microwave relay link for TV programme transmission, which is compatible with the multiplex-telephone UHF relay system. In this study, account shall be taken of the solution of (a) above.

(c) Verification of the technical possibility of the said TV programme transmission link on a microwave relay system, by calculating the performances and characteristics of it.

D. Study on the feasible TV studios to be established in KUMASI, TAMALE and BOLGATANGA.
This work shall include:

(a) Study on the basic requirements for the TV studio buildings.

(b) Engineering of the studio facilities to be implemented in the buildings.

(c) Study on the optimum studio-transmitter (S. T.) link and tail connection between the studio and the microwave radio station.

E. Studies and discussions with regard to envisaged technical problems, if any.
For instance:

(a) In respect of status quo in TV broadcasting services, e.g.
- System operation
- Transmitting facilities
- Studio facilities
- Programme production and edition

(b) In respect of Radio Regulatory Organization.

2. The following works will be carried out in Japan, with a period of around three months.

A. Establishment of a recommendable expansion plan of TV broadcasting network in GHANA.

B. Implementation programme of the expansion plan in A. above.

C. Cost estimation and financial schedule.

II. The survey report will be prepared in English and presented to the Government of GHANA by the end of March, 1973.

By the way, the man attendant of the Government of Ghana to the conference as to the scope of works is as follows.

Major T. Adu-Tutu Gyamfi	-	Chairman, Board of Directors, GBC
Major E.K. Mifetu	-	Member, GBC Board
Mr. Moses Danquah	-	Member, GBC Board
Mr. L.W. Fifi Hesse	-	Director-General, GBC
Mr. J.L. Mills	-	Director of Engineering, GBC
Mr. S.N. Amoah	-	Chief Engineer (Transmitters), GBC
Mr. A.E. Okaiyeye	-	Information Services Secretariat
Mr. P.T. Debrah	-	Engineer-in-Chief, P&T.
Mr. Peter Bawuah	-	Asst. Engineer-in-Chief, P&T.

2.2. Organization of the Survey Team

The survey team was organized by 6 members commissioned by Overseas Technical Cooperation Agency on October 16, 1972. The names, positions, and the period of dispatch are as follows.

Head	Hiroyuki Fukaya	Special Assistant to the Director General, Radio Regulatory Bureau, Ministry of Posts and Telecommunications of Japan.
Member	Shoji Takami	Chief, Engineering Section, Monistoring Engineering Division, Radio Regulatory Bureau, Ministry of Posts and Telecommunications of Japan.
Member	Tsuneo Oki	Technical Coordinator, Transmitting Facilities Division, Headquarters of Technical Administration and Construction, Japan Broadcasting Corporation (NHK)
Member	Hideto Yuu	Chief Engineer, Studio Facilities Division, Headquarters of Technical Administration and Construction, Japan Broadcasting Corporation (NHK)
Member	Takashi Suzuki	Senior Engineer, Radio Engineering Department, The Nippon Telecommunications Consulting Co., Ltd.
Member (Coordinator)	Tooru Hasegawa	Engineering Adviser, Development Survey Division, Overseas Technical Cooperation Agency

By the way, the following 5 officers comprise the counterpart dispatched from the Government of Ghana.

Mr. Haizel	:	Senior Engineer, G.B.C.
Mr. Bedu-Addo	:	" "
Mr. Attah	:	Assistant Broadcasting Engineer, G.B.C.
Mr. Simpson	:	Regional Technical Officer, P & T (Tamale)
Mr. Odai	:	" " (Kumasi)

2.3. Survey Time Schedule

The survey team engaged in the survey of the expansion project of the TV broadcasting network in Ghana from November 6 to December 23, 1972. During the above-mentioned survey period, most of the actual survey has been carried out by two groups, one engaging in survey related to microwave radio relay system and the other engaging in survey related to TV. However, as the principle, the appointment of each member of the survey team to either of the above-mentioned groups is determined at each respective case. The time schedule of the survey is as follows.

November 6 (Mon)	:	Two members of the survey team, Takami and Suzuki arrived at Accra.
November 7 (Tues)	:	Four members of the survey team, Fukaya, Oki, Yuu and Hasegawa arrived at Accra from Zaire.
November 8 (Wed)	:	The team visited the Embassy of Japan and had a conference.
November 9 (Thurs)	:	Air cargo separately shipped was received and forward. The team visited GBC and had a conference as to the scope of the survey.
November 10 (Fri)	:	The team visited P & T and had a conference as to the scope of the survey. Materials for survey were unpacked and topographical maps were procured.
November 11 (Sat)	:	Conference was held for the surveying process.
November 12 (Sun)	:	The revised draft plan of the scope of survey and the survey schedule were prepared.
November 13 (Mon)	:	Meeting with GBC and P & T.
November 14 (Tues)	:	Meeting with GBC and P & T.
November 15 (Wed)	:	Inspection of TV and microwave facilities in Accra and Adjangote.

November 16 (Thurs)	:	Separate meetings with GBC and P & T. Investigation of Accra studio.
November 17 (Fri)	:	Separate meetings with GBC and P & T. Investigation of Accra studio.
November 18 (Sat)	:	Inspection of Akosombo and Tema.
November 19 (Sun)	:	Conference of the members of the survey team. Preparation of profile maps and technical calculation.
November 20 (Mon)	:	Conference with GBC and P & T. Preparation for the survey on the site and adjustment of devices.
November 21 (Tues)	:	Left Accra, arrived at Kumasi.
November 22 (Wed)	:	Left Kumasi, arrived at Tamale.
November 23 (Thurs)	:	Left Tamale, arrived at Bolgatanga.
November 24 (Fri)	:	The microwave group investigated Walewale. The TV group investigated the selection of transmission point. Investigation of the studio. Installation of transmitter for investigation.
November 25 (Sat)	:	The microwave group investigated Gambaga. The TV group measured the field strength to the direction of Navrongo.
November 26 (Sun)	:	The microwave group investigated Diari. The TV group measured the field strength to the direction of Bawku.
November 27 (Mon)	:	The microwave group inspected Bolgatanga. The TV group measured the field strength to the direction of Bongo and Walewale.
November 28 (Tues)	:	Left Bolgatanga, arrived at Tamale.
November 29 (Wed)	:	The microwave group inspected Palbusi and Tamale. The TV group investigated the studio and measured the field strength at Tamale.
November 30 (Thurs)	:	The microwave group investigated Salaga. The TV group measured the field strength.
December 1 (Fri)	:	Left Tamale, arrived at Kumasi. Inspection of the Kapilim Station.

December 2 (Sat)	:	Arrangement of data and meeting.
December 3 (Sun)	:	Left Kumasi, arrived at Sunyani.
December 4 (Mon)	:	Inspection of Sunyani Broadcasting Station and microwave terminal station. Measurement of field strength.
December 5 (Tues)	:	Left Sunyani, arrived at Kumasi.
December 6 (Wed)	:	The microwave group investigated Atebubu, Ejura. The TV group investigated the studio and the reception of TV waves at Kumasi .
December 7 (Thurs)	:	Preparation for returning measuring instruments and arrangement of data.
December 8 (Fri)	:	Two team members, Yuu and Hasegawa, left for Accra. Investigation of Kumasi microwave terminal station.
December 9 (Sat)	:	Analysation of microwave propagation data and preparation of the interim report.
December 10 (Sun)	:	Holiday
December 11 (Mon)	:	Inspection of Ejura short wave station. Investigation of Jamasi Station on the site.
December 12 (Tues)	:	Preparation of the interim report.
December 13 (Wed)	:	Preparation of the interim report and the final conference with the counterpart from GBC.
December 14 (Thurs)	:	Left Kumasi, arrived at Accra.
December 15 (Fri)	:	Inspection of Kissi TV Broadcasting Station and Cape Coast Broadcasting Station.
December 16 (Sat)	:	Completed the draft of the interim report.
December 17 (Sun)	:	Holiday
December 18 (Mon)	:	Member Yuu left for Japan. Meeting with GBC and P & T.
December 19 (Tues)	:	Separate meetings with GBC and P & T. Visit to the personnel responsible for the radio regulation.
December 20 (Wed)	:	Inspection of Weija Monitoring Station. Meeting with P & T.

December 21 (Thurs):	Luncheon party invited by Head of State. Deliver the interim report to the Government of Ghana. Conference with the Embassy of Japan.
December 22 (Fri) :	Interview with Col. I. K. Acheampong, Head of State and Chairman of the NRC.
December 23 (Sat) :	The survey team left for Japan.

Chapter 3. ACKNOWLEDGMENT

First of all, we express our hearty thanks to His Excellency I. K. Acheampong, Head of State and Chairman of the NRC and Commissioner of Information who has determined to execute the survey of the expansion project of TV broadcasting network and granted to this survey team His audience.

This survey was planned by the hand of Principal Secretary of Information Service and executed by friendly cooperation of the Department of P & T, the Ministry of Transport and Communications. In addition, the survey team has enjoyed an overall cooperation of GBC, thanks to the far reaching understanding of the chairman and the members of Board of Directors of GBC.

For the purpose of execution of this survey, we have received a full-hearted cooperation of GBC including the dispatch of the counterpart, assignment of automobiles with drivers at the disposal of the team for a long period, and arrangement of accommodation. The above-mentioned conveniences are utterly thanks to the kind endeavor of the Director General of GBC, the Director of Engineering, and the Chief Engineer (Transmitter).

In addition, the Department of P & T willingly allowed the team to investigate the equipments for microwave communications belonging to it and cooperated with the team by instructing technical personnel to accompany the team at each location of investigation and offering valuable data in relation to the existing microwave radio relay system. We believe that the above-mentioned conveniences granted to the team show the profound understandings on the part of the engineer in chief and the assistant engineer in chief of P & T.

At each site of actual investigations, the counterpart dispatched by GBC and P & T actively participated the investigation so that the execution of the investigation was extremely facilitated. Further, the Regional Heads and his staffs of every broadcasting stations at each investigation site gave friendly and active cooperation to the survey team.

By the way, the devoted assistance given to the team by all the related personnel of Ghana at the accident at Tamale has left a deep impression on each member of the survey team.

The team was favored with an extreme assistance from all of the personnel of the Embassy of Japan in Ghana, as it served as the base of the activities of the team. During all the period of the team's activity, every member was deeply impressed by the kindness of His Excellency Kamikawa, the ambassador, and his staffs.

Lastly, we express our hearty gratitude to all the persons who have cooperated our survey. At the same time, we also express our wishes that this survey will result favorably for the benefit of the Republic of Ghana in the field of broadcasting and telecommunications and the promotion of friendship between the Republic of Ghana and Japan.

PART II

Chapter 1. INTRODUCTION

1.1. Purpose

The broadcast service in the Republic of Ghana is under the jurisdiction of the Ministry of Information and executed by the Ghana Broadcasting Corporation which operates a nationwide broadcasting net by various means including short wave, FM, TV, and wired broadcastings. However, as to TV broadcasting, practically the total broadcasting stations including attended broadcasting stations at Accra, Kumasi, Kissi, and Tamale as well as 9 unattended rebroadcasting stations are installed in the southern regions so that the area at the north of Kumasi is served extremely sparsely. Furthermore, the Tamale station situated in the northern area are conveyed the TV programs from Accra by means of the regular air lines.

For the purpose of spreading and extending broadcasting in the Northern and Upper Regions with strong features of underdevelopment and particularity in all the aspects of politics, economy, education, and religion, the Government of Ghana has determined the construction of the microwave radio relay system for TV program transmission from Kumasi via Tamale to Bolgatanga and the schedule for expansion of TV broadcasting network by constructing TV broadcasting station at Bolgatanga.

This survey team carried out survey activities in the said regions from November 6 to December 23, 1972 for the purpose of affording a technical cooperation for the promotion of the broadcasting policy of Ghana by surveying the feasibility of the said project in compliance with the request from the Government of Ghana.

This report is prepared for the purpose of clarifying the basic conditions for the establishment of a concrete schedule of execution of the expansion project of TV broadcasting network and contributing to the progress of the broadcasting service and the telecommunication service in Ghana.

1.2. Explanation of Details

The textile training center and the medical cooperation at Korle-Bu Hospital are among the items of technical cooperation of Japan to the Republic of Ghana. In addition, the technical trainees totalling more than 100 have been received from Ghana in Japan and the results are highly valued.

As to the requirements relating to the schedule for expanding the TV broadcasting network, a requirement was presented from the Ghana's Commissioner of Information to the Japanese Ambassador for the first time in November 1970. The requirement related to the additional installation of the microwave radio relay system between Jamasi and Tamale for the transmission of TV programs as well as the dispatch of experts and donation of materials. Afterwards, the requirement for cooperation relating to the TV broadcasting station at Tamale was added in March 1971. The abovementioned requirements were affirmed by the reply from the Government of Ghana in July 1972 to the effect that it continued to require the cooperation in regard to the project.

Taking the abovementioned aspects collectively, the Government of Japan determined to dispatch a team for surveying the expansion project of TV broadcasting network and dispatched a survey team during the period of 48 days from November 11, 1972.

Arriving in Ghana, the survey team had a conference with the Government of Ghana as to the scope of works in relation to this survey. It was found, however, that there existed some difference between the draft scope of works previously sent from the Government of Japan and the intention of the Government of Ghana. So, the work of adjustment was commenced. The major points are as follows.

1. The survey for the installation of a station at Tamale was already terminated, so the request of the survey of Bolgatanga in the Upper Region is correct.

2. The survey for the construction of the microwave radio relay system for TV program transmission from Tamale to Bolgatanga is also requested.

3. It is also requested to survey the studio facilities of the TV broadcasting stations at Kumasi, Tamale, and Bolgatanga.

4. Function of both ways is required for the microwave radio relay system for TV program transmission. It is requested to carry out the survey taking the possibility of transmitting 3 music channels in addition to the TV program into consideration.

The team answered at first that the area Upper Region is out of the scope of survey. However, it was found that, in case the survey was not effected by this team, the Government of Ghana would require dispatch of a new survey team in accordance with the decision of NRC. So, the survey team again investigated the situation and determined that, although the prescribed scope would be enlarged in relation to the microwave station and the TV studio, the works would be disposed of in the prescribed date. And all the requirements were accepted. Provided, however, that the addition of music channels on the microwave radio relay system was provided expressly as it was required very forcefully because of the relation to experiences with other countries although such item was not to be clarified by an express provision.

Instruction of Japanese Government was required as to the abovementioned revision of the scope of works and the instruction in the effect that the survey in relation to studio should be completed within the prescribed surveying days. Actually, the survey was completed without changing the prescribed schedule including the procedure. Therefore, the survey report relating to studios is eventually included in this report.

In addition, as to the existing microwave radio relay system between Kumasi and Tamale under the jurisdiction of P & T, breakdown of the system for a long duration are generated in nighttime, in the season of Harmattan in particular, at many sections. Such fact was not previously noticed to, and consequently not expected by the survey team, and made a big burden for the survey team although it was not an item to be prescribed on the scope of works in particular. As a considerable time and some measuring instruments are required for the investigation of propagation troubles, the perfect solution of abovementioned problem was left for the future.

The total prescription of the scope of works is mentioned in Chapter 2, Part 1.

1.3. Survey Plan

1.3.1. Microwave Radio Relay System for Television

The survey was carried out with the plan of utilizing existing microwave stations and facilities as far as possible for the microwave radio relay system for television projected to be constructed between Kumasi and Tamale. For this purpose, efforts were directed to the acquisition and analysis of topographical maps, design data, and maintenance data, etc. for the purpose of obtaining detailed data in relation to the situations of the existing microwave radio relay system for telephone (120 telephone channels). For the purpose of reinforcing the above data, it was decided to investigate on the site as to the reserve for additional installation by surveying the areas of buildings and power supply capacities and the possibility of additional installation and modification of antenna system by investigating the structure and strength of antenna towers. Further, the propagation path conditions of each hop were investigated by means of profile analysis and actual inspection. In addition, the actual situations of the telephone channels of the existing microwave radio relay system between Kumasi and Tamale were confirmed by measuring the signal-to-noise ratio.

The microwave radio relay system for television scheduled to be constructed between Tamale and Bolgatanga was also surveyed in practically the same way as the Kumasi-Tamale section excepting the assumption by the completed sections of the UHF stations now under construction as well as their design data.

On the basis of above survey results, the system design of the additional microwave radio relay system, schedule chart of construction work, and calculation of the cost of construction, were determined to be carried out after returning to Japan.

The system survey was executed on the preposition of transmitting either one (1) colour or monochrome television signal with four (4) sound channels or 960 telephone channels. Its system performance is contrived to satisfy the recommendations of CCIR. Some restrictions of range of transmission, however, was anticipated at the start of the survey.

1.3.2. TV Broadcasting Station

The scope of survey in relation to the installation project of TV broadcasting station has been agreed upon to be the study of technical items required for the installation of TV broadcasting station at Bolgatanga by the scope of works.

In case only a paticular area is included in the area of broadcasting, it will be sufficient to investigate a scale of a broadcasting station complying with such TV service area. On the other hand, in case there exists an intention to propagate the radio wave of TV broadcasting nationwide, at least in the future, it is necessary to consider the location and the scale of transmission of broadcasting stations on the basis of nationwide viewpoint. Therefore, first of all, we inquired the intention of GBC in relation to the object area of TV broadcasting.

As the result, it was found that the intention of GBC was to include not only Bolgatanga, but also such communities as Navrongo, Bawku, Nakong, Tumu, Lawra, Wa, Walewale, and Gambaga in the TV service area.

Four of the above-mentioned communities, Navrongo, Gambaga, Nakong, and Walewale, will be either included in the TV service area of, or have the possibility of receiving the radio wave of the TV broadcasting station at Bolgatanga. It is considered, however, that the remaining 4 communities are unable to receive the wave broadcast from the TV broadcasting station at Bolgatanga because of their distance and topography unless intermediate relay station or broadcasting relay station is not installed. Therefore, it was agreed with GBC to exclude the latter 4 communities from the scope of the object of this survey leaving the investigation of the location of relay station after the TV broadcasting station is installed at Bolgatanga and the distribution of field strength of TV broadcasting wave emitted from the said station in investigated.

In addition, as to the periphery of Bolgatanga which is the center of this survey, it was decided to select 2 or 3 places suitable for the installation of TV broadcasting stations on the topographical maps and to make integrated decision on each of the places on the basis of the easiness of the construction work as well as the antenna power and the width of the TV service area when TV broadcasting wave is emitted from such places. And it was further decided to install a survey transmitter on one of the abovementioned suitable places which was judged to the optimum as a site of transmitting station and to emit test emission for the purpose of surveying the distribution of field strength by actual measurement on the field. Then, the scale of the TV broadcasting station to be installed at Bolgatanga is investigated on the basis of the comparison of measured values thus obtained with those obtained from calculations at each of the communities as well as the scale of transmission and TV service area calculated on the desk.

As to Bawku, situated on the east of Bolgatanga, there is an intention of installing a broadcasting relay station as soon as possible because this is a large town. According to the investigation on topographic map, this town may be able to be relayed directly by means of the relaying of broadcasting wave without employing an intermediate relay station according to the scale of the TV broadcasting station at Bolgatanga. In addition, as to Walewale and Gambaga, it is considered to have both of them within the service area of the TV broadcasting station at Tamale by increasing the scale of the said broadcasting station. So, it was decided also to investigate as to the coverage of the said towns by the service area of which station will produce a better reception by comparing the results of field measurement of Bolgatanga with the results on the desk investigation.

By the way, Tamale TV broadcasting station covers at present only the city of Tamale and its periphery. However, GBC has already a project for increasing the output power of transmitter of Tamale TV broadcasting station for the purpose of enlarging the service area. But, GBC has requested to reconsider the situation and the transmission scale of Tamale TV broadcasting station with the intention of propagating the TV service area all over the territory of Ghana. So, it was decided to survey the distribution of field strength of the wave broadcast from the existing Tamale TV broadcasting station on the field and at the same time, to investigate an ideal position and the transmission scale of Tamale TV broadcasting station in the future.

In addition, as a referrence for the project of installation of broadcasting relay station, the investigation of the relaying method and the measurement of receiving field strength from the parent station of Sunyani TV relay station which relays broadcasting wave at present were decided to be done.

1.4. Survey Method and Schedule

1.4.1. Microwave Radio Relay System for Television

The method and schedule of survey in relation to the microwave radio relay system for television of Kumasi-Tamale-Bolgatanga are roughly as follows.

November 10: Maps of 1/50,000 and 1/62,500 necessary for the field investigation were procured.

At the same time, explanations were given at P & T as to the existing situations of the existing as well as the under-construction system of Kumasi-Tamale-Bolgatanga stations (positions of the stations, height of antenna towers and situations of troubles, etc.).

November 11 and 12: Profile maps of each hop were prepared according to the above-mentioned maps and information, and rough estimation of required antenna height and reflection point was carried out.

November 13: Execution manual of the investigation and the investigation schedule were prepared.

November 14: Conference was held with P & T as to the abovementioned execution manual of the investigation and the investigation schedule.

November 15: Discussion was held with P & T as to the problem points of the existing microwave radio relay system and their countermeasures.

At the same time, the microwave terminal station of P & T at Accra was inspected and the existing installations and operating situations were investigated.

November 16 and 17: Rough system design was carried out and it was confirmed that the transmission of television signal is probably available by means of the existing stations.

November 19 and 20: Conference was held as to the abovementioned investigation results with P & T. Also, it became clear that drawings and calculations of strength of the existing steel towers requested by the team were not held by P & T.

November 23: While the team move from Tamale to Bolgatanga, the position of the station situated on the way was confirmed and plotted on the map of either 1/50,000 or 1/62,500 and accurate values of longitude and latitude as well as the height above the sea level were calculated. Also, the profile map was rewritten according to the change of the prearranged position of each station at Bolgatanga.

November 24: Walewale station was inspected. The building and the foundation of the antenna tower were under construction at the time of inspection. The floor layout of the building was confirmed by the construction drawings.

November 25: Gambaga station was inspected. The construction work of building and antenna tower was not started yet.

By the way, the propagation path conditions between Bolgatanga and Gambaga as well as between Gambaga and Walewale were investigated on the way to Gambaga.

In particular, two ridges are situated between Bolgatanga and Gambaga which necessitate a detailed investigation of the clearance. So, Jeep was driven to the vicinity of each ridge and the topography and the tree heights were investigated.

As to reflection points, as both of the hops are situated on hilly area and considerable woods are growing, the effect of reflection wave on the system performance is practically negligible.

November 26: Diari station was inspected and the reflection point between Walewale and Diari was inspected.

Both the building and the antenna tower were under construction at Diari station. The clearance of this hop gives no particular problem. However, as the reflection point is situated, according to the map, on a swampy area, this area was investigated particularly on the actual site and it was confirmed that the said area would become swampy in rainy season. On this hop, system design was carried out considering the effect of reflection wave.

November 27: Bolgatanga station was inspected. One room in the telephone exchange station was destined for this station.

November 28: The propagation path conditions between Diari and Tamale was inspected. This hop had a ridge at a location 16 km distant from Tamale which required a detailed inspection of the clearance. So, the topography and tree heights were investigated in the vicinity of the ridge. Further, as the reflection point was situated on a swampy area, investigation was carried out on the site and obtained reference data for the execution of the system design.

November 29: The tree heights at the Tamale terminal station and the ridge point between Tamale and Palbusi as well as the reflection point were investigated on the site. The survey method was the same as other hops explained above. Further, S/N (dB) of the existing microwave radio relay system for telephone between Kumasi and Tamale was measured.

November 30: Salaga station and the route between Palbusi and Salaga were investigated.

December 1: The route between Salaga and Kapilim was investigated.

December 2: Kapilim station as well as the route between Kapilim and Atebubu were investigated.

December 4: Sunyani microwave terminal station was inspected and the situation of the system troubles between Kumasi and Sunyani was explained.

December 6: Atebubu station, Ejura station as well as the routes between Atebubu and Ejura, and between Ejura and Jamas were inspected.

December 7: Arrangement of data obtained by the inspections of the site.

December 8: Kumasi terminal station was inspected and the S/N of the existing microwave radio relay system for telephone between Kumasi and Tamale was measured.

December 9: The trouble data of microwave system was obtained from Tamale station and analyzed.

December 11: Jamasi station and the route between Jamasi and Kumasi were inspected.

December 12 and 13: Draft of the interim report was prepared on the basis of the investigation data and the final conference was held with the counterpart from GBC and P & T.

December 15: Conference was held at Accra as to the survey results with P & T.

December 16: The draft of the interim report were collected.

December 18: Conference was held with GBC and P & T as to the items to be contained in the interim report.

December 19 and 20: The general situation of telecommunication services was explained by P & T.

December 21: The interim report was offered to the Government of Ghana at the conference room of GBC and opinions were exchanged.

1.4.2. TV Broadcasting Station

The investigation method and its schedule in relation to the TV broadcasting network are roughly as follows.

November 13 and 14: The method of the field investigation around Bolgatanga and equipments required for it were roughly explained at the conference room of GBC. And arrangement was made in relation to the scope of movement in case the measurement is carried out by moving the position as well as the positions to be selected as the measurement positions and their environments and the schedule for the total survey period.

November 15: Adjangote TV transmitting station from which Accra is now served was inspected and the necessary items of transmitting and receiving equipments including the transmitters and antenna installed in the transmitting station as well as the method of program transmission were actually observed for the purpose of collecting reference data for the investigation.

November 16 and 17: The preparation process made by GBC on the basis of the arrangement of the investigation method and the schedule agreed upon at the last conference held at the conference room in Accra was reported and arrangement was made in relation to the partial readjustment of the schedule according to the abovementioned result.

November 19: The 3 locations suitable for the installation of the transmitting station of Bolgatanga TV broadcasting station selected on the basis of the map of 1/50,000 were investigated separately for the respective line of sight with the prearranged positions of measurement for field strength as well as the anticipated values of receiving field strength obrained by calculation and the method of field investigation was confirmed again. At the same time, the final preparation for the field investigation was made.

November 20: The final confirmation of the readyness for acceptance as to the lodgings during the survey period and the inspection of installations in the broadcasting station required from Japanese survey team to GBC as well as tools and other materials to be carried for the survey was made at GBC. At the same time, the final adjustment and confirmation as to the transmitter used for the investigation, measuring instruments, and other equipments for the investigation were made in the afternoon at the Embassy. The preparation for the transportation was completed.

November 21: Equipments and materials required for the survey were loaded on jeeps, and total 9 members including the head and all the members of Japanese team as well as 3 members of the counterpart from GBC started for Bolgatanga. After lodging at Kumasi on 21 and at Tamale on 22, we arrived at Bolgatanga in the afternoon of 23. On the same day, we met the head of the regional broadcas ing station of GBC at Bolgatanga and explained the aims and meanings of this survey.

Hovember 24: On each of the 3 prospective sites of the transmitting station of the TV broadcasting station previously selected on the basis of topographic map of 1/50,000, investigation on the site was carried out as to the line-of-sight on the periphery, relation of positions of highway, conditions of power supply, etc. According to an integral judgment of each of the 3 prospective sites, it was concluded that the prospective site investigated first of all was the optimum as it was situated in the proximity of the regional broadcasting station at Bolgatanga and provided with an optimum condition of location. Therefore, the regional broadcasting station at Bolgatanga, which had the equivalent conditions of location as the first prospective site, was determined as the transmitting station for field investigation and the preparation for constructing the transmitting equipment for investigation use was started.

By the way, the member responsible for the studio carried out investigation of the existing radio studio of the regional broadcasting station at Bolgatanga as well as the site of TV studio and its location required when the installation of TV broadcasting station was determined.

November 25: The measurement of field strength of test wave emitted from the test transmitter was made at 5 locations including Navrongo, Paga, Chuchiliga, situated on the west of Bolgatanga.

November 26: The field strength of test wave was measured in the same way as the previous day at 4 locations including Nangodi and Tili situated on the east of Bolgatanga.

Further, on this day, we visited Bawku where the installation of relay station for TV broadcasting is intended in the future and investigated the scale of the town, existence of suitable sites for the installation of broadcasting relay station in the future. At the same time, the sensitivity of emission was investigated by operating test communication with the investigation transmitter at Bolgatanga.

November 27: In the morning, we interviewed with the regional commissioner of Bolgatanga, prolonged to this day from the day of our arrival. Then, we carried out the measurement of field strength in the same way as the previous day at two places: one at Bongo situated at the north of Bolgatanga, and the other at the proximity of the border with Upper Volta. Further, we carried out the measurement of field strength at Pwalagu at the south of Bolgatanga.

November 28: The measurement of field strength on the field investigation was completed according to the schedule. So, we withdrew the transmitting equipments used for the investigation, and all of the team left Bolgatanga for Tamale.

November 29 and 30: We interviewed with the head of the regional broadcasting station at Tamale at Tamale regional TV broadcasting station, and heard the broadcasting situations in the region of Tamale. Then, we investigated the necessary items of broadcasting equipments and the suitable sites for the installation of TV studio etc. In addition, we measured the field strength of the actual TV broadcasting wave at each 1 km distance from the transmitting antenna to 4 directions of east, west, south, and north for the purpose of assuming the effective radiated power of TV broadcasting station at Tamale and confirming the directivity characteristics of transmitting antenna. We also investigated the requirement for the enlartement of the transmitting scale of the TV broadcasting station at Tamale for the purpose of linking the service area of Tamale TV broadcasting station with the estimated service area of the projected TV broadcasting station at Bolgatanga in Upper Region.

Also, investigation was carried out on the topographic map of 1/50,000 as to the suitable installation sites of transmitting station in case the location of the existing transmitting station is required to be shifted for the purpose of enlarging the existing service area of TV broadcasting station at Tamale, and we investigated the suitable sites.

December 2: At Kumasi, we engaged in arranging the data obtained at Bolgatanga and Tamale.

December 4: We visited the regional broadcasting station at Sunyani, interviewed with the head of the station and heard the broadcasting situations in the area of Sunyani. At the same time, we investigated the necessary items of broadcasting equipments and investigated the situations of the reception from TV broadcasting station at Jamasi as well as those from TV relay station at Sunyani at 3 points in the city of Sunyani by means of measuring instrument of field strength and portable TV receiver.

December 6: We interviewed with the head of the broadcasting station at Kumasi at the said station and investigated the necessary items of the equipments in the said broadcasting station. At the same time, we heard the situation of broadcasting in the area of Kumasi and investigated the suitable sites for the installation of studio for TV broadcasting.

Also, the receiving situation and the field strength from the TV broadcasting station at Jamasi were measured in the premise the Kumasi regional broadcasting station as well as at 4 major points in the city of Kumasi.

December 7: All the scheduled field investigation was completed. So, we inspected the tools and equipments for survey and prepared for their return. Also, we engaged in the arrangement of data obtained by this date.

December 8 and 9: We engaged in the arrangement of data.

December 11: We visited Ejura transmitting station of the short wave for broadcasting, TV broadcasting station at Jamasi, and the wired broadcasting station at Mampong and investigated the equipments and broadcasting situation of abovementioned stations as well as the method of program transmission.

December 12 and 13: We started the preparation of interim report on the basis of the data obtained at the date. Also, we exchanged opinions as to the investigation results with the counterpart of GBC.

December 15: We visited the TV broadcasting station at Kissi and the broadcasting station at Cape Coast and investigated its equipments and situations of broadcasting.

December 16: We collected the draft of the interim report relating to the TV broadcasting networks and the microwave links for relaying TV broadcasting programs.

December 18: We made a brief explanation of the contents of the interim report at GBC.

December 19: We collected data which have been requested before we started for the survey at GBC.

Also, we visited personnel in charge of radio regulation at P & T and heard the formalities for authorizing a radio station and the actual procedure of frequency assignment in the Republic of Ghana.

December 20: We visited Radio Monitoring Station at Weija and heard the equipments for radio monitoring as well as the items and procedures of radio monitoring.

December 21: We delibered the interim report to the Government of Ghana at the conference room of GBC and exchanged opinions as to the preparation period of the official report as well as the construction project of TV broadcasting network in the future on the part of the Government of Ghana.

1.5. Materials for Investigation

The transmitting equipments and measuring instruments used at the field investigation as follows.

Materials	No.	Type	Remarks
Transmitter-receiver fixed VHF band (Frequency: 149.13 MHz)	1	VM-1014A (Manufactured by Oki Electric Co.)	This is used as an equivalent TV transmitter as well as for the purpose of communication with the measuring group.
Braun type antenna of VHF band	1		
annexed feeder	1		

Transportable transmitter-receiver for VHF band (Frequency: 149.13 MHz)	1	VM-1014A (Manufactured by Oki Electric Co.	Used for communication with the transmitter side.
Whip type antenna for VHF band	1		
annexed feeder	1		
300 W Honda Super-watt engine generator	2		
Measuring instrument of field strength of VHF band (Frequency range: 25 MHz ~ 230 MHz)		E-17. (Manufactured by Anritsu Electric Co.)	
Doublet antenna for measuring field strength of VHF band	1		
annexed feeder	1		
Antenna pole for transmission	1 set		

Chapter 2. EXPANSION PROJECT OF MICROWAVE RADIO RELAY SYSTEM FOR TELEVISION

2.1. General

(1) At present, the Government of Ghana has a project for constructing a microwave radio relay system for television between Kumasi-Tamale-Bolgatanga.

This survey was carried out on the basis of above-mentioned project. The survey project, scope, and method are as explained in the preceding chapter.

The results of this survey is described in this chapter. By the way, the study of system design of this system is carried out in Chapter 3.

(2) Items requiring special attention for the construction of this microwave radio relay system are as follows.

(a) Antenna System

Four frequency plan is adopted as reflectors are used at each of the existing stations. However, it is advisable to adopt two frequency plan when the frequency arrangement in the future is taken into consideration.

In addition, for the purpose of television signal transmission, it is necessary to adopt a higher performance antenna system. For this reason, it is necessary to remove the reflector (8' x 12') installed on the antenna tower and the antenna (8' ϕ) installed on the roof of the radio room, and to install an antenna of 4 m ϕ on the tower. In this case, it is necessary to adopt low loss type waveguide (0.02 dB/m) for the purpose of reducing the feeder loss.

(b) Antenna Tower

At the following stations, the installation of new antenna towers or the increase of the tower height is presumed to be required.

Stations requiring construction of new antenna towers

i) Atebubu (130 m)
ii) Kapilim (80 m)
iii) Palbusi (130 m)

Stations requiring increase of antenna tower heights

i) Tamale (75 m → 85 m)
ii) Bolgatanga (55 m → 75 m)

However, the final decision shall be given after the drawings and strength calculations of antenna towers are obtained.

(c) Adoption of Space Diversity System

It is assumed that the adoption of space diversity system is required for the following hops.

i) Ejura - Atebubu
ii) Kapilim - Salaga
iii) Palbusi - Tamale
iv) Tamale - Diari
v) Diari - Walewale

The stations of above-mentioned hops are either under operation or under construction at present and the propagation test can be carried out without difficulty. So, it is advisable to carry out the propagation test as soon as possible and investigate the occurence of Rayleigh fading and the distribution of k variation for the purpose of confirming the hops and antenna heights required for the space diversity system under particular meteorological conditions.

In particular, the system reliability of this area significantly deteriorates at Harmattan season. Actual test is more effective than theoretical assumption in such area of specific meteorological conditions.

2.2. Survey Results of Existing Microwave Radio Relay System for Telephone Between Kumasi - Tamale

2.2.1. Survey Results of Existing Microwave Stations

(1) Buildings

(a) Radio Equipment Room

The existing radio equipment room of each stations is provided with a sufficient floor space for installing new equipment excepting the station at Jamasi. All the through repeater station are of a same floor layout as shown on Fig. 2.2.1. The floor layout of Tamale station is as shown on the annexed Fig. 2.2.2. As no floor space for installing new equipment is provided in the existing radio room of Jamasi station, it is necessary to use the adjacent vacant rooms.

(b) Engine-Generator Room

The use of existing engine-generagor room is available at all of the stations. All the stations excepting Jamasi station are of the same floor layout as shown on the annexed Fig. 2.2.3. By the way, one engine-generator is installed at Tamale station.

(c) Battery and Rectifier Room

It is desirable that the power supply of the new radio equipment will be supplied from batteries. For this purpose, it is necessary to add a battery and rectifier room to each of the stations.

(2) Antenna Towers

As will be explained in Chapter 3 "System Design", at some station, the increase of antenna tower height, the addition of space diversity antenna, and the replacement of existing antennas and reflectors are required. However, it was impossible to obtain the drawings and the strength calculations of existing antenna towers and foundations.

For this reason, the judgment of the usability of existing antenna tower when the load on the antenna tower is changed is extremely difficult.

At this survey, we judged the usability on the assumption of the following conditions.

(a) The strength of the existing antenna tower can bear the replacement of the reflector mounted on it with a parabolic antenna of approximately the same area. As the principle, no problem is generated on the strength of antenna tower by adding one piece of antenna for space diversity.

(b) The height of a self supporting type antenna tower may be increased by 10 - 20 m.

(3) Radio Facilities

(a) Supervisory and Control Equipment

In general, transmission line for supervisory and control is accomodated either in a sub-baseband of the microwave radio relay system for telephone or in a separated radio bearer. However, in case of television transmission, it is impossible to accomodate a line for supervisory and control in a sub-base band. So, it is necessary to employ existing facilities and transmission line. The existing facilities are provided with the conditions required for the supervision of new equipment.

(b) Antenna System

The existing stations adopt the so called periscope type by which a reflector is installed on the antenna tower and an antenna is installed on the roof of radio room to reduce feeder loss. However, the new system anticipates antenna instead of the reflector considering the radio frequency arrangement in the future. Existing system is according to the four-frequency plan. But the adoption of two-frequency plan is available for the new system.

No problem will be generated as to the feeder loss when low loss waveguide will be adopted.

(4) Power Facilities

The employment of the existing engine-generator is available at each of all the stations excepting Jamasi station.

Its capacity is 10 KVA, respectively.

Three sets of engine-generators of 40 KVA were installed at Jamasi station and supply the power to television transmitter, and FM transmitter, etc. However, their operation continued for more than 10 years after they were installed and their efficiency was deteriorated. So, they require a perfect overhauling.

2.2.2. Investigation Results of Propagation Path Conditions

(1) Location of Each Station

The longitude and the latitude as well as the height above sea-level of each station were calculated by means of maps of 1/50,000 and 1/62,500, detailed city maps, and actual field survey.

The location and the height above sea-level of each station are shown on the annexed Table 2.2.1.

(2) Path Profile Maps

The path profile maps of each hop were prepared with the k (coefficient of equivalent earth's radius) 4/3 and 2/3 according to the maps mentioned in above item and actual field survey.

The path profile maps of each hop are shown on the annexed papers.

(3) Antenna Height and Antenna Tower Height

The antenna heights were calculated, as the principle, according to the following conditions.

(a) To assure the clearance larger than the 1st Fresnel radius at K = 4/3.

(b) To assure the clearance larger than 0.3 times of the 1st Fresnel radius at K = 2/3.

(c) In case the space diversity system is adopted,

i) the upper antenna height: The same as the items (a) and (b) of above description.

ii) the lower antenna height: To assure the clearance larger than 2/3 time of the 1st Fresnel radius at K = 4/3.

In case, however, a lower antenna with the gain lower by 3 dB than that of the upper antenna, it is necessary to provide the clearance condition against the lower antenna similar to that of the upper antenna.

The interval between the upper and the lower antennas are determined to approximately 10 m.

(d) The maximum tree height at the minimum clearance point was assume to 15 m. However, the maximum tree height at the hop Kumasi - Jamasi is 40 m.

The antenna height and the antenna tower height of each station are shown on the annexed Table 2. 2. 2.

(4) Investigation of Reflection Area

The reflection area of each hop was investigated and the reflection coefficient was assumed. As the result, the coefficient of effective reflections of each hop is shown on the annexed tables 3. 3. 1 - 3. 3. 2.

2. 2. 3. Measurement of S/N

The S/N ratios of telephone channels accomodated in the existing microwave radio relay system for telephone (120 channels system) were measured. The measurement was carried out in day time at Kumasi and Tamale terminal stations. The measured value were better than 60 dB at both sides, and the conditions of communication were good.

2. 3. The Survey Results of the UHF Radio Relay System for Telephone between Tamale - Bolgatanga.

2. 3. 1. Survey Results of UHF Stations under Construction

(1) Buildings

It is projected that the existing microwave terminal station is employed at Tamale station and the existing telephone exchange station is employed at Bolgatanga station. The through repeater stations are now under construction.

(a) Radio Equipment Room

Each station is provided with sufficient floor space for accomodating new equipment. Same floor layout is adopted for the through repeater stations as shown on the annexed Fig. 2. 3. 1. The area of the radio room in Bolgatanga station is 5 m x 12 m which is a sufficient floor space.

(b) Engine-Generator Room

The use of the engine-generator rooms are available at every stations. All the stations have the engine-generator rooms of the same floor layout excepting Bolgatanga station as shown on the annexed Fig. 2. 3. 2.

(c) Battery and Rectifier Room

The use of the battery and rectifier rooms are available at every stations. All the stations have the battery and rectifier rooms of the sam floor layout excepting Bolgatanga station as shown on the annexed Fig. 2. 3. 1.

(2) Antenna Towers

The antenna towers now under construction are designed with the prospect of mounting reflectors for microwave from the start. However, as it is impossible to obtain the drawing etc. of the towers as in the case of the existing stations, the availability of their use was assumed under the same conditions as mentioned in the item (2) of 2. 2. 1.

(3) Radio Facility

(a) Supervisory and Control Equipment

The use of supervisory and control equipments projected to be installed will be available.

(4) Power Facilities

(a) Engine-Generator

The use of the projected engine-generators at every station is available. The capacity of respective engine-generator is 20 KVA at Bolgatanga station and 12. 5 KVA at each of the through repeater stations.

(b) Battery and Rectifier

The batteries projected for each through repeater station are -48 V and their holding time is approximately 24 hours. It is assumed that the use of the batteries and rectifiers is available.

2. 3. 2. Investigation Results of Propagation Path Conditions

This investigation was carried out according to the same method and conditions as the investigation between Kumasi - Tamale.

(1) The location and the height above sea-level of each station are as shown on the annexed Table 2. 2. 1.

(2) The path profile maps of each hop are shown on the annexed paper.

(3) The antenna height and antenna tower height of each station are shown on the annexed Table 2. 2. 2.

(4) The coefficient of effective reflection of each hop is shown on the annexed Table 3. 3. 3.

Table 2.2.1 Site Location

Name of Station	Latitude	Longitude	Altitude (m)	Azimuth From T.N.(θ)
Kumasi (P&T Station)	6°40'39"	1°38'37"	245m	32°11'33"
Jamasi	6°59'23"	1°26'44"	590m	11°19'42"
Ejura	7°21'05"	1°22'21"	295m	44°57'13"
Atebubu	7°44'42"	0°58'42"	128m	27°00'44"
Kapilim	8°09'37"	0°45'57"	113m	32°29'54"
Salaga	8°33'14"	0°30'44"	162m	0°27'44"
Palbusi	8°59'46"	0°30'31"	143m	320°53'39"
Tamale	9°24'08"	0°50'36"	191m	356°16'48"
Diari	9°52'10"	0°52'27"	137m	8°42'38"
Walewale	10°19'21"	0°48'13"	198m	59°42'33"
Gambaga	10°31'44"	0°26'38"	381m	302°13'44"
Bolgatanga	10°46'59"	0°51'17"	189m	

Remarks

Azimuth from TN(θ):

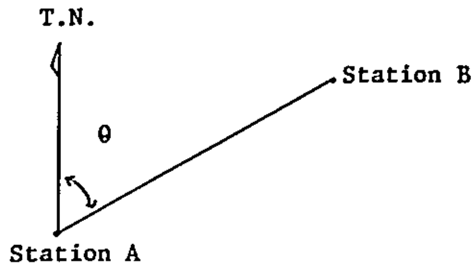


Table 2.2.2 List of Antenna and Tower Height

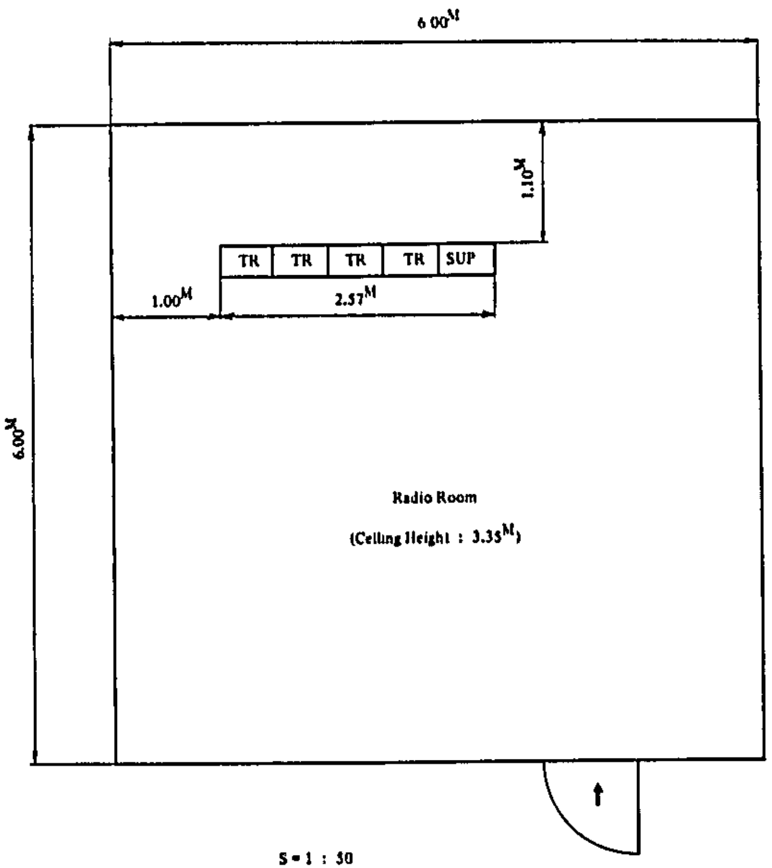
	Existing System			New System			
	Ref. Height m	Clearance (k=2/3) m	Tower Height m	Ant. Height m	Clearance (k=2/3) m	Clearance Factor (k=2/3)	Tower Height m
Kumasi							
	110		110	80			110
		33.4			6.3	0.5	
	27			27			
Jamasi			61				61
	46			46			
		60.0			36.3	1.9	
	95			30			
Ejura			95				95
	95			95(85)			
		-24.0			-2.0	-0.08	
	95			130(120)			
Atebubu			95				130
	95			105			
		-10.4			10.0	0.44	
	50			80			
Kapilim			50				80
	50			65(53)			
		-8.9			4.4	0.3	
	75			75(65)			
Salaga			75				75
	75			75			
		-30.2			5.6	0.26	
	75			130			
Palbusi			75				130
	75			105(95)			
		-4.4			7.0	0.3	
	75			75(65)			
Tamale			75				85
	75			85(75)			
		-0.9			6.0	0.29	
	100			100(88)			
Diali			100				100
	100			100(85)			
		27.5			27.5	1.44	
	50			50(35)			
Walewale			50				50
	50			50			
		6.9			6.9	0.33	
	115			115			
Gambaga			115				115
	115			115			
		-7.0			8.5	0.44	
	55			75			
Bolgatanga			55				75

(Remarks)

1) Between Kumasi and Tamale existing system is now underconstruction.

