Report on Topographic Mapping Project
for
East Kenya Area, Republic of Kenya

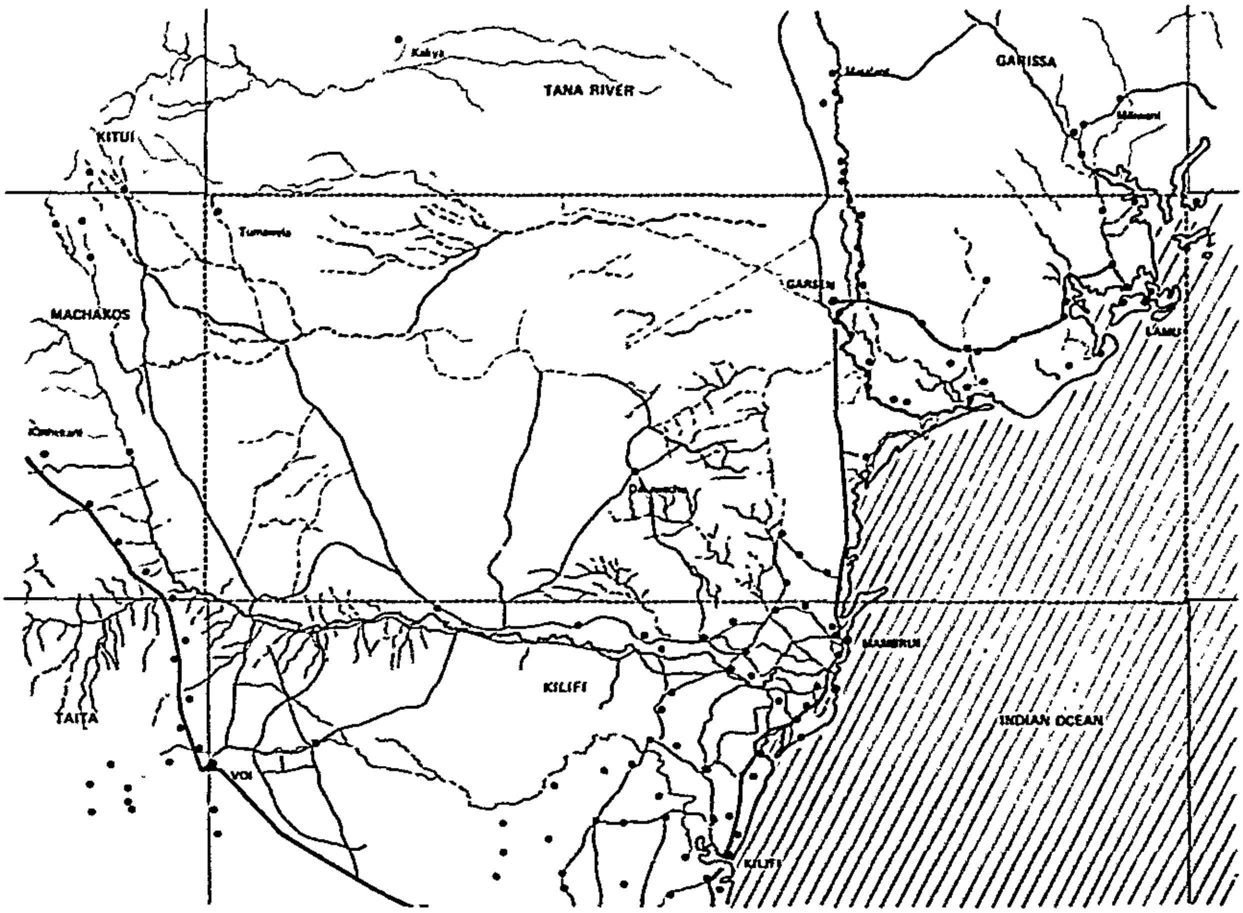
(Second Year)

PART I FIELD WORK
PART II PHOTOGRAPHING

March 1978

Japan International Cooperation Agency

Location Map of Project Area



Road   Sea and River   Project area

LETTER OF TRANSMITTAL

Mr. Shinsaku Hogan, President
Japan International Cooperation Agency

The Report on the Second-Year Survey Work of the Eastern Area of the Kenyan Topographic Mapping Project, conducted during fiscal year 1976 in compliance with your request, is herein submitted to you.

I regret that photographing which was scheduled in the second-year survey work (included with second-order traversing, second-order leveling, aerial signal repairing work) was postponed due to the unfavorable weather conditions in the field, resulting in the fact that the schedule was not totally completed.

In this report are clarified the details of the second-year survey work. I feel confident that the results of the survey conducted during this period as well as the Japanese survey techniques employed will greatly contribute to future development plans for the eastern part of Kenya and to improvement of the Kenya's own survey techniques.

I hereby express my wholehearted gratitude to Mr. Omondi, Director of Survey of Kenya, Ministry of Land and Settlement of the Kenyan Government, the Ministry's personnel, the officials of the Japanese Embassy in Kenya, and Mr. Esaki, Head of the Nairobi Office of the Japan International Cooperation Agency, and other staff members who cooperated with us during the period of the survey. At the same time it is my hope that photographing will be promptly completed under favourable weather conditions and the survey projects of the third and subsequent years will be conducted without delay.

March, 1978

Yasuo Kanai

Yasuo Kanai
Leader, Topographical Mapping Group of the East Kenya Area, KENYA
International Engineering Consultants Association

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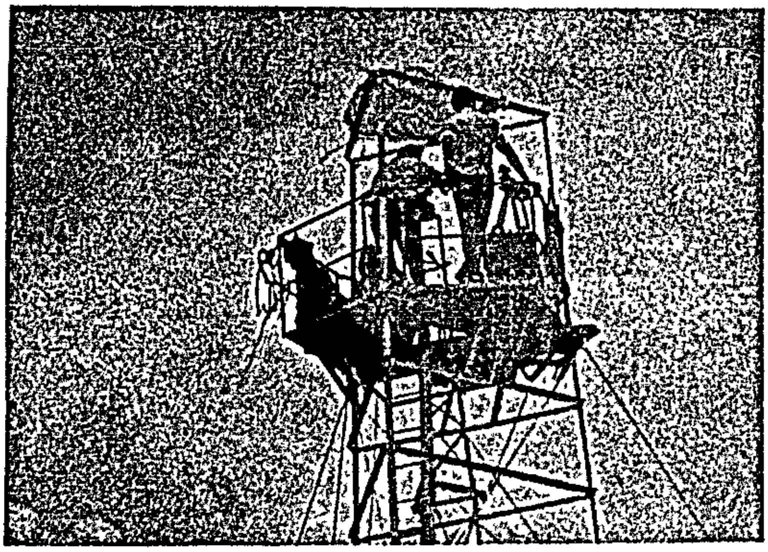
Road in the bush ▶ during the light rainy season. Rainfall for a short time dramatically changed the road into muddy ground. This bush existed at the central part of the work area.

◀ Eastern part of the work area, near Ijara

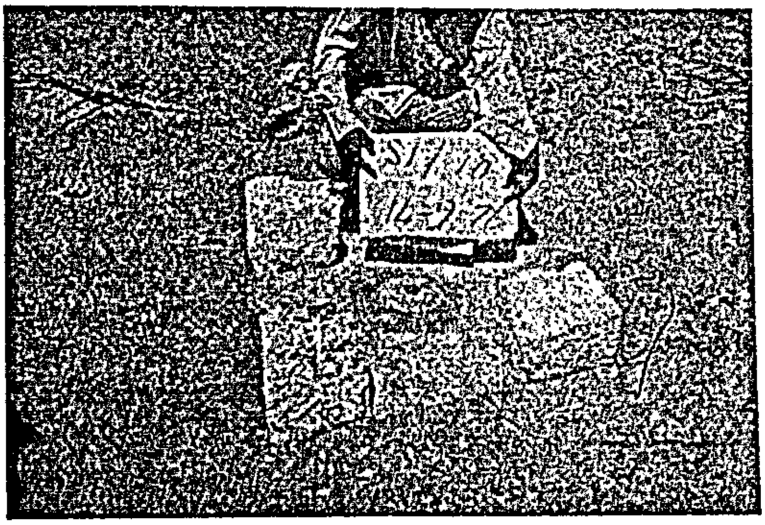
Western part of the ▶ work area, near Galana



◄ *Second-order traversing*

Second-order leveling ►

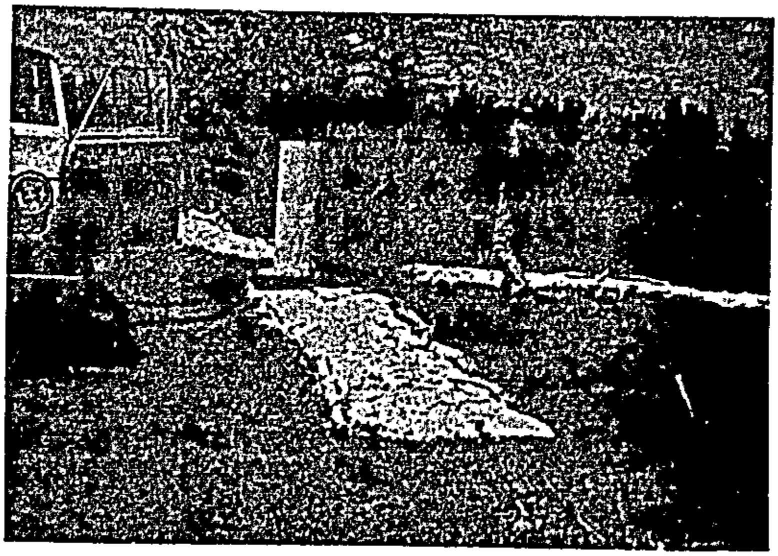
◄ *Guards (game scouts) despatched by the Kenyan Government to protect the survey party from wild animals*



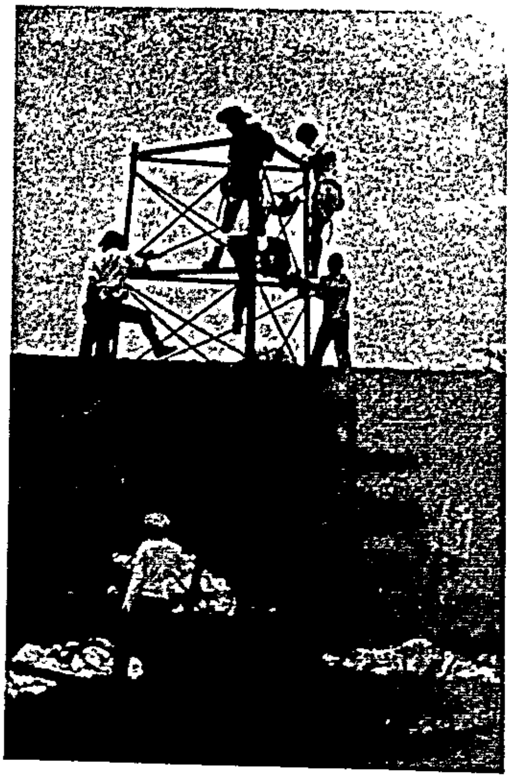
◄ *Newly established second-order bench mark protected by stones (along the main road)*

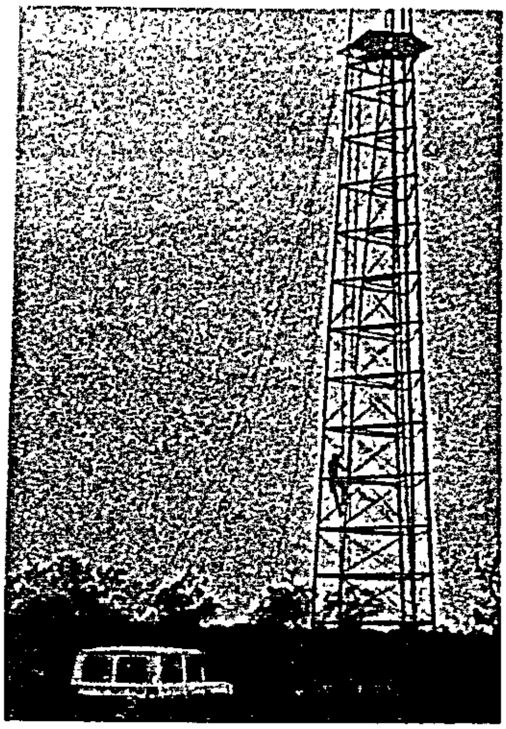
Newly established second-order fundamental bench marks ►

◄ *Newly established second-order traverse point*



Existing bench mark ▶ with aerial signal re-paired





▲

Construction of 20 m-high observing tower employed for second-order traversing ▶

PART I FIELD WORK

I. SUMMARY OF FIELD WORK

1. **Objective**
   Implementation of the field work (second-order leveling, second-order traversing, aerial signal repairing work) scheduled as the second-year portion of the map preparation project for the eastern area of Kenya (scale: 1:50,000), launched in the Republic of Kenya and Japan

2. **Project area**
   Eastern part of Kenya (Tsavo, Lamu, Malindi in the Coastal State) extending over approximately 27,000 km^2

3. **Period**
   From: July 15, 1976
   To: December 17, 1976
   (Covers from date of the advance party's departure from Japan to date of the last party's return to Japan)

4. **Work classification and workload**

	Scheduled	Completed
4-1 Second-order leveling		
a. Observation of existing first-order bench marks	2 portions	3 portions
b. Establishment of second-order bench marks	280 points	284 points
c. Observation and calculation for second-order leveling	850 km	863 km
d. Differential leveling	11 points	11 points
4-2 Second-order traversing		
a. Observation of existing control points	3 points	3 points
b. Establishment of second-order traverse points	10 points	10 points
c. Observation and calculation for second-order traversing	10 points	10 points
d. Repairing the existing control points damaged	7 points	7 points
4-3 Aerial signal repair work		
a. Aerial signals repaired	64 points	64 points
b. Newly established signals	4 points	4 points
c. Cross points of bench marks	0 point	5 points

5. Weather conditions during work period

	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total	%
Fair	7.0	23.0	20.0	24.0	19.5	12.5	106.0	67.9
Cloudy	5.0	4.0	5.5	5.5	7.5	3.0	30.5	19.6
Rainy	5.0	4.0	4.5	1.5	3.0	1.5	19.5	12.5
Total	17.0	31.0	30.0	31.0	30.0	17.0	156.0	100.0

Note: 1 Days with localized or short-term rainfall are included in the "Cloudy" or "Fair" categories, as the case may be, in the table above.
2. The work period covers from the date of departure from Japan (July 15) to that of return to Japan (December 17).

6. Spreading the news of the map preparation work to local citizens

As was the case with the previous year, prior to starting the second-year field work a letter was sent by the Director of the Survey of Kenya to the State and Prefecture Governors concerned in order to familiarize them with the outline of the field work and to ask for their co-operation. At the same time, the survey party accompanied by Mr. Suda, Technical Advisor, visited municipal offices located within the field work area to ask them to effect widespread publicity of the project for the benefit of local citizens.

Because the field work represented the second portion of the project initiated a year ago, municipal officers and local inhabitants were familiar to some degree with the project. Therefore, conflicts due to misunderstanding on the part of the local citizens were not anticipated.

7. Road conditions

The survey party started, together with establishment of the base camp, investigating the conditions of roads in the survey area in early August. August is a month immediately after the heavy rainy season and occasional, localized rainfall was encountered. Therefore, both main roads and small-scale roads in the work area were found to be in poor condition.

In September both the Ministry of Labour and the Bureau of Highways of the Kenyan Government initiated full-scale repairs so that all roads would be ready for initiated full-scale road repairs, the tourist season in December. As a result of the light rainy season in October and November, the roads readied for use were once again in poor condition, and remained so throughout this period.

Road conditions became increasingly poorer further into the bushes. Slight rainfalls during the light rainy season transformed the roads into bogs. Under such circumstances, the work party composed of a few jeeps could not take any effective measures. The party members often had to encamp in such immobile vehicles, exposed to the danger of wild animals.

8. Light rainy season

After about one month and half of the dry season which followed the localized rainfalls (retaining traces of the heavy rainy season up to mid-August), the light rainy season spread from the southeastern part of the work area.

Precipitation of the light rainy season in 1976 exceeded average rainfall considerably and caused much damage to several districts.

With the exception of the main roads in the eastern part of the work area, the roads generally consisted of clay without gravel. The road surfaces became extremely muddy as a result of only a few hours' rainfall, and remained impassible on some occasions for more than a week. The effects of rainfall were more impedimentary than the rain itself to the efficient execution of the project.

The light rainy season finally came to an end in the northeastern part of the work area in November.

9. Power and telephone facilities

A power line had been installed from Mombasa to Malindi where the base camp was established. The main parts of Malindi were supplied with power.

Concerning telephone facilities, there was the only one telephone line in the work area which had been installed along the main road in the eastern part to Lamu through Malindi and Galsen. Consequently, telephones could be utilised at principal villages along the telephone line only in case of emergency.

10. Procurement of materials

Most materials for monumentation, miscellaneous instruments, food and necessities could be procured only at Malindi. Therefore, all necessities had to be transported to the subcamping areas.

Water could be abundantly employed at Malindi. Although relatively good water was obtainable at the two subcamping areas, Garana and Mukowe, water had to be supplied from Malindi to other subcamping areas. The same was the case with gasoline.

Indispensable automobile parts were directly obtainable from Toyota and Isuzu dealers in Mombasa and Nairobi. However, some parts were difficult and in cases impossible to find. In spite of the fact that orders were placed with automobile manufactures in Japan through the dealers, some parts could not be obtained, even after a few months' wait.

With reference to the need for spare tires for each vehicle, tire problems in the previous year were called to mind. Tire punctures had occurred commonly (for example, the maximum number of punctures per vehicle per day was seven), and proved to be time—consuming for the survey party members.

As a result, two spare tires were supplied per vehicle. Dead time consumed in tire repairs was thus minimized in this portion of the project.

However, as of late, only tires made in Kenya or Tanzania are available. These were found to have a much shorter service life than tires made in Japan. Vehicular troubles resulting from these tires had occurred so often in the first year that utmost care was exercised to check the conditions of tires constantly during the field work conducted in the second year.

11. Co-operation toward the work

Mr. Owino, Deputy Director of the Mombasa Survey Suboffice, was always quick to offer cordial co-operation toward the survey party in the same manner as in the previous year. In addition, a new measure was adopted, namely the designation of Mr. Wayumba to act as a trainee of survey techniques. Mr. Wayumba served as a counterpart of the survey party from early September to the end of the field work. Both Mr. R. Omondi, Director of Survey of Kenya, and Mr. W.J. Absalomus Deputy Director of Survey of Kenya, kindly offered their utmost co-operation to the survey party's tasks ranging from collecting reference data in Nairobi, obtaining a license for wireless appratus, customs-clearing materials and equipment shipped from Japan and dealing with local authorities.

The authorities concerned within the work area were also co-operative and quite aware of the significance of the mapping project.

12. Wireless apparatus

In mid-July, the license for using long-distance wireless equipment in the vast work area amounting to 27,000 km^2 was authorised through the Survey of Kenya. This had been long desired since the start of the first-year operation. The wireless apparatus was rented at Nairobi.

The frequencies approved for the survey party was 4,055 kHz and 6,098 kHz. Immediately after obtaining the license, an order was placed for a quartz oscillator. On August 24, wireless equipment was installed at the fixed station at the Malindi Base Camp and at the moving station on vehicles. The wireless apparatus was put to use in early September.

The effect of the wireless apparatus was found to be the most useful in the communication between the subcamp in Bodini and the base camp.

II. PREPARATIONS FOR WORK

1. Encampment

Immediately after a part of the advance party arrived at Malindi on July 22, an office room was rented in the northern part of Malindi in order to use as headquarters. The base camp was established around the office. The camp for the advance party was established on July 24.

P.O. Box No. 119 Malindi, which had been employed as the mailing address in the previous year, was once again utilised as of July 24.

The advance party divided its labour into establishment of the base camp, transportation of materials and equipment from the warehouse facilities used in the Survey of Mombasa, and procurement of necessary materials. Encampment had almost been completed by August 2 when the main party arrived at Malindi.

2. Hiring local labourers

As of July 24 the date of the establishment of the base camp, the survey party started hiring local labourers as assistants for the survey work project 10 of the assistants employed in the previous year were hired. Thereafter, the necessary number of assistants were employed mainly among the local citizens who took with them a letter of introduction each, issued by the Governor of Malindi Prefecture, Policemen, or Dietmen.

Since the employment period of these assistants was rather short, all of them were employed as temporary workers. Consequently, no special employment agreements were prepared.

3. Organization of survey teams

The survey party was organized into the second-order leveling team and the second-order traversing team both of which were divided into a few subteams as follows:

3-1 Second-order leveling team

Subteam 1 Yutaka Kyakuno and Takashi Saito
Subteam 2 Yasuo Udo and Taichiro Takahashi
Subteam 3 Tomoji Kosaka and Eiichi Taguchi
Subteam 4 Isao Inoue and Yoshitada Onishi
Subteam 5 Tadashi Hiraoka and Tokuatsu Ohe

3-2 Second-order traversing team

Subteam 1 Katsuyuki Hatakeyama and Norihumi Nagashima
Subteam 2 Takashi Aoki and Katsuyuki Okugaki
Subteam 3 Chifuyu Horiuchi and Yasunori Asano
Subteam 4 Ryuji Shibuya and Yoshihisa Okuda

At first both the second-order leveling team and the second-order traversing team were combined to conduct second-order leveling. According to the original work schedule, the traversing team would collaborate with the leveling team for about a month. However, since the Bilbi Tower arrived about one month behind schedule, the collaboration with the traversing team was extended accordingly. As a result, the leveling work progressed well ahead of schedule while completion of the traversing work within the scheduled period was quite difficult to achieve. Although the original work schedule specified that the traversing team should conduct the repairing job of the signals established in the previous year after completion of traversing, this repairing job was transferred to the leveling team, shortening the work period of the leveling team by one week and extending that of the traversing team by one week under the approval of the JICA.

III. SECOND-ORDER LEVELING

1. **Objective**

   Second-order leveling was conducted over approximately 860 km within the survey area in order to establish the altitude basis for the 1:50,000 mapping project and to prepare bases for various kinds of projects such as the Tana River Agricultural Development Project and the Galana River Pipeline Project.

2. **Specifications of the second-order leveling**

   Since this was the first second-order leveling work in Kenya, there were no specifications of the second-order leveling available at the Survey of Kenya. Consequently, prior to starting the work for the second year, the Japanese party presented a draft of the specifications to the Survey of Kenya.

   This draft of the second-order leveling specifications prepared by the Japanese party was prepared in accordance with the discussion between Mr. Noriaki Suda, Technical Advisor and Mr. W.J. Absalomus, Deputy Director of the Survey of Kenya which took place at the completion of the first-year portion of the project. Prior to starting the second-year work, the draft was reviewed at the Survey of Kenya by Mr. R. Omondi, Director, Mr. W.J. Absalomus, Deputy Director, Mr. J. Gatome, Ag. Supt. of Surveys, Mr. Suda, Technical Advisor, Mr. Kanai, Leader of the Survey Party and Mr. Iijima, Chief Engineer. It was finally approved as the specifications for the second-order leveling.

3. **Reconnaissance for selection of stations**

   Rough reconnaissance for the route of second-order leveling was conducted at the end of the first-year portion of the project. In the second-year, the final reconnaissance was commenced on August 5, with the additional objectives to research the road conditions after the rainy season and to select locations for monumentation of the second-order bench marks.

   The collective reconnaissance over the entire route faced such difficulties as traveling over the extremely long distance and maintaining the supply of water, gasoline and foods. For its behalf, the entire route was divided into a few blocks in which a subcamp was established to start reconnaissance for the selection of stations.

   Stations were established every 2-4 km along the route. The average distance between stations was, in principle, 2 km for the main roads in the eastern part of the work area and the important area along the Tana River, and 4 km in the bushes in the central and western areas. Regardless of these standard distances, the survey points were established at the points crossing the main streams and at principal villages.

   The stations were selected on the basis of accessibility, easy identification and the consideration that bench marks should be free from damage.

   The total number of the stations selected was 284 points.

4. **Names of leveling routes and bench marks**

   Since it was the first time to conduct second-order leveling in Kenya, much time was consumed until names of leveling routes and bench marks were officially determined. Temporary names were assigned until the official names were established by the Survey of Kenya in early September.