2) (80): Height of space diversity antenna

Fig. 2.2.1 Floor Layout of Radio Room
(Palbusi Through Repeator Station)

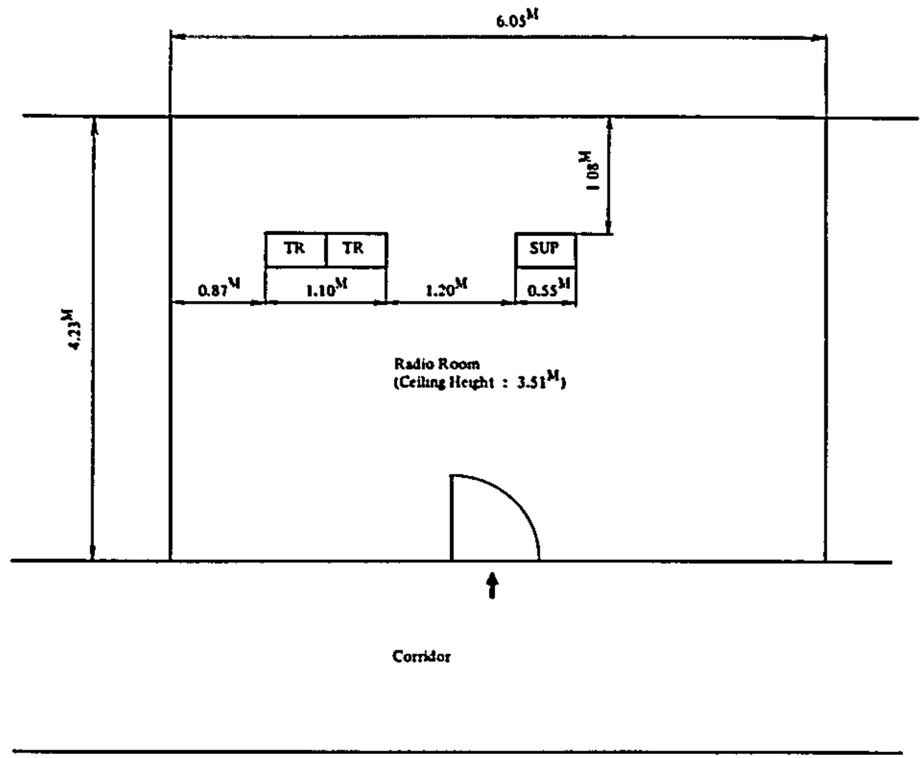


S = 1 : 50

Remarks

TR : Transmitter and Receiver
SUP : Supervisory Equipment

Fig. 2.2.2 Floor Layout of Radio Room
(Tamale Terminal Station)

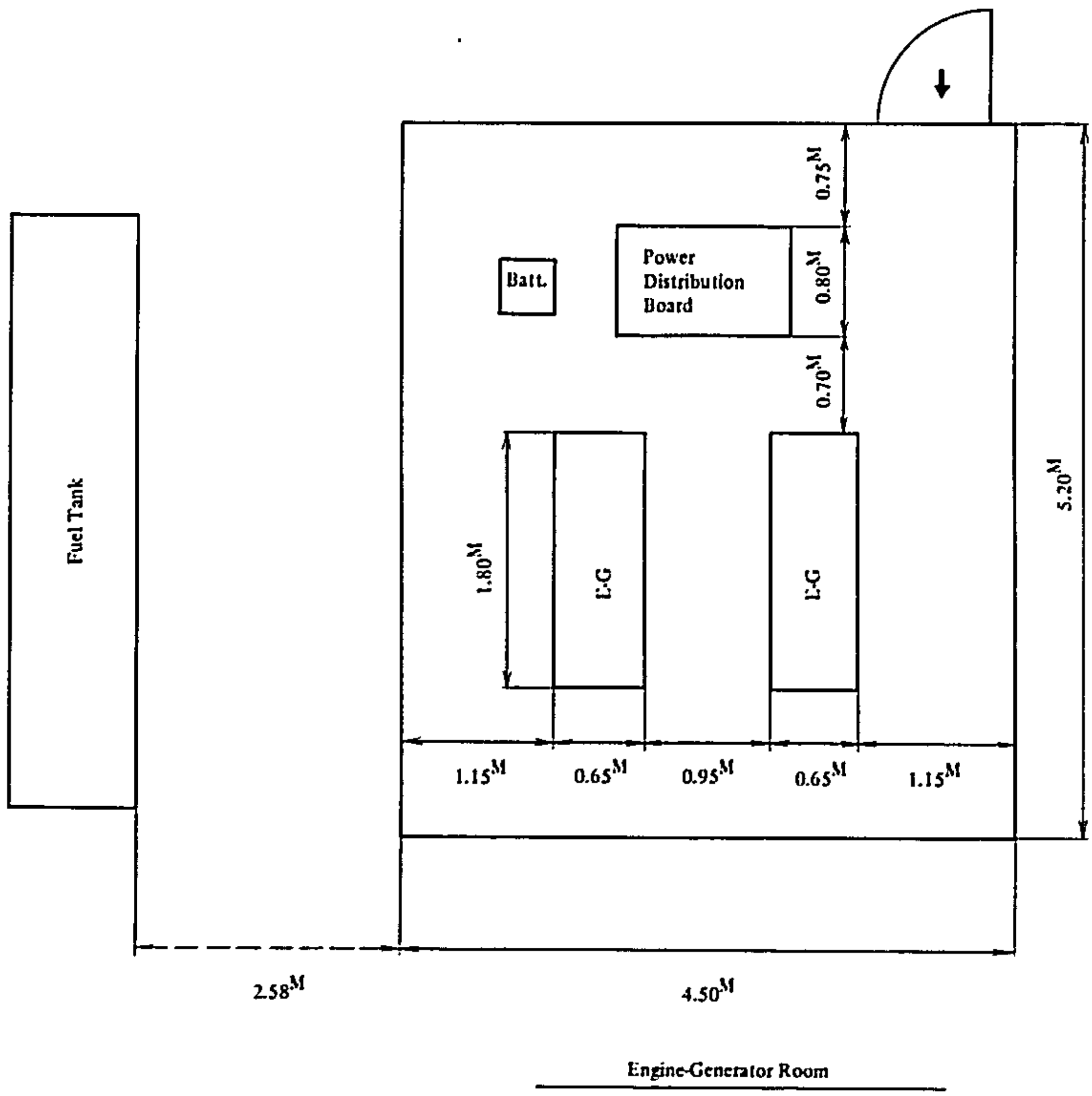


S = 1 : 50

Remarks

TR : Transmitter and Receiver
SUP : Supervisory Equipment

Fig. 2.2.3 Floor Layout of Engine-Generator Room (Palbusi Station)

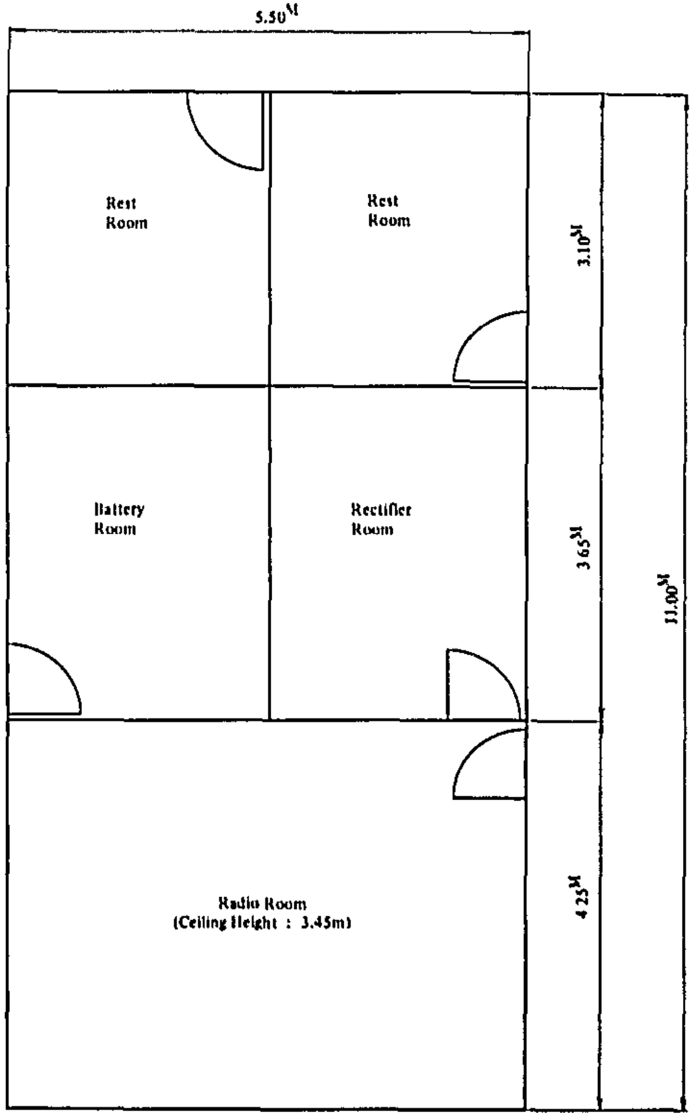


Remarks

E-G : Engine-Generator

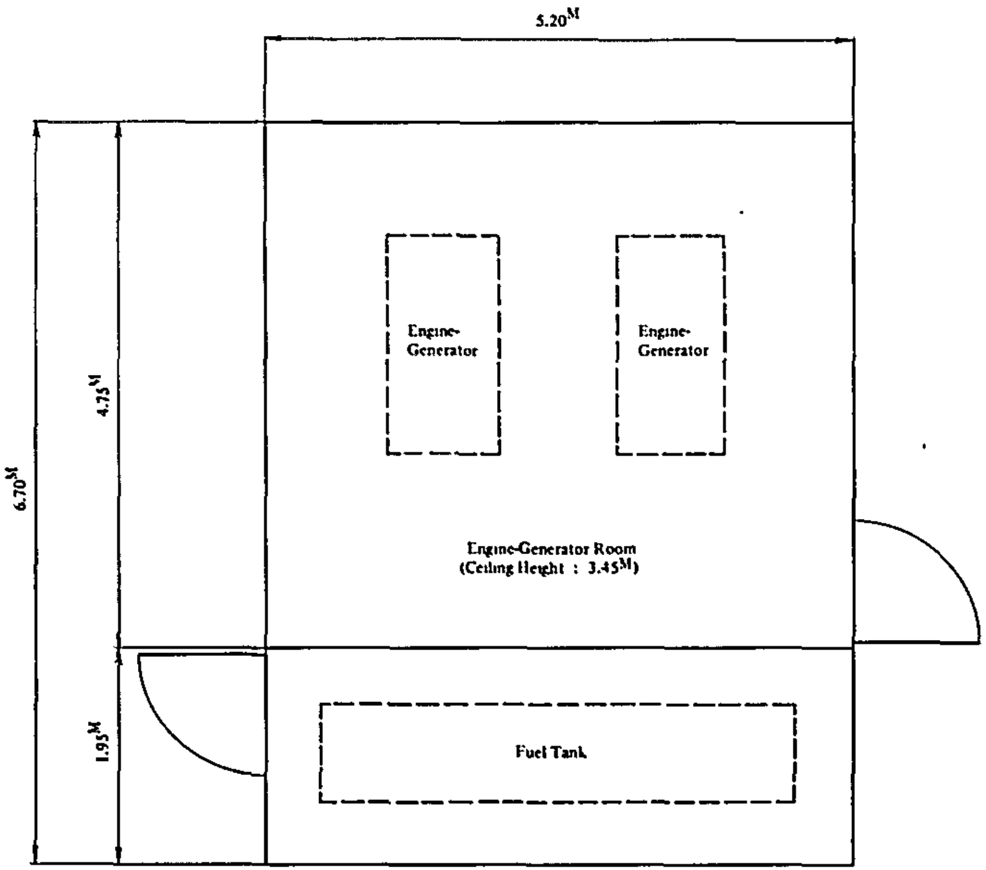
Batt : Battery for Engine-Generator

Fig. 2.3.1 *Floor Layout of Radio Building (Through Repeator Station)*



S = 1 : 60

Fig. 2.3.2 Floor Layout of Engine-Generator Room (Through Repeator Station)



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Chapter 3. SYSTEM DESIGN OF MICROWAVE RADIO RELAY SYSTEM

3.1. General

This chapter describes the process and results of studys relating to the noise performance of the microwave radio relay system projected to be constructed between Kumasi - Tamale - Bolgatanga.

As the transmission of 960 telephone channels is projected on this system in the future, the study of noise performance was carried out on the transmission of the following signals.

(1) 960 telephone channels

(2) One (1) colour or monochrome television video signal with four (4) sound (music) channels.

The reliability of the existing microwave system between Kumasi - Tamale shows a significant deterioration in the Harmattan season. For this reason, it is considered to adopt space diversity system to some of those hops.

The study process of noise performance was given a particularly detailed description because of the requirement of Your Government.

3.2. Performance of Radio Facilities assumed at the System Design

(1) Radio Equipment

Operation radio frequency band: 7425 - 7725 MHz
(Center frequency: 7575 MHz)

Transmission capacity	:	960 telephone channels or one (1) colour (or monochrome) television signal with four (4) sound channels.
Type of repeator	:	Heterodyne
Modulation	:	FM
Intermediate frequency	:	70 MHz
Transmitter output level	:	+28.5 dBm (0.7 Watt)
Receiver noise figure	:	7 dB
Threshold level	:	-83 dB
Branching circuit loss	:	2 RF 2.8 dB/hop 3 RF 3.2 dB/hop

Branching circuit VSWR	:	1.07
Emphasis improvement	:	Telephone: 4 dB at the highest channel (CCIR Rec. 275-2) Television: Based on CCIR Rec. 405-1

Psophometrical weighting factor:

Telephone: 2.5 dB (CCIR Rec. 395-1)
Television: Based on CCIR Rec. 421-2

- Telephone system -

Bandwidth of telephone channel: 3.1 KHz

Frequency deviation : 200 KHz rms. per channel (CCIR Rec. 404-2)

Highest frequency of base band: 4028 KHz

- Television system -

Nominal upper limit of video frequency band: 5 MHz

Frequency deviation of the peak-to-peak picture signal except the synchronizing signal : 5.6 MHz

Frequency of sub-carrier: 7020 kHz, 7500 kHz, 8065 kHz, 8590 kHz (4 sound channels)

Frequency deviation of sub-carrier: 140 kHz rms.

(2) Antenna System

Antenna gain	:	40.5 dB	(2.0 m ϕ)
		44.9 dB	(3.3 m ϕ)
		46.5 dB	(4.0 m ϕ)
Antenna VSWR	:	1.06	(2.0 m ϕ)
		"	(3.3 m ϕ)
		"	(4.0 m ϕ)
Antenna F/B	:	61 dB	(2.0 m ϕ)
		65 dB	(3.3 m ϕ)
		65 dB	(4.0 m ϕ)

Waveguide loss per meter: Elliptical W/G 0.067 dB/m
Circular W/G 0.02 dB/m

3.3. Noise Calculation of Telephony Transmission

3.3.1. General

The noise at the end of a microwave radio relay system is the integration of the following noises. It was confirmed that this integrated value satisfies the recommendation 395-1 of CCIR. However, for the purpose of satisfying the Rec. 395-1, it is necessary to adopt space diversity on some of the hops. Further, we have taken attention so that the recommendation of CCITT is also satisfied for the consideration of the adoption of high speed data transmission in the future. All the calculation of noise were carried out on the highest channel.

(1) Thermal noise

(a) FM thermal noise

(b) Basic thermal noise

(2) Intermodulation noise

(3) Interference noise

(a) Interference noise due to front-to-back coupling of antenna

(b) Interference noise due to over-reach propagation

(c) Propagation path distortion noise

(d) Feeder echo noise

3.3.2. Calculation of Thermal Noise

3.3.2.1. FM Thermal Noise

(1) Calculation of signal to FM thermal noise ratio at free space condition.

This S/N ratio is calculated by the following equation.

$$S/N = \frac{Pr}{KTF.fch} \cdot \frac{\sigma^2}{fp^2} \quad (dB) \quad \ldots\ldots\ldots\ldots\ldots \quad (3.3.1)$$

where, Pr : Receiving input level in free space condition (dBm)

K : Boltzman constant 1.38×10^{-23} joule/K^o

T : Absolute temperature in Kelvins 10 log KT = -173.8 dB

F : Receiver noise figure 7 dB

fch: Bandwidth of telephone channel (Hz) 3.1×10^3 (Hz)

σ : Frequency deviation of test tone 200 x 10^3 (Hz) rms

fp : Frequency of highest channel in the base band 4028 x 10^3 (Hz)

When the above conditions are substituted in the equation (3. 3. 1), the equation is simplified as follows.

In case emphasis OFF and unweighted,

$$S/N = Pr + 105.8 \text{ dB} \quad \text{.......................} \quad (3.3.2)$$

In case emphasis ON and weighted,

$$S/N = Pr + 112.3 \text{ dB} \quad \text{.......................} \quad (3.3.3)$$

Pr may be calculated from the following equation,

$$Pr = Pt + Gt + Gr - Lw - Lb - Lf \text{ (dBm)} \quad \text{........} \quad (3.3.4)$$

where, Pt : Transmitter output level (dBm) + 28.5 dBm

Gt, Gr: Transmitting or receiving antenna gain (dB)

Lw : Transmitting and receiving waveguide loss (dB)

Lb : Branching filter loss (dB)

Lf : Free space loss (dB)

Lf is calculated by the following equation.

$$Lf = 10 \log (4\pi d/\lambda)^2 \text{ (dB)} \quad \text{....................} \quad (3.3.5)$$

where, d : Hop distance (m)

λ : Radio wave length (m)

When the radio frequency is 7575 MHz, the equation (3.3.5) may be simplified as follows.

$$Lf = 110 \text{ dB} + 20 \log d \text{ (km)} \quad \text{..................} \quad (3.3.6)$$

(2) Calculation of mean FM thermal noise power in any hour

The calculation was carried out according to the following procedure.

2-1) The prediction of probability of equivalent Rayleigh fading occurrence (P_{Re}) of a hop where water or ground surface reflection is existing.

(a) The predicting method of P_{Re} in such case is according to the technical report of the Laboratory of the Nippon Telegraph & Telephone

Public Corporation (NTTPC).

(b) Standard deviation σi (dB) of the distribution of instantaneous received power under the worst case

The propagation path condition is obtained by the following equation.

$$\sigma i = K. (f/4)^{0.3}.Q.d^{0.9} \text{ (dB)} \quad .... \quad (3.3.7)$$

where, K : Coefficient (0.068)

f : Radio frequency (GHz)

Q : Coefficient of propagation path
Mountain area : 0.8
Plain area : 1.0
Sea area : $1.4 \times \frac{(1/\bar{h})^{0.13}}{0.47}$

$$\bar{h} = \frac{h1 + h2}{2} \text{ (m)}$$

h1, h2: Transmitting and receiving antenna heights above sea level (m)

d : Path length (Km)

(c) The probability of equivalent Rayleigh fading occurrence (P_{Re}) can be obtained from the standard deviation σi, the coefficient of effective reflection (ρe), as well as the annexed Fig. 3.3.1.

2-2) The prediction of the probability of Rayleigh fading occurrence (P_{Re}) when the coefficient of effective reflection (ρe) is negligibly small.

(a) The prediction was carried out in such cases according to the following equation.

By the way, P_R may be also calculated according to the annexed Fig. 3.2 - 3.3.

$$P_R = (f/4)^{1.2}.Q.d^{3.5} \quad .... \quad (3.3.12)$$

where, f : Radio frequency (GHz)

Q : Coefficient of propagation path
Mountain area : 2.0×10^{-9}
Plain area : 5.1×10^{-9}
Sea area : $3.7 \times 10^{-7} \sqrt{1/\bar{h}}$

$$\bar{h} = \frac{h1 + h2}{2} \text{ (m)}$$

h1, h2: Transmitting and receiving antenna heights above sea level (m)

2-3) The mean FM thermal noise power of the microwave radio relay system in any hour

(a) Assumption of the number of hops (K) among Z-hops where Rayleigh fading is generated at the same time.

There is practically no correlation between the fadings generated at each of the hops. So, P_K, the probability of simultaneous generation of Rayleigh fading at K hops among Z hops, while it is not generated at (Z - K) hops is calculated by the following equation.

$$P_K = \frac{Z}{K!\,(Z-K)!}\ Pi^K (1 - Pi)^{Z - K} \quad \ldots\ldots\ldots\ldots \quad (3.3.8)$$

where, Pi : Representative probability of effective Rayleigh fading occurrence of Z hops.

K in the above equation can be obtained from the annexed Fig. 3.3.4.

(b) Provided that Rayleigh fading occurs only at K hops, $\overline{N}K$, the mean thermal noise power of K hops is

$$\overline{N}K = 10.No.K \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3.3.9)$$

where, No : Thermal noise power when there is no fading.

The $\overline{N}$z-k, the mean thermal noise power of (Z - K) hops is almost the same as the case where there is no fading. So, according to the data upon experience,

$$\overline{N}z\text{-}k = 1.5 \times No \times (Z - K) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3.3.10)$$

The Nz, the mean thermal noise at the end of Z hops is assumed as the addition of the equations (3.3.9) and (3.3.10).

When the ratio in case there is no fading is considered,

$$\frac{\overline{N}z}{ZNo} = 10\,\frac{K}{Z} + 1.5\,\frac{Z - K}{Z} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3.3.11)$$

In other words, the mean FM thermal noise power at any hour is inferior than the noise at the free space condition by 10 log $\overline{N}$z/ZNo (dB).

The mean thermal noise powers in any hour between Kumasi - Tamale, Tamale - Bolgatanga, and Kumasi - Bolgatanga are shown on the annexed Table 3.3.4.

3.3.2.2. Basic Thermal Noise

The following values were assumed for the basic noise of the equipment.

One transmitter + One receiver : 7 PW

One modulator + One demodulator : 15 PW

The above-mentioned values indicate the Emp. on, weighted values.

3.3.3. Intermodulation Noise

The following values were assumed for the intermodulation noise of the equipment.

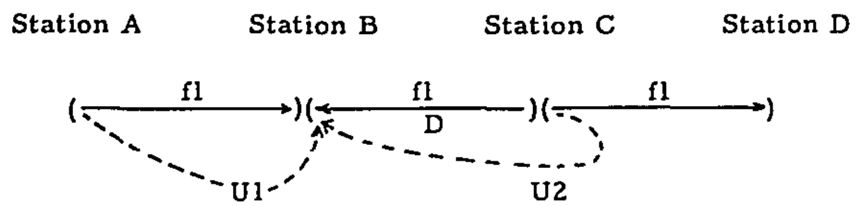
One transmitter + One receiver : 16 PW
One modulator + One demodulator : 7 PW

The above-mentioned values indicate the weighted values.

3.3.4. Interference Noise

3.3.4.1. Interference Noise due to Front-To-Back Coupling of Antenna

The interference noise due to front-to-back coupling of antenna generally occurs according to to the following process.



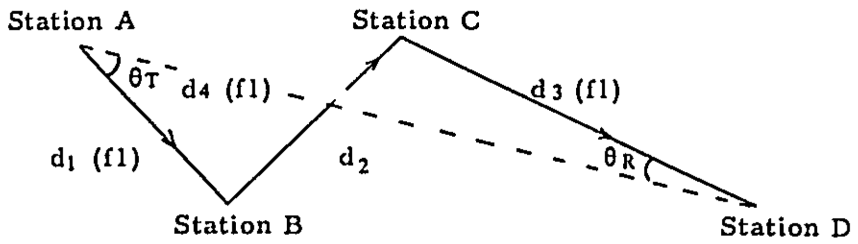
In general, many of the employment of radio frequencies are according to the above-mentioned example. That is to say, in case the direction is Station C→Station B, Station B is influenced with an interference by the undesired signals U1 and U2 as indicated on the above diagram.

However, as the radio frequency of the desired signal "D" differs from that of the undesired signal by the radio frequency allocations of existing microwave radio relay system (i.e., as the so-called 4 frequency plan is adopted), this interference noise is negligibly small.

In case the radio frequency allocations as mentioned on the above diagram (i.e., the so-called 2 frequency plan) are adopted, the mean value of this interference noise for one station is approximately 20 PW.

3.3.4.2. Interference Noise due to Over-Reach Propagation

Generally, the interference noise due to over-reach occurs according to the following process.



In case of the direction of Station C⟶Station D on the above diagram, Station D is influenced by the interference of undesired signal from Station A. In this case, the desired signal to undesired signal ratio (D/U) of the interference at Station D is calculated by the following equation.

$$D/U = D\theta_T + D\theta_R + L1 + L2 + L3 + L4 \text{ (dB)} \quad \ldots\ldots \quad (3.3.12)$$

where, $D\theta_T$, $D\theta_R$: Attenuation due to antenna directivity at θ_T or θ_R.

L1 : Ratio of path difference (dB)
L1 = 20 log d4/d3 (dB)

L2 : Difference between desired and undesired transmitting waveguide loss (dB)

L3 : Difference between disired and undesired transmitting antenna gain (dB)

L4 : Shadow loss of undesired signal (dB)

In the area north of Kumasi, the most part is plain area and there are many cases of the propagation path height above the ground level are lower than 100 m. In such cases, the distribution of the variation of K becomes exceedingly large so that the probability of K becoming infinity increases. Therefore, it is necessary to make satisfactory investigation of the interference due to over reach propagation.

For the purpose of reducing this noise, it is also necessary to arrange the polarization of antenna of each hop according to V-V-H-H so that the effect of cross polarization will be obtained.

The signal-to-noise ratio due to over-reach propagation is calculated according to the following equation.

$$S/N = D/U + 16.5 \text{ dB (unweighted value)} \quad \ldots\ldots\ldots \quad (3.3.13)$$

The interference noise of each hop is shown on Table 3.3.5.

3.3.4.3. Propagation Path Distortion Noise

In case reflection wave exists on the propagation path, distortion noise is generated on the receiving side due to the delay of the phase between direct and reflection rays.

The propagation path distortion noise is calculated by the delay time (τ) between the direct and the reflection rays and the coefficient of effective reflection (ρe).

The delay time (τ) is obtained by the following equation.

$$\tau = \frac{\ell\,(m)}{3 \times 10^8} \text{ sec} = 3.3 \times \ell(m) \ \ (m\ u.s.) \ \ \ldots\ldots \qquad (3.3.14)$$

where, ℓ : Path difference between direct and reflection rays (m)

$$\ell = \frac{2he_1 \cdot 2he_2\ (m)}{d\ (m)}$$

he_1, he_2: Effective antenna height (m)

In case $\rho e = 1$, $(S/N)_{NL}$ is calculated by the annexed Fig. 3.3.5. Also, inccase $\rho e = i$, $(S/N)_{ch}$ is the sum of above value, $-20 \log \rho e$ dB, and 16 dB.

The propagation path distortion noise on each hop is shown on the annexed Table 3.3.5.

3.3.4.4. Feeder Echo Noise

In case mismatching exists at both ends of the waveguide, i e , input or output of the radio equipment and the antenna, reflection wave is generated so that delay time occurs between the direct and the reflection rays.

(a) Calculation of Echo Ratio (γ)

$$= \gamma A \times \gamma B \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (3.3.15)$$

where, γA, $(\gamma B) = \frac{\rho - 1}{\rho + 1}$

ρ : VSWR (Antenna or radio equipment)

(b) Calculation of Delay Time (τ)

$$\tau = 2L/Vg \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (3.3.16)$$

where, L : Waveguide length (m)

Vg: Group velocity (m)

(c) Calculation of Feeder Echo Noise

The value of feeder echo noise is calculated by adding $-20 \log \gamma$ and 2LW (waveguide loss) to the value obtained by the abovementioned Fig. 3.3.6. The feeder echo noise of each hop is shown on the annexed Table 2.3.5.

3.3.5. Total Mean Noise Power in Any Hour

The values of the total mean noise power in any hour between Kumasi - Tamale, Tamale - Bolgatanga, and Kumasi - Bolgatanga are shown on the annexed Table 3.3.4.

3.3.6. Percent of Time, t 47500, in which the One-minute Mean Noise Power exceeds 47500 pwp in any Month.

3.3.6.1. Estimation of t 47500 without Space Diversity

The value of t 47500 of a hop where the coefficient of effective reflection (ρe) is negligibly small is calculated by the following equation.

$$t47500 = \frac{2NoPR}{47500} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3.3.17)$$

where, No: FM thermal noise power under free space condition expressed in pwp.

PR: Probability of Rayleigh fading (Refer to 3.3.2.1.2.)

The value of t 47500 of a hop where water or ground surface reflection exists is obtained by the following equation.

$$t47500 = \frac{NoPRe}{47500} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3.3.18)$$

where, No: Same as above

PRe: Probability of equivalent Rayleigh fading (Refer to 3.3.2.1.2.)

The value of t47500 of each hop is shown on the annexed Table 3.3.1 - 3.3.3.

3.3.6.2. Estimation of t 47500 with Space Diversity

(1) The Improvement Effect of Space Diversity

The improvement effect is significant when the correlation to the vertical direction to the receiving power (K_S^2) is 1 - 0.6. In general, the interval between the main antenna and the space diversity antenna (Δh) is determined so that K_S^2 is approximately less than 0.5. The improvement effect in this case is approximately 1/50 at the time when deep fading occurs. By this system, approximately 10 m of Δh is assumed. By doing so, the value of K_S^2 is expected approximately 0.4 - 0.2.

(2) Calculation of K_S^2

K_S^2 is calculated by the following equation.

$$K_S^2 = \exp\left[-0.002 \cdot \Delta h . f . \sqrt{0.4d + \{(k\ell)^2 - (k^2\ell)^2\} \times 10^4}\right] \quad \ldots\ldots\ldots\ldots\ldots \quad (3.3.19)$$

where, K_S^2: Mean value of the coefficients of correlation at the time of deep fading occurrence at the worst term.

Δh : Interval of antennas to the vertical direction (m)

f : Radio frequency (GHz)

d : Hop distance (km)

$$K = \sqrt{\frac{\rho e^2}{1 + \rho e^2}}$$

ρe : Coefficient of effective reflection

ℓ : Path difference between direct and reflection rays (m)

(3) Interval of Antennas by Space Diversity (Δh)

It goes without saying that Δh should be selected so that $K_S^2 \leq 0.5$ is satisified as explained above. But it is also necessary by a hop with large value of ρe to take care not to locate both antennas at the minimum point of the height pattern at the same time when the value of K lies within a certain range (quasi-normal propagation).

(a) The height pattern half pitch (P_1, P_2) is obtained by the following equation.

$$P_1 = \frac{\lambda d}{4he_2} \text{ (m)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3.3.20)$$

$$P_2 = \frac{\lambda d}{4he_1} \text{ (m)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3.3.21)$$

where, λ : Radio wave length (m)

d : Hop distance (m)

he_1, he_2: Effective antenna height (m)

(b) The depth of the interference pattern is $20 \log \left(\frac{1}{1 - \rho_e}\right)$ (dB). For example, in case $\rho e = 0.5$, the depth of the interference pattern is 6 dB. That is to say, in this case if the antenna interval is set equal to the height pattern half pitch, the receiving input level of an antenna practically remains unchanged even when the receiving input level of the other antenna is dropped by 6 dB.

3.4. Noise Calculation of Television Transmission

3.4.1. General

In the same way as the telephony transmission, it was confirmed that the noise performance satisfied the recommendation 421-2 of CCIR. The study of the continuous random noise is shown in the item 3.4.2. The interference noise has been already investigated at the study of the transmission of telephone 960 channel and gives no particular problem for the tlelvision transmission.

As will be explained later, the probability of signal (P-P) to continuous random noise ratio deteriorating lower than 44 dB satisfies the recommendation of CCIR.

However, in case television signal is transmitted, even an instantaneous system fadeout will give an important trouble to the television picture, it is necessary to adopt space diversity at some hops in the same way as the telephone transmission.

3.4.2. Calculation of Continuous Random Noise

(1) The peak-to-peak picture signal, excluding synchronizing pulses, to the r.m.s. value of continuous random noise ratio by the free space condition is calculated by the following equation.

$$S(P\text{-}P)/N(r.m.s.) = Pr - F - 10 \log KT + 10 \log \frac{3Sp^2}{fc^3} \quad (dB) \qquad \ldots\ldots\ldots\ldots\ldots \quad (3.4.1)$$

where, Pr : Receiving input level in free space (dBm)

F : Receiver noise figure 7 dB

10 log KT: -173.8 dB (Refer to 3.3.2.1)

Sp : P - P frequency deviation of picture 5.6×10^6 Hz

fc : Upper limit of video frequency band 5×10^6 Hz

The equation (3.4.1) may be simplified as follows when the above-mentioned conditions are substituted.

When emphasis is OFF and unweighted,

$$S(P - P)/N(r.m.s.) = Pr + 105.8 \text{ dB} \quad \ldots\ldots\ldots\ldots \quad (3.4.2)$$

When emphasis is ON and weighted,

$$S(P - P)/N(r.m.s.) = Pr + 122.1 \text{ dB} \quad \ldots\ldots\ldots\ldots \quad (3.4.3)$$

The S(P - P)/N(r.m.s.) of each hop is shown on Table 3.4.1.

(2) Calculation of S(P - P)/N(r.m.s.) (20 %)

The calculation in this case was operated by the following process.

2-1) Calculation of 50 % Value

In case of homogeneous hop, the 50 % values at the system end are calculated by the following equation.

$$50\ \%\ \text{value} = (t - 10)\ \log_{10} Z^{1} \quad \ldots\ldots\ldots\ldots\ldots \quad (3.4.4)$$

The value t of the above equation is obtained from Table 3.4.2.

Table 3.4.2. λ vs. t

λ	1.0	1.5	2.5	3.5	4.5	6.5	10	20	30
t	13.5	12.0	11.3	10.8	10.5	10.3	10.1	10	10

λ : Parameter of Pearson's No. 5 distribution (Refer to Fig. 3.4.1.)
z : The number of repeating hops.

2-2) Calculation of 1 % Value

In case of homogeneous hop, the 1 % value at the system end is calculated by the following equation.

$$1\ \%\ \text{value} = (u - 10)\ \log_{10} Z + V \quad \ldots\ldots\ldots\ldots\ldots \quad (3.4.5)$$

The value u of the above equation is obtained by the Table 3.4.3.

Table 3.4.3. λ vs. u

λ	1.0	1.5	2.5	3.5	4.5	6.5	10	20	30
u	10	7.8	6.9	6.9	7.3	7.7	8.1	8.9	9.1

V : Difference of the 50 % value and 99 % value of Gamma distribution. Obtained from the annexed Figure 3.4.2.

2-3) Calculation of 0.01 % Value

The 0.01 % value is obtained from the t 47,500 (%) at the system end and the FM thermal noise at the free space.

Provided that, t 47,500 (%) = 0.014 %, and FM thermal noise = 62.5 pw, the relative noise power for 0.014 % is 47,500 pw/62.5 pw = 28.8 dB.

Therefore, 0.01 % value is deteriorated by 30.3 dB compared with the free space condition.

$$28.8 \text{ dB} - 10 \log \frac{0.01}{0.014} = 28.8 \text{ dB} + 1.5 \text{ dB} = 30.3 \text{ dB}$$

2-4) Calculation of 20 % Value

Plot the values of abovementioned 3 points on a probability section paper as indicated on Figs. 3.4.3 - 3.4.5, then the 20 % value will be obtained by this curve.

The 20 % values of S(P - P)/N(r.m.s.) at the system end are shown on the annexed Table 3.4.4.

(3) Calculation of t 44 dB

The t 44 dB, the time ratio at which the signal (P - P) to noise (r.m.s.) ratio falls below 44 dB, is calculated by the following equation.

$$t\ 44\ \text{dB}\ (\%) = 100 \times \Sigma\ (10^{-\frac{Y}{10}} \times PR(e))\% \quad \ldots\ldots.\ (3.4.6)$$

where, Y : Difference between weighted S/N as in Table 3.4.1 and 44 dB.

PR : Probability of equivalent Rayleigh fading occurrence as in Tables 3.3.1 - 3.3.3.

PRe: Probability of equivalent Rayleigh fading occurrence as in Tables 3.3.1 - 3.3.3.

The t 44 dB (%) at each hop and system end are shown on the annexed Tables 3.4.1 and 3.4.4.

3.5. Noise Performance at the Transmission of Sound Channels

According to CCIR report, for the purpose of simultaneous transmission of four (4) sound channels with the television video signal, it is desirable to employ a radio equipment provided with the transmission capacity of 1800 telephone channels.

However, it is not advisable on economic basis to employ a radio equipment with 1800 ch capacity between Kumasi - Tamale - Bolgatanga.

It is not unpracticable to operate simultaneous transmission of four (4) sound channels together with television video signal by means of a radio equipment with 960 ch capacity. According to CCITT J-21, it is recommended that the signal to noise ratio shall keep 57 dB for the transmission of 2500 km. However, as there is no probability of transmitting sound channels for 2500 km in the Republic of Ghana, it is practicable, for example, to obtain signal to noise ratio not far from 57 dB between Accra - Bolgatanga.

Table 3.3.1 Path Information (Kumasi-Tamale)

Items	Kumasi~ Jamasi		Jamasi~ Ejura		Ejura~ Atebubu		Atebubu~ Kapilim	
1) Hop Distance(km)	40.8		41.0		61.8		51.9	
2) Type of Path	M		P		P		P	
3) Antenna Size (Main)(mø)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
" (S/D) (")	-	-	-	-	4.0	4.0	-	-
4) Antenna Height (Main)(m)	80	27	46	30	95	130	105	80
" (S/D) (")	-	-	-	-	85	120	-	-
5) Feeder Length, Loss(m)/(dB)	90/2.3	47/3.2	66/2.3	*40/2.7	105/2.6	140/3.3	115/2.8	90/2.3
6) Branching Filter Loss (dB)	3.2		3.2		3.2		3.2	
7) Reflection Point (km)	5.5		30.6		41.1		29.0	
8) Altitude of Ref. Point (m)	283		185		175		85	
9) Condition of Ref. Point	Hill(Trees)		Hill(Trees)		Hill(Trees)		Swamp(Bush)	
10) Effective Reflection Coefficient	0.1		0.01		0.26		0.1	
11) Equivalent Ant. Height (m)	40	261	356	134	116	58	99	77
12) Path Difference (m)	0.5		2.6		0.2		0.3	
13) Receiver Input Level (dBm)	-32.6		-32.1		-36.6		-34.3	
14) FM Thermal Noise(dB/PW)	-79.7/10.7		-80.2/9.6		-75.7/27.0		-78.0/15.8	
15) Standard Deviation(dB)	1.9		2.3		3.4		2.9	
16) $P_{Re}/2P_R$	/0.004		/0.0097		0.1/		/0.02	
17) S/D	-		-		S/D		-	
18) Interval of S/D Antenna	-		-		10	10	-	
19) Correlation Co-efficient of S/D	-		-		0.33	0.33	-	
20) Hight Pattern Half Pitch(m)	1.6	10.0	3.0	1.0	10.6	5.3	6.7	5.2
21) Depth of Interference Pattern (dB)	0.8		0		2.6		0.8	
22) t47,500($\times 10^{-3}$%)								
Without S/D	0.09		0.2		5.7		0.67	
With S/D	-		-		0.11		-	
23) t1,000,000 ($\times 10^{-4}$%)								
Without S/D	0.076		0.167		4.83		0.57	
With S/D	-		-		0.1		-	

Table 3.3.2 Path Information (Kumasi-Tamale)

Items	Kapilim~ Salaga		Salaga~ Palbusi		Palbusi~ Tamale	
1) Hop Distance (km)	51.9		49.2		58.2	
2) Type of Path	L		P		P	
3) Antenna Size(Main)(mø)	4.0	4.0	4.0	4.0	4.0	4.0
" (S/D) (")	4.0	4.0	-	-	4.0	4.0
4) Antenna Height(Main)(m)	65	75	75	130	105	75
" (S/D) (")	53	65	-	-	95	65
5) Feeder Length,Loss(m)/(dB)	75/2.0	85/2.2	85/2.2	140/3.3	115/2.8	95/2.8
6) Branching Filter Loss (dB)	3.2		3.2		3.2	
7) Reflection Point (km)	21.2		21.8		27.8	
8) Altitude of Ref. Point(m)	85		130		100	
9) Condition of Ref. Point	Lake		Farm		Swamp(Bush)	
10) Effective Reflection Coefficient	0.7		0.1		0.2	
11) Equivalent Ant.Height(m)	67	97	79	99	103	112
12) Path Difference	0.2		0.3		0.4	
13) Receiver Input Level(dBm)	-33.4		-34.2		-35.8	
14) FM Thermal Noise(dB/PW)	-78.9/12 8		-78.1/15.5		-76.5/22.4	
15) Standard Deviation (dB)	4.1		2.7		3.2	
16) $P_{Re}/2P_R$	0.5/		/0.02		0.05/	
17) S/D	S/D		-		S/D	
18) Interval of S/D Antenna	12	10	-		10	10
19) Correlation Coefficient of S/D	0.2	0.2	-		0.23	0.23
20) Hight Pattern Half Pitch(m)	5.3	7.7	4.9	6.2	5.2	5.6
21) Dept of Interference Pattern (dB)	10.5		0.8		2.0	
22) t47,500 ($\times 10^{-3}$ %)						
Without S/D	13.5		0.65		2.4	
With S/D	0.27		-		0.05	
23) t1,000,000 ($\times 10^{-4}$ %)						
Without S/D	11.55		0.56		2.0	
With S/D	0.23		-		0.04	

Table 3.3.3 Path Information (Tamale~Bolgatanga)

	Tamale~ Diali	Diali~ Walewale	Walewale~ Gambaga	Gambaga~ Bolgatanga
1) Hop Distance(km)	52.1	51.0	45.5	53.1
2) Type of Path	P	P	P	P
3) Antenna Size (Main)(mφ)	4.0 4.0	4.0 4.0	4.0 4.0	4.0 4.0
" (S/D) (")	4.0 4.0	4.0 4.0	- -	- -
4) Antenna Height (Main)(mφ)	85 100	100 50	50 115	115 75
" (S/D) (")	75 88	85 35	- -	- -
5) Feeder Length, Loss(m)/(dB)	105/3.0 110/2.7	110/2.7 60/1.7	60/1.7 125/3.0	125/3.0 95/2.8
6) Branching Filter Loss (dB)	3.2	3.2	3.2	3.2
7) Reflection Point (km)	29.4	24.7	10.1	42.7
8) Altitude of Ref. Point	143	115	170	215
9) Condition of Ref. Point	Swamp(Bush)	Swamp(Bush)	Hill(Trees)	Hill(Trees)
10) Effective Reflection Coefficient	0.47	0.46	0.05	0.05
11) Equivalent Ant. Height (m)	82 64	86 92	72 252	174 43
12) Path Difference (m)	0.2	0.3	0.8	0.3
13) Receiver Input Level (dBm)	-35.0	-33.5	-32.8	-35.2
14) FM Thermal Noise (dB/PW)	-77.3/18.6	-78.8/13.2	-79.5/11.2	-77.1/19.5
15) Standard Deviation (dB)	2.9	2.8	2.6	2.9
16) $P_{Re}/2P_R$	0.19/	0.19/	/0.01	/0.02
17) S/D	S/D	S/D	-	-
18) Interval of S/D Antenna	10 12	15 15	-	-
19) Correlation Coefficient of S/D	0.24 0.2	0.1 0.1	-	-
20) Hight Pattern Half Pitch(m)	8.1 6.3	5.5 5.9	1.8 6.3	12.3 3.0
21) Depth of Interference Pattern (dB)	5.5	5.4	0.4	0.4
22) t47,500 ($x10^{-3}$ %)				
Without S/D	7.4	5.3	0.24	0.82
With S/D	0.15	0.11	-	-
23) t 1,000,000 ($x10^{-4}$ %)				
Without S/D	6.3	4.47	0.19	0.7
With S/D	0.13	0.09	-	-

Remarks on "Path Information"

1) Type of Path

   M: Path passing over mountain
   P: Path passing over plain
   L: Path passing over lake

2) Antenna Size

   S/D: Space diversity antenna

3) Feeder Length

   The mark * shows the elliptical waveguide.
   No mark means the circular waveguide

4) FM Thermal Noise

   Under free space condition.
   (Emphasis on, psophometrically weighted)

5) Standard Deviation

   Standard deviation of instanteneous received powerdistribution in dB

6) P_{Re}

   Probability of equivalent Rayleigh fading

7) P_R

   Probability of Rayleigh fading

8) $t_{47,500}$

   Percent of time the FM thermal noise exceeds 47,500 PWP

9) $t_{1,000,000}$

   Percent of time the FM thermal noise exceeds 1,000,000 PW

Table 3.3.4 Total Hourly Mean Noise Power and t47,500, t1,000,000

Items	Kumasi ~Tamale	Tamale ~Bolgatanga	Kumasi ~ Bolgatanga
Distance (km)	454.8	201.7	656.5
Noise Objective (PW)	1,564.4	805.1	2,169.5
Estimated Value (PW)			
FM Thermal Noise	721.5	493.8	1,215.3
Equipment Noise	183.0	114.0	297.0
Interference Noise	232.9	135.6	368.5
Total Noise	1,137.4	743.4	1,880.8
t47,500 Objective (%)	0.018	0.011	0.026
Estimated Value (%)			
Without S/D	0.023	0.014	0.037
With S/D	(0.002)	(0.001)	(0.003)
t1,000,000 Objective(%) (CCITT)	0.00018	0.0001	0.00026
Estimated Value (%)			
Without S/D	0.002	0.0012	0.0032
With S/D	(0.00016)	(0.0001)	(0.00026)

Remarks

Noise Value:

Psophometrically weighted and Emphasis on.