   The second-order leveling net in this portion of the project was composed of 9 routes, including 2 circuits, 5 fundamental bench marks, 279 bench marks and 2 existing points. They were designated as follows:

- o Second-order leveling routes S1-S9
  S denotes "Second-order"
  1-9 represents the serial number of the routes
- o Second-order bench marks S1/1 , S 2/3
  S1, S2 ...denote the name of the routes
  1-60 represents the serial number of the bench marks for each route
- o Second-order fundamental bench marks S/FBM1-S/FBM5
  S denotes "Second-order"
  FMB denotes "Fundamental Bench Mark"
  1-5 represents the serial number
- o Second-order leveling circuit,, Circuit MSA, MSB
  The word "Circuit" is added as a suffix to the name of each circuit.
  "M" denotes the name of the first-order circuit (the work area in this project was covered by the first-order circuit named "M".)
  "S" signifies "Second-order"
  "A" or "B" denotes the second-order circuit.

5. Monumenting

The monuments for second-order bench marks included the two types, namely, those for fundamental bench marks and for ordinary bench marks. Monumenting was effected in accordance with specifications proposed by the Japanese party and approved by the Survey of Kenya.
The original Japanese proposal called for a protrusion of the upper end of the bench marks of about 30 cm above the ground surface in order to facilitate detection at a later date. However, the Director of the Survey of Kenya insisted that the upper end should be deeply embedded to the height of the ground level, placing top priority to the long-term preservation of the bench marks. As a result, the specifications were modified to that effect.
To compensate for the difficulty in discovering the bench marks which were to be embedded to the ground level, the Survey of Kenya demanded that an index monument should be located near each bench mark monument. It was agreed that index monuments should be prepared by utilising natural features as much as possible. White and black paint was coated on tall standing trees, electric poles, or cairns. In addition, four coral blocks were installed as a protective device around the bench marks along the main roads, so that bench marks may be preserved for a long period.

6. Instruments for surveying

The Carl Zeiss Ni 2 and the precision invar rod attached to it were employed. Both levels and rods were calibrated at the Technical Center of the Survey Association.

7. Survey

The observation was conducted, using the Carl Zeiss Ni 2 at one reading per sight with the minimum reading unit of 1mm.

The measured values were written on the specified format by a member either in charge of the field book or observation. To determine the difference in height between the bench marks calculation was conducted on the field book and the results were checked twice at the site by a person other than the field book keeper, as well as by the chief engineer.

Atmospheric temperature was measured with the minimum reading unit of 1°C at the beginning and end of the survey. Measurement was also conducted in the course of the survey at a fixed point. The longest allowable distance between rods was 70 m except in special instances such as when crossing a main stream.

Diagramme 4 shows the field book for the second-order leveling survey.

8. Surveying precision

The limits on survey results were 7.5 $\sqrt{S}$ km both in the difference between surveying from opposite sides and in closure error. Those sections in which survey results exceeded the limit were measured once again.

When the measurement was repeated, the two better measured values of the three were adopted, considering the divergence in the measurements.

The routes (S7 and S8) which were closed from the first-order bench mark (FBM MAMBURUI) to the first-order level route No. II (II/90) exceeded the limit value by about 1 cm. The entire routes S7 and S8 were checked and remeasured, but no significant mistakes in measurement were discovered.

Closure of the two circuits was excellently conducted.

When reviewing the measured results of routes S7 and S8, a difference of approximately 10 cm between the fundamental bench mark (FMB MAMBURUI) and the first-order bench mark II/90 could explain the excess of the previously stated limit.

9. Measurement made between the first-order bench marks as given points

In order to check for any age deformation or other abnormality in the first-order bench marks which were employed as given points, the distance between them was measured.

Regarding the first-order bench mark II/90, the two sections from II/80 to II/90 were measured. When reviewing the closure error detected in observation and measurement of the routes S7 and S8, however, there was such a large difference that the measurement range was extended from II/90 to II/92. However, no special abnormality was detected in the bench mark II/90.

Since all the first-order bench marks had been lost around the FBM (Mamburui), no measurement was conducted between this mark and any first-order bench marks. Consequently, the FBM was measured with reference to the main mark (underground monument) and to the auxiliary mark (ground monument). As a result, no abnormality was detected in the main mark of the FBM.

The measurement between first-order bench marks was conducted in accordance with the specifications for measuring second-order bench marks. Diagramme 5 reveals the comparison between the results and measured values.

10. Field computation

After completing calculation and adjustment in the field books and checking such calculation results, the below-mentioned field computation was conducted to check whether or not the results were acceptable.

10-1 Correction calculation of rod using a constant

This calculation was made to correct the error which would have been produced by elongation of an invar rod under temperature fluctuation during measurement. Such an error would represent the measured difference in height, by referring to an average figure of measured values in two directions within the specified limits for the bench marks.

The correction was made utilising the correction table prepared by the Technical Center of the Japan Survey Association when it conducted calibration of the rods prior to the survey party's departure from Japan.

Diagramme 6 displays the correction table.

10-2 Orthometric correction

This correction is required due to the fact that the earth is elliptical. The correction was calculated based on the variation of the latitude along the leveling route as well as on the altitude.

The orthometric correction calculation made in the field was considered to be a tentative value, and the formal correction calculation was made using a computer after the survey party had returned to Japan. For the calculation formulas which were employed in orthometric correction calculation, refer to the appended sheet No. 14.

11. Accurate calculation

Accurate calculation was made utilising an electronic computer (TOSBAC 3400 Model 41) after the survey party arrived in Japan. Net adjustment calculation was effected according to the survey equations.

11-1 Net adjustment calculation

Calculation formula (survey equation)

$V(h) = -xi + xj - (hi - hi + \Delta h)$

where: hi, hj ..... Presumed altitude at bench marks i and j

xi, xj ..... Correction for the presumed altitude at bench marks i and j

Δ h .... Difference in height observed between bench marks i and j

11-2 Mean error of observed values along the route

Formula: $m \pm \sqrt{\frac{1}{4}\left(\frac{Ui}{U^2}\right)^2 \frac{1}{n}}$

where: Ui . . . .Duplicate error in each interval between bench marks

Si. . . . .Distance between bench marks (m)

n . . . . .Number of intervals between bench marks

Diagramme 7 reveals the mean errors per 1 km of leveling observation.

11-3 Weight employed in calculation

P=1/S

where: P = length of the route (km)

P = weight

12. Arrangement of the results

After completing accurate calculation, the final result was prepared utilising the specified formats.

Diagramme 8 displays the final result of the second-order leveling.

IV. SECOND-ORDER TRAVERSING

1. Objective

Ten traverse points were established within the work area in order that they might first serve as a basis for horizontal location which would be required by 1:50,000 mapping and second, act as control points which would be utilised for local development in the future.

The new traverse points were established based on second-order traversing which was started from and closed into existing triangulation and traverse points.

2. Specifications for second-order traversing

In order to satisfy the local conditions of the survey area, to make full use of the latest survey technology and to obtain the best survey results, the Japanese party prepared specifications for second-order traversing. These specifications complied with those available from the Survey of Kenya. Prior to commencing traversing work, the Japanese specifications were submitted to the Survey of Kenya in the same manner as the specifications for second-order leveling. Second-order traversing was conducted according to the specifications duly approved by the office.

3. Reconnaissance and selection of stations

Reconnaissance was effected mainly for researching the conditions of roads to check whether or not large vehicles could reach the established traverse points. Such vehicles would be used to transport high observing towers which would be employed while traversing.

Four stations were newly selected. Three second-order traversing routes were fixed, using these new stations as well as the six stations selected for use during the first-year survey.

4. Monumenting

Monuments of the second-order traverse points were established according to the survey regulations of the Survey of Kenya.

Diagramme 10 illustrates the monuments of second-order traverse points.

5. **Transportation and establishment of high observing towers**

The major part of the work area was flat and there were many trees around the stations at which new traverse points would be established. Consequently, for maximum visibility, the use of high observing towers was required at all the new stations and some of the existing ones.

The four high observing towers steel-made Bilbi Towers (20 m high x 2, 15 m high x 2) were procured in Japan and shipped to Kenya by sea.

In order to transport these high observing towers whose unit weight was about 4 tons, large vehicles were required. A 10-ton truck was obtained on a rental basis at Malindi for this purpose.

This large truck could directly reach the stations in the central and western part of the work area. It could not reach those in the eastern part, however, and the towers were transferred onto an Isuzu 3-ton truck.

Of all the tasks involved in second-order traversing, transportation of the Bilbi Towers to and from the stations was one of the most difficult.

20 m and 15 m-high observing towers were respectively employed. The height of the towers was quite suitable for the traversing work.

6. Instruments employed for survey

Wild T3.......used to observe horizontal and vertical angles

Tellurometer MRA101.......used to measure distance

Signal light and heliotrope.......employed to act as an object for measuring angles

The Wild T3 and Tellurometer MRA101 had been calibrated by the Technical Centre of the Japan Survey Association prior to use in the field. The Tellurometer MRA101 also underwent periodical frequency testing at the field, using frequency counters.

7. Observation

7-1 Horizontal angle measurement

The pairs of horizontal angles were measured by utilising the Wild T3 under the direction method. The minimum reading was 0.1 sec. We made it a rule to conduct measurement in the morning and in the evening. Measurements were not made at noon. Signal lights were usually employed as objects.

Diagramme 11 and 12 illustrate field results of horizontal angle measurement.

7-2 Vertical angle measurement

The vertical angle was measured four times (each time a set of simultaneous measurements were made from both sides) between 10 am and 3 pm. The interval of each set of simultaneous measurements was approximately one hour. Heliotropes were usually employed as objects. Each set of measurements was composed of two measurements each using a telescope in regular and reverse directions.

Diagramme 13 reveals field results of vertical angle measurement.

7-3 Distance measurement

Distance measurement was conducted using the Tellurometer MRA101 in two sets each (rough reading 8 times and accurate reading 40 times) of measurements from both ends of the distance measured.

Meteorological observation (atmospheric pressure, dry bulb, wet bulb) was conducted both at the beginning and end of each half-set of chaining, at opposite ends of the measured.

Diagramme 14 reveals field results of chaining.

8. Table of conditions of observation

No. of pairs	Discrepancy between pairs	Observation method	Objects	Observation time	Remarks
9	10"	Direction method	Signal light and heliotrope	Observation time (not including the time around noon)	

8-1 Horizontal angle

No. of sets	Discrepancy between sets	Observation method	Objects	Observation time	Remarks
4	10"	Simultaneous observation in regular and reserve directions	Signal light and heliotrope	10-15 hours	

8-2 Vertical angle

No. of sets	Discrepancy of average measured values between sets	Observation method	Meteorological observation	Observation time	Remarks
2	1/75,000	Rough reading 8 times, accurate reading 40 times	Twice per half set of distance measurements (at the beginning and the end)	One set in the morning and the other in the afternoon	

8-3 Distance measurement

After neatly arranging the calculation made in each field book of horizontal and vertical angles and of distance measurement, it was confirmed that the results were within the specified limits. Then the records of horizontal and vertical angles and chaining were prepared, using the formats specified.
Diagrammes 15, 16 and 17 reveal the records of horizontal and vertical angles and distance measurement, respectively.
Computation of coordinates was manually effected in the field to check for errors of closure. On the other hand, the computation data were sent to Japan so that rough calculation could be made using an electronic computer. As a result, it was confirmed in the field that the survey results were within the limits specified.
Immediately after completing the calculation in each field book and record, the head of the team (or chief engineer) checked it.
The limits on the closure error for coordinates were based on the specifications prepared by the Survey of Kenya.

9. Accurate calculation

All accurate calculations were effected in Tokyo, utilising an electronic computer. The net adjustment calculation was conducted under the formulas specified.

9-1 Outline of the calculation

The calculation was made by utilising the calculation element of Clarke 1880 (a - 6378249.145 m, 1/f = 293.4663).

10. Final results table

After completing accurate calculation, the final results table for second-order traverse points was prepared utilising the format specified.
Diagramme 19 reveals the final results table.

V. AERIAL SIGNAL REPAIRING WORK

1. Objective

All aerial signals which had been established in the first year were researched and, if necessary, repaired.

2. Situations of the locations of aerial signals

The aerial signals which had been established from December, 1975 to February, 1976, were exposed to heavy rainfall in the rainy season. It was found that with reference to all the aerial signals, white paint had been peeled off and grass around them had grown excessively tall, almost preventing them from being detected. Consequently, all the aerial signals were repainted and the grass around them eliminates.
Damage possibly caused by man was the greatest source of anxiety concerning the aerial signals established in the first-year portion of the project. However, as a result of sufficient consideration given to procuring materials and establishing methods during the project, preservation conditions of the aerial signals were excellent.

3. Repaired aerial signals and newly added ones

Repaired aerial signals 64
Newly added aerial signals..........5 (those established in the second year among the second-order traverse points newly established)
Second-order fundamental bench marks..........5 (in compliance with the request of the Survey of Kenya)
Second-order bench marks..........A few (those points where pin-pricking of bench marks seemed to be quite difficult)

VI. SURVEY WORK IN THE THIRD AND SUBSEQUENT YEARS

Conference with the Survey of Kenya

A conference was held on December 10, 1976 at the headquarters of the Survey of Kenya attended by Mr. Absalomus, Deputy Director of the Survey of Kenya (Mr. Omondi, Director, was out on business) representing Kenya, Mr. Kida, Technical Advisor, Mr. Kimura, Councillor of the JICA, Mr. Kanai, Leader of the Topographic Mapping Team, Mr. Iijima, Chief Surveyor, Mr. Fujita, ujita, Coordinator, and Mr. Murakoshi, Head of the JICA Nairobi Office. At this conference, the field work in the third and subsequent years was discussed, ssed, and the minutes shown on separate sheets were produced.
It was agreed on that the Japanese party would prepare the specifications for survey of orienting points (traversing and leveling) and submit them to the Kenyan party prior to commencing the project.
The following was also agreed upon concerning the field work.

(1) The Survey of Kenya shall be, as a rule, responsible for place names.
(2) For the purpose above, the Survey of Kenya shall despatch at least two experts to the survey fields while the Japanese survey team is working in the fields.
(3) The Japanese party should preferably prepare all the necessary vehicles. However, the Survey of Kenya may prepare one vehicle.
(4) The administrative division shall be plotted by the Survey of Kenya on compilation sheets after completing map compilation.
(5) Prior to starting field survey, both Kenyan and Japanese experts shall bring about a good understanding of the symbols and system of representation by selecting appropriate sample sheets and effecting field survey.
The foregoings are the principal items of the minutes mentioned above.

Diagram 1

TOPOGRAPHIC MAPPING IN EAST KENYA

SECOND YEAR SURVEY

SCALE 1:1,000,000

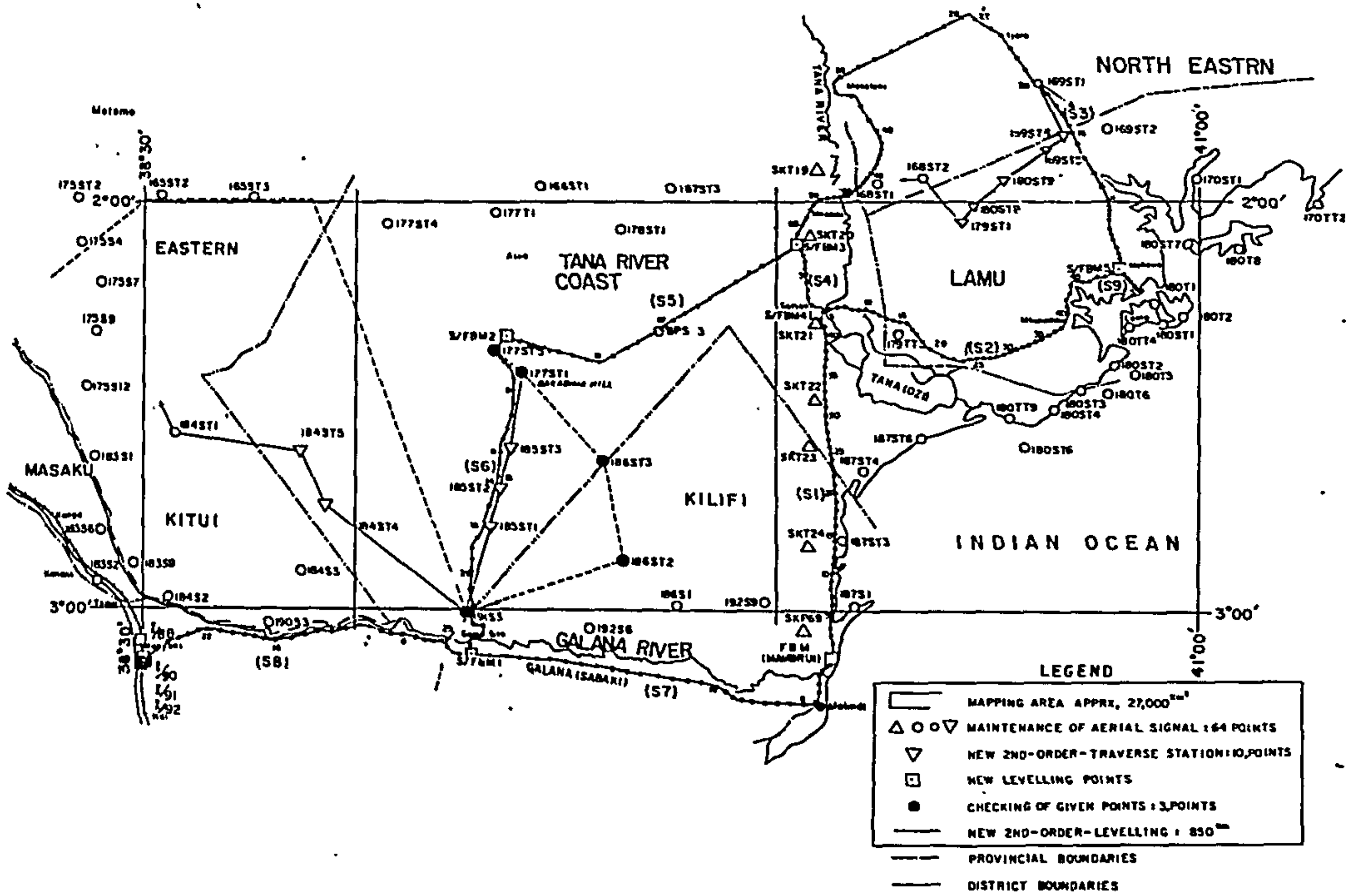


Diagram 2

FIELD SHEETS OF SECOND ORDER LEVELING

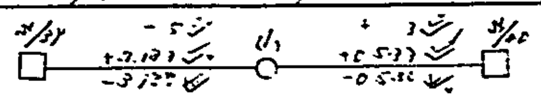
151

ROUTE (51) FROM [illegible] TO [illegible] (I)

Date: 23. Aug. '76	Weather: Fine	File page No.
Instrument: Carl Zeiss Ni 2 No 76950	Rods: 7613 7614	Circuit. MSA
Observer: [illegible]	Checked: [illegible]	IV-29

PT.	DIST. (m)	SCALE BACK-SIGHT (m)	SCALE FORE-SIGHT (m)	DIFFERENCE + (m)	DIFFERENCE − (m)	REMARKS
						[illegible] 10h16m 22°C
1	[illegible]	[illegible]	[illegible]	[illegible]		
2	[illegible]	[illegible]	[illegible]	[illegible]		
3	[illegible]	[illegible]	[illegible]	[illegible]		
4	[illegible]	[illegible]	[illegible]	[illegible]		+3.183
5	[illegible]	[illegible]	[illegible]		[illegible]	
6	[illegible]	[illegible]	[illegible]		[illegible]	
7	[illegible]	[illegible]	[illegible]	[illegible]		
8	[illegible]	[illegible]	[illegible]	[illegible]		
9	[illegible]	[illegible]	[illegible]	[illegible]		
10	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]
11	[illegible]	[illegible]	[illegible]		[illegible]	+5.327
12	[illegible]	[illegible]	[illegible]		[illegible]	−2.144
13	[illegible]	[illegible]	[illegible]		[illegible]	+3.183
14	[illegible]	[illegible]	[illegible]	[illegible]		
15	[illegible]	[illegible]	[illegible]	[illegible]		+0.593
16	[illegible]	[illegible]	[illegible]	[illegible]		
17	[illegible]	[illegible]	[illegible]		[illegible]	
18	[illegible]	[illegible]	[illegible]		[illegible]	[illegible] 10h53m 28°C
	I = [illegible]					
	II = [illegible]					
	[illegible]					
TOTAL		49.951	45.235	9.669	[illegible]	T_1 = 28.°C
CHECK			3.716	3.716		T_2 = 32.°C
RESULT	1/2 Δh				+ 1.858	T_m = 30.°C

FROM [illegible] TO [illegible] (I) = + 1.858 (I) : S.P. IV-32



CHECK SESULT OF GIVEN POINT

IN

SECOND ORDER LEVELING

BENCH-MARK NO.	FINAL RESULT TABLE	1 ΔH	2 VALUE OF CHECK SURVEY (FROM TABUL.)	1 – 2 DIFF.	REMARKS
	m	m	m	mm	
II /88	543.219				
		+ 2.703	+ 2.702	+ 1	
II /90	545.922				
		– 0.349	– 0.346	– 3	
II /91	545.573				
		+ 6.089	+ 6.078	+ 11	
II /92	551.662				

No.

ツアイス 一等標尺

標尺補正数表

（会社名：パシフィック航業KK）

昭和51年6月2日 検定

単位μ

（膨張係数 1m.0×10⁻⁶）

指標 尺No. \ 温度(℃)		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	76.13 76.14	+23	+24	+25	+26	+27	+28	+29	+30	+31	+32	+33	+34	+35	+36	+37	+38	+39	+40
2																			
3																			
4																			
5																			
6																			
7																			

指標 尺No. \ 温度(℃)		18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
1	76.13 76.14	+41	+42	+43	+44	+45	+46	+47	+48	+49	+50	+51	+52	+53	+54	+55	+56	+57	+58
2																			
3																			
4																			
5																			
6																			
7																			

摘要 国土地理院の検定要領により検定、目盛りの精度良
2級水準測量に使用可
測量技術センター　技術士　太田晃

社団法人　日本測量協会測量技術センター

指導・点検者　橋　敏　孝

TABULATION OF SUPERVISION-ACCURACY

(SECOND ORDER LEVELING)

ROUTE	DIST. (K)	M.S.E (mm)	INSTRUMENT	RODS. No.	OBSERVER
(1)	94.264	1.43	Carl Zeiss Ni2 No. 116 815 No. 116810 No. 86350 No. 116 800 No. 8630 No. 116 817 No. 86307	Carl Zeiss No. 7605 7606 NO. 7603 7604 No. 7613 7614 No. 7607 7608 No. 7611 7612 No. 7601 7602 No. 7609 7610	Y. KYAKUNO Y. UDO T. KOSAKA I. INOUE T. HIRAOKA K. HATAKEYAMA T. AOKI C. HORIUCHI T. SHIBUYA Y. OKUDA T. SATO T. TAKAHASHI E. TAGUCHI Y. ONISHI T. OE N. NAGASHIMA K. OKUGAKI Y. ASANO
(2)	107.130	1.52			
(3)	200.065	1.72			
(4)	22.151	1.98			
(5)	93.047	1.73			
(6)	116.391	1.61			
(7)	112.122	1.75			
(8)	107.660	2.10			
(9)	10.708	1.50			
All Route	863.538	1.68			