Table 3.3.5 Interference Noise

Name of Hop	Due to Over-Reach (PW)	Path Distortion (PW)	Feeder Echo (PW)		Remarks
Kumasi - Jamasi	Less than 1 PW	Less than 1 PW	4.9	3.2	
Jamasi - Ejura	"	"	4.9	3.2	
Ejura - Atebubu	13.8	"	4.3	3.1	
Atebubu - Kapilim	Less than 1 PW	"	3.9	4.9	
Kapilim - Salaga	"	"	5.6	5.1	
Salaga - Palbusi	"	"	5.1	3.1	
Palbusi - Tamale	"	"	3.9	3.9	
Sub Total	13.8	Neglectible Small	59.1		
Tamale - Diali	Less than 1 PW	Less than 1 PW	3.5	4.1	
Diali - Walewale	"	"	4.1	6.5	
Walewale - Gambaga	"	"	6.5	3.5	
Gambaga-Bolgatanga	"	"	3.5	3.9	
Sub Total	Neglectible Small	Neglectible Small	35.6		

Table 3.4.1 Signal (P-P) to Continuous Randam Noise (r.m.s) Ratio

Name of Hop	$\frac{S(P-P)}{N(r.m.s)}$(dB) (In Free Space)	t44dB (%)	Remarks
Kumasi - Jamasi	89.5	0.00001	
Jamasi - Ejura	90.0	0.000024	
Ejura - Atebubu	85.5	0.00071	
Atebubu - Kapilim	87.8	0.00008	
Kapilim - Salaga	88.7	0.0017	
Salaga - Palbusi	87.9	0.00008	
Palbusi - Tamale	86.3	0.000295	
Tamale - Diari	87.1	0.00093	
Diali - Walewale	88.6	0.00066	
Walewale - Gambaga	89.3	0.000029	
Gambaga - Bolgatanga	86.9	0.0001	

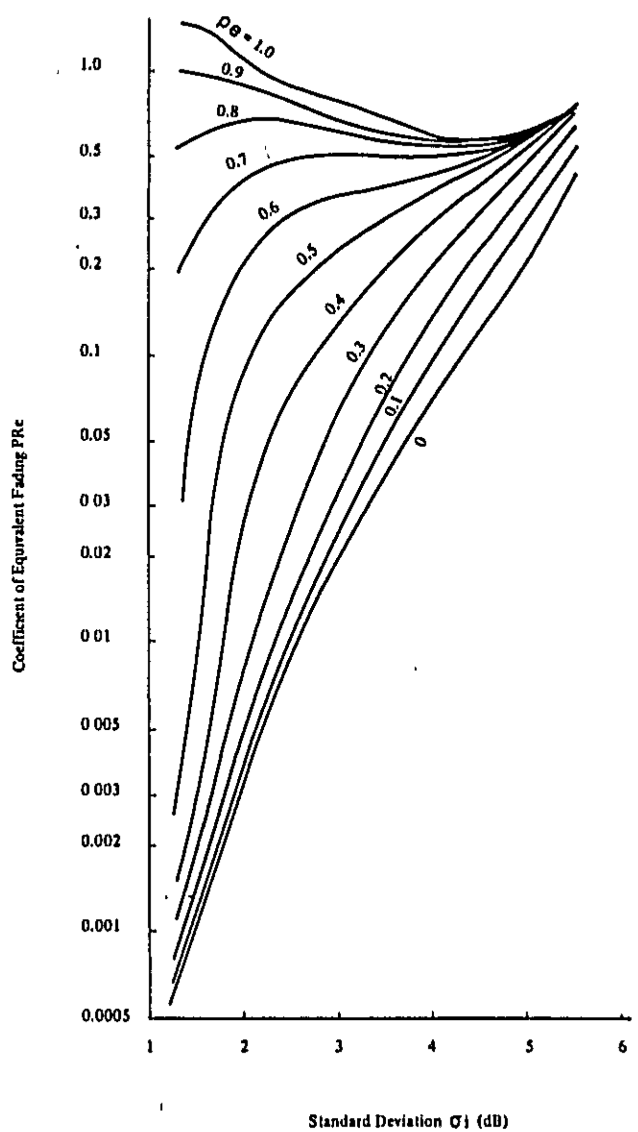
Remarks

S(P-P)/N(r.m.s) Value: Emphasis on and weighted value.

Table 3.4.4 Signal (P-P) to Noise (r.m.s) Ratio

Items	Kumasi~ Tamale	Tamale~ Bolgatanga	Kumasi~ Bolgatanga
Distance (km)	454.8	201.7	656.5
Objective (20% Value)			
Signal(P-P) to Continuous Randam Noise Ratio (dB)	60.8	60.8	60.8
Estimated Value (Weighted Value, Emphasis on)			
In Free Space (dB)	79.2	81.8	77.3
20% Value (dB)	76.5	78.8	74.6
Signal to White Noise (Modem, Weighted Value)	70.0	70.0	70.0
Objective (t 44dB) (%)	0.033	0.033	0.033
Estimated Value (%)	0.0029	0.0017	0.0064

Fig. 3.3.1 Coefficient PRe of Equivalent Fading when Standard Deviation σ_l of Received Power Distribution (when $\rho e = 0$) vs $\rho e \gtrless 0$ (Standard of Free Space Value)



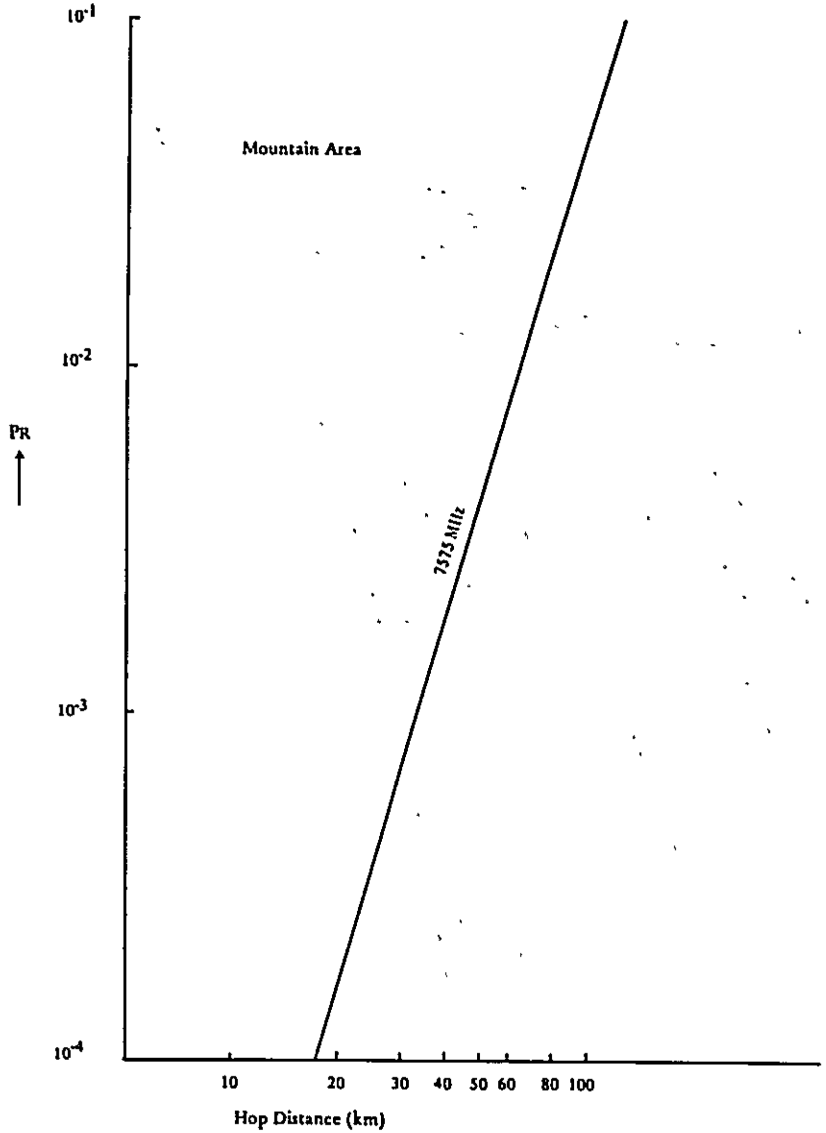


Fig. 3.3.2 Probability of Rayleigh Fading (P_R)

Fig. 3.3.3 Probability of Rayleigh Fading (PR)

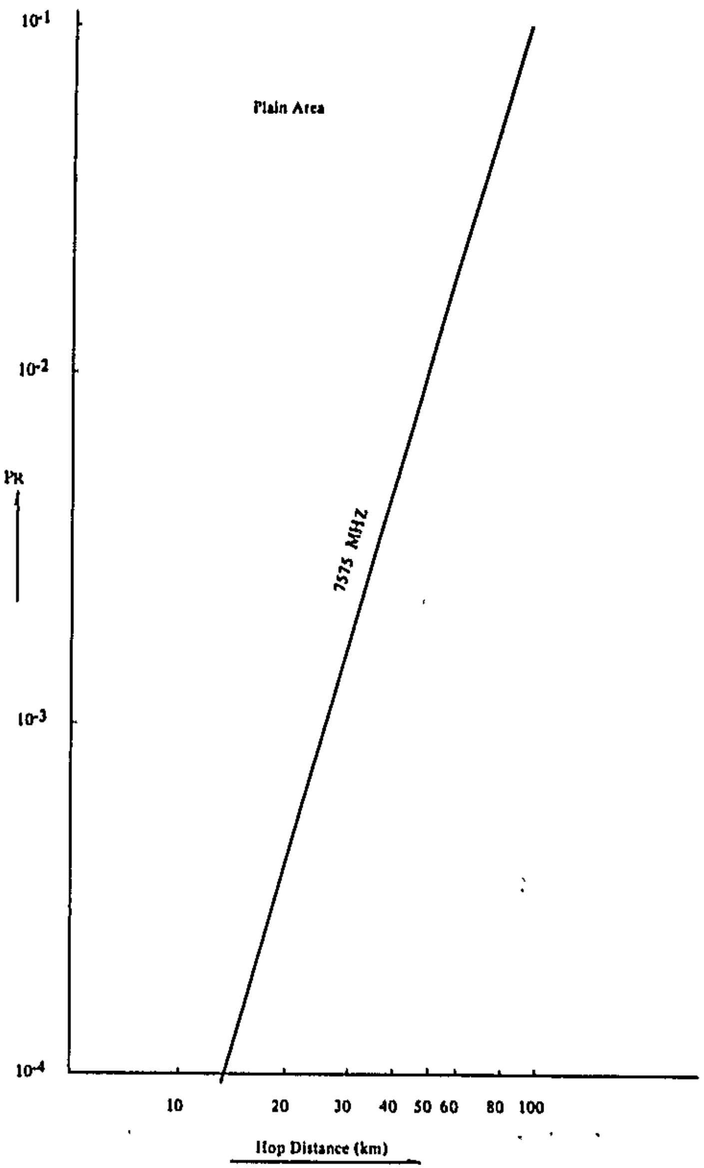


Fig. 3.3.4 K VS. Z

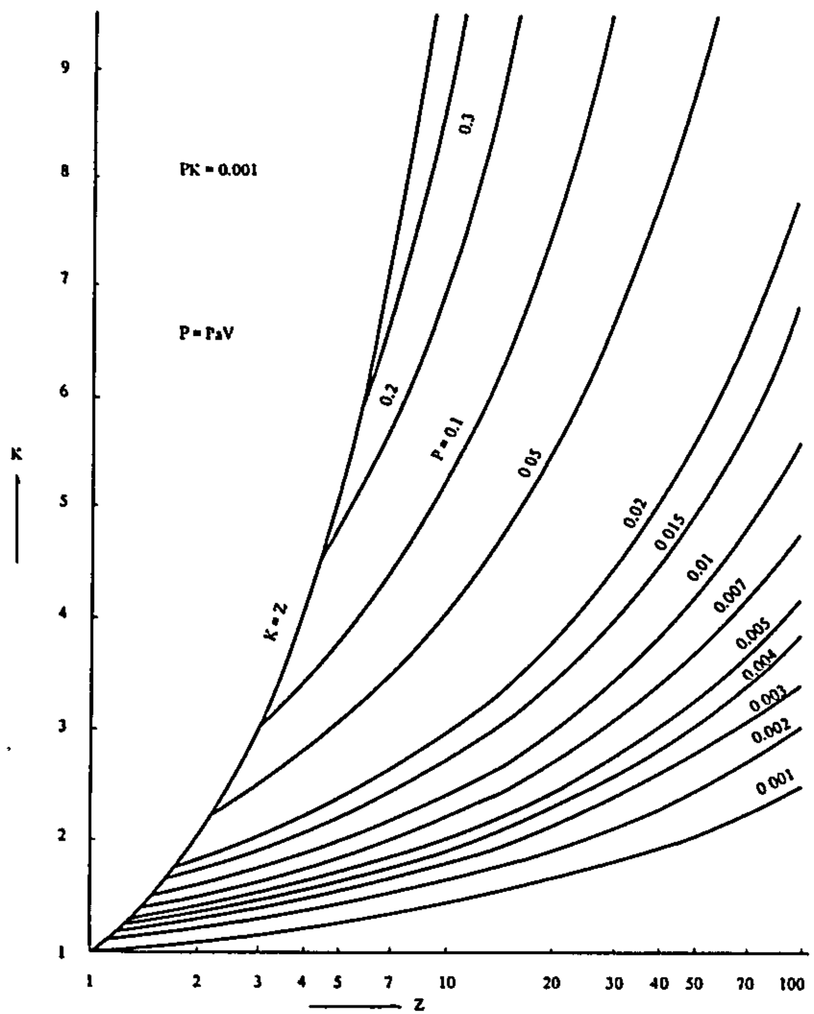


Fig. 3.3.5 Propagation Path Distortion Noise

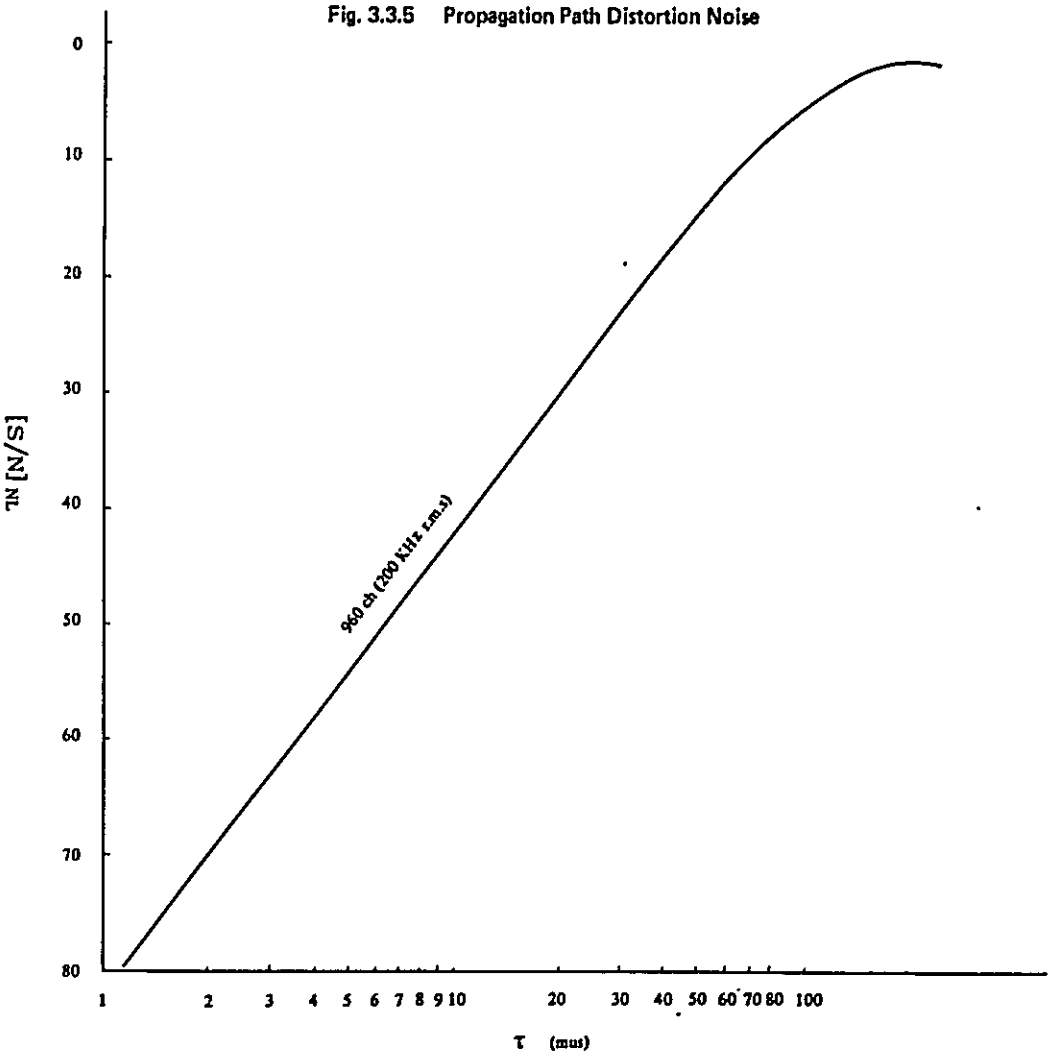


Fig. 3.3.6 Feeder Echo Noise

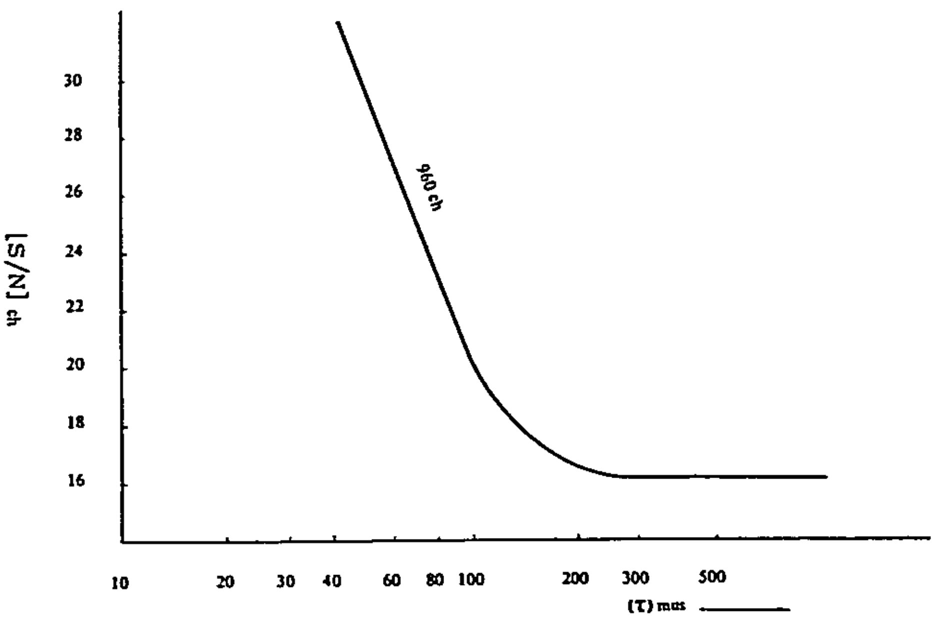


Fig. 3.4.1 σ VS. λ

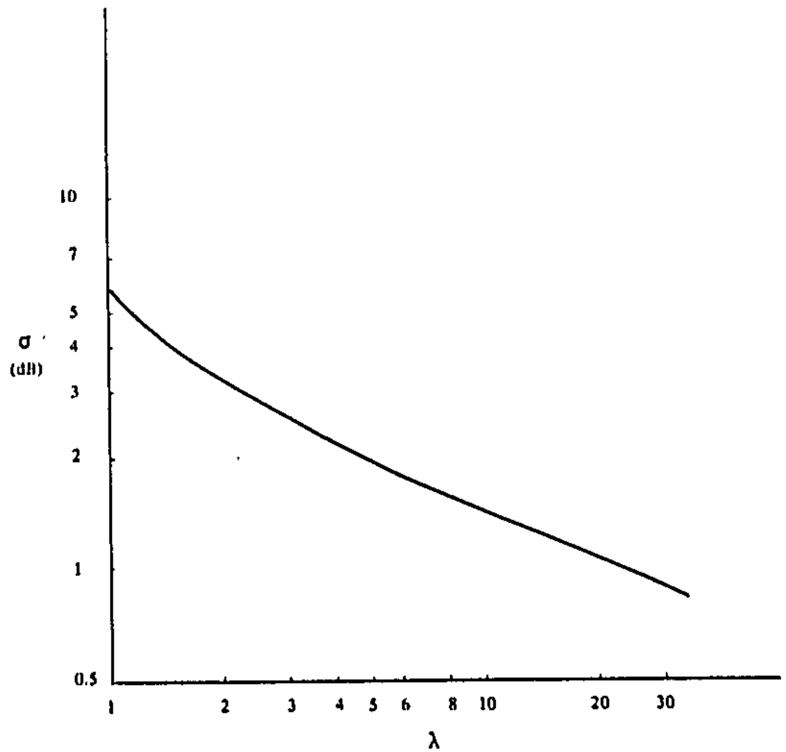
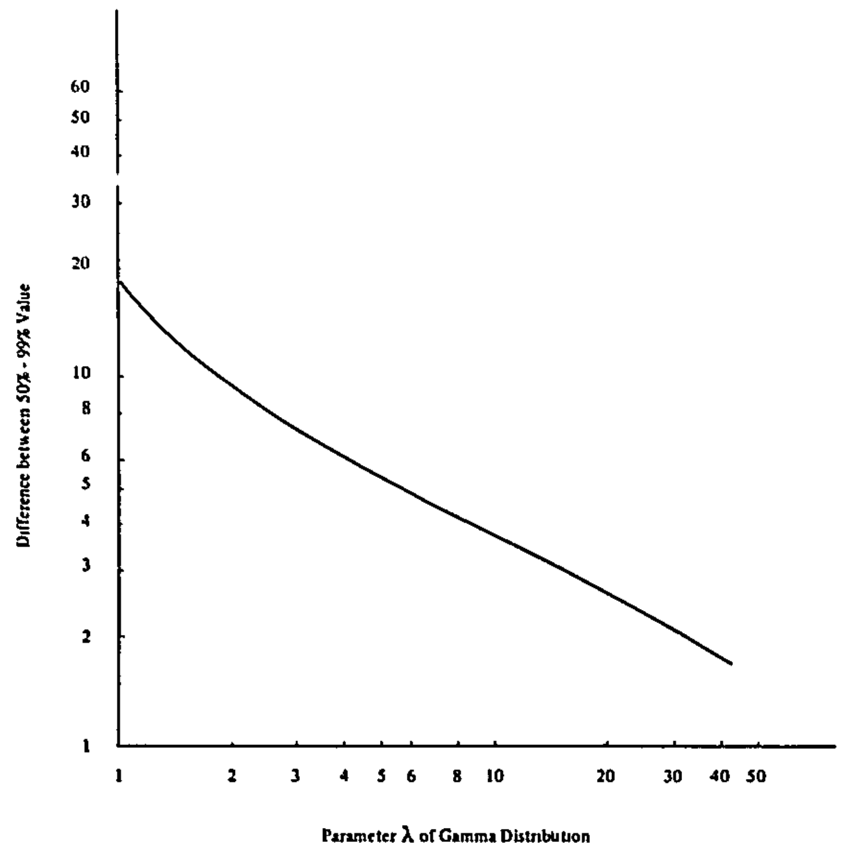


Fig. 3.4.2 Relation between "Difference 50% - 99%" and λ.



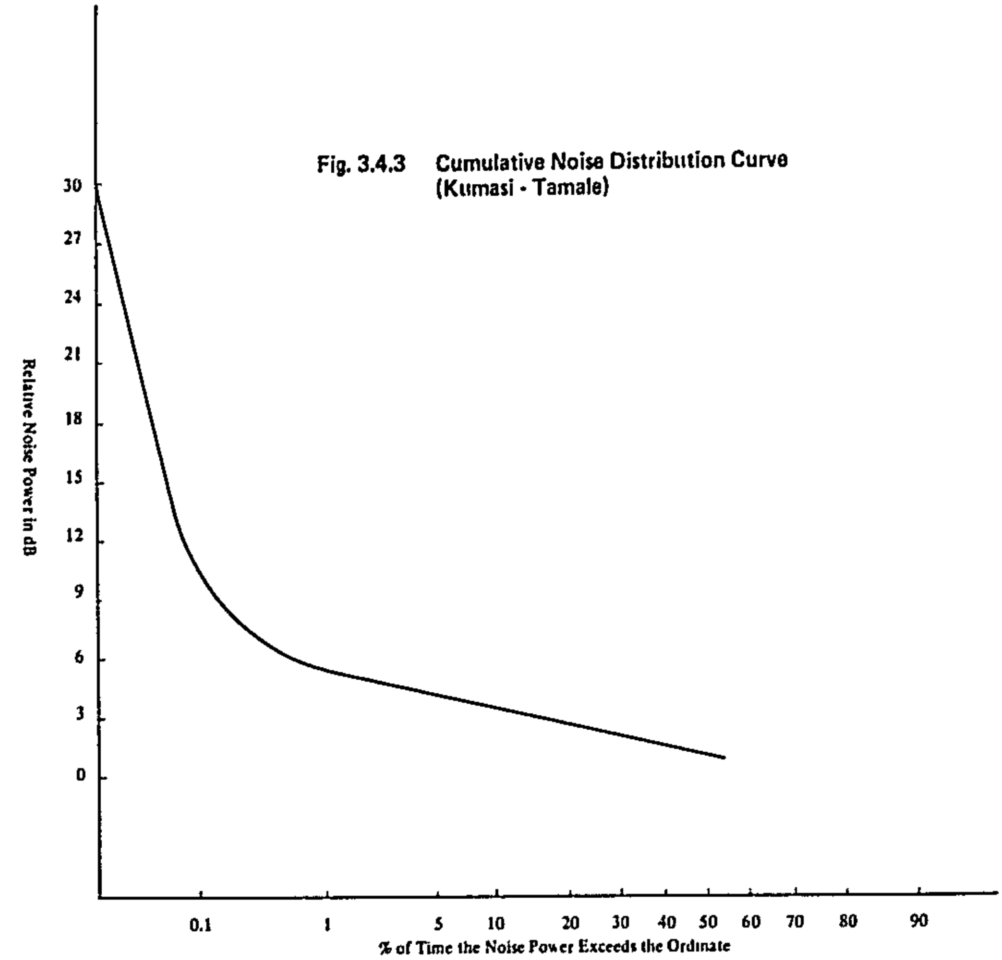


Fig. 3.4.3 Cumulative Noise Distribution Curve
(Kumasi - Tamale)
Relative Noise Power in dB
30
27
24
21
18
15
12
9
6
3
0
0.1
1
5
10
20
30
40
50
60
70
80
90
% of Time the Noise Power Exceeds the Ordinate

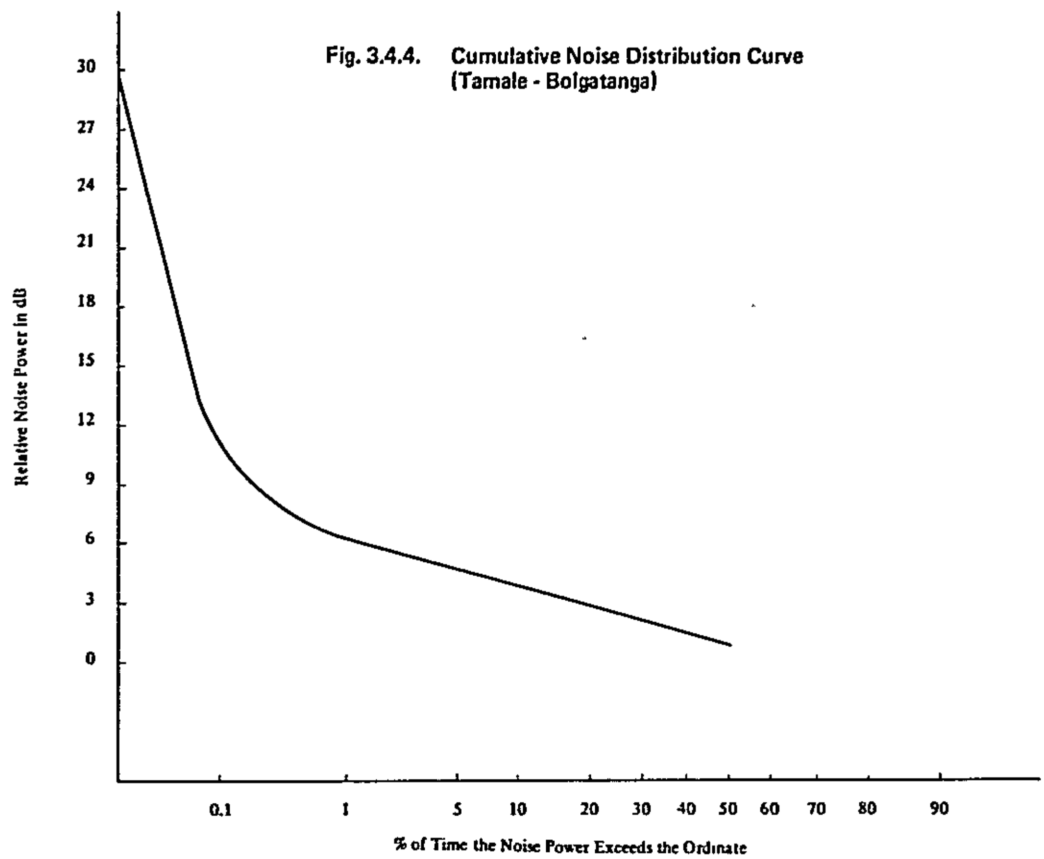
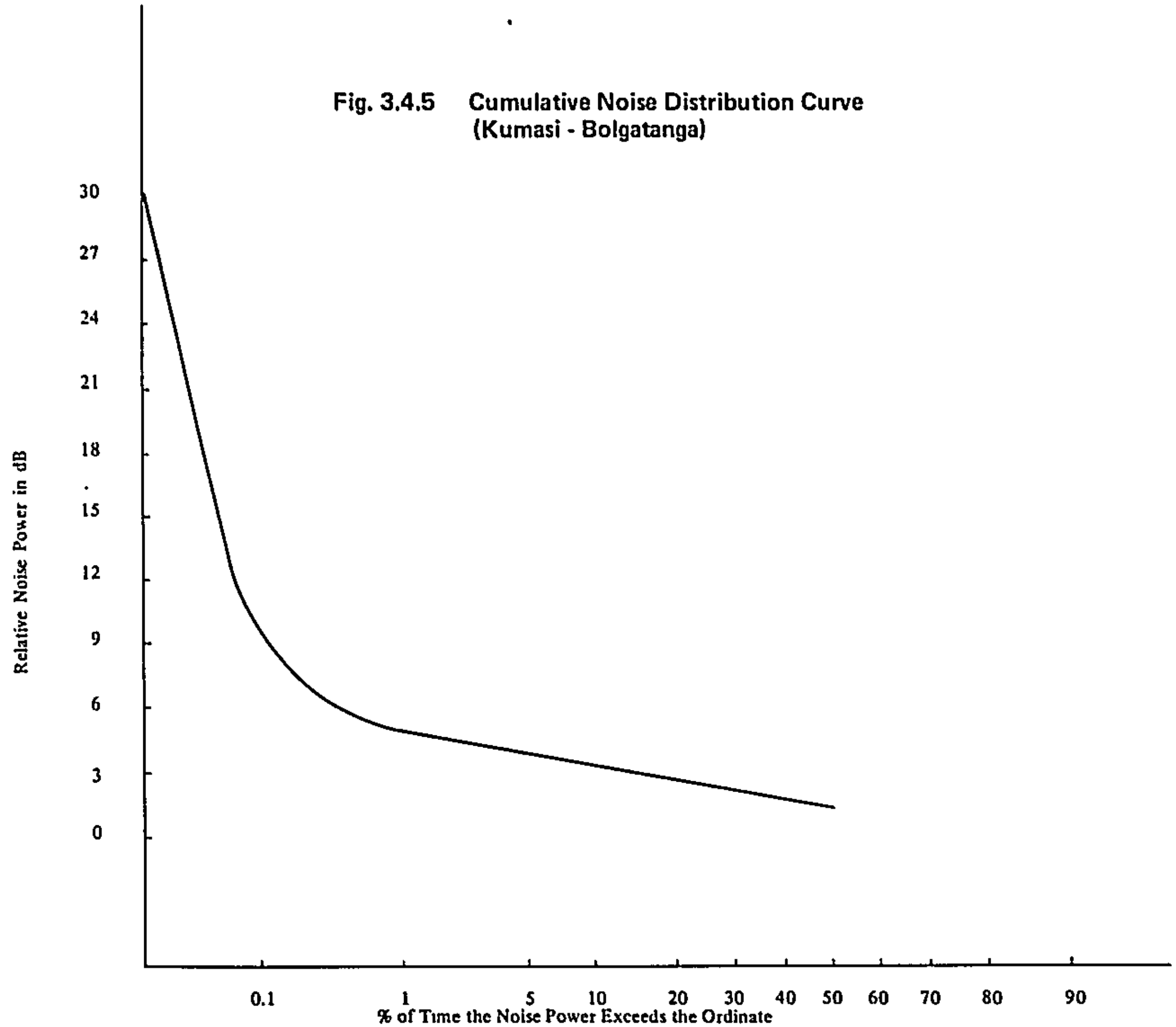


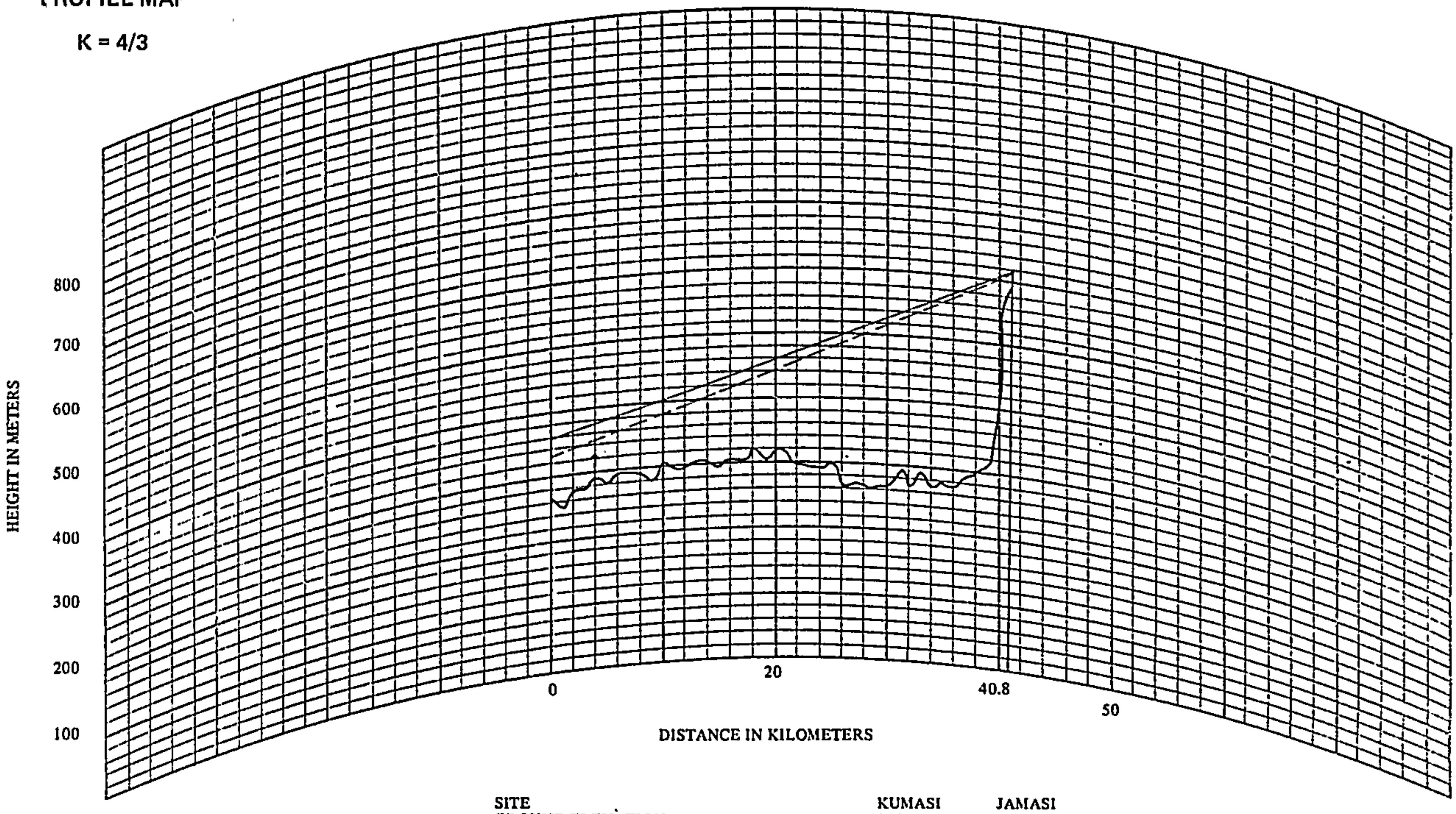
Fig. 3.4.4. Cumulative Noise Distribution Curve
(Tamale - Bolgatanga)
Relative Noise Power in dB
30
27
24
21
18
15
12
9
6
3
0
0.1
1
5
10
20
30
40
50
60
70
80
90
% of Time the Noise Power Exceeds the Ordinate

Fig. 3.4.5 Cumulative Noise Distribution Curve
(Kumasi - Bolgatanga)



PROFILE MAP

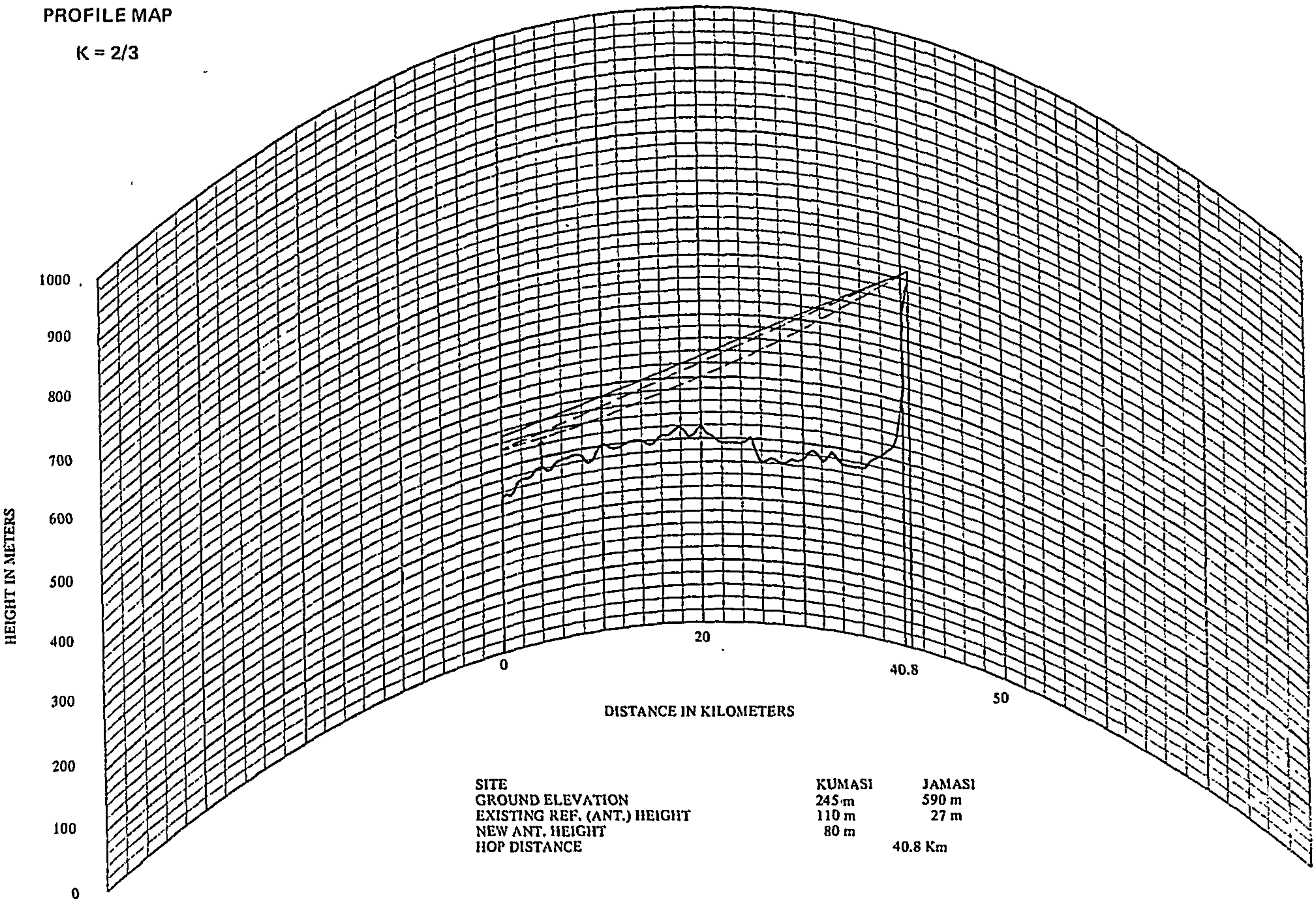
K = 4/3



SITE	KUMASI	JAMASI
GROUND ELEVATION	245 m	590 m
EXISTING REF. (ANT.) HEIGHT	110 m	27 m
NEW ANT. HEIGHT	80 m	
HOP DISTANCE	40.8 Km	

PROFILE MAP

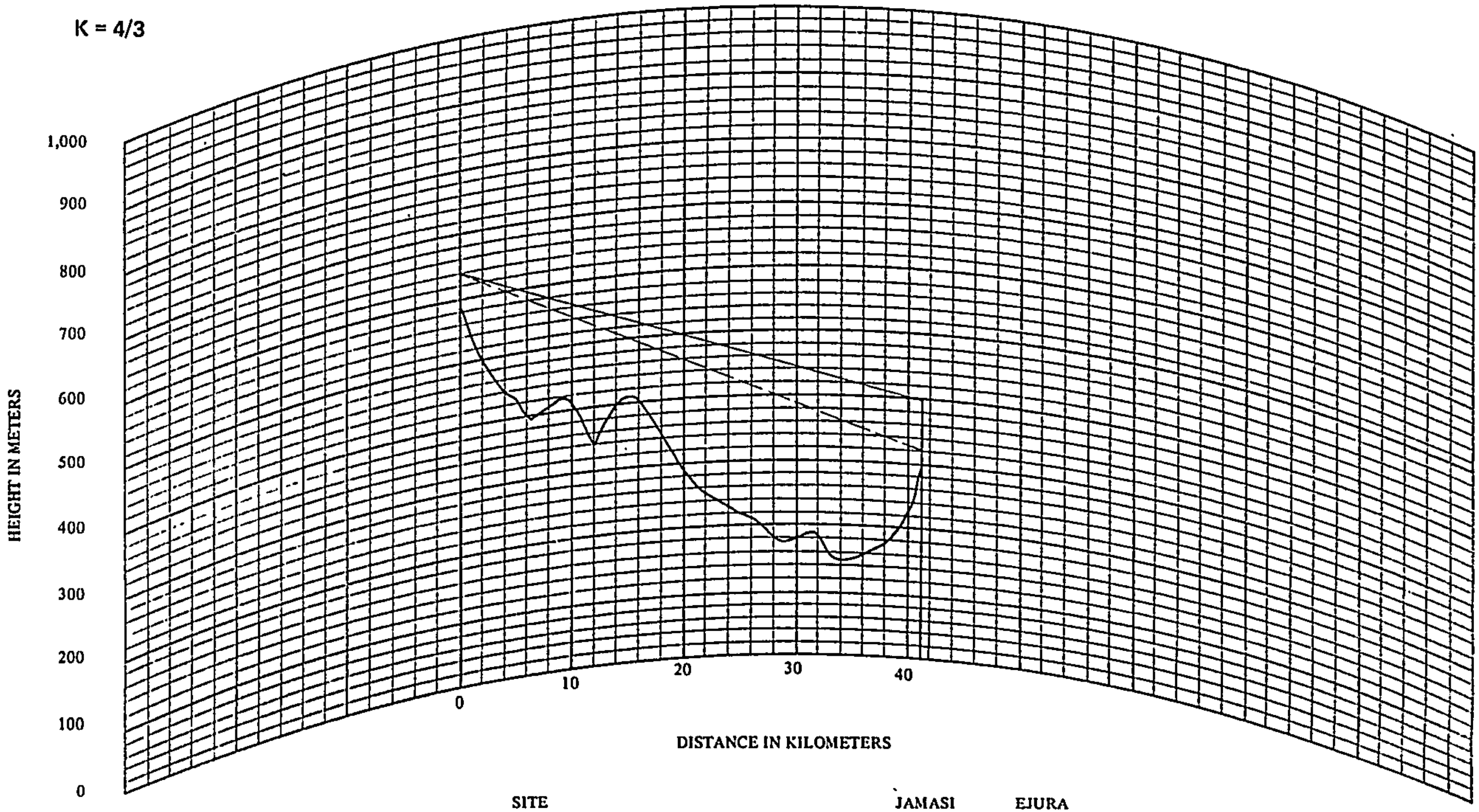
K = 2/3



SITE	KUMASI	JAMASI
GROUND ELEVATION	245 m	590 m
EXISTING REF. (ANT.) HEIGHT	110 m	27 m
NEW ANT. HEIGHT	80 m	
HOP DISTANCE	40.8 Km	