REMARKS

TOTAL OF DISTANCE .... 863.538 K

TRAVERSE POINT

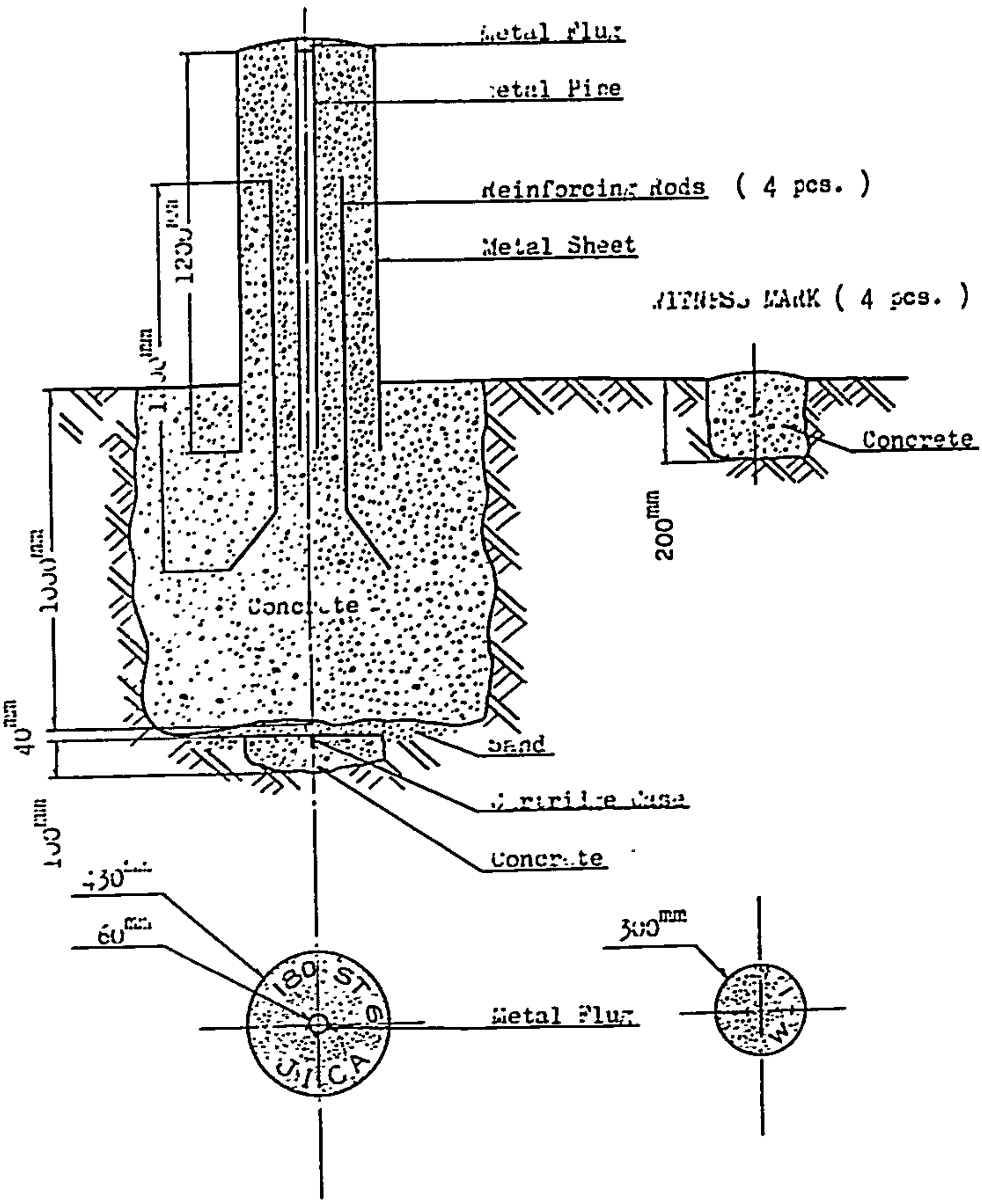


Diagram 7

FINAL RESULT TABLE FOR (SECOND) ORDER LEVELING			
ROUTE (5)	From S/FBM.3 (UNDERGROUND)	To S/FBM.2 (UNDERGROUND)	
Station	Distance	Elevation	Remarks
S/FBM.3		33.772	UNDERGROUND
S5/1	4.137	37.579	
S5/2	4.223	45.101	
S5/3	4.245	52.574	
S5/4	4.026	61.484	
S5/5	4.694	71.882	
S5/6	4.314	84.507	
S5/7	4.354	102.984	
S5/8	4.497	114.677	
S5/9	4.359	125.273	
S5/10	4.135	130.339	
S5/11	4.450	142.095	
S5/12	4.071	150.621	
S5/13	4.316	158.695	
S5/14	4.401	160.422	
S5/15	4.580	155.927	
S5/16	4.175	170.077	
S5/17	4.307	172.974	
S5/18	4.403	181.291	
S5/19	3.980	185.237	
S5/20	4.356	193.965	
S5/21	4.401	200.130	
S/FBM.2	2.591	205.762	SURFACE
S/FBM.2	0.032	205.492	UNDERGROUND
TOTAL ...	93.047		

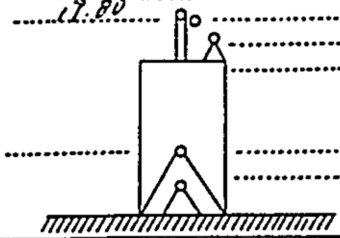
Diagram 8

HORIZONTAL ~~& VERTICAL~~ ANGLE OBSERVATIONS.

Station: 17 · ST - 1

Date: 7 Nov '76

Instrument Ht ~~feet~~ metres 17.80	Signal Ht.
Notes on observing	Observer: C Hirsch
Conditions:	Booker: Y Aame
	Reduced: Y Aame
	Checked: C Hirsch
	Ins. No: A 3067
	Weather: Fine
	Visibility: Good



Sin Page 1 of 2

3

Station	Face	Signal		Reading A	Reading B	Mean	Reduced Read'g	Remarks
17-ST-2	R	Lamp	[illegible]	0 0	[illegible]	[illegible]	0 0 00	
18-51-6		Lamp		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	L			[illegible]	[illegible]	[illegible]	[illegible]	
				[illegible]	[illegible]	[illegible]	0 0 00	
	L			[illegible]	[illegible]	[illegible]	[illegible]	
				[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	R			[illegible]	[illegible]	[illegible]	[illegible]	
				[illegible]	[illegible]	[illegible]	[illegible]	
	R			[illegible]	[illegible]	[illegible]	[illegible]	
				[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	L			[illegible]	[illegible]	[illegible]	[illegible]	
				[illegible]	[illegible]	[illegible]	[illegible]	
	L			[illegible]	[illegible]	[illegible]	[illegible]	
				[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	R			[illegible]	[illegible]	[illegible]	[illegible]	
				[illegible]	[illegible]	[illegible]	[illegible]	
	R			[illegible]	[illegible]	[illegible]	[illegible]	
				[illegible]				
				[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	L			[illegible]	[illegible]	[illegible]	[illegible]	
				[illegible]	[illegible]	[illegible]	[illegible]	
	L			[illegible]	[illegible]	[illegible]	[illegible]	
				[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	R			[illegible]	[illegible]	[illegible]	[illegible]	
				[illegible]	[illegible]	[illegible]	[illegible]	

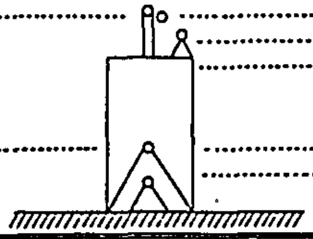
HORIZONTAL & ~~VERTICAL~~ ANGLE OBSERVATIONS.

Station: [illegible]-ST-1

Date:

Stn Page 2 of 2

Instrument Ht ~~feet~~ metres Signal Ht.



Notes on observing

Conditions:

Observer:

Booker:

Reduced:

Checked:

Ins. No.

Weather:

Visibility:

Station	Face	Signal		Reading A	Reading B	Mean	Reduced. Read'g	Remarks
[illegible]-ST-2	R	lamp		[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]-ST-6		lamp		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	L			[illegible]	[illegible]	[illegible]	[illegible]	
				[illegible]	[illegible]	[illegible]	[illegible]	
	L			[illegible]	[illegible]	[illegible]	[illegible]	
				[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	R			[illegible]	[illegible]	[illegible]	[illegible]	
				[illegible]	[illegible]	[illegible]	[illegible]	
	R			[illegible]	[illegible]	[illegible]	[illegible]	
				[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	L			[illegible]	[illegible]	[illegible]	[illegible]	
			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
							Diff. Sets =	[illegible]

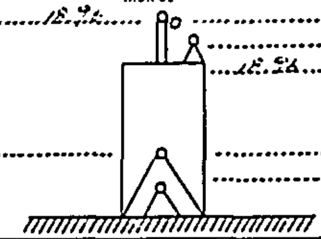
Diagram 10

~~HORIZONTAL & VERTICAL~~ ANGLE OBSERVATIONS.

Station: 184-ST-4

Date: 17 Oct '76

Instrument Ht	~~feet~~ metres	Signal Ht.	Notes on observing	
18.24		18.24	Conditions.	Observer: [illegible]
				Booker: Y. [illegible]
				Reduced: Y. [illegible]
				Checked: [illegible]
				Ins. No. [illegible]
				Weather: Fine
				Visibility: Good



Stn Page 2 of 2

13

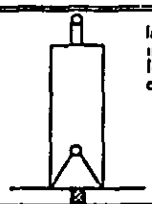
Station	Face	Signal		Reading		A	B	Mean	Reduced Read'g			Remarks
184-ST-5	R	Helio	[illegible]	89	54	59.1	59.4	59.2½				
	L			90	4	49.3	49.6	49.4½	− 0	8	10.2½	
				180	0			24.5½	90	8	10.2½ = Z	
	L			90	4	26	21	42½				
	R		[illegible]	89	54	58.8	58.4	58.7½	− 0	8	10.0½	
				180	0			44.4½	90	8	10.0½ = Z	
									90	8	10.1½ = Mean	
	R	Helio	[illegible]	89	54	58.5	58.4	58.5½				
	L			90	4	48	51	49.5½	− 0	8	10.0½	
				180	0			50.8½	90	8	10.0½ = Z	
	L			90	4	40	41	40.5½				
	R		[illegible]	89	54	58.0	57.9	57.9½	− 0	8	10.2½	
				180	0			40.0½	90	8	10.2½ = Z	
									90	8	10.1½ = Mean	

Diagram 11

Survey ______ Job No. ______

TELLUROMETER LINE MEASUREMENT (BY MRA101)

Master at:	186-ST-1
Remote at:	191-S-3
Date:	12 0.6 '72
Measure No:	3-4
File Page No.	56



Time: 1520 Weather: Cloudy Visibility: Good Booker: Y Aarau Checked: C. Hibrick

Master Inst.	No: 778	Ht: 1.081	Operator: C Hibrick	Calc'n: Y Aarau
Remote Inst.	No: 773	Ht: 1.25	Operator: T. Aoki	Checked: C Hibrick

Carrier	F	R	Mean	Graph
1.0	422	432	427	
2.0	410	410	410	
3.0	412	418	415	
4.0	425	424	424	
5.0	422	429	426	
6.0	431	434	432	
7.0	438	427	432	
8.0	442	442	442	
9.0	422	425	424	
10	404	409	406	

COARSE READINGS

Initial: A 4 212; E 14; D 23; C 13; B 21

Carrier Tune 1.0: 2 1 2 6 4 2 2

Final: A 4 04; E 60; D 23; C 12; B 21

Carrier Tune 2.0: 2 1 2 6 4 0 4

Sum		4233	Pressure Mbs			Temp °C	
Mean		423	Read'g	Corr	Press	Dry	Wet
No of Rdgs 10	M. Baro No. 26797	Start			987	27.0	23.2
		Finish			988	30.4	24.0
Swing 36	R. Baro No 982	Start			965	28.2	22.4
		Finish			965	27.7	20.4
		Sum			3907	113.3	88.0
		Mean			P. 977	t: 28.0	t': 22.0

CALCULATION

Met correctn factor $Q = 1{,}000325/n-1$

$(n-1)\times 10^6 = A + B(P-1000)$;

A and B obtained from table under t and t−t'

P = 977 P−1000 = −23

t = 28.0 B = 0.238

t' = 22.0 B(P−1000) = −5.47

t−t' = 7.0 A = 344.13

$(n-1)\times 10^6$ = 338.66

Q = −0.000014

21,264.23 D = Ind. Dist.

− 0.30 D·Q

21,263.93 L = Sum

− 0.05 Zero Corrn

21,261.88 Field Length

Diagrams remarks etc

Diagram 12

TRIG. INDEX CARD

Name of Station	No. of Station	Order	Projection
	169-ST-5	II	U.T.M.Zone: 37

Location	IJARA	Map Ref.	169
Abstract No.		T. C. No.	Comps. No.