PROFILE MAP

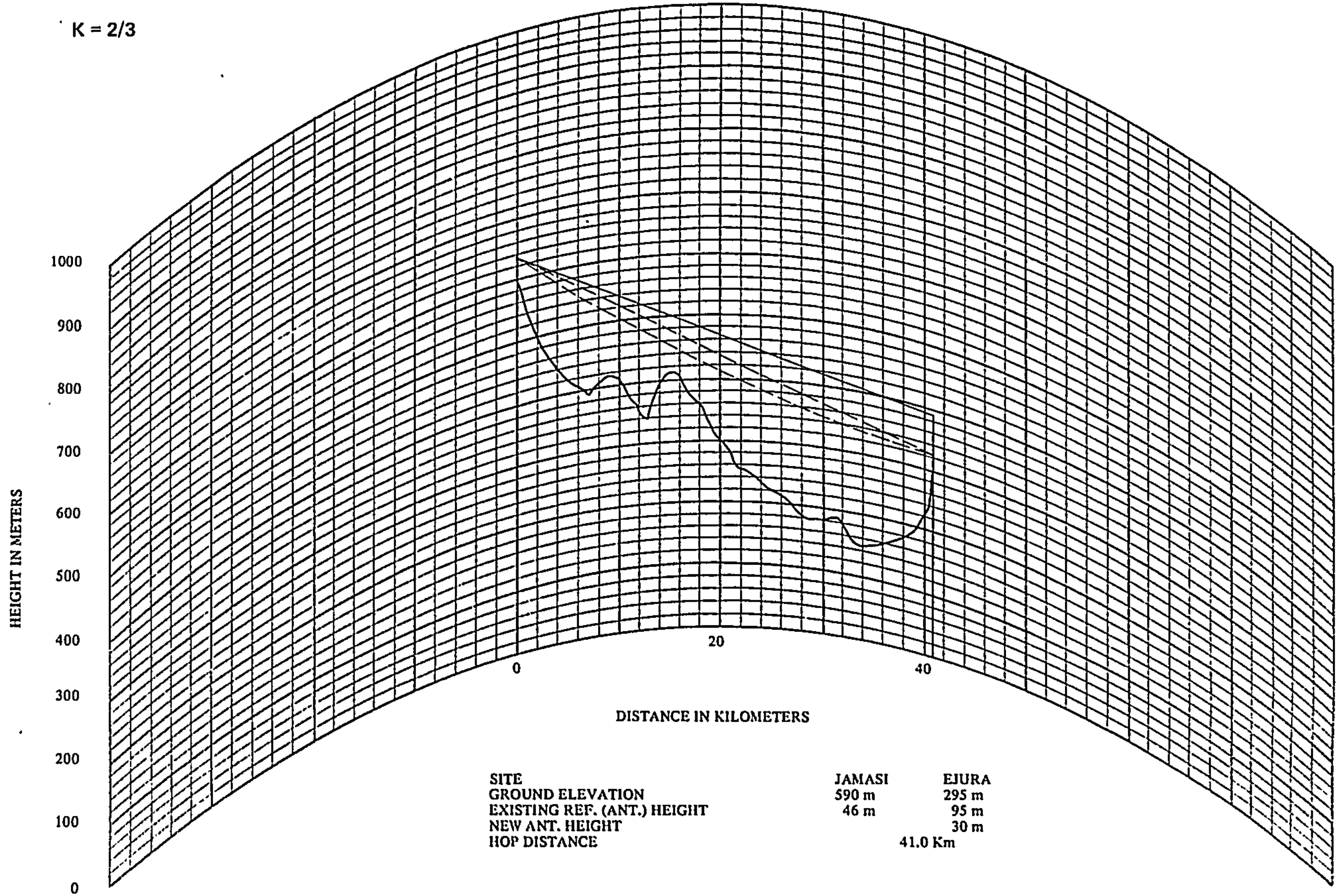
K = 4/3



SITE	JAMASI	EJURA
GROUND ELEVATION	590 m	295 m
EXISTING REF. (ANT.) HEIGHT	46 m	95 m
NEW ANT. HEIGHT		30 m
HOP DISTANCE	41.0 Km	

PROFILE MAP

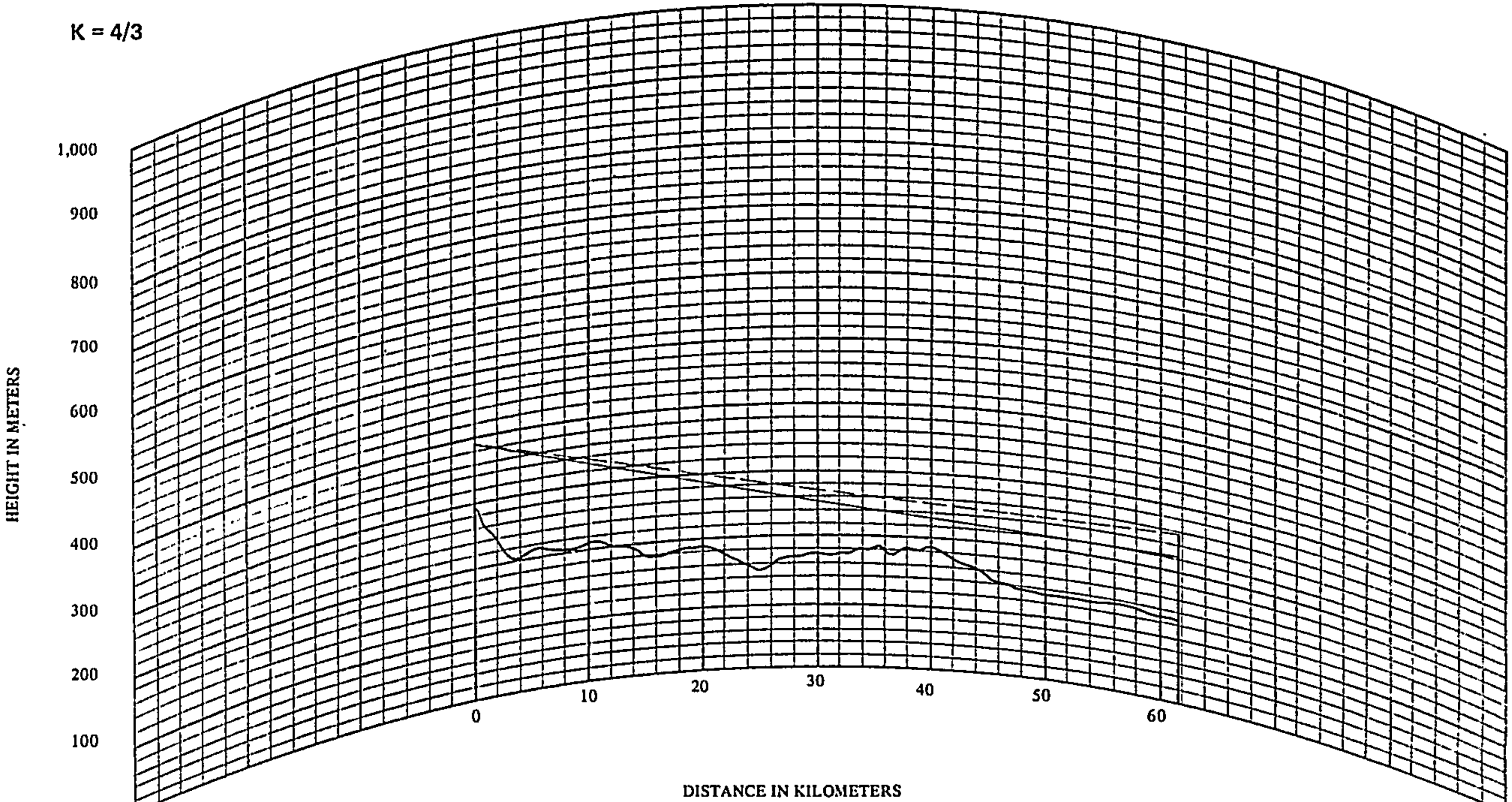
K = 2/3



SITE	JAMASI	EJURA
GROUND ELEVATION	590 m	295 m
EXISTING REF. (ANT.) HEIGHT	46 m	95 m
NEW ANT. HEIGHT		30 m
HOP DISTANCE	41.0 Km	

PROFILE MAP

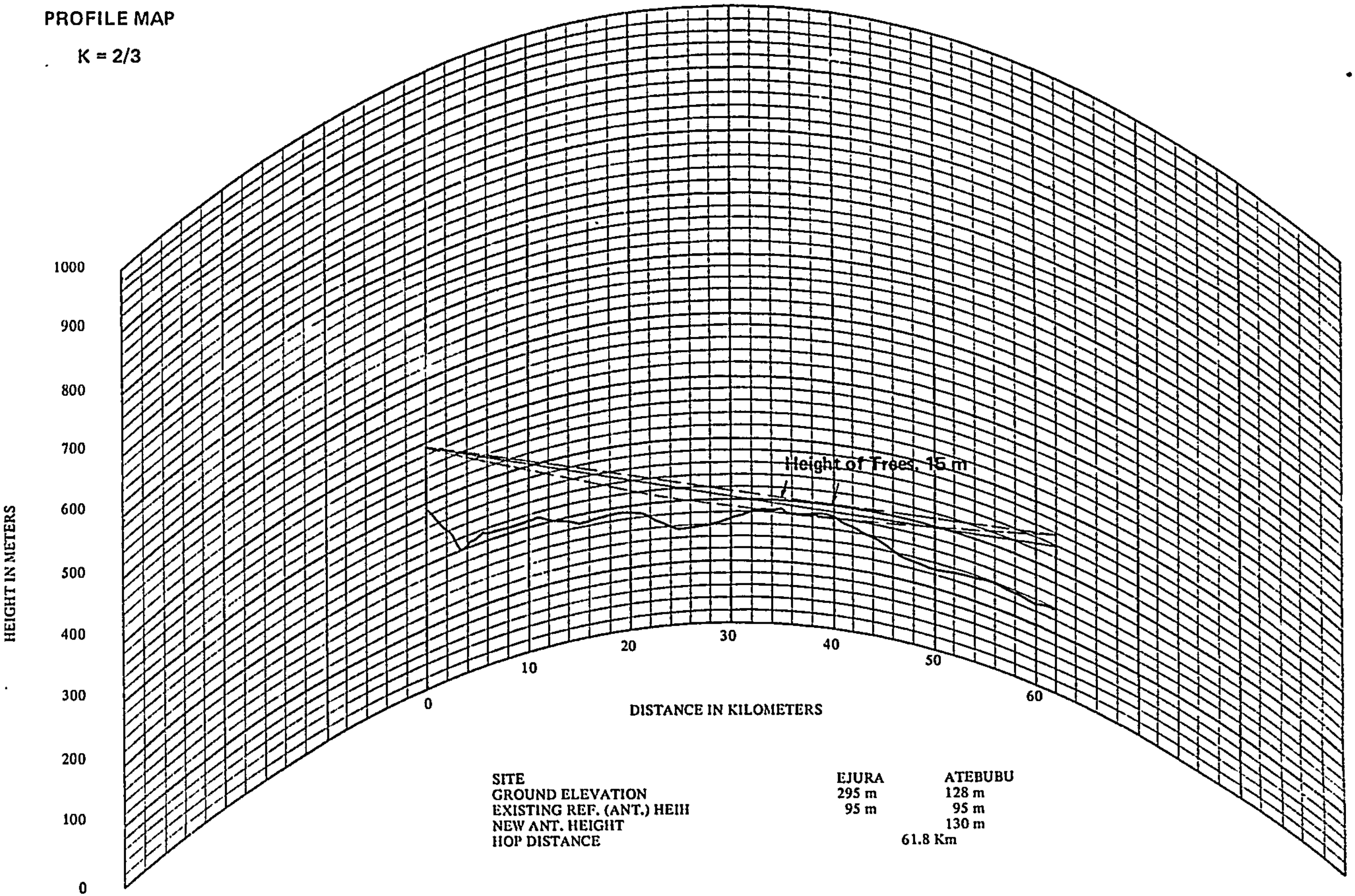
K = 4/3



SITE	EJURA	ATEBUBU
GROUND ELEVATION	295 m	128 m
EXISTING REF.(ANT.) HEIGHT	95 m	95 m
NEW ANT. HEIGHT		130 m
HOP DISTANCE	61.8 Km	

PROFILE MAP

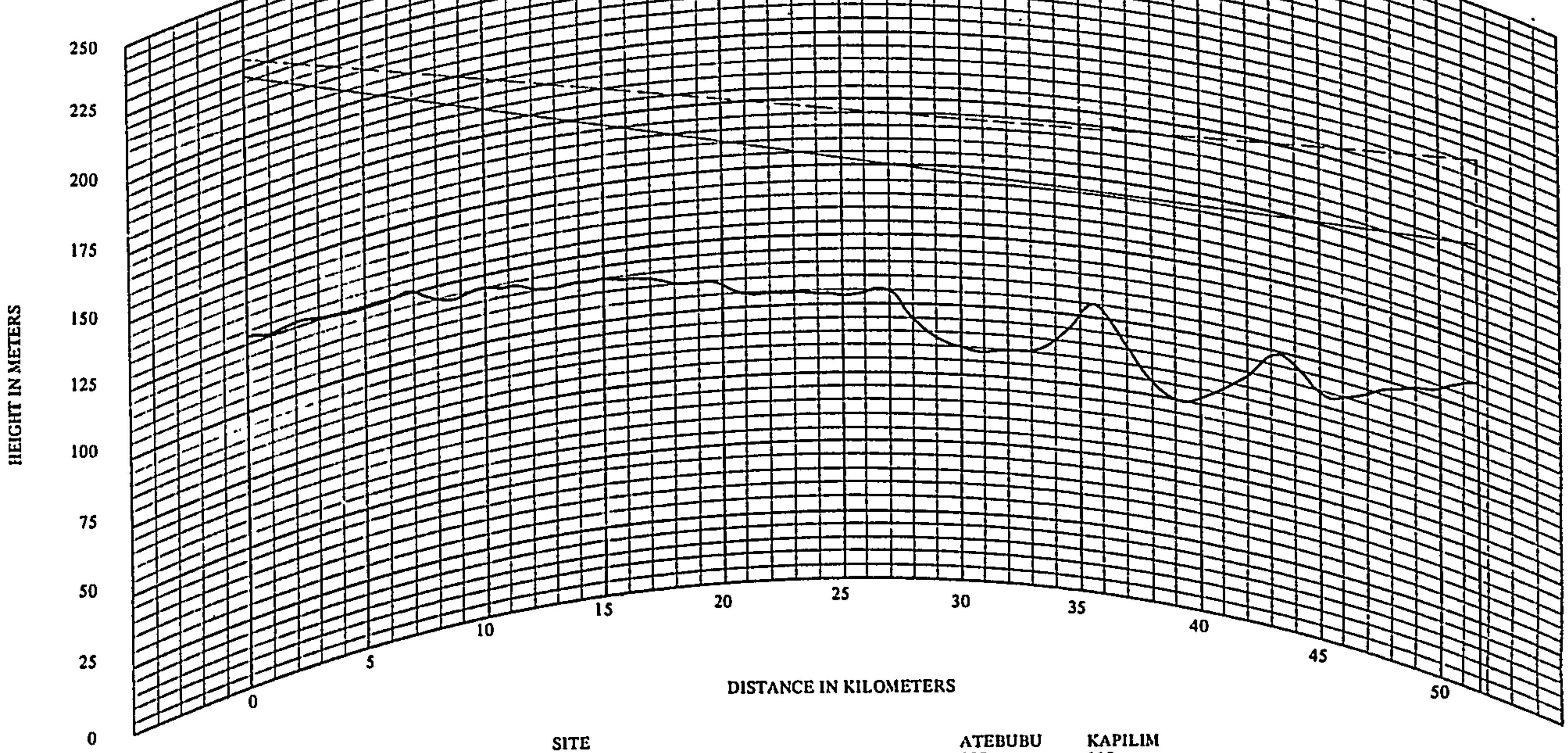
K = 2/3



SITE	EJURA	ATEBUBU
GROUND ELEVATION	295 m	128 m
EXISTING REF. (ANT.) HEIH	95 m	95 m
NEW ANT. HEIGHT		130 m
HOP DISTANCE	61.8 Km	

PROFILE MAP

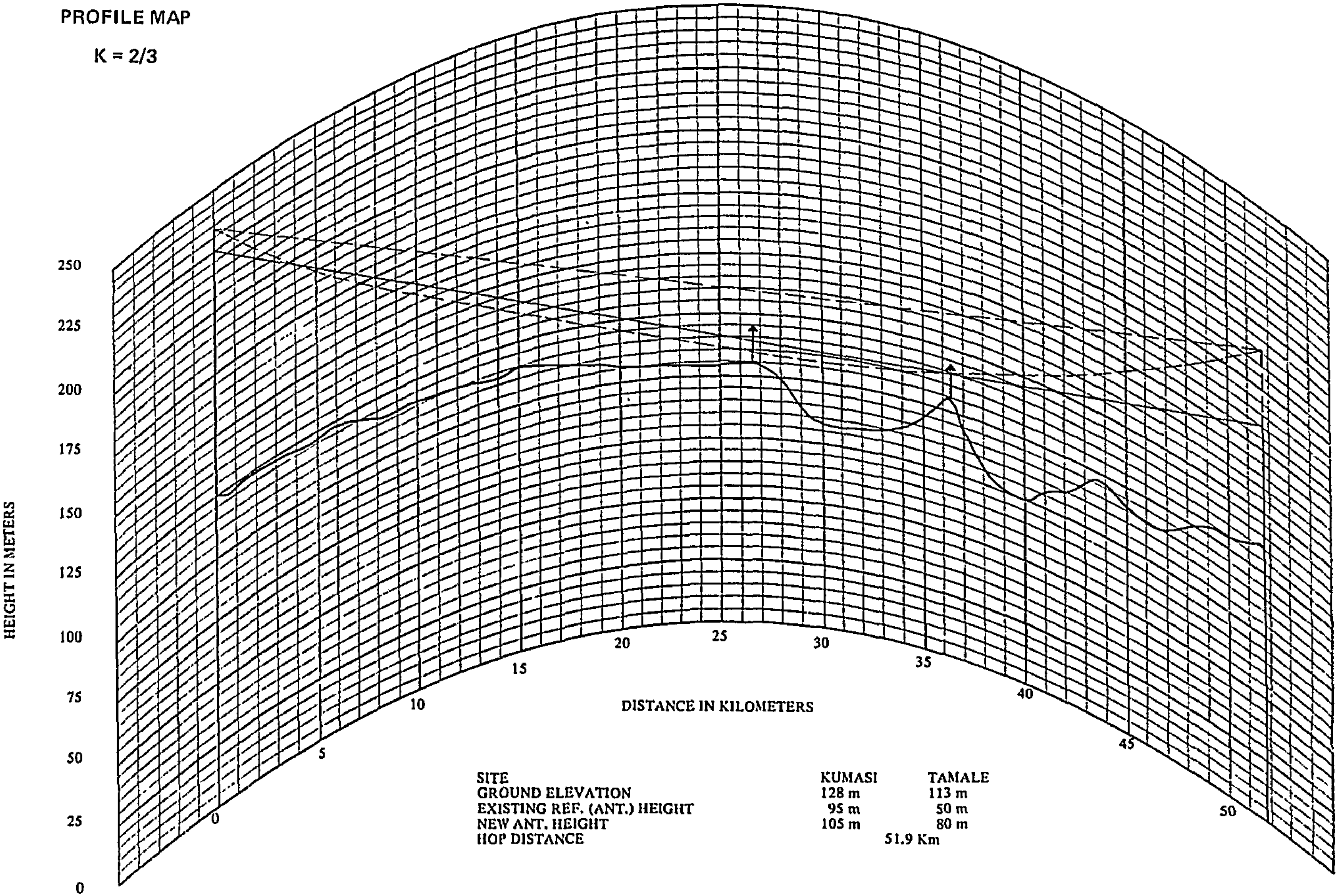
K = 4/3



SITE	ATEBUBU	KAPILIM
GROUND ELEVATION	128 m	113 m
EXISTING REF. (ANT.) HEIGHT	95 m	50 m
NEW ANT. HEIGHT	105 m	80 m
HOP DISTANCE	51.9 Km	

PROFILE MAP

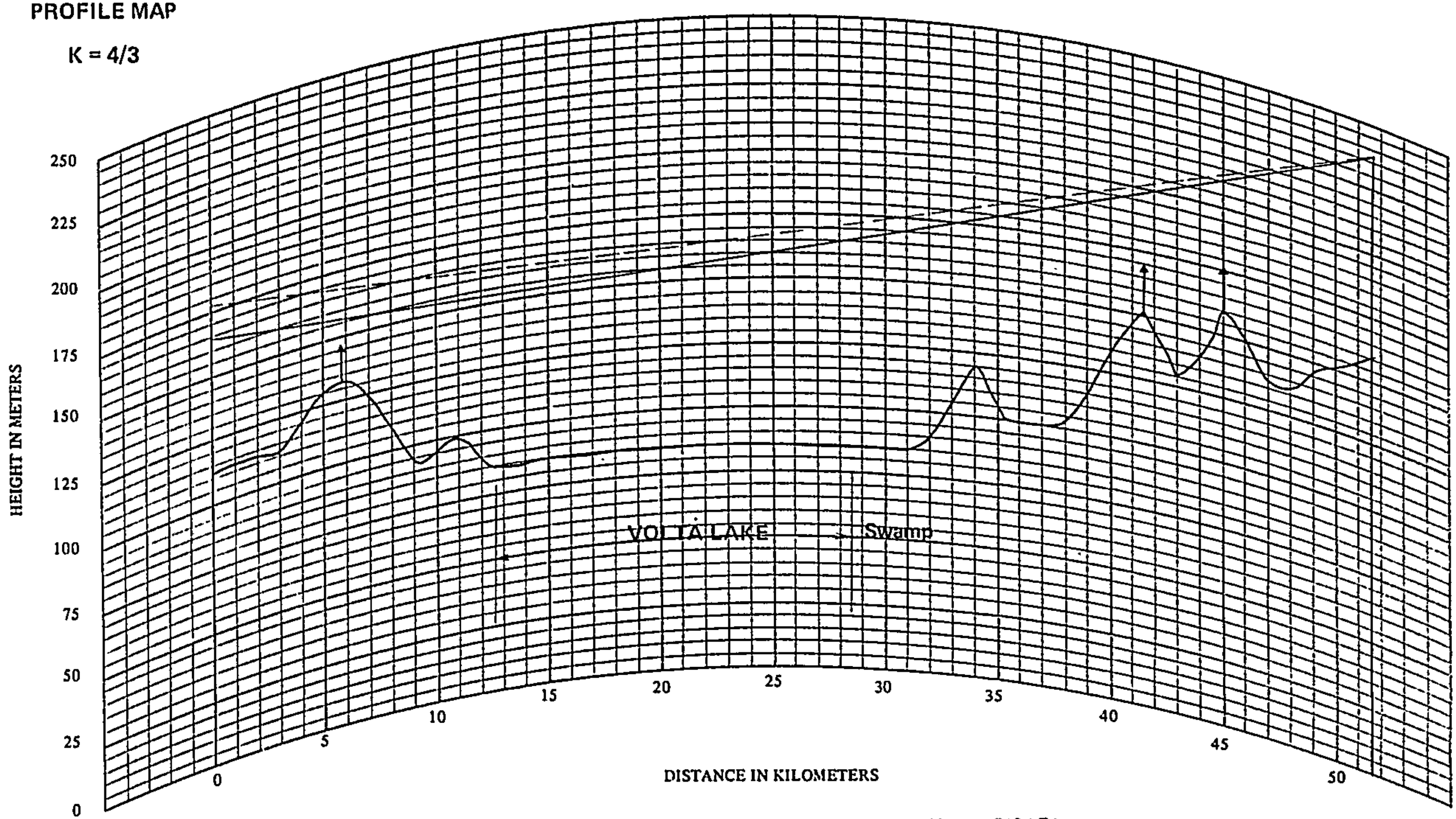
K = 2/3



SITE	KUMASI	TAMALE
GROUND ELEVATION	128 m	113 m
EXISTING REF. (ANT.) HEIGHT	95 m	50 m
NEW ANT. HEIGHT	105 m	80 m
HOP DISTANCE	51.9 Km	

PROFILE MAP

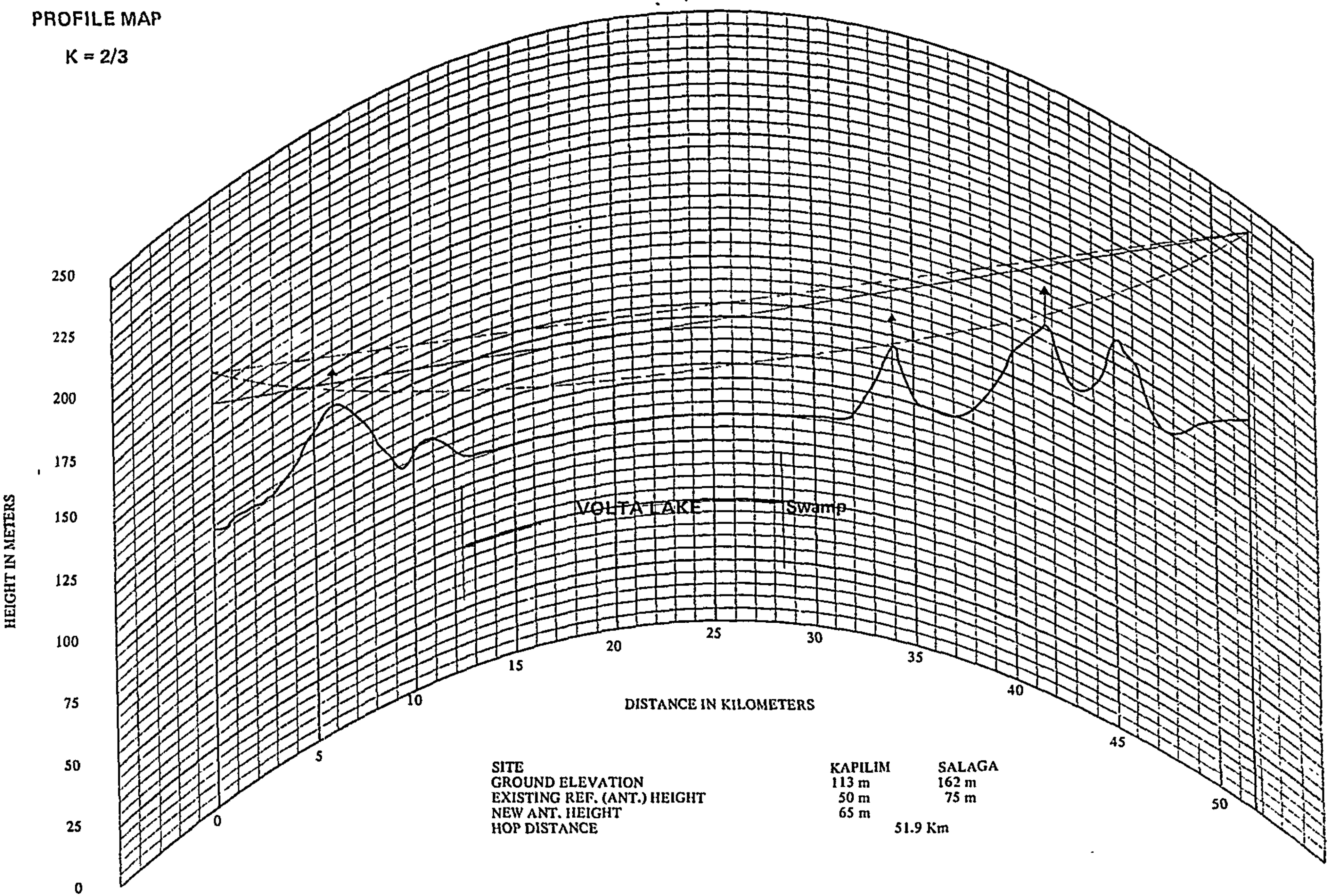
K = 4/3



SITE	KAPILIM	SALAGA
GROUND ELEVATION	113 m	162 m
EXISTING REF. (ANT.) HEIGHT	50 m	75 m
NEW ANT. HEIGHT	65 m	
HOP DISTANCE	51.9 Km	

PROFILE MAP

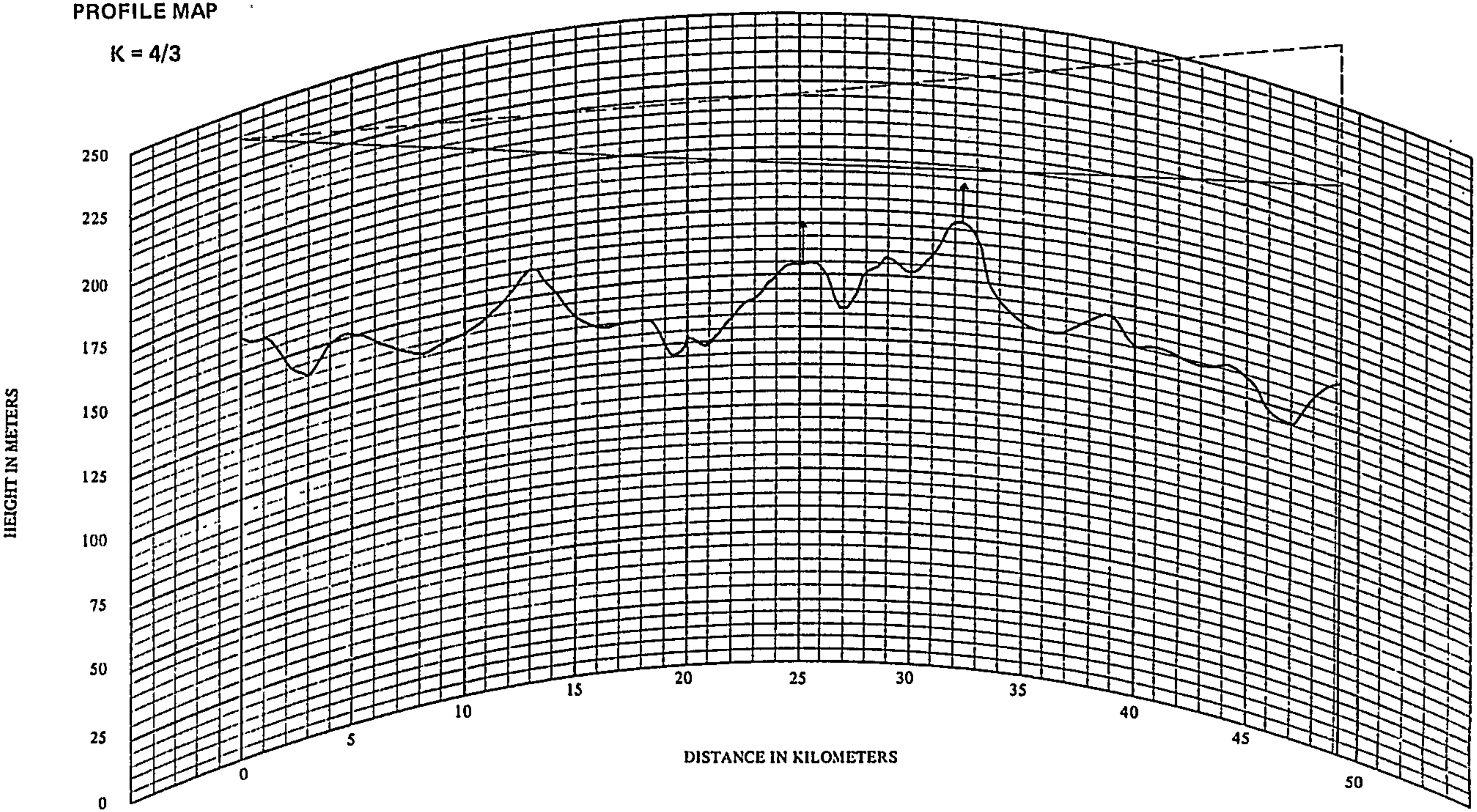
K = 2/3



SITE	KAPILIM	SALAGA
GROUND ELEVATION	113 m	162 m
EXISTING REF. (ANT.) HEIGHT	50 m	75 m
NEW ANT. HEIGHT	65 m	
HOP DISTANCE	51.9 Km	

PROFILE MAP

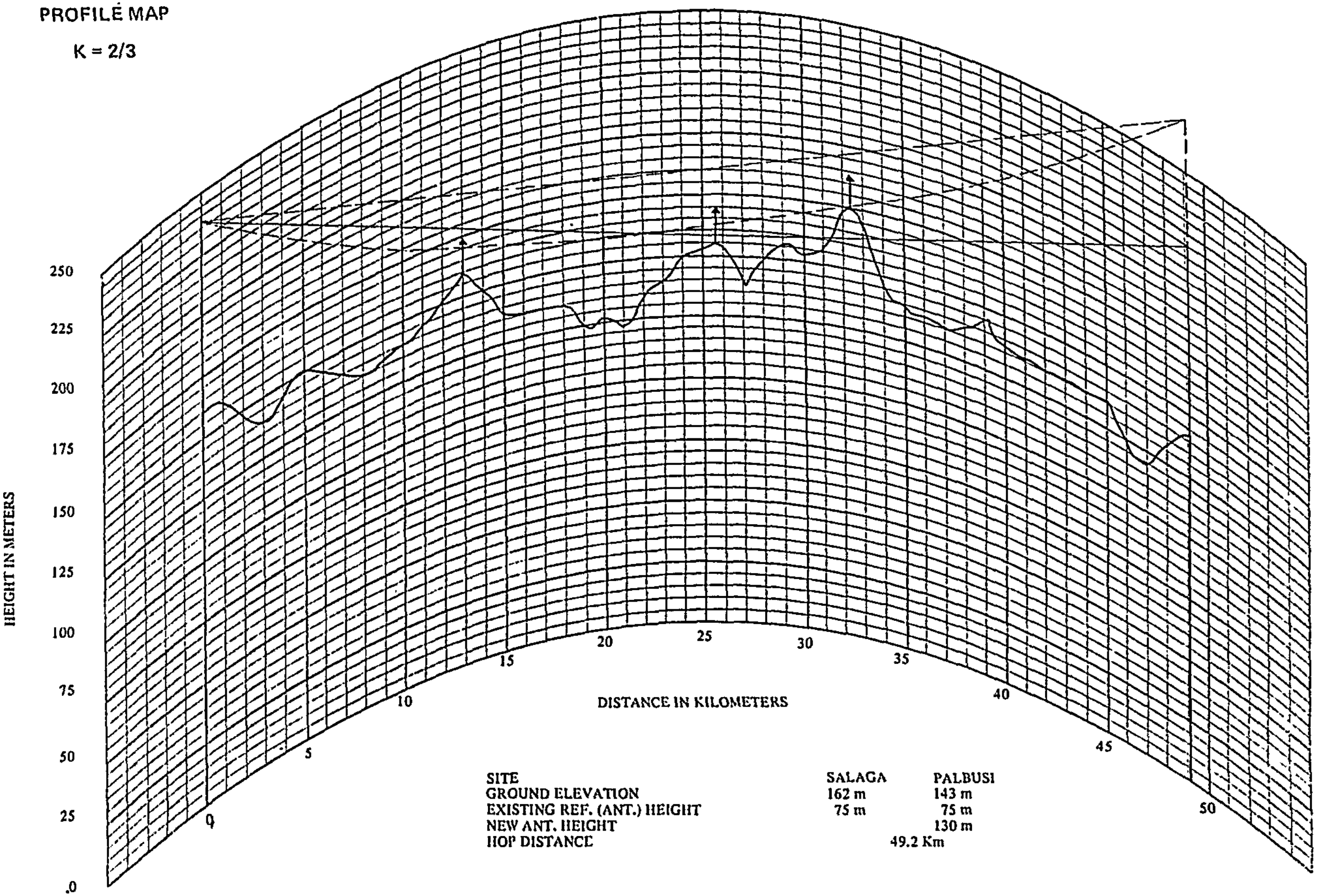
K = 4/3



SITE	SALAGA	PALBUSI
GROUND ELEVATION	162 m	143 m
EXISTING REF. (ANT.) HEIGHT	75 m	75 m
NEW ANT. HEIGHT		130 m
HOP DISTANCE	49.2 Km	

PROFILE MAP

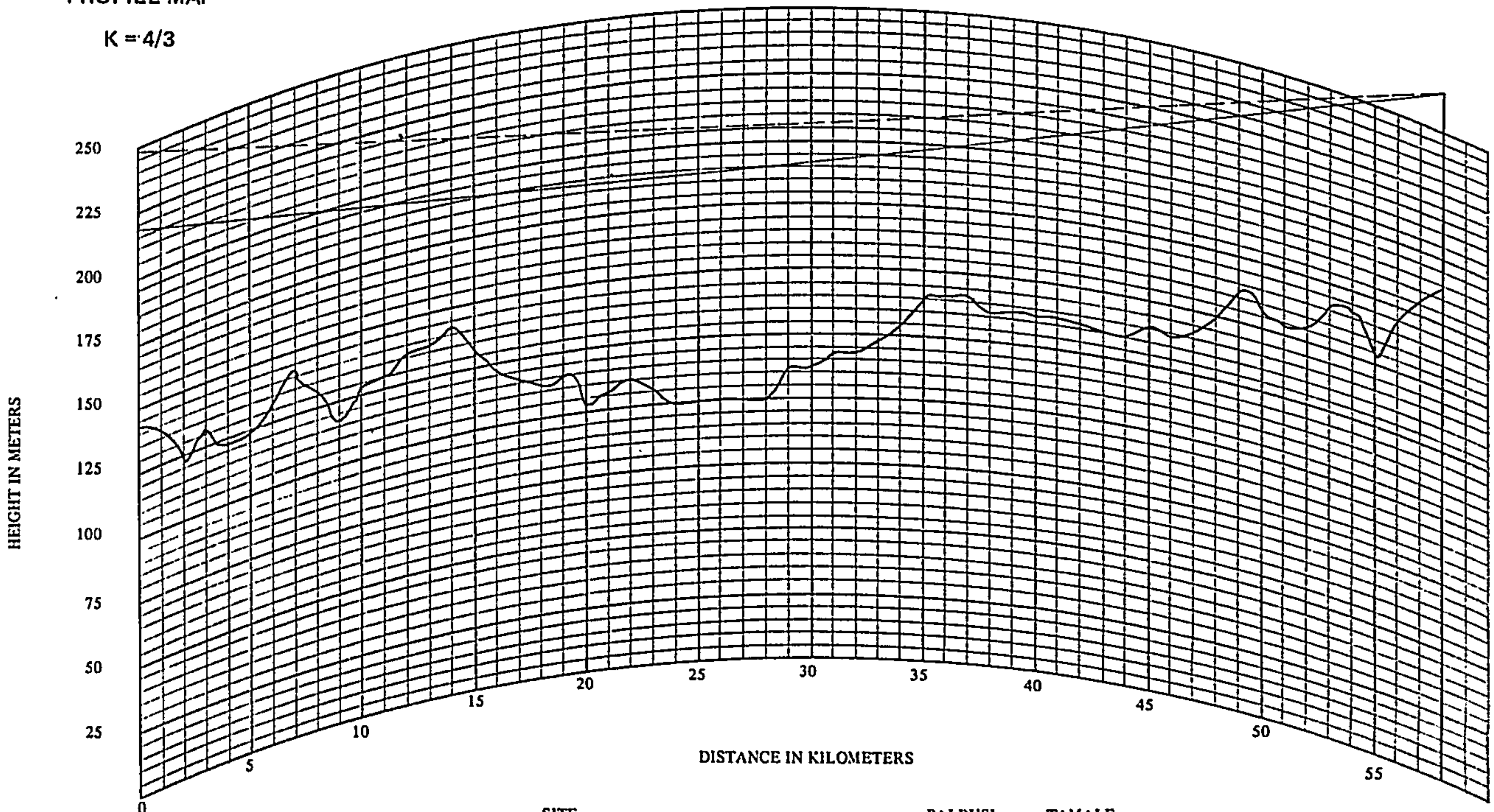
K = 2/3



SITE	SALAGA	PALBUSI
GROUND ELEVATION	162 m	143 m
EXISTING REF. (ANT.) HEIGHT	75 m	75 m
NEW ANT. HEIGHT		130 m
HOP DISTANCE	49.2 Km	

PROFILE MAP

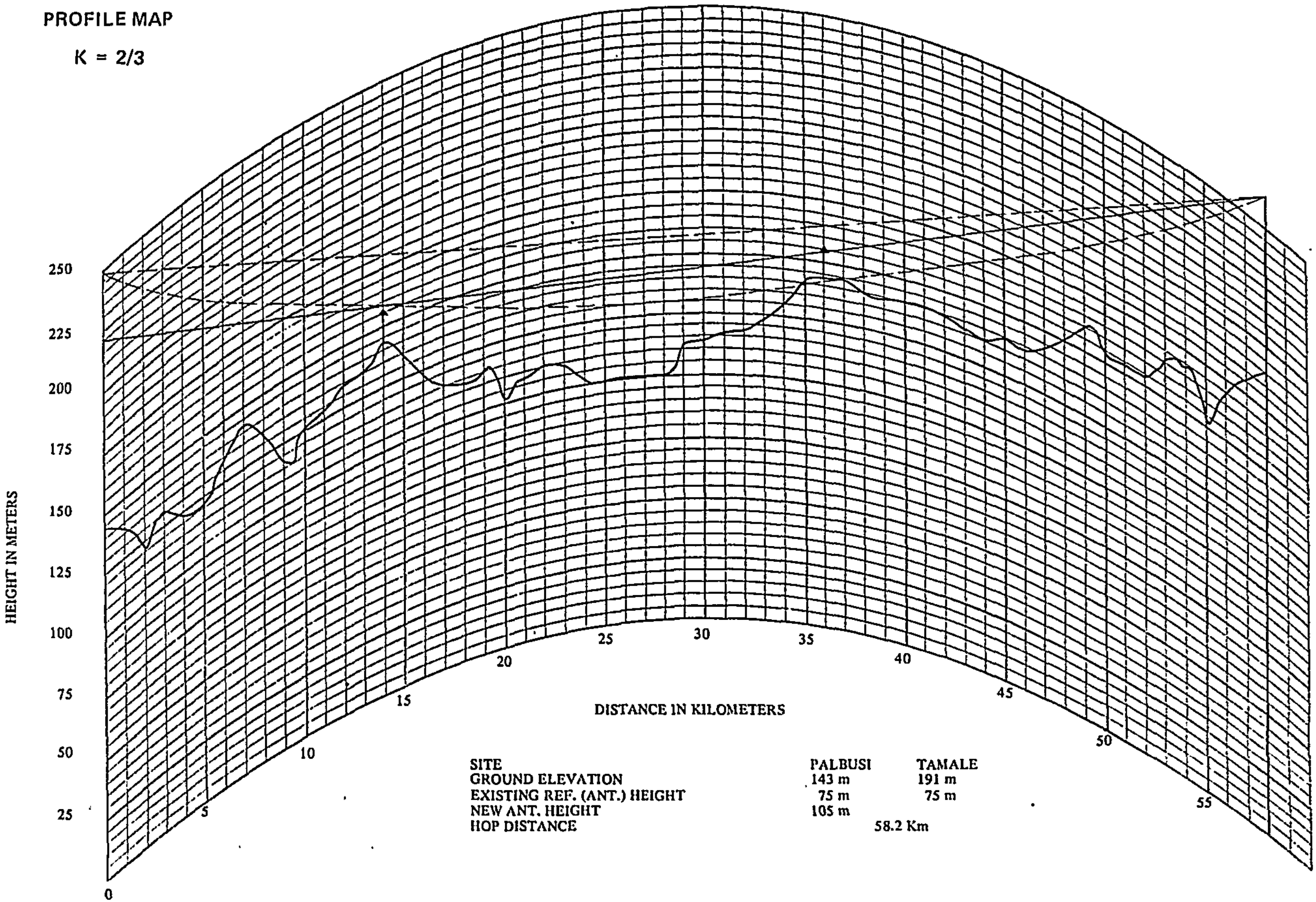
K = 4/3



SITE	PALBUSI	TAMALE
GROUND ELEVATION	143 m	191 m
EXISTING REF. (ANT.) HEIGHT	75 m	75 m
NEW ANT. HEIGHT	105 m	
HOP DISTANCE	58.2 Km	

PROFILE MAP

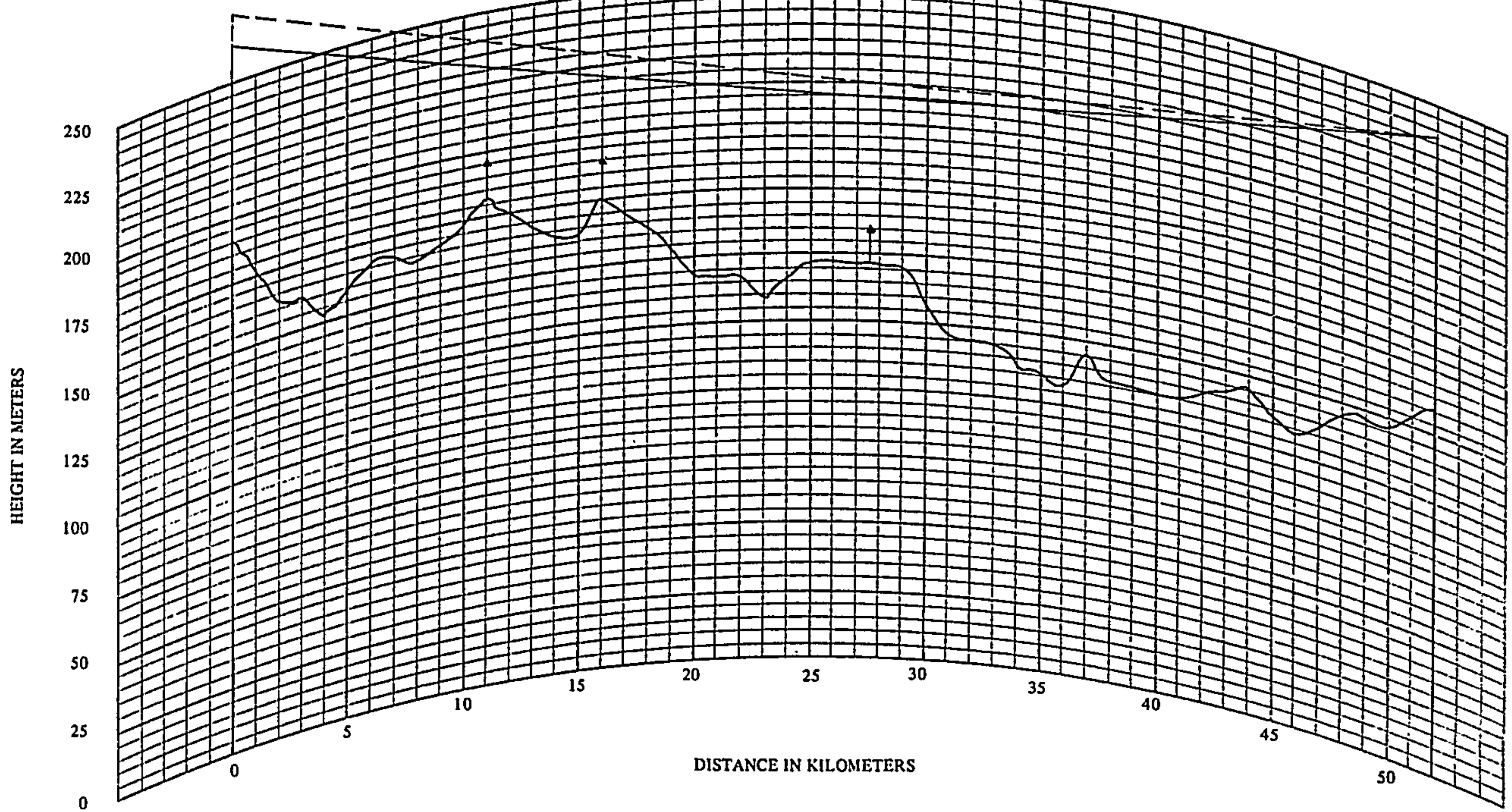
K = 2/3



SITE	PALBUSI	TAMALE
GROUND ELEVATION	143 m	191 m
EXISTING REF. (ANT.) HEIGHT	75 m	75 m
NEW ANT. HEIGHT	105 m	
HOP DISTANCE	58.2 Km	

PROFILE MAP

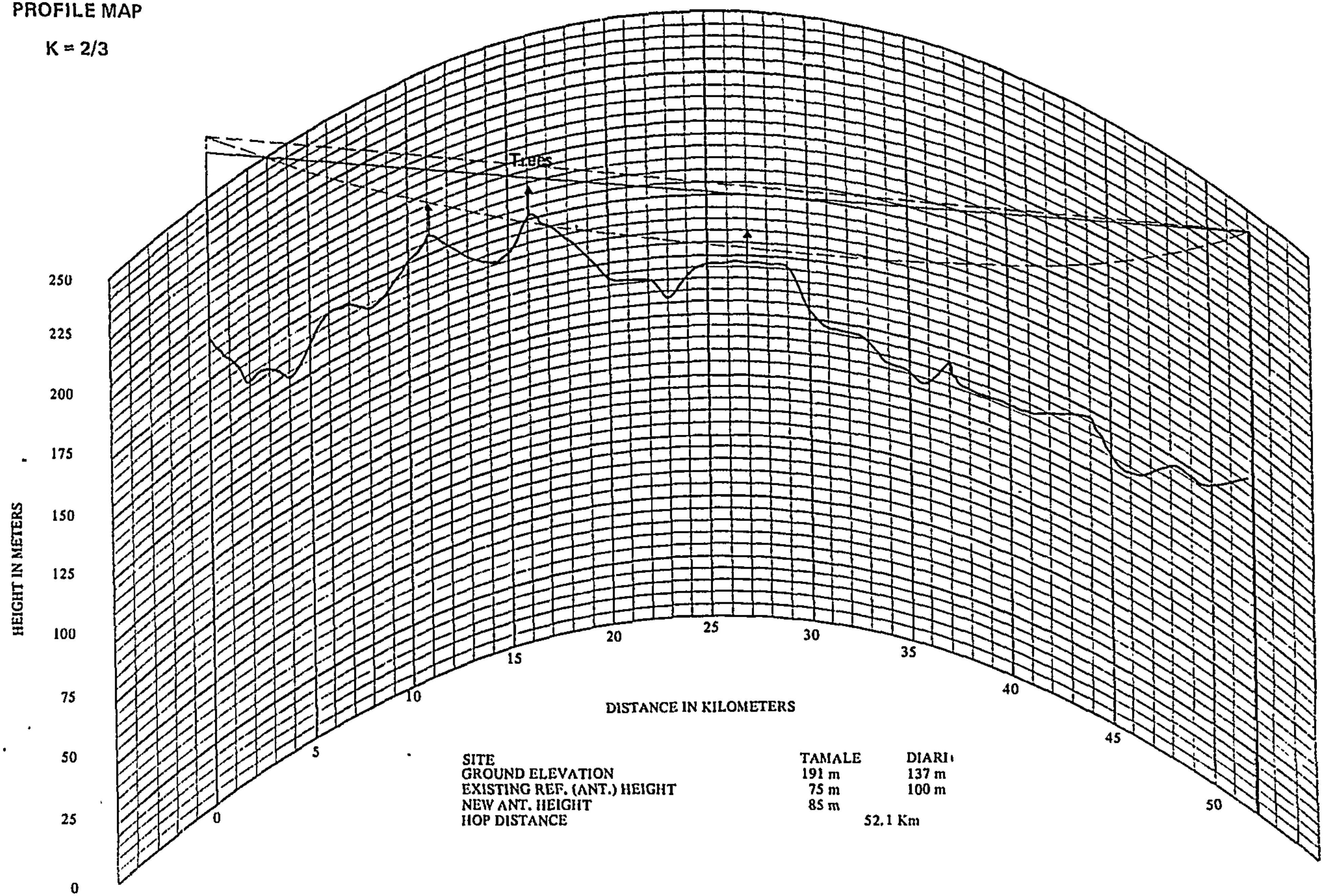
K = 4/3



SITE	TAMALE	DIARI
GROUND ELEVATION	191 m	137 m
EXISTING REF. (ANT.) HEIGHT	75 m	100 m
NEW ANT. HEIGHT	85 m	
HOP DISTANCE	52.1 Km	

PROFILE MAP

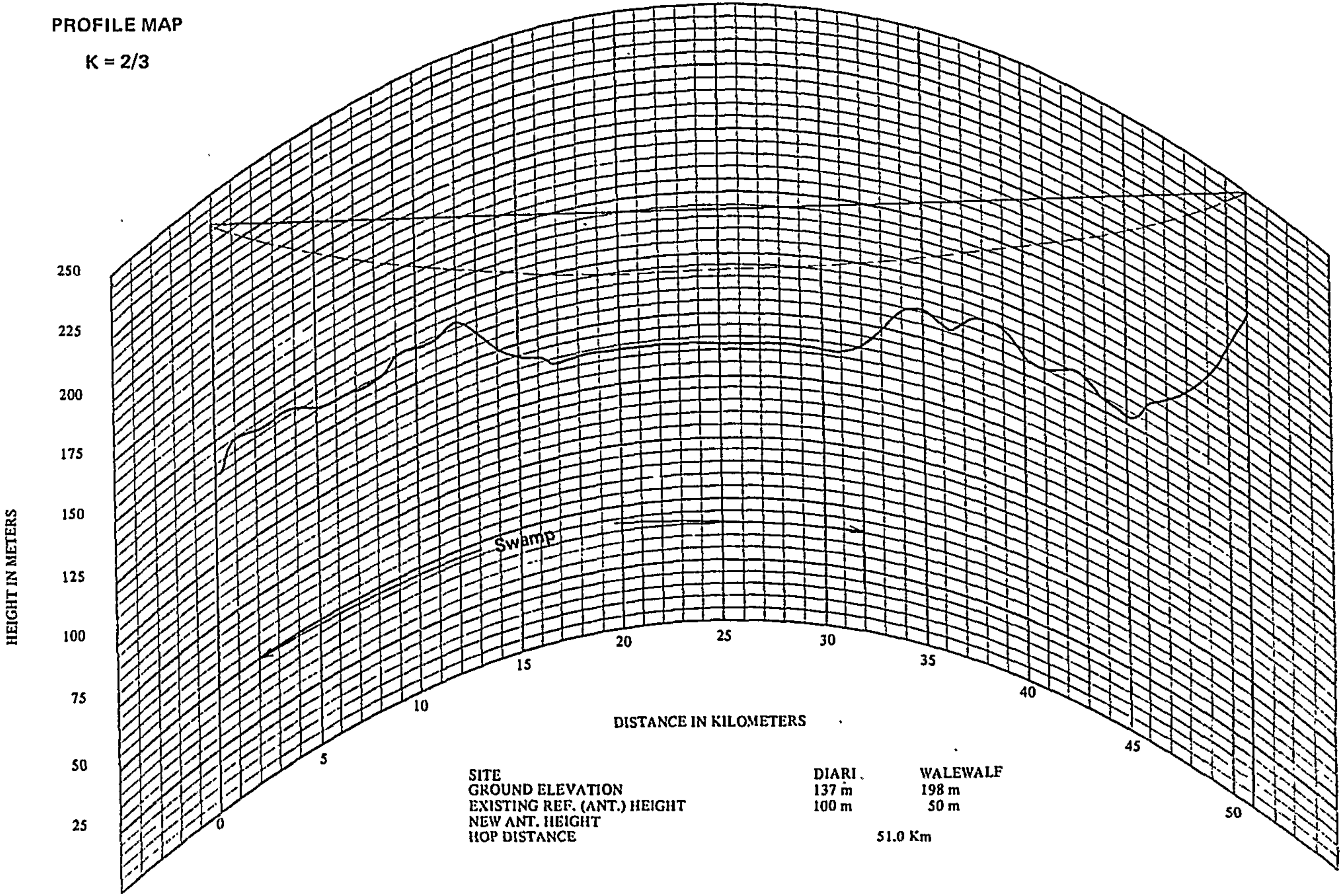
K = 2/3



SITE	TAMALE	DIARI
GROUND ELEVATION	191 m	137 m
EXISTING REF. (ANT.) HEIGHT	75 m	100 m
NEW ANT. HEIGHT	85 m	
HOP DISTANCE	52.1 Km	

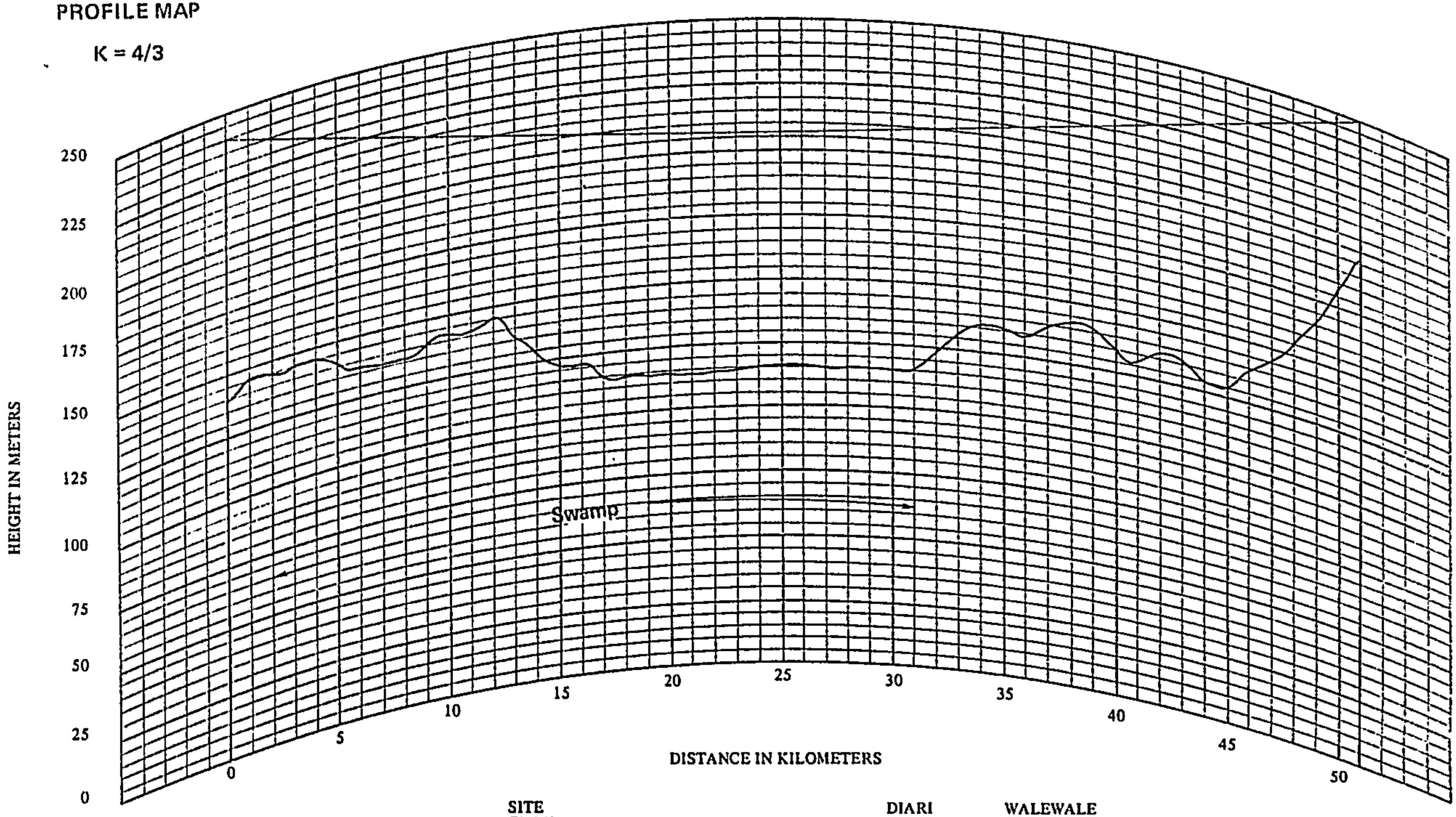
PROFILE MAP

K = 2/3



PROFILE MAP

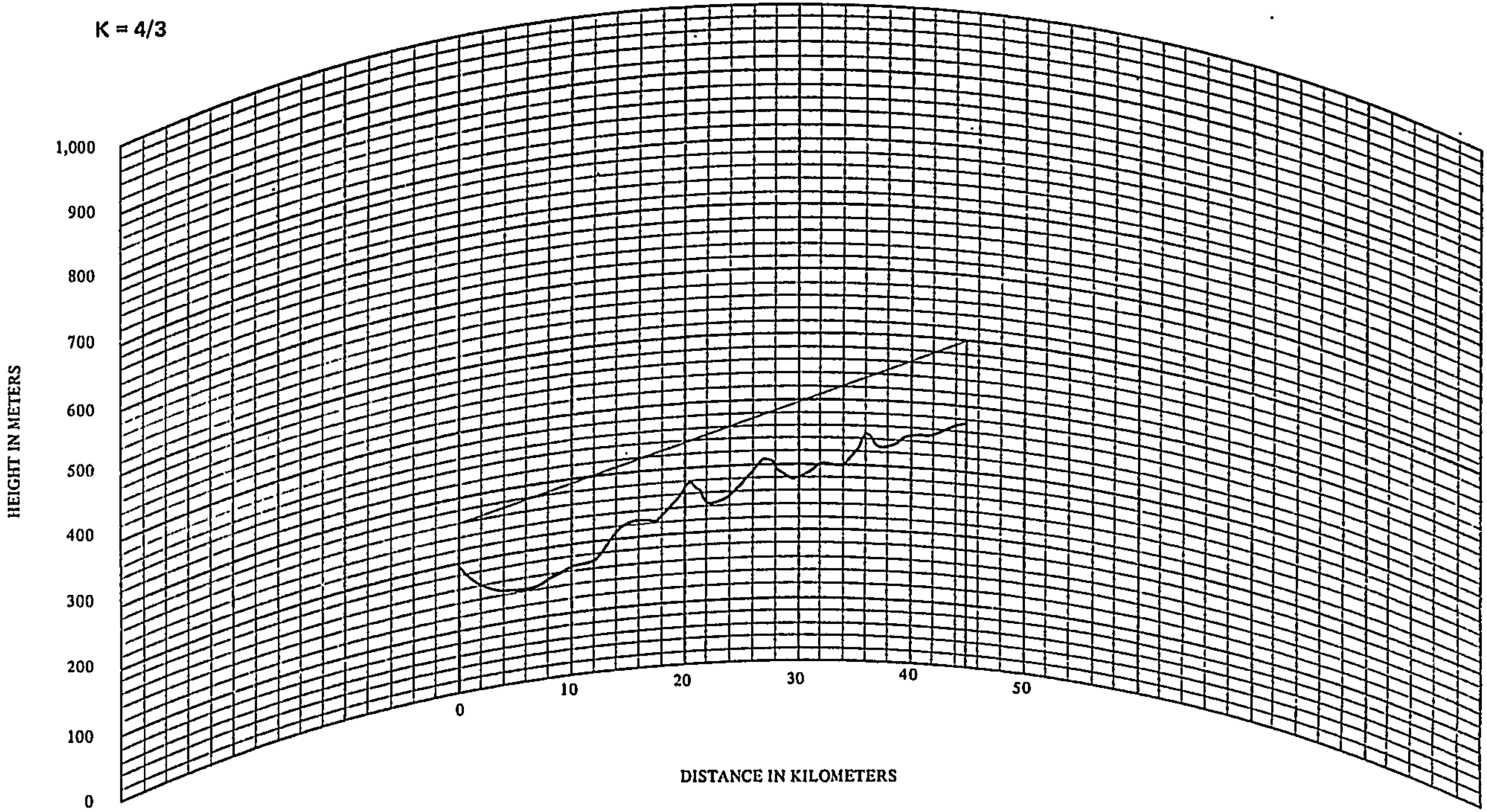
K = 4/3



SITE	DIARI	WALEWALE
GROUND ELEVATION	137 m	198 m
EXISTING REF. (ANT.) HEIGHT	100 m	50 m
NEW ANT. HEIGHT		
HOP DISTANCE	51.0 Km	

PROFILE MAP

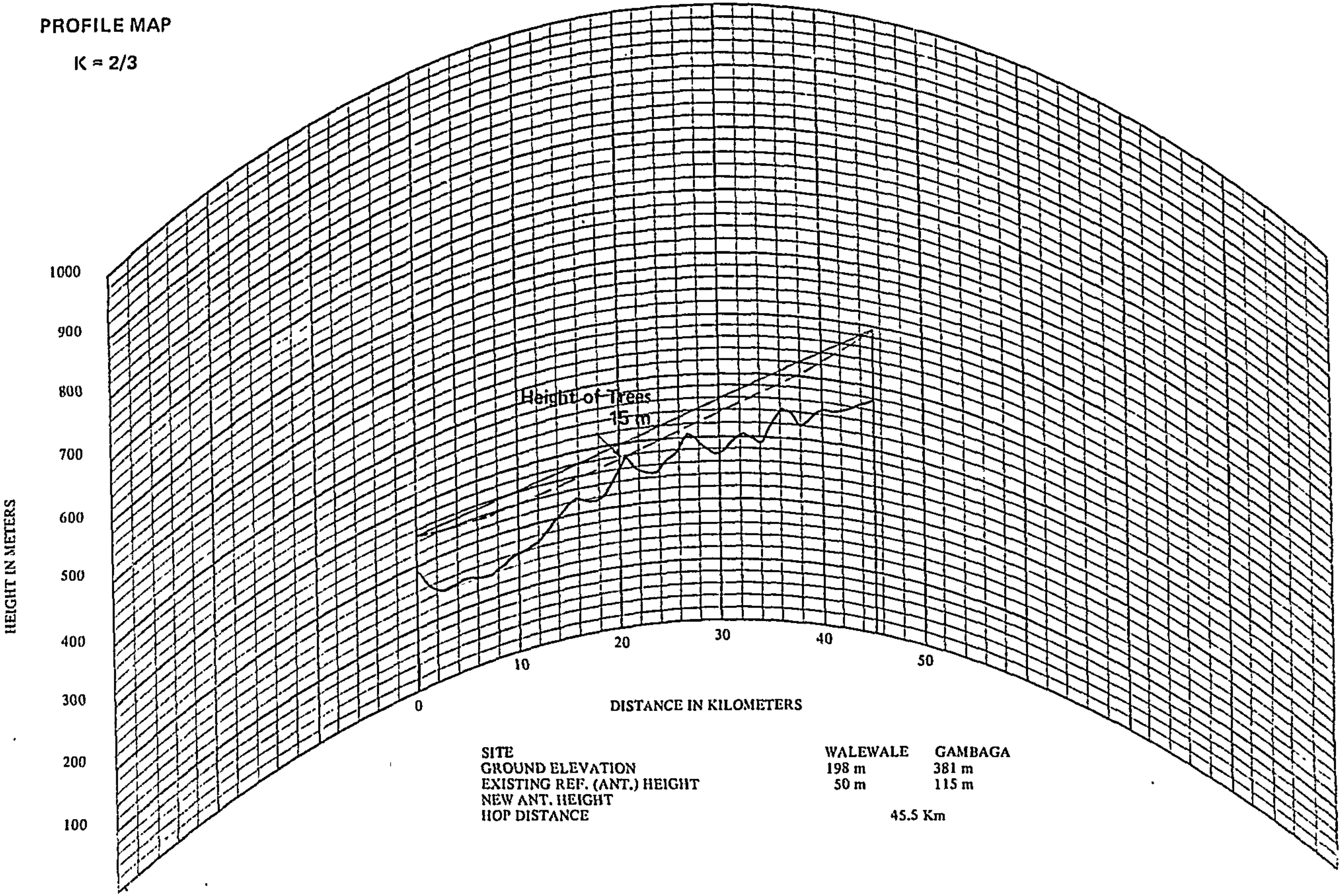
K = 4/3



SITE	WALEWALE	GAMBAGA
GROUND ELEVATION	198 m	381 m
EXISTING REF. (ANT.) HEIGHT	50 m	115 m
NEW ANT. HEIGHT		
HOP DISTANCE	45,5 Km	

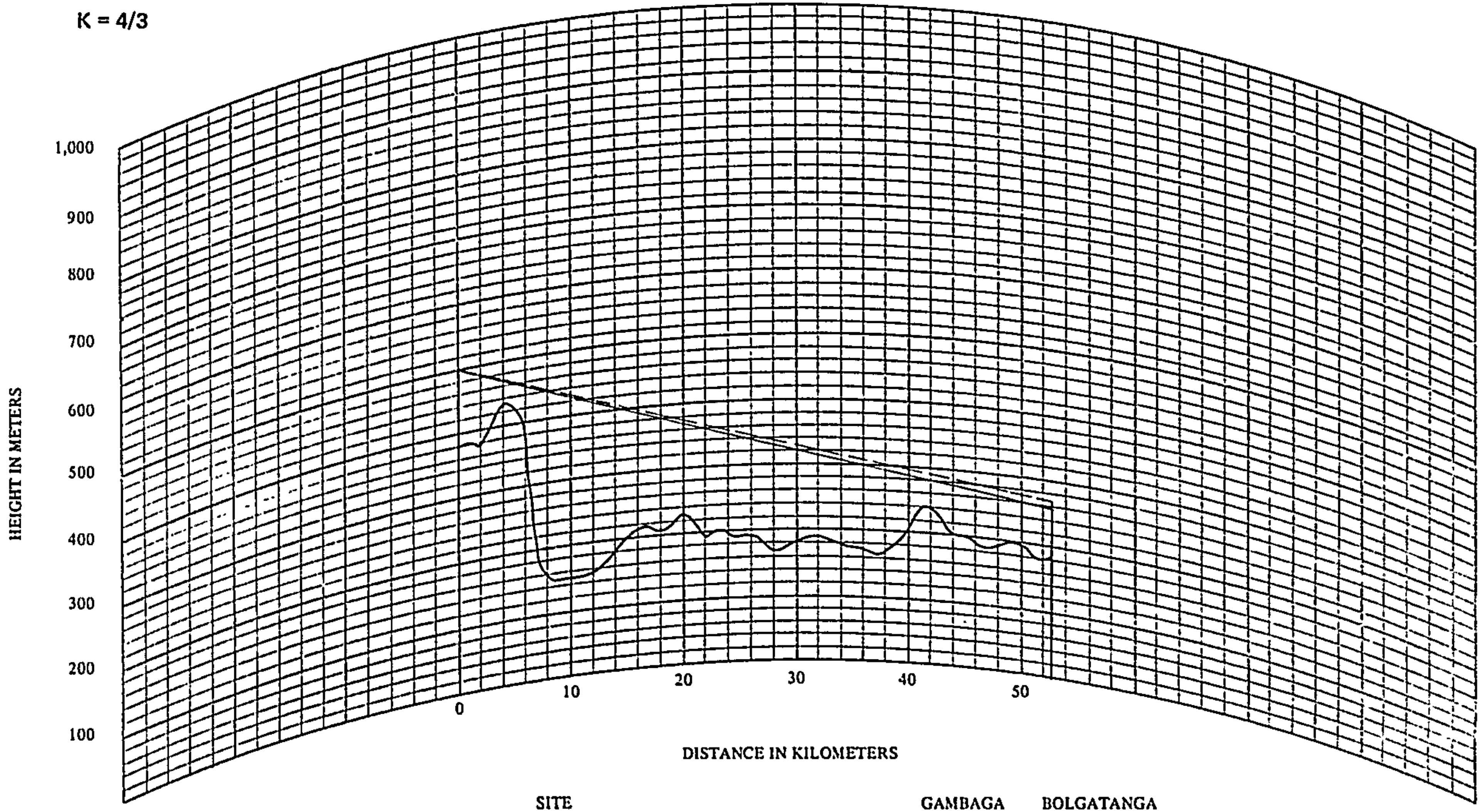
PROFILE MAP

K = 2/3



PROFILE MAP

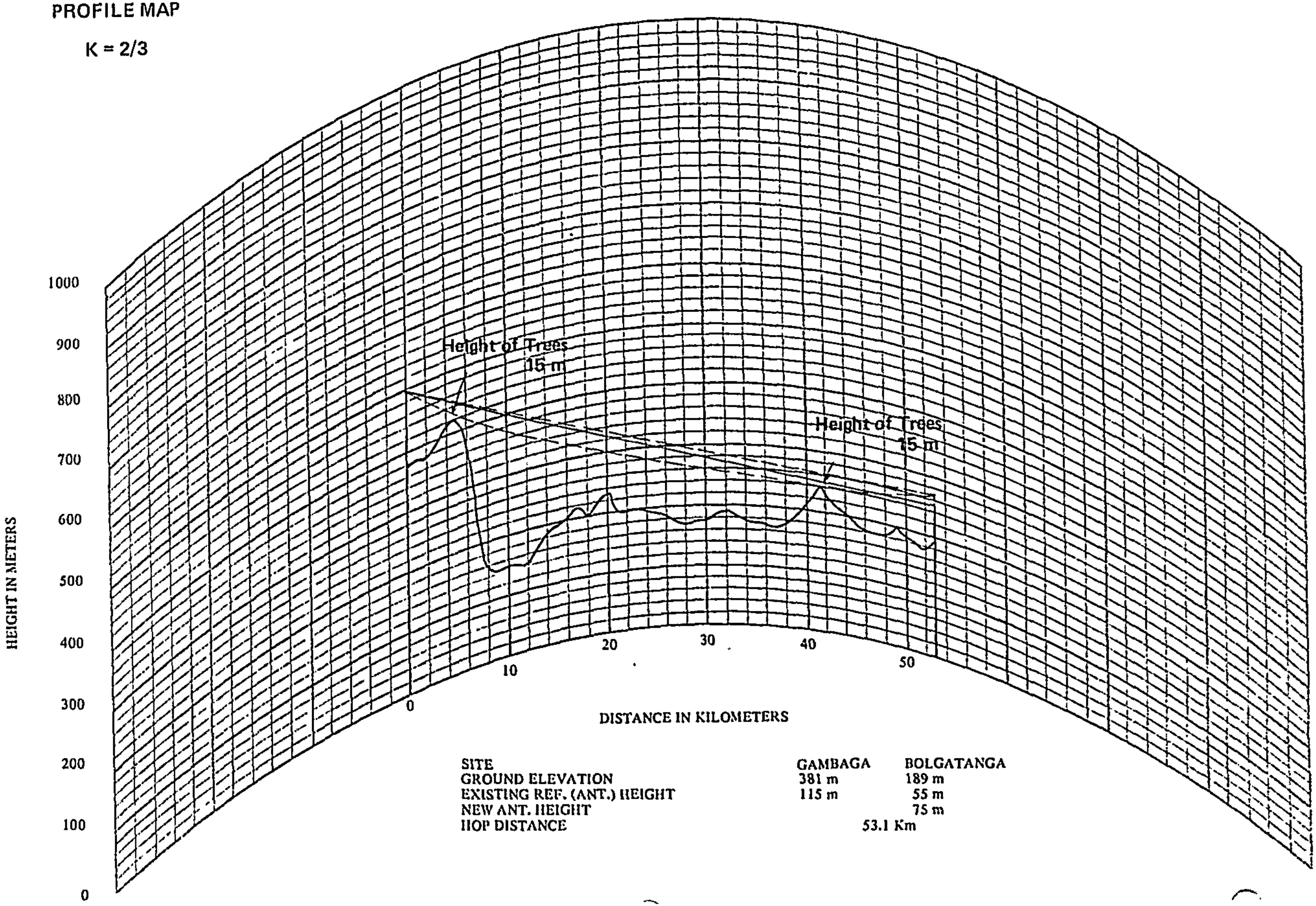
K = 4/3



SITE	GAMBAGA	BOLGATANGA
GROUND ELEVATION	381 m	189 m
EXISTING REF. (ANT.) HEIGHT	115 m	55 m
NEW ANT. HEIGHT		75 m
HOP DISTANCE	53.1 Km	

PROFILE MAP

K = 2/3



SITE	GAMBAGA	BOLGATANGA
GROUND ELEVATION	381 m	189 m
EXISTING REF. (ANT.) HEIGHT	115 m	55 m
NEW ANT. HEIGHT		75 m
HOP DISTANCE	53.1 Km	

Chapter 4. EXPANSION PROJECT OF TELEVISION BROADCASTING FACILITIES

4.1. Television Transmitting Facilities

Television transmitting facilities mean all the equipments including transmitter, power supply, antenna, relay links, buildings, etc. The equipment is, in general, required to satisfy the following conditions.

Adequate performance
High reliability
Easiness of maintenance and operation
Cheap cost

(1) Performance

The performance shall be determined according to the electric performance, reliability and economy. The conditions to be taken into consideration are as follows.

(a) To satisfy the value stipulated into radio regulations relating to radio equipment.

It is desirable that the performance is provided with sufficient allowance so that provisions of radio regulations will be satisfied not only at the time of its construction, but also several years after construction.

(b) To consider that the equipment comprises a part of the total broadcasting system.

To consider a total boradcasting system from camera to receiver. To consider the technical level and economy of each section. And to determine the performance of the transmitting equipment as one part of the total broadcasting system.

(c) To be provided with the capacity of coping with the technical progress in the future.

As the technical progress is exceedingly rapid, it is difficult to predict the technical level in future correctly. However, it is necessary to pay attention so that the predictable progress in the future shall be coped with without difficulty.

(2) Reliability

Because of the increase of amount of maintenance the improvement of the reliability of the transmitting equipment is exceedingly important. On the other hand, it is also necessary to make optimum distribution of reliability with the full consideration of the role of a transmitting equipment as a participating part of the total broadcasting system. For this purpose, sometimes the redundant system will be adopted, or reliability of each of equipments will be improved. For the improvement of reliability of each of equipments, low level stages are applied with either solid state elements or IC.

(3) Maintenance and Operation

For maintenance of performance and prevention or repair of troubles, the easiness of maintenance is also one of the prerequisites. For this purpose, it is required for the design that the system is clear and easily recognizable, while it is required for the manufacture that the distribution of parts and materials is adequate.

(4) Cost

The installation of spare equipments, required performance, and time and interval of maintenance etc. are required on the basis of the consideration of the size of the service area as well as the geographical and meteorological conditions of the location of transmitting equipment. Therefore, the transmitting equipment shall be determined to be such equipment which is the most economical, yet capable of coping with the above-mentioned prerequisits.

4.1.1. Determination of the Location and the Transmitting Conditions of Bolgatanga Television Broadcasting Station

The suitable site for the construction of a television broadcasting station at Bolgatanga was investigated on the topographic map of 1/50,000. As the result, it was found that there existed three locations approximately 2 km to north-west, approximately 5 km to north-north-east, and approximately 9 km to east-north-east from the center of the city of Bolgatanga, each of which was a highland of approximately 750 ft above sea level and suitable for a prospective site of transmitting station.

Each of the above-mentioned probable sites of transmitting station had a highway in the vicinity which provided an extremely favourable condition for the construction work as well as the maintenance after the completion of the construction work of the transmitting station. So, inspection on the site was carried out on each of the three prospective sites. As the result, it was found that the prospective site mentioned the first, that is, the highland located approximately 2 km to north-east of the center of the city of Bolgatanga was located within the radius of approximately 800 m from the existing building of Bolgatanga Regional Broadcasting Station installed for the purpose of wired broadcasting. Further, it was also found that the both places were situated approximately the same height above sea level.

So, the conclusion was obtained that, taking the above-mentioned convenience of construction work including the construction of power line as well as the maintenance of transmitting equipments after the completion of the construction work into consideration, it would be most effective and advantageous to build the television broadcasting station on the site of the existing Bolgatanga Regional Broadcasting Station or on a site adjacent to it.

By the way, according to the investigation results of each of the 3 prospective sites of the transmitting station selected on the topographic map as to the line-of-sight between each of three sites and major communities, there was no big difference between them and it was concluded that the conditions of radio wave propagation would be practically the same for each of the three prospective sites. (Fig. 4.1.2 - 4.1.5)

Therefore, the selected site is considered to be an extremely advantageous location as it is the nearest to the capital of Upper Region, the city of Bolgatanga, and capable of sending a television picture of sufficiently good quality to the city of Bolgatanga, and, at the construction work, construction of connection road from the highway to the transmitting station, consturction of connecting power line, and the other superfluous troubles and costs are dispensed with when the construction base is established at the existing Bolgatanga Regional Broadcasting Station.

4.1.2. Frequencies of Bolgatanga Television Broadcasting Station

It is optimum to select the frequencies to be assigned to Bolgatanga Television Broadcasting Station from E 5 ch to E 12 ch belonging to the television broadcast Band III. Because of the shape and dimensions of a transmitting antenna, shapes and dimensions of receiving antennas installed on the side of the viewers, as well as the difficulty of the establishment, the propagation characteristics of radio wave, and the increase of external noise in the future etc. are taken into consideration.

By doing so, it is further considered to be optimum to assign E 7 ch in consideration of the power increase of the existing Tamale Television Broadcasting Station in the future whose broadcasting area lies adjacent to that of Bolgatanga Television Broadcasting Station as well as for the purpose of preventing interference with the emission of the Republic of Upper Volta which borders the northern border of the Republic of Ghana.

4.1.3. Scale of Transmission of Bolgatanga Television Broadcasting Station

(1) Examination

The adequate transmission scale of Bolgatanga Television Broadcasting Station obtained by the calculation on the basis of the investigation results carried out by means of transmitting equipments for investigation as well as the required television service area on the topographic map is determined as follows. The transmitter output power, 1 kw, and maximum effective radiated power, 5 kw.

In this case, it is determined that it is optimum for the purpose of securing the required broadcasting area as well as on economical basis regarding to the construction of the transmitting antenna system to have the height of a transmitting antenna above ground of approximately 50 m.

Therefore, according to the above-mentioned transmission scale, the television service area to be object of Bolgatanga Television Broadcasting Station is as shown on Fig. 4. 1. 1.

The minimum value of field strength required for a television service area is, as indicated in the CCIR report 409-1 "Boundaries of the television service area in rural districts having a low population density" according to CCIR recommendation 417-2, 49 dB (1μV/m = 0 dB) at the antenna height above ground 10 m in case of the television broadcast frequency Band III. However, it was reported that, the lowest limit for viewing a television picture in rural districts having a low population density is 40 dB with the antenna height above ground of 4 m.

When the actual situation of the Republic of Ghana is investigated, it is considered to adopt the value of field strength indicated in the CCIR report 409-1 according to the distribution of the population density. So, we adopted the value 49 dB with the receiving antenna height above ground of 10 m as the value of the minimum field strength in the television service area. Therefore, the area surrounded by the blue line on Fig. 4.1.1 is the television service area obtained by the above-mentioned transmission scale where the television transmission will be received with good quality.

In this case, the population included in the television service area is assumed to be approximately 295,000. However, viewed from the viewpoint of the actual situation of television broadcasting service in Ghana, it will be rather practicable to strive for presenting television to the wider public of the nation than to show the area of better quality of television presentation. So, it is considered to be more suitable for the existing situation to indicate the television service area for the viewing of television presentation at the lowest quality level.

In this case, it is extremely difficult to erect a receiving antenna with the height of 10 m above ground because of the building style of private dwellings in the Republic of Ghana. So, such height is somewhat unpracticable. Therefore, we adopted the height of 4 m above ground as the most practicable height, and plotted the area where the value of field strength is 40 dB with the antenna height above ground of 4 m. Thus, we obtained the television service area encircled by the red line on Fig. 4.1.1, and this television service area is considered to be the area accepted in general.

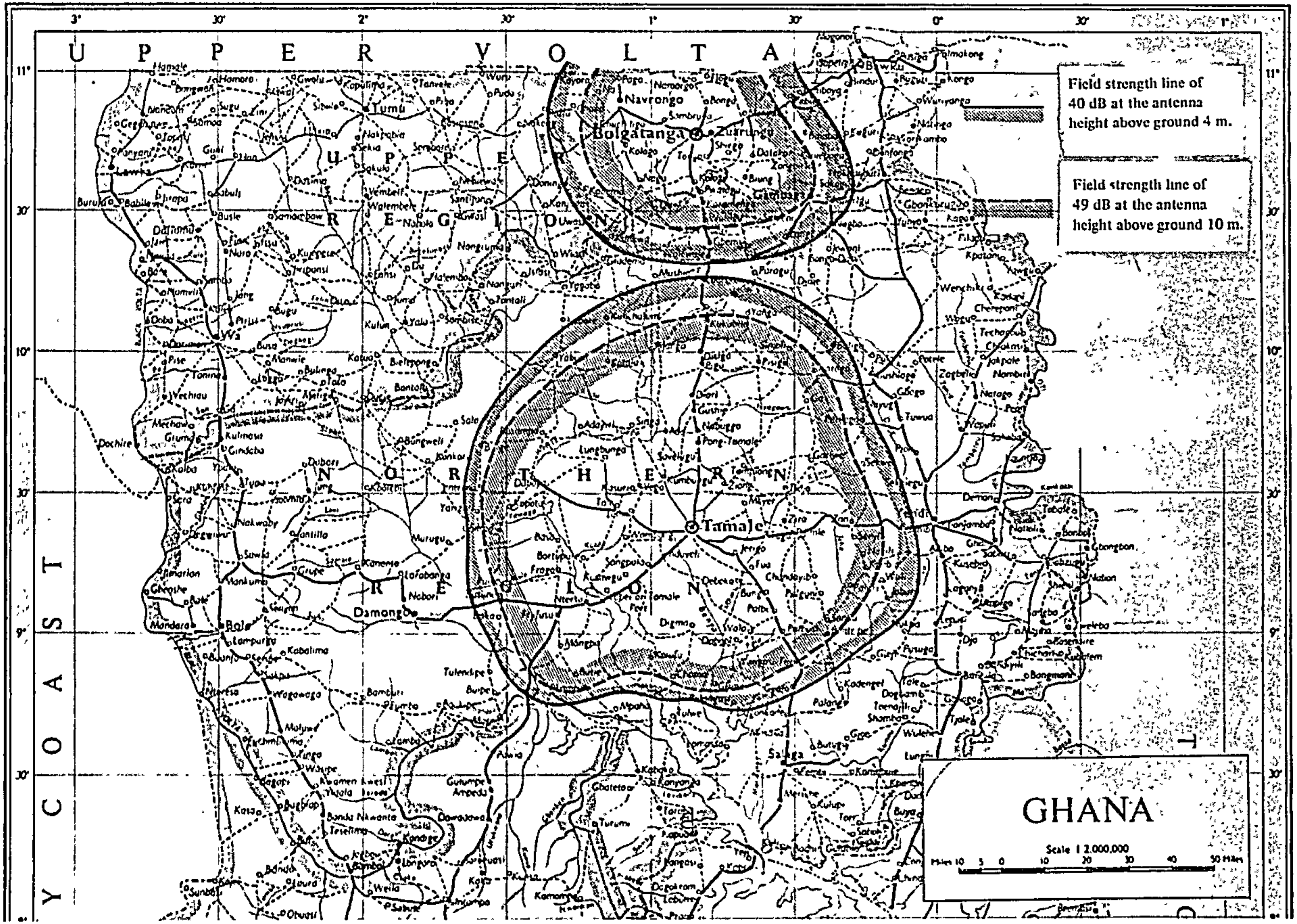
The population included in the abovementioned television service area where the value of field strength is 40 dB with the antenna height above ground of 4 m is assumed to be approximately 441,000.

(2) Basis for Calculation

The transmitter output power 1 kw, the maximum effective radiated power 5 kw, and the transmitting antenna height above ground 50 m for Bolgatanga Television Broadcasting Station were calculated according to the following process.

(a) The output power of the transmitter for investigation employed at the field investigation is 10 w, and the frequency is 149. 13 MHz.

Fig. 4.1.1 ADMINISTRATIVE



The transmitting antenna was erected 8 m high above ground and Braun type antenna was employed. Therefore, the effective radiated power was approximately 9 w.

(b) The values of field strength between the prospective sites of transmission points and major communities as well as the points projected to operate the measurement by the output of the transmitter for investigation were previously obtained by calculation on profile maps prepared according to the topographic map of 1/50,000.

The values of field strength in this case were calculated by the following equation.

$$E = \frac{7\sqrt{G.P}}{d} \times 2 \times \sin \frac{2\, h_t\, h_r}{\lambda d} \quad (V/m)$$

where, E : Value of field strength to be calculated

P : Output power of transmitter (W)

G : Transmitting antenna gain

d : Distance between the transmitting and receiving point

λ : Wavelength (m)

h_t : Transmitting antenna height above ground (m)

h_r : Receiving antenna height above ground (m)

(c) The communities to be included in the television service area were determined beforehand, and it was assumed that the area circled by a line connecting these communities was the required television service area temporally.

(d) We calculated the values of the effective radiated power with the transmitting antenna height above ground of 50 m, receiving antenna height above ground of 4 m and 10 m which will be 40 dB on the above-mentioned curve.

(e) We emitted radio wave from the transmitter for investigation located on the prospective site of transmitting station and measured the field strength of the above-mentioned wave by means of measuring instrument previously located on the position of measurement.

(f) We correlated and calibered the measured values thus obtained with the values of field strength calculated according to the item (b) and the values of effective radiated power calculated according to the item (d), with the values of effective radiated power calculated according to the item (a) respectively, and eventually determined the required effective radiated power.

(g) The effective radiated power is decided on the basis of the structure of the transmitting antenna used for the purpose of obtaining the abovementioned effective radiated power including its type and composition as well as the economy and output ratings of transmitter.

(h) Further, as to the transmitting antenna height above ground, it goes without saying that the higher, the better on the reason of the relation with the line of sight. However, there exists an optimum height on the basis of the construction cost of a steel tower and economy. So, the construction of a steel tower higher than 100 m is not very advantageous.

4.1.4. Transmitting Antenna for Television

An antenna used for transmitting television broadcasting requires to be structured in such a way that a good receiving situation is created in the television service area. In other words, it is desirable that a transmitting antenna is provided with the power gain which gives the minimum required field strength and the directivity which gives the total television service area with the field strength as uniform as possible. In addition, the impedance matching is required for the purpose of restricting the ghost picture caused by reflection less than the allowable value on the visual sense. A transmitting antenna provided with abovementioned basic characteristics is also required to satisfy such conditions as the frequency, the plane of polarization, the band width, and the power capacity, and its structure is required to adapt to the environmental conditions (wind speed, temperature, humidity, etc.). Further, the decision is required to be made with the overall consideration as to the easiness of manufacture and maintenance, economy, and reliability.

(1) Power Gain

The power gain is generally given by the relation with the transmitting output power so that the total television service area receives the minimum required field strength (at VHF band, 49 dB (1 μ V/m = 0 dB, the height above ground 10 m according to the CCIR recommendation)). For this purpose, it is necessary to consider topographic features, to assume field strength at various locations on the basis of the data relating to radio wave propagation, and its directivity.

The increase of the gain is advantageous in such points as the reduction of transmitting output power. On the other hand, there are restrictions due to the increase of mechanical length of the antenna, the vibration due to wind pressure and fluctuation of field strength at receiving point by vibration, and the deterioration of field strength in the vicinity of the transmitting point.

(2) Directivity

It is desirable to assimilate the vertical directivity to the directivity in proportion to cosec θ (θ : magnetic inclination) so that the field strength in the major television service area becomes approximately even. However, as the structure becomes more complex when the degree of assimilation is raised, the value of vertical directivity is generally determined in consideration of the regional distribution of viewers as well as the easiness of manufacture and maintenance. Further, the maximum direction of the vertical directivity is often inclined because of the relation with the television service area. This is called the beam tilt and its inclined angle is called the beam tilt angle. Here, the beam tilt angle θ_h which serves to the furthermost location in relation to the curvature of the Earth's surface is calculated. Then, the following equation is obtained.

$$\theta_h \simeq 0.0278\sqrt{Ht\ (m)}\ \text{(degree)}\quad (Ht:\ \text{Transmitting antenna height})$$

In general, the beam tilt angle θt of a large power station is determined to $t \gtreqqless 2\theta_h$, while the value lower than $5 \sim 6°$ is adopted for a small power station as it is directed to major television service area in its vicinity.

(3) Impedance Matching

Ghost picture is generated on the received picture when the input impedance of the transmitting antenna is not matched with the characteristic impedance of the feeder. The allowable value in such case is related to the voltage reflection coefficient of the transmitting antenna, time lag of ghost picture (related to the length of feeder), and frequency characteristics of voltage reflection coefficient, etc. The frequency characteristics of the reflection coefficient is adjusted to flat line, and in case of long feeder, it is sometimes necessary to restrict the reflection coefficient lower than 2.5 % (VSWR less than 1.05). On the other hand, in case the feeder length is short somewhat larger reflection coefficient will be allowed. Generally, it is necessary to restrict the reflection coefficient in the range of band width at the input terminal of antenna to less than 2.5 %, and less than 5 % including the feeder line (VSWR less than 1.1).

(4) Mechanical Strength

The characteristics of the resistibility for wind pressure of a transmitting antenna is required to be provided with such mechanical structure as may resist the maximum instantaneous wind speed supposed to be generated in the vicinity of the transmitting station. Further, the structure shall be provided with such capacity that the fluctuation of field strength in the various places in the television service area caused by the vibration of the transmitting antenna due to a maximum instantaneous wind speed arising seldom in a long period will be allowed on the basis of visual sense. The wind pressure for the purpose of calculating the design of supports of an antenna in Japan is calculated according to the following equation.

$$\text{Wind pressure } P = 120\ \sqrt[4]{H}\quad (kg/m^3)$$

H : Height above sea level (m)

(5) Antenna Type

There are many types of antennas according to the frequencies, the plane of polarization, and the directivity, etc., which will be classified as the following table.

Types of Transmitting Antenna

	Types of antenna	Plane of polarization	Frequency	Horizontal directivity
Dipole antenna	Superturnstile antenna	Horizontal	VHF	No-directivity
	Dipole antenna with reflecting plate, supergain antenna	Horizontal	VHF	Directivity
	0.7 wavelength, dipole type	Vertical	UHF	No-directivity
	Corner reflector antenna	Horizontal	VHF	Directivity
		Vertical	UHF	
	Yagi antenna	Horizontal	Chiefly VHF	Chiefly directive
		Vertical		
	Combination of circular pole and dipole	Chiefly Vertical	Chiefly VHF	Chiefly directive
Loop antenna	Stacked loop antenna	Horizontal	UHF	Directivity
		Vertical	VHF	No-directivity
	Slotted ring antenna	Horizontal	VHF	No-directivity
	Yagi antenna with loop	Horizontal	Chiefly VHF	Chiefly directive
		Vertical		
Slot antenna	Cylindrical slot antenna	Horizontal	UHF	Chiefly no-directivity
			VHF	
	Waveguide type slot antenna, Omniguide antenna, Merber antenna	Horizontal	UHF	No-directivity
				Directivity
Helical antenna	Side fire helical antenna	Horizontal	Chiefly UHF	No-directivity
Zigzag antenna	Zigzag antenna	Horizontal	UHF	Directivity
			VHF	No-directivity

According to the abovementioned types, the investigation is carried out on the basis of frequency band, VHF, and directivity, etc., and it is decided to adopt supergain antenna, and the number of stages on each side is decided according to the transmitter output power and ERP.