Latitude & Longitude		Co-Ordinnate		Scale Factor
Lat. =	1° 53′ 40.″8838 (S)	N =	9790513.36 m	
Long. =	40 37 38.8350 (E)	E =	681024.21	
Conv. =	+ 0 3 13.7612	H =	34.13	

To Station	Azimuth	Distance	Remarks
169-ST-6	53° 56′ 29″.380	6426.m627	GEOD. DIST.
180-ST-9	238 3 39 .290	13244.815	"

TRIG. INDEX CARD

Name of Station	No. of Station	Order	Projection
	169-ST-6	II	U.T.M.Zone: 37

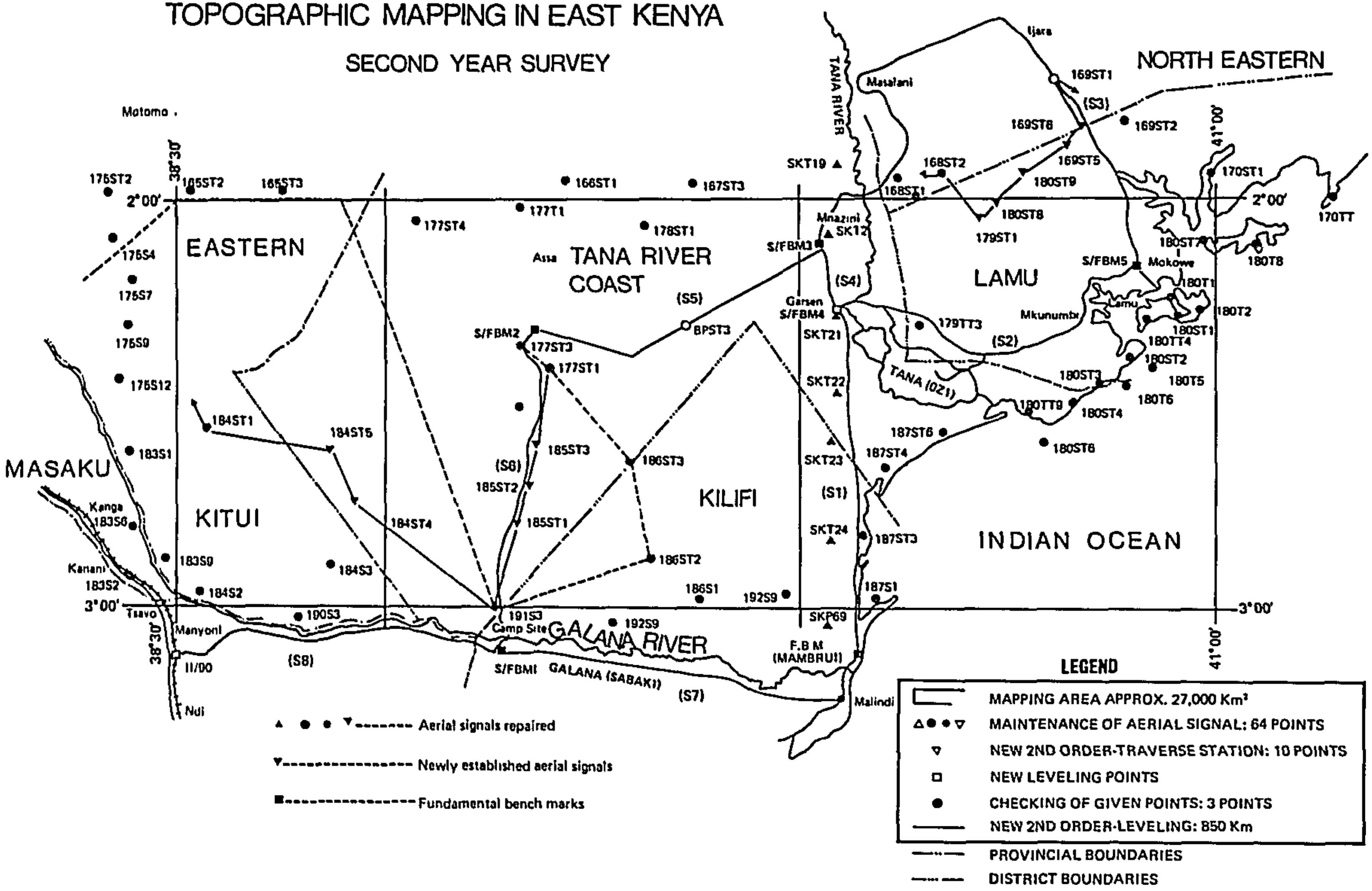
Location	IJARA	Map Ref.	169
Abstract No.		T. C. No.	Comps. No.

Latitude & Longitude		Co-Ordinnate		Scale Factor
Lat. =	1° 51′ 37.″7143 (S)	N =	9794291.37 m	
Long. =	40 40 26.9356 (E)	E =	686223.21	
Conv. =	+ 0 3 15.7256	H =	30.551	

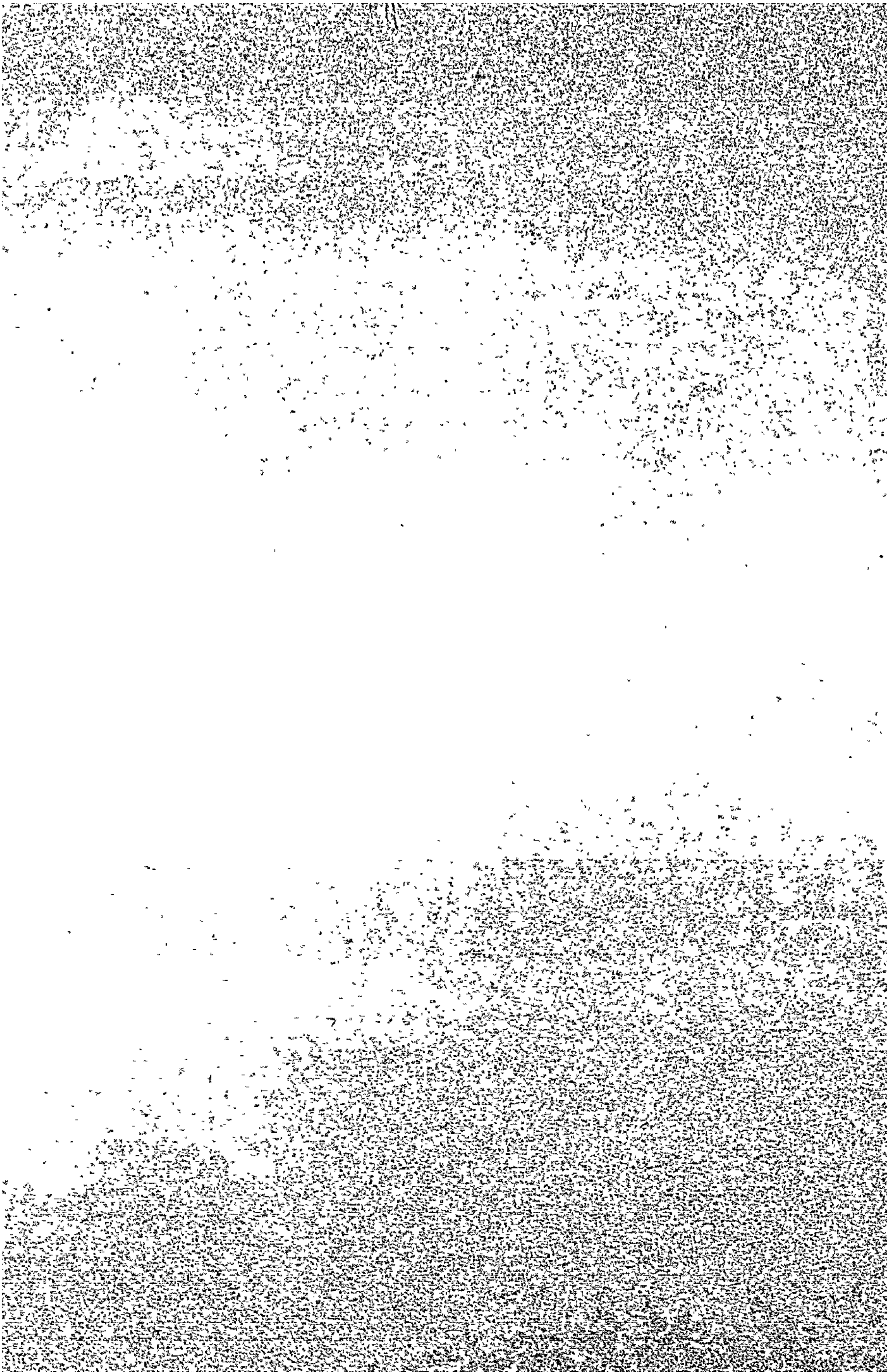
To Station	Azimuth	Distance	Remarks
169-ST-5	233° 56′ 23″.880	6426.m627	GEOD. DIST.
169-ST-1	338 23 44 .590	14952.873	"

TOPOGRAPHIC MAPPING IN EAST KENYA

SECOND YEAR SURVEY



PART II PHOTOGRAPHING



I. DESCRIPTION OF THE AERIAL PHOTOGRAPHING WORK

1. **Objective**
   The objective of the aerial photographing work is to take vertical aerial photographs which are necessary for preparing basic maps of the area concerned.

2. **Area concerned**
   The whole area to be covered by the 1:50,000 basic map for the east Kenyan area (around Tsavo, Lamu, and Malindi), approx. 30,000 km²

3. ***Volume of photographing work***
   Photographing scale: 1:60,000
   Photographing area scheduled: Approx. 30,000 km²
   Photographing area completed: 18,000 km² (60% of the whole volume)
   Photographing area to be photographed: 12,000 km² (40% of the whole volume)
   Refer to Diagramme 1 and Table 1.

4. **Photographing period**
   From: January 3, 1977
   To: March 15, 1978

5. **Equipment and instrument employed**
   a. Aeroplane: Cessna Aerocraft, double-engined, Cessna 402A, Register No. 51-AMS
   b. Navigation equipment: Signer Doppler SK-1000 with Sperry C12 Compass system
   c. Camera: RC-10 Aerial photographic camera Machine No. 1349 and 2903 equipped with Wild NF2 navigation sight
   d. Lens: Wild superwide angle Super Aviogon II, Lens No. SAG2056, focal length f = 88.86mm
   e. Film cassette: Nos. 1250, 1573, 2855, 3853
   f. Developer: Zeiss FE-120, Machine No. 120-730
   g. Dryer: Zeiss TG-24, Machine No. 116-945 (for printer) Kodak drum dryer, Machine No. T24R-1407
   h. Printer: Milligan Electronic Printer CP10A, Machine No. 517

6. **Materials employed**
   a. Film: Kodak Double X Aerographic, length 500 ft.
   b. Printing paper: Kodak WSG
   c. Developing solution: (for film) Kodak DK50
      (for printing) Kodak Unifix
   d. Fixing solution: (for film) Kodak RT-Fixer
      (for printing) Kodak DA-163
   e. Antidrop solution: Kodak Photo-F10

7. **Photographing conditions**
   a. Photographing scale: Approximately 1:60,000
   b. Photographing altitude: Altitude specified: 5500 m above mean sea level
      Allowance: Within 7% of the above
   c. Overlap: Forward overlap: 60% as a rule
      Lateral overlap: 30% as a rule

d. Angle of inclination: Within 5% of inclination against the perpendicular direction of the camera axis

e. Angle of deflection: Within 10° against the center of the photographing direction; should not give any effect on the subsequent mapping work

f. Allowable volume of clouds: Within the effective range of the stereocomplier. Clouds should not exist on or over the important area, control points, and principal points.

II. WEATHER CONDITIONS

In Eastern Africa, January and February are usually most appropriate for photographing since precipitation is at its lowest. However, from December, 1976 to February, 1977 and from December, 1977, to February, 1978, the weather conditions were unfavourable for aerial photographing, because weather prevailed at that time, and there were several rainfalls. It was said that abnormal meteorological conditions were unfavourable for aerial photographing, because unusual weather prevailed at that time, and there were several rainfalls. It was said that abnormal meteorological conditions rather rare in Kenya had occurred. In addition to these abnormal conditions, the weather in the survey area is usually severe as a result of the influence from the Indian Ocean which the area borders. This is the reason why the photographing work was completed earlier in the western part of the survey area than in the eastern part.

Even on a fair day, clouds appeared in shortly after 8:30 am, thereby preventing photographing. The clouds usually formed a low wide stratum widely covering the sky, and sometimes formed double strata. As a result, the specified altitude of the airplane was usually above cloud level. When clouds existed high in the sky, the powerful sunlight produced clear shadows of clouds on the ground. Judging from the fact that there are many trees in Galsen and to the east, it is presumed that precipitation in that area is relatively large throughout the year.

Diagramme 2 reveals the precipitation in Malindi during the photographing period. We deeply regret that we could not complete the entire photographing work in the area, for the reasons stated above.

III. SITUATIONS OF PHOTOGRAPHING WORK

The base for photographing work was located at Wilson Airport in Nairobi. It was moved to the airport in Malindi from September 2 to 3 and from September 10 to October 28, during which it was expected that the weather conditions would become favourable. In both cases, the weather conditions in the survey area and flight preparations were checked every day at seven in the morning. When weather permitted, flight for photographing was conducted. During the period when the base was located at Wilson Airport, weather information from tourism airplanes could be obtained through wireless communications, in addition to the information from airports in Malindi and Mombasa.

During the 437-day work period, the days on which photographing could be realised numbered only 18 or 4% of the entire period, namely February 5, 9, 19, September 4, 10, 24, 25, 27, 29, October 4, 6, 13, 19, 20, 22, 23, 25, 26, (1976), and 3 days in February, 6 days in September and 9 days in October (1977).

The total flight hours during the above-mentioned period amounted to 98 hours 38 minutes, including flights in which photographing could not be realised. A total of 71 flights were recorded. (Refer to the appended photographing record).

There was a special case which prevented us from photographing: from late September to October, the agricultural fields were burnt on fair days in the survey area. The smoke prevented us from photographing.

IV. RESULTS OF PHOTOGRAPHING

After taking aerial photographs, prints for inspection were produced to check whether or not the photographs were acceptable. Those photographs which had been taken of areas beyond the assigned photographing strips not suitable for aerial triangulation purposes were put aside. When drafting the schedule, we were afraid of the influence of clouds on the photographs. Although the effects of clouds exerted on the execution of the photographing work were great, almost all results proved to be valuable for aerial triangulation and map compilation, even if some small clouds were photographed along the photographing strips.

Almost all photographs were judged to be acceptable with regards to photographing height, overlap and angle of deflection. Although there are many photographs taken under slightly misty conditions, they are still useful in map compilation work.

Some photographs had unclear machine numbers. However, annotation made up for this defect. Photographs taken early in the morning or late in the evening are generally regarded as most acceptable for map compilation purposes since the ground surface was free from relief. Since there are some photographs on which aerial signals cannot be identified, it is necessary to confirm it by means of the pin-pricking work conducted in the field.

After putting aside photographs showing areas beyond the photographing strips, the final results were prepared and necessary annotations were added to each acceptable photograph. The annotation was described in the manner mutually agreed upon by the Survey of Kenya and us.

V. SUBSEQUENT PHOTOGRAPHING WORK

The photographing work that remains represents 40% of the total volume of the work. It is necessary to conclude a new contract to make a schedule to complete the remaining photographing work. As indicated in the report from the photographing supervisor dated March, 1978, the desirable photographing period is from September to October based on past experience and data. There are several days in June which are also suitable for photographing; therefore, photographing at such a period should also be considered. Another suitable photographing opportunity comes in the period from January to February, 1978.

After completion of the photographing, it is necessary to promptly confirm the location of the aerial signals which are not identified in the photographs and to conduct eccentric pricking. At the same time, the schedule for the remaining portion of the project will be reviewed accordingly.

Diagram 1

TOPOGRAPHIC MAPPING IN EAST KENYA
GROUND SURVEY NETWORK

SCALE 1:1,000,000

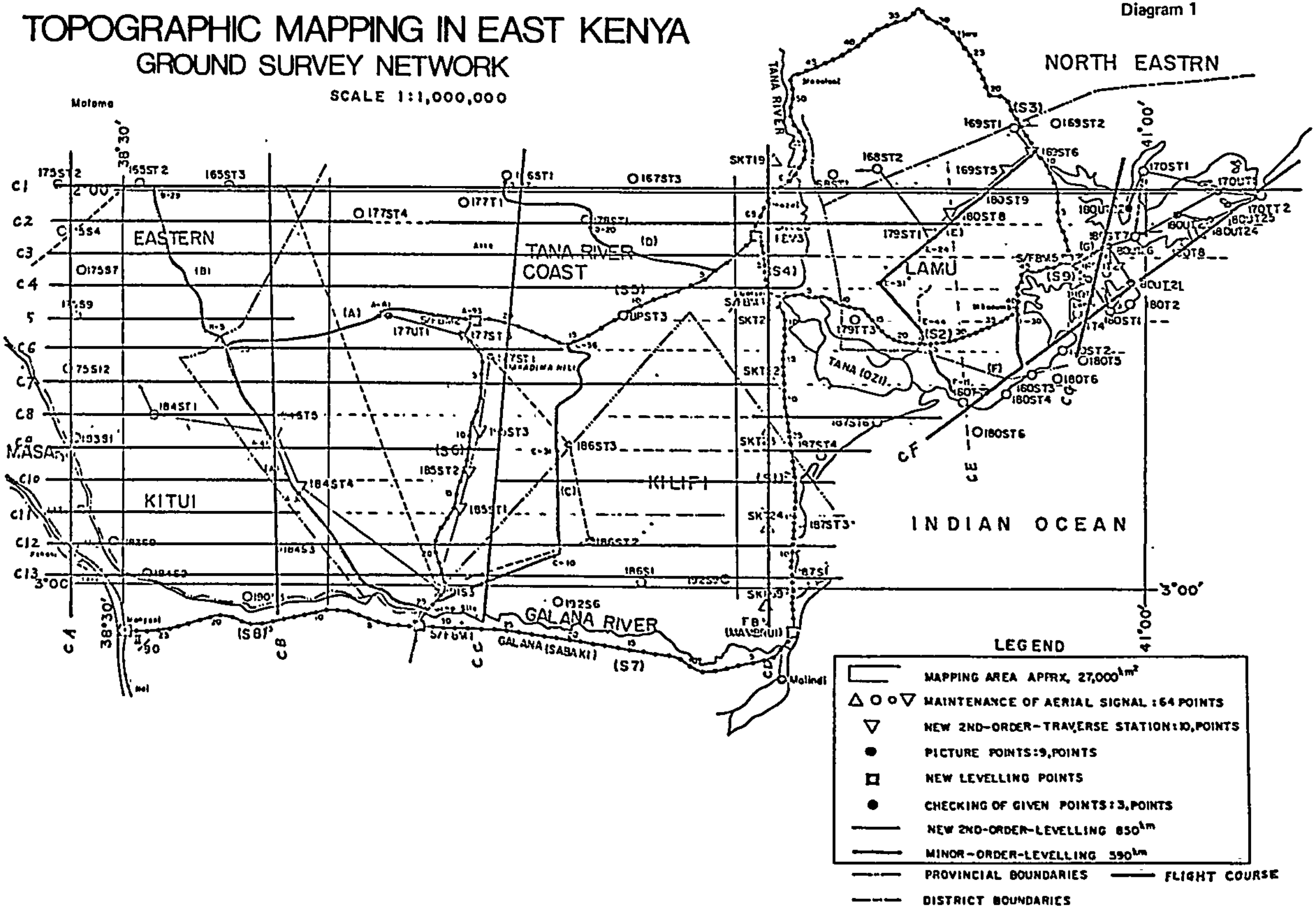


Diagram 2

Table of total length of unphotographed strips in the eastern area of Kenya

Strip No.	Total length scheduled (km)	Total length unphotographed (km)	% of unphotographed length
1	335	0	0
2	330	179	54
3	320	123	38
4	302	110	36
5	300	242	81
6	281	174	62
7	275	163	59
8	240	156	65
9	220	155	70
10	210	71	34
11	210	162	77
12	210	68	32
13	210	0	0
Subtotal	3443	1603	47
A	132	0	0
B	126	0	0
C	131	0	0
D	133	0	0
E	82	82	100
F	50	0	0
G	115	0	0
Subtotal	769	82	11
Total	4212	1685	40

Ratio of photographed strip to the total length = 100% - 40% = 60%

Diagram 3

Precipitation Table

Date	1977 Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	1978 Jan	Feb	Mar	Remarks
1	NIL	NIL	NIL	TR	5.5	TR	4.3	NIL	0.5	TR	22.6	2.1	TR	0.2	TR	Surveyed
2	NIL	NIL	NIL	TR	28.4	0.5	NIL	TR	NIL	NIL	0.5	NIL	NIL	NIL	NIL	on March
3	NIL	NIL	NIL	0.3	2.9	3.8	0.6	NIL	3.7	TR	4.2	0.9	NIL	TR	NIL	13, 1978
4	NIL	NIL	NIL	NIL	NIL	24.0	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	
5	0.2	NIL	NIL	7.4	0.6	TR	1.9	NIL	TR	1.1	NIL	TR	NIL	NIL	1.1	
6	NIL	NIL	NIL	7.8	1.4	1.1	0.6	NIL	NIL	1.4	NIL	NIL	NIL	0.1	5.5	
7	0.9	NIL	NIL	46.4	21.8	2.0	0.4	59.9	NIL	24.6	NIL	NIL	NIL	NIL	NIL	
8	NIL	NIL	NIL	NIL	3.2	NIL	NIL	7.7	NIL	6.5	1.5	NIL	NIL	NIL	NIL	
9	NIL	NIL	NIL	9.0	NIL	NIL	NIL	TR	NIL	0.6	0.3	NIL	NIL	NIL	NIL	
10	NIL	NIL	NIL	1.0	0.2	0.2	NIL	8.4	3.2	3.1	5.8	NIL	NIL	NIL	NIL	
11	TR	NIL	NIL	NIL	1.6	19.0	2.9	2.9	4.5	25.3	1.7	NIL	NIL	NIL	NIL	
12	NIL	NIL	NIL	9.2	1.1	NIL	0.5	2.1	0.3	TR	9.1	NIL	NIL	NIL	NIL	
13	NIL	NIL	NIL	2.4	NIL	NIL	0.3	NIL	1.2	NIL	23.4	NIL	NIL	NIL	NIL	
14	NIL	NIL	NIL	49.0	NIL	0.4	0.3	1.0	2.8	8.3	21.7	14.3	NIL	NIL		
15	NIL	NIL	NIL	NIL	0.3	NIL	6.1	44.6	6.5	2.0	NIL	TR	NIL	NIL		
16	NIL	0.2	NIL	NIL	0.5	0.4	0.9	3.0	NIL	8.3	TR	NIL	NIL	NIL		
17	NIL	NIL	NIL	0.3	NIL	TR	NIL	2.7	NIL	NIL	NIL	1.0	0.1	NIL		
18	TR	NIL	NIL	0.6	TR	5.1	0.8	0.5	2.6	NIL	NIL	0.4	4.8	TR		
19	NIL	NIL	NIL	16.0	NIL	13.8	2.0	3.8	2.9	1.0	NIL	0.6	0.2	TR		
20	NIL	NIL	2.3	NIL	22.8	0.2	3.1	TR	5.9	6.5	NIL	13.9	TR	0.4		
21	NIL	NIL	NIL	NIL	7.0	8.3	NIL	0.4	3.0	NIL	NIL	2.8	1.1	NIL		
22	NIL	NIL	NIL	TR	1.8	TR	0.7	2.3	NIL	NIL	NIL	NIL	TR	NIL		
23	NIL	NIL	NIL	TR	9.0	NIL	0.5	TR	1.8	NIL	10.3	6.9	NIL	NIL		
24	NIL	NIL	NIL	0.7	NIL	NIL	NIL	NIL	1.9	NIL	NIL	NIL	NIL	0.2		
25	NIL	NIL	NIL	1.3	1.1	NIL	TR	NIL	TR	NIL	NIL	NIL	TR	TR		
26	NIL	NIL	NIL	TR	14.5	NIL	0.4	NIL	NIL	NIL	4.9	NIL	0.6	NIL		
27	NIL	NIL	0.7	0.2	6.8	NIL	NIL	NIL	TR	1.7	14.8	NIL	NIL	NIL		
28	NIL	TR	3.8	NIL	1.0	NIL	NIL	8.2	TR	0.8	2.1	NIL	NIL	NIL		
29	NIL		1.1	NIL	0.6	0.6	NIL	TR	0.2	19.7	17.9	NIL	NIL	NIL		
30	TR		NIL	0.1	4.1	12.2	TR	NIL	TR	55.2	NIL	0.2	NIL			
31	TR		2.1		NIL		NIL	NIL		38.0		NIL	TR			
Total	1.1	0.2	10.0	151.7	136.2	91.6	26.3	147.5	41.0	204.6	140.8	43.1	6.8	0.9		
Total yearly precipitation	1.1	1.3	11.3	163.0	299.2	370.8	417.1	564.6	605.6	810.2	951.0	994.1	6.8	7.7		
Rainy days	0	0	4	10	17	9	6	12	12	15	13	6	2	0		

Notes: NIL = No precipitation
TR = No measurable rainfall
Rainy days denote the total of the days on which precipitation of 1.0mm or more was recorded.