(6) Supergain Antenna

The dipole is mounted on the side of the tower according to Fig. 4.1.6 (a) and various types of power are fed. Here, for the purpose of obtaining the directivity of the first quadrant on Fig. 4.1.6 (a), the following equation is obtained.

$$D(\phi) = \left[A_1^{\,2} + A_2^{\,2} + 2A_1A_2 \cos\left\{md(\cos\phi - \sin\phi) - mx(\cos\phi + \sin\phi) \pm \delta.\right\}\right]^{\frac{1}{2}}$$

$$\begin{cases} A_1 = \sin\left\{mH \sin\phi\right\} \times \dfrac{\cos\left\{\frac{\pi L}{\lambda}\cos\phi\right\} - \cos\left\{\frac{\pi L}{\lambda}\right\}}{\sin\phi} \\ A_2 = ki \sin\left\{mH\cos\phi\right\} \times \dfrac{\cos\left\{\frac{\pi L}{\lambda}\sin\phi\right\} - \cos\left\{\frac{\pi L}{\lambda}\right\}}{\cos\phi} \\ ki = I_2/I_1 \\ m = 2\pi/\lambda \end{cases}$$

Provided, however, that the width of the reflection plate is infinitely great. For the purpose of obtaining non-directive horizontal plane, all the surfaces are magnetized by a current of same phase or 90° with a same amplitude.

Fig. 4.1.6 (b) shows an example of calculation according to the above-mentioned equation when the width of reflection plate is set to one wavelength. In case directivity is given to the antenna, structure of each surface and the power supply are changed. By the way, for the purpose of improving the deviation of directivity, sometimes the mounted position of the dipole is shifted from the center of the reflection plate.

The power gain as non-directivity within the horizontal plane is obtained by $\sin(2\pi H/\lambda \cdot \cos\theta)$ which indicates the vertical directivity of a single body. Here, the value is calculated on an antenna with N = 6 ~ 12 steps, and Fig. 4.1.7 is obtained. Fig. 2 is an example excited by current of same phase and same amplitude. In actual operation, however, it is necessary to consider the drop of power gain due to null fill in, etc.

(7) Conclusion

The transmitting antenna of Bolgatanga Television Station operates VHF frequency band and requires to be provided with directivity. So, supergain type antenna shall be adopted. And as it requires the gain of approximately 7 dB, it is desirable to install antenna with 3 steps to the direction of the Republic of Upper Volta, while antenna of 6 ~ 7 steps is adopted to other directions.

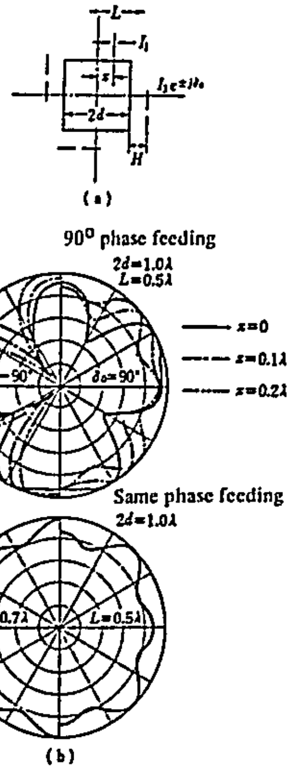


Fig. 4.1.6 Horizontal pattern of dipole antenna with reflecter

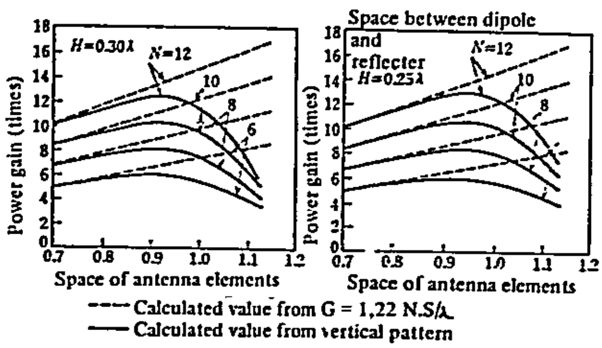


fig. 4.1.7 Antenna gain of dipole with reflecter

4.1.5. Television Broadcasting Transmitter

The present television broadcasting uses different carrier frequencies for the transmission of vision and sound signal's respectively. So, the television broadcasting transmitters are roughly separated into the two kinds, vision transmitter and sound transmitter. Further, the carrier frequencies and channel band width differ according to the standard television systems of respective countries. So, the performance of television broadcasting transmitters differs according to the respective standard system.

The Republic of Ghana adopts system B as the standard system.

Radio Frequency Characteristics	
Nominal radio-frequency channel bandwidth (MHz)	7
Sound carrier relative to vision carrier (MHz)	+5.5
Nearest edge of channel relative to vision carrier (MHz)	-1.25
Nominal width of main sideband (MHz)	5
Nominal width of vestigial sideband (MHz)	0.75
Minimum attenuation of vestigial sideband (MHz)	20 (-1.25 MHz) 20 (-3.00 MHz) 30 (-4.43 MHz)
Type and polarity of vision modulation	A 5 C negative
Synchronizing level as percentage of peak carrier	100
Balancing level as a percentage of pead carrier	72.5 ~ 77.5
Difference between black level and blanking level as a percentage of peak carrier	10 ~ 12.5
Type of sound modulation	F3 ± 50 kHz 50 μs pre-emphasis
Ratio of effective radiated powers of vision and sound	5/1

A television broadcasting equipment comprises the following devices.

(1) Vision transmitter (2) Sound transmitter
(3) Vestigial sideband filter (4) Dummy antenna

In addition, the following accessory equipments are also required.

(5) Input device (6) Monitoring device (7) Cooling device

As the characteristics having influence on the performance of vision transmitter, modulation frequency characteristics, lower sideband attenuation characteristics, wave-form distortion, differential gain, differential pahse, envelope delay time characteristics, output variation, output fluctuation, signal to noise ratio, noise due to different types of modulation shall be considered, while, as the performance of sound transmitter, modulation frequency characteristics, distortion factor, frequency deviation (linearity), signal to noise ratio, vestigial amplitude modulation noise, etc. shall be paid attention.

As to the modulation system of vision transmitter, formerly the major system was either the high power modulation system or the medium power modulation system. Of late, however, the advantage of intermediate frequency modulation system is remarked in accordance with the leaping progress of solid state equipments, compact size VSBF, as well as the improvement of reliability, and this system is becoming to occupy the major position. The advantages and disadvantages of above-mentioned two systems are explained below.

Item	IF modulation system	Medium and high power stage modulation system
Relating to modulator and modulated equipment	Because of the IF modulation in addition to the adoption of semi-conductor, extremely stabilized and excellent characteristics are maintained for many years.	(1) As modulator of large power output is required (100 ~ 150 V output), it is difficult to employ semi-conductors. So, a great number of vacuum tubes are employed. (2) The high frequency input circuit of modulated equipment requires extremely delicate adjustment. (3) As C class grid modulation system is adopted, unfavourable effect may be generated on the degree of modulation, output, and colour characteristics by the fluctuation of vacuum tube characteristics.
Relating to VSBF	(1) VSBF may be composed of concentrated constant circuit, so compact size is available. (2) As the phase compensation of VSBF lies in the IF band, so the compensation is operated without difficulty.	(1) VSBF of large size is required. (2) In case the redundant system of a transmitter including VSBF is considered, problems arise as to its location, reliability, and economic properties, etc. (3) It is desirable to compensate the phase characteristics of VSBF at the high frequency circuit. However, it is difficult to realize an equalizer which can pass large power and yet the amount of compensation is variable.

Number of vacuum tubes	Only two transmitting tubes are required (one for each of the vision transmitter and sound transmitter), and high reliability can be expected.	As a considerable number of vacuum tubes are required, the insufficient contact of sockets, deterioration of peripheral section due to calorification, and fluctuation of characteristics, etc. will influence to the reliability as much as the greater number of vacuum tubes.

In case 1 kw transmitter proposed by this report is taken as an example, both of the vision and the sound transmitters are constructed with each one vacuum tube at their respective final stages so that it is extremely economical on the viewpoint of both maintenance and operation in addition to the superior quality of the characteristics. So, we will promote our proposal based on this system.

4.1.6. Power Source Equipment

It is already recommended that the optimum location of Bolgatanga TV Broadcasting Station is the site of the existing GBC station itself or somewhere neighbouring to the site. By doing so, there is no necessity for the power source equipment newly receiving the power. Instead, an increase of the receiving capacity required for the new installation of two broadcasting transmitters and accessory equipments related to broadcasting equipments will be approximately 25 KVA. (In case of overall requirement of the station is considered, the increase of approximately 100 KVA will be required.)

Further, for the purpose of securing the continuation of service while the power supply is disconnected, it is necessary to install in a separate building an equipment with the capacity of approximately 75 KVA for the emergency use.

4.1.7. Building of Transmitting Station

As described in the recommendation, it is desirable to construct a building for installing transmitters etc. separated from the building for studio equipments. The floor space is required to be wide enough for accommodating two units of 1 kw broadcasting transmitters while giving consideration to the installation of countermeasures for dust-proofness (special consideration shall be paid for the dust-proofness as required by the particular conditions in the region of Bolgatanga.) and air conditioning devices. At the same time, the building shall be connected to the studio building by corridor.

(1) Structure

Windowless structure made of reinforced concrete or block construction. One floor building with the area approximately 70 m^2.

(2) Cooling System

The transmitters themselves are provided with forced cooling system. In normal time, outdoor air is taken in and exhausted after cooled. As the countermeasure for dust-proofness, however, the method by which both of the suction and exhaust airs are sealed and the room is cooled by circulation of air within the room shall be also considered. That is to say, the installation of a unit cooler shall be considered so that room cooling is also available according to the requirement so that a unit cooler may be operated for circulation of cooled wind within the building or when maintenance work is under operation.

By the way, an example of the layout of buildings is indicated on Fig.4.1.8.

4.1.8. Accessory Equipments

In addition to above-mentioned equipments, the followings shall be also installed in the buildings.

(1) CIN for Composition of Transmitter Output

CIN for output composition is installed for the purpose of generating composite output of vision transmitter and sound transmitter and feed to the transmitting antenna through one feeder.

(2) Demodulation Board Rack

This rack is provided for the purpose of monitoring or measuring the demodulated output of the transmitter.

(3) Dummy Antenna

Air cooled dummy antenna is provided for the measurement and adjustment.

(4) Change-over Control Board Rack

For the time being, this rack is not required as the operation is provided by one transmitter. However, when a spare transmitter will be installed in the future, this rack will be also installed. This rack will accomodate an automatic monitoring device so that a trouble of the working transmitter will be detected and changed over to the spare transmitter. Further, all the controlling systems including that are used for changing over to the spare transmitter by manual operation according to the requirement will be accommodated in this rack.

(5) Measurement Frame

The measurement frame is installed for the purpose of providing the immediate measurement required either for periodical maintenance or in case of emergent trouble.

(6) Spare Parts Accommodation Rack

Spare parts accommodation rack is provided for the purpose of keeping spare parts always in good order so that, in case spare parts or measuring instruments are required, the requirement may be immediately answered.

4.2. Studios

On the basis of the expansion of television broadcast programmes in accordance with the expansion project of television broadcasting network, cultural programmes, news, and interveiws are to be produced in 3 regional broadcasting stations - Kumasi, Tamale, and Bolgatanga. Because of the contents of programmes and method of programme production as well as construction cost, the construction work is divided in two phases as shown on Table 4.2.1.

The first phase concerns with the construction work of a television studio and the attached rooms indispensable for them as well as studio facilities conformed to them, while the second phase concerns with buildings and facilities conforming to the expansion of the production of broadcast programmes, presentation studio, master control room, film processing room provided with all the functions of development, printing, and editing, as well as television OB van and its garage.

The abovementioned project has been proposed on the viewpoint of an ideal nationwide network with full respect of the operational situation and way of thinking of the Accra Headquarters of GBC.

4.2.1. Buildings

The building style is a detached reinforced concrete building of one floor excepting the upper part of the studio etc. with special consideration to the interface with the premises and the gradual extension. The traffic lines connecting various rooms and the expansibility by means of the additional buildings and the other functions are viewed with importance rather than external appearance.

The total floor space (nominal effective area) is 935 m^2 for the first phase and 356 m^2 for the second phase totalling 1291 m^2. The floor space of the studio is 180 m^2 (nominal effective area, the same applies hereinafter), which is approximately the same as the Studio No. 1 (or No. 2) of the Accra Headquarters. The list of the floor space of each room is shown on Table 4.2.1. Also, the external appearance, are shown on Fig. 4.2.1. And Fig. 4.2.2, 4.2.3 show the room planning which includes an example of the second phase extension of the building with expansibility.

The site planning adopts the type of locating the detached buildings on a wide site following the planning adopted by the existing stations. Fig. 4.2.4, 4.2.5 and 4.2.6 show the site planning of the abovementioned stations. As a TV transmitting station is also installed at Bolgatanga Station, a connecting corridor is built at the first stage. The installation of connecting corridors with the building of each existing station should be considered as the future construction work in relation to the overall adjustment of the site planning.

The studio is situated at the center of the building with full consideration of sound lock provided with double to triple walls on required positions and ceilings treated with sound insulation. The height of a cyclorama is determined to be 5 m with economic considerations, which is a height sufficient for making the composition complete when a scenery is taken by a standard TV camera with lenses of focal length 50 mm (vertical angle of view 33°) at the position of height 1.5 m apart from distance 10 m. (Refer to Fig. 4.2.8 and 4.2.9)

The studio control room comprises a vision control room and a sound control room separated to each other. The type is according to that adopted by the studio at the Accra Headquarters and adopted for the purpose of valuing custom of GBC staffs. The front room for the VTR room and telecine room are adopted for the purpose of dust-proofness as well as sound insulation. In case of the station of the northern part affected with harmattan condition, such provisions are considered to be very effective. The dimmer room is provided on the 1st floor parallel to the upper part of the studio. Such room distribution contributes to reducing the amount of load wiring in the same way as the electric power room. The film processing room which has a particular relation with water supply and hot-water supply is located adjacent to the air-conditioning and sanitary room.

4.2.2. Studio Facilities

Table 4.2.2 shows the list of the essential equipments, all of which are for monochrome television System B. As vision control function, a part of master control function, the transmission control rack and the terminal set for tail connection betwen the studio and the microwave station of P & T as indicated on the floor layout of the studio control room (Fig. 4.2.10), is installed here till the construction work of the second phase will be completed. It goes without saying that they will be removed to the master control room when the work of the second phase is completed. The character generator provides the elements of letter signal. A character generator provided with memory function is extremely useful and contributes to the more effective employment of the studio live camera and the caption camera.

There is no decisive formula for the floor layout of a control room. Provided, however, that the position of the programme director and the switcher who have an important influence on the performance effect on the programme production should be at the optimum viewing distance, i.e., generally 4 - 5 times the size of the monitor kinescope, from the preview monitor. According to this proposal, the above-mentioned distance is determined to 2 m (6 feet 8 inches), 5 times the size of the picture monitor, 400 mm (16 inches).

The distribution of studio lighting battens is shown on Fig. 4.2.7. Battens B1 - 5 are provided for the purpose of back light (modeling light) Load circuits and those capacity sufficient for providing the lighting of approximately 2 to 3 settings of the programmes of Drumming and Dancing projected to be produced as the cultural programmes are considered. (Refer to Fig. 4.2.14.) The number of load circuits is 3 circuits for each batten and 12 circuits for floor consents, totalling 81 ($3 \times 23 + 12 = 81$)

circuits. The distribution of lights is calculated on the basis of 1 kw for floor area 1 m^2 (monochrome system) and the capacity for lighting control is selected to 70 % - 80 % of the above-mentioned value. According to this proposal, the capacity is 138 kw ($180 \times 0.77 \simeq 138$), or 46 units of the 3 kw lighting control unit. These 46 dimmer circuits are distributed to 81 load circuits together with 35 direct-fed circuits. The capacity of the lighting trunk line is calculated on the basis of 0.36 kw for floor area 1 m^2, which gives the value of 65 kw ($0.36 \times 180 \doteq 65$). In case colour system is introduced, the above-mentioned capacities for lighting should be approximately doubled. Therefore, it is necessary to assure the space for dimmer racks and wiring ducts to secure the possibility of expansion in case colour system is introduced. Further, it is also necessary to assure the space of the air conditioning room for the increase of the capacity of air conditioning.

The floor layout of the VTR room and telecine room is shown on Fig. 4.2.11. The distribution of telecine chains is based on the effective utilization of floor space.

As the broadcasting system, the video block diagram and the audio block diagram are shown on Fig. 4.2.12 and 4.2.13 respectively.

Table 4.2.1 Dimension of the Building

1.	Structure	Reinforced Concrete	
2.	Number of the Floor	1	(except a certain part of the rooms)
3.	Height	9.5m	(from the ground)
4.	Building Space	1,600m	(2nd phase Completion)
5.	Total Floor Space	1,291m	(2nd phase Completion)

The details are as follows:

Phase	Name of the Room	Floor Space(m^2)
1st Phase	Studio	180
	Front Room (for Studio)	18
	Makeup Room	27
	Dressing Room	16
	Storage Equipment	33
	Scenery Assembly	105
	Air-conditioner & Sanitary	102
	Vision Control Room	66
	Sound Control Room	23
	VTR Room	42
	Telecine Room	42
	Front Room	13
	Library	33
	Maintenance	33
	Offices	58
	Toilets	33
	Electric Power Room	66
	Dimmer Room	28
	Storage Room	17
	(Total)	935
2nd Phase	Master Control Room	60
	Presentation Studio	27
	Front Room (for Studio)	12
	Sub-Control Room	53
	Film Proccessing Room	105
	OB Van Garage	66
	Maintenance (for Van)	33
	(Total)	356
	Grand Total	1,291

6.	Electric Power System	Receiving	3 phase 4 Wire	415V
		Distribution	1 phase 2 Wire	240V
		Engine Generator	Not Proposed	
7.	Air and Sanitary Conditioning System		Central System	

Table 4.2.2 List of the Essential Equipments (Monochrome System B)

No.	Description	Q'ty	Rating	Supplement
	TV STUDIO			
	Studio Camera	2	Equivalent to the 3" image orthicon	
	Character Generator	1	With memory	
	Video Control Console	1	8 inputs, 2 buses, with a master monitor and racks	
	Audio Control Console	1	16 inputs	
	Audio Disk Player	2	Single turntable	
	Audio Tape Reproducer	2	With recording function	
	Picture Monitor	8	16'x7, 21'x1	Plus 2(16') on the 2nd phase
	Sound Monitor	3		
	Microphone	1*		
	Microphone Boom & Stand	1*		
	Lighting Control Console	1	With control units' racks	
	Light Elevation System	1*		includes cyclorama system and the 2 scenery battens
	Light	1*		
	Other Ancillary Equipment	1*		
	VTR & TELECINE			
	VTR	2	highband with colour expansibility	plus 1 on the 2nd phase
	Input-Output Selector	1	3 x 3, 3 x 2	mounted inside the attached rack
	Telecine Chain	1	16mm proj x 2, slide proj x 1, MPX x 1, Camera x 1	
	Caption System	1	display x 1, vidicon camera x 1	
	Other Ancillary Equipment	1*		
	PRESENTATION STUDIO			
	Studio Camera	1	1" vidicon	2nd phase
	Character Generator	1	with memory	(do)
	Video Control Console	1	8 inputs, 2 buses, with a master monitor and racks	(do)
	Audio Control Console	1	11 inputs	(do)
	Audio Disk Player	2	Single turntable	(do)
	Audio Tape Reproducer	2	With recording function	(do)
	Picture Monitor	8	16'x7, 21'x1	(do)
	Sound Monitor	2		(do)
	Microphone	2		(do)
	Microphone Stand	2		(do)
	Lighting System	1*	lights, switch box	(do)
	Other Ancillary Equipment	1*		(do)

No.	Description	Q'ty	Rating	Supplement
	MASTER CONTROL			
	Transmission Control Console	1		2nd phase
	Rack	1*	Sync generators, distribution amplifiers, test instruments	Some equipments are to be used on the 1st phase.
	Link	2	Normal & reverse	for tail connection with P&T
	Field Pick-up Unit	2	Microwave receiver	for OB Van, 2nd phase
	Other Ancillary Equipment	1*		2nd phase
	FILM PROCESSING			
	Developing Machine	2	16mm	2nd phase
	Printer	1	16mm	(do)
	Chemical Supplies System	1*		(do)
	Editing System	1*	Splicers, viewers, 16mm projector	(do)
	Dark Room System	1*		(do)
	Cine-Camera	1*	16mm	(do)
	Still-Camera	1*		(do)
	Other Ancillary Equipment	1*		(do)
	OB VAN			
	Field Camera	3	equivalent to the 3" image orthicon	2nd phase
	Video Control Console	1	4 inputs 2 buses, with a master monitor and racks	(do)
	Audio Control Console	1	6 inputs	(do)
	Audio Disk Player	1	Single turntable	(do)
	Audio Tape Reproducer	1	With recording function	(do)
	Picture Monitor	5	9" x 5, 12" x 1	(do)
	Air Monitor	1	12" x 1	(do)
	Sound Monitor	2		(do)
	Microphone & Stand	1*		(do)
	VTR	1	highband with colour expansibility	(do)
	Field Pick-up Unit	2	Microwave transmitter	(do)
	Other Ancillary Equipment	1*		(do).

Remarks * .. quantity unit "set"

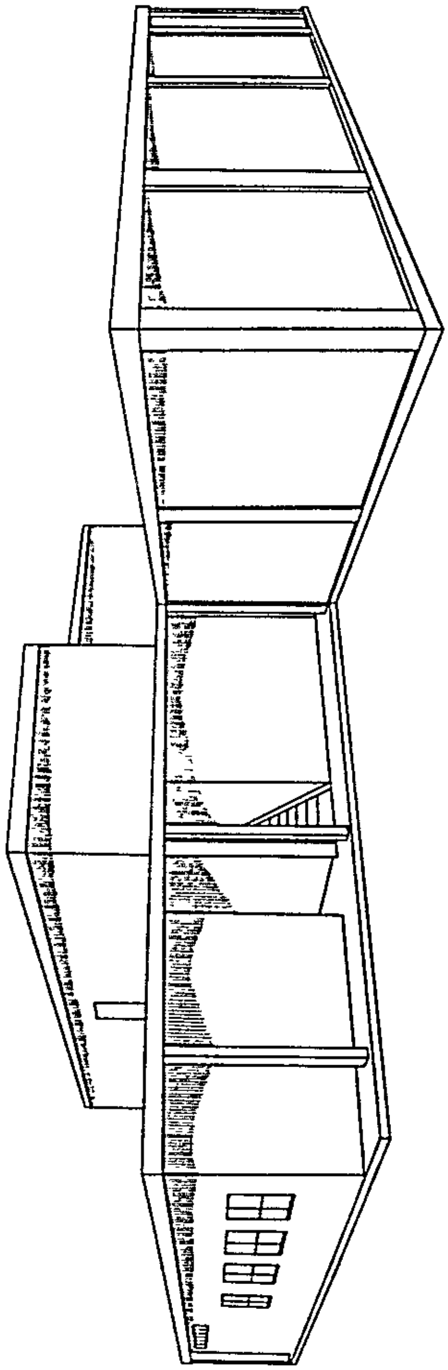
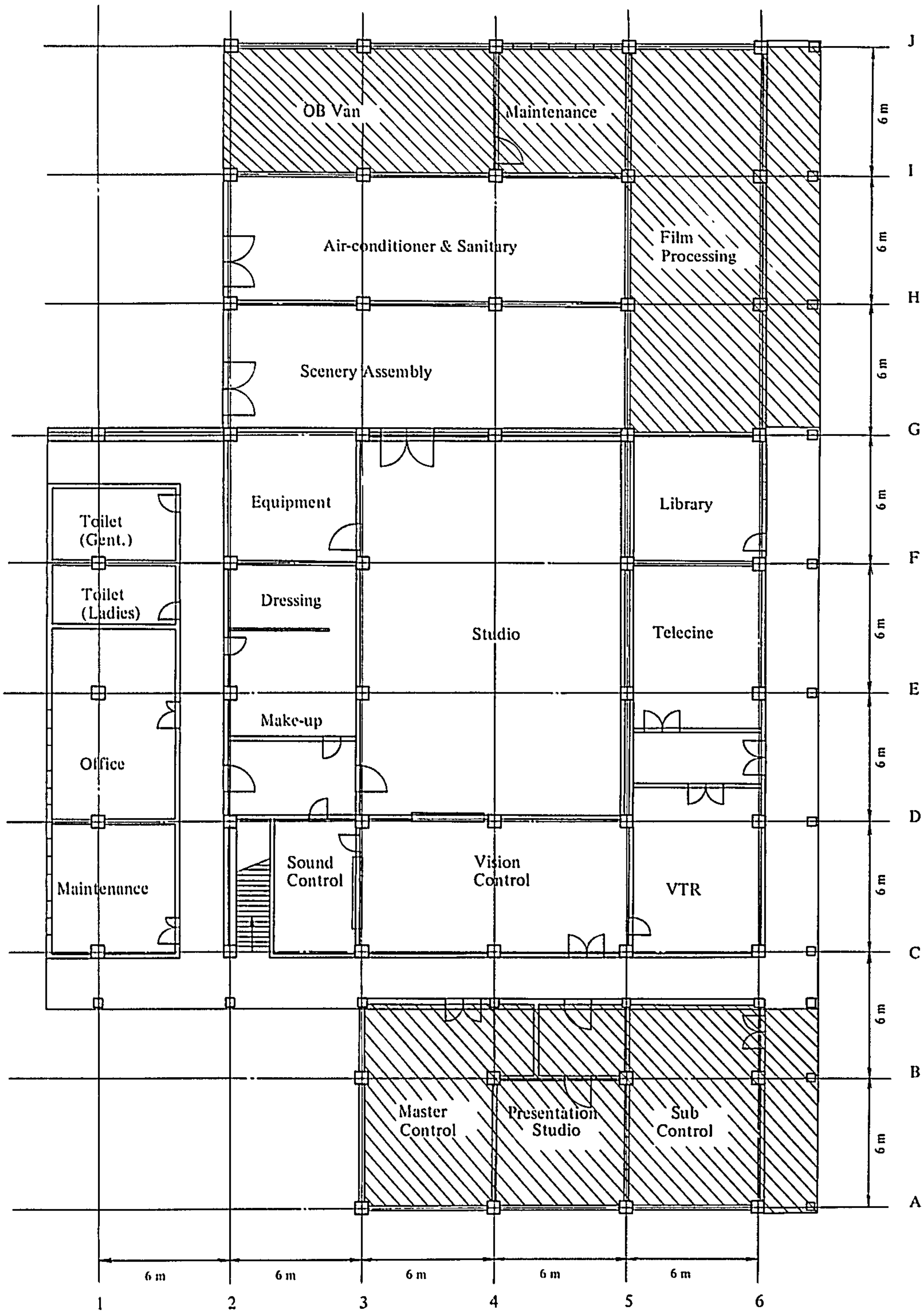


Fig. 4.2.1 PICTORIAL VIEW of the STUDIO BUILDING
(2nd Phase Completion)

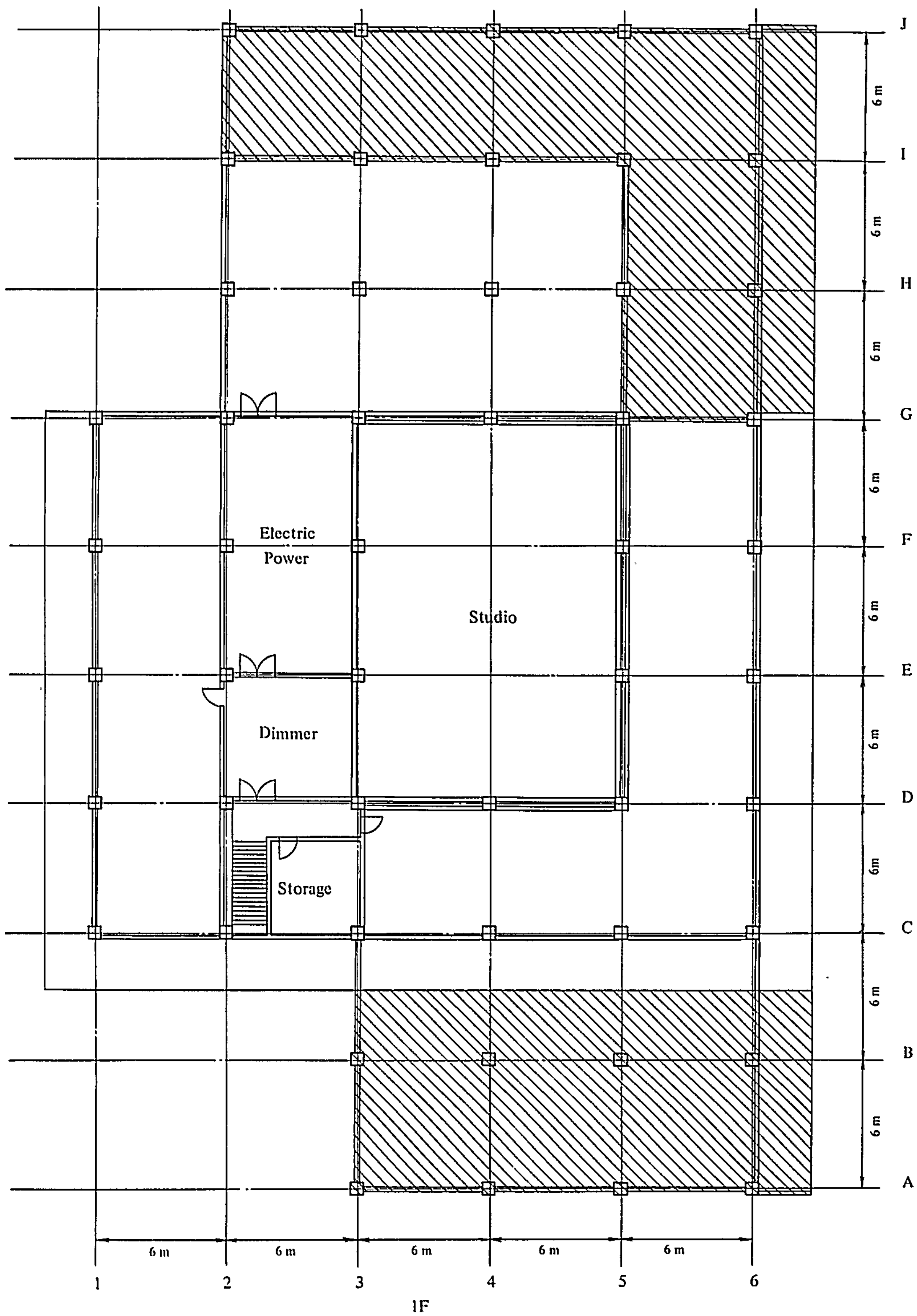


GF

Scale : 1/200

Remarks : ////// 2nd Phase

Fig. 4.2.2 Regional Station, GBC-TV
STUDIO FLOOR PLAN (1)



Scale : 1/200

Remarks ://////2nd Phase

Fig. 4.2.3 Regional Station, GBC-TV
STUDIO FLOOR PLAN (2)

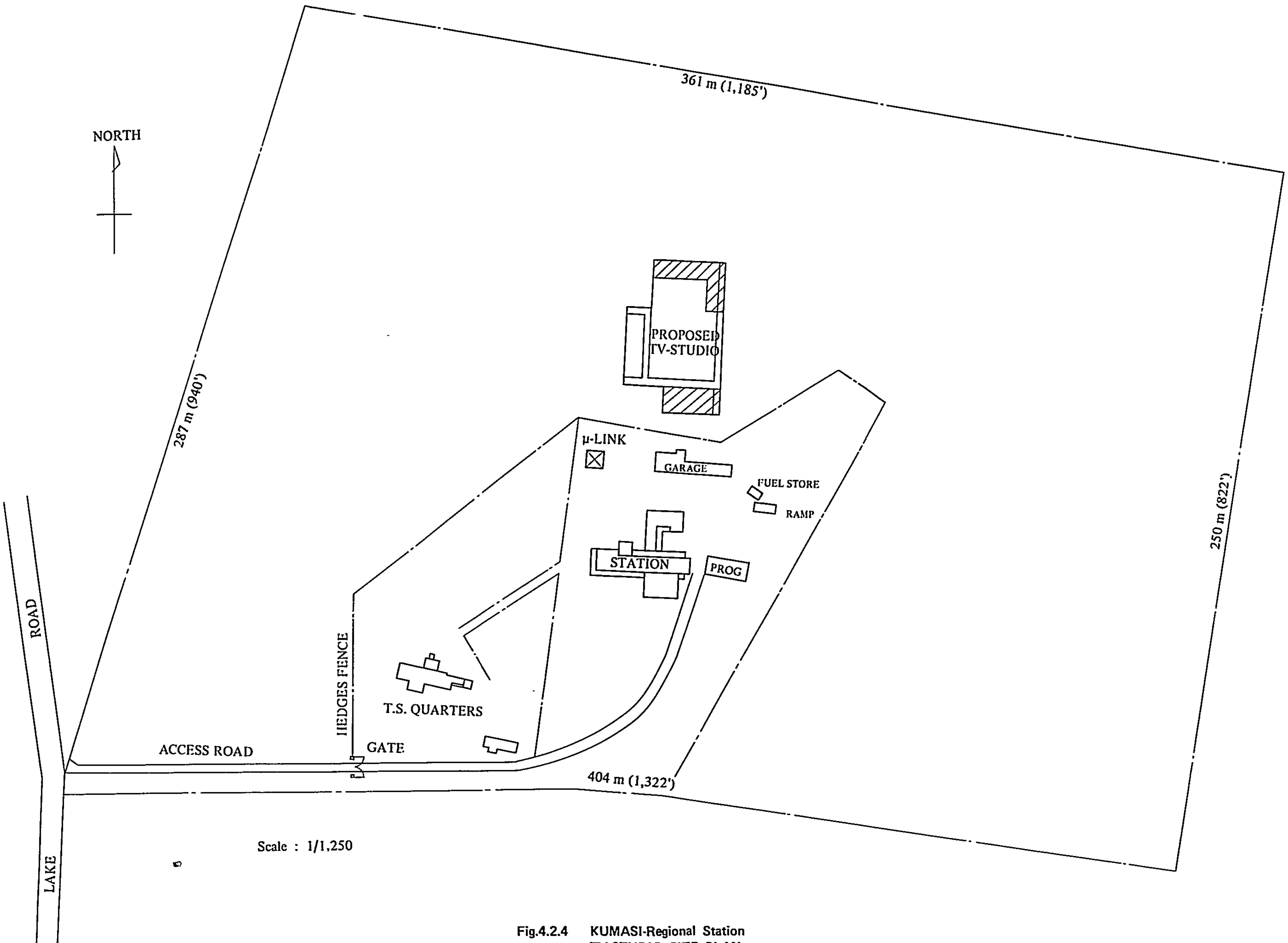


Fig.4.2.4 KUMASI-Regional Station
TV-STUDIO SITE PLAN

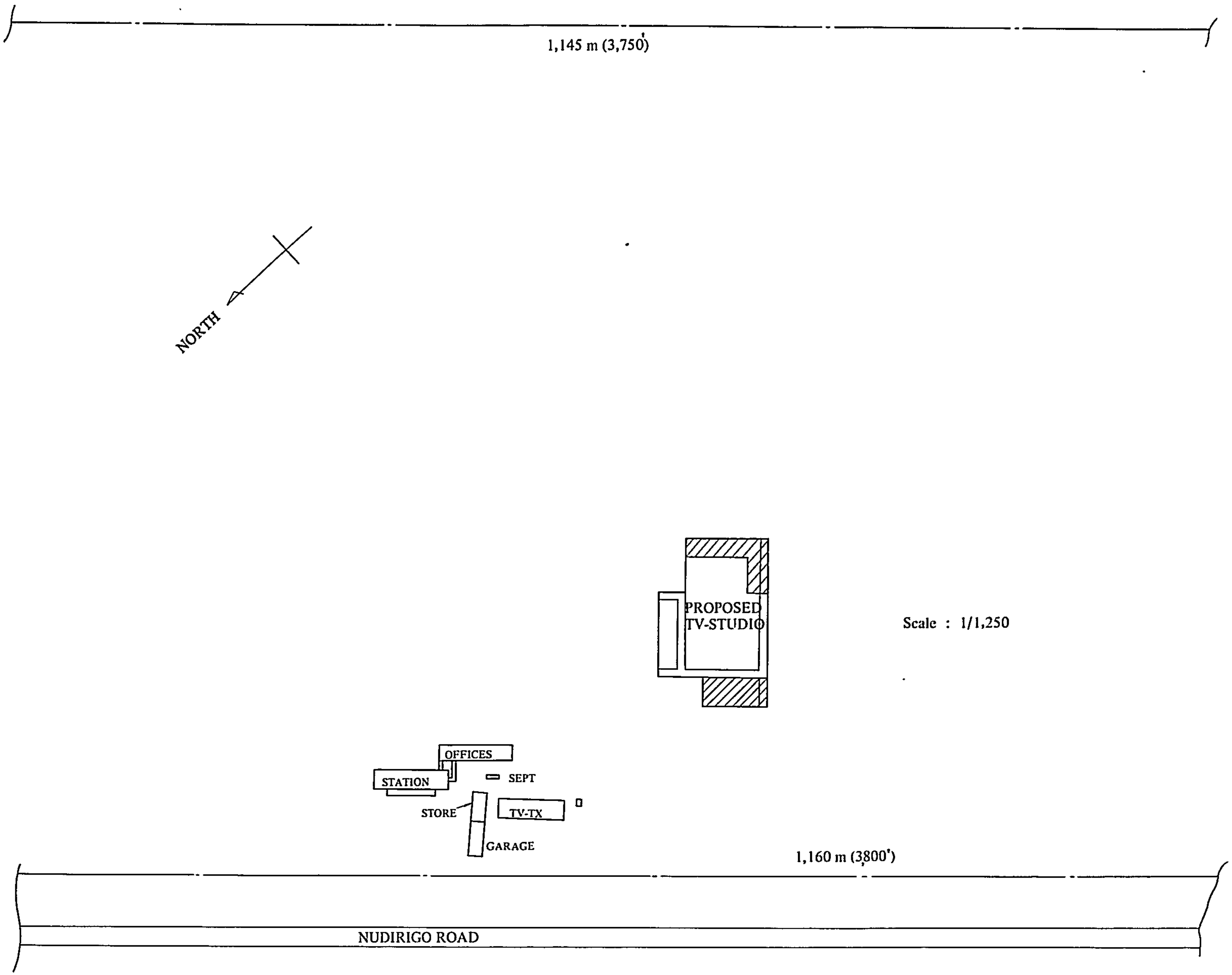


Fig. 4.2.5 TAMALE-Regional Station
TV-STUDIO SITE PLAN

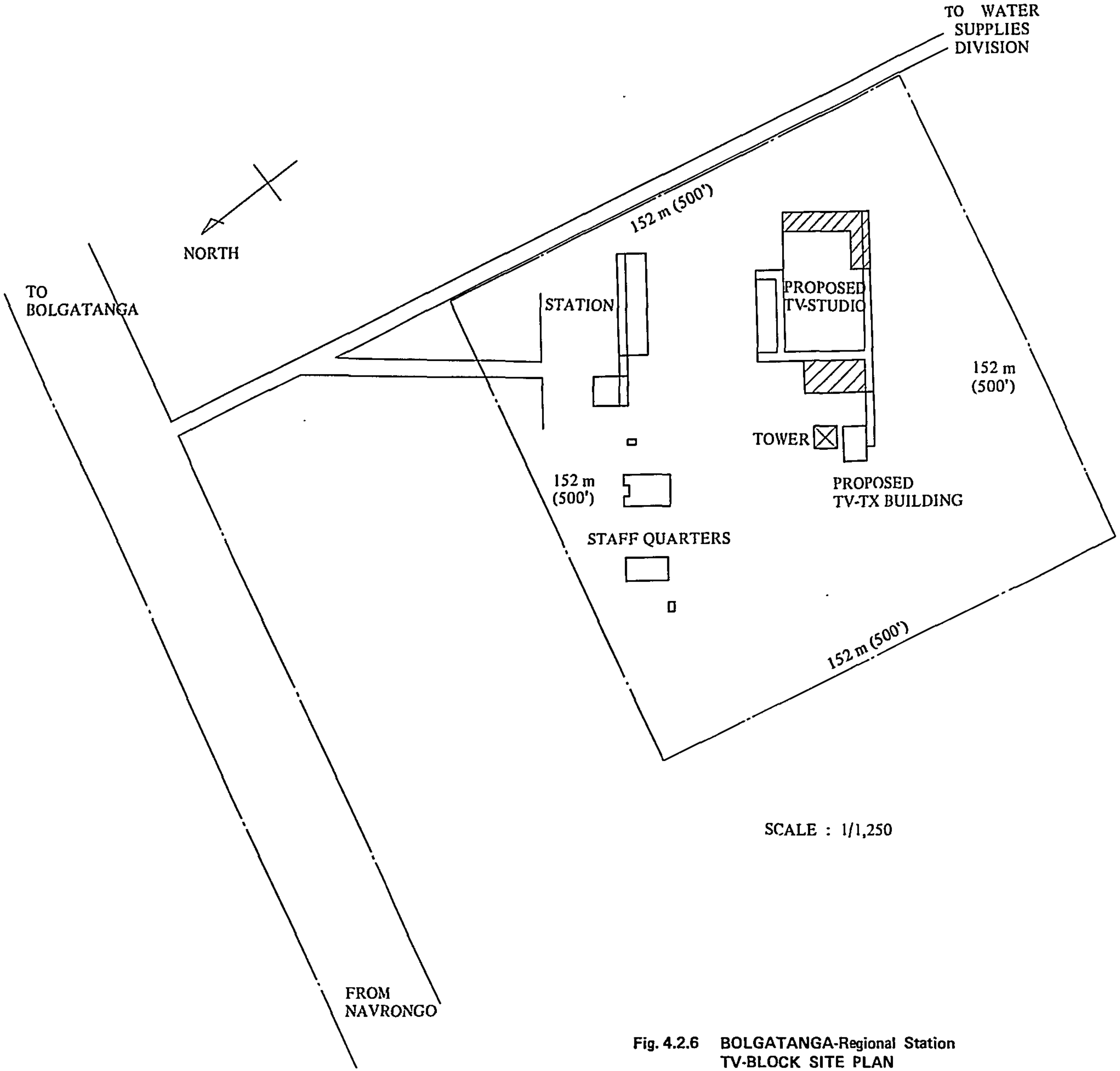
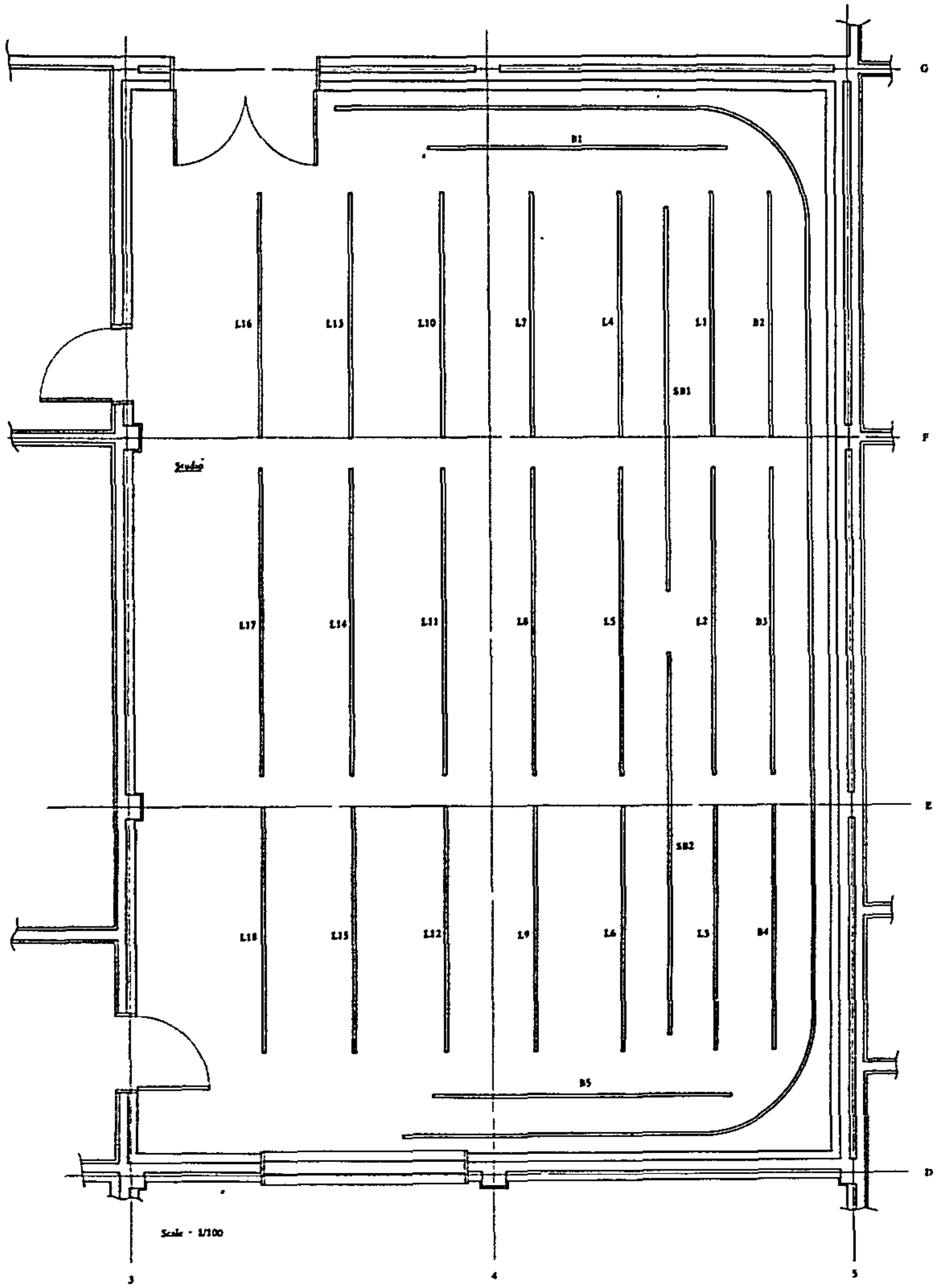


Fig. 4.2.6 BOLGATANGA-Regional Station TV-BLOCK SITE PLAN



Remarks . CT . Cyclorama Track
SB 1 - 2 : Scenery Battens
B 1 5 . Lighting Battens
L 1 18 . Lighting Battens