List of aerial photographs adopted for topographic mapping project in the eastern area of Kenya

Strip No.	Photograph No.	No. of photographs
1	3168 ~ 3179	12
1	1784 ~ 1800	17
1	2707 ~ 2759	53
2	2820 ~ 2842	23
2	1811 ~ 1827	17
2	2772 ~ 2786	15
3	0779 ~ 0824	46
4	0871 ~ 0886	16
4	0828 ~ 0862	35
5	0891 ~ 0905	15
6	0910 ~ 0938	29
7	1831 ~ 1846	16
7	3243 ~ 3263	21
8	2629 ~ 2639	11
8	1868 ~ 1882	15
9	2616 ~ 2622	7
9	1887 ~ 1902	16
10	1907 ~ 1922	16
10	2794 ~ 2816	23
11	2004 ~ 2019	16
12	1944 ~ 1957	14
12	3187 ~ 3211	25
13	1960 ~ 1973	14
13	2405 ~ 2421	17
13	3213 ~ 3237	25
Subtotal		514

Strip No.	Photograph No.	No. of photographs
A (14)	0966 ~ 0966	31
B (15)	2331 ~ 2359	29
C (16)	2655 ~ 2683	29
D (17)	2096 ~ 2125	30
F (19)	2281 ~ 2294	14
G (20)	2253 ~ 2276	24
Subtotal		157
Total		671

Appendix 1 Record on photographing work

Date	Taking off time	Landing time	Flight hour	Types of works	Total photographing length	Remarks
3 Jan 1977				Waiting for favourable weather conditions		
6 Jan 1977				Waiting for favourable weather conditions		
7 Jan 1977	08.00	09.10	1.10	Returned due to excessively cloudy weather		
8 Jan 1977				Waiting for favrourable weather conditions		
20 Jan 1977				Waiting for favourable weather conditions		
21 Jan 1977	08.00	09.10	1.10	Returned due to excessively cloudy weather		
22 Jan 1977	08.15	08.45	0.30	Returned due to excessively cloudy weather		
23 Jan 1977	08.10	08.45	0.35	Returned due to excessively cloudy weather		
24 Jan 1977				Waiting for favourable weather conditions		
25 Jan 1977	07.40	09.40	2.00	Returned due to excessively cloudy weather		
26 Jan 1977	08.30	10.00	1.30	Returned due to excessively cloudy weather		
27 Jan 1977				Waiting for favourable conditions		
28 Jan 1977	08.10	09.40	1.30	Returned due to excessively cloudy weather		

29 Jan 1977				Waiting for favourable weather conditions		
30 Jan 1977				Waiting for favourable weather conditions		
31 Jan 1977	07.55	08.50	0.55	Returned due to excessively cloudy weather		
1 Feb 1977	08.10	09.20	1.10	Returned due to excessively cloudy weather		
2 Feb 1977				Waiting for favourable weather conditions		
3 Feb 1977	07.55	09.25	1.30	Returned due to excessively cloudy weather		
4 Feb 1977				Waiting for favourable weather conditions		
5 Feb 1977	08.00	12.45	4.45	Partially photographed strip No. 3, 4, 5 and 6	580 km	
6 Feb 1977	07.55	09.05	1.10	Returned due to excessively cloudy weather		
7 Feb 1977	07.55	09.15	1.20	Returned due to excessively cloudy weather		
8 Feb 1977				Waiting for favourable weather conditions		
9 Feb 1977	08.00	10.15	2.15	Photographed tie Strip A	132 km	
10 Feb 1977	07.55	09.10	1.15	Returned due to excessively cloudy weather		
11 Feb 1977	08.05	09.10	1.05	Returned due to excessively cloudy weather		
12 Feb 1977	07.55	08.55	1.00	Returned due to excessively cloudy weather		

13 Feb 1977				Waiting for favourable weather conditions		
14 Feb 1977				Waiting for favourable weather conditions		
15 Feb 1977	07.55	08.45	0.50	Returned due to excessively cloudy weather		
16 Feb 1977	08.10	08.45	0.35	Returned due to excessively cloudy weather		
17 Feb 1977				Waiting for favourable weather conditions		
18 Feb 1977	08.00	09.05	1.05	Returned due to excessively cloudy weather		
19 Feb 1977	07.55	09.45	1.50	Partially photographed Strip No. 1	60 km	
20 Feb 1977				Waiting for favourable weather conditions		
24 Feb 1977				Waiting for favourable weather conditions		
25 Feb 1977	07.55	08.50	0.55	Returned due to excessively cloudy weather		
26 Feb 1977				Waiting for favourable weather conditions		
1 Mar 1977				Waiting for favourable weather conditions		
2 Mar 1977	08.00	09.00	1.00	Returned due to excessively cloudy weather		
3 Mar 1977	07.55	08.25	0.30	Returned due to excessively cloudy weather		

4 Mar 1977	07.54	09.04	1.10	Returned due to excessively cloudy weather		
5 Mar 1977	07.55	09.00	1.05	Returned due to excessively cloudy weather		
6 Mar 1977				Waiting for favourable weather conditions		
9 Mar 1977				Waiting for favourable weather conditions		
10 Mar 1977	07.45	08.45	1.00	Returned due to excessively cloudy weather		
11 Mar 1977	07.45	08.45	1.00	Returned due to excessively cloudy weather		
12 Mar 1977	07.50	08.50	1.00	Returned due to excessively cloudy weather		
13 Mar 1977	07.45	08.45	1.00	Returned due to excessively cloudy weather		
14 Mar 1977	07.50	09.40	1.50	Returned due to excessively cloudy weather		
15 Mar 1977				Waiting for favourable weather conditions		
16 Mar 1977				Waiting for favourable weather conditions		
17 Mar 1977				Waiting until the rainy season ended		
3 Sep 1977				Waiting until the rainy season ended		
3 Set 1977				Moved to Malindi Airport and waiting		

4 Sep 1977	07.15	12.15	5.00	Partially photographed the western side of Strips No. 1, 2, 7, 8, 9, 10, 12 and 13	508 km	
5 Sep 1977				Waiting at Wilson Airport, Nairobi		
9 Sep 1977				Waiting at Wilson Airport, Nairobi		
10 Sep 1977	07.25	09.25	2.00	Moved to Malindi Airport and photographed part of the western side of Strip No. 11	63 km	
11 Sep 1977	07.00	07.30	0.30	Returned due to excessively cloudy, partly rainy, weather		
12 Sep 1977				Waiting for favourable weather conditions		
14 Sep 1977				Waiting for favourable weather conditions		
15 Sep 1977	08.00	08.50	0.50	Returned due to excessively cloudy weather		
15 Sep 1977	14.55	16.25	1.30	Returned due to excessively cloudy weather		
16 Sep 1977	07.10	08.15	1.05	Returned due to excessively cloudy weather		
17 Sep 1977				Waiting for favourable weather conditions		
18 Sep 1977				Waiting for favourable weather conditions		
19 Sep 1977	07.30	08.55	1.25	Returned due to excessively cloudy weather		
20 Sep 1977	07.20	08.15	0.55	Returned due to excessively cloudy weather		

21 Sep 1977				Waiting for favourable weather conditions		
22 Sep 1977	07.05	07.45	0.40	Returned due to excessively cloudy weather		
23 Sep 1977	15.25	16.10	0.45	Returned due to excessively cloudy weather		
24 Sep 1977	07.20	08.45	1.25	Partially photographed Strip No. 13	52 km	A distance of 25 km was overlapped in the total 77 km
25 Sep 1977	06.30	07.50	1.20	Partially rephotographed Strip No. 13	0 km	Overlapped photographing
26 Sep 1977	07.15	08.32	1.17	Returned due to excessively cloudy weather		
27 Sep 1977	07.10	07.40	0.30	Returned due to excessively cloudy weather		
27 Sep 1977	15.00	16.40	1.40	Photographed tie strip F and G	165 km	
28 Sep 1977				Waiting for favourable weather conditions		
29 Sep 1977	07.00	08.30	1.30	Returned due to excessively cloudy weather		
29 Sep 1977	15.25	17.25	2.00	Photographed tie strip B	126 km	
30 Sep 1977				Waiting for favourable weather conditions		
1 Oct 1977	07.00	07.30	0.30	Returned due to excessively cloudy weather		

2 Oct 1977				Waiting for favourable weather conditions		
3 Oct 1977				Waiting for favourable weather conditions		
4 Oct 1977	15.25	16.25	1.00	Photographed tie strip D	133 km	
5 Oct 1977	06.55	07.25	0.30	Returned due to excessively cloudy weather		
6 Oct 1977	07.00	09.15	2.15	Partially photographed Strip No. 9 and 12	63 km	A distance of 29 km was overlapped for the total length of 92 km
7 Oct 1977				Waiting for favourable weather conditions		
8 Oct 1977				Waiting for favourable weather conditions		
9 Oct 1977	06.55	07.26	0.31	Returned due to excessively cloudy weather		
10 Oct 1977	06.55	08.15	1.20	Returned due to excessively cloudy weather		
11 Oct 1977				Waiting for favourable weather conditions		
12 Oct 1977				Waiting for favourable weather conditions		

13 Oct 1977	07.00	08.20	1.20	Partially photographed Strip No. 12	29 km	A distance of 8 km was overlapped for the total length of 37 km
14 Oct 1977				Waiting for favourable weather *conditions*		
17 Oct 1977				Waiting for favourable weather *conditions*		
18 Oct 1977	07.00	07.20	0.20	Returned due to excessively cloudy weather		
19 Oct 1977	07.00	08.05	1.05	Photographed along seashore the eastern side of Strips No. 8 and 9	85 km	
20 Oct 1977	06.50	09.20	2.30	Photographed tie strip C	131 km	
21 Oct 1977				*Waiting for* favourable weather conditions		
22 Oct 1977	14.30	17.00	2.30	Partially photographed Strip No. 1	223 km	A distance of 27 km was overlapped for the total length of 250 km
23 Oct 1977	07.00	09.00	2.00	Partially photographed Strips No. 2 and 10	256 km	A distance of 21 km was overlapped for the total length of 277 km

24 Oct 1977	07.00	08.40	1.40	Returned due to excessively cloudy weather		
24 Oct 1977	12.15	14.15	2.00	Returned due to excessively cloudy weather		
25 Oct 1977	06.50	08.35	1.45	Returned due to excessively cloudy weather		
25 Oct 1977	14.40	17.00	2.20	Photographed the eastern end of Strip No. 1	31 km	
26 Oct 1977	07.00	10.40	3.40	Partially photographed Strip No. 7, 12 and 13	337 km	A distance of 34 km was overlapped for the total length of 371 km
27 Oct 1977				Waiting for favourable weather conditions		
28 Oct 1977	07.30	09.00	1.30	Moved to Wilson Airport, Nairobi		
29 Oct 1977				Waiting until the rainy season ended		
7 Dec 1977				Waiting until the rainy season ended		
8 Dec 1977	07.00	08.00	1.00	Returned due to excessively cloudy weather		
9 Dec 1977				Waiting due to unfavourable weather conditions		
10 Dec 1977				Waiting due to unfavourable weather conditions		
11 Dec 1977	07.00	08.30	1.30	Returned due to excessively cloudy weather		
12 Dec 1977	07.00	07.20	0.20	Returned due to excessively cloudy weather		

13 Dec 1977				Returned due to unfavourable weather conditions		
18 Dec 1977				Returned due to unfavourable weather conditions		
19 Dec 1977	07.00	08.30	1.30	Returned due to excessively cloudy weather		
20 Dec 1977	07.00	08.30	1.30	Returned due to excessively cloudy weather		
21 Dec 1977				Waiting due to unfavourable weather conditions		
15 Mar 1978				Waiting due to unfavourable weather conditions		
Total			98.38		2974 km	70.6% to the total sched-uled length of 4212 km
				Photographs adopted	2527 km	60.0% to the total sched-uled length