Fig. 4.2.7 Regional Station, GBC - TV
LAYOUT of the STUDIO LIGHTING BATTENS

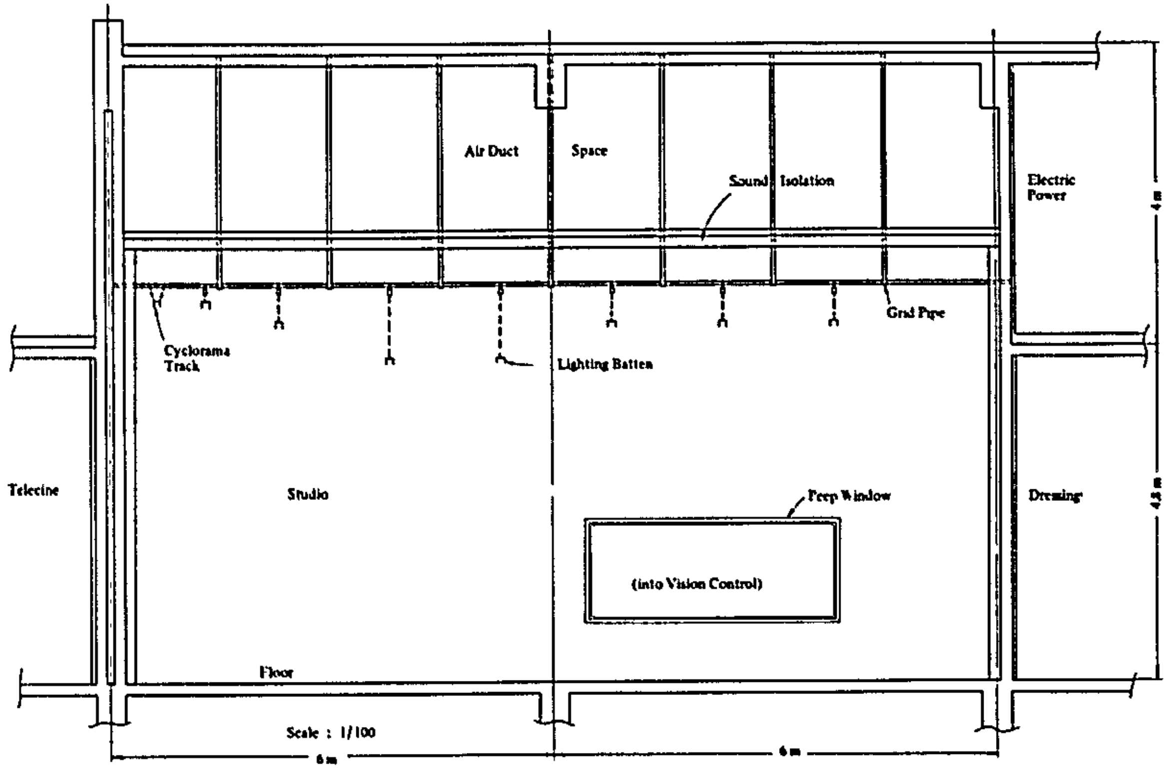
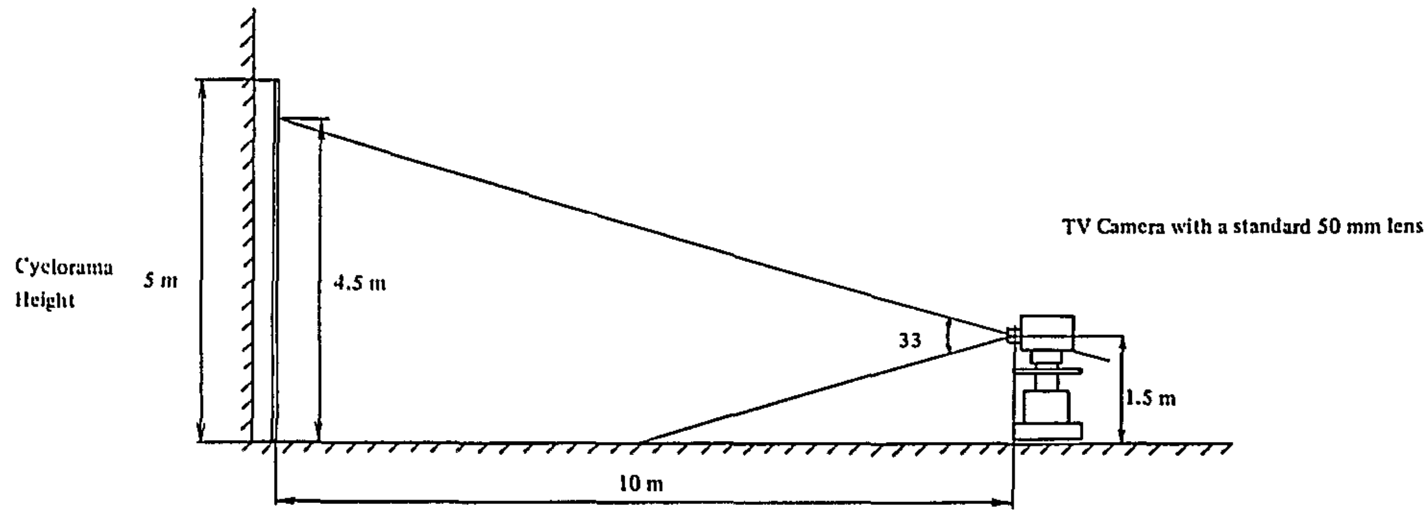


Fig. 4.2.8 Regional Station, GBC-TV
STUDIO ELEVATION

Fig. 4.2.9 Cyclorama Height and Vertical Angle of View



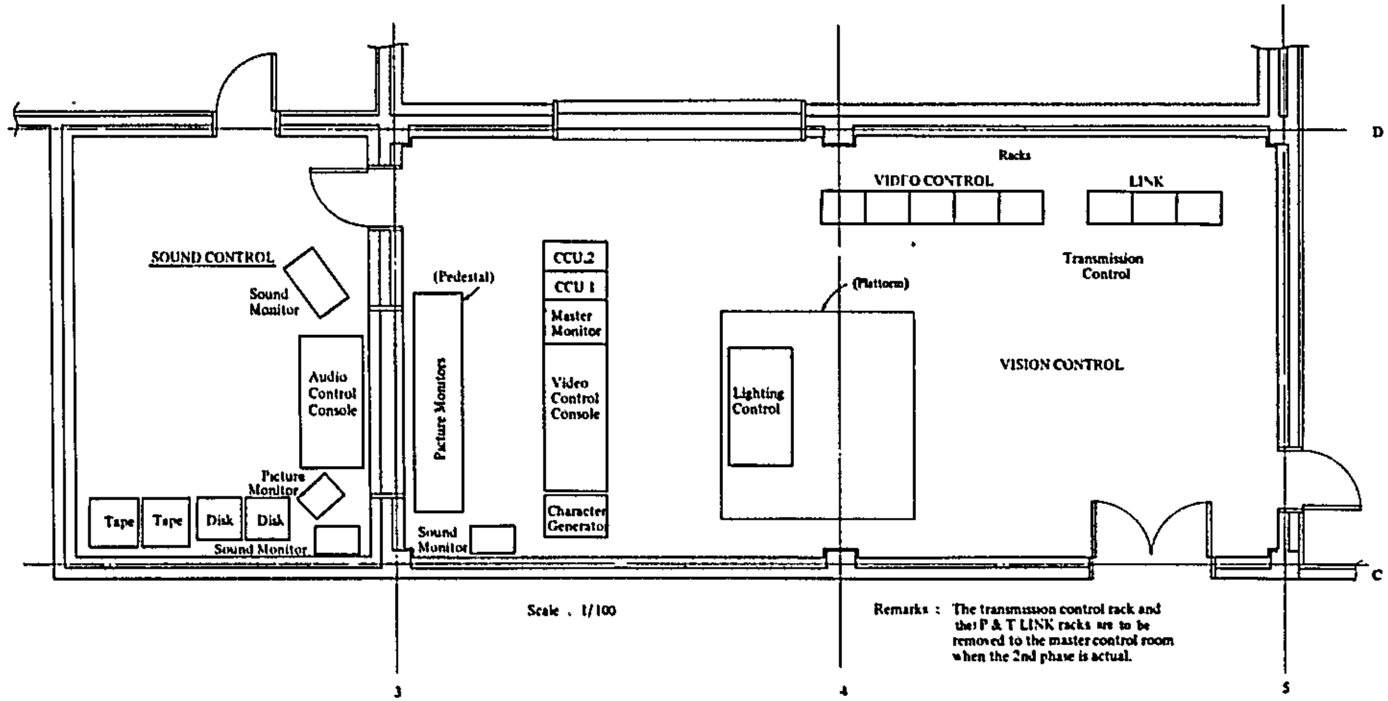
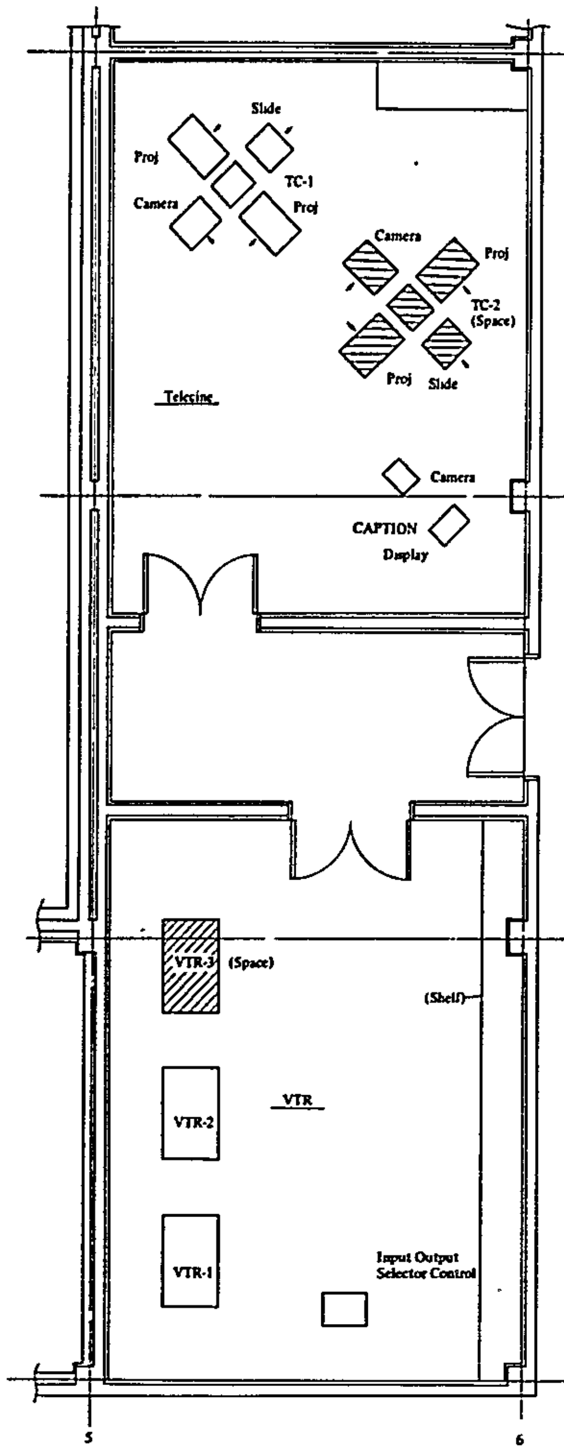


Fig. 4.2.10 Regional Station, GBC-TV
LAYOUT of STUDIO CONTROL ROOM

Scale . 1/100

Remarks : The transmission control rack and the P & T LINK racks are to be removed to the master control room when the 2nd phase is actual.



Remarks :

The symbol— points out facing to the operational position.

Scale : 1/100

Fig 4.2.11 Regional Station, GBC-TV
LAYOUT of VTR & TELECINE ROOM

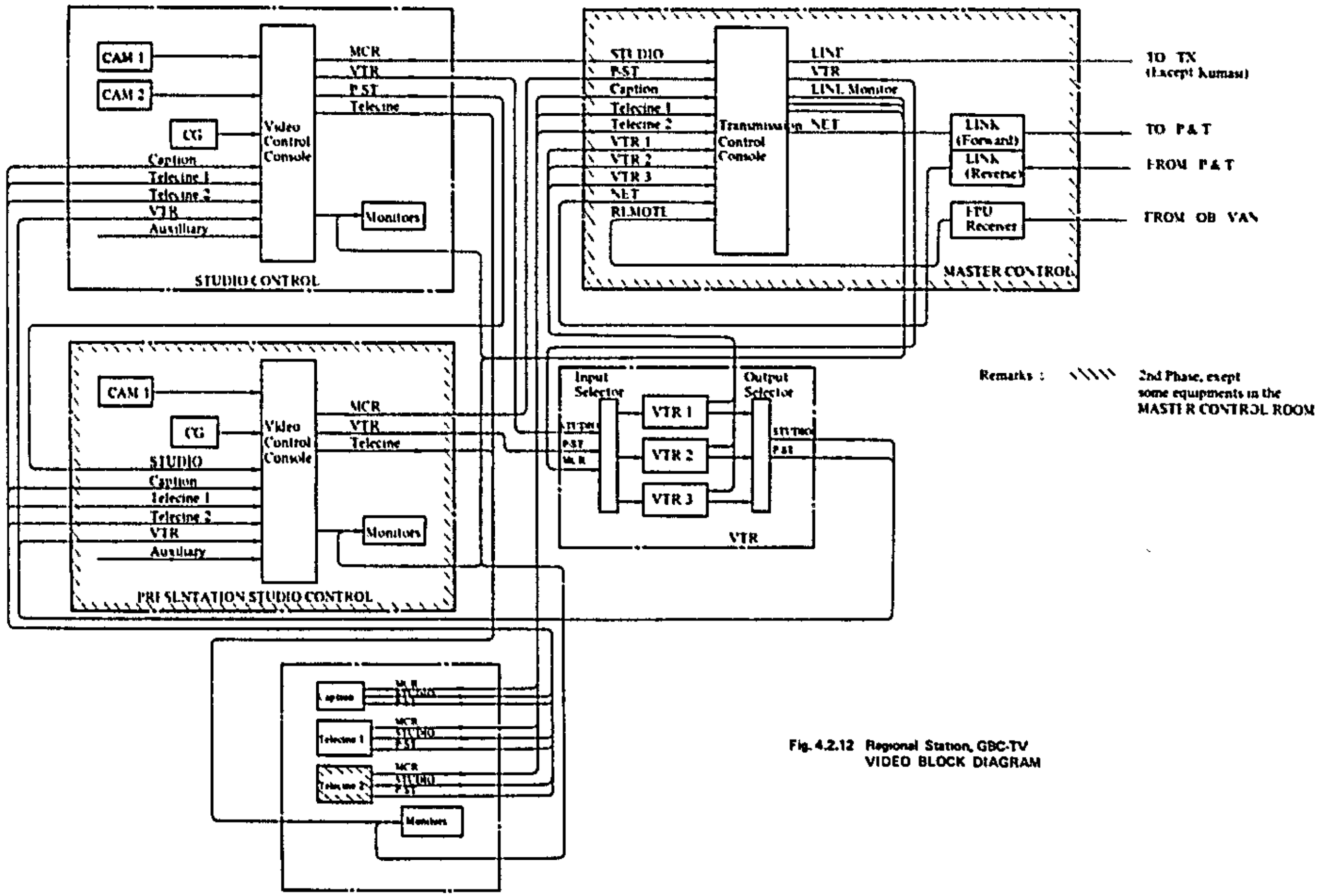


Fig. 4.2.12 Regional Station, GBC-TV
VIDEO BLOCK DIAGRAM

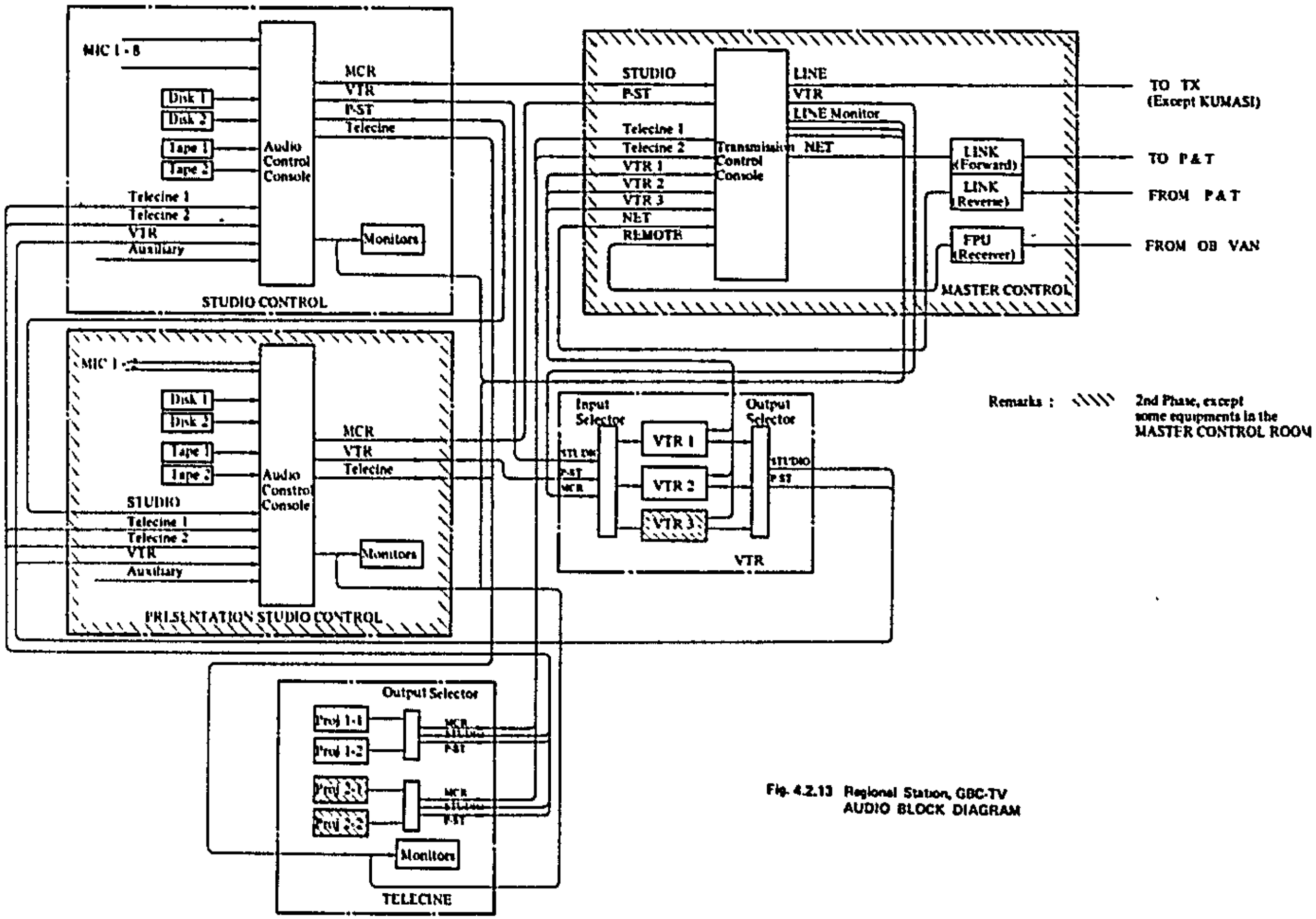


Fig. 4.2.13 Regional Station, GBC-TV
AUDIO BLOCK DIAGRAM

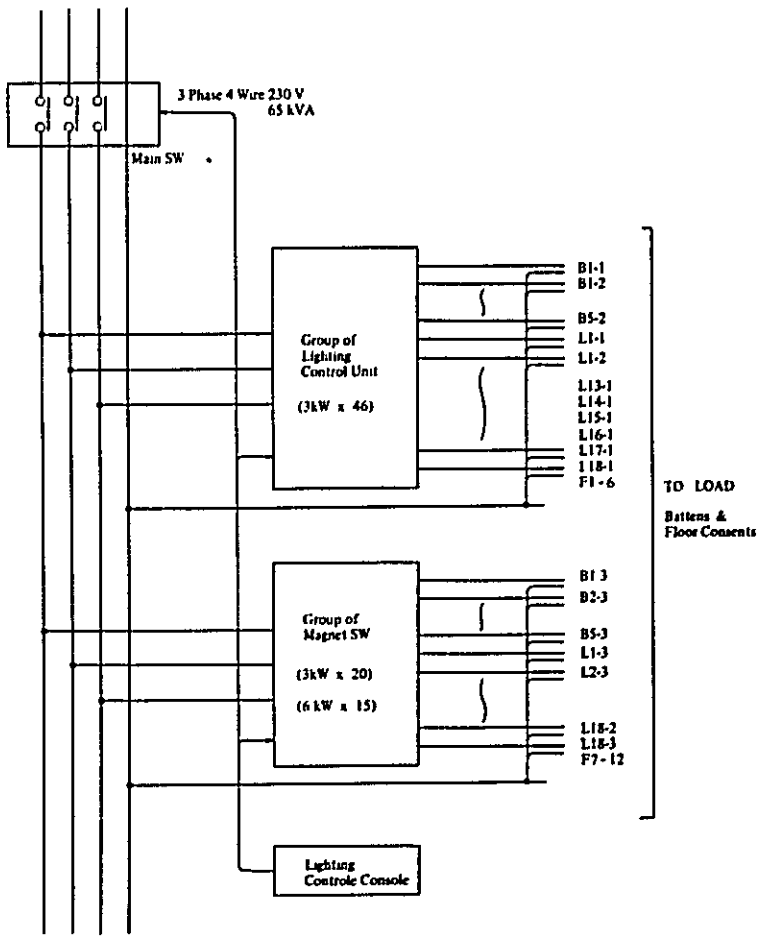


Fig. 4.2.14 Regional Station, GBC-TV
STUDIO LIGHTING BLOCK DIAGRAM

4.3. Links

The following points are required to be considered for the investigation of the link system connecting studio and transmitting station as well as studio and microwave radio station. That is to say, it is required to determine whether radio system or cable system shall be adopted as the circuits relaying the TV signals.

Generally, microwave system, adapted for the wide band transmission, is adopted as the radio system, while cable system is adopted chiefly for tail connection between a microwave relay station and a studio because it provides an economical structure for transmission of short distance.

4.3.1. Tail Connection between Bolgatanga TV Station and P & T Terminal Station

The Bolgatanga TV station has the studio for TV programme production. So, it is necessary that the said station is provided with the programme transmitting function to the Accra station situated at the Capital City through the southward relay system. Normally, the programmes sent from Accra studio are broadcast from Bolgatanga TV station. Therefore, it is indispensable to provide at least each 1 channel of the southward and northward relay system to the P & T terminal station. It becomes clear by Fig. 4.3.1 (City Planning Map of Bolgatanga) that the line-of-sight distance between P & T and TV broadcasting station is approximately 1.9 km, and approximately 2.3 km along the road. According to the existing situation of the road, it is judged that the burying work of coaxial cable will be executed without difficulty as there is no clustering of cities. Further, as is clear by the following comparison of cost, the cable system is more advantageous.

CIF ¥

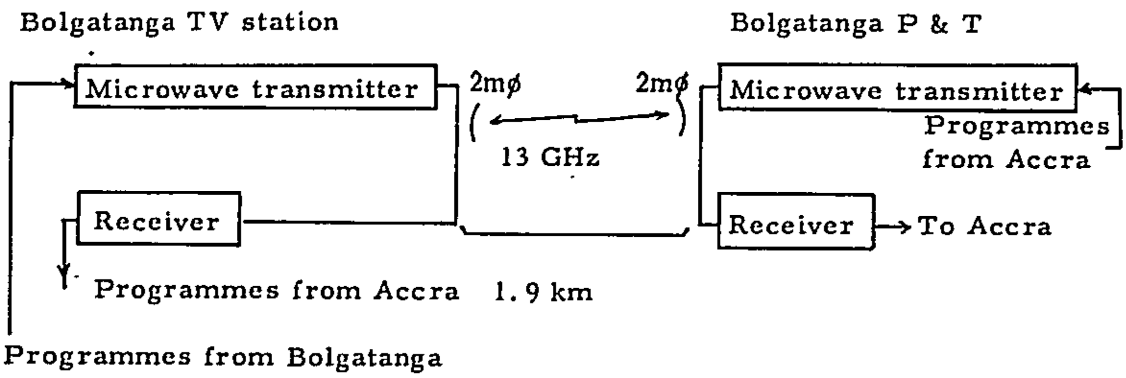
Wireless system		Cable system	
Equipment for transmitting and receiving antenna	(thousand ¥) 10,000	Coaxial cable	(thousand ¥) 18,500
Transmitting and receiving equipment	34,000	Terminal equipment	18,000
Total	44,000	Total	36,500

The investigation was carried out on the basis of 13 GHz band for the wireless system as the distance is short, and a parabolic antenna of 2 mφ are assumed as the transmitting and receiving antenna each of which is installed on the roof of the station building, with waveguides of each 30 m long for transmitting and receiving.

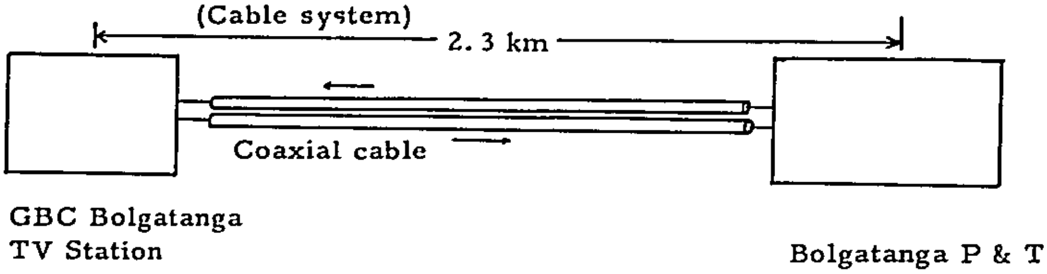
Although one coaxial cable may be employed for both of forward and return, the investigation was carried out on the assumption of installing 2P for operating in normal case each of forward and return. Also, the transistorized terminal equipment was assumed as the system of coaxial cable operation. The terminal equipment comprises two major parts of transmitting section and receiving section, on the transmitting equipment of which is connected a vision transformer for the matching of line and equipment and the disturbance due to the low frequency induction is supressed by cutting the earthing from the external conductor of the coaxial cable. The receiving equipment comprises the pre-equalizer board, equalizing amplifier board, clamper, alarm board, and power supply, change over board, etc.

Followings are the block diagrams of each of the systems.

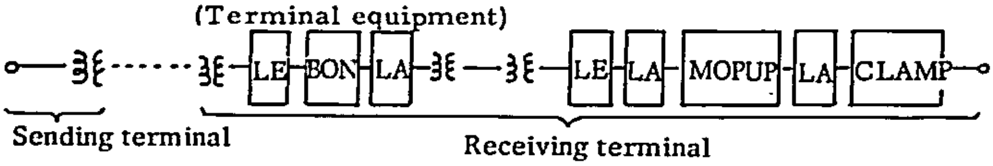
(Wireless system)



(Cable system)



(Terminal equipment)



LA : Line amplifier
LE : Line equalizer
MOPUP : Mop-up equalizer
CLAMP : Clamper
BON : Building-out line network

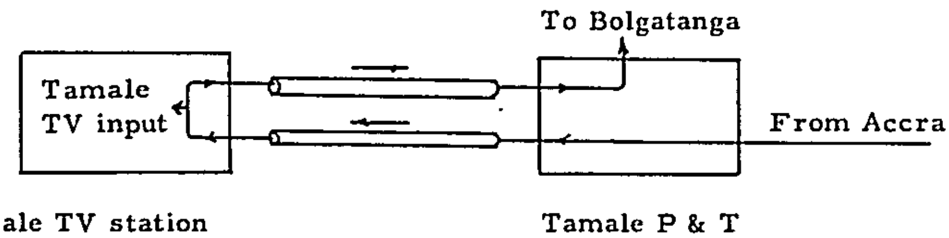
At cost calculation, the construction cost was included in each item. Further, for cost calculation, the existing steel towers are employed for the wireless system, and all the equipments are calculated on the basis of installing two sets. (normal and emergency)

4.3.2. Tail Connection between Tamale Station and P & T Terminal Station

At present, Tamale station of GBC broadcasts TV programmes of VTR and films sent from Accra by aeroplane by means of TV broadcasting transmitter and antenna installed at the said station.

In case the studio for TV programme production is installed at Tamale station, the station will transmit programmes sent from Accra in normal time, while the station will be provided with the capacity of transmitting programmes of its own generation to Accra through its southward relay system. In this case, each one for forward and return will be provided by the coaxial system between Tamale and P & T. The cable route is shown on Fig. 4.3.2 (City Planning Map of Tamale). The adoption of the coaxial system is determined as it is more advantageous as is investigated by the project of Bolgatanga TV station.

It is desirable that the equipments at Tamale Station are provided with the capacity of transmitting programmes always to both directions of forward and return as shown on the following diagram.



In case of outgoing signal from Tamale, the signal is transmitted on the southward relay system and connected at P & T.

4.3.3. Tail Connection between Kumasi Station and P & T Terminal Station

At Kumasi station, there is no function for TV programme production at present. In case the studio for TV programme production is installed at Kumasi, the situation differs from the abovementioned two stations in respect to the fact that the existing TV broadcasting is transmitted from Jamasi station. As either replacement or additional installation is projected for the installation of Patasi station which is a relay station of TV at Kumasi by a microwave radio relay system project under consideration in other place, it is investigated to install the system for transmitting TV signal between Kumasi station and Patasi station of P & T. In this case, it becomes an indispensable condition to convert the existing Patasi station, which is now a through relay station of frequency convertion system, to a modem station. According to Fig. 4.3.3 (City Map of Kumasi), to bury a cable between both stations is not so simple a work as the burying of cable between two cities on the topographical reasons because of the necessity of twice crossing railways and abundant undulation of the topography. So, we recommend microwave system for Kumasi.

(1) Microwave Link at Kumasi Station

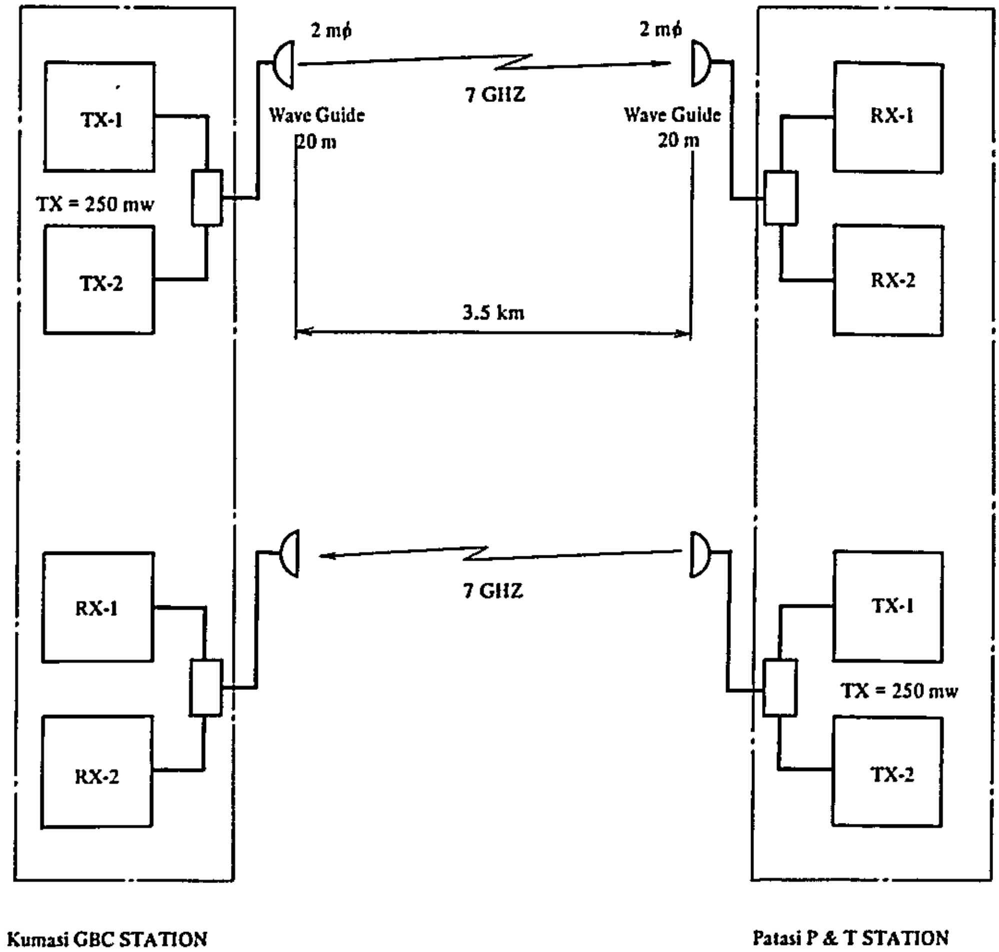
The investigation is made on Fig. 4.3.3 (City Map of Kumasi).

The line of sight distance between Kumasi station of GBC and Patasi microwave station of P & T is approximately 3.5 km. The forward and return microwave link for transmitting TV signal are installed between the abovementioned two stations. A parabolic antenna for transmission and reception are mounted on the existing steel tower so the line-of-sight is perfectly secured. Further, although 10 ~ 13 GHz is available as the operating frequency on the basis of the distance, the design is investigated with the operating frequency in 7 GHz band. The elements are shown below.

7 GHz microwave link design (λ= 4.3 cm)

Elements	Designed values	Remarks	Notes
Transmission output (Pt)	24 dBm	250 mW	Solid state transmitter
Transmission antenna gain (Gt)	37 dB	2 mϕ parabolic antenna	Mirror surface parabolic antenna
Reception antenna gain (Gr)	37 dB	2 mϕ parabolic antenna	"
Free space loss (Lp)	-120.4 dB	d = 3.5 km	$Lp = 122 + 20 \log_{10} d$ (km) $-20 \log_{10} \lambda$ (cm)
Transmission feeder loss	-5 dB	20 m	Square waveguide
Reception feeder loss	-5 dB	20 m	"
Filter loss (L_f)	-3 dB		Common equipment loss
Fading margin (L_F)	-3.7 dB		L_F = 0.2 dB/km + 3 dB
Power distribution (L_D)	-4 dB		Two-way distribution
Ageing margin (α)	-3 dB		Fluctuation of ageing
Received input power (Pr)	-46.1 dB		
Receiver noise power (Prn)	-105.5 dB		Prn.= 10 log B + F - 144 ≒ 10 log 450 (kHz) + 12 - 144 (band width) (NF)
(C/N)	59 dB		(C/N)=Pr - Prn = -46.1 + 105.5 ≒ 59
(S/N)	59 dB		(S/N) = (C/n) + I (In this case the improvement coefficient I = 0)

Following is the block diagram.


2 mϕ
2 mϕ
7 GHZ
TX-1
Wave Guide
20 m
Wave Guide
20 m
RX-1
TX = 250 mw
TX-2
RX-2
3.5 km
7 GHZ
RX-1
TX-1
TX = 250 mw
RX-2
TX-2
Kumasi GBC STATION
Patasi P & T STATION

PROFILE MAP

K = 4/3

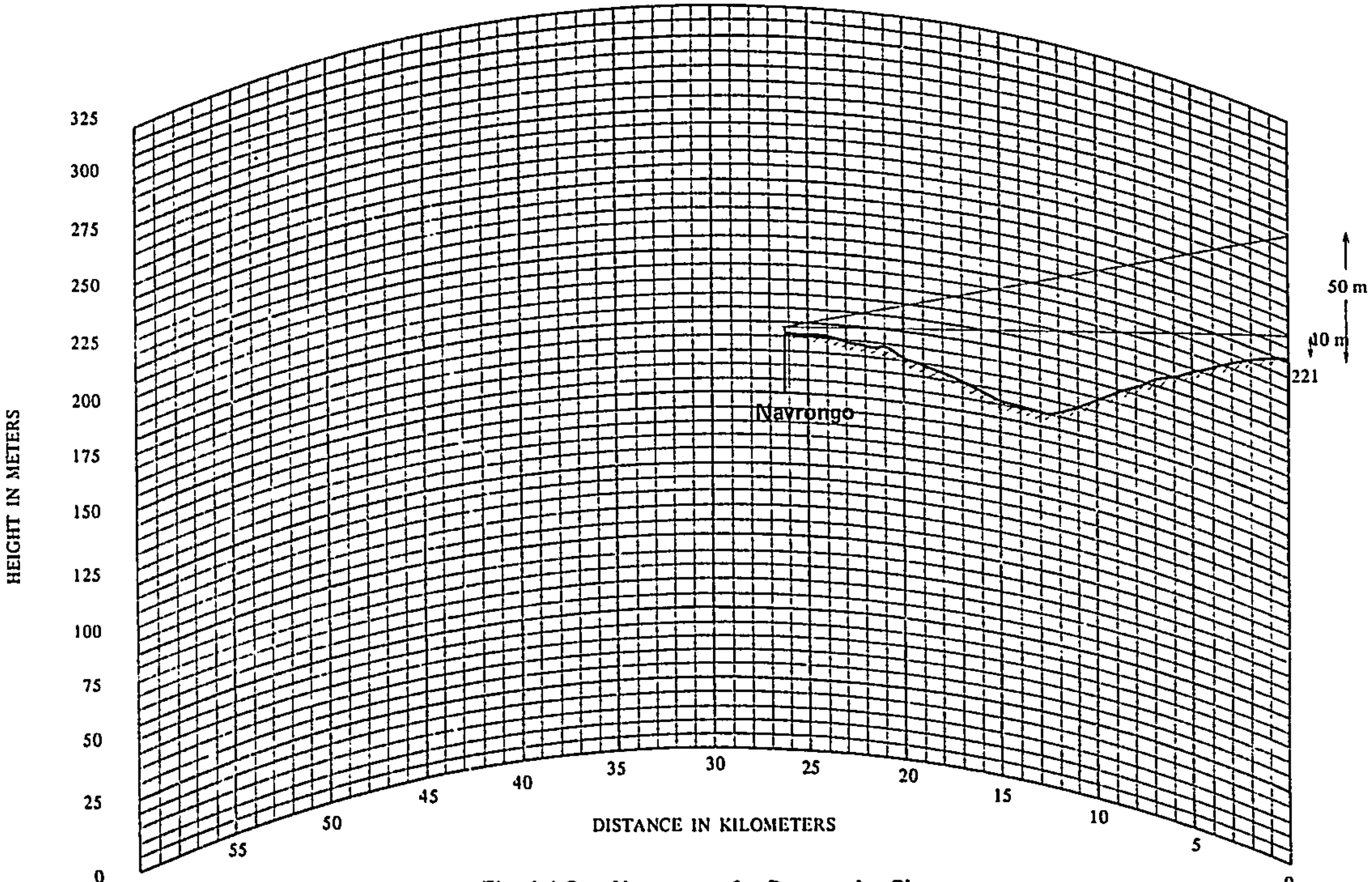


Fig. 4.1.2 Navrongo—1st Prospective Site

PROFILE MAP

K = 4/3

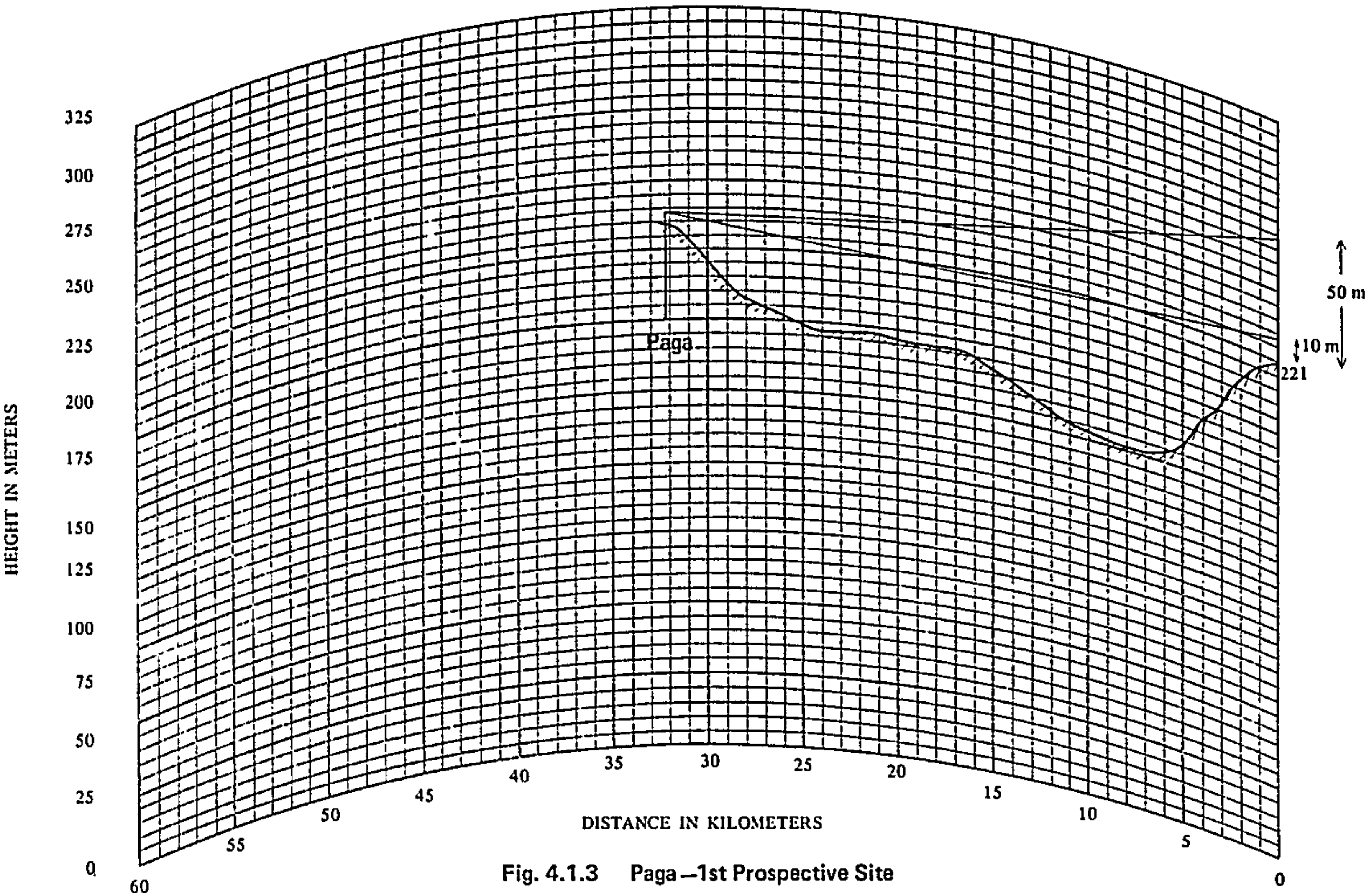


Fig. 4.1.3 Paga—1st Prospective Site

PROFILE MAP

K = 4/3

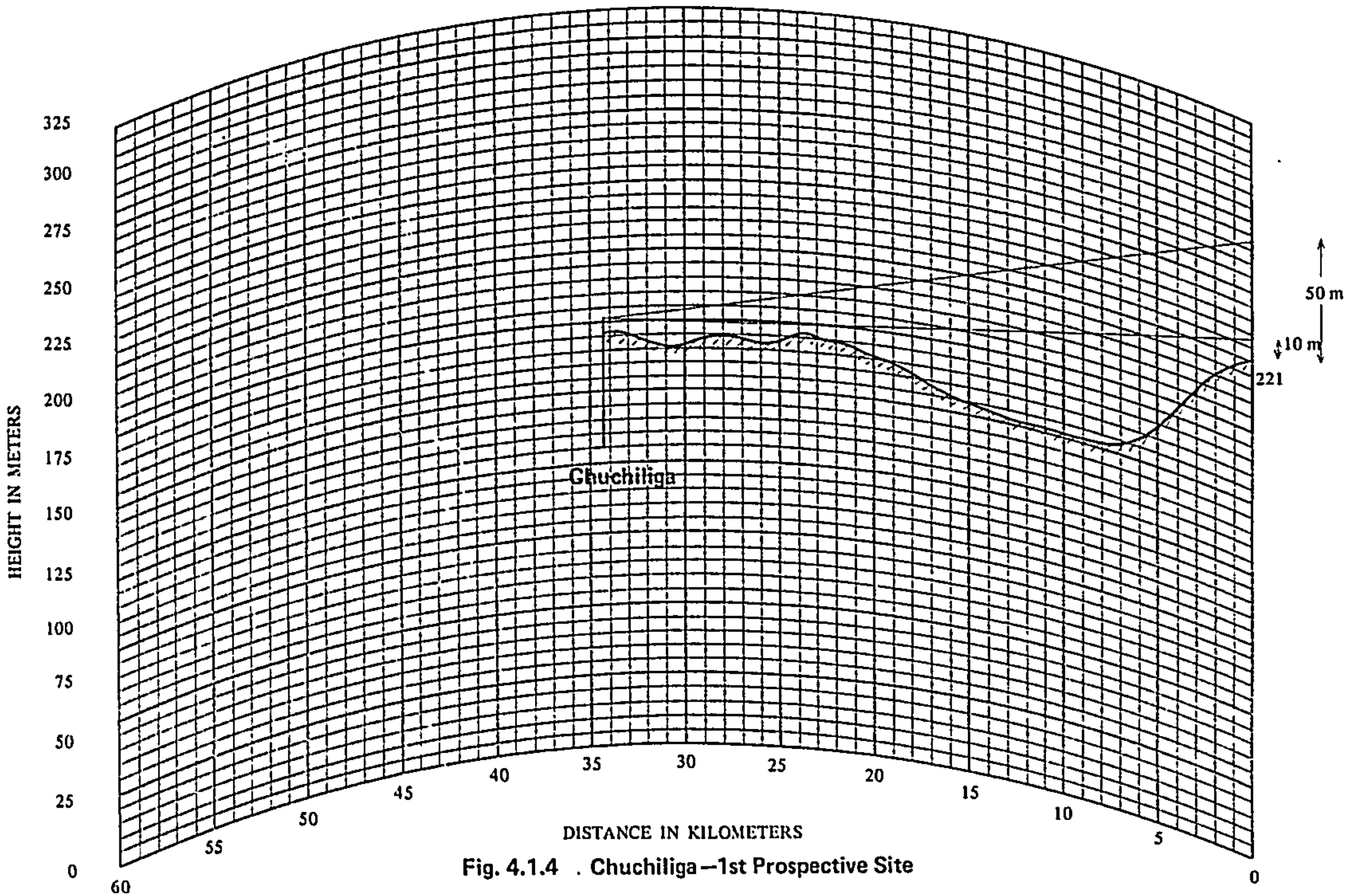


Fig. 4.1.4 . Chuchiliga—1st Prospective Site

PROFILE MAP

K = 4/3

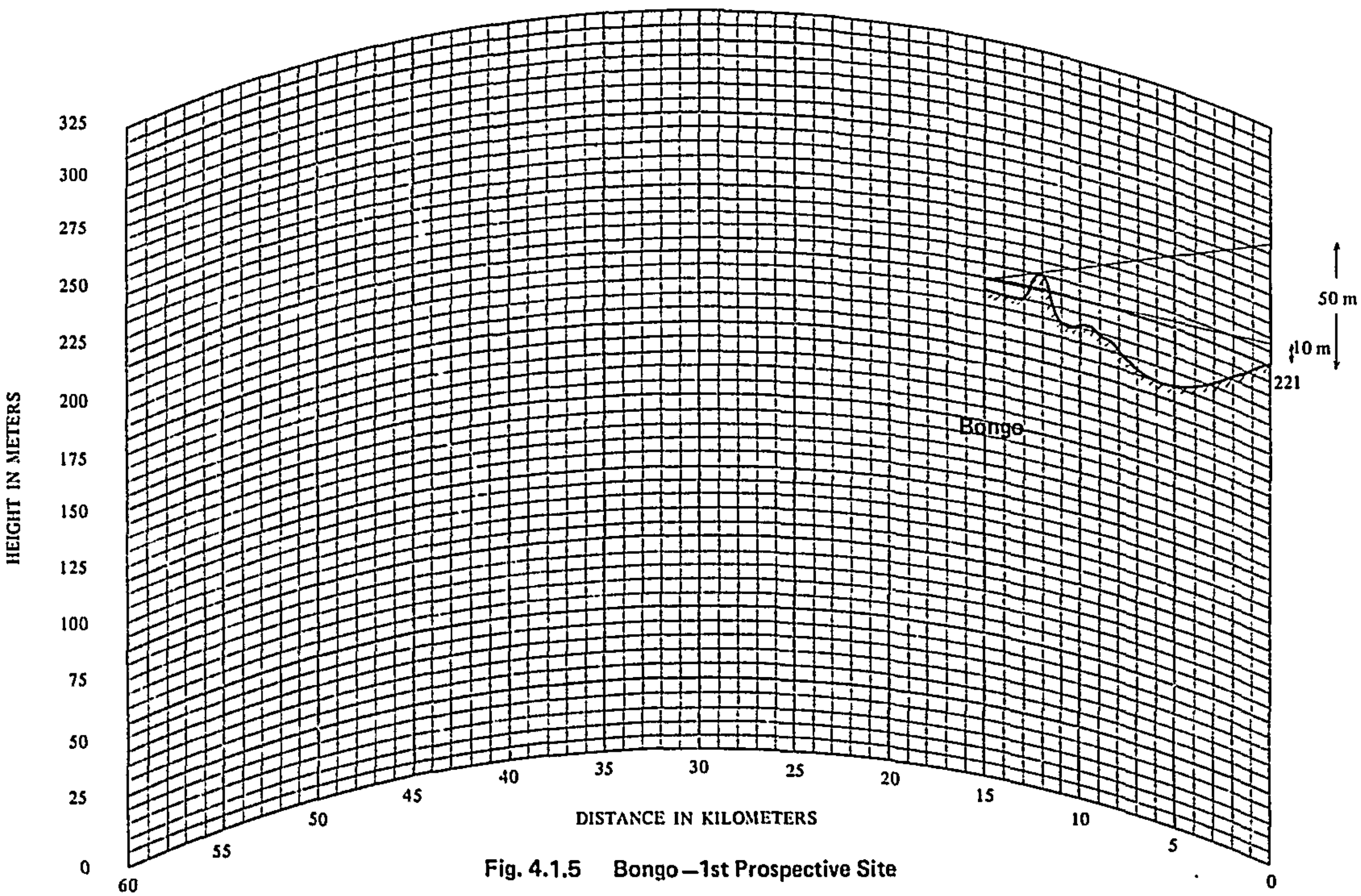


Fig. 4.1.5 Bongo—1st Prospective Site

Fig. 4.1.8 Layout of New Bolgatanga TV Transmitting Station

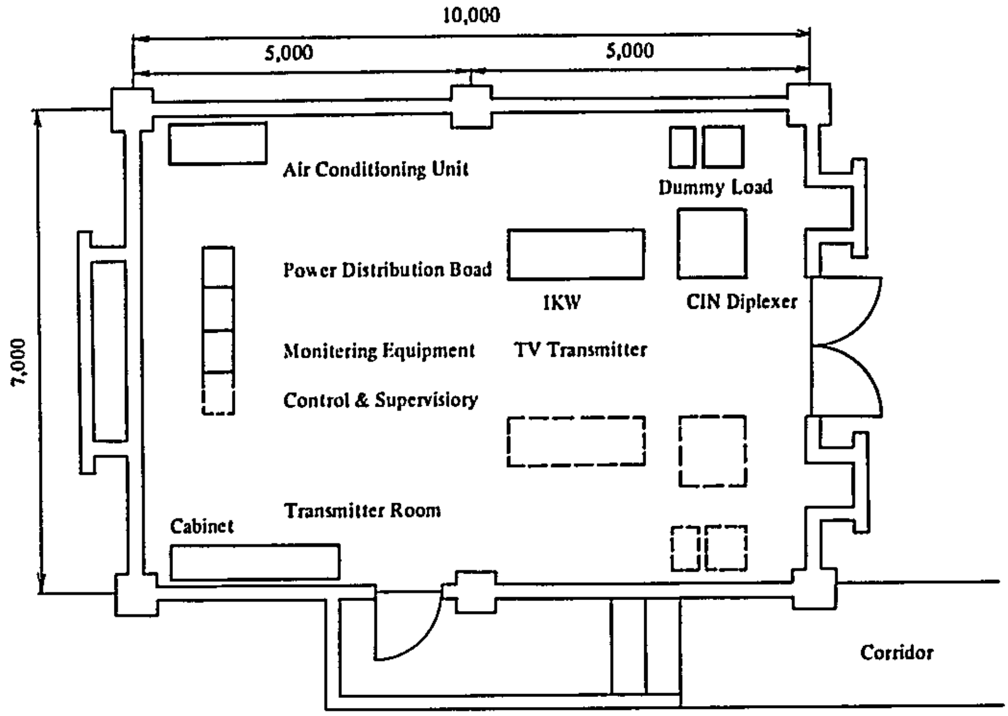


Fig. 4.3.1

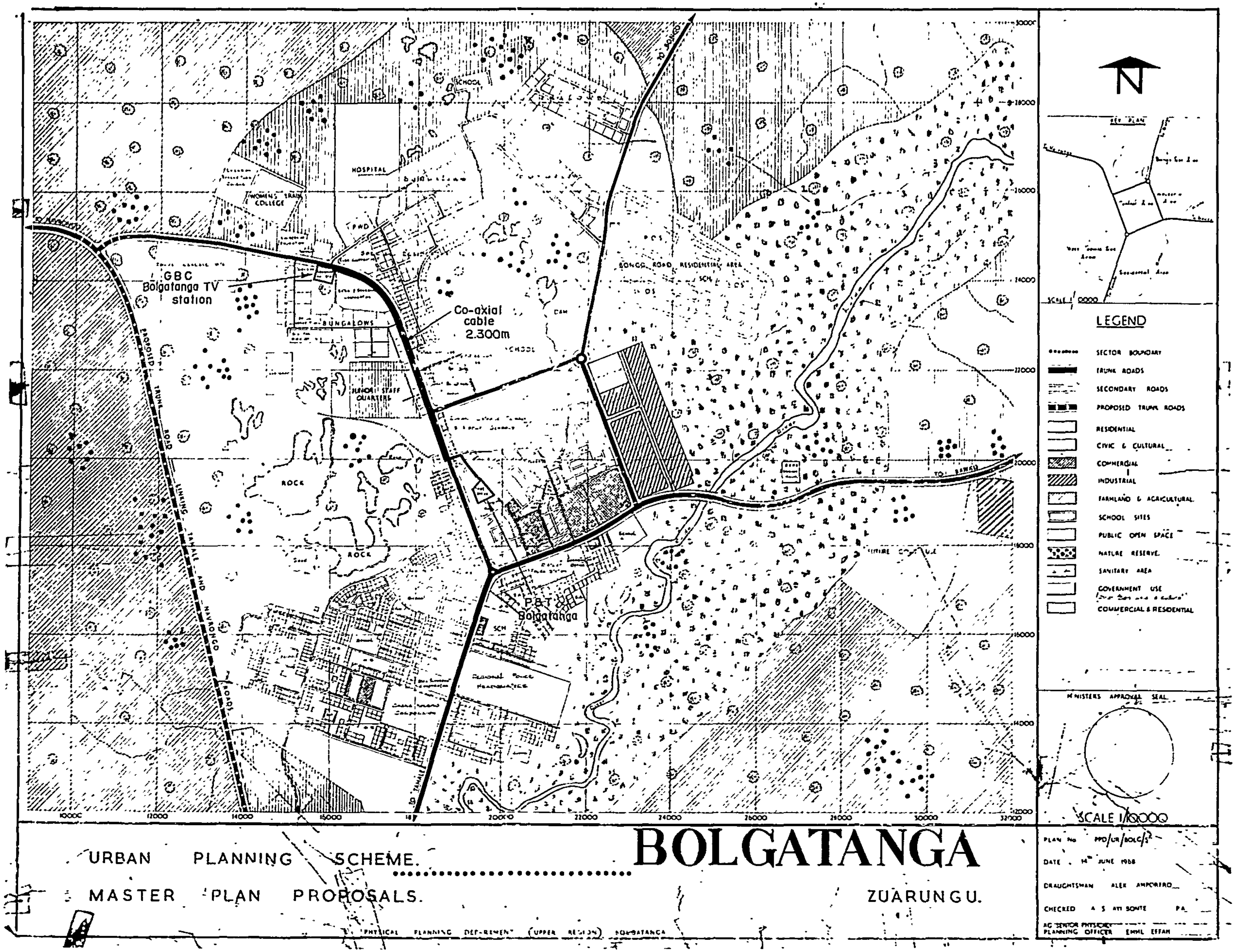
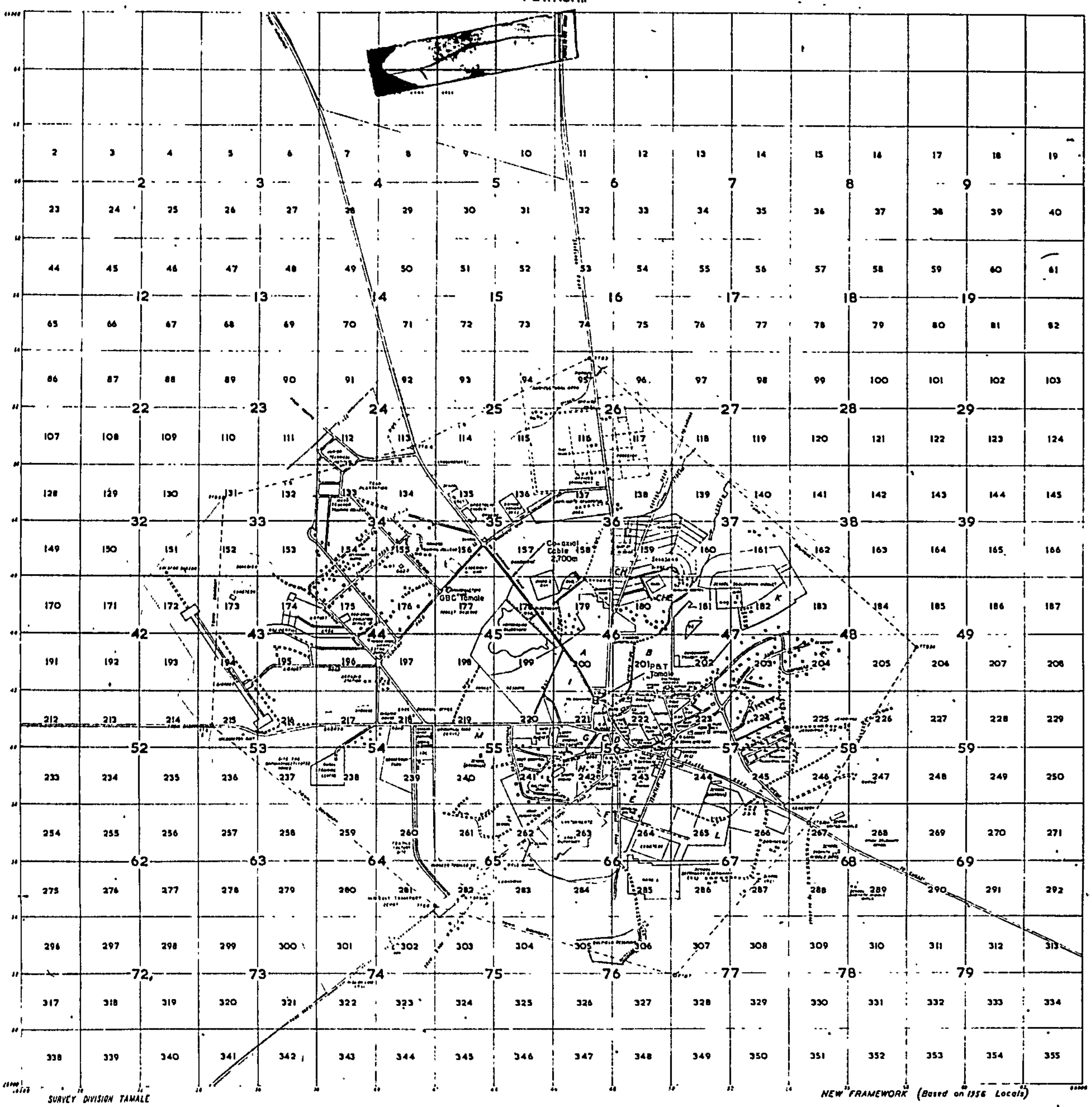

GBC
Bolgatanga TV
station
Co-axial
cable
2.300m
P&T
Bolgatanga
HOSPITAL
BUNGALOWS
ROCK
ROCK
SCHOOL
BONGO ROAD RESIDENTIAL AREA
PROPOSED TRUNK ROAD LINKING TAMALE AND NAVRONGO ROADS
TO BAWKU
TO BOLGO
TO TAMALE
N
KEY PLAN
LEGEND
SECTOR BOUNDARY
TRUNK ROADS
SECONDARY ROADS
PROPOSED TRUNK ROADS
RESIDENTIAL
CIVIC & CULTURAL
COMMERCIAL
INDUSTRIAL
FARMLAND & AGRICULTURAL
SCHOOL SITES
PUBLIC OPEN SPACE
NATURE RESERVE
SANITARY AREA
GOVERNMENT USE
COMMERCIAL & RESIDENTIAL
MINISTERS APPROVAL SEAL
SCALE 1/10000
URBAN PLANNING SCHEME
BOLGATANGA
MASTER PLAN PROPOSALS.
ZUARUNGU.

Fig. 4.3.2

TAMALE
TOWNSHIP



SCALE 1:20000

NEW FRAMEWORK (Based on 1956 Locals)

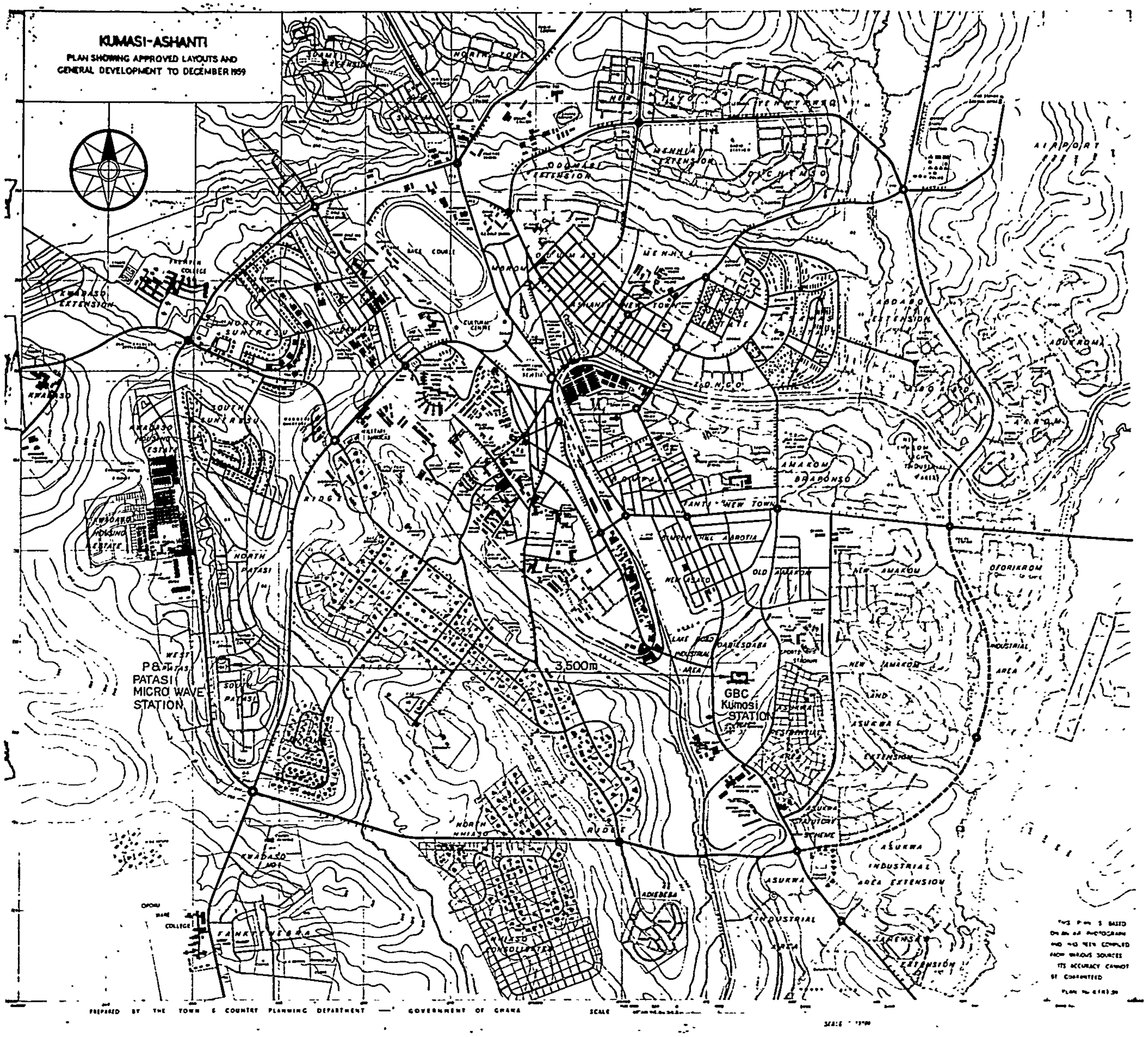
LIMITS OF SURVEY ....

1:1250 SHEETS (Based on 1956 Locals) 91

1:2500 SHEETS FOR REPRODUCTION 24

1:2500 SHEETS PRINTED 64

Fig. 4.3.3


KUMASI-ASHANTI
PLAN SHOWING APPROVED LAYOUTS AND
GENERAL DEVELOPMENT TO DECEMBER 1959
P&T PATASI
MICRO WAVE
STATION
GBC
Kumasi
STATION
3,500m
NORTH SUNTRESO
SOUTH SUNTRESO
NORTH PATASI
SOUTH PATASI
KWADASO
KWADASO HOUSING ESTATE
RACE COURSE
CULTURAL CENTRE
ASHANTI NEW TOWN
FANTI NEW TOWN
AMAKOM
OLD AMAKOM
NEW AMAKOM
ZONGO
ASOKWA
ASOKWA INDUSTRIAL AREA EXTENSION
INDUSTRIAL AREA
ADIEBEBA
NORTH NHIASO
AIRPORT
ODOMASI EXTENSION
PREPARED BY THE TOWN & COUNTRY PLANNING DEPARTMENT — GOVERNMENT OF GHANA

Chapter 5. OUTLINE OF THE CONSTRUCTION COST

5.1. Construction Cost of Microwave Radio Relay System for Television

5.1.1. General Discription

(1) It is advisable to construct the microwave radio relay system projected to be constructed between Kumasi - Tamale - Bolgatanga according to the two phases as mentioned below.

The 1st phase : Kumasi - Tamale
The 2nd phase : Tamale - Bolgatanga

The time schedules of above the two phases are shown on the annexed Table 5.1.1.

(2) The estimation of the construction cost was carried out according to the following conditions.

(a) Number of radio bearers

One radio bearer for television (Forward and return)

One radio bearer for standby (Forward and return)

(b) *Capacity of radio bearer*

One colour (or monochrome) television video signal with four sound channels

(c) The availability of the employment of the existing antenna towers is, as explained above, extremely difficult to judge due to the insufficient data. Therefore, the estimation of the cost of antenna towers is carried out according to the following assumption.

i) The strength of the existing antenna tower permits to replace the reflector mounted on it with a parabolic antenna of practically same area.
As the principle, one more antenna for space diversity can be mounted on it.

ii) Self supporting type antenna towers can be increased their height by 10 - 20 m.
The antenna tower heights and antenna sizes recuired for each station are shown on the annexed Table 2.2.2.
When the abovementioned conditions are applied, stations where the existing antenna towers may be utilized and stations where construction of new antenna towers is required are as follows.
The stations where the existing antenna towers may be utilized are as follows.
Kumasi, Jamasi, Ejura, Salaga, Diari, Walewale, and Gambaga.

The stations where construction of new antenna towers is required are as follows.

Atebubu (130 m), Kapilim (80 m), and Palbusi (130 m).

The stations where the increase of the existing antenna tower height are as follows.

Tamale (self supporting type) (75 m⟶85 m)
Bolgatanga (self supporting type) (55 m⟶75 m)

(d) Of the radio equipments, as to the supervisory and control equipments, it is assumed to use existing equipments.

(d) As to antennas, it is assumed to replace existing reflectors by antennas, with the consideration of the improvement of the microwave system and the radio frequency allocations in the future. As to waveguide, low loss type is presumed.

(f) The all of the engine-generators installed in the stations are available for the use. As to rectifiers and batteries, it is assumed to be newly installed between Kumasi - Tamale, while those now under construction will be available for use between Tamale - Bolgatanga. Mobile power plants (30 KVA) are projected each one unit at Kumasi, Tamale, and Bolgatanga stations.

(3) The equipment costs are indicated by CIF (Cost, Insurance, Freight).

(4) The exchange rate between Yen and US Dollar is calculated by US$1 = ¥270.

The exchange rate between NC (New Cedi) and US Dollar is calculated by US$1 = 1.26 NC.

5.1.2. Construction Cost of Kumasi - Tamale Microwave Radio Relay System for Television

Items	Foreign currency (US$)	Local currency (NC)	Remarks
1) Cost of radio eqipment	1,323,000	-	
2) Construction cost for above equipments	357,000	46,000	
3) Cost of antenna towers	185,000	-	
4) Construction cost for above antenna towers	95,000	252,000	
5) Consultant fee	98,000	-	1) + 2) + 3) + 4) x 5%

6) Reserve funds	196,000	-	[1) + 2) + 3) + 4)] x 10%
7) Total	2,254,000	298,000	

(Note) NC : New Cedi

5.1.3. Construction Cost of Tamale - Bolgatanga Microwave Radio Relay System for Television

Items	Foreign currency (US$)	Local currency (NC)	Remarks
1) Cost of radio equipment	773,000	-	
2) Construction cost for above equipments	209,000	21,000	
3) Cost of antenna towers	-	-	
4) Construction cost for above antenna towers	5,000	13,000	
5) Consultant fee	59,000	-	[1) + 2) + 4)] x 6%
6) Reserve funds	148,000	-	[1) + 2) + 4)] x 15%
7) Total	1,194,000	34,000	

(Note) NC : New Cedi

5.2. Construction Cost of the Broadcasting Station

5.2.1. General Description

The construction cost of the broadcasting station was estimated according to the following items.

(1) The cost for the television broadcasting equipment at Bolgatanga was calculated divided in the cost relating to buildings and a steel tower and the cost relating to equipments.

(2) The construction cost of the studios at Bolgatanga, Tamale, and Kumasi was calculated divided in the first phase and the second phase.

(3) The cost for the link was calculated as to the following three stations: Tamale, and Kumasi.

By the way, the calculation was operated according to the following items.

1) The price of equipments is indicated in CIF price.

2) The exchange rate of Yen and US$ is 1 US$ = ¥270.

3) The exchange rate of NC (New Cedi) and US$ is 1 US$ = NC1.26.

The time schedules of construction are shown on the annexed Table 5.2.1, 5.2.2, and 5.2.3.

5.2.2. TV Broadcasting Equipment at Bolgatanga

The TV broadcasting equipment at Bolgatanga is as follows.

One reinforced concrete building of 1 floor with the area of 70 m^2 connected with the studio by a corridor, provided with one set of accessory equipments including the self supporting steel tower of 50 m high, SG antenna, feeder, TV broadcasting transmitter of 1 kw, demodulation board, and air conditioner, as well as receiving and power distributing board, emergency generator, and a set of measuring instruments.

Items	Foreign currency (US$)	Local currency (NC)	Remarks
1) Radio equipment	250,000	-	
2) Construction cost for above works	54,000	6,300	
3) Cost of building and steel tower	71,000	-	
4) Construction cost for above works	10,000	31,500	
5) Consultant fee	19,200	-	[1) + 2) + 3) + 4)] x 0.05
6) Reserve fund	38,400	-	[1) + 2) + 3) + 4)] x 0.1
Total	442,600	37,800	

5.2.3. Studio

A same construction work will be carried out at Bolgatanga, Tamale, and Kumasi.

The construction work of the first phase includes all the works a TV studio and their related works, while that of the second phase includes all the works related to a presentation studio, master control room, film processing room, and OB van.

(1) Construction Cost of the First Phase (per one station)

Items	Foreign currency (US$)	Local currency (NC)	Remarks
1) Studio equipment	631,000	-	
2) Construction cost for above works	119,000	3,000	
3) Building	384,000	-	
4) Construction cost for above works	89,000	253,000	
5) Consultant fee	71,000		[1)+ 2)+ 3)+ 4)]x 0.05
6) Reserve fund	142,000	-	[1)+ 2)+ 3)+ 4)]x 0.1
Total	1,436,000	256,000	

(2) Construction Cost of the Second Phase (per one station)

Items	Foreign currency (US$)	Local currency (NC)	Remarks
1) Studio equipment	840,000	-	
2) Construction cost for above works	67,000	2,000	
3) Building	127,000	-	
4) Construction cost for above works	22,000	80,500	
5) Consultant fee	56,000	-	[1) + 2)+ 3)+ 4)]x 0.05
6) Reserve fund	112,000	-	[1) + 2)+ 3)+ 4)]x 0.1
Total	1,224,000	82,500	

5.2.4. Links

The cost of link for Bolgatanga and Tamale is calculated respectively for each one channel of coaxial cable of forward and return, while that for Kumasi is calculated for each one channel of forward and return of radio system of 7 GHz.

(1) Coaxial Cable for TV at Bolgatanga

Items	Foreign currency (US$)	Local currency (NC)	Remarks
1) Vision terminal equipment	67,000	-	
2) Coaxial cable	43,000	-	
3) Construction cost for above works	2,000	30,000	
4) Consultant fee	5,600	-	[1) + 2) + 3)] x 0.05
5) Reserve fund	11,200	-	[1) + 2) + 3)] x 0.1
Total	128,800	30,000	

(2) Coaxial Cable for TV at Tamale

Items	Foreign currency (US$)	Local currency (NC)	Remarks
1) Vision terminal equipment	67,000	-	
2) Coaxial cable	51,000	-	
3) Construction cost for above works	2,400	35,000	
4) Consultant fee	6,000	-	[1) + 2) + 3)] x 0.05
5) Reserve fund	12,000	-	[1) + 2) + 3)] x 0.1
Total	138,400	35,000	

(3) Microwave Link at Kumasi

Items	Foreign currency (US$)	Local currency (NC)	Remarks
1) Transmitting and receiving equipments	126,000	-	
2) Transmitting and receiving antenna equipments	35,000	-	
3) Construction cost for above works	-	2,500	
4) Consultant fee	8,100	-	[1) + 2) + 3)] x 0.05
5) Reserve fund	16,100	-	[1) + 2) + 3)] x 0.1
Total	185,200	2,500	

5.3. Comprehensive Consideration

Individual construction cost and progress schedule are described in the above for each of microwave radio relay system and television broadcasting facilities, based upon which description a comprehensive judgment may be made as follows.

(1) What is most needed and appropriate to implement its plan at an early date is the microwave radio relay system between Kumasi and Tamale and along with this it is necessary to provide coaxial circuit for television service in the city of Tamale. To this added is the part of studio facilities which represents the first phase of their construction works making the total cost as shown in the following table.

However, it is conceivable for the studio facilities to select the minimum of works needed immediately from among the works of the first phase and execute them.

Items	Cost in foreign currency (U.S.$)	Cost in domestic currency (NC)
Microwave facilities	2,254,000	298,000
Coaxial circuit	138,000	35,000
Studio facilities	1,436,000	256,000
Total	3,828,000	589,000

(2) It is desirable that the work on the television broadcasting facilities at Bolgatanga will be completed simulataneously with the completion of the work on the microwave radio relay system between Tamale and Bolgatanga and the construction costs related to them are as shown in the following table. Also it is possible for the studio facilities to make the same choice as that mentioned in the preceding paragraph.

Items	Cost in foreign currency (U.S.$)	Cost in domestic currency (NC)
Microwave facilities	1,194,000	34,000
Coaxial circuit	128,800	30,000
Transmitting facilities	442,600	37,800
Studio facilities	1,436,000	256,000
Total	3,201,400	357,800

(3) At Kumasi the whole works on studio facilities can be executed effectively even at present. Although complete equipment will be provided in future including that to be installed in the second phase of construction works it is also reasonable at this point of time to undertake the works to be executed in the first phase.

Items	Cost in foreign currency (U. S. $)	Cost in domestic currency (NC)
Studio facilities, phase I	1,436,000	256,000
" , phase II	1,224,000	85,500
S. T. L.	185,200	2,500
Total	2,845,200	344,000

(4) Among those mentioned in the above the studio facilities provide a considerable room of free choice and if it is assumed that only the studio facilities at Kumasi planned in the first phase will be constructed omitting those at Tamale and Bolgatanga the total construction costs will amount to about U. S. $5,778,000 in foreign currency.

Table 5.1.1. Time Schedule for Microwave Radio Relay System

	Item \ Month	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32
1st Phase	1) Consultant work	a) - c)			d) & e)					f)			g) & h)				
	2) Manufacturing																
	3) Transportation																
	4) Installation																
	5) Acceptance test																

	Item \ Month	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60
2nd Phase	1) Consultant work	a) - c)		d) & e)				f)		g) & h)						
	2) Manufacturing															
	3) Transportation															
	4) Installation															
	5) Acceptance test															

Remarks Consultant works are: a) Detailed field survey, b) Detailed engineering, c) Preparation of Bid documents, d) Evaluation of Bid offered, e) Contract negotiation f) Factory test, g) Supervision of installation works, h) Witness to acceptance test.

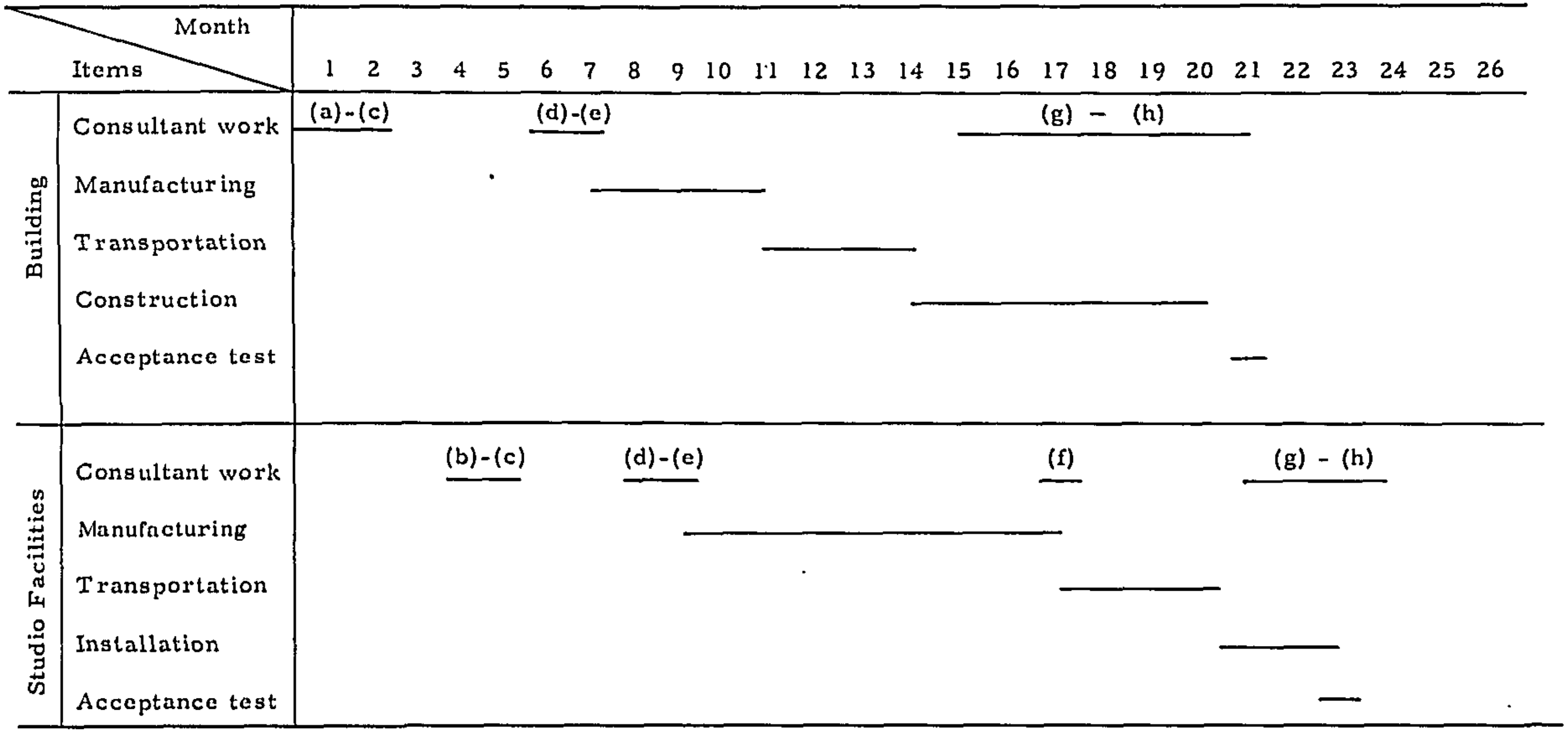
Table 5.2.1. Time Schedule for Telelvision Transmitting Facilities

Items \ Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1) Consultant work	(b), (c)		(d) (e)							(f)					(g) (h)	
2) Manufacturing																
3) Transportation																
4) Installation																
5) Acceptance test																

Remarks;

Symbols (a) - (h) are accordi n g to the abovementiond notation.

Table 5. 2. 2. 1st Phase Time Schedule for TV Studio Construction (per one studio)



Remarks: Symbols (a) - (h) are according to the above-mentioned notation.

Table 5. 2. 3. 2nd Phase Time Schedule for TV Studio Construction (per one studio)

	Items \ Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Building	Consultant work		(a)-(c)			(d)-(e)									(g) - (h)												
	Manufacturing																										
	Transportation																										
	Construction																										
	Acceptance test																										
Studio Facilities	Consultant work	(b)-(c)			(d)-(e)								(f)					(g) - (h)									
	Manufacturing																										
	Transportation																										
	Installation																										
	Acceptance test																										

Remarks: Symbols (a) - (h) are according to the above-mentioned notation.

Chapter 6. REFERENCE

6. 1. The Transmission Scale of Tamale TV Broadcasting Station in the Future

The existing Tamale TV Broadcasting Station is situated on a position approximately 620 ft above sea level and approximately 2. 5 km distant to the direction of north-east from the center of the city of Tamale. The height of the antenna center of radiation is located approximately 30 m above ground.

Further, its output power of transmitter is 500 W and its effective radiated power is also approximately 500 W. Therefore, the service area to be the object of the broadcast from the existing Tamale TV Broadcasting Station is the City of Tamale and its peripheral area, and the area where the field strength is higher than 40 dB is assumed to be within a circle of 25 km radius from the transmitting antenna.

For the purpose of acquiring nationwide TV broadcasting network in the Republic of Ghana in the future, it is assumed that more than 30 broadcasting relay stations are required to be established, if the transmitting scale of Tamale TV Broadcasting Station will remain as it is today, and if the total area of Northern Region is to be included in the object of broadcast.

When the conditions of the location of the existing Tamale TV Broadcasting Station are investigated, the location is extremely favourable for maintenance and operation of broadcasting equipment as it is located in the existing site of Tamale Regional Broadcasting Station. However, when this location is viewed on the viewpoint of television service area, the existing position is not provided with the optimum topographical conditions as the location is a hilly area with gradual undulation of hills of 500 - 700 ft high as is the characteristics of the topography of Ghana.

Therefore, in case the location of TV Broadcast Transmitting Station is strictly adhered to the existing position, the range of line-of-sight from a transmitting antenna 30 m high above ground is approximately 25 km if the topography of the periphery of the transmitting antenna is assumed to be a plane according to the following calculation.

$$d = 4.15 \left(\sqrt{ht} + \sqrt{hr} \right) \ \text{km}$$

d : Distance of line-of-sight (provided that $k = \frac{4}{3}$)

ht : Transmitting antenna height above ground (m)

hr : Receiving antenna height above ground (m)

So, for the purpose of enlarging the area with the field strength higher than 40 dB, the output power of transmitter is required to be increased. However, by simply increasing the output power of transmitter the reception of TV picture at a position of diffraction region outside the line-of-sight region is not recommendable on the reasons of radio wave propagation.

For the purpose of enlarging the distance of line-of-sight, it is necessary to increase the antenna height. However, it is impossbile to increase the height of existing transmitting antenna tower by connecting additional tower on its top because of structural reasons of the existing tower. In addition, as the existing location is not the highest position in the vicinity of Tamale, the tower height of approximately 100 m will be required for enlarging the distance of line-of-sight. This is not a recommendation of the first priority because of the economical basis.

Then, the case of transferring the TV Broadcast Transmitting Station will be investigated. We searched for the highest position around the City of Tamale which was near to the city, and found a highland of approximately 730 ft above sea level at a position approximately 9 km distant to the direction of north-west from the center of the City of Tamale. After the investigation on topographic map of 1/50,000, it was confirmed that, as there was no other place higher than 700 ft above sea level in the vicinity, the above-mentioned position was the highest place in the periphery of Tamale.

In addition, it was further confirmed by actual investigation on the site that the position was relatively near to a highway and situated on the rear side of the St. Victor Seminary where a connecting road was provided, and power line was also introduced into the said Seminary.

Therefore, it was judged that an approximately equivalent effect of erecting an antenna tower of 100 m above ground on the site of existing station would be actually obtained by constructing TV Broadcast Transmitting Station at the said point and erecting the transmitting antenna approximately 50 m above ground.

As to the output power of transmitter by this case, if the television service area is to be as far as the vicinity of Walewale, as the northern area from Walewale in Northern Region is projected to be covered by Bolgatanga TV Broadcasting Station to be established in the future, it is assumed that approximately half of the Northern Region, i.e., 262,000 people comprising the half of the total population of Northern Region will be included in the television service area if the output power of 10 kw and the effective radiated power of 50 kw are secured. And the area where the field strength is higher than 40 dB is shown on Fig. 6.1.1.

As the result, it is assumed that, for the purpose of including the total area of the Northern Region as the object of television service area, it is required to install broadcasting relay stations at Salaga, Damongo, and Bole, as well as at three of so other places.

6.2. Installation of TV Broadcasting Relay Stations at Accra and Kumasi

Accra and Kumasi are at present served by TV broadcasting wave transmitted from Adjangote TV Broadcast Transmitting Station and Jamasi TV Broadcast Transmitting Station respectively.

However, the distances from above-mentioned respective TV broadcast transmitting stations to either of the Cities of Accra or Kumasi which is the object of TV broadcasting of the said TV broadcast transmitting stations are approximately 20 km between Adjangote - Accra and approximately 35 km between Jamasi - Kumasi.

In addition, the height above sea level of the transmitting antennas of the abovementioned transmitting station is not exceedingly higher compared with the height above sea level of two cities which are the object of the TV broadcast from respective transmitting stations. Therefore, it is assumed that the effective height of the transmitting antennas is approximately 100 m in relation to the average height above sea level of each of the cities of Accra and Kumasi.

Because of abovementioned fact, the field strength of the TV broadcasting wave transmitted from Adjangote transmitting station in the City of Accra is calculated to be approximately 53 dB at E 4 ch, the frequency broadcast from Adjangote transmitting station, belongs to 60 MHz band. Also, the field strength of the TV broadcasting wave transmitted from Jamasi transmitting station in the City of Kumasi was approximately 48 dB at E 3 ch, also belonging to 60 MHz band, which is the frequency assigned to Jamasi transmitting station. (The value of field strength at Kumasi was actually measured by the survey team, while the value of field strength at Accra was informed by the GBC staff.)

Accra is the capital of the Republic of Ghana and has the population more than 600,000 residents. Also, Kumasi is the second largest city in the Republic of Ghana with the residents of more than 340,000. In addition, both of the above-mentioned cities have relatively great number of high buildings and a great number of automobiles pass through the city streets. Therefore, it is presumed that there are relatively high level of the strength of urban noise level. In particular, in case the frequency band of TV broadcasting belongs to the lower part of E channels, or 60 MHz band, the noise level in average rises more than 6 dB compared with a frequency belonging to the higher part of E channel, or 170 MHz band. So, it may be said that it is impossible to obtain a TV picture of good quality with the signal fiels strength of approximately 50 dB.

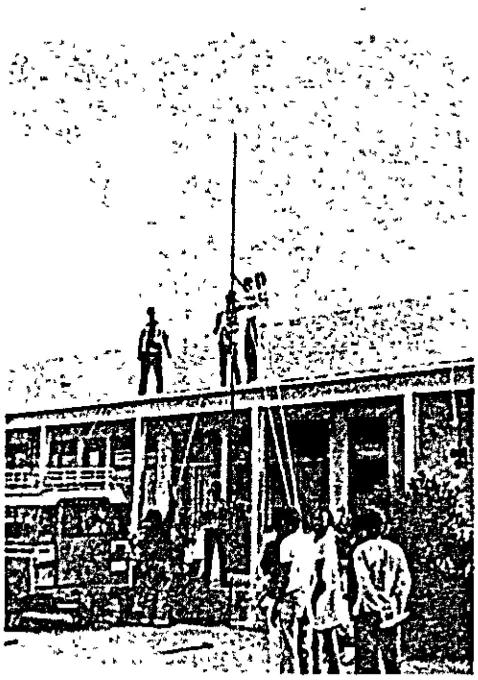
Of course, it is not practical to argue the suitable position of the existing station on the assumption of various conditions at the time of the installation of a TV broadcast transmitting station. However, it seems to be a reality at least that the existing situation is not in conformity with the state of the cities of Accra and Kumasi.

Therefore, it is recognized, at least as far as the two cities of Accra and Kumasi are concerned, that there exists a requirment for applying some method required for the improvement of the quality of received picture in considerations of the situation of the viewers in Accra and Kumasi.

Fortunately, the buildings and antenna towers of GBC of both of Accra and Kumasi are situated nearly at the center of the respective cities and also the antenna towers of sufficient height above ground are erected at both of them. Therefore, when broadcasting relay stations with the scale of output power of transmitter approximately 100 W or 500 W are installed on the existing positions and when the frequency to be assigned to them is selected among the higher part of E channels, or higher than E5 channel, for the TV broadcast, the picture received at Accra and Kumasi will be largely improved.

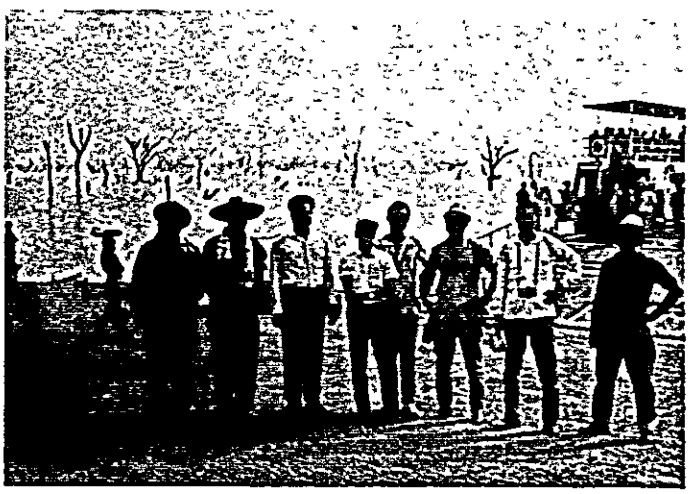
As to the method of programme transmission to both broadcasting relay stations at Accra and Kumasi in this case, it is assumed that one of methods is to receive the TV wave broadcast from Adjanagote and Jamasi respectively and re-transmit them after converting them to other channel, that is to say, to adopt the broadcast wave repeating system.

In case broadcast relay stations are installed at Accra and Kumasi, the optimum frequencies to be assigned to both of them are considered to be those belonging to E6 ch. to Accra TV Broadcasting Relay Station and E6 ch. to Kumasi TV Broadcasting Relay Station for the purpose of avoiding mutual interference with other existing TV broadcasting stations or TV broadcasting relay stations.



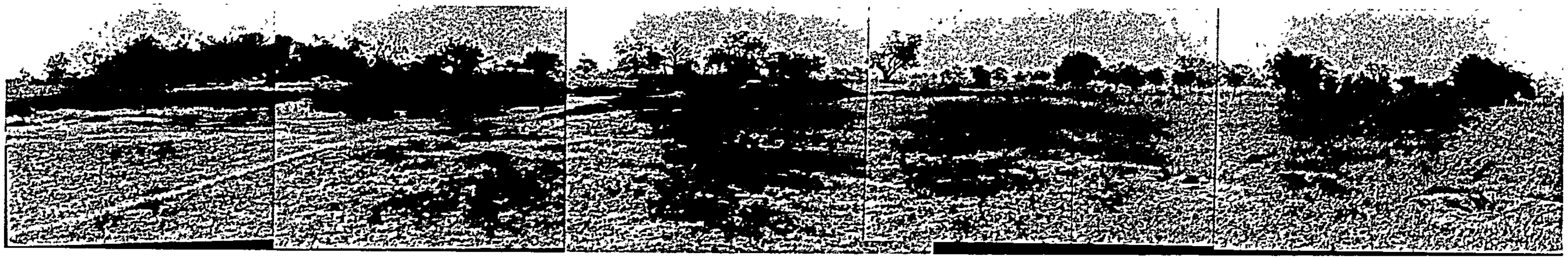
Scene of construction of transmitting antenna for field investigation

Scene of measurement of field strength



Members of survey team at Lake Volta

Field Survey of the site No. 1 for Bolgatanga TV Station



Field Survey of the site No. 2 for Bolgatanga TV Station

Field Survey of the site No. 3 for Bolgatanga TV Station